Project Deliverable

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D3.4 - Results of the Request for Ideas: mapping RTOs and Industry potential, response and trends related to Fire-IN CCC/ FCCCs #3

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Abstract:

This document describes results of the implementation of the "Request for Ideas" procedure of the third cycle of FIRE-IN. The "Request for Ideas" has been defined in Task 3.1. The particularities, the methodology and the issues raised during the third cycle of interaction with the Industry, RTOs and standardization bodies, as well as, the necessary adaptation of the actions and communication methods for the maximisation of the results of T3.2 are presented also in this deliverable. During the third cycle of "Request for Ideas" the inputs and outputs of the previous cycles are also considered in order to build a robust and coherent outcome, regarding the coverage level of both Current Common Capability Challenges and Future Common Capability Challenges. The deliverable provides specific results regarding the coverage level of the capabilities of the third cycle, based on the traffic light system according to Task 3.1. The results of two questionnaires, one for technology providers and one for practitioners, the results of a joint event and workshop of FIRE-IN with the MEDEA project and interviews with technological providers are also presented in detail. The document also presents the key conclusions regarding the "Request for Ideas" and the key points for the five working groups.

Keywords:

Communication, Industry, Request for Ideas

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Executive Summary

The FIRE-IN project is an initiative funded by the European Commission that has been launched on the 1st of May 2017. 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 need much stronger guidance from practitioners and better exploitation of the technology potentially available for the discipline.

The purpose of this report is to describe the steps and procedures followed for establishing cooperation schemes with Research and Technology Organizations (RTOs) and industry suppliers in an attempt to collect "responses" to the identified Common Capabilities Challenges (CCCs) and Future Common Capabilities Challenges (FCCCs) and implement the "**Request for Ideas**" (**RfI**), based on the methodology described in D3.1 (*Salvi et al*., 2018).

The actions described in this report are based on the work carried out so far in WP1 (the identification of the CCCs - FCCCs) and in WP2 (the screening of existing solutions). This document refers to the third cycle of the implementation of T3.2. The deliverable includes the results of the interactions with the Industry, RTOs and standardization bodies during the third cycle of implementation of "RfI" process.

This report encompasses the strategies followed, in order to establish interaction with stakeholders (practitioners, technology providers and standardization experts), as well as the application of the Traffic Light System (TLS) to the identified CCCs and FCCCs of the third and final cycle, having aggregated the total number of technological, research and standardization solutions, addressing each challenge.

Before proceeding to the method followed and analysis, a brief overview of the main results from the first and second cycle is presented along with a short description of TLS, which is the outcome of Task 3.1 (deliverable D3.1, Salvi *et al.*, 2018).

The third cycle challenges are an update of the Current Common Capability Challenges identified in the first two cycles and the Future Common Capability Challenges. In total, 24 challenges, 10 FCCCs and 14 CCCs identified during the third cycle. The CCCs and FCCCs are presented in Table 5 of the main document.

Table 5: The matrix of the third cycle Current and Future Common Capability Challenges. FCCCs are represented coloured blue with blue shading. CCCs are coloured black with no shading, while CCCs with a future aspect as well, are coloured blue.

	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multi-agency / Multi-leadership (ML)	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations.	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system.	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency.	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
Community involvement	CCC-5. Develop public self-protection and awareness.	CCC-6. Involve communities and key stakeholders as active actors in risk management.	FCCC-7. Negotiate the values with communities before the emergency.	FCCC-8. Cultural change towards risk tolerance and resilience.

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	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multi-agency / Multi-leadership (ML)	High level of uncertainty (UN)
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.

The **methodology followed** in this cycle in order to reach to the main outcomes of the RfI procedure and the kye points per Thematic Working Group is described below:

- Bridging the three cycles. Although there is no doubt about the evolution of the outputs of FIRE-IN during the cycles, especially for the CCCs and FCCCs, this step is considered necessary in order to show this evolution and also to support the further analysis of the data.
- Aggregation of the solutions found in the previous cycles with the third cycle. Also, new solutions uploaded in the FIRE-IN platform after the end of the third cycle are also examined.
- Assessment of the TLS and evaluation of each solution separately.
- Assessment of the TLS and evaluation of each CCC and FCCC considering the qualitative criteria of TLS and the quantitative matching of solutions to the relevant CCCs and FCCCs.

The **interaction with the stakeholders** was based on a different approach for this cycle:

- Two questionnaires were developed, one for practitioners and one for technology suppliers.
- A joint event that gave the floor to technology providers and a common workshop between technology providers and practitioners was organized.
- Brief discussions, in the form of private interviews, with technological organizations.

The third cycle approach was a more targeted action compared to the previous cycles and an action that supports interaction between FIRE-IN stakeholders. The questionnaires and the joint event were disseminated to all registered FIRE-IN members and to other projects on which partners of FIRE-IN participate or know their existence and have common goals or similar topics to the five TWGs.

In general, almost 300 technologies have been included, encompassing those screened in the context of WP2 and those uploaded to the platform, by providers, approached in the context of the Request for Ideas

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procedure. The majority of these technological solutions are either on the market (TRL>9) or TRL≥ 7 and include the following categories:

- Unmanned vehicles, either aerial or ground
- Personal Protective Equipment (PPE) and smart
- Geographic Information System (GIS) and geolocation software
- Applications for the management of volunteers
- Sensors for the detection of fire/smoke/embers
- Sensors for early detection of dangerous chemical, biological, radiological, nuclear and explosive agents
- Aircrafts and other innovative gear for firefighting
- Early warning systems
- Applications for the education of the public
- AR/VR training systems for first responders
- Crowdsourcing applications for mass notifications and alert
- Command and control systems
- Hazard and risk assessment technologies
- Weather forecasting systems
- Fire propagation models
- Technologies for resilient communications in harsh environments
- Tools for big data analysis
- Artificial Intelligence systems and machine learning
- Applications for remote disease diagnosis
- Other types of sensors, such as advanced seismometers, accelerometers etc.
- Cameras, which can locate people underwater
- Satellite images providing real or near-real time information

For **Research solutions**, the precondition for the chromatic characterization is almost exclusively related to the number of solutions. This is because Research is examined from the perspective of the number of terminated and/or ongoing projects and of papers. Moreover, papers, in order to satisfy the "Access to knowledge" criterion, have to be peer reviewed, the vast majority of which, covers the specific criterion. Therefore, a more arithmetical approach is followed. Yet again, there are cases, with some disproportions between these two types of solutions. There are challenges, which although well covered in terms of numbers, are yellow, due to the exact fact, that there are few projects addressing their topic.

Finally, regarding solutions deriving from the **Standardization** domain, these are categorised in Standards and Guidelines. In the case that a challenge is addressed by at least one standard, it is automatically considered green. Standards, especially those developed by EU or international standardization bodies e.g., CEN, ISO, IEC etc., provide quality and ensure wide acceptance and adoption. There are challenges with a few or even only one solution, which are green, because this solution represents one or more formal standards. On the other hand, challenges with higher numbers of solutions addressing them, are yellow due to the fact, that these solutions represent only guidelines, without information on their level of adoption by practitioners, and no standards at all.

Regarding the questionnaires, 109 responses were gathered in a period of 42 days. 43 responses belong to technology providers and 66 to practitioners. Regarding the joint event and workshop, in total 170 participants registered to the event, while 100 of them participated in.

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The **main outcomes** of the work carried out in the third cycle and the interaction between the stakeholders is summarized below. In terms of coverage level of the CCCs/FCCCs Table 26 represents the status quo for technologies, standards and research items.

Table 26: Application of the Traffic Light System to the Challenges of the third Cycle.

	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
	T	T	T	T
	R	R	R	R
	S	S	S	S
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.
	T	T	T	T
	R	R	R	R
	S	S	S	S
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
	T	T	T	T
	R	R	R	R
	S	S	S	S
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
	T	T	T	T
	R	R	R	R
	S	S	S	S
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
	T	T	T	T
	R	R	R	R
	S	S	S	S
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
	T	T	T	T
	R	R	R	R
	S	S	S	S

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As depicted in the above table, solutions coming from the domain of Standardization, adequately cover the majority of the identified CCCs and FCCCs. There is a great variety of both formal standards and guidelines, which are widely adopted by first responders' organizations. Moreover, in this case, there is no need for high numbers of solutions, as one standard can address, if not all, the majority of challenges, lying within the same capability.

Research, also covers, at least to a certain degree, the challenges of the third cycle. The fact, that a considerable number of challenges has a yellow colour does not necessarily mean that they are uncovered, as there are challenges addressed by a large number of papers and not by projects, or the opposite. This is explained, in the current deliverable, in detail. On the contrary, "*Knowledge Cycle*" and "*Preparedness*" capabilities include challenges addressed by only a handful of solutions, thus lying on the red colour and remaining aspects to be intensively and more analytically studied. Similarly, the "*High level of Uncertainty*" main challenge, which has an overall future character, requires special attention, and is expected to be a focal point of future research.

Technological innovations greatly address the "*Incident Command Organization*", "*Decision Making Cycle*" and "*Community Involvement*" capabilities. On the contrary, "*Risk Reduction*" and "*Preparedness*", which include challenges, focusing on the integration of disaster risk management in policies and legislations, on synergies between practitioners' organizations and on other procedural aspects, are less covered by technological solutions, something more or less expected, taking into consideration the essence of these challenges.

Request for Ideas: main conclusions

Already, from the previous cycles of FIRE-IN it became evident that technologies do exist and the majority of the CCCs were either covered (green level) or at a development stage (yellow level).

Standards, related to the topics raised by the CCCs/FCCCs, may not be so many in numbers, but on the other hand, a standard can address several challenges or challenges that belong to the same capability. Standardization can be a wide field for the future.

During the 3rd cycle it became clear, that these two categories of solutions, technologies and standards, are important both from the solution providers' and practitioners' point of view.

Currently, many different types of technologies exist, as described in the previous sections. All these types of technologies are available products in the market, are constantly developing and new products enter the market every day.

The key influencing factors, that were revealed during the 3rd cycle of FIRE-IN, which affect all the solutions categories of FIRE-IN are summarized below.

Data, data quality and proper sharing of the information. Data was, is and will be crucial for all phases of crisis/disaster management. To have the proper information, to the right people, at the right time, is crucial, especially for proper response. Moreover, this information, of any kind, must be reliable.

Openness in data, data formats and source codes is another topic. Open data boost research outcomes and make technologies to adapt more functionalities faster. Nevertheless, all these data must be valid, so filtering and validation, especially from open data, is extremely important as well. Open data formats and common data formats are important and helpful in exchanging and sharing of information between various sources.

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At the same time, open-source codes may help the transition from traditional tools to more high-tech tools. Nevertheless, issues such as credibility are extremely important in this case, as practitioners need credible and reliable software, hardware and materials built with high quality standards.

Experience and training help to take the right decisions and filter the information. Practitioners must be trained frequently. Too much of information can be even more confusing than little to even no information at all. Only through training and experience, practitioners can have the ability to filter properly the information received.

Isolation or fragmentation of technologies. As described earlier technologies are already available. The problem does not focus on the existence of technologies but on how the various technologies and their integration is applied. Technologies must integrate within each other and be interoperable with old, legacy systems and new systems as well. Currently, various projects deal with that, but the overall results are demonstrated in pilot cases usually, and more time is required to see it operationally applied in the field. Besides time, other topics are also important for new technology to be widely used. These issues can be issues of acceptance, permission, legal framework and support, as well as safety issues. Integrated solutions also exist but these are usually from individual suppliers and, usually, the solutions can "speak" to each other but not with other products from other suppliers.

Conservatism of practitioners to use new technologies. This is an issue that pointed out by technological suppliers. There is no simple and straight answer, but this is something that must be taken into consideration for the future. What prevents practitioners to adapt solutions that are available? Procurement issues? Costs? Lack of information for a valuable technology? How friendly is a new system/technology to a practitioner? Trust to specific large suppliers? This conservatism may be in relation to the general access of practitioners to technologies and standards. Is it simply the costs and the procurements issues? Is it problems of bureaucracy inside first responders' organizations? Is it a problem on the high level/strategic level of first responders?

It seems that practitioners do not follow technological progress when suppliers try to cover their needs. This is, without a doubt, an issue related to limited access to technologies and standards and possible conservatism. This could even be something simpler. As nowadays, in the high levels of hierarchy of practitioners there are people who grew up in different times without having too much technology and in our era, the overloading with new technologies may pose difficulties and credibility issues.

Risk awareness is a key point to all the above. Another significant topic that was raised irrespective of technology was risk awareness. If, as a society, which includes both practitioners and citizens, we do not have a good understanding of the potential risks and threats, then many technological tools may be totally useless (or perceived as such).

Interoperability and standardization. Standards make things typical and common to everyone. Standards can cover technical topics, data and information exchange, procedures and planning, inside an organization or between organizations (cross-organization communication, planning and response), or even between nations (cross-border communication, planning and response). Even, in the form of guidelines, standardization is extremely important for practitioners. The issue of practitioners' access to standards is important. The transformation of various standard operating procedures to formal or widely accepted guidelines would also be a solving factor that would ensure a standard method across nations and even continents. Interoperability is solved only through standardization. Common data formats are a pure

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standardization topic either for formal or professional standards. Interoperability is the main key for an easy step to integration.

Finally, **key conclusions for each Thematic Working Group** from the viewpoint of their leaders are presented.

Thematic Working Group A: "Search and Rescue Emergency Response"

Any Search and Rescue incident is a unique case and consequently a unique mission and it could be a crisis management topic inside another crisis/disaster management. To that extent, Search and Rescue requires proper experience and training, proper equipment and a common information sharing the proper. Low frequency of occurrence of certain events does not allow to learn from them frequently and the only way to overcome such issues is constant training. Engagement of local population is crucial, especially in cases on which there no adequate resources.

Thematic Working Group B: "Structure Fires"

CCC-1 "*Organize to sustain safe operations*", CCC-5 "*Develop public self-protection and awareness*" and CCC-6 "*Involve communities and key stakeholders as active actors in risk management*" are the current challenges, considered as the most essential regarding this TWG, while FCCC-8 "*Cultural change towards risk tolerance and resilience*" and FCCC-12 "*Focus on capacity building towards more resilient societies*" are the most important future challenges. Regarding essential technologies, which could facilitate structure fire operations, the development of advanced sensors (for embers, smoke or fire), the analysis and filtering of big data, coming from several sources and, finally, AR/VR simulation systems for the training of first responders, seem to be at the forefront. Moreover, there is significant concern regarding the evacuation of people from burning buildings. This is due to the increase of elder and overweight population in Europe, as forecasts predict. This is something, that could make operations more difficult in the future, as semi-autonomous or not autonomous persons require different procedures. Another point of interest is the introduction of new building construction materials, as well as new energy sources, which could potentially lead to changes and adaptations of operational procedures.

Thematic Working Group C: "*Landscape Fires Mitigation*"

While FIRE-IN is aimed at the response community, it is nonetheless critical to point out that research, experts, and most practitioners acknowledge the requirement of proactively addressing the *drivers* of landscape fire challenges as many catastrophic fires result in damages and casualties because systems have reached their limits. Catastrophic fires are increasingly *rarely* controlled through response efforts, but primarily by a change in weather conditions and to a degree the available fuel. This notion is also supported through a recent expert survey conducted by TWG-C where only one third of respondents saw the potential for technology and innovation to have significant improvements on operational firefighting while two-thirds were either sceptical of "technological fixes" or saw advancing technology and innovation to play an important role, but with relatively limited room for improvement in operational wildland firefighting. Overall, the majority of respondents estimated technology and innovation to play an increasingly important role in better preparing for, preventing, and recovering from wildfires – but only when combined with social changes and economic investments in in proactive, integrated fire management. In sum, as is consistent with the

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discussions in this document, most challenges could be considered as covered by solutions, but because landscape fires are complex interconnected and 'scaled' events there remain many coverage gaps in reality and more importantly changes in investment, social changes, and the landscape-level efforts resulting in more resilience and are much less addressed by the evaluated solutions – but are consistently highlighted by experts and practitioners through surveys and workshops.

Uncertainty (low-frequency high-impact events), spending/funding allocation, interoperability, planning, applied science knowledge, rural exodus, community awareness and safety and decision-maker awareness are the top challenges for this TWG. Cross-border interoperability standards for aerial firefighting, standardized emergency information dissemination systems, standardized incident management structure for unified command, standardizes maps and symbols, fire weather standardized indices and landscape classification system, and cross-agency and cross-border interoperability for landscape fire management are the most important future standardization items.

Although identified evaluated solutions do exist for the majority of the CCCs and FCCCs, some key concerns are still low in terms of solutions: These are:

- Solutions that addressed over-dependence on water and or low-water solutions (excluding suppressants and retardants)
- Solutions to scale up prescribed burning efforts
- Solutions for better citizen awareness and self-protection
- Solutions for basic/competency-based wildfire training (particularly in newly fire-prone countries) such as e-learning platforms or basic training standards in different languages
- Solutions which integrate fuel mapping with risk parameters and planning tools

Thematic Working Group D: "*Natural Hazard Mitigation*"

CCC-14 – "*Choose a strategical scenario of resolution, and distribute tactical decision-making*", CCC-5 "*Develop public self-protection and awareness*", FCCC-7 – "*Negotiate the values with communities before the emergency*" and FCCC-8 "*Cultural change towards risk tolerance and resilience*" are the most important common and future common capability challenges respectively. Moreover, according to the TWG leader, apart from technology, that definitely plays a significant role in the management of natural hazards, there is also a great need for standardization of the procedures. Standardization can prove an efficient tool for the appropriate training of the personnel, it can provide interoperability, at a procedural and technical level, and it can facilitate decision making processes. Additionally, regarding the involvement of the community, for certain, it is crucial that well prepared citizens may lead to less effort from the practitioners' side and more efficient management of emergencies. On the other hand, especially regarding natural disasters, which may have enormous impact and very low frequency, only adequately trained first responders' organizations can provide effective means to confront them. Population cannot be sufficiently ready for such emergencies beforehand. Interactions between the technology providers and the end users, which has been the main goal of the project, throughout its lifetime, could provide solutions, addressing, all phases of the disaster management cycle. Also, the links of TWG-D are strong with TWG-C and common ground between the two TWGs is obvious.

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Thematic Working Group E: "*CBRNE*"

Regarding CCCs, CCC-2 "*Anticipate and prioritize avoiding the collapse of the emergency system*" and CCC-5 "*Develop public self-protection and awareness*" are voted as the most important ones, with the same applying to FCCC-7 "*Negotiate the values with communities before the emergency*" and FCCC-8 "*Cultural change towards risk tolerance and resilience*", for the future challenges. Again, community involvement is highlighted, especially in the face of terrorist and malevolent attacks, which are becoming more frequent. In addition, new and resilient communication tools, GIS, AI and machine learning software can facilitate practitioners' operations. Standardization can provide certification and high quality of these systems. Something, on which discussions emphasized, is the market uptake of new technologies. There is a great need for informing end users about the new products and their characteristics, as well as standards, providing objective criteria for the evaluation of the performance and usefulness of these solutions for the practitioners.

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1. Introduction

The FIRE-IN project aims to identify (a) challenges and gaps that practitioners face in their everyday operations and make response more difficult and complicated, and (b) solutions that can bridge the gaps by bringing together practitioners, researchers and industry. The closure of the challenges is examined in terms of current research items (projects and publications), guidelines, standards and innovative technologies. These solutions will facilitate effective and timely operations and greatly enhance the disaster management capacity of first responders' organizations.

The project consists of five Thematic Working Groups (TWGs), which represent five domains of disaster management. These TWGs are the following:

- Search and Rescue Emergency Response
- Structure Fires
- Landscape Fires Crisis Mitigation
- Natural Hazard Mitigation
- CBRNE

The structure of the project is based on three sequential steps. The first one, under the framework of WP1, is the identification of challenges in first responders' capabilities. The next step is the identification of solutions capable of minimising the Common and Future Capability Challenges. Solutions are screened in the context of WP2 and aim to bridge the gaps and address the challenges, already identified in WP1. The third step, on which **WP3** "***Collaboration with research, industry and standardization bodies and recommendations"*** focuses, is related to the interaction of practitioners with solution providers, whether they come from the technology or the standardization and research domains. The goal of this interaction is to validate the challenges and identify the needs for future innovation and research. These steps are looped in 3 cycles.

Task 3.2 "Request for RDI ideas addressing CCCs and FCCCs and capitalisation of the feedback" is dedicated to the identification of research and development ideas and related to the implementation of the Request for Ideas (RfI) process. The deliverable D3.4 describes the actions and procedures followed for the interaction with industry, standardization bodies and RTOs aiming to the RfI implementation during the third cycle of the project.

The first two cycles were devoted to the identification of the Common Capability Challenges (CCCs), while the third cycle focuses on the Future Common Capability Challenges (FCCCs).

This document builds on the results of WP1 and deliverable D1.4 (Miralles *et al.*, 2021) and the screening performed in WP2 and deliverable D2.4 (Schlierkamp *et al.*, 2021), both dedicated to the third cycle, but also briefly presents the results from the previous two cycles.

Deliverable D3.4 presented herein consists of the following chapters:

- Chapter 1 is the introductory section.

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- Chapter 2 briefly describes the results of the previous cycles as well as the third cycle CCCs and FCCCs.
- Chapter 3 focuses on the methodology followed for the 3rd cycle of RfI and the interaction with stakeholders.
- Chapter 4 focuses on the analysis that was carried out and the results of this analysis both from questionnaires and the application of the Traffic Light System (TLS) used for the solutions found in the third cycle.
- Chapter 5 describes the main outcomes from the questionnaires developed and dedicated to practitioners and providers.
- Chapter 6 presents the basic results of the joint event, organised in the framework of the synergy between the FIRE-IN and MEDEA projects.
- Chapter 7 is related to interviews with specific technology providers, with whom discussions, regarding the challenges and essential technologies, were held.
- Chapter 8 is a section dedicated to the overall results and conclusions, drawn from all the above steps and processes, implemented for the RfI procedure of the third cycle.
- Chapter 9 includes the references of this document.
- Chapter 10 is the appendix with the various annexes, such as the first and second cycle Common Capability Challenges matrices, the traffic light system, the application of the TLS to the PCCCs, as presented in D3.3, the invitation to the joint event, the participants list, the set of questions for the questionnaires and the solutions currently uploaded on the e-FIRE-IN platform as an easy guide to the reader with the respective links.

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2. The three cycles of FIRE-IN

2.1. The Traffic Light System (TLS)

The basic tool for the evaluation of the interaction with industry is the Traffic Light System (TLS). TLS is a classification scheme specifically designed for characterising/classifying the CCCs and FCCCs as "*covered*" (green light), "*in progress*" (yellow light), and "*still a gap*" but with a future trend (red light). Based on TLS, the FIRE-IN project can relatively easily characterise a CCC or FCCC as practically covered or not by research items, technology, and standards.

TLS is based on specific criteria, for the three categories of solutions. For research items, the criteria are (a) the operational value of existing solutions and (b) access to knowledge. For standards the basic criterion is the operational value of the identified standard/guideline, while for technological solutions the criteria focus on (a) the operational value of existing solutions, (b) the maturity level of the solutions based on the well-known TRL indicator and (c) the interoperability and standards addressed. TLS was developed in the framework of FIRE-IN in deliverable D3.1, specifically developed for the needs of the project.

Table 1: Criteria examined for the characterization of each challenge from the perspective of research (D3.1 – Salvi and Frecenon, 2018).

Criteria	Green	Yellow	Red
Operational value	Many projects on the topic, that are already completed and delivered available knowledge in articles and guidance documents.	Few projects completed on the topic, sometimes only at national level. 1 or 2 on-going projects.	Further research and development needed.
Access to Knowledge	Peer reviewed international guidance document or standard available. Training courses available.	A few papers available sometimes only at national level.	Only papers or communication pointing the need to address the topic.

Table 2: Criteria examined for the characterization of each challenge from the perspective of standardization (D3.1 – Salvi and Frecenon, 2018).

Criteria	Green	Yellow	Red
Operational value	Peer reviewed international guidance document or standard available.	Standard or guidance document in preparation or mentioned as future work of some technical committees.	The need to address the topic has been expressed by the community.

Table 3: Criteria examined for the characterization of each challenge from the perspective of technology (D3.1 – Salvi and Frecenon, 2018).

Criteria	Green	Yellow	Red

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Operational value of existing solution	Already available and operational.	Available as pilot solution / demonstration.	Further research and development needed.
Solution maturity (TRL) and industrialization level (time to market, TTM)	TRL>9 Already available on the market.	6<TRL<9 Already developed as prototype and being tested / validated.	TRL<6 Still need some research and development.
Interoperability and standardization	Availability of the standards describing to solutions and interoperability issues.	Awareness of need for standard.	Standard not yet addressed.

In this document, the TLS is applied to the challenges of the third cycle, CCCs and FCCCs, taking into consideration the input and feedback gained from all three cycles, in order to examine the level of coverage of each challenge. Also, each CCC and FCCC is examined considering the three dimensions of the project, meaning the technology, research and standardization aspect. The tables depicting the level of coverage, in terms of the first and second cycle, are used as a first input, whereas the solutions screened in the third cycle of the project are added. This results in a final configuration of the number of technological, research and standardization solutions addressing each third cycle challenge, and at the same time considering all the work that has been done so far.

2.2. Brief overview of the first and second cycle

2.2.1. First cycle Common Capability Challenges

During the first cycle of workshops with practitioners and experts of the five TWGs, 27 Common Capability Challenges (CCCs) were identified. These CCCs were distributed in a table of seven rows and four columns.

The seven rows represent the following capabilities:

- Incident Command Organization
- Pre-planning
- Guidance Instruments
- Knowledge Cycle
- Information Management
- Community Involvement
- Technology

On the other hand, the four columns represent the following main challenges:

- High flow of effort in hostile environment
- High impact, low frequency events

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- Multi-agency/multi-leadership environment
- High level of uncertainty

The above seven capabilities and four main challenges form a matrix, in which the CCCs are distributed. Most of the challenges are in accordance with the Sendai Framework (UNISDR, 2015) articles and the International Forum to Advance First Responder Innovation (IFAFRI) challenges. More details can be found in D1.2 (Lahaye *et al.*, 2018). The matrix of the 27 capabilities is also provided in Appendix A1 Table 31).

According to the results of the first cycle the CCCs "*Use technology to assess risks and minimize responder's engagement*" and "*Technological tools to support data sharing*" were characterized as green according to the Traffic Light System (TLS) classification scheme, while the "*Simulate complex scenarios*" and "*Get a clear picture of the risk evolution*" were characterized as yellow.

From the first cycle RfI procedure the most important topics raised were the following:

- Adaptation of common European symbology for civil protection.
- Existing and future software, platforms and decision support tools should be governed by interoperability.
- Public procurement procedures can raise and necessitate the issue of interoperability.
- Communicating Risk.
- The existence of various decision support software, tools and platforms may complicate significantly operational decisions.
- Regulatory issues related to the liability of use of decision support systems and tools.

More details on these topics can be found in deliverable D3.2 (Varela *et al.*, 2019).

2.2.2. Prioritised Common Capability Challenges of the second cycle

In the second cycle, a revision of the CCCs was conducted, with the aim to provide more information and a better description of the challenges. Through workshops, a list of 12 challenges emerged, that comprise a prioritization of the first cycle CCCs. The table with the 12 Prioritised Common Capability Challenges (PCCCs) is found in Appendix A2 (Table 32). The description of each challenge, the relevant topic (capability) and the magnitude of importance, as expressed by experts, participating in the workshops, are provided.

One important aspect that was revealed, is that the "*Technology*" and "*Guidance Instruments*" capabilities of the second cycle matrix, had a quite generic description. This led to a different way of handling these capabilities, as in reality "*Technology*" and "*Guidance instruments*" are a kind of "umbrella" capabilities, meaning that every CCC can be examined in terms of available/existing technologies and standards. These capabilities are placed at a higher level and, to some extent, encompass transversally all the others. Thus, in the list of PCCCs, PCCC-2 and PCCC-10 were not handled as specific challenges and screened solutions were matched only with the other ten PCCCs. Nevertheless, these two challenges were considered in the overall Request for Ideas for the second cycle in order to examine their level of coverage.

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Based on the second cycle regarding Technology, the "*Incident Command Organization*" (PCCC-6, PCCC-7, PCCC-9) and "*Pre-planning*" (PCCC-8) capabilities are both well covered by solutions and are characterised as green. The "*Knowledge Cycle*" (PCCC-5, PCCC-11) capability, although well addressed by technological innovations, is overall characterised as yellow, because of some tools lacking information regarding their operational value and the adoption of standards. "*Community Involvement*" (PCCC-1, PCCC-3, PCCC-4 and PCCC-12), which seems to be the most important from the end users' point of view, is also characterised as yellow. Although a satisfying number of solutions exists, many are yellow to red, with the "interoperability and standards" criterion lacking information.

For the Research domain the majority of PCCCs are yellow. The reason is, that, although research papers exist for all aspects examined by the challenges, the number of solutions identified is small and cannot provide a sufficient sample for safe conclusions. Nevertheless, the "operational value" and "access to knowledge" criteria are green for the majority of solutions. The "*Community Involvement*" capability was characterized with a yellow colour as the topic has been identified through many papers and articles but with a limited number of projects addressing it.

Except for PCCC-3 and PCCC-5, all other challenges were rated green from the viewpoint of standardization. Furthermore, from the analysis of technological solutions, PCCC-9 is on equal level with the other two challenges of this capability (PCCCs 6 and 7). Overall, the number of standards and guidelines screened is low and mainly consists of professional standards, guidelines and manuals and not formal standards. Formal standards are standards published by CEN, ISO and the official standardization bodies, while professional standards are standards published by other organizations. More information regarding the distinction between formal and professional standards can be found in deliverable D3.5 (Lahaye *et al.*, 2019). At the time, when deliverable D3.3 (Sakkas *et al.*, 2020) was submitted, the generic view was that, regarding formal standards, the level of coverage of most of the challenges was yellow, or even red. Moreover, the extent, to which guidelines are followed and adopted internationally, an aspect examined by the Traffic Light System for the standardization domain, is largely unknown, as is the integration of these guidelines into policies and legislations.

During the second cycle, regarding the RfI procedure the main topics raised are the following:

- Many technological solutions are already available or will be available in the next years, concentrating on early warning systems, use of artificial intelligence, unmanned vehicles, satellite technologies, augmented reality, crowdsourcing technologies and citizen engagement.
- Training both for citizens and first responders will be a key issue.
- Risk communication is increasingly crucial.
- Interoperability: systems and tools must be interoperable.
- Standardization: improvement of existing standards and development of new standards.

These are described in detail in deliverable D3.3 (Sakkas *et al.*, 2020). Moreover, the application of the TLS to the twelve PCCCs of the second cycle are presented in Appendix A3.

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2.3. Common and Future Common Capability Challenges of the third cycle

In the framework of WP1 the Future Common Capability Challenges for the third cycle were identified, again in consultation with experts and practitioners. In this cycle two main differentiations were made. The first one is the change in the number of capabilities, from seven in the first and second cycle, to six in the third cycle, as presented in Table 4.

Table 4: The change in the capabilities from first and second cycle to third cycle.

First and second cycle Capabilities	Third cycle Capabilities
Pre-planning	Incident Command Organization
Guidance Instruments	Preparedness
Incident Command Organization	Risk reduction
Knowledge cycle	Knowledge cycle
Information management	Community Involvement
Community Involvement	Decision making cycle
Technology	

This change was considered necessary in order to simplify the Common Capability Challenges and focus on the challenges that are the most important according to the experts engaged in this process. Also, **technology and standards (represented by Knowledge cycle capability) are removed from the table under the condition that each future challenge should be checked against these two aspects**.

The second major change is the update of the Common Capability Matrix encompassing both CCCs and FCCCs. Thus, CCCs and FCCCs are presented in a common table. CCCs represent challenges with a time frame of 5-10 years maximum (short and medium term), while the FCCCs are expected to continue with a horizon of more than 10 years (long term).

The current challenges are practically the Common Capability Challenges, already identified in the first cycle of the project. These challenges continue to pose difficulties to first responders' operations, according to the practitioners and fire and rescue experts, who participated in the webinars and events, held in the framework of the WP1. As for the FCCCs, these are challenges, expected to emerge in the long-term, and especially, in the face of high impact and increasing complexity disasters. One significant point that highlights this fact is that all challenges, under the umbrella of the "Uncertainty" main challenge, are considered as FCCCs. Additionally, there are challenges, which are both considered as current and future, *i.e.*, they currently pose and will continue to pose threats in the future. More information regarding the identification of the third cycle challenges can be found in D1.4 (Miralles *et al.*, 2021).

The updated matrix of CCCs and FCCCs is presented in Table 5 below.

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Table 5: The matrix of the third cycle Current and Future Common Capability Challenges. FCCCs are represented coloured blue with blue shading. CCCs are coloured black with no shading, while CCCs with a future aspect as well, are coloured blue.

	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multi-agency / Multi-leadership (ML)	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations.	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system.	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency.	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
Community involvement	CCC-5. Develop public self-protection and awareness.	CCC-6. Involve communities and key stakeholders as active actors in risk management.	FCCC-7. Negotiate the values with communities before the emergency.	FCCC-8. Cultural change towards risk tolerance and resilience.
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.

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3. Request for Ideas implementation methodology for the third cycle

3.1. Methodology for the RfI

Before laying the foundations, upon which the interaction and communication with stakeholders were set, a specific stepwise process was developed, with the aim to apply the traffic light system and check the overall level of coverage of each challenge by solutions, as described below:

a) The first step was to establish links between the challenges of the three cycles and, specifically between the CCCs of the first and second cycle with the CCCs-FCCCs of the third cycle. These correlations were conducted based on the content and the core meaning of each third cycle challenge, as it is described in D1.4 (Miralles *et al.,* 2021).

b) The second step was to aggregate all solutions, screened in the first, the second and the third cycle, along with the ones uploaded to the e-FIRE-IN platform, according to the results of WP2, and distribute them to the challenges of the third cycle. In the second cycle of the project a prioritization of the 27 challenges of the first cycle was made, thus leading to the 12 PCCCs. This procedure also affected the screening for solutions (carried out in WP2), which had to be adjusted during the second cycle. The first screening was used as a basis for the second screening, as it is stated in D2.3 (Walter *et al.*, 2020). The fact, that some solutions were very specific, addressing directly particular PCCCs, whereas others were very generic, necessitated refinements and updates of the already screened solutions. Moreover, new ones were identified. The conclusion was that in order to come up with the final numbers of Research and Standardization solutions of all three cycles, summing solutions from the first, the second and the third cycle would lead to false numbers, because in the second screening, solutions from the first were also included, therefore leading to double registrations. The approach that followed with the aim to have the exact total numbers, was to use the matrix from the second screening, as the most up to date, and to add to it solutions, which were screened during the third cycle (D2.4, Schlierkamp *et al.*, 2022).

c) After having gathered and allocated all solutions to the CCCs and FCCCs, a thorough examination of each solution was conducted, in terms of their level of maturity. The Traffic Light System criteria were used and thus, a qualitative analysis adding on the quantitative one, described in the second step, was performed.

d) Finally, the TLS is applied to each challenge, regarding the level of coverage by technology, research and standardization solutions. Taking into consideration the above methodology, each challenge was coloured, not only with regards to the number of solutions addressing it, but also with regards to the maturity of these solutions as proposed by the TLS.

Traffic Light System (TLS) has been built based on quality criteria, such as the operational value of the solution, the technology readiness level and the interoperability topics (details in section 2.1 and deliverable D3.1). As TLS is the main tool for classifying challenges, is has been used in both a

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qualitative and a quantitative approach for the three types of solutions (technologies, research items, standards).

In order to decide on the colour of each, meaning to decide if the CCCs/FCCCs are well covered or not as a first step each solution is examined individually according to what CCC/FCCC addresses and of course, its type and the respective criteria of the TLS. Thus, an overview of the individual solution is gained. The next step is to get the overview of the CCC/FCCC based on how many solutions are related to the specific CCCs/FCCCs. This provides the overall overview and guides the final characterization of the CCCs/FCCCs in terms of the TLS.

At this point it must be reminded that the solutions have been examined by the WP3 leader which is a research organization, a consulting body of first responders and not a practitioner organization.

Traffic Light System (TLS) has been used following the proposed criteria for the three types of solutions (technologies, research items, standards) in a qualitative and quantitative manner. The number of solutions (quantitative approach) that address specific CCCs/FCCCs is an indication that the field is of interest to solution providers and could be covered at least in a "yellow" level. The qualitative approach is a more difficult procedure as it aims to see if the solution is truly useful for the practitioners and address/solves the gap/challenge.

For example, if a CCC/FCCC is addressed by a large number of technological solutions with a TRL<9, not providing adequate information regarding interoperability capabilities and use of standards, and not having clear outcomes of the operational value then, the challenge is characterized as "yellow" despite the availability of solutions. Other combinations such as many solutions with very high TRL>9, low operational value and not sufficient information in interoperability and standards, results again to a "yellow" level. Meaning that the whole process is based not only on quantity but also on quality. Quantity is an indication of addressing a challenge but is not the definitive factor.

In Appendix A9 (Table 41, Table 42, Table 43), all the solutions examined during the RfI procedures are presented along with the relevant CCCs and FCCCs and their characterization according to Traffic light system.

3.2. Interaction and communication with stakeholders

Apart from the TLS application, a strategy regarding the establishment of communication with stakeholders, mainly practitioners and technology providers, with the aim to implement the RfI procedures and gain valuable feedback, was planned. During the third cycle it was decided to follow a different approach compared to the first two cycles for the communication and interaction with the stakeholders of FIRE-IN. The aim was, not only to focus on discussions with providers, with the ambition to upload their solutions to the platform, but to have a holistic view on what practitioners and solution providers believe and expect to confront in the short, mid and long term. For that reason, the following procedures were decided:

a) To create two questionnaires, one for practitioners and one for solution, mainly technology, providers. These questionnaires examined two important issues, technology and

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standardization. The aim was to see if and to what extent, these two domains can facilitate and have a positive impact on first responders' everyday operations and on disaster management as a whole. Apart from this, another important aspect was to collect feedback on future trends, regarding technologies relevant to disaster management. Interesting results and conclusions, between the answers of practitioners and providers, were drawn and are presented in this deliverable.

b) To take full advantage of the synergies between the FIRE-IN and the MEDEA projects. Both are networking projects of practitioners and KEMEA is the coordinator of the latter. MEDEA, although it does not focus exclusively on disaster management, deals with Wildland Urban Interface fires (WUI fires) and Flash floods, which are examined by TWG-C and TWG-D of FIRE-IN, respectively. In addition, except for common topics, the two projects share a similar methodology regarding the identification of gaps (as so-called in MEDEA) and challenges (as so-called in FIRE-IN) in first responders' operations. Thus, it was decided to organise a joint event between the two projects. Stakeholders, namely practitioners and technology providers, were invited, with the aim to discuss about these challenges, identify essential types of technologies, while providers were given the opportunity to present and disseminate their innovations to a wide audience. Technology providers were also asked to upload the solutions they presented on the FIRE-IN platform.

c) To organise a dedicated workshop in the framework of the joint event, in order to discuss in more detail, the concept of FIRE-IN, the CCCs and FCCCs and gain insight regarding future aspects, in a live discussion between practitioners and providers.

d) To hold brief discussions with technology providers, in the form of interviews, elaborating further on the results of the joint event and requesting their view on the importance of the third cycle challenges and on technologies, which they believe will enable safer and more efficient operations in the future. Their opinion regarding future technological trends was also asked.

e) Disseminate the event to the registered members of FIRE-IN.

f) Disseminate the event to the MEDEA project network.

g) Disseminate the event to various EU funded projects that work on similar topics.

h) Disseminate the event through social media channels of the two projects.

Both questionnaires and the joint event, were targeted to a European and international audience in order to gain a more widely accepted opinion on future trends.

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4. Analysis and results

4.1. Bridging the challenges of the three cycles

As described in the methodology chapter (see section 3.1) the first step, in order to apply the TLS, was to find correlations and interconnections between challenges of the first, the second and the third cycle, in order to (a) show the evolution and the continuity between the three cycles and (b) use the input and feedback gathered in the previous cycles for the analysis of the third cycle as well.

In order to achieve the bridging between the three cycles, all challenges, from all FIRE-IN cycles, were checked one by one considering their description according to deliverables D1.2 (Lahaye *et al.*, 2018), D1.3 (Gallardo *et al.*, 2019) and D1.4 (Miralles *et al.*, 2021). The challenges, current and future ones are analyzed in detail in the respective deliverables. The matching between the three cycles in some cases is easy as there is a forward aspect with direct links between the challenges, while in other cases, especially in terms of the FCCCs, present oblique interconnections. This is related to the intrinsic character of the CCCs/FCCCs. Some CCCs/FCCCs, especially if they belong to the same capability or the same challenge, may present overlaps, which could complicate a bit the process of matching. The matching between the three cycles is presented in Table 6.

Table 6: Correlations between the challenges of the three cycles.

Capability	1st cycle CCCs	2nd cycle PCCCs	3rd cycle CCCs/FCCCs
Incident Command Organization	CCC-1. Focus on sustainability of safe operations	PCCC-9. Maintain situation awareness. Avoid the loss of information with shifts' changes.	CCC-1. Organize to sustain safe operations.
	CCC-2. Prioritize the reduction of vulnerability and increase interactions with the public.	PCCC-7. Prioritise response and resources allocation to avoid the collapse of the emergency response system: triage, build alternative scenario, identify trigger points…	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system. CCC-5. Develop public self-protection and awareness. FCCC-7. Negotiate the values with communities before the emergency.
	CCC-3. Distribute decision-making	PCCC-6. Identify points of coordination in the different zones: from local (hot zone, warm zone ...) to regional and to national. Establish different levels of liaison officers, translators; communication; entrance points; and infrastructures as needed.	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency. CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making CCC-15. Build a shared understanding of the scenario to synchronize decision-making
	CCC-4. Strategies choosing safe scenarios, and maintaining credibility		FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency. FCCC-16. Create certainty and shared vision of emergencies.
Pre-planning	CCC-5. Pre-plan a time efficient, safe response.		CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement

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	CCC-6. Negotiate solutions with stakeholders for anticipated scenarios.	PCCC-8. Base the prediction of scenarios on historical events and on statistics (baseline), including the modelling of the actual conditions (at local level) and human factors.	CCC-18. Negotiate solutions with stake holders for anticipated scenarios
	CCC-7. Plan interoperability and enhance synergies.		FCCC-19. Integrate risk prevention and safety into other policies and actors. CCC-22. Plan in a more integral way. FCCC-23. Pre-plan interoperability and enhance synergies
	CCC-8. Focus on governance and capacity building towards more resilient societies.		FCCC-12. Focus on capacity building towards more resilient societies. FCCC-20. Focus on governance and integral risk management.
Guidance Instruments	CCC.9 Establish procedures and guides.		CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement
	CCC-10. Standardize capabilities in front of pre-established scenarios.	PCCC-10. Adapt the legal framework and requirements on prevention and self-protection of infrastructures and activities to first responders' needs, lessons learned from past events... Plan the implementation of laws and plans. Adapt the regulations to emergency situations.	CCC-18. Negotiate solutions with stake holders for anticipated scenarios
	CCC-11. Establish an interagency framework.		CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency. CCC-11. Build a shared understanding of the emergency, and train interagency scenarios. FCCC-23. Pre-plan interoperability and enhance synergies
	CCC-12. Build doctrine for resilience in emergency services and societies.		FCCC-12. Focus on capacity building towards more resilient societies
Knowledge Cycle	CCC-13. Train specific roles		CCC-9. Train specific roles and risks and invest in a robust knowledge cycle
	CCC-14. Learn about possible scenarios focusing efforts in key risks and opportunities.	PCCC-11. Towards a complete cycle of knowledge. Adjust Standard Operational Procedures (SOPs), doctrine and pre-plans using the feedback from real incidents and from exercises testing them (evaluators, assessors, statistics...) and identify the main gaps to focus efforts in training, procedures, personnel and equipment. Evidence based on fire scenarios. The process learning of an organization goes through the identification of own 'best practices' and the external ones: to collect experiences and convert them into guides, to collect 'lessons learned' and transform the best points into protocols,	FCCC-10. FRS empowered to innovate and build organizational learning. CCC-18. Negotiate solutions with stake holders for anticipated scenarios.

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		to share experiences with the aim of generating standards.	
	CCC-15. Build a shared understanding of emergency and train interagency scenarios.	PCCC-5. Once the standard roles of different actors have been trained and drilled inside each agency, organize multiagency joint trainings and exercises with the focus on decision-making, coordination and interactions between agents. Train in overlapped competences and limits of competences. Train the trainers of the different agencies. Share on-line training and exercises.	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios
	CCC-16. Focus on integral risk management.		FCCC-24. Focus on governance and integral risk management.
Information management	CCC-17. Information cycle.		CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution. CCC-15. Build a shared understanding of the scenario to synchronize decision-making
	CCC-18. Manage key information focused on decision-making		CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency. CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making.
	CCC-19. Define common information management processes between agencies.		CCC-15. Build a shared understanding of the scenario to synchronize decision-making
	CCC-20. Provide an efficient, flexible flow of information for a shared understanding		CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making. FCCC-16. Create certainty and shared vision of emergencies.
Community Involvement	CCC-21. Develop public self-protection to minimize responders exposures	PCCC-1. Train/educate/inform general population starting from scratch and in a basic and easy way, about knowledge of risk and appropriate behaviours, specially targeting those more exposed and vulnerable. Address all phases of emergency and the different levels of risk. Provide tools to facilitate adequate decision-making: checklists, emergency kits …	CCC-5. Develop public self-protection and awareness. CCC-17. Focus encouraging self-capacities and safety.
	CCC-22. Prepare population for the worst scenario before it happens.	PCCC-3. Change of paradigm. From 'We, authorities, will protect you' to 'You, citizen, should be actively involved'. These affirmations mean that you should be prepared to be self-sufficient concerning to your own protection and your community protection always inside the framework of the emergency. Be used to this sort of situations normalizing them. PCCC-4. Build trust involving communities and key stakeholders in risk management permanently: from risk awareness to the	CCC-6. Involve communities and key stakeholders as active actors in risk management. FCCC-7. Negotiate the values with communities before the emergency.

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		preparation of scenarios, to the decisions and behaviour during the emergency, to verifications, to drills and exercises. PCCC-12. Be prepared to provide massive alerts to population.	
	CCC-23. Cultural changes in risk tolerance and resilience		FCCC-8. Cultural change towards risk tolerance and resilience.
Technology	CCC-24. Use technology to assess risks and minimize responder's engagement	PCCC-2. Technologies used in interventions should be: Useful, simple, intuitive and easy to use, easy to integrate and interoperable, easy to transport, deployable on field, light, with high autonomy, robust, resistant, long duration, able to tolerate severe/harsh conditions. open access, usable by people with disabilities	CCC-1. Organize to sustain safe operations. CCC-17. Focus encouraging self-capacities and safety.
	CCC-25. Simulate complex scenarios	PCCC-2. Technologies used in interventions should be: Useful, simple, intuitive and easy to use, easy to integrate and interoperable, easy to transport, deployable on field, light, with high autonomy, robust, resistant, long duration, able to tolerate severe/harsh conditions. open access, usable by people with disabilities	FCCC-24. Focus on governance and integral risk management.
	CCC-26. Technological tools to support data sharing	PCCC-2. Technologies used in interventions should be: Useful, simple, intuitive and easy to use, easy to integrate and interoperable, easy to transport, deployable on field, light, with high autonomy, robust, resistant, long duration, able to tolerate severe/harsh conditions. open access, usable by people with disabilities	CCC-1. Organize to sustain safe operations. FCCC-24. Focus on governance and integral risk management.
	CCC-27. Get a clear picture of the risk evolution	PCCC-2. Technologies used in interventions should be: Useful, simple, intuitive and easy to use, easy to integrate and interoperable, easy to transport, deployable on field, light, with high autonomy, robust, resistant, long duration, able to tolerate severe/harsh conditions. open access, usable by people with disabilities	CCC-1. Organize to sustain safe operations.

4.2. Analysis of solutions

In the context of FIRE-IN, solutions can be any of the following:

- Good/best practices,
- Standards,
- Guidelines,
- Results of research projects
- Publications (scientific papers, white papers, technical reports etc.)
- Software,
- Hardware,
- Materials

The solutions are classified in three categories: (a) best practices and standards, (b) research items and (c) technologies.

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Solutions screened in WP2, are analysed in WP3 with the Traffic Light System, with an overall goal to characterise each CCC or FCCC as covered, partly covered or as a challenge to be addressed in the future and thus, gain an overview, if a specific challenge is truly covered by existing solutions or not.

As mentioned in the methodology chapter (see section 3.1) the first step of the analysis conducted was to match the third cycle CCCs/FCCCs with the first and second cycle CCCs, where possible.

After having completed the correlations and the matching between the CCCs/FCCCs of the three cycles, the second step was to assign all solutions, already distributed among the first and second cycle challenges, to their respective equivalents in the third cycle. The results from the solution screenings of the previous cycles were used as the basic input, and, making the appropriate transformations between the challenges, the coverage of the CCCs and FCCCs can be clearly depicted.

4.2.1 First cycle research and standardization solutions addressing third cycle challenges

In deliverable D2.2 (Berchtold *et al.*, 2019), solutions, which were screened during the first cycle, were distributed to the respective matrix of challenges of the first cycle. Following the methodology and the modification matrix (Table 6), developed in the framework of this deliverable, these solutions are additionally allocated to the matrix of the CCCs-FCCCs. In the following table the assignment of first cycle solutions to third cycle CCCs/FCCCs is presented. Research papers and projects, as well as standardization documents, guidelines and best practices are presented. Technological innovations are examined separately.

Table 7: Number of research (publications and projects) and standardization (standards-guidelines) solutions, screened during the first cycle according to WP2, matched to third cycle challenges. Projects and publications are merged into one cell, named "Research".

	High flow of effort in hostile environment (HF)	**High Impact, Low Frequency (HILOF)**	**Multiagency / Multileadership (ML)**	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
Number of Research-Standards Solutions	Research: 13	Research: 10	Research: 20	Research: 3
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 3	Guidelines-Standards: 0
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.

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	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Number of Research-Standards Solutions	Research: 31	Research: 21	Research: 31	Research: 20
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 0
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
Number of Research-Standards Solutions	Research: 7	Research: 7	Research: 15	Research: 15
	Guidelines-Standards: 1	Guidelines-Standards: 1	Guidelines-Standards: 4	Guidelines-Standards: 2
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
Number of Research-Standards Solutions	Research: 17	Research: 23	Research: 54	Research: 6
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 0
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
Number of Research-Standards Solutions	Research: 21	Research: 10	Research: 14	Research: 14
	Guidelines-Standards: 0	Guidelines-Standards: 3	Guidelines-Standards: 0	Guidelines-Standards: 0
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
Number of Research-Standards Solutions	Research: 6	Research: 14	Research: 14	Research: 12
	Guidelines-Standards: 4	Guidelines-Standards: 0	Guidelines-Standards: 3	Guidelines-Standards: 1

4.2.2 Second cycle research and standardization solutions addressing third cycle challenges

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The same methodology is also applied to solutions *i.e.*, research and standardization, of the second cycle. Also in this case, technological innovations are examined separately. Following the modification matrix and the links between the challenges, the number of second cycle solutions addressing each CCC and FCCC is presented in Table 8.

Table 8: Number of research (publications and projects) and standardization (standards-guidelines) solutions, screened during the second cycle according to WP2, matched to third cycle challenges. Projects and publications are merges into one cell, "Research".

	High flow of effort in hostile environment (HF)	**High Impact, Low Frequency (HILOF)**	**Multiagency / Multileadership (ML)**	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
Number of Research-Standards Solutions	Research: 23	Research: 23	Research: 32	Research: 0
	Guidelines - Standards: 0	Guidelines - Standards: 1	Guidelines - Standards: 10	Guidelines - Standards: 0
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.
Number of Research-Standards Solutions	Research: 89	Research: 53	Research: 76	Research: 0
	Guidelines - Standards: 15	Guidelines - Standards: 12	Guidelines - Standards: 13	Guidelines - Standards: 0
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
Number of Research-Standards Solutions	Research: 0	Research: 9	Research: 8	Research: 0
	Guidelines - Standards: 0	Guidelines - Standards: 5	Guidelines - Standards: 1	Guidelines - Standards: 0
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
Number of Research-Standards Solutions	Research: 0	Research: 32	Research: 32	Research: 0
	Guidelines - Standards: 0	Guidelines - Standards: 10	Guidelines - Standards: 10	Guidelines - Standards: 0
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
	Research: 66	Research: 62	Research: 0	Research: 0

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	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Number of Research-Standards Solutions	Guidelines – Standards: 14	Guidelines – Standards: 9	Guidelines – Standards: 0	Guidelines – Standards: 0
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
Number of Research-Standards Solutions	Research: 0	Research: 0	Research: 0	Research: 0
	Guidelines - Standards: 0	Guidelines - Standards: 0	Guidelines - Standards: 0	Guidelines - Standards: 0

4.2.3 Third cycle research and standardization solutions addressing third cycle challenges

Table 9 presents the number of research and standardization solutions found in WP2, deliverable D2.4 (Schlierkamp *et al.*, 2021) during the third cycle categorized in the respective FCCCs.

Table 9: Number of research and standardization solutions, screened during the 3rd cycle according to WP2, and their allocation to CCCs and FCCCs.

	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
Number of Research-Standards solutions	Research: 0	Research: 0	Research: 0	Research: 5
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 8
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.
Number of Research-Standards solutions	Research: 0	Research: 0	Research: 5	Research: 7
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 12	Guidelines-Standards: 7
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
	Research: 0	Research: 4	Research: 0	Research: 7

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	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Number of Research-Standards solutions	Guidelines-Standards: 0	Guidelines-Standards: 3	Guidelines-Standards: 0	Guidelines-Standards: 4
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
Number of Research-Standards solutions	Research: 0	Research: 0	Research: 0	Research: 10
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 4
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
Number of Research-Standards solutions	Research: 0	Research: 0	Research: 11	Research: 10
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 5	Guidelines-Standards: 2
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
Number of Research-Standards solutions	Research: 0	Research: 0	Research: 5	Research: 12
	Guidelines-Standards: 0	Guidelines-Standards: 0	Guidelines-Standards: 6	Guidelines-Standards: 1

The final step was to combine the numbers of solutions of the third cycle screening conducted in WP2, as shown in the Table 6, to the results from the second cycle screening, presented in Table 5. Significant attention had to be paid, in order to avoid double-registered solutions (see chapter 3.1, step b). Moreover, research and standardization documents, uploaded to the platform were added.

The sums of all three cycles that emerged represent the total number of Research and Standardization solutions, as presented in Table 10.

Table 10: Total number of research and standardization Solutions, by the sum of all cycles, addressing 3rd cycle solutions.

	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
	Research: 21	Research: 24	Research: 32	Research: 6

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	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Number of Research-Standards solutions	Guidelines-Standards: 2	Guidelines-Standards: 4	Guidelines-Standards: 11	Guidelines-Standards: 9
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.
Number of Research-Standards solutions	Research: 96 Guidelines-Standards: 23	Research: 55 Guidelines-Standards: 16	Research: 84 Guidelines-Standards: 32	Research: 10 Guidelines-Standards: 11
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
Number of Research-Standards solutions	Research: 0 Guidelines-Standards: 0	Research: 14 Guidelines-Standards: 10	Research: 10 Guidelines-Standards: 5	Research: 10 Guidelines-Standards: 7
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
Number of Research-Standards solutions	Research: 4 Guidelines-Standards: 0	Research: 33 Guidelines-Standards: 10	Research: 36 Guidelines-Standards: 10	Research: 12 Guidelines-Standards: 5
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
Number of Research-Standards solutions	Research: 72 Guidelines-Standards: 19	Research: 64 Guidelines-Standards: 12	Research: 14 Guidelines-Standards: 5	Research: 13 Guidelines-Standards: 4
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
Number of Research-Standards solutions	Research: 0 Guidelines-Standards: 3	Research: 3 Guidelines-Standards: 0	Research: 8 Guidelines-Standards: 7	Research: 12 Guidelines-Standards: 1

4.2.4 Coverage of third cycle challenges by technological solutions from all three cycles

This project has received funding from the European Union's Horizon 2020 Coordination and Support Action programme under grant agreement No 740575.

During the previous cycles 197 technological solutions were screened. These solutions were allocated to CCCs and PCCCs, of both the first and the second cycle. Following the methodology of the matching between challenges of different cycles, a rearrangement of these solutions, in order to match the CCCs and FCCCs of the final cycle, was made. Additionally, technological innovations, identified in the third cycle were included, as well as solutions, uploaded to the FIRE-IN e-platform, throughout the lifetime of the project. In Table 11, the matrix of third cycle challenges, along with the number of all solutions, in terms of technology, addressing each challenge, is presented.

Table 11: Total number of technological solutions addressing the CCCs and FCCCs of the 3rd cycle.

	High flow of effort in hostile environment (HF)	**High Impact, Low Frequency (HILOF)**	**Multi-agency / Multi-leadership (ML)**	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
Number of Technologies	160	89	68	18
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.
Number of Technologies	124	74	155	1
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
Number of Technologies	2	25	55	9
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
Number of Technologies	14	77	67	31
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
Number of Technologies	1	69	2	1
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
Number of Technologies	33	1	9	87

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4.2.5 3rd cycle CCCs/FCCCs matrix for all types of solutions

The conclusions from deliverable D3.3 (Sakkas et al., 2020), i.e., the colours of TLS applied to the challenges of the second cycle (Appendix A4), also play a significant role for the application of the TLS methodology to the CCCs/FCCCs of the third cycle, since the former, practically, feed the latter. Taking into consideration, that a PCCC is already covered or partly covered since previous cycles, its respective equivalent in the third cycle is likewise addressed. Therefore, the colourisation of each challenge also builds on these conclusions and results and the reader is provided with the most updated view, regarding the level to which each challenge is addressed by solutions.

In the following table, the CCCs and FCCCs, along with the number of technological, research and standardization solutions for each challenge is presented.

Table 12: Total numbers of solutions for the Challenges of the third Cycle. "T" applies for technology, "R" for research and "S" for standards and guidelines.

	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
	T=160	T=89	T=68	T=18
	R=21	R=24	R=32	R=6
	S=2	S=4	S=11	S=9
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.
	T=124	T=74	T=155	T=1
	R=96	R=55	R=84	R=10
	S=23	S=16	S=32	S=11
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
	T=2	T=25	T=55	T=9
	R=0	R=14	R=10	R=10
	S=0	S=10	S=5	S=7
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.

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	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
	T=14	T=77	T=67	T=31
	R=4	R=33	R=36	R=12
	S=0	S=10	S=10	S=5
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
	T=1	T=69	T=2	T=1
	R=72	R=64	R=14	R=13
	S=19	S=12	S=5	S=4
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
	T=33	T=1	T=9	T=87
	R=0	R=3	R=8	R=12
	S=3	S=0	S=7	S=1

As already described, the level of coverage of each challenge from **technological solutions**, depends on the total number of solutions addressing it. Nevertheless, there are challenges, with a high number of solutions, that may be coloured in yellow. This is due to the fact, that, in these challenges, there is a large proportion of technologies, not satisfying the appropriate criteria, needed to be classified as green. Many of these solutions do not provide sufficient information regarding the adoption of formal standards, or their operational value. On the other hand, there might be challenges, addressed by a smaller number of solutions, which satisfy the respective criteria, i.e., high operational value, high TRL and adoption of standards, to be considered green. In general, almost 300 technologies have been included, encompassing those screened in the context of WP2 and those uploaded to the platform, by providers, approached in the context of the Request for Ideas procedure.

The majority of these technological solutions are either on the market (TRL>9) or TRL≥ 7 and include the following categories:

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- Unmanned vehicles, either aerial or ground
- Personal Protective Equipment (PPE) and smart
- Geographic Information System (GIS) and geolocation software
- Applications for the management of volunteers
- Sensors for the detection of fire/smoke/embers
- Sensors for early detection of dangerous chemical, biological, radiological, nuclear and explosive agents
- Aircrafts and other innovative gear for firefighting
- Early warning systems
- Applications for the education of the public
- AR/VR training systems for first responders
- Crowdsourcing applications for mass notifications and alert
- Command and control systems
- Hazard and risk assessment technologies
- Weather forecasting systems
- Fire propagation models
- Technologies for resilient communications in harsh environments
- Tools for big data analysis
- Artificial Intelligence systems and machine learning
- Applications for remote disease diagnosis
- Other types of sensors, such as advanced seismometers, accelerometers etc.
- Cameras, which can locate people underwater
- Satellite images providing real or near-real time information

All solutions that have been uploaded on the e-FIRE-IN platform are presented briefly in Appendix A9.

For **Research solutions**, the precondition for the chromatic characterization is almost exclusively related to the number of solutions. This is because Research is examined from the perspective of the number of existing and/or ongoing projects and of papers. Moreover, papers, in order to satisfy the "Access to knowledge" criterion, have to be peer reviewed, the vast majority of which, covers the specific criterion. Therefore, a more arithmetical approach is followed. Yet again, there are cases, with some disproportions between these two types of solutions. There are challenges, which although well covered in terms of numbers, are yellow, due to the exact fact, that there are few projects addressing their topic.

Finally, regarding solutions deriving from the **Standardization** domain, these are categorised in Standards and Guidelines. In the case that a challenge is addressed by at least one standard, it is automatically considered green. Standards, especially those developed by EU or international standardization bodies e.g., CEN, ISO, IEC etc., provide quality and ensure wide acceptance and adoption. There are challenges with a few or even only one solution, which are green, because this solution represents one or more formal standards. On the other hand, challenges with higher numbers of solutions addressing them, are yellow due to the fact, that these solutions represent only guidelines, without information on their level of adoption by practitioners, and no standards at all.

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5. Questionnaires for practitioners and technology providers

The questionnaires were developed with Microsoft Forms and their basic topic was technology and standardization. Both practitioners and technology providers submitted, in the respective questionnaire, their opinions regarding these two major domains and how they can affect and facilitate disaster management operations.

The questionnaires were communicated to numerous persons. At first, all registered people in the FIRE-IN platform (276) were notified. Along these 276 people, participants of the project were included. Furthermore, these questionnaires were also sent to practitioners and providers, of other projects, in which KEMEA and other FIRE-IN partners are involved, along with the urging, these organizations, to further disseminate the questionnaires to potential interested stakeholders of their network. Overall, partners from at least seven EU Horizon 2020 funded projects, e.g., STRATEGY, SILVANUS, VALKYRIES, RISKPACC, FIRELOGUE, FIREURISK and MEDEA, and ISFP-2019 project DRONEWISE were notified.

Additionally, the European Fire Fighters Unions Alliance, which is an association, with the participation of firefighting organizations from 14 European countries, was asked to fill in the questionnaire, devoted to practitioners.

The questionnaires were online for 42 days, from the 23rd of December until the 4th of February, and shared to at least 400 people, from whom 109 persons responded, filled them in and provided a significant sample for both categories of respondents. Out of the 109 participants, 43 were technology providers and 66 were practitioners.

Table 13: Number and percentage of responses to the two questionnaires.

Type of participant	Number of responses	Percentage
Technology provider	43	39%
Practitioner	66	61%

5.1. FIRE-IN Request for Ideas from technology providers

From the 43 persons, who filled in the providers' questionnaire, 25 are working in Small and Medium Enterprises (SMEs), 14 in Research and Technology Organizations (RTOs) and only four (4) in large industrial companies. This comes as no surprise. Already during the previous cycles, it was recognised, that the project is more appealing to SMEs than to large companies. The reason is, that large companies have already conquered the market and gained recognition, not only from the public, but also from researchers, practitioners and policy makers. Moreover, in large companies, bureaucracy can make procedures more complicated and time consuming. Employees, in order to submit a solution may have to take approval from their superiors, something that could lead to delays and, eventually, to reluctance. Also, another issue that is related to large industries and their drawback from being highly engaged in such procedures are the confidentiality and patents topics. These ha already been raised in deliverable D3.3 (Sakkas et al., 2020).

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Table 14: Values and percentages of responses regarding the type of organization, for which participants are working.

Type of organization	Number of responses	Percentages
Large industry	4	9%
Small Medium Enterprise	25	58%
Research Technology Organization	14	33%

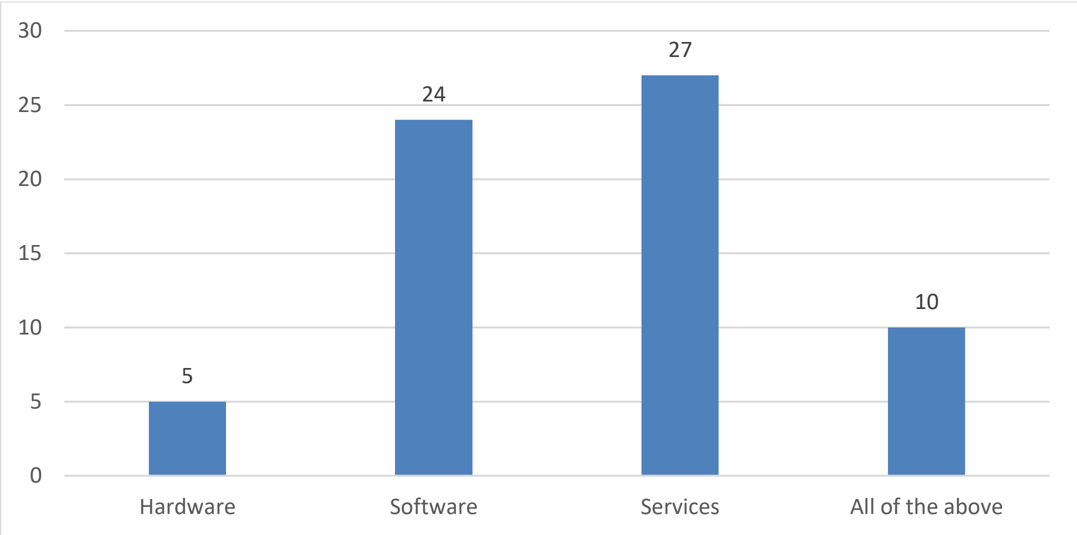

Figure 1: Number of responses regarding the type of technologies developed by technology providers.

Most of the technology providers develop services and software, while, only a few, are related to the development of hardware. Hardware is in the interests and capabilities of, mainly, larger industries whereas services and software are developed, also from Small and Medium Enterprises (SMEs) and Research and Technology Organizations. Ten of the respondents declared, that all the above technologies are produced by their organization. More specifically, technology providers were asked to elaborate on the exact type of technology, developed by their enterprise. These types originate, mainly, from the types of solutions, that are screened, throughout the lifetime of the project and its three cycles, but seem to cover the majority of solutions, which are relevant to disaster management.

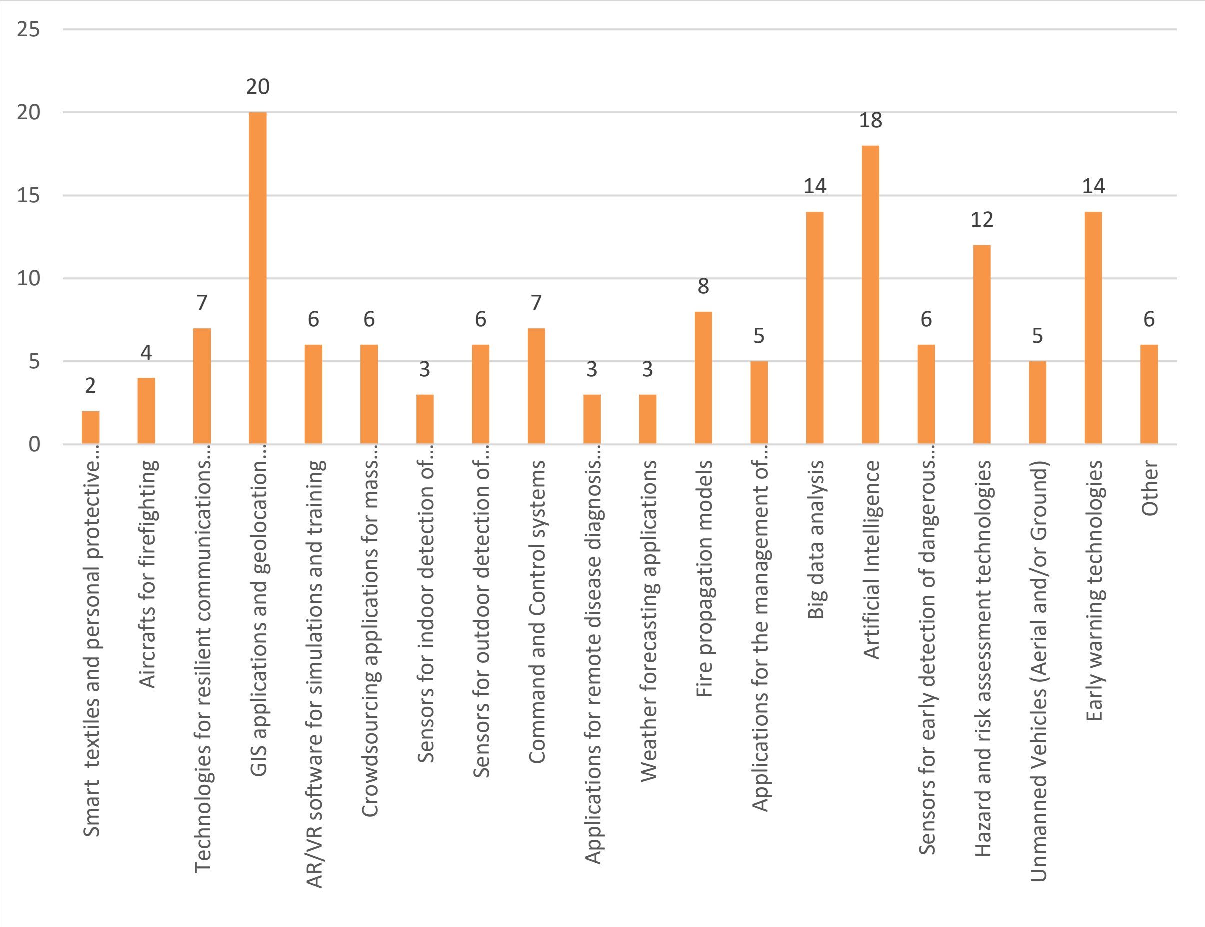

Figure 2: Values of the technological types, developed by the providers.

GIS applications and geolocation systems dominate the interests of the developers, at least as it is ensued from the sample collected by the questionnaire. Artificial Intelligence presents also high values, with early warning technologies, big data analysis systems and hazard and risk assessment technologies closely following. On the other hand, weather forecasting applications are of low interest, with the same applying to sensors for indoor detection of fire, smoke or embers. A possible assumption for this is that these sectors are, more or less, covered by existing technologies and tools. Surprising is the fact that very few providers are dealing with applications for remote disease diagnosis and healthcare, especially taking into consideration, that the COVID-19 pandemic is still concerning most of the countries and therefore health systems and health practitioners. Equally interesting is the fact, that smart textiles and PPE shows the lowest values.

The participants were also asked to declare the Thematic Working Group(s), which is/are the most relevant to the organizations, they are working for, and products they develop. Apart from the five groups, the choice to select all or none of them was provided. Landscape fires, followed by Natural Hazard and Search and Rescue Emergency Response, were the TWGs most relevant to the interests of technology providers.

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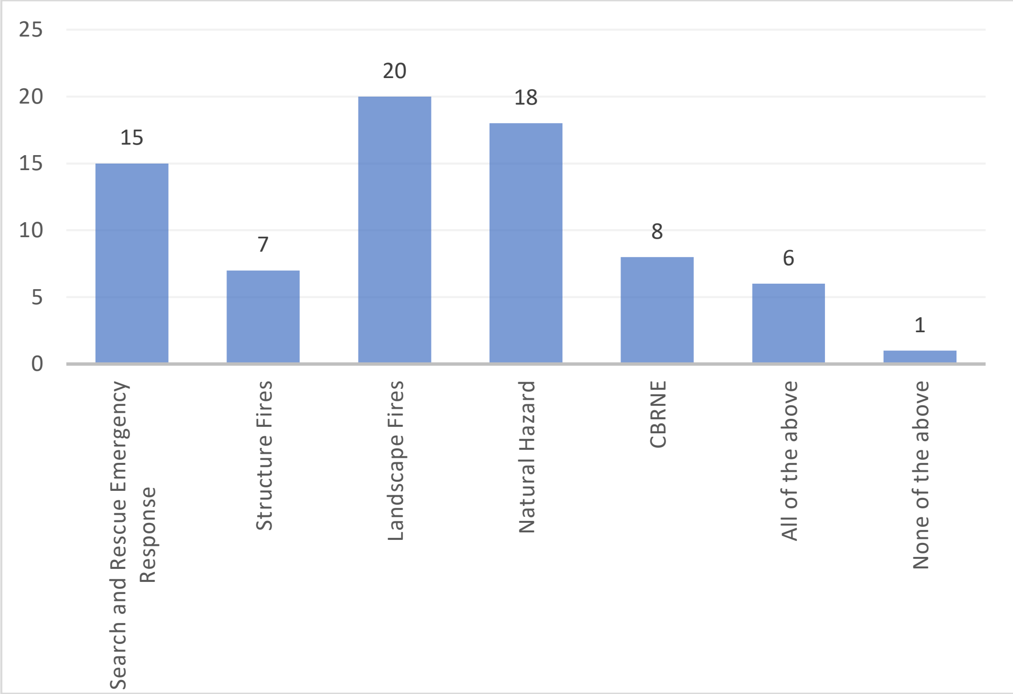

Figure 3: Responses related to the TWGs.

Participants provided insight, regarding which of the four phases of disaster management, e.g., prevention, preparedness, response and recovery, are addressed by technologies, developed by their organizations. Respondents had the opportunity to select up to two answers, although the choice to select all four phases was also provided.

Table 15: Number of responses regarding the disaster management phase addressed by the solutions, developed by technological organizations.

Disaster management phase	Number of responses
Prevention (risk assessment)	19
Preparedness (early warning, training etc.)	23
Response (PPE etc.)	17
Recovery	8
All the above	7

In addition to the previous results, participants were asked to rate the extent of coverage of the four phases by the technology domain, considering their experience on this topic. Prevention, Preparedness and Response are largely addressed by technology. Regarding response, this is most expected. Technological innovations are largely focusing on solutions, which can in fact, ensure safety and facilitate first responders' operations. Similarly, technologies related to hazard and risk analysis, early warning systems, early detection of dangerous agents, smoke, fire etc., which are also developed in large quantities, are linked to pre-disaster phases, i.e., prevention and preparedness. Recovery is also

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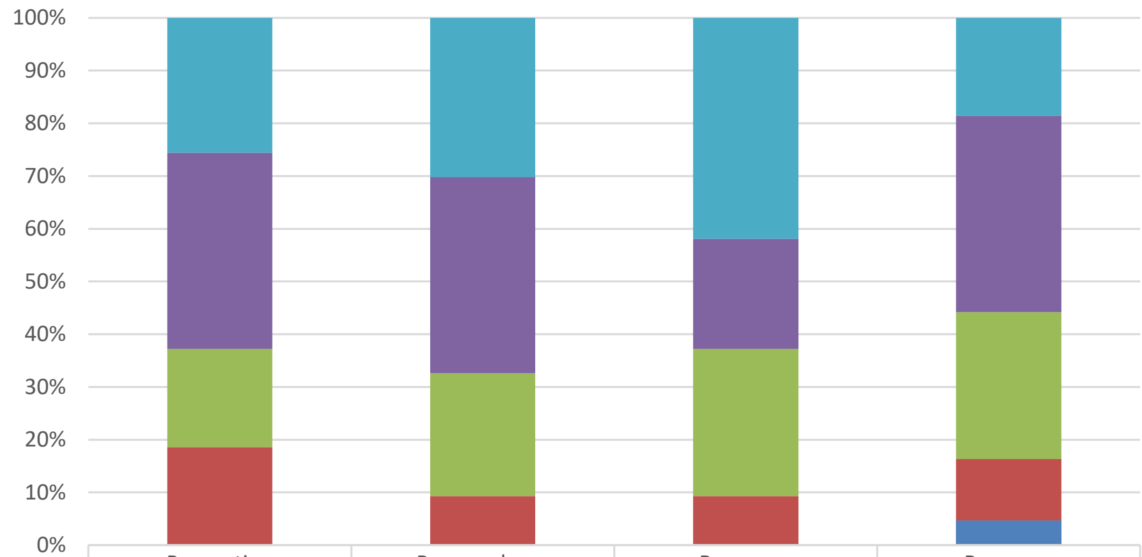
addressed by the technology domain, but not to the same extent, as the other three phases of the cycle. This comes as no surprise, as this phase could be equally, if not even more effectively, addressed by guidelines and policies.



	Prevention	Preparedness	Response	Recovery
Very much	25.60%	30.20%	41.90%	18.60%
Much	37.20%	37.20%	20.90%	37.20%
Quite	18.60%	23.30%	27.90%	27.90%
A little	18.60%	9.30%	9.30%	11.60%
Not at all	0%	0%	0%	4.70%

Figure 4: Level of coverage of each disaster management phase by technology.

Regarding FIRE-IN more specifically, a distinction between the current and future capability challenges was made. Participants were asked to select the most important challenges, both current and future, based on the technological products and interests of their organizations.

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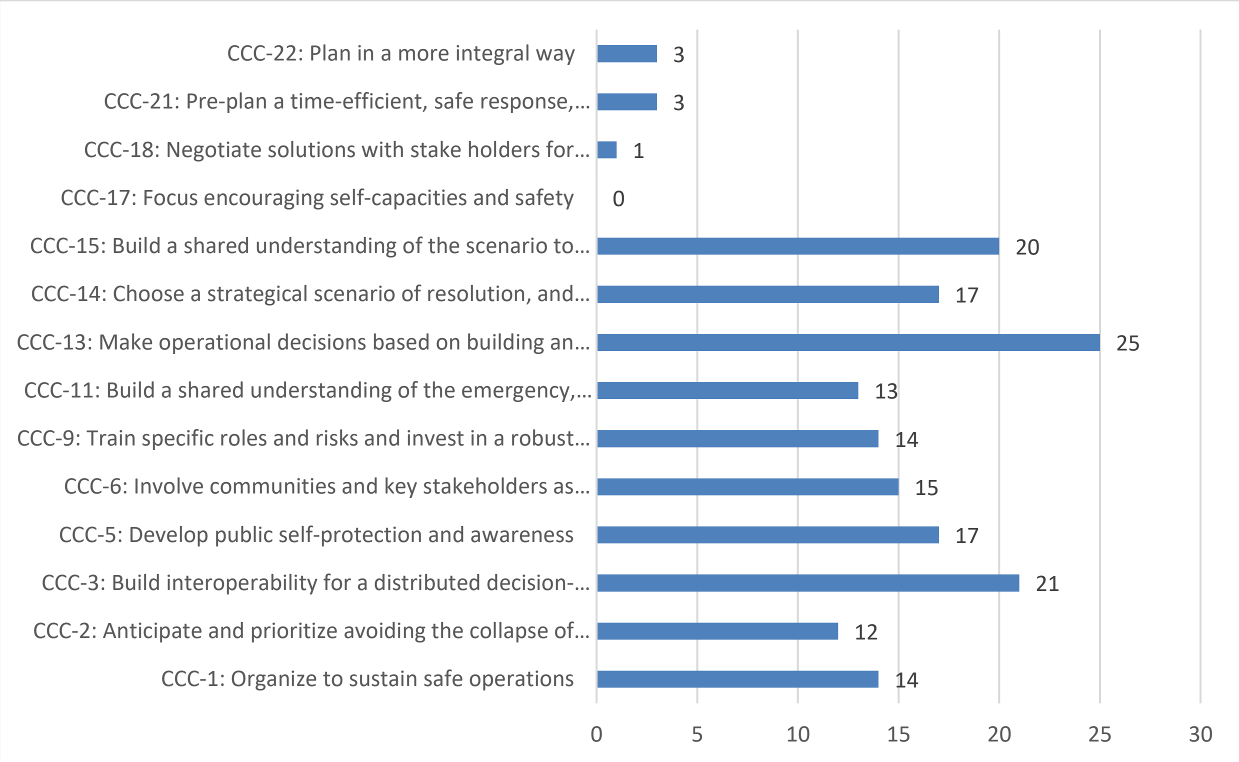

Figure 5: Values of responses, regarding the importance of CCCs for technology providers.

CCC-13 “Make operational decisions based on building an understanding of the emergency and its evolution”, CCC-3 “Build interoperability for a distributed decision-making based on a shared understanding of the emergency” and CCC-15 “Build a shared understanding of the scenario to synchronize decision-making” seem to be of utmost importance for the participants. On the other hand, CCC-17 “Focus encouraging self-capacities and safety”, CCC-18 “Negotiate solutions with stake holders for anticipated scenarios”, CCC-21 “Pre-plan a time-efficient, safe response, minimizing responder’s engagement” and CCC-22 “Plan in a more integral way” did not concentrate a significant number of answers. This is logical, because these challenges are more theoretical, whereas “Focus encouraging self-capacities and safety” could be connected with “Smart textiles and personal protective equipment”, presenting similarly low numbers.

Technology providers were also optionally asked to point out other challenges, apart from the ones they selected, which could be addressed by technologies, developed by their organizations, in the future. Again CCC-13 “Make operational decisions based on building an understanding of the emergency and its evolution” was selected. According to the participants a holistic approach is necessary for an effective decision support, which takes into consideration all available data, without focusing on specific fields. Moreover, CCC-14 “Choose a strategical scenario of resolution, and distribute tactical decision-making”, which, although it is not included in the three most important CCCs, concentrated 17 answers, will concern providers in the future. In general, “Decision Making Cycle”, at present and in the future, seems to be a target capability for technological providers. It

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examines issues, which are critical for the efficiency of response operations and could lead to better comprehension and management of risk.

The same pair of questions was used for the Future Capability Challenges, with the results presented in the following figure:

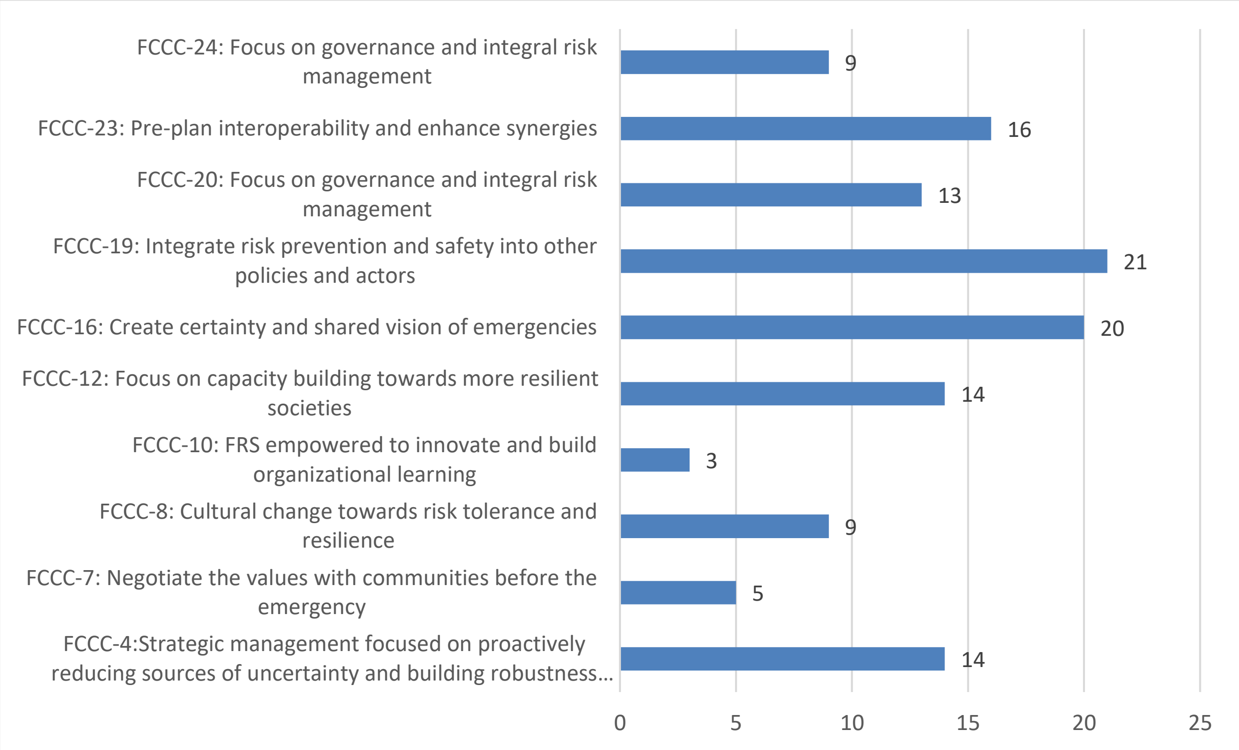

Figure 6: Values of responses, regarding the importance of FCCCs for technology providers.

FCCC-19 “Integrate risk prevention and safety into other policies and actors”, FCCC-16 “Create certainty and shared vision of emergencies” and FCCC-23 “Pre-plan interoperability and enhance synergies” are the future challenges concentrating most answers. Regarding challenges, which may be addressed by technological organizations in the future, again FCCCs-19 “Integrate risk prevention and safety into other policies and actors” and FCCC-23 “Pre-plan interoperability and enhance synergies” again seem to stand out. Synergies between organizations from different countries, with practitioners speaking different languages and following different protocols, could boost up procedural interoperability in the face of disasters with international impact. Technologies, such as big data analysis systems, could greatly enhance these synergies, according to providers. Furthermore, newly developed algorithms should be fast integrated into policies and first responders’ operational procedures.

Regarding future technological trends, a question, which aimed at distinguishing specific areas, that are about to be further developed in the future, results are quite complicated, without a clear distinction between those domains, already conquered, and those, which will continue to be

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Figure 7: Main keywords extracted from the answers.

developed, providing cutting edge systems and tools. Nevertheless, some conclusions can be drawn. Artificial Intelligence, for instance, is one sector that greatly concerns technological organizations for the integration of multi-source satellite and ground data, for the provision of visual recognition, for image analysis, semantics etc. Moreover AR/VR solutions, although already developed, will likely continue to further evolve, providing simulation systems for the training of first responders. Earth Observation techniques, satellite data and geolocation, also combining ground observations, is also another technological domain expected to further develop. Remote sensing and in general early detection tools, for CBRNE agents and fire, are important and will continue to concern organizations and enterprises, as will remote health management systems for the monitoring of patients, thus minimizing the risk for responders. Finally next generation early warning systems with an all-hazard approach are of great significance.

Moving to the second part of the questionnaire, technology providers were asked to provide their opinions, regarding standardization, which is another important issue, significantly affecting technological development and production. The majority of the participants declared that formal standards, developed by official national (e.g., DIN, BSI), EU (CEN, CLC, ETSI) and international (ISO, IEC, ITU etc.) standardization bodies, are adopted and used for the production of systems and tools. Nevertheless, a not inconsiderable number of respondents do not make use of formal standards, whereas many are not aware.

Table 16: Adoption of formal standards from technology suppliers.

Adoption of formal standards	Number of responses	Percentage
Yes	22	51%
No	12	28%
Not aware	9	21%

Even more complicated is the situation regarding the adoption of standards, developed by industrial consortia, such as the Open Geospatial Consortium (OGC) and OASIS. These organizations are not standardization bodies, but, due to the fact, that they comprise of groups of experts in specific sectors, they provide professional standards, mainly of technical character. The answers are more or less equally split, with negative answers prevailing.

Table 17: Adoption of professional standards from technology suppliers.

Adoption of standards, developed by industrial consortia	Number of responses	Percentage
Yes	13	30%

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No	16	37%
Not aware	14	33%

On the contrary, in a question, regarding, whether providers prefer the adoption of standards or not, positive answers are dominant.

Table 18: Preference of technology suppliers in adopting standards, according to the participants' point of view.

Preference of technological organizations in adopting standards	Number of responses	Percentage
Yes	26	61%
No	4	9%
Not aware	13	30%

Building on the above answers, participants were asked to elaborate. Standards and more specifically technical ones, facilitate system performances, as long as they are provided along with the appropriate training, while they also foster data exchange and interoperability, especially between systems. On the other hand, there are also opinions supporting that standards display constraints and restrict innovation. Additionally, it seems that large enterprises do not prefer the adoption of standards, not only because they slow down innovation, but also because they want to dominate the market and keep it as niched as possible. Therefore, industrial players can keep their customer base intact, providing them with specific trademark products. According to these opinions, following standards, could lead to generalization of products and reduce the opportunity to innovate.

Figure 8: Main keywords extracted from the answers

In general standardization paves the way for innovation. They enable and facilitate interoperability; they can be easily mandated into regulations and policies and they provide the framework for future developments. Nevertheless, a considerable part of technology providers sees standards as obstacles, especially when they are not reviewed and adjusted to present needs. For instance, there are old standards, referring to older technologies, which can stifle innovation. They should derive from interdisciplinary work and be open for recurrent evaluation, every time technological advancements seem to be ahead.

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5.2. FIRE-IN Technology and standards from the practitioners' point of view

The second questionnaire was dedicated to practitioners. The basic topics were the same, as in the case of the technology providers' questionnaire, technology and standardization and how these two domains can address and facilitate disaster management operations. Overall, 66 persons filled in the questionnaire, which was a quite significant sample. The vast majority of the respondents comprised of professional first responders, but also a few persons from volunteering organizations participated. From the nine volunteers, six have a monthly employment of more than 30 hours per month and three with less than 30 hours.

Table 19: Participants' occupational relationship with the organizations they are working for.

Occupational relationship	Number of answers	Percentage
Professional	57	86%
Volunteering	9	14%
Volunteers with monthly occupation > 30 hours per month	6	67%
Volunteers with monthly occupation < 30 hours per month	3	33%

Similarly with the providers' questionnaire, practitioners were asked to point out the Thematic Working Groups, to which they belonged to. All TWGs are sufficiently addressed, with Search and Rescue Emergency Response concentrating most of the answers, while a significant percentage of the participants denoted, that they are relevant to all groups. Respondents had the capability to select up to two answers.

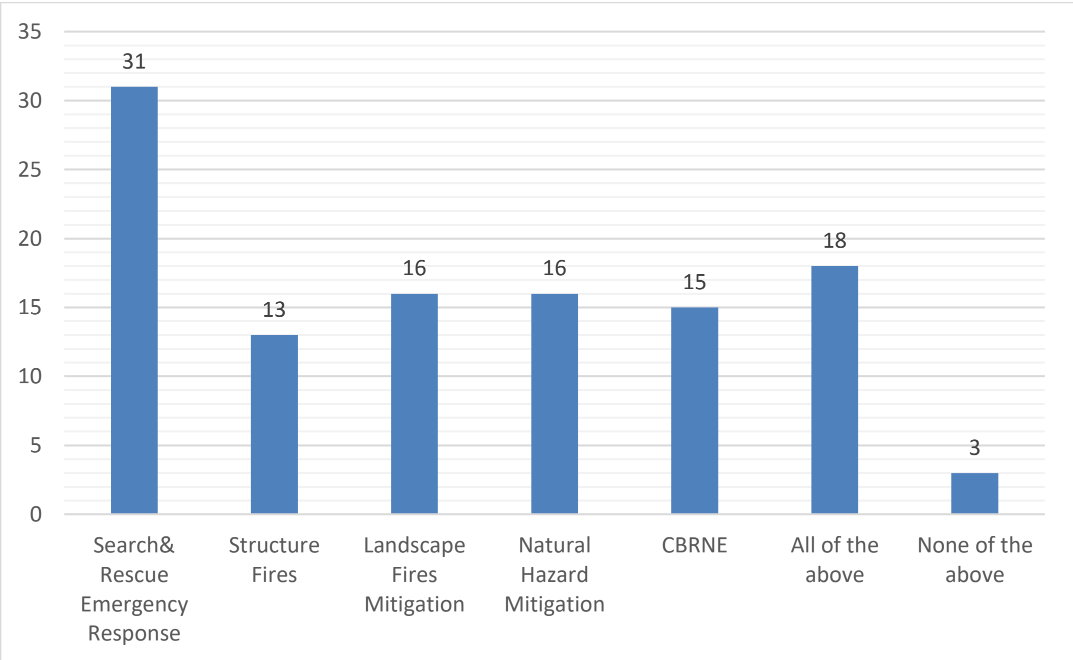

Figure 9: Relevance of the participants to the five TWGs of FIRE-IN

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On the other hand, if a comparison could be made between the relevance of practitioners and the relevance of providers to the TWGs, it is seen, that providers develop solutions, which are more related to Landscape Fires, Natural Hazard Mitigation and Search and Rescue operations. In both cases, Structure Fires and CBRNE present lower numbers, without connoting that these two are less important.

Another important aspect, for which practitioners were asked to provide their inputs, was the types of technological innovations, that they expect to be further developed and advanced, with the aim to provide responders with more efficient tools in their everyday operations. From the answers, that are presented in the following figure, first responders expect advancements in a variety of technologies, such as GIS applications and geolocation technologies, resilient communications in harsh environments, command and control systems, AR/VR software for simulations, PPE and smart textiles, connected with sensors for biometrics and other measurements, hazard and risk assessment technologies, unmanned vehicles, big data analysis systems and fire propagation models.

Figure 10: Tree map depicting technologies, which practitioners expect to be further developed and advanced. The bigger the size of the cell, the larger the number of votes is.

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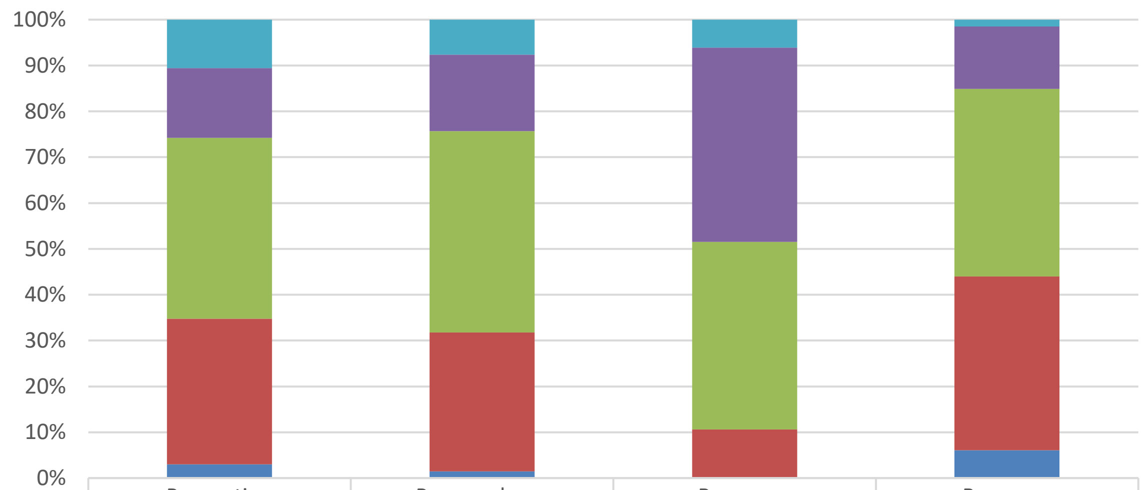
Of course, apart from the above-mentioned technological types, almost all types of technologies, included in the questionnaires, aggregate significant numbers of responses. On the contrary, studying the results from the providers' questionnaire, there are four technologies, that stand out:

- GIS and geolocation systems, which are the most essential, according to the practitioners' point of view are in the forefront of the disaster management related technology.
- Artificial Intelligence, which also interests practitioners, although this kind of solutions is not included in the top priorities of responders.
- Big data analysis systems are both extensively developed by technological organizations and expected by practitioners to be further advanced.
- Early warning systems, which do not concern practitioners to such extent, maybe because they consider this sector already addressed by existing technologies.

Practitioners, as the main and most direct players in disaster operations provided their opinions, regarding the extent to which the technology domain can, in fact, address the four cycles of crisis management. Interesting results emerged, which can be compared with the respective answers from the technological providers.



	Prevention	Preparedness	Response	Recovery
Very much	10.60%	7.60%	6.10%	1.50%
Much	15.20%	16.70%	42.40%	13.60%
Quite	39.40%	43.90%	40.90%	40.90%
A little	31.80%	30.30%	10.60%	37.90%
Not at all	3%	1.50%	0%	6.10%

Figure 11: The extent, to which the 4 phases of disaster management are addressed by technology, according to practitioners.

Practitioners, similar to providers, consider technology as a very useful tool to address all four phases of the cycle, although not to the same extent. Recovery is, according to both stakeholder categories, the phase with lower numbers, in comparison with the other three phases, without implying, that technology does not address this phase at all. Recovery could be more efficiently covered by standards,

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guidelines and policies. The basic difference between the answers of first responders and providers, is that for the latter, technology addresses the phases to a much greater extent. In the Likert scale, used to rate the providers' answers, "Much" and "Very much" values are higher in contrast to "A little" and "Quite" values, whereas the opposite is happening in the practitioners' answers, where the "Quite" value is dominant against "Much" and "Very much". In general, although first responders have faith in technology to provide them with proper solutions and address the disaster management cycle as a whole, this is not to the same degree as with providers. They seem more reluctant and, moreover, rely on their operating procedures and protocols. Procedural interoperability between organizations offsets technological advancements.

However, most of the participants declared, that technology, overall, enhances the capacities of their organizations.

Table 20: Practitioners' opinion regarding the degree, to which technology enhances their capacity.

Enhancement of practitioners' capacities by technology	No. of answers
Yes	60
No	1
Not aware	5

Figure 12: Main keywords extracted from the answers.

When asked to elaborate their answers, practitioners provided interesting feedback. Technology can greatly facilitate operations, whether they are firefighting, search and rescue, CBRNE operations etc., while minimising the time to act. Technology increases safety, provides early detection of multiple threats, enhances situational awareness and accelerates decision making. Sensors for early detection have improved CBRNE as well as fire-fighting operations. The same applies to satellite images, propagation models and weather forecasting systems. Augmented, Virtual and Extended reality solutions have particularly increased the level of training of first responders, while resilient communication tools have enhanced situational awareness and conciliation, both between actors on the field and between actors and the command-and-control post. Smart textiles, equipped with biometric and other sensors increase the safety of operating first responders and can provide alerts, whenever needed. Big data systems and crowdsourcing tools, provide practitioners with information, regarding to "where" and "when" they are most needed, although here attention should be paid to the filtering of incoming information, meaning, that too much information can prove misleading and creates unnecessary noise. However, as it was pointed out, technologies need to be more user-friendly and easier to use. Complicated technologies could create problems, especially in the field. Furthermore, practitioners may not have scientific background, thus lacking the knowledge

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to use specific tools. Training to new tools could be the solution. Another important issue, that was expressed, is that procurement procedures may pose difficulties and constraints. Although technologies do exist, bureaucratic processes and delays in procurement may lead to insufficiently equipped organizations. Moreover, according to practitioners, community involvement and investment in the preparedness of the population should be equally weighed. The education and training of citizens, as well as the harmonisation of operational procedures at an EU or even international level could prove essential means to combat disasters.

Building on the practitioners' opinion, regarding the user-friendliness of solutions and the training of responders to state-of-the-art technologies, a significant percentage claims, that it is not adequately trained to use innovative tools and systems, although the majority of organizations involve, not only initial, but also recurring training to these tools. The accurate results are included in the following two figures.

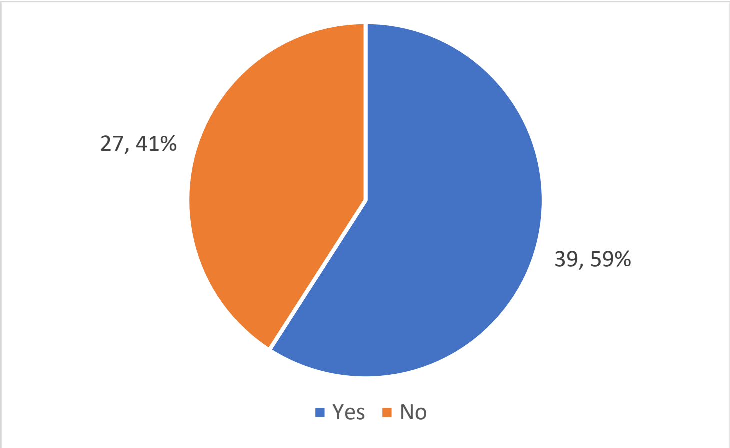

Figure 13: Percentages of the answers regarding the adequacy of practitioners' training to new technologies.

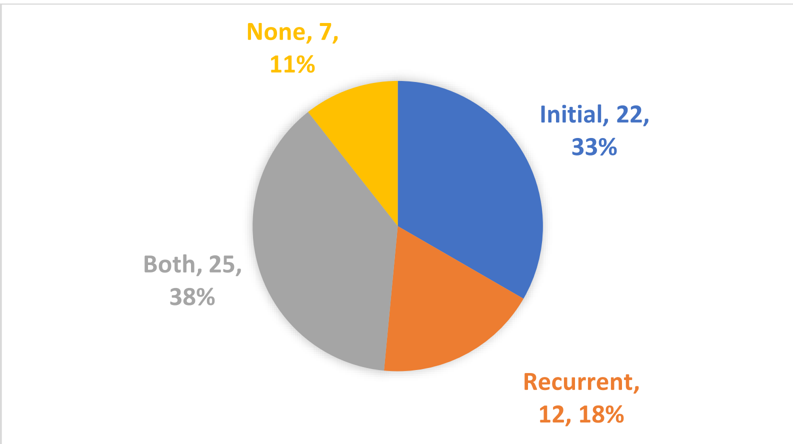

Figure 14: Answers, regarding the existence of initial and/or recurrent training of responders to technologies.

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According to the participants' elaboration on the above answers, the use of innovative tools should be periodically trained through exercises and become part of the standard training of practitioners, in order to make technology more efficient. Moreover, especially regarding simulation tools, these should be tailored to first responders' needs and encompass real scenarios and practitioners' experiences for more hands-on training.

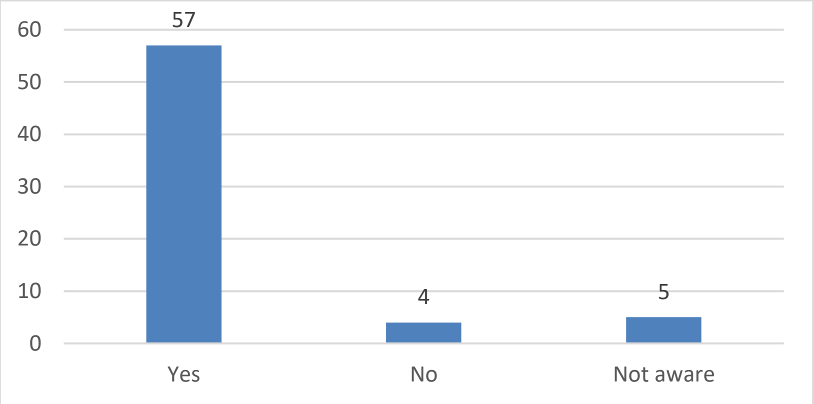

Figure 15: Values of the responses, regarding the enhancement of first responders' capacity by standardization.

The second part of the questionnaire was related to standardization. According to most practitioners, standards, either technological or procedural, greatly enhance the capacities of first responders' organizations.

Practitioners seem to agree, that through standardization, interoperability between organizations can be greatly facilitated. And this kind of interoperability is most crucial, in the face of high impact disasters, which are increasingly occurring worldwide and affect countries simultaneously, thus requiring coordinated operations between organizations, that have different protocols. There is a great need for harmonization of these procedures, something, that can be achieved through standards. Moreover, standardization can pave the way for effective sharing of best practices and lessons learnt. The sharing of the experience, that an organization gains from the management of an emergency situation can prove a useful tool and provide added value to another organization, thus enabling collaboration, should the need arise. Technical standards providing interoperability between systems and tools cannot be excluded. Some indicative answers, which derive from the questionnaire and support the above statements could be the following:

- "Common SOPs of all first responders will make cooperation on the field easier"
- "Standardization activities enhance the capacity of first responders' organizations because they guarantee homogeneity in behavior, reduce response times and the risk of committing gross errors."
- "In an emergency, only the sharing of SOPs allows for effective work between different partners"

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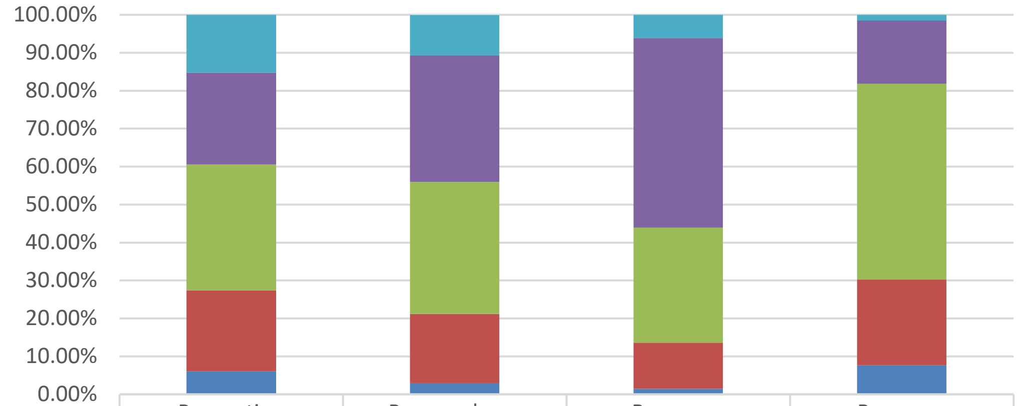
- “The cooperation between first responders is very important: the standardization could help for that”
- “Standardization is always needed in order to maintain compatibility of different assets/modules.”

Figure 16: Main keywords extracted from the answers.

In addition, practitioners were asked to rate the level of coverage of the disaster management phases by standardization. According to them, all four phases of the disaster management cycle are adequately addressed by standardization activities, although some focus should be given on prevention and recovery, which present increased “Not at all” and “A little values”. Recovery is the phase which seems to have space to be further covered, not only by standards and guidelines, but also from the technology domain. 43.9 % of the participants answered “Not at all” and a “A little” in the question regarding the coverage of the recovery phase by technology, whereas 30.3% provided the same answers for the respective standardization question. It is apparent, that standards, guidelines and best practices approach this phase more effectively. Technological innovations, are mainly focused on response and on pre-disaster phases (prevention and preparedness) and this is something that comes as no surprise, taking into consideration, that early warning technologies, big data analysis systems, AI and machine learning propagation models, unmanned vehicles, simulation models for training and other similar solutions are in the core of evolution and further development, and all address prevention preparedness and response. Moreover, regarding standardization, there is also the possibility of practitioners not being aware of all existing standards and guidelines facilitating post-disaster and rehabilitation procedures, but, regardless of this presumptive unawareness, the fact, that both public and authorities, seem to quickly forget and have the belief, that emergencies and disastrous events are not likely to affect them, or, if this does eventually happen, it will not happen again. There should be a stronger urge for the development of standards and technologies, which will enable faster and more effective recovery strategies. In the figure below, the level of coverage of each phase by standardization, according to practitioners, is presented.



	Prevention	Preparedness	Response	Recovery
Very much	15.20%	10.60%	6.10%	1.50%
Much	24.20%	33.30%	50%	16.70%
Quite	33.30%	34.80%	30.30%	51.50%
A little	21.20%	18.20%	12.10%	22.70%
Not at all	6.10%	3%	1.50%	7.60%

Figure 17: Percentages of the level of coverage of the phases of disaster management by standardization.

Practitioners consider themselves, to a great extent, aware of the use of both procedural and technical standards. The same applies to the adoption and incorporation of technical standards and SOPs in the protocols of their organizations.

For the first responders technical and procedural standards have equal significance in everyday operations. As stated above, interoperability is a crucial aspect. There is a need for effective cooperation between organizations from different sectors or even different countries, since disasters are affecting concurrently more than one country, and, additionally, for effective and resilient communication between systems and tools.

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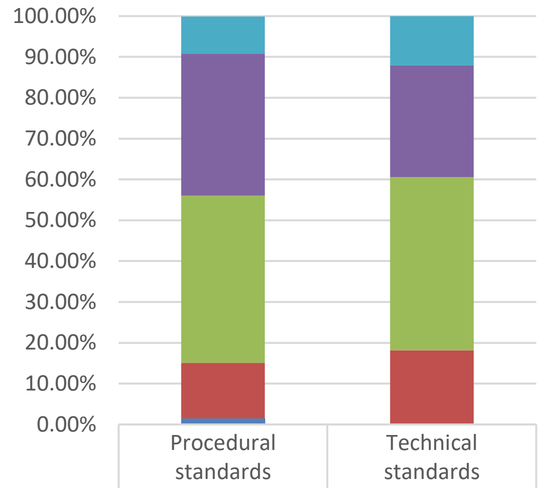
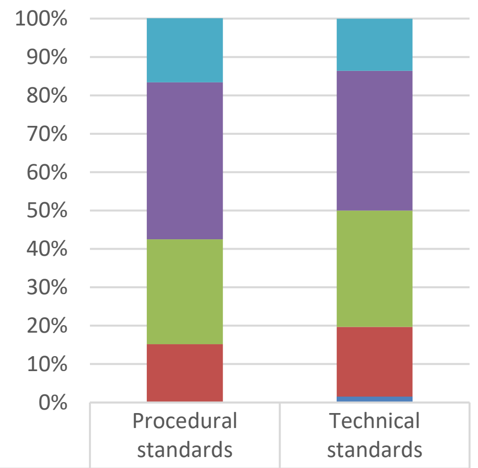


	Procedural standards	Technical standards
Very much	9.10%	12.10%
Much	34.80%	27.30%
Quite	40.90%	42.40%
A little	13.60%	18.20%
Not at all	1.50%	0%

Figure 18: Level of practitioners' awareness of technical and procedural standards.



	Procedural standards	Technical standards
Very much	16.70%	13.60%
Much	40.90%	36.40%
Quite	27.30%	30.30%
A little	15.20%	18.20%
Not at all	0%	1.50%

Figure 19: Level of adoption and incorporation of standards in practitioners' organizations.

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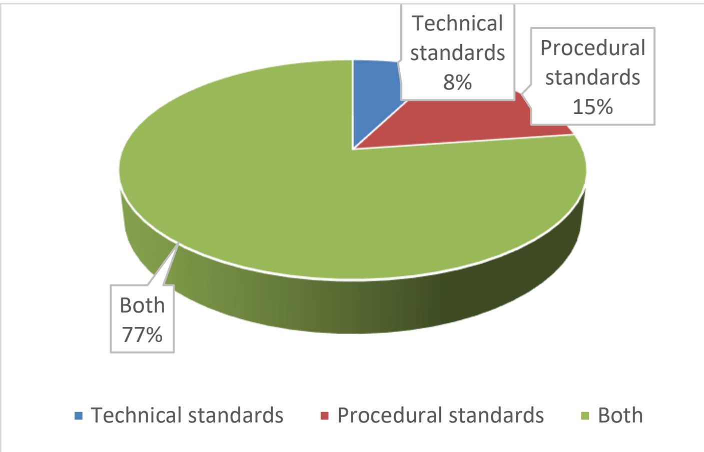

Figure 20: Essentiality of technical and/or procedural standards in practitioners' operations.

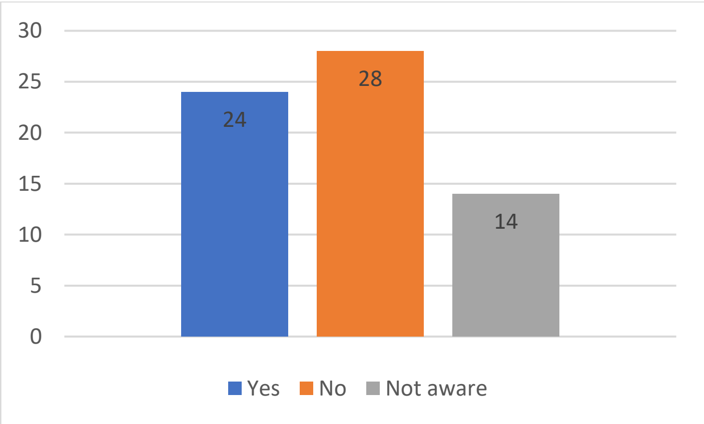

Figure 21: Values of answers regarding the adoption of formal standards by practitioners' organizations.

On the other hand, when it comes to the adoption of formal standards, meaning documents developed by the official standardization bodies, the answers are shared, with practitioners, who do not use formal standards slightly overweighing those who do.

Nevertheless, SOPs and widely accepted guidelines, i.e., documents in the form of best practices, issued by organizations with international influence and outreach, whether civilian (WHO, INSARAG), or military (NATO), which greatly enhance capacities and facilitate cross-organization, cross-sector and even cross-border collaborations, are largely preferred by first responders. Most practitioners' organizations have adopted and make full use of them, while for the few participants, who declared, that they do not have such guidelines incorporated into their protocols, the intention of their organizations is to adopt such operational procedures in the near future. Participants were asked to name a few with characteristic guidelines. INSARAG guidelines for Urban Search and Rescue, IFRC practices, certifications for advanced cardiac life support and advanced trauma life support (ACLS, ATLS) in medical operations are, among others, highlighted. According to the respondents, such guidelines can be of great value in everyday operations and cross-organization and cross-border collaborations. The following figures clearly depict the above presumptions.

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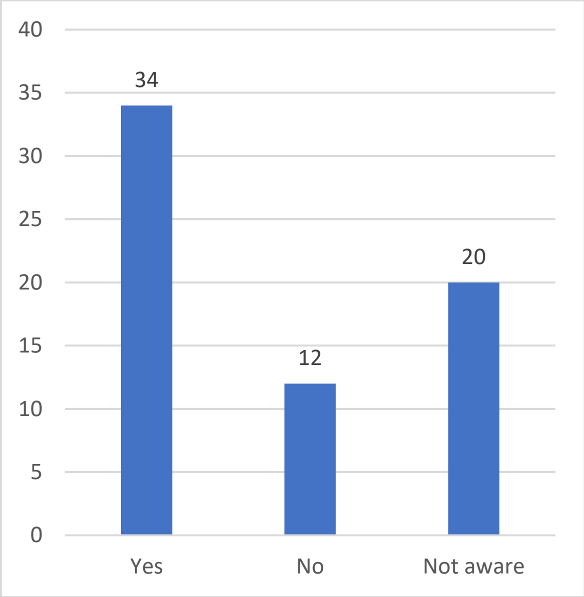
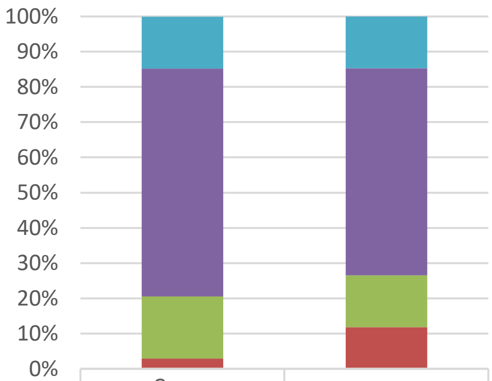


Figure 22: Values of answers regarding the adoption of SOPs and broadly accepted guidelines by practitioners' organizations.



	Cross-organization	Cross-border
Very much	14.70%	14.70%
Much	64.70%	58.80%
Quite	17.60%	14.70%
A little	2.90%	11.80%
Not at all	0%	0%

Figure 23: Level of coverage of cross-organization and cross-border operations by SOPs and widely accepted best practices.

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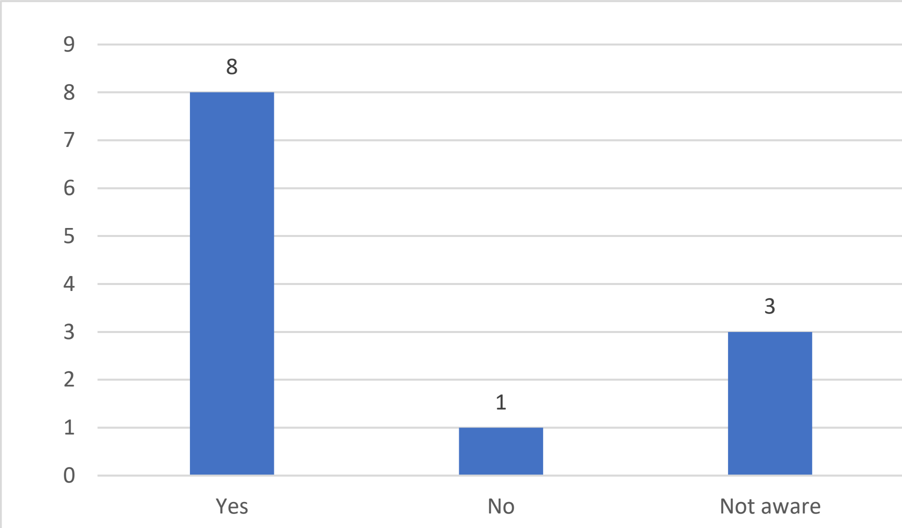

Figure 24: Intention of adoption of best practices and widely accepted SOPs, by organizations, which do not make use of them until now

Finally, it is important to point out the high level of the participants' unawareness, not only regarding the adoption of formal standards, but also of SOPs and guidelines. The possibility of practitioners implementing standards and guidelines, without being aware of it, is high. Therefore, also for the formal standards, the percentage of positive answers could be significantly higher. The latter applies also to the adoption of guidelines. Taking into consideration that the use of widely accepted practices is in the immediate plans of organizations, which, at least until now, have not done so, will greatly increase positive answers.

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6. FIRE-IN – MEDEA joint event

As stated in chapter 3.2 a joint event was organised between the FIRE-IN and MEDEA projects as the two projects share common topics and interests. The joint event was selected as an opportunity during COVID pandemics, in early 2022, to boost the dissemination of both projects, but also to boost interaction between solution providers and practitioners. On one hand solutions providers had the opportunity to learn on the gaps that practitioners face, and on the other hand, practitioners had the chance to see a sample of innovative solutions, that currently exist in the market.

The event was structured upon two axes. The first one was devoted to solution providers and the presentation of their products/solutions, with additional, adequate time for questions. The second axis comprised of a workshop, that engaged, in a more efficient way, both practitioners and providers, in discussions, with the aim to gain feedback for the "Request for Ideas". The joint event was a chance for FIRE-IN partners to meet with other practitioners and solution providers, in order to discuss the progress of the project so far, and, of course, to gain feedback for the current and future challenges.

Two widely used tools were used for the interaction, the «Miro» and the «Sli.do» tools. Miro was used as an open canvas with predefined data, on which the moderator (KEMEA) asked questions and navigated the discussion. The Sli.do tool was used to gain feedback on questions, similar to the ones already asked to the questionnaires, shared among various stakeholders across Europe.

The registered participants almost reached the number of 170 persons (industry, researchers, practitioners), while the active participants reached 100 persons at peak time. Based on the registered data, the ratio between practitioners and solution providers (incl. researchers) was close to 1, meaning that around 45% were practitioners and 55% were solution providers (incl. researchers). In Appendix A8, a list with the organizations of the participants to the event belong, is presented (Table 35).

The workshop was divided in two parts, during which a more general discussion about the CCCs and FCCCs, current technologies that address specific CCCs/FCCCs were discussed based on the findings of the questionnaires and retrieving feedback mainly from solution providers, while in the second part the participants were clustered in the five TWGs for a more comprehensive discussion about the challenges and the gaps. Unfortunately, due to the low participation per TWG, TWG-B, TWG-C and TWG-D were merged in the same group, as the links between TWG-B (Structure fires) and TWG-C (landscape fires mitigation) and TWG-D (natural hazard mitigation) are more than direct and obvious.

As a first step, and, in order to familiarize the audience with the FIRE-IN challenges and the MEDEA gaps, a snapshot of the two project challenges and gaps and the common grounds between them was shown (Figure 21).

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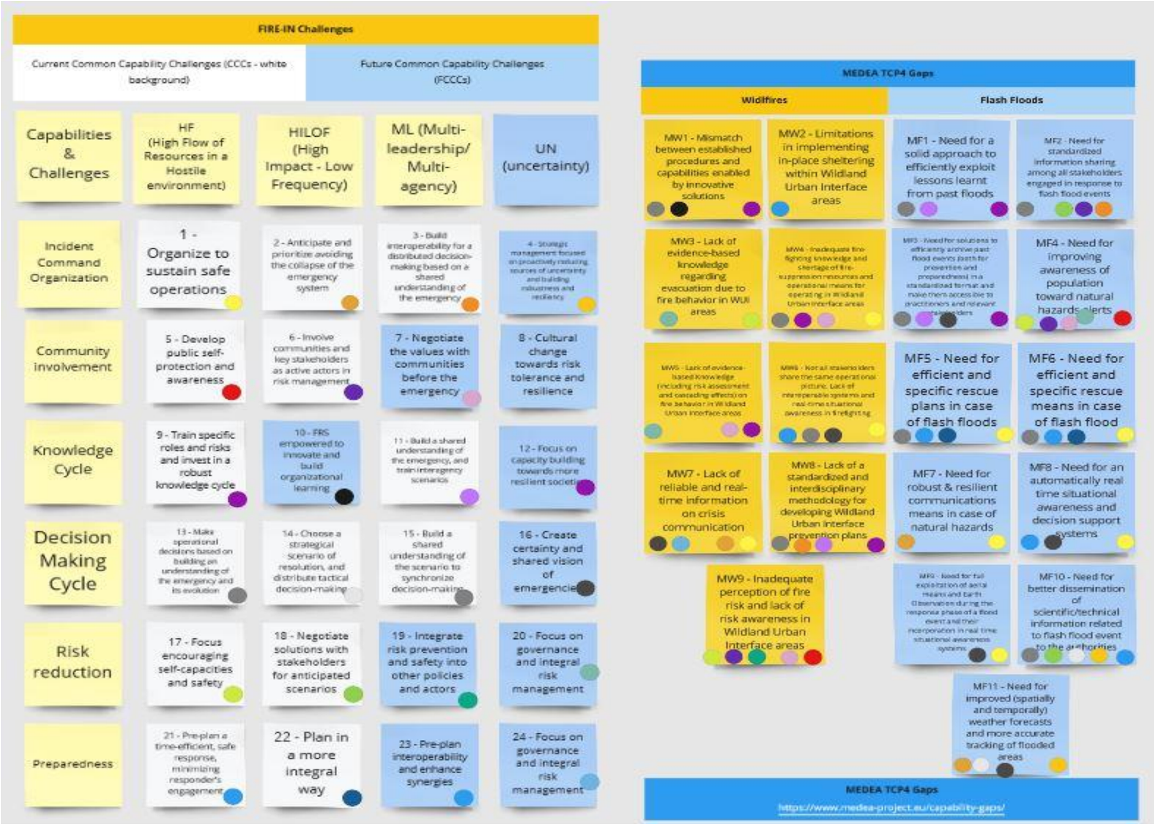

Figure 25: Left: FIRE-IN challenges. Right: MEDEA gaps. The coloured dots denote common grounds between the two project end user needs/gaps.

As a second step, a series of eight questions was presented in a form of an online survey, using the Sli.do interaction app. Practically, four questions were asked, in turns to practitioners and solutions providers. This was deliberate with the aim to have a clear discretization between their answers. The questions asked were related to the most important CCCs and FCCCs, as well as the most important technologies for the next 2-7 years and 7+ years. Participants were instructed to select only the three most important and no more than 3 minutes of time was given to the participants, in order to select their answers. Answers were shown live to the participants. Answers and graphs follow.

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Question 1 (for solution providers only): Which of the following Common Current Challenges (CCCs) do you consider the most important?

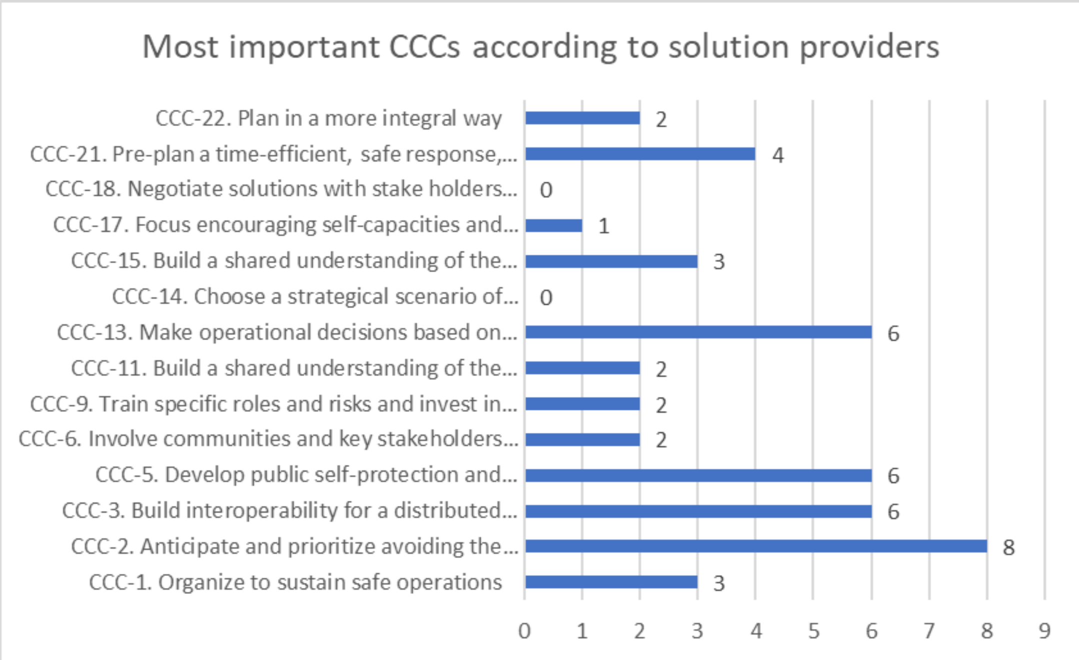

Figure 26: Most important CCCs according to solution providers.

The total number of received answers was equal to fifteen. It is apparent, that CCCs "Anticipate and prioritize avoiding the collapse of the emergency system", "Build interoperability for a distributed decision-making based on a shared understanding of the emergency", "Develop public self-protection and awareness" and "Make operational decisions based on building an understanding of the emergency and its evolution" are the most important for solution providers, who participated in the voting. In this online poll there were two CCC with zero votes: "Choose a strategical scenario of resolution and distribute tactical decision-making" and "Negotiate solutions with stake holders for anticipated scenarios had zero votes".

Question 2 (for solution providers only): Which of the following Common Current Challenges (CCCs) do you consider the most important?

In total, ten answers were received, out of which "Involve communities and key stakeholders as active actors in risk management" and "Plan in a more integral way" are the most important, followed by "Train specific roles and risks and invest in a robust knowledge cycle" and "Anticipate and prioritize avoiding the collapse of the emergency system". "Build a shared understanding of the scenario to synchronize decision-making" and "Negotiate solutions with stake holders for anticipated scenarios" received no votes (Figure 27).

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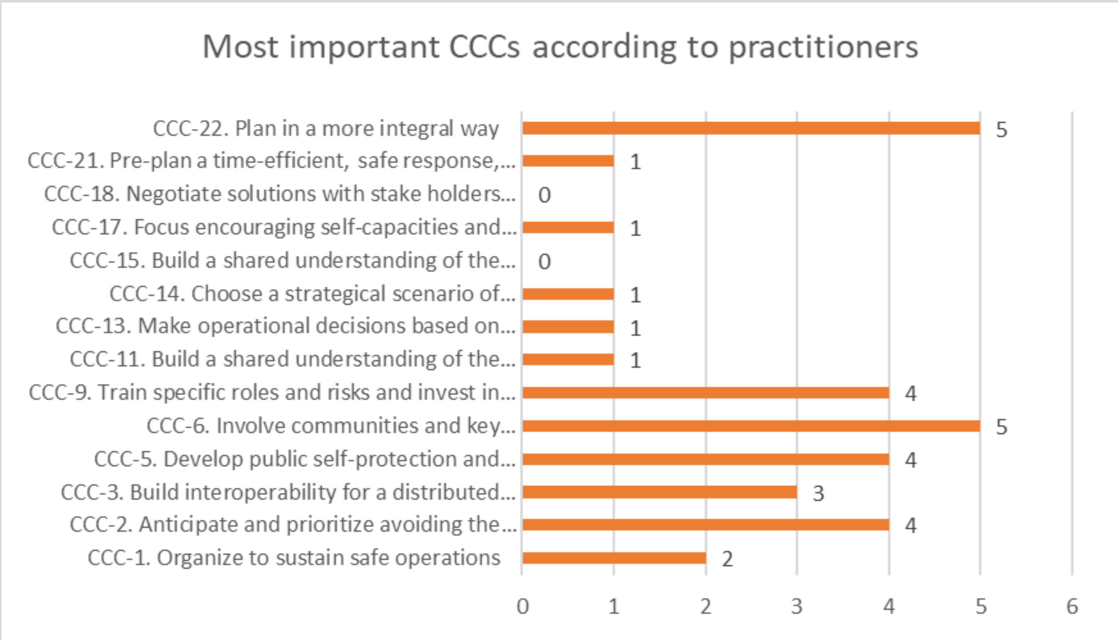

Figure 27: Most important CCCs according to practitioners.

Question 3 (for solution providers only): Which of the following Future Capability Challenges (FCCCs) consider the most important?

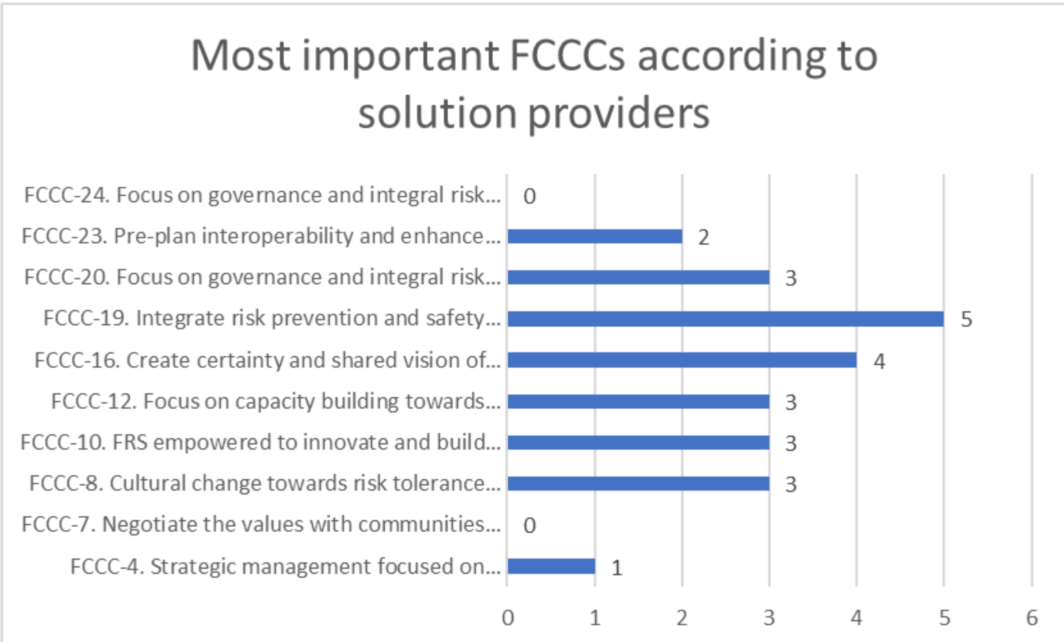

Figure 28: Most important FCCCs according to solution providers.

In total, twelve answers were received. "Integrate risk prevention and safety into other policies and actors" and "Create certainty and shared vision of emergencies" are the two most important, while many of the FCCCs seem to be among the choices of the solution providers. On the opposite side

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"Negotiate the values with communities before the emergency" and "Focus on governance and integral risk management" were not selected at all by solution providers.

Question 4 (for practitioners only): Which of the following Future Capability Challenges (FCCCs) consider the most important?

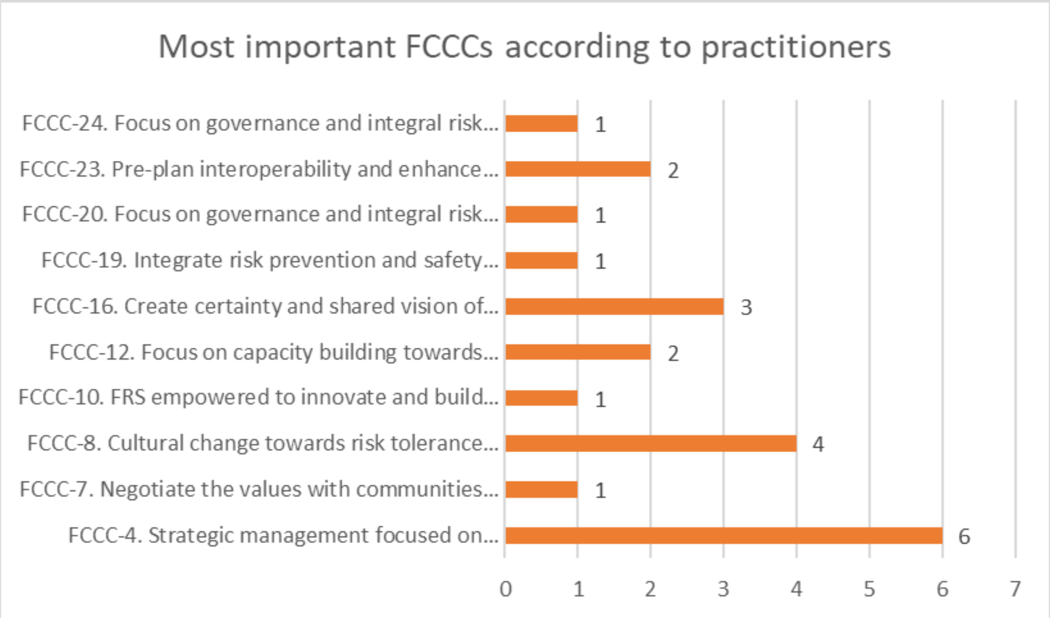

Figure 29: Most important FCCCs according to practitioners.

In total, eleven answers were received. Clearly, "Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency" is the most important FCCC for practitioners followed by "Cultural change towards risk tolerance and resilience" and "Create certainty and shared vision of emergencies".

Question 5 (for solutions providers only): Which technologies do you consider as the most important in a time frame of the next 2 to 7 years?

According to the nine answers, "Early Warning technologies" are the most prevailing for the near future, followed by "technologies for resilient communication in harsh environments" (Figure 30).

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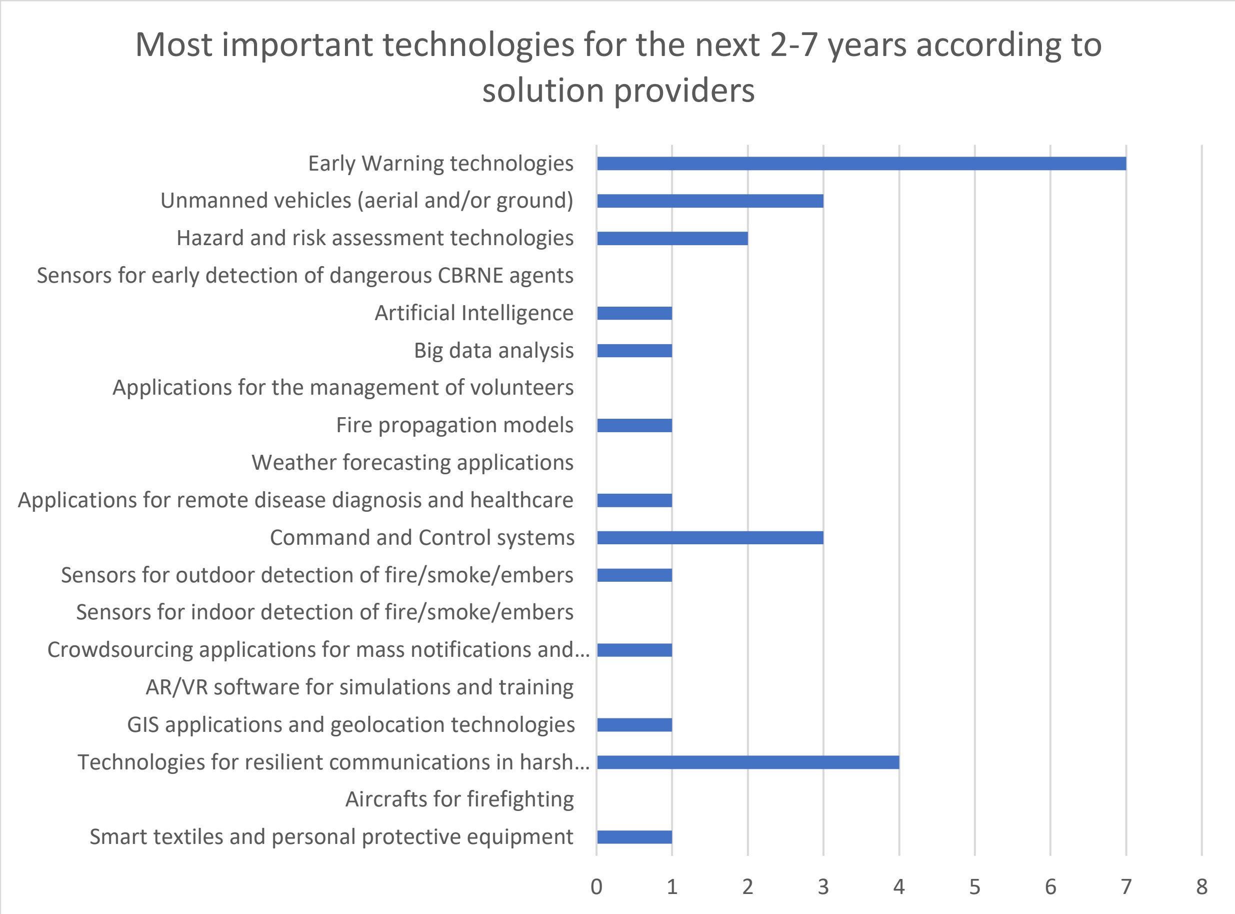

Figure 30: Most important technologies for the next 2-7 years according to solution providers.

Question 6 (for practitioners only): Which technologies do you consider as the most important in a time frame of the next 2 to 7 years?

According to the ten answers, “Early Warning technologies” are the most prevailing according to practitioners, although other technologies, such as GIS applications, crowdsourcing applications for mass notifications, artificial intelligence and unmanned vehicles are also important (Figure 31).

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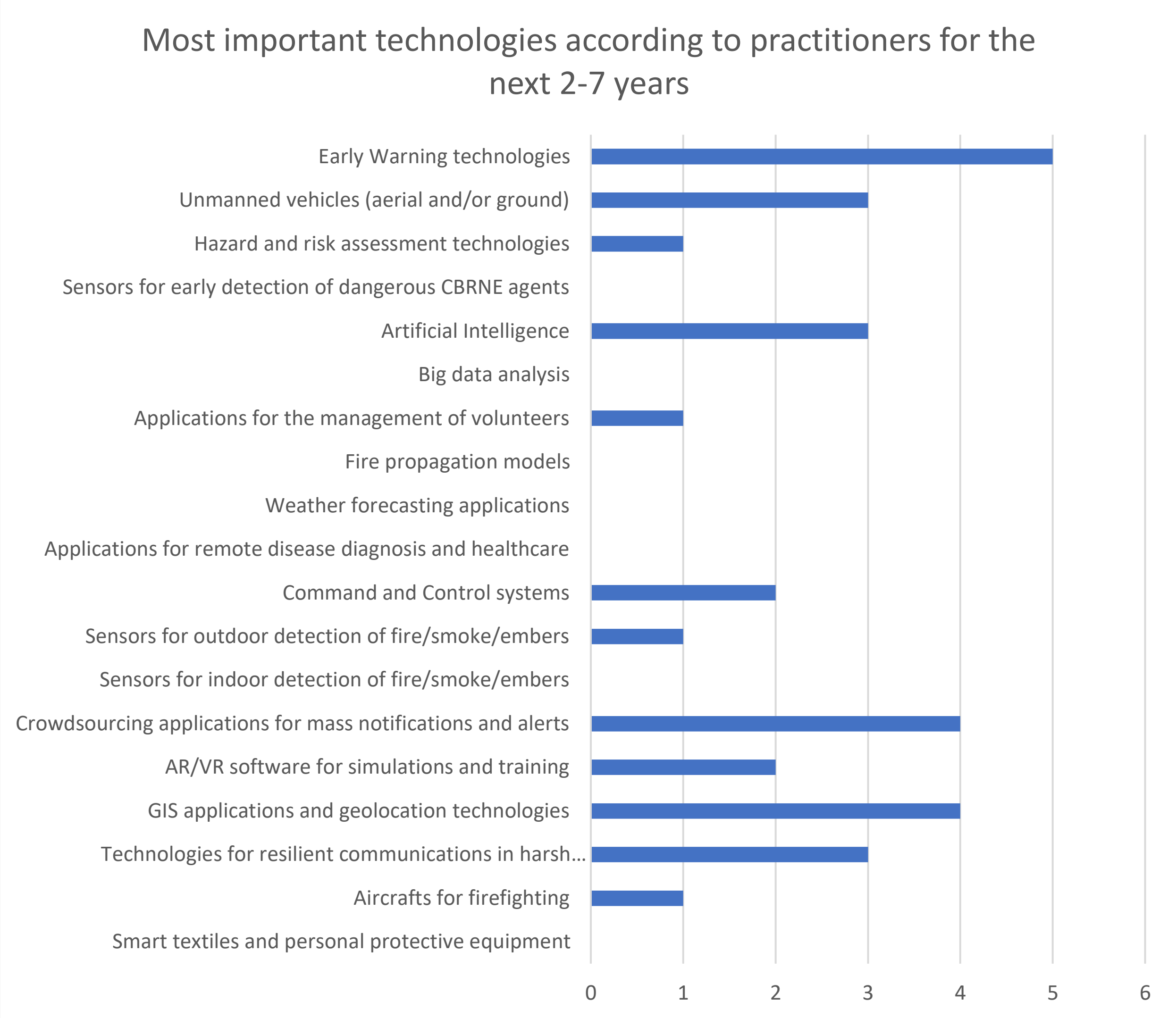

Figure 31: Most important technologies for the next 2-7 years according to practitioners.

Question 7 (for solutions providers): Which technologies do you consider as the most important in a time frame of the next 7+ years?

Based on the nine answers received, command and control systems artificial intelligence, technologies for resilient communications in harsh environments, software for simulations and training will prevail the next 7+ years (Figure 32).

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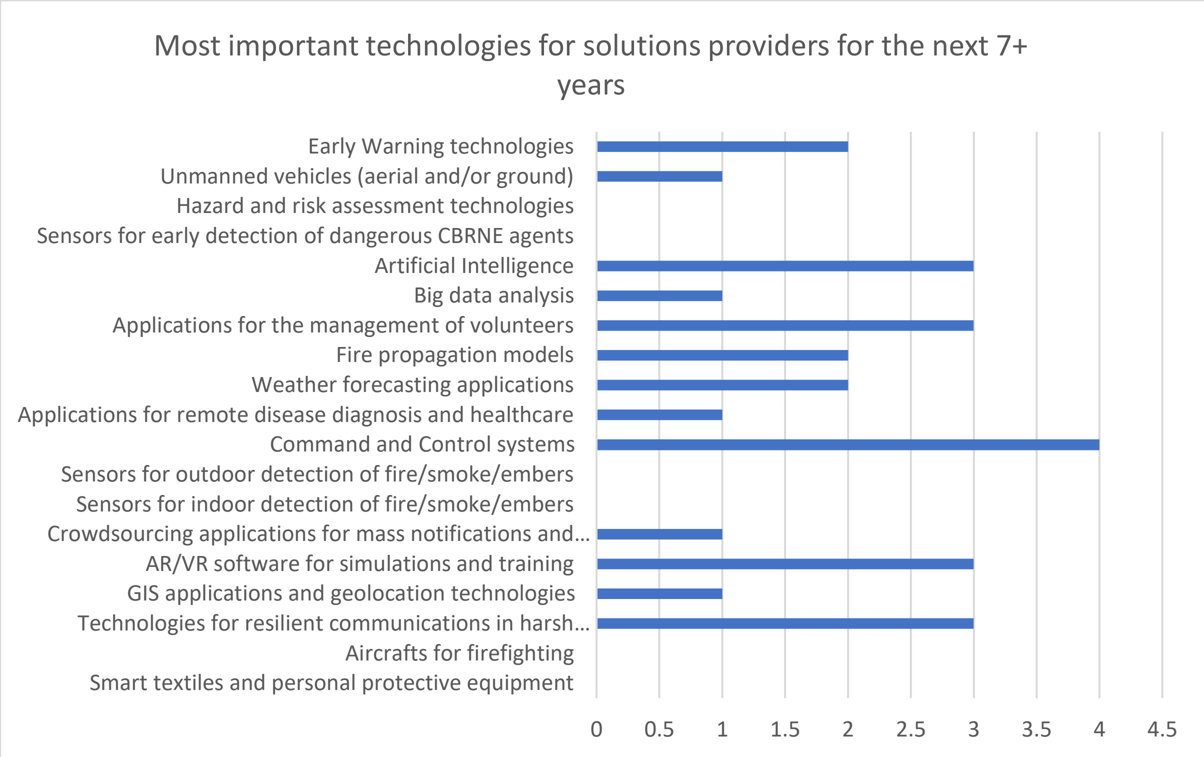

Figure 32: Most important technologies for the next 7+ years according to solution providers.

Question 8 (for practitioners): Which technologies do you consider as the most important in a time frame of the next 7+ years?

Based on the ten answers for practitioners Early Warning technologies and Big Data Analysis will prevail for the next 7+ years. On the contrary, other technologies, selected by practitioners, such as command and control systems are not that significant in the long term for practitioners (Figure 33).

Compared to the number of participants, the number of received answers is small, and especially compared to the number of questionnaires gathered. Clearly, not all participants to the workshop answered the predefined questions. Also, it must be noted that these answers are not the ones on which the conclusions of this deliverable are necessarily based.

As a third step, a brief comparison between the answers of the participants and the answers gathered from the questionnaires, until the day of the event, were shown to the participants for the CCCs (Figure 34) and the FCCCs (Figure 35).

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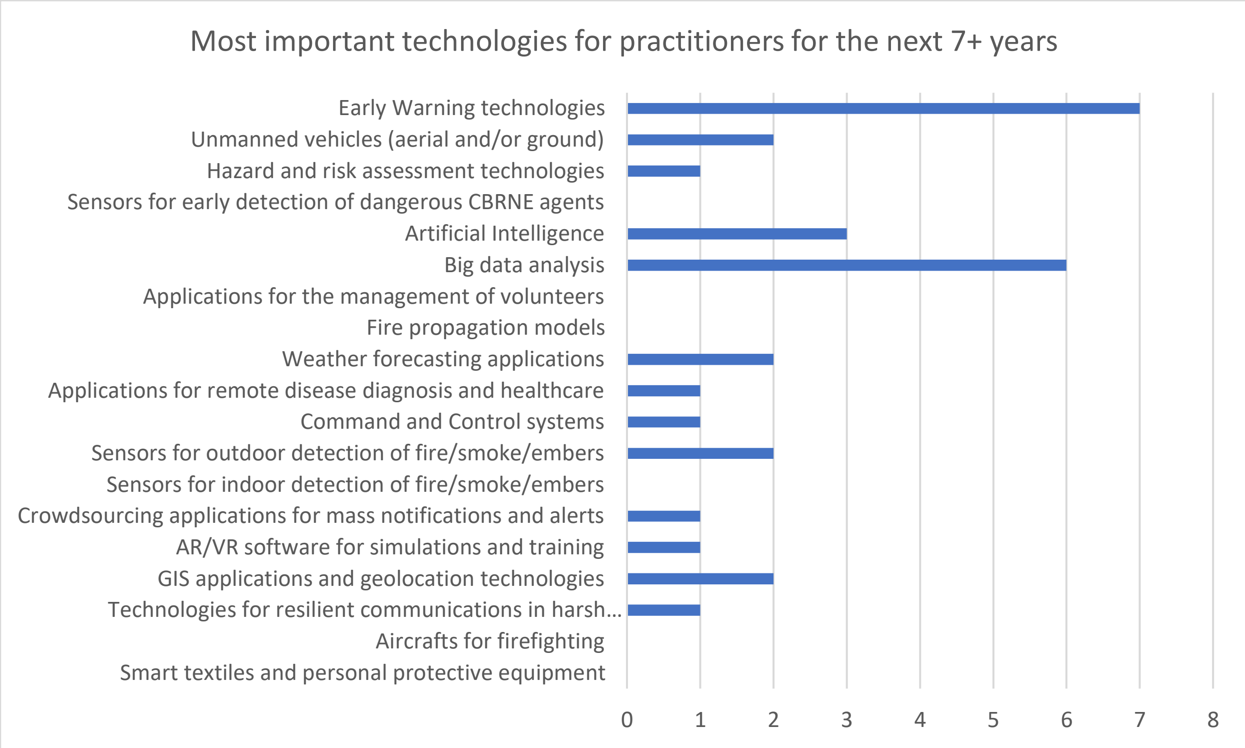

Figure 33: Most important technologies for the next 7+ years according to practitioners.

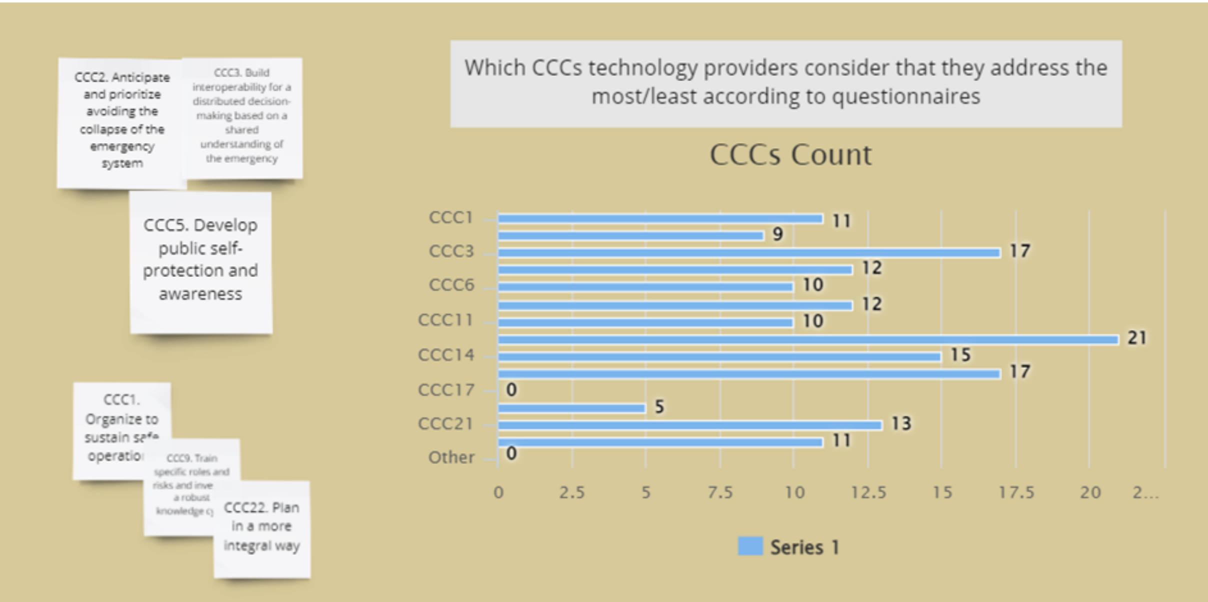

Figure 34: Comparison between the most important CCCs, according to the participants of the workshop, and the CCCs, most addressed by technological innovations, developed by the organizations of the respondents of the questionnaire.

Clearly from Figure 34, the direct comparison, reveals differences and commonalities. Based on the answers from the participants and the discussion followed the CCCs most interested in for technology providers are the following:

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- Build interoperability for a distributed decision-making based on a shared understanding of the emergency.
- Anticipate and prioritize avoiding the collapse of the emergency system.
- Develop public self-protection and awareness.

Also, the following CCCs present some interest as well:

- Organize to sustain safe operations.
- Train specific roles and risks and invest to a robust knowledge cycle.
- Plan in a more integral way.

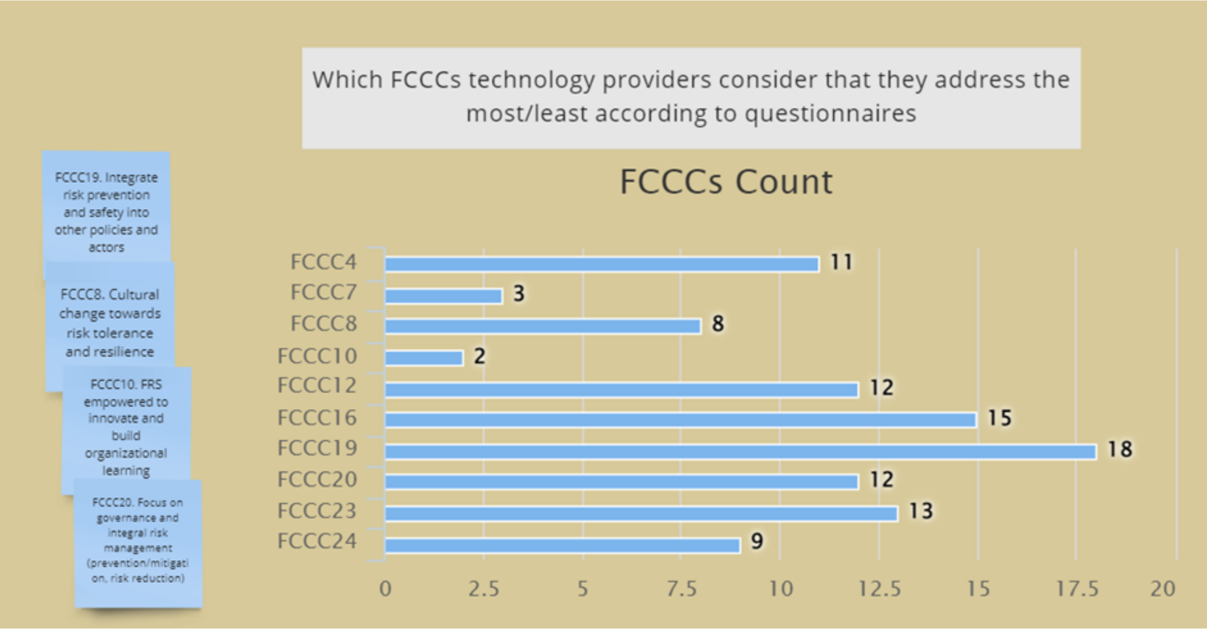

Figure 35: Comparison between the most important FCCCs, according to the participants of the workshop, and the FCCCs, most addressed by technological innovations, developed by the organizations of the respondents of the questionnaire.

Following the same procedure for the FCCCs and the comparison with the preliminary results of the gathered questionnaires, there are some commonalities and some differences. The most characteristic example is the fact, that *FCCC "Integrate risk prevention and safety into other policies and actors"* is the one most selected. Overall, and following a constructive discussion, the FCCCs, considered of highest interest for technology providers, are the following:

- Integrate risk prevention and safety into other policies and actors.
- Cultural change towards risk tolerance and resilience.
- FRS empowered to innovate and build organizational learning.
- Focus on governance and integral risk management (prevention/mitigation, risk reduction).

Regarding the importance of FCCCs, a crucial statement was made by several participants, regarding the essentiality of the "Cultural change towards risk tolerance and resilience". There is a great need

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for cultural change, regarding risk tolerance and the perspective of the population. People need to be constantly aware and informed and their perspective should change, from waiting to be saved by first responders, in case of a disaster, to anticipating their exposure to danger in advance, and preventing acts, that could potentially improve their vulnerability. Even the most advanced technologies will not be sufficient to save everybody, if the population is not properly prepared, having taken appropriate measures.

Regarding technologies, which is a significant part of the Request for Ideas process, and one of the most important factors to address the practitioners' challenges, after the answers to the questions, by the participants, a similar to the CCCs approach was followed. Preliminary results from the questionnaires were shown to the participants (Figure 32) through which an interesting graph has been built. More specifically, a graph depicting the differences between practitioners and technology providers in the answers collected through the questionnaires was the initiation point for further discussion. From Figure 32, some differences are revealed. While practitioners believe that smart textiles, AR/VR software for training, command and control systems and unmanned vehicles will have developments in the future, technology providers work on other technologies. At the same time, GIS applications, big data analytics, artificial intelligence, hazard and risk assessment technologies and early warning are the most important for technology providers according to the questionnaires results.

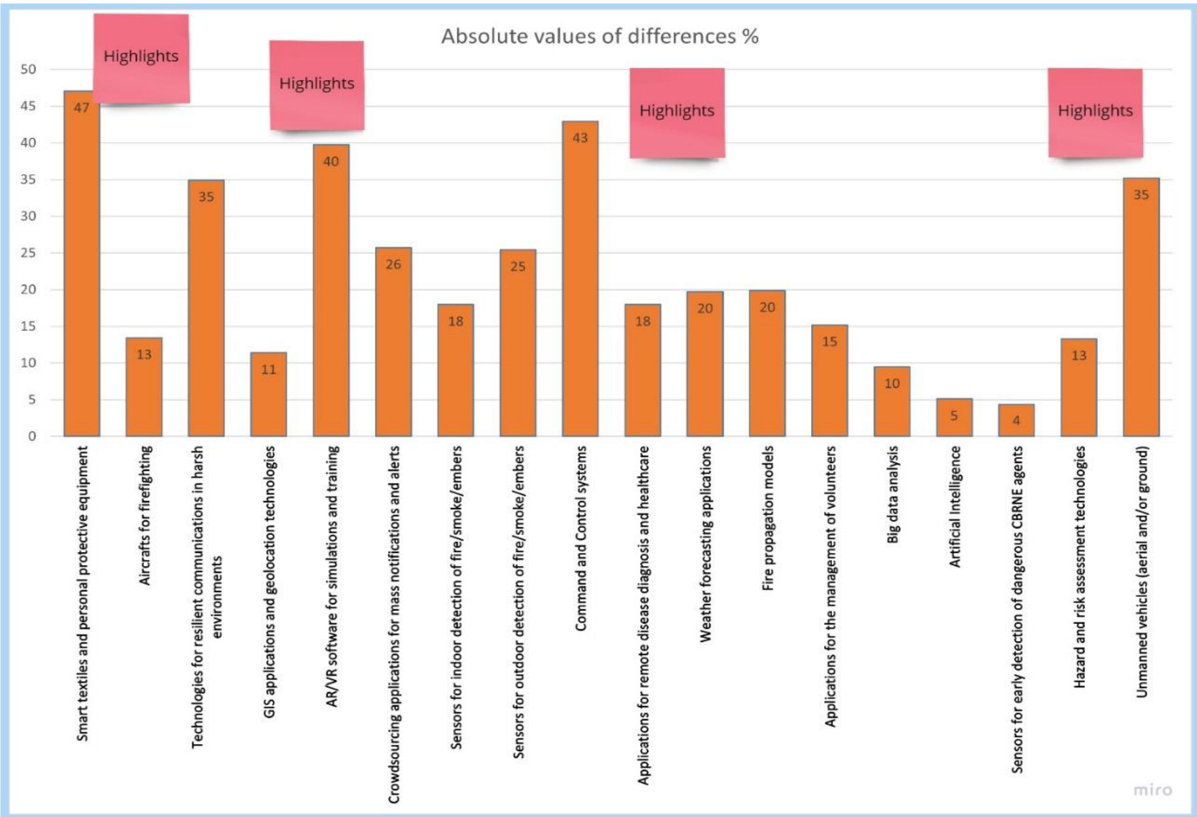

Figure 36: Absolute values of the differences, expressed in terms of percentage, of technologies on which technology providers currently develop and the technologies that practitioners consider that will have further developments in the future. The label "Highlights" indicate the technologies which there is a significant different in the opinion of technology suppliers and practitioners.

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Regarding technologies and based on the answers of the participants during the workshop, the most interested technologies both for practitioners and technology providers are summarized in Figure 33. These are also clustered according to a time frame, short-medium term, and long term.

Technologies are interesting, because it seems that there is not always an easy match between practitioners and technology providers. The only type of technology that seems to be common is early warning technologies, although technology providers consider this important only for the next 7 years. This probably can be attributed to the fact that early warning will have developed adequately since then.

Nevertheless, all the current trends in technologies are somehow identified by both groups such as early warning, artificial intelligence, big data, virtual reality and augmented reality for training, command and control systems, unmanned vehicles, Geographic Information Systems and crowd sourcing.

Also, some of the results between the workshop and the questionnaires seem to be a bit contradictory, but the sample of the workshop was smaller than the one of the questionnaires and thus may be only a portion of the questionnaires answers.

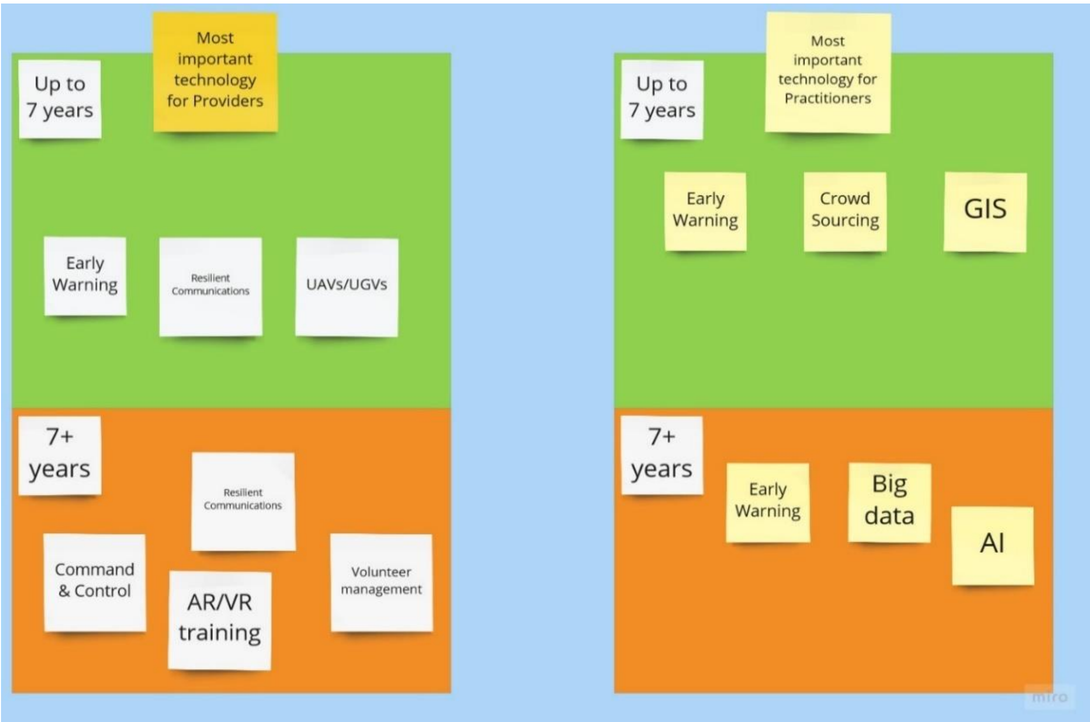

Figure 37: Most important technologies up to 7 years (green background) and for the next 7+ years (orange background) for technology providers (left) and for practitioners (right). Snapshot from Miro board that was used during the workshop.

One important point is the issue of open data, open-source code and open format in order to increase the access of interested parties to new tools. Open data could be everything, from constant information from social media to the download of satellite images from the Copernicus EO programme.

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In addition, command and control systems should integrate a variety of technologies, such as GIS system, crowdsourcing systems, sensors for real-time monitoring. Therefore, there is a need for open data and, especially, for interoperable systems. The standardization process could pave the way to effective and interoperable technologies.

Integration of existing technologies is also a key topic for closing the practitioners' challenges.

Regarding the GIS system, which is a sector already conquered and highly developed, there is the need to become a friendlier and easier to use tool for the end user, who has a more operational, rather than a scientific background. Practitioners tend to tie to certain technology suppliers and get used to their systems and devices, thus they are more hesitant to learn how to use a new tool.

Finally, resilient communications, especially in hostile and harsh environments, is another sector, that requires attention and further development, taking into account, that in high impact disasters communications will almost certainly collapse, decreasing the capability of practitioners to effectively and timely respond.

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7. Interviews with providers regarding challenges and future technological trends.

Apart from the questionnaires and the joint event between MEDEA and FIRE-IN, it was decided to conduct some interviews, in the form of a discussion, with stakeholders and particularly technological providers, regarding the challenges of the third cycle and future technological trends. The interviews are a good way to discuss with the interested party in a more relaxed and personalized manner and get targeted feedback. Potential interviewees included persons, working for technological organizations, who are registered in the e-FIRE-IN platform. The majority was from Small Medium Enterprises, but also people from companies of the industrial level were invited for an interview. Overall, 25 organizations, were approached, via email, whereas one RTO, two SMEs and one industrial organization responded.

The sample may seem, at a first glance, small, nevertheless, it fueled significant results, which can provide added value to what has already come to light. The desirable outcome was not so different compared to the outputs of the respective questionnaire and of the workshop.

The basic axes to which these interviews build on were, as discussed, three:

- Interviewees to have a closer look on the CCCs and FCCCs, identified in the third and final cycle of workshops between fire and rescue experts. The basic advantage of the interviews, especially against the workshop was that the participants had enough time to read through the 24 challenges and digest, along with elaborations provided by the organizers, the meaning of each challenge and the exact topic it deals with.
- To hold more thorough discussions with providers, regarding identified types of technological solutions. These types, as already mentioned, include all different kinds of solutions, identified throughout the three solution screenings, conducted in the framework of WP2, and, moreover, solutions uploaded to the e-platform, in the context of WP3 and the RfI procedure.
- Interviewees to provide feedback, regarding future technological trends, not only generic, but also specifically related to their expertise and areas of interest.

7.1. Highlight of the most essential CCCs/FCCCs

From the discussions several interesting conclusions were drawn. Regarding the importance of Current and Future Common Capability Challenges, the entire "*Community Involvement*" capability is of utmost importance. Similar to the outcomes of the workshop, the active participation and involvement of the public in disaster management strategies is essential, even to a higher degree than innovative technologies for practitioners. To this end, technology may prove to be an effective tool, along with guidelines and policies, targeting the change in the perspective of the public. A great example of how technology can provide solutions to the crucial issue of community involvement could be platforms, which are currently being developed, with the aim to be utilized by schools, for the educational and

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training purposes. In the face of high impact disasters, which are becoming increasingly common, the need for aware and adequately trained future citizens, with the right attitude against disasters, is more than crucial. Moreover, citizens, who can proactively take measures, might increase their own capacities and, at the same time, reduce the exposure and the possibility of harm for practitioners.

Another issue, that was highlighted in the conversations with the providers, was the essentiality of adjusting and enhancing risk reduction strategies, thus focusing on the "Risk Reduction" and "Preparedness" capabilities. Although not a challenge highly covered by technological innovations, as seen, at least, by the number of relevant solutions addressing it, CCC-17 *"Focus encouraging self-capacities and safety"* is pinpointed. It is important, according to the providers' point of view, that all actors in disaster management understand the risk and develop mechanisms, in order to minimize it. These mechanisms could be in the form of training, education, or even related to safe operations, such as operational procedures, focused on increasing the window of opportunity and the time to act. FCCC-20 *"Focus on governance and integral risk management"* also plays a significant role. Adaptation of policies, especially in the short-term after a disaster strikes, could be an effective weapon for the confrontation of future, similar disasters.

Finally, interoperability, both technical and procedural is crucial. Technological providers have been developing and continue to do so, systems and tools, which can communicate with each other and facilitate the exchange of significant information, thus providing increased situational awareness. Except for technical interoperability, collaborations between first responders' organizations are another important issue and, although this is something more related to practitioners than to providers, it seems to equally concern both sides.

7.2. Essential technologies, that can facilitate disaster management, according to providers

The second major topic for discussion was to point out the most important technologies that are currently being developed and, additionally, what are the trends regarding future production and developments. In this case, the answers were subjective, at least to a certain degree. The reason is, that technology providers present the areas, on which they are working on, as essential, to say the least. Nevertheless, discussions hovered at more generic levels, and, aiming at reducing the level, to which the participants' answers were biased, interviewees were asked to highlight at least three types of technologies, they consider crucial and also future trends.

Answers were unsurprisingly similar to the ones, provided in the questionnaires and also in the workshop. Big data analysis systems are amongst the most important technologies. There is a need for an increase in the incoming information, whether this derives from scientific projects and systems, such as satellite images or from crowdsourcing tools, which are related to social media sensing. One main constraint is the "filtering" of this information, in order not to mislead or create noise, something, that could lead to delays or false mobilization of resources.

GIS applications, as pointed also in the questionnaires, is another domain, on which providers are focusing. Moreover, geolocation technologies are essential, not only to locate but also to provide safe

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escape routes. Such kind of technology could be used by the 112 emergency service. Alerts alone are not sufficient. On the contrary, pointing out potential victims' position, via tracking the GPS signal from mobile phones, and providing evacuation routes, that complement the alert, could save lives.

Artificial Intelligence (AI) and machine learning is another sector, expected to be further developed. Systems integrating historical data from past disasters, with the aim to achieve a multi-hazard approach are currently being examined and developed. Moreover, significant advancements in Augmented Reality (AR), Virtual Reality (VR) XR simulation systems have been observed and are under the microscope of several research projects.

In addition, technologies regarding the recruiting and management of volunteers are being increasingly developed, something that is tied to the significance of the involvement of the community as an active player in disaster management.

Emphasis has been given on the centralization of services in a common platform, which receives and shares the appropriate information to the interested parties and first responders. This concerns, not only volunteer management tools, but, in general, all technologies, that can be utilized during emergencies. This opinion, that a platform, in which sensors, models and other interconnected applications and systems are integrated, complements what had also been vividly expressed in the workshop, regarding the openness and filtering of data.

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8. Conclusions

This chapter is dedicated to the main conclusions drawn from the 3rd cycle RfI procedure, how the CCCs/FCCCs identified in WP1 are addressed by existing solutions screened in WP2 and what are the future trends regarding technology, research and standards related to the CCCs/FCCCs.

In addition, in this cycle, besides the overall conclusions, an approach to present key outcomes for the five Thematic Working Groups is also attempted. With this approach we want this document to be the initiation point for the 3rd cycle Strategic Research and Innovation Agenda, which is the last step for closing the loops of cycles in the project lifetime.

8.1. Coverage level of CCCs and FCCCs

The coverage level of the third cycle Future and Current Common Capability Challenges is presented in the following chapters (8.1.1 up to 8.1.5) according to the respective capability they belong to. In chapter 8.1.6 an overview of the third cycle matrix in the terms of the traffic light system and level of coverage of CCCs/FCCCs is presented along with the basic conclusions.

8.1.1 Incident Command Organization

This capability is largely covered by technological innovations. Moreover, having examined and applied the TLS to each solution separately, it has been seen, that most of these technologies have a significant level of maturity by having a high TRL with interoperability capabilities and a significant operational value. A variety of systems, that promote and ensure safe operations and foster interoperability exists, such as Unmanned Vehicles, sensors for early detection of dangerous CBRNE agents or of smoke/fire/embers and others. These conclusions are apparent in the following table, which presents the number of technological solutions, addressing each challenge, as well as, the criteria, used for the chromatic characterization.

Table 21: Numbers of technological solutions addressing the challenges of "Incident Command Organization".

CCCs / FCCCs of the 3rd Cycle	No. of technological solutions	Criteria	Green	Yellow	Red
CCC-1: Organize to sustain safe operations.	160	Operational Value	148	8	4
		Solution Maturity	147	8	5
		Interoperability & Standards	148	12	0
	89	Operational Value	82	6	1

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CCCs / FCCCs of the 3rd Cycle	No. of technological solutions	Criteria	Green	Yellow	Red
CCC-2: Anticipate and prioritize avoiding the collapse of the emergency system.		Solution Maturity	82	7	0
		Interoperability & Standards	80	9	0
CCC-3: Build interoperability for a distributed decision-making based on a shared understanding of the emergency.	68	Operational Value	63	3	2
		Solution Maturity	62	4	2
		Interoperability & Standards	63	5	0
FCCC-4: Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.	18	Operational Value	14	4	0
		Solution Maturity	14	4	0
		Interoperability & Standards	16	2	0

Additionally, research papers and projects, as well as, guidelines and standardization documents also cover the challenges of this capability, to a large extent. CCC-1 "*Organize to sustain safe operations*" and CCC-2 "*Anticipate and prioritize avoiding the collapse of the emergency system*" respectively, although covered by research, this is mainly in terms of papers, whereas the number of screened projects is limited.

In our opinion the whole capability should be on the green side regarding standardization. Formal standards, developed by EU standardization bodies, providing good practices, related to the incident command organization, have been screened, as well as, official guidelines, widely adopted by practitioners' organizations, such as the National Incident Management System Doctrine by FEMA. Moreover, although CCC-1 "*Organize to sustain safe operations*" is only covered by very few solutions, the fact, that several standards and guidelines address the Future Challenge of this Capability (FCCC "*Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency*"), means also, that current challenges are also covered. The matrix should be assessed not only vertically, but also horizontally, especially when it comes to a generic and broad domain, such as Standardization. Standards can be generic enough, so that they may address, at least to a certain degree, more than one challenges and thus, it would make no sense for existing or even under developments standards to address a future challenge and not to be appropriate to cover a current one of the same capability. Nevertheless, there is a need for more substantial standards, addressing a topic to its core, and this is something also highlighted by the practitioners, who took part in the workshop. Standards diving deeper to the specifics of a certain domain, should be a very significant point of interest and concern for research and development in the future.

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8.1.2 Community Involvement

"Community involvement" is also a capability well addressed by all kinds of solutions. There are systems related to the recruiting and management of volunteers, crowdsourcing and big data analysis software and, generally, technologies, which enable and facilitate the collaboration between first responders and citizens. There is a lack of information though, regarding the interoperability and adoption of standards from technological solutions. This is the reason, why CCC-6 "*Involve communities and key stakeholders as active actors in risk management*" is yellow, because although this challenge is well addressed, the criterion "Interoperability and standards" includes a plethora of technologies falling to the yellow or even the red category.

Table 22: Numbers of technological solutions addressing the challenges of "Community Involvement".

CCCs / FCCCs of the 3rd Cycle	No. of technological solutions	Criteria	Green	Yellow	Red
CCC-5: Develop public self-protection and awareness.	124	Operational Value	108	15	1
		Solution Maturity	116	8	0
		Interoperability & Standards	95	22	7
CCC-6: Involve communities and key stakeholders as active actors in risk management.	74	Operational Value	58	15	1
		Solution Maturity	69	5	0
		Interoperability & Standards	36	27	11
FCCC-7: Negotiate the values with communities before the emergency.	155	Operational Value	133	20	2
		Solution Maturity	144	11	0
		Interoperability & Standards	108	36	11
FCCC-8: Cultural change towards risk tolerance and resilience.	1	Operational Value	1	0	0
		Solution Maturity	1	0	0
		Interoperability & Standards	1	0	0

Research, with papers and projects, related to a more active engagement of the public in disaster management, also exists. More specifically, FCCC "*Cultural change towards risk tolerance and resilience*", is not addressed by technology. This is due to the fact, that the approach in this challenge is more theoretical, focusing on a change in the perspective of citizens and, therefore, technology cannot provide sufficient solutions.

On the other hand, as is the case with the other three challenges of "*Community Involvement*", there are guidelines, standards and research documents satisfyingly addressing this topic.

8.1.3 Knowledge Cycle

"Knowledge Cycle", although it is a challenge decently covered, it includes challenges, such as CCC-9 "*Train specific roles and risks and invest in a robust knowledge cycle*" and FCCC-12 "*Focus on capacity building towards more resilient societies*", with only a few technologies, two and nine respectively.

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Again, these are challenges, that cannot be addressed by the technology domain and require a different approach. The following table provides a clear picture, regarding the technological coverage of the "Knowledge Cycle" challenges.

Table 23: Numbers of technological solutions addressing the challenges of "Knowledge Cycle".

CCCs / FCCCs of the 3rd Cycle	No. of technological solutions	Criteria	Green	Yellow	Red
CCC-9: Train specific roles and risks and invest in a robust knowledge cycle	2	Operational Value	1	1	0
		Solution Maturity	1	1	0
		Interoperability & Standards	1	1	0
FCCC-10: FRS empowered to innovate and build organizational learning	25	Operational Value	18	7	0
		Solution Maturity	23	2	0
		Interoperability & Standards	14	11	0
CCC-11: Build a shared understanding of the emergency, and train interagency scenarios	55	Operational Value	43	10	2
		Solution Maturity	50	5	0
		Interoperability & Standards	30	23	2
FCCC-12: Focus on capacity building towards more resilient societies	9	Operational Value	6	3	0
		Solution Maturity	7	2	0
		Interoperability & Standards	8	1	0

Standards and widely adopted guidelines can and do solve the problem of low coverage and, although, CCC-9 "*Train specific roles and risks and invest in a robust knowledge cycle*" is a challenge without screened solutions, standards, that cover the FCCC-12 "*Focus on capacity building towards more resilient societies*" can also be applied to it. For this challenge, the fact that no research solutions exist also comes as no surprise, since the training of the roles of practitioners derives usually from protocols, SOPs and practices they adopt and use.

8.1.4 Decision Making Cycle

In the *"Decision Making Cycle"* a large number of technological solutions, such as decision support systems, command and control centres etc. has been examined. These solutions have a very high TRL (>9), are being used by practitioners, and, to a significant degree, make use of technical standards, also facilitating interoperability.

Table 24: Numbers of technological solutions addressing the challenges of "Decision Making Cycle".

CCCs / FCCCs of the 3rd Cycle	No. of technological solutions	Criteria	Green	Yellow	Red
CCC-13: Make operational decisions based on building an understanding of the emergency and its evolution	14	Operational Value	9	3	2
		Solution Maturity	9	3	2
		Interoperability & Standards	9	5	0
	77	Operational Value	70	5	2

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CCC-14: Choose a strategical scenario of resolution, and distribute tactical decision-making		Solution Maturity	69	6	2
		Interoperability & Standards	72	5	0
CCC-15: Build a shared understanding of the scenario to synchronize decision-making	67	Operational Value	60	5	2
		Solution Maturity	59	6	2
		Interoperability & Standards	59	8	0
FCCC-16: Create certainty and shared vision of emergencies	31	Operational Value	26	5	0
		Solution Maturity	26	5	0
		Interoperability & Standards	29	2	0

Research and standardization solutions closely follow. Regarding standards and guidelines "*Decision Making Cycle*" is examined in the same way as is "*Incident Command Organization*". For both capabilities, Future Challenges are well covered from formal standards and widely adopted guidelines. The fact, that Future Challenges are well addressed by this type of solutions, inevitably affects even the CCCs of the same capability, that may have low numbers.

8.1.5 Risk Reduction and Preparedness

"*Preparedness*" and "*Risk Reduction*", are the capabilities least covered by technology. Emphasis should be given on "*Risk Reduction*" (CCC-17, CCC-18, FCCC-19 & FCCC-20), which has the lowest numbers. The fact, that CCC-17 "*Focus encouraging self-capacities and safety*", FCCC-19 "*Integrate risk prevention and safety into other policies and actors*" and FCCC-20 "*Focus on governance and integral risk management*" have such few solutions is not surprising. In deliverable D1.4 (Miralles *et al.*, 2021), a detailed description of the topics of these challenges is provided. The integration of disaster and risk management policies, as well as strategies, related to the self-protection of both practitioners and the population are topics not related to technological innovations. The same applies also for "*Preparedness*" (FCCC-20, CCC-21, FCCC-23 & FCCC-24). CCC-22 "*Plan in a more integral way*" and FCCC-23 "*Pre-plan interoperability and enhance synergies*". The latter is focused on the development of Standard Operating Procedures (SOPs) and the sharing of best practices between organizations, as is implied in deliverable D1.4 (Miralles *et al.*, 2021), while CCC-22 deals with the adoption of guidelines and best practices in the preparedness phase. The exact numbers of technologies addressing the challenges of these two capabilities are presented in the table below.

Table 25: Numbers of technological solutions addressing the challenges of "Risk Reduction" (CCC-17 to FCCC-20) and "Preparedness" (CCC-21 to FCCC-24).

CCCs / FCCCs of the 3rd Cycle	No. of technological solutions	Criteria	Green	Yellow	Red
CCC-17: Focus encouraging self-capacities and safety	1	Operational Value	1	0	0
		Solution Maturity	1	0	0
		Interoperability & Standards	1	0	0
CCC-18: Negotiate solutions with stake	69	Operational Value	55	13	1
		Solution Maturity	62	7	0

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holders for anticipated scenarios		Interoperability & Standards	43	26	0
FCCC-19: Integrate risk prevention and safety into other policies and actors	2	Operational Value	2	0	0
		Solution Maturity	2	0	0
		Interoperability & Standards	1	1	0
FCCC-20: Focus on governance and integral risk management	1	Operational Value	1	0	0
		Solution Maturity	1	0	0
		Interoperability & Standards	0	1	0
CCC-21: Pre-plan a time-efficient, safe response, minimizing responder's engagement	33	Operational Value	25	6	2
		Solution Maturity	28	3	2
		Interoperability & Standards	30	2	1
CCC-22: Plan in a more integral way	1	Operational Value	1	0	0
		Solution Maturity	1	0	0
		Interoperability & Standards	1	0	0
FCCC-23: Pre-plan interoperability and enhance synergies	9	Operational Value	6	3	0
		Solution Maturity	6	3	0
		Interoperability & Standards	7	2	0
FCCC-24: Focus on governance and integral risk management	87	Operational Value	75	9	3
		Solution Maturity	74	9	4
		Interoperability & Standards	80	6	1

Research and Standardization are domains, more appropriate to provide solutions, and this is something that can be confirmed, taking into consideration, that for both, there are many solutions screened. Another important issue is that both "*Preparedness*" and "*Risk Reduction*" are Capabilities, of the pre-disaster phase. They are both linked to prevention and preparedness, as the name of the former implies, and the significant level of coverage of "*Risk Reduction*" simultaneously implies that also "*Preparedness*" is a well-covered capability.

8.1.6 Overall conclusion and application of the TLS for all three types of solutions

In general, the standardization domain addresses, to a great extent, all capabilities. There are standards, either developed by national, EU and international standardization bodies or by private consortia, comprising of relevant experts e.g., the Open Geospatial Consortium (OGC) and the Organization for the Advancement of Structured Information Standards (OASIS), which are widely adopted by practitioners. The same applies to guidelines and best practices, developed by large organizations, such as FEMA and NATO, which are also used by first responders' organizations worldwide. The same applies to technology, with the exception of the "Risk Reduction" capability.

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On the opposite, there seems to be a lack of research, mainly in terms of projects, for the main Future Challenge, which is "Uncertainty", while the same would be also valid for the "Preparedness" capability.

On the contrary, "Community Involvement" is highly addressed by research, which seems to go hand in hand with technology, regardless the fact, that innovations, which actively involve the public are being constantly developed.

Having analysed the results, the application of the Traffic Light System to the matrix of the 3rd challenges is presented in Table 26 below.

Table 26: Application of the Traffic Light System to the Challenges of the third Cycle.

	High flow of effort in hostile environment (HF)	**High Impact, Low Frequency (HILOF)**	**Multiagency / Multileadership (ML)**	High level of uncertainty (UN)
Incident Command Organization	CCC-1. Organize to sustain safe operations	CCC-2. Anticipate and prioritize avoiding the collapse of the emergency system	CCC-3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency	FCCC-4. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency.
	T	T	T	T
	R	R	R	R
	S	S	S	S
Community involvement	CCC-5. Develop public self-protection and awareness	CCC-6. Involve communities and key stakeholders as active actors in risk management	FCCC-7. Negotiate the values with communities before the emergency	FCCC-8. Cultural change towards risk tolerance and resilience.
	T	T	T	T
	R	R	R	R
	S	S	S	S
Knowledge Cycle	CCC-9. Train specific roles and risks and invest in a robust knowledge cycle	FCCC-10. FRS empowered to innovate and build organizational learning	CCC-11. Build a shared understanding of the emergency, and train interagency scenarios	FCCC-12. Focus on capacity building towards more resilient societies
	T	T	T	T
	R	R	R	R
	S	S	S	S
Decision Making Cycle	CCC-13. Make operational decisions based on building an understanding of the emergency and its evolution	CCC-14. Choose a strategical scenario of resolution, and distribute tactical decision-making	CCC-15. Build a shared understanding of the scenario to synchronize decision-making	FCCC-16. Create certainty and shared vision of emergencies.
	T	T	T	T
	R	R	R	R
	S	S	S	S
Risk reduction	CCC-17. Focus encouraging self-capacities and safety	CCC-18. Negotiate solutions with stake holders for anticipated scenarios	FCCC-19. Integrate risk prevention and safety into other policies and actors	FCCC-20. Focus on governance and integral risk management.
	T	T	T	T
	R	R	R	R
	S	S	S	S

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	High flow of effort in hostile environment (HF)	High Impact, Low Frequency (HILOF)	Multiagency / Multileadership (ML)	High level of uncertainty (UN)
Preparedness	CCC-21. Pre-plan a time-efficient, safe response, minimizing responder's engagement	CCC-22. Plan in a more integral way	FCCC-23. Pre-plan interoperability and enhance synergies	FCCC-24. Focus on governance and integral risk management.
	T	T	T	T
	R	R	R	R
	S	S	S	S

These colours, as already stated above, are the outcomes of the application of the Traffic Light System. Criteria, upon which the TLS is built. These criteria are objective and check almost all relevant aspects, needed, in order to consider a solution "mature" according to TLS. Moreover, the point of view of the WP3 leader is included and taken into account for the final application of these colours. The examination of solutions and their colourisation has been carried out by WP3 leader, which is not only a research organization with experience in safety and security issues, but also a consulting body of practitioners' organizations and, additionally. Even so, in order to have most accurate outcomes, solutions need to be reviewed and rated by the first responders at a later stage. These solutions, whether they are research documents, standards or technological innovations, address first responders' challenges. Therefore, it is imperative, that this process has to be one of the core points of interest for Task 3.3 *"Development of the Strategic Research and Standardization Agenda (SRSA) and Policy Brief".*

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8.2. RfI main conclusions

Already, from the previous cycles of FIRE-IN it became evident that technologies do exist and the majority of the CCCs were either covered (green level) or at a development stage (yellow level). This was explicitly mentioned in the deliverable D3.3. (Sakkas et al., 2020) and visualized in Table 17 of D3.3. This table is also provided here in appendix A3.

Standards, related to the topics raised by the CCCs/FCCCs, may not be so many in numbers, but on the other hand, a standard can address several challenges or challenges that belong to the same capability. As it is pointed out in D3.3 (Sakkas et al., 2020) standardization can be a wide field for the future. Standards should get in more detail, providing guidelines for more specific problems. Similarly, research items do exist and have addressed most of the topics. Deliverables D2.3 and D2.4 clearly reveal this. And research somehow belongs to the "Knowledge Cycle" capability a cycle that is constantly updated.

During the 3rd cycle it became clear, that these two categories of solutions, technologies and standards, are important both from the solution providers' and practitioners' point of view. This is revealed from the answers that we received from the questionnaires and, of course, in the discussion and interaction between practitioners and technology providers during the workshop that was organized in the framework of the joint event of FIRE-IN and MEDEA.

Currently, many different types of technologies exist, as described in the previous sections. All these types of technologies are available products in the market, are constantly developing and new products enter the market every day.

The key influencing factors, that were revealed during the 3rd cycle of FIRE-IN, which affect all the solutions categories of FIRE-IN are summarized below. All these key factors are generally equally significant and, in order to "solve" the problem, we must pay attention to them, because they influence the relevance, the performance and the attractiveness of the solutions for the practitioners. If we do not keep in mind these influencing factors, the efforts to proposed new solutions, that can bridge the gaps and minimize the challenges, will be useless.

Data, data quality and proper sharing of the information. Data was, is and will be crucial for all phases of crisis/disaster management. To have the proper information, to the right people, at the right time, is crucial, especially for proper response. Moreover, this information, of any kind, must be reliable.

Openness in data, data formats and source codes is another topic. Open data boost research outcomes and make technologies to adapt more functionalities faster. Nevertheless, all these data must be valid, so filtering and validation, especially from open data, is extremely important as well. Open data formats and common data formats are important and helpful in exchanging and sharing of information between various sources. At the same time, open-source codes may help the transition from traditional tools to more high-tech tools. Nevertheless, issues such as credibility are extremely important in this case, as practitioners need credible and reliable software, hardware and materials built with high quality standards.

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Experience and training help to take the right decisions and filter the information. Practitioners must be trained frequently. From the questionnaires, it seems that most of the practitioners are trained to the equipment that they use and receive a recurring training. With the adoption of new technologies, receiving input, feedback and intelligence may become a difficult task by itself, becoming confusing and create similar problems as if the information was totally unknown. Too much of information can be even more confusing than little to even no information at all. Only through training and experience, practitioners can have the ability to filter properly the information received.

Isolation or fragmentation of technologies. As described earlier technologies are already available. The problem does not focuses on the existence of technologies but on how the various technologies and their integration is applied. For example, today a practitioner may have access to information from GIS systems, images from satellites and drones, alerts and warnings from various sensors installed, situational awareness systems, risk awareness with levels of risks, command and control centres that handle information but then the problem becomes two-fold. On one side is the amount of information that is received and, the on the other, which is not a "technical", but a policy issue as well, is the integration of all these types of technologies, machines and systems. Technologies must integrate within each other and be interoperable with old, legacy systems and new systems as well. The issue of integration is really important and it has been addressed. Currently, various projects deal with that, but the overall results are demonstrated in pilot cases usually, and more time is required to see it operationally applied in the field. Besides, time, other topics, are also important for new technology to be widely used. These issues can be issues of acceptance, permission, legal framework and support, as well as safety issues. Integrated solutions also exist but these are usually from individual suppliers and, usually, the solutions can "speak" to each other but not with other products from other suppliers. In general, Internet of Things and other new solutions try to address this problem but there is a long road ahead for this to become reliable and credible for operational purposes. Interoperability is a basic standardization topic.

Conservatism of practitioners to use new technologies. This is an issue that pointed out by technological suppliers. There is no simple and straight answer but this is something that must be taken into consideration for the future. What prevents practitioners to adapt solutions that are available? Procurement issues? Costs? Lack of information for a valuable technology? How friendly is a new system/technology to a practitioner? Trust to specific large suppliers? This conservatism may be in relation to the general access of practitioners to technologies and standards. Is it simply the costs and the procurements issues? Is it problems of bureaucracy inside first responders' organizations? Is it a problem on the high level/strategic level of first responders?

It was also identified that practitioners have a different perspective from solution providers on what they think will develop further in the future regarding technologies. It seems that practitioners do not follow technological progress when suppliers try to cover their needs. This is, without a doubt, an issue related to limited access to technologies and standards and possible conservatism. This could even be something simpler. As nowadays, in the high levels of hierarchy of practitioners there are people who grew up in different times without having too much technology and in our era, the overloading with new technologies may pose difficulties and credibility issues.

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Risk awareness is a key point to all the above. Another significant topic that was raised irrespective of technology was risk awareness. If, as a society, which includes both practitioners and citizens, we do not have a good understanding of the potential risks and threats, then many technological tools may be totally useless (or perceived as such). In order to save lives, we need, risk awareness, continuous and recurring training of both practitioners and citizens to technology and standards. Research is by no means excluded. On the contrary, research is a fundamental supportive pillar in all these activities, as it is closely related with risk awareness and technology.

Interoperability and standardization. Standards make things typical and common to everyone. Standards can cover technical topics, data and information exchange, procedures and planning, inside an organization or between organizations (cross-organization communication, planning and response), or even between nations (cross-border communication, planning and response). Standards are published either by official standardization organizations such as CEN, or by other associations, industry or first responders' driven. Even, in the form of guidelines, standardization is extremely important for practitioners. For practitioners, according to their answers from the questionnaires, both procedural and technical standards are important. The issue of practitioners' access to standards is important. A significant percentage does not use standards or is not aware if standards are used in their daily operations. Instead, practitioners do use standard operating procedures. This raises a broad domain for future. The transformation of various standard operating procedures to formal or widely accepted guidelines would also be a solving factor that would ensure a standard method across nations and even continents. Interoperability is solved only through standardization. Common data formats are a pure standardization topic either for formal or professional standards. Interoperability is the main key for an easy step to integration.

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8.3. Thematic Working Groups: Key points for the future

Based on the discussions and topics raised from the questionnaires, the workshops and in general the overall experience from FIRE-IN so far, a few main conclusions dedicated to each Thematic Working Group (TWG) are presented herein. Even though FIRE-IN is organized in five thematic working groups, the common ground between all the TWGs is an issue that affects all groups at the same time and is something that should also be considered in the Strategic Research and Standardization Agenda (SRSA) and policy briefs.

8.3.1 TWG-A "Search and Rescue Emergency Response"

TGW-A "Search & Rescue Emergency Response" is a horizontal TWG that is practically related to all the rest of TWGs. It has multiple challenges as any type of incident is a unique case and consequently a unique mission. Differentiations and different assumptions must be made, according to the type of incident that practitioners are called to respond to. The challenges are different in case of a car accident, a CBRNE incident, a mountain rescue, a house rescue due to a fire or a search and rescue due to an earthquake or a flash flood.

The first challenge that usually must be solved is that search and rescue is usually a crisis management topic inside another crisis/disaster management. Access to hostile environment is a usual case that requires the proper experience, training and equipment for the mission to be safely and successfully fulfilled. In many such cases, multi-leadership is also usual with a lack of shared command and control and common information sharing. Also, the issue of linking different urgencies at different scales is something usual for search and rescue. To pre-plan difficulties for search and rescue is an extremely difficult that can be based on experience, on multiple scenarios and specific guidelines and protocols for each scenario.

It is without a doubt that the low frequency of occurrence of specific events does not allow to learn from them frequently. This can only be overcome through continuous training. Community involvement and the engagement of local population is extremely crucial especially in cases on which resources are not adequate, and/or victims to save and handle are too many. Search and Rescue deals mainly with response but it is extremely crucial to be properly prepared. Efficient rescue comes only with proper training, equipment and coordination.

8.3.2 TWG-B "Structure Fires"

TWG-B "Structure Fires" tackles the mission of extinguishing, mitigating the risk of, preventing and protecting from fires involving any man-made building and structure.

Although this TWG has some aspects in common with the other groups, the fact, that it is related to indoor events, with rapid development and high risk for the exposed, some peculiarities are evident in the present and future capabilities that emerged during the three cycles.

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Based on discussions with practitioners and researchers during the workshops, the subsequent survey, and, most recently, the joint event with the MEDEA project, the CCCs that were mostly discussed are:

- CCC-1 "*Organize to sustain safe operations*"
- CCC-5 "*Develop public self-protection and awareness*"
- CCC-6 "*Involve communities and key stakeholders as active actors in risk management*"

Regarding the FCCCs, attention should be paid on the "IAFSS agenda 2030 for a fire safe world", in which it is stated, that research forecasts predict an increase in the population, which in turn, is expected to lead to societies, tending to concentrate in large cities with tall buildings to save territory.

In Europe, however, the population tends to decrease but, on the contrary, an increase in the elderly and overweight people is expected, with all consequent problems in the evacuation of people, who are not completely autonomous, in case of fire.

In addition, new energy, communication and construction technologies will bring new materials into the buildings with possible new risks in the event of a fire.

In view of this, participants in the third cycle of the project agreed that the FCCCs most characteristic of the issue of structure fires were as follows:

- FCCC-8 "*Cultural change towards risk tolerance and resilience*"
- FCCC-5 "*Focus on capacity building towards more resilient societies*"

The technologies/standards, that industry/researchers believe are key to achieving these goals include the development of performance-based design (PBD) and the development of technologies, that enable large-scale testing of new materials. Practitioners also assert that VR/AR development and the use of big data to share information about the structures and the various sensors, present among the various agencies, that use them, are the guiding tool to implement and sustain safe operations.

8.3.3 TWG-C "Landscape Fires Mitigation"

Countries well-accustomed to dealing with wildfires are being confronted with new extremes that are challenging contemporary suppression response systems, while countries less frequented by wildfires are confronted with signifcant limitations to their ability to respond to a hazard that, until now, has been rather benign. These extreme events, as we have witnessed in Portugal in 2017 and in Greece in 2018 and again widespread across the Mediterranean Basin in 2021, are overwhelming emergency response and evacuation systems and, more importantly, are highlighting critical failures in landscape management and peri-urban planning. An important and underexploited point is that people are integral to the health and resilience of these landscapes.

While FIRE-IN is aimed at the response community, it is nonetheless critical to point out that research, experts, and most practitioners acknowledge the requirement of proactively addressing the *drivers* of landscape fire challenges as many catastrophic fires result in damages and casualties because systems have reached their limits. Catastrophic fires are increasingly *rarely* controlled through response efforts,

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but primarily by a change in weather conditions and to a degree the available fuel. This notion is also supported through a recent expert survey conducted by TWG-C where only one third of respondents saw the potential for technology and innovation to have significant improvements on operational firefighting while two-thirds were either sceptical of "technological fixes" or saw advancing technology and innovation to play an important role, but with relatively limited room for improvement in operational wildland firefighting. Overall, the majority of respondents estimated technology and innovation to play an increasingly important role in better preparing for, preventing, and recovering from wildfires – but only when combined with social changes and economic investments in in proactive, integrated fire management.

In sum, as is consistent with the discussions in this document, most challenges could be considered as covered by solutions, but because landscape fires are complex interconnected and 'scaled' events there remain many coverage gaps in reality and more importantly changes in investment, social changes, and the landscape-level efforts resulting in more resilience and are much less addressed by the evaluated solutions – but are consistently highlighted by experts and practitioners through surveys and workshops. Once again these include:

Table 27: Top eight Challenges identified in cycle 1 and 2 for TWG-C

Uncertainty (low-frequency high-impact events)
Spending / funding allocation
Interoperability
Planning
Applied science/ knowledge
Rural exodus
Community awareness and safety
Decision-maker awareness

Table 28: Top six standardization items for TWG-C

Interoperability standards for firefighting aerial resources shared across borders
Standardized emergency information dissemination systems (e.g., especially for evacuation procedures/signage; standardization of signs and symbols aimed at overcoming language barriers such as in the case of tourists)
Standardized emergency incident management structure for unified / joint command (i.e., for multi-agency / multi-country incident response)
Standardization of maps and symbols and mapping of important landmarks/resources, vegetation types etc. (also relevant for the planning of resilient landscapes)
Standardization of criteria for the development of fire weather indices; and for a landscape fire classification system (e.g., fire/incident typology).
National coordination and interoperability in landscape fire management at (a) inter-agency and (b) between States / Regions (NUTS 1) as well as European / international cross-border interoperability in landscape fire crisis mitigation (during crisis) between Member States / countries.

Table 29: Top themes expressed in terms of current /expected challenges and required approaches.

Command and control structures must be harmonized at national level before cross-border aid can be effectively rendered; sometimes reach their limit and do not serve first responders
Competency-based training and technical standardization extremely important

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Current and expected trends in extreme fire behavior and high-level of uncertainty plus high impact matrix requires new proactive broadscale approaches- not present reactionary response
Risk perception and community engagement must greatly expand to meet oncoming challenges – a culture of reliance on first responders cannot continue; a greater commitment to prevention work must be established
Self-protection is important emerging discussion: people, houses, infrastructure, and surrounding landscapes need to be equipped or designed to also withstand fire; issue of shelter in place
Landscape level changes need to be invested in – from a greater understanding and application of fire ecology, to grazing practices, to soil, water, and fuel management
Limitations plus overreliance on water supply and emerging challenge- especially outside Mediterranean area
Limitations of current models – the fire behavior we are seeing today defy many of the prediction tools we have; our tools we have today is based on older science; today's management approaches need to be based on projected future conditions (e.g., climate change)
Prescribed burning efforts are near-trivial compared to the required scale to reach objectives at landscape level; fire-use programs need big expansion and to meet more objectives simultaneously – for instance as hands-on training for firefighters

In this respect, taken the above challenges, the most relevant CCCs and FCCCs are expressed above, however it should be noted that several key concerns were not addressed by the evaluated solutions, such as for instance:

- Solutions that addressed over-dependence on water and or low-water solutions (excluding suppressants and retardants)
- Solutions to scale up prescribed burning efforts
- Solutions for better citizen awareness and self-protection
- Solutions for basic/competency-based wildfire training (particularly in newly fire-prone countries) such as e-learning platforms or basic training standards in different languages
- Solutions which integrate fuel mapping with risk parameters and planning tools.

8.3.4 TWG-D "Natural Hazard Mitigation"

An appropriate response to a disaster situation and to the mitigation of the consequences is based on (local) capacities and available resources. If responsibilities, decision-making processes, and coordination structures are not sufficiently clarified, disaster management may fail, despite the available resources and capabilities. Therefore, standardization is an extremely important aspect. This was confirmed both in the surveys and in the discussions at the workshop, as pointed out.

Response is a very complex part of emergency management because it typically takes place in high-stress situations, under intense time pressure, and with limited information. Through standardization and new techniques disaster management becomes considerably more professional.

The pillar of professional, efficient operational disaster risk management is a qualified and well-prepared personnel. Information about the targets of the organization and concepts must be conveyed. The organizational structure, communication hierarchies, responsibilities, and decision-making competencies must be explicitly defined and communicated. Therefore, the procedures and

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regulations should be more standardized. This also helps the call for a more integrated pathway as requested during the workshops by both industry and practitioners:

CCC14 – "*Choose a strategical scenario of resolution, and distribute tactical decision-making*"

FCCC7 – "*Negotiate the values with communities before the emergency*".

But disaster plans are based on assumptions and a lot can change until a disaster occurs. No plan, no matter how good it is researched and written, can ever fully prepare a community for a disaster. Therefore, the best way for a community to prepare, is to have well-trained disaster response teams. These points appeared also in the surveys and in the workshop. The importance of prevention and preparation was emphasized several times, as well as the response capabilities. For example, risk awareness is crucial for both citizens and practitioners as well as training. Risk understanding makes things easier in terms of planning based on probabilities and assumptions and with proper training, the elements at risk, people, are capable to adapt and respond more efficiently. Linking industry and end users as FIRE-IN strives to do on its formats, helps to adapt new developments to actual needs and at the same time informs response organizations about new technologies.

In addition, the following CCCs/FCCCs are also important:

- CCC-5 "*Develop public self-protection and awareness*"
- FCCC-8 "*Cultural change towards risk tolerance and resilience*"

8.3.5 TWG-E "CBRNE"

Regarding the most important CCCs, CCC2 "Anticipate and prioritize avoiding the collapse of the emergency system" and CCC4 "Develop public self-protection and awareness" were identified by the participants. Moreover, the need for improvement of the resilience of first responders was expressed.

For the FCCCs, FCCC2 "Negotiate the values with communities before the emergency" and FCCC3 "Cultural change towards risk tolerance and resilience" seem to be the most important to be addressed in the future, according to the participants. The resilience of population is generally a highlight for the workshop. In addition, participants identified the resilience of tools and ICT systems as a further challenge, needed to be addressed, especially by the technology domain.

AI and GIS software are among the most essential technologies for the practitioners. Rapid damage assessment tools and unmanned vehicles are also prioritized. Furthermore, standardization and certification is the key to high-quality and interoperable systems, that will greatly facilitate operations.

The need to improve the resilience of the population as a key priority for CBRNE, especially because a lot of chemical and hazardous substances can be obtained easily by potential terrorists or malevolent groups. Indeed, we can remember the attack of the Christmas market in Berlin on December 19, 2016, where a terrorist drove a truck into the crowd, killing 12 people and injuring about 100. The truck was used to harm people, but it could have been more severe with hazardous material, if the truck would

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have been a hazmat truck. It is necessary to raise awareness among the population, companies, at every level to increase vigilance and resilience.

Another priority is the "Effective resilience of the ICT and tools for fire & rescue services". Indeed, fire and rescues services are the last barrier (layer of protection) to save people and protect the environment. They have to rely on their technology to perform their mission and therefore guarantee their resilience too. It is necessary to have robust ICT and tools, that should not be affected in case of accident or attack.

Then, during the discussion we mentioned the need to facilitate the market uptake of new and performing technologies. It is necessary to inform the procurers and the end-users about the characteristics and the performance of the technologies and solutions to be purchased. It was recommended to define standard with test protocol for equipment and technology, that shall enable testing with objective criteria by independent labs and to compare the performance of equipment or solutions having the same function. These standards would effectively enable the identification of the efficiency of the solutions and support the market uptake as the procurers might refer to the expected characteristics and performance according to these standards. This would be in particular useful for sensors, detectors and for robot technologies in hostile environment.

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10. Appendix

10.1. Appendix A1 - 1st cycle CCCs matrix

Table 30: Common Capability Challenges / Sendai framework and IFAFRI. Sendai XX refers to articles of the Sendai framework and IFAFRI X refers to one of the four IFAFRI challenges. More information on CCCs of the 1st cycle can be found in Deliverable D1.2 and in the FIRE-IN website.

	High Flow of effort in hostile environment	**Low frequency, high impact events**	**Multi-agency/multi-leadership environment**	**High level of uncertainty**
Incident Command Organization	Focus on sustainability of safe operations	Prioritize the reduction of vulnerability and increase interactions with the public. **Sendai 7, 19, 33**	Distribute decision-making	Strategies choosing safe scenarios, and maintaining credibility
Pre-planning	Pre-plan a time efficient, safe response. **Sendai 6, 8, 19, 24, 27, 33, 34**	Negotiate solutions with stakeholders for anticipated scenarios. **Sendai 6, 7, 19, 24, 27, 33**	Plan interoperability and enhance synergies. **Sendai 8, 19, 34**	Focus on governance and capacity building towards more resilient societies. **Sendai 7, 24, 33**
Guidance instruments	Establish procedures and guides. **Sendai 34**	Standardize capabilities in front of pre-established scenarios. **Sendai 34**	Establish an interagency framework. **Sendai 8, 19, 34**	Build doctrine for resilience in emergency services and societies.
Knowledge Cycle	Train specific roles	Learn about possible scenarios focusing efforts in key risks and opportunities. **Sendai 24.**	Build a shared understanding of emergency and train interagency scenarios. **Sendai 8, 19, 24, 33, 34.**	Focus on integral risk management. Sendai 33
Information management	Information cycle. **Sendai 24 IFAFRI 4**	Manage key information focused on decision-making **IFAFRI 4**	Define common information management processes between agencies. **Sendai 19, 24**	Provide an efficient, flexible flow of information for a shared understanding
Community Involvement	Develop public self-protection to minimize responders exposures **Sendai 27, 33**	Prepare population for the worst scenario before it happens. **Sendai 7, 24, 25, 33**		Cultural changes in risk tolerance and resilience **Sendai 7, 19, 24, 33**
Technology	Use technology to assess risks and minimize responder's engagement **IFAFRI 1, 2, 3**	Simulate complex scenarios **IFAFRI 4**	Technological tools to support data sharing	Get a clear picture of the risk evolution **IFAFRI 1**

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10.2. Appendix A2 - 2nd cycle PCCCs

Table 31: The list of prioritized concerns as it emerged from the cross analysis of capabilities and challenges during the 2nd cycle (source deliverable D1.3).

Nr	Description	Topic	Magnitude of importance for experts
1	Train/educate/inform general population starting from scratch and in a basic and easy way, about knowledge of risk and appropriate behaviours, specially targeting those more exposed and vulnerable. Address all phases of emergency and the different levels of risk. Provide tools to facilitate adequate decision-making: checklists, emergency kits …	Community involvement	13
2	Technologies used in interventions should be: • Useful. • Simple, intuitive and easy to use. • Easy to integrate and interoperable. • Easy to transport, deployable on field, light, with high autonomy. • Robust, resistant, long duration, able to tolerate severe/harsh conditions. • Open access. • Usable by people with disabilities	Technology	8
3	Change of paradigm. From 'We, authorities, will protect you' to 'You, citizen, should be actively involved'. These affirmations mean that you should be prepared to be self-sufficient concerning to your own protection and your community protection always inside the framework of the emergency. Be used to this sort of situations normalizing them.	Community involvement	7
4	Build trust involving communities and key stakeholders in risk management permanently: from risk awareness to the preparation of scenarios, to the decisions and behaviour during the emergency, to verifications, to drills and exercises.	Community involvement	7
5	Once the standard roles of different actors have been trained and drilled inside each agency, organize multiagency joint trainings and exercises with the focus on decision-making, coordination and interactions between agents. Train in overlapped competences and limits of competences. Train the trainers of the different agencies. Share on-line training and exercises.	Knowledge cycle	7
6	Identify points of coordination in the different zones: from local (hot zone, warm zone ...) to regional and to national. Establish different levels of liaison officers, translators; communication; entrance points; and infrastructures as needed.	Incident Command Organization	6
7	Prioritise response and resources allocation to avoid the collapse of the emergency response system: triage, build alternative scenario, identify trigger points…	Incident Command Organization	5
8	Base the prediction of scenarios on historical events and on statistics (baseline), including the modelling of the actual conditions (at local level) and human factors.	Pre-planning	4
9	Maintain situation awareness. Avoid the loss of information with shifts' changes.	Incident Command Organization	4

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Nr	Description	Topic	Magnitude of importance for experts
10	Adapt the legal framework and requirements on prevention and self-protection of infrastructures and activities to first responders' needs, lessons learned from past events... Plan the implementation of laws and plans. Adapt the regulations to emergency situations.	Guidance instruments and standards	3
11	Towards a complete cycle of knowledge. Adjust Standard Operational Procedures (SOPs), doctrine and pre-plans using the feedback from real incidents and from exercises testing them (evaluators, assessors, statistics…) and identify the main gaps to focus efforts in training, procedures, personnel and equipment. Evidence based on fire scenarios. The process learning of an organization goes through the identification of own 'best practices' and the external ones: • to collect experiences and convert them into guides, • to collect 'lessons learned' and transform the best points into protocols, • to share experiences with the aim of generating standards.	Knowledge cycle	3
12	Be prepared to provide massive alerts to population	Community involvement	3

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10.3. APPENDIX A3 - Application of the TLS to the PCCCs of the second cycle

Table 32: TLS for the prioritised CCCs, based on technological solutions, screened in the second cycle of WP2 (source deliverable D3.3 – Sakkas et al., 2020).

PCCC	CCCs 2nd Cycle
1	Train/educate/inform general population starting from scratch and in a basic and easy way, about knowledge of risk and appropriate behaviours, specially targeting those more exposed and vulnerable. Address all phases of emergency and the different levels of risk. Provide tools to facilitate adequate decision-making: checklists, emergency kits …
3	Change of paradigm. From 'We, authorities, will protect you' to 'You, citizen, should be actively involved'. These affirmations mean that you should be prepared to be self-sufficient concerning to your own protection and your community protection always inside the framework of the emergency. Be used to this sort of situations normalizing them.
4	Build trust involving communities and key stakeholders in risk management permanently: from risk awareness to the preparation of scenarios, to the decisions and behaviour during the emergency, to verifications, to drills and exercises.
5	Once the standard roles of different actors have been trained and drilled inside each agency, organize multiagency joint trainings and exercises with the focus on decision-making, coordination and interactions between agents. Train in overlapped competences and limits of competences. Train the trainers of the different agencies. Share on-line training and exercises.
6	Identify points of coordination in the different zones: from local (hot zone, warm zone ...) to regional and to national. Establish different levels of liaison officers, translators; communication; entrance points; and infrastructures as needed.
7	Prioritise response and resources allocation to avoid the collapse of the emergency response system: triage, build alternative scenario, identify trigger points…
8	Base the prediction of scenarios on historical events and on statistics (baseline), including the modelling of the actual conditions (at local level) and human factors.
9	Maintain situation awareness. Avoid the loss of information with shifts' changes.
11	Towards a complete cycle of knowledge. Adjust Standard Operational Procedures (SOPs), doctrine and pre-plans using the feedback from real incidents and from exercises testing them (evaluators, assessors, statistics…) and identify the main gaps to focus efforts in training, procedures, personnel and equipment. Evidence based on fire scenarios. The process learning of an organization goes through the identification of own 'best practices' and the external ones: • to collect experiences and convert them into guides, • to collect 'lessons learned' and transform the best points into protocols, • to share experiences with the aim of generating standards.
12	Be prepared to provide massive alerts to population

Table 33: TLS for the prioritised CCCs, based on research solutions (source deliverable D3.3 – Sakkas et al., 2020).

Prioritized CCC
CCC1: Train/educate/inform general population starting from scratch and in a basic and easy way, about knowledge of risk and appropriate behaviours, specially targeting those more exposed and vulnerable. Address all phases of emergency and the different levels of risk. Provide tools to facilitate adequate decision-making: checklists, emergency kits …
CCC3: Change of paradigm. From 'We, authorities, will protect you' to 'You, citizen, should be actively involved'. These affirmations mean that you should be prepared to be self-sufficient concerning to your own protection and your community protection always inside the framework of the emergency. Be used to this sort of situations normalizing them.

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Prioritized CCC
CCC4: Build trust involving communities and key stakeholders in risk management permanently: from risk awareness to the preparation of scenarios, to the decisions and behaviour during the emergency, to verifications, to drills and exercises.
CCC5: Once the standard roles of different actors have been trained and drilled inside each agency, organize multiagency joint trainings and exercises with the focus on decision-making, coordination and interactions between agents. Train in overlapped competences and limits of competences. Train the trainers of the different agencies. Share on-line training and exercises.
CCC6: Identify points of coordination in the different zones: from local (hot zone, warm zone ...) to regional and to national. Establish different levels of liaison officers, translators; communication; entrance points; and infrastructures as needed.
CCC7: Prioritise response and resources allocation to avoid the collapse of the emergency response system: triage, build alternative scenario, identify trigger points…
CCC8: Base the prediction of scenarios on historical events and on statistics (baseline), including the modelling of the actual conditions (at local level) and human factors.
CCC9: Maintain situation awareness. Avoid the loss of information with shifts' changes.
CCC11: Towards a complete cycle of knowledge. Adjust Standard Operational Procedures (SOPs), doctrine and pre-plans using the feedback from real incidents and from exercises testing them (evaluators, assessors, statistics…) and identify the main gaps to focus efforts in training, procedures, personnel and equipment. Evidence based on fire scenarios. The process learning of an organization goes through the identification of own 'best practices' and the external ones: • to collect experiences and convert them into guides, • to collect 'lessons learned' and transform the best points into protocols, • to share experiences with the aim of generating standards.
CCC12: Be prepared to provide massive alerts to population

Table 34: TLS for the prioritised CCCs, based on standardization solutions (source: deliverable D3.3 – Sakkas et al., 2020).

Prioritized CCC
CCC1: Train/educate/inform general population starting from scratch and in a basic and easy way, about knowledge of risk and appropriate behaviours, specially targeting those more exposed and vulnerable. Address all phases of emergency and the different levels of risk. Provide tools to facilitate adequate decision-making: checklists, emergency kits …
CCC3: Change of paradigm. From 'We, authorities, will protect you' to 'You, citizen, should be actively involved'. These affirmations mean that you should be prepared to be self-sufficient concerning to your own protection and your community protection always inside the framework of the emergency. Be used to this sort of situations normalizing them.
CCC4: Build trust involving communities and key stakeholders in risk management permanently: from risk awareness to the preparation of scenarios, to the decisions and behaviour during the emergency, to verifications, to drills and exercises.
CCC5: Once the standard roles of different actors have been trained and drilled inside each agency, organize multiagency joint trainings and exercises with the focus on decision-making, coordination and interactions between agents. Train in overlapped competences and limits of competences. Train the trainers of the different agencies. Share on-line training and exercises.
CCC6: Identify points of coordination in the different zones: from local (hot zone, warm zone ...) to regional and to national. Establish different levels of liaison officers, translators; communication; entrance points; and infrastructures as needed.
CCC7: Prioritise response and resources allocation to avoid the collapse of the emergency response system: triage, build alternative scenario, identify trigger points…
CCC8: Base the prediction of scenarios on historical events and on statistics (baseline), including the modelling of the actual conditions (at local level) and human factors.
CCC9: Maintain situation awareness. Avoid the loss of information with shifts' changes.
CCC11: Towards a complete cycle of knowledge. Adjust Standard Operational Procedures (SOPs), doctrine and pre-plans using the feedback from real incidents and from exercises testing them (evaluators, assessors, statistics…) and identify the main gaps to focus efforts in training, procedures, personnel and equipment. Evidence based on fire scenarios. The process learning of an organization goes through the identification of own 'best practices' and the external ones: • to collect experiences and convert them into guides, • to collect 'lessons learned' and transform the best points into protocols, • to share experiences with the aim of generating standards.
CCC12: Be prepared to provide massive alerts to population

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10.4. APPENDIX A5 – "Request for Ideas from Technology Providers" Questionnaire

The FIRE-IN project is an initiative funded by the European Commission and initiated on the 1st of May 2017. 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. The project is divided in five thematic areas, the Thematic Working Groups (TWGs):

- Search & Rescue Emergency Response
- Structure Fires
- Landscape Fires
- Natural Hazard
- CBRNE

In workshops, organized in the framework of the project, practitioners held conversations regarding the current state of the Fire & Rescue domain, existing and future gaps in disaster management, that first responders are likely to confront, as well as, the increasing complexity of disasters and crises. The output of these practitioners' interactions was the identification of 24 capability challenges. These challenges are practically areas, that need to be addressed and covered, with the ultimate goal being to enhance the capacity of first responders. They are called Common Capability Challenges (CCCs), while those, that, according to the practitioners, will continue to raise discussions in the future, are the Future Common Capability Challenges (FCCCs).
Policies, research projects and papers, best practices, standards, and technological innovations can provide solutions and address these challenges, thus greatly facilitating and strengthening, not only the capabilities of first responders' organizations, but also disaster management as a whole.
The purpose of this questionnaire is to gather feedback from, mainly, technological providers, regarding their view, about the CCCs-FCCCs, their expectations for future developments and how and to what extent these challenges will be addressed by the technology domain in the future.

Q1. In which category of the following does your organization belong to? *(please select only one)*

○	Large Industry
○	Small Medium Enterprise
○	Research, Technology Organization

Q2. Does your organization develop hardware, software or provide services? (*you can select multiple answers)*

☐	Hardware
☐	Software
☐	Services
☐	All of the above

Q3. What type(s) of technologies does your organization develop? (*you can select multiple answers)*

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☐	Smart textiles and personal protective equipment
☐	Aircrafts for firefighting
☐	Technologies for resilient communications in hostile environments
☐	GIS applications and geolocation technologies
☐	AR/VR software for simulations and training
☐	Crowdsourcing applications for mass notifications and alerts
☐	Sensors for indoor detection of fire/smoke/embers
☐	Sensors for outdoor detection of fire/smoke/embers
☐	Command and Control systems
☐	Applications for remote disease diagnosis and healthcare
☐	Weather forecasting applications
☐	Fire propagation models
☐	Applications for the management of volunteers
☐	Big data analysis
☐	Artificial Intelligence
☐	Sensors for early detection of dangerous CBRNE agents
☐	Sensors for early detection of dangerous CBRNE agents
☐	Hazard and risk assessment technologies
☐	Unmanned Vehicles (Aerial and/or Ground)
☐	Early warning technologies
☐	Other answer

Q4. Which of the following Thematic Working Group(s) do you consider as the most relevant to your organization/products, taking into account your area of expertise? *(you can select multiple answers)*

☐	Search & Rescue Emergency Response
☐	Structure Fires

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☐	Landscape Fires
☐	Natural Hazard
☐	CBRNE
☐	All of the above
☐	None of the above

Q5. In your opinion, and taking into consideration existing technological solutions, to what extent can the technology domain, in general, address the four phases of disaster management?

	Not at all	A little	Quite	Much	Very much
Prevention	○	○	○	○	○
Preparedness	○	○	○	○	○
Response	○	○	○	○	○
Recovery	○	○	○	○	○

Q6. Based on the technologies produced by your organization, which domain of disaster management do these solutions mostly address? (you can select up to two answers)

☐	Prevention (e.g. Risk assessment)
☐	Preparedness (e.g. early warning, training etc.)
☐	Response (e.g. personal protective equipment)
☐	Recovery
☐	All the above

Q7. Which of the Common Capability Challenges (CCCs) do you consider, that technologies, developed by your organization, address? (*you can select multiple answers*)

☐	1. Organize to sustain safe operations
☐	2. Anticipate and prioritize avoiding the collapse of the emergency system
☐	3. Build interoperability for a distributed decision-making based on a shared understanding of the emergency
☐	4. Develop public self-protection and awareness
☐	5. Involve communities and key stakeholders as active actors in risk management
☐	6. Train specific roles and risks and invest in a robust knowledge cycle

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☐	7. Build a shared understanding of the emergency, and train interagency scenarios
☐	8. Make operational decisions based on building an understanding of the emergency and its evolution
☐	9. Choose a strategical scenario of resolution, and distribute tactical decision-making
☐	10. Build a shared understanding of the scenario to synchronize decision-making
☐	11. Focus encouraging self-capacities and safety
☐	12. Negotiate solutions with stake holders for anticipated scenarios
☐	13. Pre-plan a time-efficient, safe response, minimizing responder's engagement
☐	14. Plan in a more integral way

Q8. Do you believe that there are other CCCs, apart from the ones you have already selected in question no. 7, which could be addressed by technologies, produced by your organization, in the future? *(please indicate number of challenge and elaborate)*

Q9. Which of the Future Common Capability Challenges (FCCCs) do you consider, that technologies, developed by your organization, address? *(you can select multiple answers)*

☐	1. Strategic management focused on proactively reducing sources of uncertainty and building robustness and resiliency
☐	2. Negotiate the values with communities before the emergency
☐	3. Cultural change towards risk tolerance and resilience
☐	4. FRS empowered to innovate and build organizational learning
☐	5. Focus on capacity building towards more resilient societies

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☐	6. Create certainty and shared vision of emergencies
☐	7. Integrate risk prevention and safety into other policies and actors
☐	8. Focus on governance and integral risk management
☐	9. Pre-plan interoperability and enhance synergies
☐	10. Focus on governance and integral risk management

Q10. Do you believe that there are other FCCs, apart from the ones you have already selected in question no. 9, which could be addressed by technologies, produced by your organization, in the future? *(please indicate number of challenge and elaborate)*

Q11. What are the technological trends in your area of expertise? What types of technologies are expected to be developed in the future?

Q12. Does your organization develop technologies based on formal standards, produced by national (e.g. DIN, BSI), EU (e.g. CEN, CLC), or international (e.g. ISO, IEC, ITU) standardization bodies ?

○	Yes
○	No
○	Not aware

Q13. Does your organization develop technologies based on standards, influenced by industrial consortia, such as OGC, OASIS etc. ?

○	Yes
○	No
○	Not aware

Q14. Do technology providers prefer the adoption of technical standards?

○	Yes
○	No
○	Not aware

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Q15. Please explain your answer in the previous question.

Q16. In your opinion, do standards pave the way for innovation or do they pose problems and constraints?

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10.5. APPENDIX A6 – “Technology and Standards from the Practitioners’ point of view” Questionnaire

The FIRE-IN project is an initiative funded by the European Commission and initiated on the 1st of May 2017. 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. The project is divided in five thematic areas, the Thematic Working Groups (TWGs):

- Search & Rescue Emergency Response
- Structure Fires
- Landscape Fires
- Natural Hazard
- CBRNE

In workshops, organized in the framework of the project, practitioners held conversations regarding the current state of the Fire & Rescue domain, existing and future gaps in disaster management, that first responders are likely to confront, as well as the increasing complexity of disasters and crises. The output of these practitioners' interactions was the identification of 24 capability challenges. These challenges are practically areas, that need to be addressed and covered, with the ultimate goal being to enhance the capacity of first responders. They are called Common Capability Challenges (CCCs), while those, that, according to the practitioners, will continue to raise discussions in the future, are the Future Common Capability Challenges (FCCCs).

Policies, research projects and papers, best practices, standards, and technological innovations can provide solutions and address these challenges, thus greatly facilitating and strengthening, not only the capabilities of first responders' organizations, but also disaster management as a whole. The purpose of this questionnaire is to gather feedback from practitioners regarding their view, about technology and standards, how and to what extend these two domains can facilitate disaster management and enhance the capacity of first responders' organizations.

Q1. What is your occupational relationship with the organization you are working for?

○	Professional
○	Volunteering

Q2. If the answer to the previous question is "Volunteering", please specify your monthly employment.

○	Less than 30 hours per month
○	More than 30 hours per month

Q3. In which of the following Thematic Working Group(s) does your organization belong to? (you can select up to two answers)

☐	Search & Rescue Emergency Response

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☐	Structure Fires
☐	Landscape Fires Mitigation
☐	Natural Hazard Mitigation
☐	CBRNE
☐	All of the above
☐	None of the above

Q4. In your opinion, in which of the following types of technologies do you expect further developments and advancements? (you can select multiple answers)

☐	Smart textiles and personal protective equipment
☐	Aircrafts for firefighting
☐	Technologies for resilient communications in hostile environments
☐	GIS applications and geolocation technologies
☐	AR/VR software for simulations and training
☐	Crowdsourcing applications for mass notifications and alerts
☐	Sensors for indoor detection of fire/smoke/embers
☐	Sensors for outdoor detection of fire/smoke/embers
☐	Command and Control systems
☐	Applications for remote disease diagnosis and healthcare
☐	Weather forecasting applications
☐	Fire propagation models
☐	Applications for the management of volunteers
☐	Big data analysis
☐	Artificial Intelligence
☐	Sensors for early detection of dangerous CBRNE agents
☐	Hazard and risk assessment technologies
☐	Unmanned Vehicles (Aerial and/or Ground)

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Q5. As far as you are aware of, to what extent each of the four phases of disaster management is covered by technology?

	Not at all	A little	Quite	Much	Very much
Prevention	○	○	○	○	○
Preparedness	○	○	○	○	○
Response	○	○	○	○	○
Recovery	○	○	○	○	○

Q6. In your opinion, does technology enhance the capacity of first responders' organizations?

○	Yes
○	No
○	Not aware

Q7. Please, briefly explain your answer to the previous question.

Q8. Do you consider yourself adequately trained to the technologies, which are used by your organization?

○	Yes
○	No

Q9. Does your organization involve initial and/or recurrent training to state-of-the-art technologies?

○	Both
○	Recurrent
○	None
○	Initial

Q10. In your opinion, do standardization activities enhance the capacity of first responders' organizations?

○	Yes
○	No
○	Not aware

Q11. Please, briefly explain your answer to the previous question.

Q12. As far as you are aware of, to what extent each of the four phases of disaster management is covered by standardization activities?

	Not at all	A little	Quite	Much	Very much
Prevention	◯	◯	◯	◯	◯
Preparedness	◯	◯	◯	◯	◯
Response	◯	◯	◯	◯	◯
Recovery	◯	◯	◯	◯	◯

Q13. To what extent do you consider yourself aware of the use of procedural and technological standards?

	Not at all	A little	Quite	Much	Very much
Procedural standards	◯	◯	◯	◯	◯
Technical standards	◯	◯	◯	◯	◯

Q14. To what extent are standards adopted and incorporated in operational procedures of your organization?

	Not at all	A little	Quite	Much	Very much
Procedural standards	◯	◯	◯	◯	◯
Technical standards	◯	◯	◯	◯	◯

Q15. Do you consider technical standards (those that facilitate interoperability between systems, devices, software) or procedural standards (those, that promote interoperability between agencies) as more essential in everyday operations?

◯	Technical Standards
◯	Procedural Standards
◯	Both
◯	Not aware

Q16. Do standards enable more effective and timely operations?

◯	Yes
◯	No
◯	Not aware

Q17. Does your organization make use of formal standards (ISO, CEN, DIN ETC.) for everyday operations?

◯	Yes
◯	No
◯	Not aware

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Q18. Does your organization make use of widely accepted SOPs and best practices, e.g. INSARRAG?

○	Yes
○	No
○	Not aware

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10.6. APPENDIX A7 – RDI Day Invitation

This project has received funding from the European Union's Horizon 2020 Coordination and Support Action programme under grant agreement No 740575.

10.7. APPENDIX A8 – Organizations of practitioners and technology providers, which attended the RDI Day event

Table 35: List of organizations representatives of which took part in the joint event between MEDEA and FIRE-IN, on the 18th of January 2022

No.	Name of the organization
1	ACCELIGENCE LTD
2	ADDITESS | Advanced Integrated Technology Solutions & Services
3	AeroMind sp. z o.o. sp. k
4	BAVARIAN RED CROSS
5	BUILDAIR BARCELONA
6	ČAHD – Česká asociace hasičských důstojníků
7	CEIT | MENBER OF BASQUE RESEARCH $ TECHNOLOGY ALLIANCE
8	Civil Defence - Ministry of Interior Cyprus
9	Corpo Nazionale dei Vigili del Fuoco - CNVVF
10	COUNCIL OF THE BALTIC SEA STATES
11	CRISPRO
12	DIPUTATION OF AVILA
13	EDGE in Earth Observation Sciences
14	ENEA |Italian National Agency for New Technologies, Energy and Sustainable Economic Development
15	Escola Nacional de Bombeiros
16	European Fire Sprinkler Network
17	European Organization for Security (EOS)
18	Expert.ai
19	FIBRAN GREECE
20	Fire Rescue Service of the Czech Republic – FRS CR
21	Fraunhofer INT
22	Gencat.cat
23	GEOLSemantics
24	Global Smart Rescue
25	GMV Innovation Solutions
26	Hulpverleningszone Noord-Limburg
27	INERIS DEVELOPPEMENT
28	INFALIA
29	Inforest Research o.c.
30	Intaero Ltd
31	Center for Security Studies (KEMEA)
32	Laurea University of Applied Sciences
33	LEBANON REFORESTATION INITIATIVE
34	Madrid City Council
35	MINISTERE DE L'INTERIEUR
36	Ministry for Climate Crisis and Civil Protection

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No.	Name of the organization
37	Ministry Of Defence Of Georgia
38	National Headquarters of the State Fire Service of Poland
39	navarra.es |La información, servicios y trámites del Gobierno de Navarra
40	NOI Techpark South Tyrol in Bolzano
41	OMIKRON Consultants SA
42	Orange S.A.
43	Pau Costa Foundation
44	Pegaso Telematic University - Headquarters
45	Physical Safety Institute (IFV)
46	Practicioners Network for EUROPEAN Development COOPERATION
47	Priority 1 Air Rescue Operations SART/TAC
48	PROJECTON TECHNOLOGY
49	PSTECH
50	Public Policy Consulting Firm | DMI Associates
51	REGIONE PIEMONTE
52	SAFE CLUSTER
53	SAPIEZA UNIVERSITA DI ROMA
54	SatCen - European Union Satellite Centre
55	Scientific and Research Centre for Fire Protection – National Research Institute (CNBOP)
56	SDIS13
57	Serco Group Plc
58	SIGNALERT
59	Solar Impulse Foundation
60	STME FIRE
61	Szkoła Główna Służby Pożarniczej (Main School of Fire Service)
62	Technisches Hilfswerk
63	TH FINNISH NATIONAL RESCUE ASSOSIATION | SPEK
64	The Institute of Communication and Computer Systems (ICCS)
65	THE JAMES HUTTON INSTITUTE
66	UNIVERSITY OF ALCALA MADRID
67	UNIVERSITY OF GREENWICH
68	VALABRE
69	Vallfirest Tecnologías Forestales
70	Vogt-CTE
71	VOST PORTUGAL
72	VWORLD

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10.8. APPENDIX A9 – Solutions of the e-FIRE-IN platform

Table 36: All Research (publications, projects) solutions uploaded to the e-FIRE-IN platform. The colour denotes the traffic light system colour according to WP3 leader assessment.

No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
1	Rôle et missions des conseillers techniques zonaux dans l'organization des entraînements pour faire face aux menaces NRBCE	Notre travail s'intéresse à la place du conseiller technique zonal dans ce dispositif. Il est l'un des référents techniques en la matière et doit contribuer à la diffusion des savoirs. Dans un premier temps, nous sommes intéressés à l'articulation CNCMFE-NRBCe / Zone de défense et de sécurité / Centre d'entraînement Zonal. Puis nous avons réalisé un sondage auprès des conseillers techniques zonaux afin de qualifier leurs implications dans ce dispositif. Ce sondage a été complété par des entretiens avec des personnalités qualifiées dans le domaine NRBCe. Enfin, nous proposons quelques pistes d'améliorations pour davantage clarifier le rôle et les missions des conseillers techniques zonaux.	https://fire-in.eu/challenges-resources/validated-solutions/role-et-missions-des-conseillers-techniques-zonaux-dans-l-organization-des-entrainements-pour-faire-face-aux-menaces-nrbce	CCC-11
2	Research - Building local level engagement in disaster risk reduction. A Portuguese case study	Contributing to the global dialogue on disaster risk reduction (DRR), the purpose of this paper is to address a key priority for the Post-2015 Framework for DRR (HFA2) by analysing initiatives used by one local government to increase local-level engagement in DRR. Design/methodology/approach	https://fire-in.eu/challenges-resources/validated-solutions/research-building-local-level-engagement-in-disaster-risk-reduction.-a-portugese-case-study	CCC-5, CCC-17
3	Renforcons notre resilience	La résilience c'est la capacité à s'adapter et à rebondir en période d'adversité. Et donc à traverser une épreuve avec le plus d'adaptabilité possible. Les études montrent que la résilience est corrélée à la souplesse (émotionnelle et cognitive), un brin de positivisme réaliste et une capacité à faire face aux événements douloureux de façon calme, mais proactive. Centre National de Ressources et de Résilience, France.	https://fire-in.eu/challenges-resources/validated-solutions/renforcons-notre-resilience	FCCC-8
4	Community-Based Disaster Coalition training	One key activity of the University of South Florida Preparedness and Emergency Response Learning Center is designing, developing, and delivering community preparedness, response, and recovery system training. Coalitions are vital for addressing emergencies or disaster situations within communities. The University of South Florida Community-Based Disaster Coalition was designed to address the challenges of building and sustaining coalitions, emphasize methods to enhance their sustainability and effectiveness, and strengthen their purpose and community impact during disasters.	https://fire-in.eu/challenges-resources/validated-solutions/community-based-disaster-coalition-training	CCC-5, CCC-17
5	The Eight Step Training Model: Improving Disaster Management Leadership	One method for emergency managers to achieve success may be through the implementation of a disciplined training methodology, developed in the United States Army, known as the "Eight Step Training Model." At its essence, the eight step training model provides a logical, structured and repeatable framework for developing and executing training that is designed to build confident and competent emergency managers and improve the individual and collective training proficiency of primary and secondary responders (training participants). A time investment in this planning and training methodology will increase preparedness, response and recovery efforts and desired outcomes immeasurably. The model can focus upon local, State or Federal levels, incorporating Private Volunteer Organizations (PVOs), Non-Government Organizations (NGOs) or commercial industry whether local, regional or national.	https://fire-in.eu/challenges-resources/validated-solutions/the-eight-step-training-model-improving-disaster-management-leadership	CCC-5, CCC-17
6	Earthquake induced crises	The need to deaggregate earthquake effects, associated economic loss and preparedness level due to the earthquake itself and its secondary and	https://fire-in.eu/fr/challenges-	FCCC-4, CCC-5,

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	game: game tree approached risk communication and lessons learnt	tertiary phenomena is nowadays apparent. Fatalities and economic losses due to secondary phenomena have been reported in past earthquakes, when the level of preparedness was low, or practically inexistent. However, in recent earthquakes, their percentage seems to follow an increasing trend. There is, therefore, a need for improved models for associated effects of recent earthquakes.	resources/validated-solutions/earthquake-induced-crises-game-tree-approached-risk-communication-and-lessons-learnt	CCC-6, FCCC-7, FCCC-8, FCCC-10, FCCC-12, CCC-13, CCC-15, FCCC-16, CCC-17, CCC-18, FCCC-19, FCCC-20, CCC-22, FCCC-23
7	Data Fusion and AI processes from Hyperspectral Satellites	TRUTHS is a new satellite mision that will be added to the list of missions to be financed in the Earth Observation Earth Watch programme. The TRUTHS mission aims to establish an SI-traceable space-based climate and calibration observing system to improve confidence in climate-change forecasts – a kind of 'standards laboratory in space'. It would carry a hyperspectral imager to provide benchmark measurements of both incoming solar radiation and outgoing reflected radiation with an unprecedented accuracy.	https://fire-in.eu/challenges-resources/validated-solutions/data-fusion-and-ai-processes-from-hyperspectral-satellites	CCC-1, CCC-2, CCC-5, FCCC-7, CCC-18, FCCC-19, CCC-22, FCCC-23
8	DITSEF (Digital and Innovative Technologies for Security and Efficiency of First Responders operation)	Self organising robust ad-hoc communications where the existing infrastructure may be compromised, allowing communication between the First Responders and between them and their command level. - Accurate novel 3D positioning in indoor environments. - Sensors that offer a reliable overview of the situation and of the potential threats (explosives, chemicals, fire, etc.). Enhanced vision for the FR in visually -impaired conditions, trough ingenious and unprecented HMIs consisting of sensors-based visual elements, showing spatial features and thermal imagery overlaid on the direct perception of the First Responder.	https://fire-in.eu/en/challenges-resources/validated-solutions/ditsef-digital-and-innovative-technologies-for-security-and-efficiency-of-first-responders-operation	CCC-1
9	HELIOS (Second Generation Beacon for GALILEO/EGNOS EGNSS Search And Rescue applications)	Innovative aviation, maritime and outdoor search and rescue distress beacons	https://fire-in.eu/en/challenges-resources/validated-solutions/helios-second-generation-beacon-for-galileo-egnos-egnss-search-and-rescue-applications	CCC-1
10	Asymmetric synchronous collaboration within distributed teams	Teams performing physical tasks must often be distributed in space, and are often organized hierarchically. This means that systems to support collaboration between members must account for the asymmetry in physical environment, organizational roles, and available technology. Using urban search and rescue as an example, we first describe the factors that cause this asymmetry. We then discuss the way information should be shared, and the type of awareness that should be supported. We suggest the use of very different display and interaction devices for operators at the organizational levels, to complement their situations and needs.	https://fire-in.eu/en/challenges-resources/validated-solutions/asymmetric-synchronous-collaboration-within-distributed-teams	CCC-1
11	Disaster management, crowdsourced R&D and probabilistic	This paper argues the developing field of probabilistic innovation (innovation increasing probability of solving societal problems through radically increasing coordination of volumes of problem-solving inputs and analysis), and its methodologies, such as those drawing from crowdsourced R&D and social media, may offer useful insights into enabling real time research capabilities, with important implications for	https://fire-in.eu/en/challenges-resources/validated-solutions/disaster-management-crowdsourced-r-d-and-	CCC-2, CCC-5, FCCC-7

No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	innovation theory	disaster and crisis management. Global collaborative innovation platforms and large-scale investments in emerging crowdsourced R&D and social media technologies together with synthesis of appropriate theory may contribute to improved real time disaster response and resilience across contexts, particularly in instances where data required to manage response is only available after disasters unfold.	probabilistic-innovation-theory	
12	It'll never happen to me'	Drawing on data collected during research undertaken for the Environment Agency, this paper contributes to understanding of one aspect of flood awareness: people's recognition that their property is in an area that is potentially at risk of flooding.	https://fire-in.eu/en/challenges-resources/validated-solutions/it-ll-never-happen-to-me	CCC-2, CCC-5, FCCC-7
13	E-Government Challenge in Disaster Evacuation Response	This position paper, which is based on a review of the literature and a field case study, intends to contribute to the definition of the e-government research priorities needed to build regional disaster preparedness, as an integral part of e-government development policy.	https://fire-in.eu/en/challenges-resources/validated-solutions/e-government-challenge-in-disaster-evacuation-response	CCC-2, CCC-5, FCCC-7
14	Citizen Communications in Crisis	Drawing on disaster social science, we consider a critical aspect of post-impact disaster response that does not yet receive much information science research attention. Public participation is an emerging, large-scale arena for computer-mediated interaction that has implications for both informal and formal response. With a focus on persistent citizen communications as one form of interaction in this arena, we describe their spatial and temporal arrangements, and how the emerging information pathways that result serve different post-impact functions.	https://fire-in.eu/en/challenges-resources/validated-solutions/citizen-communications-in-crisis	CCC-2, CCC-5, FCCC-7
15	Twitter Floods when it Rains	In this paper, we explore the use of Twitter as a mechanism used in disaster relief, and consequently in public safety. In particular, we perform a case study on the floods that occurred in the United Kingdom during January 2014, and how these were reflected on Twitter, according to tweets (i.e., posts) submitted by the users. We present a systematic algorithmic analysis of tweets collected with respect to our use case scenario, supplemented by visual analytic tools. Our objective is to identify meaningful and effective ways to take advantage of the wealth of Twitter data in crisis management, and we report on the findings of our analysis.	https://fire-in.eu/en/challenges-resources/validated-solutions/twitter-floods-when-it-rains	CCC-2, CCC-5, FCCC-7
16	Information sharing in interteam responses to disaster	This paper presents a case study of a national disaster response exercise involving 1,000 emergency responders. Data consist of structured observations, recordings of interteam meetings, and interviews with emergency responders. Results of mixed-method analysis indicate that interteam information sharing is delayed by limited situation awareness and poor articulation. Conversely, adopting behaviours that promote common frames for understanding interteam capabilities and information requirements improves information sharing and potentially reduces cognitive effort required to process information. Findings contribute to interteam communication theory by highlighting that in complex, time-constrained environments, having a shared understanding of responsibilities and information requirement is important for minimizing redundant deliberation and improving relevance and speed.	https://fire-in.eu/en/challenges-resources/validated-solutions/information-sharing-in-interteam-responses-to-disaster	CCC-2, CCC-5, FCCC-7
17	Public Organization Adaptation to Extreme Events	The study responds to the growing call for a more systematic approach to research on organizational responses to extreme events. It develops and tests an integrated framework based on the organizational adaptation and learning theory to shed light on how public organizations manage exposure and vulnerability to extreme events	https://fire-in.eu/en/challenges-resources/validated-solutions/public-organization-adaptation-to-extreme-events	CCC-2, CCC-5, FCCC-7
18	Site management of health issues	The terrorist destruction of the World Trade Center led to the greatest loss of life from a criminal incident in the history of the United States. There were 2,801 persons killed or missing at the disaster site, including 147	https://fire-in.eu/en/challenges-resources/validated-	CCC-18

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	in the 2001 World Trade Center disaster	dead on two hijacked aircraft. Hundreds of buildings sustained direct damage or contamination. Forty different agencies responded with command and control exercised by an incident command system as well as an emergency operations center. Dozens of hazards complicated relief and recovery efforts	solutions/site-management-of-health-issues-in-the-2001-world-trade-center-disaster	
19	What Have We Learned since September 11, 2001? A Network Study of the Boston Marathon Bombings Response	This research assesses the effectiveness of interorganizational coordination and collaboration in response to the Boston Marathon bombings. After reviewing the major changes in federal emergency management policies and frameworks since September 11, 2001, this article applies a social network analysis to compare the disaster response networks embodied in formal disaster preparedness plans with the actual response networks.	https://fire-in.eu/en/challenges-resources/validated-solutions/what-have-we-learned-since-september-11-2001-a-network-study-of-the-boston-marathon-bombings-response	CCC-18
20	Crisis Management Training	We report on research of early phases of the development of a crisis management training simulator, with the goal of understanding different representations and transitions between steps of a development process. The focus of the research study was on how the different representations did align with a given process model and how these representations lent themselves to a consolidation activity. The results were that consolidation across data sources starts early during the understanding phase and that stakeholders like to validate abstract models.	https://fire-in.eu/en/challenges-resources/validated-solutions/crisis-management-training	FCCC-10, CCC-18
21	25 Years of MCDA in nuclear emergency management	This work reviews a range of mathematical models, computing tools and, particularly, multi-criteria decision-making techniques that have been applied in the last 25 years to help politicians, health officials, local authority representatives and emergency planning officers devise better countermeasure strategies in the event of a radiation accident. The paper discusses all phases of a nuclear emergency as well as emergency training and planning.	https://fire-in.eu/en/challenges-resources/validated-solutions/25-years-of-mcda-in-nuclear-emergency-management	FCCC-10, CCC-18
22	Analysis of large fires in European Mediterranean landscapes	In this article we analyze some of the most damaging fire episodes in Europe in the last decades. Our analysis relates the events to existing conditions in terms of number of fires and burnt areas in the countries and regions where they occurred, showing that these large fire episodes do not follow the general trend of those variables and constitute outstanding critical events.	https://fire-in.eu/en/challenges-resources/validated-solutions/analysis-of-large-fires-in-european-mediterranean-landscapes	FCCC-10, CCC-18
23	EU Efforts in Managing CBRN Terror Attacks	This paper reports on: (1) Results of a comprehensive gap analysis among 80 EU first responder organizations (police, fire fighters, emergency medical services) in 25 EU Member States concerning the management of a mega-crisis, inter alia also concerning CBRN; (2) Analysis of major CBRN counterterrorism research achievements in the EU.	https://fire-in.eu/en/challenges-resources/validated-solutions/eu-efforts-in-managing-cbrn-terror-attacks	FCCC-10, CCC-18
24	Organising Response to Extreme Emergencies	Obviously, extreme events - events that are in scope or scale or type beyond the range of our ordinary experience and expectations - by definition will occur only relatively rarely (and very rarely to any given emergency organization). Nonetheless, when they do occur they tend to be of defining importance to the people and institutions that are thrust into them and that must find their way through them.	https://fire-in.eu/en/challenges-resources/validated-solutions/organising-response-to-extreme-emergencies	CCC-3, CCC-14
25	Integrating nowcasting with crisis management and risk prevention in a transnational and	This paper presents the recent WWRP/WMO Forecast Demonstration Project INCA-CE (INtegrating now-CAsting for Central Europe) co-funded by the European Union. Twenty-four partners of national and regional hydro-meteorological services, national and regional crisis and disaster management centers, and authorities for road management world-wide have participated in INCA-CE for international cooperation on now-casting development, interdisciplinary cooperation for nowcasting applications and transnational cooperation for nowcasting services.	https://fire-in.eu/en/challenges-resources/validated-solutions/integrating-nowcasting-with-crisis-management-and-risk-prevention-in-a-transnational-and-	CCC-3, CCC-14

No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	interdisciplinary framework		interdisciplinary-framework	
26	Collaboration Capabilities for Crisis Management	This paper presents Part I of a three-part framework that explicitly addresses the multiple characteristics of crisis management collaboration: time-sensitivity, synchronicity, non-collocation, and unrelated organizations. Based on a literature search, governance review, and 19 on-site interviews with many aviation security stakeholders, we synthesize the common challenges discovered into 13 essential collaboration capabilities.	https://fire-in.eu/en/challenges-resources/validated-solutions/collaboration-capabilities-for-crisis-management	CCC-3, CCC-14, CCC-15
27	Collaboration Exercises	This article aims to study whether exercises contribute to learning that can be useful in actual emergency work. It reports the findings of a study about professional emergency personnel's perceptions of the impact of collaboration exercises. Surveys were distributed and collected from emergency personnel in conjunction with three collaboration exercises that took place in Sweden in spring 2012. The survey included personnel holding different positions within the police department, fire department and ambulance services.	https://fire-in.eu/en/challenges-resources/validated-solutions/collaboration-exercises	CCC-3, CCC-14, CCC-15
28	CRISIS MANAGEMENT EVALUATION	In this paper, a real world incident of a fire in the Amsterdam Airport Schiphol train tunnel was formalised, based on a public inquiry report, and subsequently, the emergency response to the incident was analysed by means of automatic property checking.	https://fire-in.eu/en/challenges-resources/validated-solutions/crisis-management-evaluation	CCC-3, CCC-14, CCC-15
29	Improving crisis management in the imperfect world of foreign electoral assistance	This article's primary focus is on improving techniques of crisis management of electoral assistance. In so doing it intends to contribute to a more systematic sharing of information about lessons learned and possible responses to the pressure of providing electoral support when time is short.	https://fire-in.eu/en/challenges-resources/validated-solutions/improving-crisis-management-in-the-imperfect-world-of-foreign-electoral-assistance	CCC-3, CCC-14, CCC-15
30	Regional coordination in medical emergencies and major incidents; plan, execute and teach	Background: Although disasters and major incidents are difficult to predict, the results can be mitigated through planning, training and coordinated management of available resources. Following a fire in a disco in Gothenburg, causing 63 deaths and over 200 casualties, a medical disaster response centre was created. The center was given the task to coordinate risk assessments, disaster planning and training of staff within the region and on an executive level, to be the point of contact (POC) with authority to act as "gold control," i.e. to take immediate strategic command over all medical resources within the region if needed. The aim of this study was to find out if the centre had achieved its tasks by analyzing its activities.	https://fire-in.eu/en/challenges-resources/validated-solutions/regional-coordination-in-medical-emergencies-and-major-incidents-plan-execute-and-teach2	CCC-1, CCC-3, CCC-14, CCC-15
31	Multidisciplinary coordination of on-scene command teams in virtual emergency exercises	This paper presents the design and the results of a comparative study of multidisciplinary on-scene command teams at work in virtual emergency training exercises. The principal goals of the study were to understand how "on-scene command teams" coordinate on multidisciplinary objectives and tasks, and how the manner in which this is done affects their performance.	https://fire-in.eu/en/challenges-resources/validated-solutions/multidisciplinary-coordination-of-on-scene-command-teams-in-virtual-emergency-exercises	CCC-3, CCC-14, CCC-15
32	The Common Operational Picture as Collective Sensemaking	We focus on how emergency responders develop collective sensemaking from information. We employ a trading zone' perspective, in which information is negotiated, to study information management in an ethnographic study of disaster exercises in the Netherlands.	https://fire-in.eu/en/challenges-resources/validated-solutions/the-common-operational-picture-as-collective-sensemaking	CCC-3, CCC-14, CCC-15

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
33	Darius ((Deployable SAR Integrated Chain with Unmanned Systems))	interoperability of unmanned air, ground and maritime vehicles in Search and Rescue (SAR) operations	https://fire-in.eu/en/challenges-resources/validated-solutions/darius-deployable-sar-integrated-chain-with-unmanned-systems	FCCC-19, CCC-22, FCCC-23
34	Whole of Government	A number of key themes emerge including the nature of crisis management, role of leadership, understanding coordination, impact of organizational culture, and the interactions between individuals and institutions. This paper will consider these issues and provide a review of the relevant literature, to understand the synergies that exist in connected responses to crises.	https://fire-in.eu/en/challenges-resources/validated-solutions/whole-of-government	CCC-3, CCC-14, CCC-15
35	Crisis Decision-Making During Hurricane Sandy	Objective This collective case study examined how and why specific organizational decision-making processes transpired at 2 large suburban county health departments in lower New York State during their response to Hurricane Sandy in 2012. The study also examined the relationships that the agencies developed with other emerging and established organizations within their respective health systems.	https://fire-in.eu/en/challenges-resources/validated-solutions/crisis-decision-making-during-hurricane-sandy	CCC-3, CCC-14, CCC-15
36	MEDRN - A mutual aid information network for emergency response	MEDRN uses Semantic Network technology to facilitate the access, dissemination and sharing of information across all parties involved in emergency management. The technology is currently fielded by SPAWAR, the Marine Corps and other Department of Defense (DoD) and non DoD national security agencies.	https://fire-in.eu/en/challenges-resources/validated-solutions/medrn-a-mutual-aid-information-network-for-emergency-response	CCC-3, CCC-14, CCC-15
37	Planning for disaster	This paper describes how a modified version of the methods from soft systems methodology (SSM), chosen through methodological reflections informed by critical systems thinking, was used to support the planning of a multi-agency counselling service that could be activated in the event of a disaster.	https://fire-in.eu/en/challenges-resources/validated-solutions/planning-for-disaster	CCC-3, CCC-14, CCC-15
38	Collaborative Incident Planning and the Common Operational Picture	Here, we focus on the common operational picture in disaster response, with a view to bridging the gap between its technological and operational components. We use a typical incident planning outline to highlight how software solutions developed at the disaster preparedness phase can reduce the uncertainty during disaster response and streamline the operational planning process.	https://fire-in.eu/en/challenges-resources/validated-solutions/collaborative-incident-planning-and-the-common-operational-picture	CCC-3, CCC-14, CCC-15
39	Collaborative Disciplines, Collaborative Technologies	The goal of this primer is to examine the dimensions of the domain in existing literature, define concepts and functional capabilities that join the domain, categorize the systems and tools which support the domain, and propose a framework for a broader literature review of these unique disciplines.	https://fire-in.eu/en/challenges-resources/validated-solutions/collaborative-disciplines-collaborative-technologies	CCC-11
40	Virtual training	In our study we applied a virtual training environment to train police personnel for complex collaborative tasks.	https://fire-in.eu/en/challenges-resources/validated-solutions/virtual-training	CCC-11
41	Integration between Telecommunication, Navigation and Earth Observation Systems for	This article discusses the main mission requirements that new assets dedicated to crisis management will have to fulfill.	https://fire-in.eu/en/challenges-resources/validated-solutions/integration-between-telecommunication-navigation-and-earth-observation-systems-for-	CCC-11

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	Crisis Response Management		crisis-response-management	
42	Interoperable semantic access control for highly dynamic coalitions	This paper presents a platform-driven approach to HDCs. It first defines a life cycle inherent to HDC formations, and then presents a platform-driven access control model that takes advantage of semantics of partners' requirements to provide interoperable access control to resources shared in a coalition.	https://fire-in.eu/en/challenges-resources/validated-solutions/interoperable-semantic-access-control-for-highly-dynamic-coalitions	CCC-11
43	Gamification for Data Gathering in Emergency Response Exercises	Description on how gamification can be implemented in an emergency response exercise and the value of doing so.	https://fire-in.eu/en/challenges-resources/validated-solutions/gamification-for-data-gathering-in-emergency-response-exercises	CCC-11
44	Dynamic Knowledge Management Toolkit	In this paper we describe a Dynamic Knowledge Toolkit (DKT) that is used in knowledge elicitation and representation based upon Knowledge maps.	https://fire-in.eu/en/challenges-resources/validated-solutions/dynamic-knowledge-management-toolkit	CCC-11
45	Establishing cross-border co-operation between professional organizations	This article explores the conditions under which local and regional governments will establish and sustain cross-border co-operation in the fields of police, fire fighting and emergency health services. It argues that understanding this type of cross-border co-operation requires a focus on the way in which professionals define and apply their professional standards in cross-border contexts.	https://fire-in.eu/en/challenges-resources/validated-solutions/establishing-cross-border-co-operation-between-professional-organizations	CCC-11
46	eEDUCATION and eTRAINING	Over the years, the crisis management structures, now located within the European External Action Service, have established well-functioning processes based on lessons learned. One of the recurring conclusions is the lack of training and education. These issues can be solved using eLearning tools, specifically developed for the European Security and Defence College (ESDC), with the same content for every participant. Through the ESDC, a certain standardization process can be guaranteed and the eLearning tools are independent from time and location constraints.	https://fire-in.eu/en/challenges-resources/validated-solutions/eeducation-and-etraining	CCC-11
47	Building a Generic Model for Early Warning Information Systems (EWIS)	Throughout this research, we aim to put a general methodology and set standard rules for risk-prone organizations or sectors that need an early warning system to prevent or at least reduce these risks. This research suggests a generic EWIS model that can be adapted to the dynamic needs of the field of crisis management.	https://fire-in.eu/en/challenges-resources/validated-solutions/building-a-generic-model-for-early-warning-information-systems-ewis	CCC-11
48	WEB SERVICES AND INFORMATION SUPPORT DURING EMERGENCIES	The management of emergencies is hardly ever imaginable without proper information support. This information support must be consistent across all phases of emergencies, during the planning and preparation phase, during life saving and rescue operation and also during the recovery phase. The web services enable uniform a standardized publishing of the data and algorithms for various applications.	https://fire-in.eu/en/challenges-resources/validated-solutions/web-services-and-information-support-during-emergencies	CCC-11
49	CARTOGRAPHIC PRINCIPLES FOR STANDARDIZED CARTOGRAPHI	The project "Geoinformatics as an instrument to support integrated emergency and rescue operations of state" aimed to develop a methodology of unified cartographic symbology for IRS. It consists of the recommended basic principles for the construction and definition of a symbol set, scaling range and standardized description of individual	https://fire-in.eu/en/challenges-resources/validated-solutions/cartographic-principles-for-	CCC-11

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	C VISUALIZATION FOR CRISIS MANAGEMENT COMMUNITY	symbols to be used for maps in the analogue and digital forms. The presented paper describes the basics of the aforementioned methodology and experience retrieved during the IRS practice ZONA 2015, where the proposed cartographic visualization rules were used.	standardized-cartographic-visualization-for-crisis-management-community	
50	EXPERIMENT FOR DETERMINATION OF MAP GRAPHICS SEGMENT STANDARD FOR HANDHELD CRISIS MAPS MANAGEMENT	This paper describes a study of map symbols to display on maps that are in the service of making decisions and solving problems in crisis situations, as well as providing support to residents and experts on crisis management in times of decision making, before and during the crisis.	https://fire-in.eu/en/challenges-resources/validated-solutions/experiment-for-determination-of-map-graphics-segment-standard-for-handheld-crisis-maps-management	CCC-11
51	Challenges and obstacles in sharing and coordinating information during multi-agency disaster response	In this paper, we provide an overview of the relevant obstacles and challenges by examining existing literature and then investigating a series of multi-agency disaster management exercises, using observations and a survey.	https://fire-in.eu/en/challenges-resources/validated-solutions/challenges-and-obstacles-in-sharing-and-coordinating-information-during-multi-agency-disaster-response	CCC-13, CCC-15
52	Transforming Crisis Management	In this paper we address the gap between the concept and reality of NCO. The necessary capabilities for NCO are identified using literature research and potential benefits are analyzed using field research, We found that NCO is not a silver bullet for overcoming the inherent problems of crisis management and could even reinforce existing problems. Our findings suggest that NCO is difficult to implement and needs to be complemented with capability development in the information and cognitive domain.	https://fire-in.eu/en/challenges-resources/validated-solutions/transforming-crisis-management	CCC-15
53	Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management	This paper offers a comprehensive state-of-the-art review of the overlapping domains of the Sensor Web, citizen sensing and 'human-in-the-loop sensing' in the era of the Mobile and Social Web, and the roles these domains can play in environmental and public health surveillance and crisis/disaster informatics.	https://fire-in.eu/en/challenges-resources/validated-solutions/crowdsourcing-citizen-sensing-and-sensor-web-technologies-for-public-and-environmental-health-surveillance-and-crisis-management	CCC-13, CCC-15
54	Reducing time in emergency medical service by improving information exchange among information systems	There are many organized units involved to perform an emergency rescue mission: dispatch center, mobile rescue units and emergency departments (ED) in hospitals. Communication among them is often not fully automated, and then personnel need to cope with unnecessary work. That of course takes time in cases of urgent interventions, while time is one of the most important factors for patient survival. There are several processes in which better performance could be established. Improvement can be made by reducing communication obstacles between actors in processes and among three different information systems involved: hospital information system (HIS) in emergency department, computer aided dispatch (CAD) and records management system (RMS) used by mobile units.	https://fire-in.eu/en/challenges-resources/validated-solutions/reducing-time-in-emergency-medical-service-by-improving-information-exchange-among-information-systems	CCC-15
55	The growing role of web-based geospatial	This paper examines changes in disaster response and relief efforts and recent web-based geospatial technological developments through an evaluation of the experiences of the Center for Geographic Analysis,	https://fire-in.eu/en/challenges-resources/validated-solutions/the-growing-	CCC-15

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	technology in disaster response and support	Harvard University, of the Sichuan (2008) and Haiti (2010) earthquake responses.	role-of-web-based-geospatial-technology-in-disaster-response-and-support	
56	Design and Function of the European Forest Fire Information System	Since its inception in 2001, EFFIS has evolved into the central reference point for pan-European forest and wildfire information, and this paper describes and current applications demonstrate the state-of-the-art fire information systems that provide data to civil protection authorities across Europe.	https://fire-in.eu/en/challenges-resources/validated-solutions/design-and-function-of-the-european-forest-fire-information-system2	CCC-11, CCC-15
57	Knowledge-Based Service Architecture for Multi-risk Environmental Decision Support Applications	This paper describes our work to date on knowledge-based service architecture implementations for multi-risk environmental decision-support. The work described spans two research projects, SANY and TRIDEC, and covers application domains where very large, high report frequency real-time information sources must be processed in challenging timescales to support multi-risk decision support in evolving crises.	https://fire-in.eu/en/challenges-resources/validated-solutions/knowledge-based-service-architecture-for-multi-risk-environmental-decision-support-applications	CCC-15
58	Developing a Community of Practice to Learn, Share and Improve in Emergency Management	This paper describes the findings obtained during the development of a VCoP within a project funded by the European Commission. The paper describes the barriers that limit the members of the VCoP to sharing lessons learned and best practices identified in three disaster scenario based workshops. Furthermore, it explains the functionalities for the technological platform of the VCoP to overcome these barriers validated by the VCoP members in a case study.	https://fire-in.eu/en/challenges-resources/validated-solutions/developing-a-community-of-practice-to-learn-share-and-improve-in-emergency-management	CCC-15
59	Distributed collaborative situation-map making for disaster response	In this study, we propose to let the affected population be utilized as an additional resource that can actively help to make such a situation map. The aim of this study was to investigate the possibility of constructing a shared situation map using a collaborative distributed mechanism.	https://fire-in.eu/en/challenges-resources/validated-solutions/distributed-collaborative-situation-map-making-for-disaster-response	CCC-15
60	Common frameworks of networking and information-sharing for advanced rescue systems	Ad-hoc network with wireless communication is one of important candidates to provide robust communication infrastructure. Our task force tries to figure out requirements of robot and sensor networks for search-and-rescue and tune-up middle-ware of ad-hoc networks for it.	https://fire-in.eu/en/challenges-resources/validated-solutions/common-frameworks-of-networking-and-information-sharing-for-advanced-rescue-systems	CCC-15
61	The Impacts of ICT Support on Information Distribution, Task Assignment for Gaining Teams' Situational Awareness in Search and Rescue Operations	To study the effects of ICT for Information Distribution (ID) and Task Assignment (TA) for gaining Teams' Situational Awareness (TSA) across and within rescue teams, an indoor fire game was played with students. We used two settings (smartphone-enabled support vs. traditional walkietalkies) to analyze the impact of technology on ID and TA for gaining TSA in a simulated Search and Rescue operation. The results presented in this paper combine observations and quantitative data from a survey conducted after the game.	https://fire-in.eu/en/challenges-resources/validated-solutions/the-impacts-of-ict-support-on-information-distribution-task-assignment-for-gaining-teams-situational-awareness-in-search-and-rescue-operations	CCC-15

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62	An Open GeoSpatial Standards-Enabled Google Earth Application to Support Crisis Management	In this paper, we present development of the "Google Earth Dashboard" (GED), a web-based interface powered by open geospatial standards and designed for supplementing and enhancing the geospatial capabilities of GE. The GED allows users to create custom maps through WMS layer addition to GE and perform traditional GIS analysis functions.	https://fire-in.eu/en/challenges-resources/validated-solutions/an-open-geospatial-standards-enabled-google-earth-application-to-support-crisis-management	CCC-15
63	A case study of factor influencing role improvisation in crisis response teams	The aim of this study is to deepen the understanding of the processes taking place during improvised work "as it happens". A case study of a crisis management team at work is presented and provides an in-depth analysis of the information and communication flow of persons acting in improvised roles, including contextual factors influencing the task at hand.	https://fire-in.eu/en/challenges-resources/validated-solutions/a-case-study-of-factor-influencing-role-improvisation-in-crisis-response-teams	CCC-13, CCC-15
64	Communication Platform for Disaster Response	The present research proposes an information platform for enhanced communication and information sharing in municipalities struck by disasters. Once a disaster happens, collecting and sharing information with and among citizens is the most important tasks for municipalities.	https://fire-in.eu/en/challenges-resources/validated-solutions/communication-platform-for-disaster-response	CCC-15
65	Mining the Disaster Hotspots - Situation-Adaptive Crowd Knowledge Extraction for Crisis Management	The lack of semantically-grounded situational context does not allow to fully implement situation-adaptive crowd knowledge extraction, meaning the system can utilize already established (crowd) knowledge to correspondingly adapt its crowd-sensing and knowledge extraction process alongside the monitored situation, to keep pace with the underlying real-world incidents. In the light of this, in the present paper, we illustrate the realization of a situation-adaptive crowd-sensing and knowledge extraction system by introducing our crowd(SA) prototype, and examine its potential in a case study on a real-world Twitter crisis data set.	https://fire-in.eu/en/challenges-resources/validated-solutions/mining-the-disaster-hotspots-situation-adaptive-crowd-knowledge-extraction-for-crisis-management	CCC-15
66	ENABLING INFORMATION GATHERING PATTERNS FOR EMERGENCY RESPONSE WITH THE OPENKNOWLEDGE SYSTEM	This work focuses on the exploitation and evaluation of the OpenKnowledge framework to support different information-gathering patterns in emergency contexts. The OpenKnowledge (OK) system has been adopted to model and simulate possible emergency plans.	https://fire-in.eu/en/challenges-resources/validated-solutions/enabling-information-gathering-patterns-for-emergency-response-with-the-openknowledge-system	CCC-15
67	Information sharing and decision-making in multidisciplinary crisis management teams	In this paper, we investigate information processing and decision-making behaviors in an exploratory study of 12 organizational multidisciplinary crisis management teams. We identify three types of information sharing and track the emergence of distinct communicative phases as well as differences between high- and low-performing teams in the occurrence of sequences of information sharing behaviors.	https://fire-in.eu/en/challenges-resources/validated-solutions/information-sharing-and-decision-making-in-multidisciplinary-crisis-management-teams	CCC-14, CCC-15, FCCC-16
68	Data Mining Meets the Needs of Disaster Information Management	Our proposed techniques create a disaster domain-specific search engine and a geographical information presentation and navigation platform using advanced data mining and information retrieval techniques for disaster preparedness and recovery that helps impacted communities better understand the current disaster situation.	https://fire-in.eu/en/challenges-resources/validated-solutions/data-mining-meets-the-needs-of-disaster-information-management	CCC-13, CCC-15

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
69	Preparing for complex interdependent risks	This study advocates the need for disaster preparedness strategies to go beyond linear approaches to risk management. This is necessary in order to better address complex interdependent risks where such risks may be novel or unforeseen and which may connect in a cascading manner.	https://fire-in.eu/en/challenges-resources/validated-solutions/preparing-for-complex-interdependent-risks2	CCC-3, FCCC-4, CCC-11, CCC-14, CCC-15, FCCC-16
70	Building a Birds Eye View	Drawing on our engagement with disaster response teams, including ethnography of their training work, we unpack the ways in which situational uncertainty is managed while a shared operational 'picture' is constituted through various practices around tabletop work. Our analysis reveals how this picture is collaboratively assembled as a socially shared object and displayed by drawing on digital and physical resources.	https://fire-in.eu/en/challenges-resources/validated-solutions/building-a-birds-eye-view3	CCC-1, CCC-3, FCCC-4, CCC-14, CCC-15, FCCC-16
71	SUSTAINING NETWORKS IN EMERGENCY MANAGEMENT A Study of Counties in the United States	This study develops a model of the factors that influence network sustainability in emergency management. Using data from a national survey of county emergency managers in the United States, the study finds that convergence of organizational goals, utilization of information and communication technology, and, most important, interorganizational trust are all significant influences on network sustainability in emergency management.	https://fire-in.eu/en/challenges-resources/validated-solutions/sustaining-networks-in-emergency-management-a-study-of-counties-in-the-united-states3	CCC-1, CCC-3, FCCC-4, CCC-14, CCC-15, FCCC-16
72	TRANSCRISIS: Enhancing the EU's transboundary crisis management capacity	Report on "Enhancing the EU's Transboundary Crisis Management Capacity: Recommendations for Practice" (https://www.transcrisis.eu/wp-content/uploads/2018/02/D7.3-policy-recommendations.pdf)	https://fire-in.eu/en/challenges-resources/validated-solutions/transcrisis-enhancing-the-eu-s-transboundary-crisis-management-capacity	FCCC-12, FCCC-20
73	Harnessing a Community for Sustainable Disaster Response and Recovery	Our review shows that federal policy stresses the importance of partnerships between NGOs and government agencies and among other NGOs. Such partnerships can build deep local networks and broad systems that reach from local communities to the federal government. Understanding what capacities NGOs need and what factors influence their ability to perform during a disaster informs an operational model that could optimize NGO performance.	https://fire-in.eu/en/challenges-resources/validated-solutions/harnessing-a-community-for-sustainable-disaster-response-and-recovery2	FCCC-12, FCCC-19, FCCC-20, CCC-22, FCCC-23
74	Striving to be resilient	The objective and novelty of the study were to propose a holistic framework that enables to evaluate and prioritise concepts, approaches and practices that should be incorporated into European guidelines for resilience management.	https://fire-in.eu/en/challenges-resources/validated-solutions/striving-to-be-resilient	FCCC-12, FCCC-20
75	Institutional development and scale matching in disaster response management	In this paper we consider the case of the Katrina hurricane to identify successful strategies that enable institutions to respond effectively and at the appropriate scale. The importance of cross-scale linkages matched to the size and needs of the disaster is discussed as a central component of socio-ecological resilience.	https://fire-in.eu/en/challenges-resources/validated-solutions/institutional-development-and-scale-matching-in-disaster-response-management	FCCC-12, FCCC-20
76	Disaster response and recovery	disaster recovery, strategic planning, tactical planning, resilience	https://fire-in.eu/en/challenges-resources/validated-solutions/disaster-response-and-recovery	FCCC-12, FCCC-20
77	MEASURING PERFORMANCE FOR COLLABORATIVE PUBLIC	Social network analysis and centrality measures are used with the UCINET software program to analyze the outcomes of an evolving collaborative network through the relationship structures and processes of an interorganizational governance network. The study data were collected from content analyses of newspapers, situation reports, and	https://fire-in.eu/en/challenges-resources/validated-solutions/measuring-performance-for-	FCCC-12, FCCC-20

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	MANAGEMENT USING NETWORK ANALYSIS METHODS AND TOOLS	organizational documents. In the context of disaster response networks, the structure and performance of the planned networks are compared to the actual networks. The results indicate that the September 11 response network's performance differed from that of the Federal Response Plan network and that the outcomes of the Hurricane Katrina response network showed different structures from those of the National Response Plan. The insights generated about the structural differences between these formal versus informal and planned versus actual networks demonstrate the utility of the measurements of network performance outcomes discussed here.	collaborative-public-management-using-network-analysis-methods-and-tools	
78	Disaster Mitigation	The objective of this review is to stimulate the reader's considerations for developing community disaster mitigation. Disaster mitigation begins long before impact and is defined as the actions taken by a community to eliminate or minimize the impact of a disaster.	https://fire-in.eu/en/challenges-resources/validated-solutions/disaster-mitigation	FCCC-12, FCCC-20
79	Resilience assessment	We conducted this evaluation using participant observation, semistructured interviews, and a survey of the participants. Our findings show that the resilience assessment contributed to ongoing planning practices by addressing sustainability challenges that were not being addressed within the normal municipal planning or operations, such as local food security.	https://fire-in.eu/en/challenges-resources/validated-solutions/resilience-assessment	FCCC-12, FCCC-20
80	Conceptualizing Dimensions and Characteristics of Urban Resilience	This paper provides an example of how co-design methods can be employed for conceptualizing resilience. This paper can be considered as an initial step towards further exploration of participatory approaches for clarifying the underlying dimensions of complex concepts such as resilience.	https://fire-in.eu/en/challenges-resources/validated-solutions/conceptualizing-dimensions-and-characteristics-of-urban-resilience	FCCC-12, FCCC-20
81	Iterative Factors Favoring Collaboration for Interorganizational Resilience	We evaluated the factors that promote collaboration between public and private organizations that manage the Greater Montreal transportation infrastructure. These factors are based on adaptive management processes such as mutual agreements, common organizational culture, knowledge and financial resources, levers of power, regulations, and pressure. Crisis management coordination represents the ability to build and assess the effectiveness of common response plans to risks to which they are exposed.	https://fire-in.eu/en/challenges-resources/validated-solutions/iterative-factors-favoring-collaboration-for-interorganizational-resilience	FCCC-12, FCCC-20
82	SOME SUGGESTIONS FOR MAKING EMERGENCY RESPONSE EXERCISES MORE CONSISTENT AND MORE SUCCESSFUL	This paper suggests some criteria for successful exercises, including consistency of design and of documentation, and building ability to learn from experience. It outlines several attempts to achieve these goals, including a software framework for exercise design and assessment.	https://fire-in.eu/en/challenges-resources/validated-solutions/some-suggestions-for-making-emergency-response-exercises-more-consistent-and-more-successful	FCCC-12, FCCC-20
83	Towards integrative risk management and more resilient societies	This article focuses on the development and characterization of an integrative risk-management which, from the perspective of "resilient systems", can be seen as an innovative and pro-active crisis management approach dealing with the increasing amount of complexity in societies in a comprehensive, agile and adaptive way.	https://fire-in.eu/en/challenges-resources/validated-solutions/towards-integrative-risk-management-and-more-resilient-societies	CCC-11
84	Crisis Management Simulations -	This paper reviews a study of over 200 crisis management simulation participants over 4 years who have represented their experiences through reflective narrative accounts. The specific focus is on co-locating the	https://fire-in.eu/en/challenges-resources/validated-	CCC-11

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	Narrative Inquiry Into Transformative Learning	deeper level narratives of transformation, including the development of a coding schema based on Mezirow's Transformative Learning Theory.	solutions/crisis-management-simulations-narrative-inquiry-into-transformative-learning	
85	Decision Support System for Crisis Management Planning	Following the general phases of a typical risk management cycle, this presentation will illustrate their main characteristics and analyze their application in the safety and security domain. This paper presents the main results gained during the definition and the implementation of such systems. It also comments on the main limits and gaps imposed by data unavailability or interoperability constraints.	https://fire-in.eu/en/challenges-resources/validated-solutions/descision-support-system-for-crisis-management-planning	CCC-11
86	How prepared is prepared enough?	This paper presents an economic model to address the thorny question, 'how prepared is prepared enough?' Difficulties related to the use of cost-benefit analysis in the field of disaster management concern the tension between the large number of high-probability events that can be handled by a single emergency response unit and the small number of low-probability events that must be handled by a large number of them.	https://fire-in.eu/en/challenges-resources/validated-solutions/how-prepared-is-prepared-enough	CCC-11
87	Decision-making and evacuation planning for flood risk management in the Netherlands	This study considers the top strategic decision-making' for mass evacuation owing to flooding in the Netherlands. It reveals that the top strategic decision-making process itself is probabilistic because of the decision-makers involved and their crisis managers (as advisers). The paper concludes that deterministic planning is not sufficient, and it recommends probabilistic planning that considers uncertainties in the decision-making process itself as well as other uncertainties, such as forecasts, citizens responses, and the capacity of infrastructure.	https://fire-in.eu/en/challenges-resources/validated-solutions/decision-making-and-evacuation-planning-for-flood-risk-management-in-the-netherlands	CCC-11
88	Disaster management	The paper aims to discuss a systematic review of the literature about disaster management within the period 1980-2006. The research protocol is based on the methodology that is commonly used in healthcare for analysing the literature and provides a state-of-art medical discipline. The paper presents both it descriptive analysis and a thematic analysis in order to provide a state-of-art of international literature The research protocol is provided in order to make transparent the review process.	https://fire-in.eu/en/challenges-resources/validated-solutions/disaster-management	CCC-11
89	Improving risk assessment by defining consistent and reliable system scenarios	Formative Scenario Analysis, as a supplement to conventional risk assessment methods, is a technique to construct well-defined sets of assumptions to gain insight into a specific case and the potential system behaviour. By two case studies, carried out (1) to analyse sediment transport dynamics in a torrent section equipped with control measures, and (2) to identify hazards induced by woody debris transport at hydraulic weak points, the applicability of the Formative Scenario Analysis technique is presented.	https://fire-in.eu/en/challenges-resources/validated-solutions/improving-risk-assessment-by-defining-consistent-and-reliable-system-scenarios	CCC-11
90	On the Use of Global Flood Forecasts and Satellite-Derived Inundation Maps for Flood Monitoring in Data-Sparse Regions	In this study, we performed comparative evaluations of several operational global flood forecasting and flood detection systems, using 10 major flood events recorded over 2012-2014. Specifically, we evaluated the spatial extent and temporal characteristics of flood detections from the Global Flood Detection System (GFDS) and the Global Flood Awareness System (GloFAS). Furthermore, we compared the GFDS flood maps with those from NASA's two Moderate Resolution Imaging Spectroradiometer (MODIS) sensors.	https://fire-in.eu/en/challenges-resources/validated-solutions/on-the-use-of-global-flood-forecasts-and-satellite-derived-inundation-maps-for-flood-monitoring-in-data-sparse-regions	CCC-11
91	European Cooperation on Future Crises	This article explores the dilemmas inherent to producing common crisis management capacities across national governments. Drawing on the literature related to "international public goods," the article builds an approach for understanding these dilemmas through the lens of collective action and the perverse incentives associated therein.	https://fire-in.eu/en/challenges-resources/validated-solutions/european-cooperation-on-future-crises	CCC-11

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92	Process analysis, modeling and simulation for crisis management	The paper aims to present a real experience of designing a Control, Command, Communication, and Intelligence system to support crisis management through a three step business process.	https://fire-in.eu/en/challenges-resources/validated-solutions/process-analysis-modeling-and-simulation-for-crisis-management	CCC-11
93	Dual system for management of natural and anthropogenic emergencies and its training	This work aims at approaching the problem in an integral way, presenting the design of an informatics system that enables crisis management as well as training for the members of the organizations involved in the response to a natural or anthropogenic emergency.	https://fire-in.eu/en/challenges-resources/validated-solutions/dual-system-for-management-of-natural-and-anthropogenic-emergencies-and-its-training	CCC-11
94	REFIRE	Refire is a research project running for two years (2012-2013), co-funded by the European Commission, Directorate-General Home Affairs in the framework of the call "CIPS Action Grants 2010". The project aims to the adoption of effective location and communication services for indoor and deep-indoor emergencies and define a set of standards and protocols able to enable daily use of interoperable systems.	https://fire-in.eu/en/challenges-resources/validated-solutions/refire	CCC-14, FCCC-16
95	A FRAMEWORK FOR THE APPLICATION OF GROUP DECISION SUPPORT SYSTEMS TO THE PROBLEM OF PLANNING FOR CATASTROPHIC EVENTS	This paper discusses the application of decision analysis methods and decision support tools to the development of a scenario driven planning process. The methodology and structured group interactions on which this technology should be based have been demonstrated and are discussed in the context of planning for earthquakes and catastrophic oil spills.	https://fire-in.eu/en/challenges-resources/validated-solutions/a-framework-for-the-application-of-group-decision-support-systems-to-the-problem-of-planning-for-catastrophic-events2	FCCC-19, CCC-21, CCC-22, FCCC-23
96	Full-scale regional exercises	We examined a full-scale regional exercise (FSRE) to identify gaps in logistics and operations during a simulated mass casualty incident.	https://fire-in.eu/en/challenges-resources/validated-solutions/full-scale-regional-exercises2	FCCC-19, CCC-21, CCC-22, FCCC-23
97	Information and Expertise Sharing in Inter-Organizational Crisis Management	Our work entails an examination of the practices of information and expertise sharing, and the obstacles to it, in inter-organizational crisis management. We conceive of this as a design case study, such that we examine a problem area and its scope; conduct detailed enquiries into practice in that area, and provide design recommendations for implementation and evaluation.	https://fire-in.eu/en/challenges-resources/validated-solutions/information-and-expertise-sharing-in-inter-organizational-crisis-management	FCCC-19, CCC-21, CCC-22, FCCC-23
98	MULTIPLE TYPES OF SENSOR DATA; CHALLENGES AND PERSPECTIVES FOR AN OPERATIONAL PICTURE FOR RESPONSE TO CRISES WITH	Taking into account the experience of the recent past and anticipating future developments, crises with mass involvement require the availability of holistic data sources. Such data have to be integrated into the crisis management procedures to gain the necessary, full-scale operational pictures for an efficient, timely, and sustainable response by the teams in the field and on strategic levels. Learning from past developments and practice examples it becomes clear, that additional, multiple types of sensor data can and should be taken into account and integrated. Thus, special needs, targeted assistance in emergencies, but also security related issues like the separation of rivaling groups can be facilitated. Due to the inclusion of multiple types of sensors like audio	https://fire-in.eu/en/challenges-resources/validated-solutions/multiple-types-of-sensor-data-challenges-and-perspectives-for-an-operational-picture-for-response-to-crises-with-mass-involvement2	FCCC-19, CCC-21, CCC-22, FCCC-23

This project has received funding from the European Union's Horizon 2020 Coordination and Support Action programme under grant agreement No 740575.

No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	MASS INVOLVEMENT	data, chemical sensing, digital meta-data or enhanced pattern detection and processing adding up to commonly used visual sources, the tackling of blind spots and weaknesses in current crisis management can be supported.		
99	GIS in Disasters and Emergency Management	GIS is a tool that can help both in the planning phase to develop contingency scenarios and in the operational phase when teams are on the ground attending to the effects of a disaster. This paper describes the use of GIS in disaster planning.	https://fire-in.eu/en/challenges-resources/validated-solutions/gis-in-disasters-and-emergency-management	CCC-21
100	IMPROVING CRISIS COMMUNICATION SKILLS IN HEALTH EMERGENCY MANAGEMENT	Aiming at setting up a common pattern of content in crisis communication and health emergency management a consortium of six partners from Portugal, Spain, Italy, Germany, Belgium and Denmark is developing an innovative training approach, to support health authorities to improve the cooperation with the others actors involved in health emergency management and crisis scenarios.	https://fire-in.eu/en/challenges-resources/validated-solutions/improving-crisis-communication-skills-in-health-emergency-management	FCCC-12, FCCC-20
101	An architecture for co-designing participatory and knowledge-intensive serious games	In this paper we present the "Architecture for Representations, Games, Interactions, and Learning among Experts" (ARGILE) suitable for "participatory and knowledge-intensive" serious games. It proposes solutions within the context of targeted learning, concerning scenarios, in which conception of serious games, and their utilization through a better share by designers is considered.	https://fire-in.eu/en/challenges-resources/validated-solutions/an-architecture-for-co-designing-participatory-and-knowledge-intensive-serious-games	FCCC-12, FCCC-20
102	Education and Training in Crisis Management	This article aims to highlight the inconsistence in educating "target groups" in the field of crisis management which is becoming a systematic problem in the educational system of the Czech Republic. Moreover, the paper analyses the possibility to prepare "a common minimum", which could be reflected in curricula of universities and colleges preparing students in the field of crisis management.	https://fire-in.eu/en/challenges-resources/validated-solutions/education-and-training-in-crisis-management	FCCC-12, FCCC-20
103	INFORMATION TECHNOLOGIES AND THEIR USAGE IN CRISIS MANAGEMENT AS A TOOL TO INCREASE THE QUALITY OF EDUCATIONAL PROCESS	The purpose of the research is to define the procedures of the crisis management and use information technologies to create simulation, which will increase the quality of educational process.	https://fire-in.eu/en/challenges-resources/validated-solutions/information-technologies-and-their-usage-in-crisis-management-as-a-tool-to-increase-the-quality-of-educational-process	FCCC-12, FCCC-20
104	E-LEARNING TECHNOLOGIES IN SUPPORT OF CRISIS MANAGEMENT	The possibilities of Computer Based Training help in an efficient manner to improve the organizational culture by developing the cooperation spirit between the structures that are activated in the virtual model assuring the suitable instruments as for the performers to find good solutions for the operational environment created for them. Based on the experience of the leaders, computers can be used to extend learning. By implementing the process of e-Learning in crisis management at all levels, facilitates quick connection of the national system that are dealing with the situation with similar European and NATO sub-systems, with the help of computers.	https://fire-in.eu/en/challenges-resources/validated-solutions/e-learning-technologies-in-support-of-crisis-management	CCC-13, CCC-15
105	Education in Disaster Management and Emergencies	The European Union's (EU) increasing visibility as a disaster response enterprise suggests the need not only for financial contribution but also for instituting a coherent disaster response approach and management structure. The DITAC (Disaster Training Curriculum) project identified deficiencies in current responder training approaches and analyzed the	https://fire-in.eu/en/challenges-resources/validated-solutions/education-in-	CCC-13, CCC-15

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
		characteristics and content required for a new, standardized European course in disaster management and emergencies.	disaster-management-and-emergencies	
106	SIN	This article presents a new multimedia-based teaching tool SIN that has been designed for computer-supported theoretical knowledge delivery during fire-fighter training, where the emergency operations are visualised within environments familiar to the trainees. This application has already been successfully tested and is currently in use by the fire-fighter school at the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief. (C) 2013 Elsevier Ltd. All rights reserved.	https://fire-in.eu/en/challenges-resources/validated-solutions/sin	CCC-13, CCC-15
107	Specialisation and training for fire-fighters driving heavy rescue vehicles	Our study concerns the improvement of this training, taking account of the particularities of driving these vehicles in emergency situations typical to the profession of fire-fighters.	https://fire-in.eu/en/challenges-resources/validated-solutions/specialisation-and-training-for-fire-fighters-driving-heavy-rescue-vehicles	CCC-13, CCC-15
108	SOCIAL MEDIA IN CRISIS SITUATIONS	In the last decade an alternative approach has been introduced, which promises to cover many of the gaps and blind spots of the classical approach: Social Media. We discuss the available Social Media and their use in responding to disasters.	https://fire-in.eu/en/challenges-resources/validated-solutions/social-media-in-crisis-situations	CCC-13, CCC-15
109	Identification of local information items needed during search and rescue following an earthquake	This paper aims to identify the local information items that are needed by search and rescue (S&R) teams for an effective disaster response following an earthquake.	https://fire-in.eu/en/challenges-resources/validated-solutions/identification-of-local-information-items-needed-during-search-and-rescue-following-an-earthquake	CCC-13, CCC-15
110	Dynamic and Context Aware Reporting of Observations from the Field for Situation Assessment in Crisis Situation	In this paper we present a concept system for crisis management with focus on how observations from the field are reported using hand held devices and integrated into a common operational picture. The application used for reporting situation from the field adapts to the current situation in real time by adding and hiding input field based on what the user is reporting.	https://fire-in.eu/en/challenges-resources/validated-solutions/dynamic-and-context-aware-reporting-of-observations-from-the-field-for-situation-assessment-in-crisis-situation	CCC-13, CCC-15
111	Critical Message Scheduling for Disaster Response and Recovery Phases	In this paper, we use the combination of contextual information including importance, urgency, and uniqueness to schedule messages under extreme situations.	https://fire-in.eu/en/challenges-resources/validated-solutions/critical-message-scheduling-for-disaster-response-and-recovery-phases	CCC-13, CCC-15
112	Big data analytics for disaster response and recovery through sentiment analysis	In this paper, we propose a big data driven approach for disaster response through sentiment analysis. The proposed model collects disaster data from social networks and categorize them according to the needs of the affected people. The categorized disaster data are classified through machine learning algorithm for analyzing the sentiment of the people.	https://fire-in.eu/en/challenges-resources/validated-solutions/big-data-analytics-for-disaster-response-and-recovery-through-sentiment-analysis	CCC-13, CCC-15
113	Challenges to effective crisis management	The purpose of this study is to identify the major challenges to coordination between emergency department (ED) teams and emergency medical services (EMS) teams.	https://fire-in.eu/en/challenges-resources/validated-	CCC-13, CCC-15

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
			solutions/challenges-to-effective-crisis-management	
114	Socializing in emergencies-A review of the use of social media in emergency situations	Social media tools are integrated in most parts of our daily lives, as citizens, netizens, researchers or emergency responders. Lessons learnt from disasters and emergencies that occurred globally in the last few years have shown that social media tools may serve as an integral and significant component of crisis response. Communication is one of the fundamental tools of emergency management. It becomes crucial when there are dozens of agencies and organizations responding to a disaster.	https://fire-in.eu/en/challenges-resources/validated-solutions/socializing-in-emergencies-a-review-of-the-use-of-social-media-in-emergency-situations	CCC-13, CCC-15
115	Crisis Communication in Libraries	Among the many roles librarians embrace, managing outreach, marketing, and communication are increasingly important. This is especially true during a natural disaster or other crisis situation that might occur in a library. Media and public relations are often the last aspects of crisis management that libraries consider when they complete emergency preparations. A description of a case study in one university library demonstrates implementation of the theory of crisis communication to achieve results of community engagement and trust.	https://fire-in.eu/en/challenges-resources/validated-solutions/crisis-communication-in-libraries	CCC-13, CCC-15
116	Burnside-Lawry, Judy; Carvalho, Luis (2015): Building local level engagement in disaster risk reduction. A Portugese case study. In: Disaster Prevention and Management 24 (1), S. 80–99. DOI: 10.1108/DPM-07-2014-0129.	Contributing to the global dialogue on disaster risk reduction (DRR), the purpose of this paper is to address a key priority for the Post-2015 Framework for DRR (HFA2) by analysing initiatives used by one local government to increase local-level engagement in DRR.	https://fire-in.eu/en/challenges-resources/validated-solutions/burnside-lawry-judy-carvalho-luis-2015-building-local-level-engagement-in-disaster-risk-reduction.-a-portugese-case-study.-in-disaster-preve	CCC-5, CCC-17
117	EASeR (Enhancing Assessment in Search and Rescue)	identify all the relevant elements to overcome USAR assessment problems and to enhance response capacity in a complex emergency scenario due to catastrophes (i.e. earthquake).	https://fire-in.eu/en/challenges-resources/validated-solutions/easer-enhancing-assessment-in-search-and-rescue	CCC-1
118	DHRS-CIM (Distributed Human-Robot System for Chemical Incident Management)	Deliver, through a strategic and intersectoral exchange of researchers, an intelligent decision support system for humans to manage chemical incidents.	https://fire-in.eu/en/challenges-resources/validated-solutions/dhrs-cim-distributed-human-robot-system-for-chemical-incident-management	CCC-1
119	COSMIC (The COntribution of Social Media In Crisis management)	identify the most effective ways to utilise new information and communication technologies (ICTs) in crisis situations for the protection of ordinary citizens	https://fire-in.eu/en/challenges-resources/validated-solutions/cosmic-the-contribution-of-social-media-in-crisis-management	CCC-2, CCC-5, FCCC-7

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
120	MEDI@4Sec: Understanding of the opportunities, challenges and ethical consideration of social media use for public security	Understanding of the opportunities, challenges and ethical consideration of social media use for public security	https://fire-in.eu/en/challenges-resources/validated-solutions/medi-4sec-understanding-of-the-opportunities-challenges-and-ethical-consideration-of-social-media-use-for-public-security	CCC-2, CCC-5, FCCC-7
121	SAYSO project (Standardization of Situational Awareness sYstems to Strengthen Operations in civil protection)	situational awareness systems for multiple stakeholders: roadmap and reference architecture	https://fire-in.eu/en/challenges-resources/validated-solutions/sayso-project-standardization-of-situational-awareness-systems-to-strengthen-operations-in-civil-protection	CCC-3, CCC-14, CCC-15
122	TACTIC project (Tools, methods And training for CommuniTIes and Society to better prepare for a Crisis)	The overall aim of the TACTIC project is to increase preparedness to large-scale and cross-border disasters amongst communities and societies in Europe.	https://fire-in.eu/en/challenges-resources/validated-solutions/tactic-project-tools-methods-and-training-for-communities-and-society-to-better-prepare-for-a-crisis	CCC-6, FCCC-7
123	HEIMDALL: enhance cooperation and inter-organizational coordination	Solutions to enhance cooperation and inter-organizational coordination, based on technologies already existing or currently under development	https://fire-in.eu/en/challenges-resources/validated-solutions/heimdall-enhance-cooperation-and-inter-organizational-coordination	CCC-3, CCC-14, CCC-15
124	WUIWATCH (Wildland - Urban Interface Forest Fire Risk Observatory and Interest Group in Europe)	The objective is to create and consolidate a European Observatory on prevention and defence against forest fires affecting urban areas and communities in the so called Wildland-Urban interfaces (WUI) in Europe by assembling a permanent forum and a special interest group.	https://fire-in.eu/en/challenges-resources/validated-solutions/wuiwatch-wildland-urban-interface-forest-fire-risk-observatory-and-interest-group-in-europe	CCC-3, CCC-14, CCC-15
125	MIRACLE (MobIle Laboratory Capacity for the Rapid Assessment of CBRN Threats Located within and outside the EU)	harmonize the definition of a CBRN mobile laboratory and to identify the needs and solutions for deployment in- and outside the EU	https://fire-in.eu/en/challenges-resources/validated-solutions/miracle-mobile-laboratory-capacity-for-the-rapid-assessment-of-cbrn-threats-located-within-and-outside-the-eu	FCCC-19, CCC-22, FCCC-23
126	IDIRA (Interoperability of data and procedures in	This core result of IDIRA will take the form an architectural framework and an exemplary implementation of a Mobile Integrated Command and Control Structure supporting co-ordinated large-scale disaster management.	https://fire-in.eu/en/challenges-resources/validated-solutions/idira-	FCCC-19, CCC-22, FCCC-23

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	large-scale multinational disaster response actions)		interoperability-of-data-and-procedures-in-large-scale-multinational-disaster-response-actions	
127	C2-Sense (Interoperability Profiles for Command/Control Systems and Sensor Systems in Emergency Management)	C2-SENSE project's main objective is to develop a profile based Emergency Interoperability Framework by the use of existing standards and semantically enriched Web services to expose the functionalities of C2 Systems, Sensor Systems and other emergency/crisis management systems.	https://fire-in.eu/en/challenges-resources/validated-solutions/c2-sense-interoperability-profiles-for-command-control-systems-and-sensor-systems-in-emergency-management	CCC-11
128	SecInCoRe (Secure Dynamic Cloud for Information, Communication and Resource Interoperability based on Pan-European Disaster Inventory)	The overall objective of SecInCoRe (Secure Dynamic Cloud for Information, Communication and Resource Interoperability based on Pan-European Disaster Inventory) is to identify data sets, processes, information systems and business models used by first responders and Police authorities leading to a dynamic and secure cloud based 'common information space'.	https://fire-in.eu/en/challenges-resources/validated-solutions/secincore-secure-dynamic-cloud-for-information-communication-and-resource-interoperability-based-on-pan-european-disaster-inventory	CCC-15
129	EPISECC project (Collaborative Project which will Establish a Pan-European Information Space to Enhance seCurity of Citizens)	The project EPISECC is aiming at developing a concept of a common "European Information Space". This information space is dedicated to become the key element in a future integrated pan-European crisis and disaster response capacity. Besides the development of a common Taxonomy and an ontology model, aimed at addressing the Semantic Interoperability issue, EPISECC will focus on the establishment of Interoperability at Physical (i.e. network) and Syntactical (i.e. automated information exchange) levels. One of the main purposes of the EPISECC approach, is to allow analysis of interoperability at all levels.	https://fire-in.eu/en/challenges-resources/validated-solutions/episecc-project-collaborative-project-which-will-establish-a-pan-european-information-space-to-enhance-security-of-citizens	CCC-15
130	COBACORE	Close the collaboration gaps between stakeholders involved in post-crisis recovery, especially with regard to local communities	https://fire-in.eu/en/challenges-resources/validated-solutions/cobacore	CCC1, FCCC-24
131	Fire Regulation Compliance through Alternative Solutions	On this page you'll find a summary of the process that can be used to develop Alternative Solutions. Three WoodSolutions Technical Design Guides have been written to summarise the Alternative Solution process for each element. The guides are:	https://fire-in.eu/challenges-resources/reviewed-solutions/fire-regulation-compliance-through-alternative-solutions	CCC-13, CCC-15

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Table 37: All Standardization solutions (standards, guidelines, best practices) uploaded to the e-FIRE-IN platform. The colour denotes the traffic light system colour according to WP3 leader assessment.

No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
1	Decontamination procedures	Procedure for decontaminating individuals as well as victims of a mass casualty incident. It was derived from Guidelines for Mass Casualty Decontamination during an HAZMAT/Weapon of Mass Destruction Incident: Volumes I and II, published by the U.S. Army Edgewood Chemical Biological Center (ECBC) and updated in August 2013, and from the Emergency Response Safety and Health Database.	https://fire-in.eu/challenges-resources/validated-solutions/decontamination-procedures	CCC3, CCC-11, FCCC-12, CCC-18, CCC-21, FCCC-23
2	Entrainement interministériel zonal NRBCE - France	Objectifs - Améliorer les capacités d'intervention face aux menaces et aux risques NRBC-e - Partager des connaissances spécifiques à chaque entité - Amplifier l'interopérabilité - Optimiser les capacités conjointes des acteurs de l'intervention Organization Ces entrainements sont financés par le CNCMFE. Ils sont réalisés et joués au sein des sept zones de défense. Concrètement, l'EIZ se déroule sur 2 journées : - J1 Apport théorique et ateliers de mécanisation selon son secteur d'appartenance - J2 Entrainement	https://fire-in.eu/challenges-resources/validated-solutions/entrainement-interministeriel-zonal-nrbce-France	CCC-11
3	GUIDE FOR CORONAVIRUS PLANNING & RESPONSE	As fire departments and local governments continue planning to respond to Coronavirus (COVID-19) occurrences in their communities, the IAFC Coronavirus Task Force has developed a guide to identify key recommendations, best practices, and considerations.	https://fire-in.eu/challenges-resources/validated-solutions/guide-for-coronavirus-planning-response	CCC-2, CCC-5, FCCC-7
4	Integrated flood management tools series management of flash floods	This publication is part of the "Flood Management Tools Series" being compiled by the Associated Programme on Flood Management. The "Management of Flash Floods" Tool is based on available literature and draws findings from relevant works wherever possible. The Tool is considered as a resource guide/material for practitioners and not an academic paper.	https://fire-in.eu/challenges-resources/validated-solutions/integrated-flood-management-tools-series-management-of-flash-floods	CCC-13, CCC-15
5	CBFIM – VILLAGE DEFENSE	In order to enhance the capabilities of local rural communities to defend themselves against wildfires a set of guidelines was developed for the Balkans as a pilot region, designed to be adapted to the conditions of other regions and countries as deemed appropriate.	https://fire-in.eu/challenges-resources/validated-solutions/cbfim-village-defense	CCC5, CCC-17
6	Guidelines to increase the benefit of social media in emergencies	The EmerGent project summarised its findings and conclusions in the form of guidelines and provides a list of recommendations for emergency services and citizens on how to make the most of social media.	https://fire-in.eu/challenges-resources/validated-solutions/guidelines-to-increase-the-benefit-of-social-media-in-emergencies	CCC5, CCC-17
7	ORGANIZATION DE LA RÉPONSE SANITAIRE	L'objectif principal est de s'adapter aux risques et de limiter les brassages et les échanges au sein du Service: Activation d'une cellule de veille « Coronavirus » Rappels des consignes en matière de prévention et d'hygiène individuelle et collective, augmenter le niveau de rigueur S'assurer de la présence des produits d'hygiène et de nettoyage et dresser l'inventaire des stocks existants (savon, gel hydro alcoolique, lessives…).	https://fire-in.eu/challenges-resources/validated-solutions/organization-de-la-reponse-sanitaire	CCC2, FCCC-4, CCC-5, FCCC-7, FCCC-16

This project has received funding from the European Union's Horizon 2020 Coordination and Support Action programme under grant agreement No 740575.

No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
8	Flash info covid 19 - french content	La réorganization du SDIS qui vise à inscrire notre capacité opérationnelle dans la durée pour fournir un service public de qualité et un niveau de protection aux agents optimal est aujourd'hui en place. Ainsi une distribution de masques chirurgicaux et de solutions hydro-alcooliques vers les centres de secours va débuter selon les modalités établies par la chaine logistique.	https://fire-in.eu/challenges-resources/validated-solutions/flash-info-covid-19-french-content	CCC-1, CCC-2, CCC-5, FCCC-7
9	Firefighters Plus	The first online platform (www.firefightersplus.eu) for firefighters on how to use their position as role models to promote fire safety among the most vulnerable groups has been developed. The platform includes the following sections:	https://fire-in.eu/challenges-resources/validated-solutions/firefighters-plus	FCCC-8
10	Global Recommendations for Emergency Services Organizations to manage the outbreak of COVID-19	Recommendations on the use of emergency numbers and communication techniques to the public, paying attention to misinformation.	https://fire-in.eu/challenges-resources/validated-solutions/global-recommendations-for-emergency-services-organizations-to-manage-the-outbreak-of-covid-19	CCC-1, CCC-21
11	Development of Trauma-Informed Practices in US Classrooms and Refugee Camps in Greece	Identification of best practices in social and emotional learning that educators and volunteers could use in different environments and situations. U.S. Child Traumatic Stress Network distributed resources for teachers, primary care providers, clinicians, and parents for children traumatized by refugee trauma, natural disasters, and other severe stressors.	https://fire-in.eu/challenges-resources/validated-solutions/development-of-trauma-informed-practices-in-us-classrooms-and-refugee-camps-in-greece	CCC-5, CCC-6, FCCC-7, FCCC-8, FCCC-10, CCC-11, FCCC-12, CCC-17, CCC-18, FCCC-20
12	Mocking Disaster with NIMS: Global Disaster Policy	National Incident Management System (NIMS) is a template that is used as a national model for natural and man-made disasters in USA. It is a proactive guide to authorize disaster responders to seamlessly address all of the theoretical possibilities and needs subsequent to a disaster. Its primary purpose is to create a common approach to calamities.	https://fire-in.eu/fr/challenges-resources/validated-solutions/mocking-disasters-with-nims-global-disaster-policy	CCC-5, CCC-6, FCCC-7, FCCC-8, FCCC-10, CCC-11, FCCC-12, CCC-17, CCC-18, FCCC-20
13	Mappe degli effetti	Feedback from the affected population after an earthquake: www.haisentitoilterremoto.it this can be an exemple on how to prepare similar platforms for feedback from population in other types of risk.	https://fire-in.eu/en/challenges-resources/validated-solutions/mappe-degli-effetti	CCC-6, FCCC-7
14	TAFF (Development of operational strategies and guidance on Tackling consequences of extreme rainfalls and Flash Floods)	The consortium intends to provide a full process beginning with localized knowledge and ending with a comprehensive response approach that can be used to improve flash flood response in the EU. Specific products such as guidelines and tactical guidance documents will be created and tested in specifically developed trainings and exercises.	https://fire-in.eu/en/challenges-resources/validated-solutions/taff-development-of-operational-strategies-and-guidance-on-tackling-consequences-of-extreme-rainfalls-and-flash-floods	CCC-1
15	DARWIN: improving responses to expected and unexpected	resilience management guidelines: https://h2020darwin.eu/wp-content/uploads/2018/08/DARWIN-Resilience-Management-Guidelines_Book_220818-1.pdf	https://fire-in.eu/en/challenges-resources/validated-solutions/darwin-improving-responses-to-	FCCC-12, FCCC-20

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No.	Name of Solution	Short Description	Link to the FIRE-IN e-platform	CCCs/FCCCs addressed
	crises affecting critical societal structures; resilience guideline		expected-and-unexpected-crises-affecting-critical-societal-structures-resilience-guideline	
16	EDUCEN: the role of culture in disaster risk	handbook, toolkit and case study manuals as examples to enhance the capabilities of the main actors involved in the different phases of DRR, and especially in crisis management, to use cultural aspects as an asset to increase the effectiveness of their actions.	https://fire-in.eu/en/challenges-resources/validated-solutions/educen-the-role-of-culture-in-disaster-risk	FCCC-12, FCCC-20
17	FUME (Forest fires under climate, social and economic changes in Europe, the Mediterranean and other fire-affected areas of the world)	"documenting and evaluating which changes in the land or in other factors occurred in the last decades that affected forest fires understanding of the causes underlying past changes in fire regime and with projections of future (XXI century, several time-slices) climate and other socioeconomic factors that could affect fire, projections of the likely impacts on the vegetation and landscapes and on fire regime will be made	https://fire-in.eu/en/challenges-resources/validated-solutions/fume-forest-fires-under-climate-social-and-economic-changes-in-europe-the-mediterranean-and-other-fire-affected-areas-of-the-world	CCC-1
18	DITAC (Disaster Training Curriculum)	holistic and highly structured curriculum for first responders and strategic crisis managers that are tasked in dealing with disasters on a national and international scale.	https://fire-in.eu/en/challenges-resources/validated-solutions/ditac-disaster-training-curriculum	CCC-21
19	PEP (Public Empowerment Policies for Crisis Management)	best practices in a community approach to crisis resilience, and gives directions for future research and implementation, including the use of social media and mobile services	https://fire-in.eu/en/challenges-resources/validated-solutions/pep-public-empowerment-policies-for-crisis-management	CCC-5, CCC-17
20	OASIS Tactical Situation Object A route to interoperability	In this document we describe the adoption of a common European standardised interchange format (Tactical Situation Object TSO), one of the cornerstones of the OASIS Project (Open Advanced System for Disaster and Emergency Management) enabling a minimum level of interoperability between civil protection agencies using heterogeneous systems during operations by sharing a timely and comprehensive operating picture.	https://fire-in.eu/en/challenges-resources/validated-solutions/oasis-tactical-situation-object-a-route-to-interoperability	CCC-11

Table 38: All technological solutions (technological innovations and technological outputs of projects) uploaded to the e-FIRE-IN platform. The colour denotes the traffic light system colour according to WP3 leader assessment.

No.	Name of Solution	Short Description	CCCs/FCCCs addressed
1	Climate change scenarios at the local scale	State of the art technological innovation, which assesses the vulnerability of infrastructure to meteorological hazards, due to the cilmate change phenomenon. It contains a large database and maximizes the re-use of existing related technologies. Based on the description of the supplier, the technology is available on the market and is used at least in pilot projects. It seems that it is in the form of service inside a decision support system. Not further information is provided if the system is currently in use by an organization outside the project CLARITY (H2020).	FCCC-10, FCCC-12, CCC-18, CCC-21

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
		Link to FIRE-IN e-platform: https://fire-in.eu/challenges-resources/validated-solutions/climate-change-scenarios-at-the-local-scale	
2	Saver: management system for vulnerable elements	A GIS with weather analytics and tools for risk assessment. Based on the description provided by the supplier, it is already in operational use and its continued to further development and customisation for Latin American countries. Interoperable with other systems. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/saver-management-system-for-vulnerable-elements	CCC-18, CCC-21, FCCC-24
3	Fire simulator	Use of related technologies (GIS web platform, e.t.c.) and assessment of already existing or future threats, which are related to weather conditions. Essential for fir fighting and civil protection agencies. Similar to the previous although concentrated to forest fires. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/saver-management-system-for-vulnerable-elements	FCCC-24
4	Weather forecasts systems (WFS) and Early Warning Systems (EWS)	Meteogrid provides detailed forecasting services in the short (up to ten days) and medium term (next months) with high spatial resolution. Forecast variables can be transformed into high value-added derivative products to provide warnings or alarms in different sectors of activity, including fire danger and impacts on the territory. Furthermore, these forecasts are supported by gis-web platforms and patented supply systems. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/weather-forecasts-systems-wfs-and-early-warning-systems-ews	CCC-14, FCCC-16, CCC-18, CCC-21, FCCC-23, FCCC-24
5	Toxi-triage project	A set of solutions that is developed in the framework of Toxi-project. The solution is still under development. Although this technological innovation is at a premature level, in the design of the concept the factor of interoperability is already considered. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/toxi-triage-project	CCC-1
6	SAPI - système de surveillance et d'alerte du personnel	A solution that warns first responders for imminent danger and, at the same time, the general public that is entering the safety zone during search and rescue operations. Addresses both first responders and the public. Already in use. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/sapi-systeme-de-surveillance-et-d-alerte-du-personnel	CCC-5
7	Ofire+	Innovation that currently is under development. Technological innovation with high interoperability, using cloud and mobile apps for informing and alerting both agencies, responsible for critical infrastructure and the community. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/ofire	CCC-2, CCC-3, CCC-5, FCCC-7, CCC-14, FCCC-24
8	Seismic Hazard Assessment	This technological innovation assesses the seismic hazard for critical infrastructure combining not only historical data, but also pioneering scientific tools and technologies. Thus, it has high operational value for all civil protection agencies and responders in case of seismic events close to critical structures. Practically a service, not a technogy itself. Technological innovations, especially, high-end seismometers and software for further analysis are used in order to carry out the described services. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/seismic-hazard-assessment	FCCC-12, CCC-18, CCC-21, FCCC-24
9	First responders flow simulation	A behavioral simulator named ONHYS ONE®, that incorporates Building information Modeling (BIM) technology along with spatial processing algorithms that makes it capable of using standard 3D mockups for simulation without further user effort. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/first-responders-flow-simulation	FCCC-24
10	CIPcast DSS, Critical Infrastructure Protection risk analysis and foreCAST Decision Support System	CIPCast is a decision support platform with high level of interoperability that can run scenarios and can provide the user with an overall picture. Already being used in Italy. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/cipcast-dss-critical-infrastructure-protection-risk-analysis-and-forecast-decision-support-system	CCC-3, CCC-11, FCCC-23

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
11	Raybird 3 Fixed-wing Drone / Autonomous Swarm-Unmanned Aerial System	An Unmanned Aerial Vehicle (UAV) with multiple features and capable of completing various missions. This technology is addressed only to professionals and mainly in governmental agencies. Already in the market and used by various organizations. **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/raybird-3-fixed-wing-drone-autonomous-swarm-unmanned-aerial-system	CCC-3, CCC-14, CCC-15, FCCC-16, CCC-21, FCCC-23
12	Aerial Robotic Fire Defender Drone (ARFiDD)	ARFiDD is an innovative fire protection system against fires in open and forest areas, aiming to the detection of fire outbreaks and the support of firefighting, with emphasis on the initial fire intervention. The ARFiDD integrated solution will consist of two types of drone (rotorcrafts), respectively A and B. **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/aerial-robotic-fire-defender-drone-arfidd	CCC-21
13	THE FOREST FIRE DETECTION AND MONITORING SYSTEM	Although this technological innovation is at a premature level, regarding the technological readiness aspect, it has a good operational value potential, especially regarding remote areas, that are difficult to handle during landscape fire crises. Nevertheless, is more a research that can lead to technological innovation than a ready to system, application or sensor. **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/the-forest-fire-detection-and-monitoring-system	FCCC-24
14	SmokeD Wildfire Detector	Technologies are usually used by governmental agencies or critical infrastructure in order to monitor forests and acquire early warnings. Proven capability especially in remote area with small degree of supervision. Already in the market for purchase. **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/smoked-wildfire-detector	CCC-21
15	White Hawk Tethered Aerostat	CNIM Air Space's White Hawk tethered aerostat presents advantages such as 24/7 persistence: the tethered aerostat can be deployed on missions lasting up to several weeks. It is also a mobile solution, with low operational costs (only 1 person to operate the camera) and quickly deployable. Finally, the tethered aerostat is quick to handle and no remote certification pilot is required. **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/white-hawk-tethered-aerostat	FCCC-24
16	drone on a moving platform enabling autonomous landing and battery replacement and further flight	The technology was created for the needs of the Fire Brigade so that interoperability could be ensured. Often the Fire Brigade needs to perform several flights one after the other - the technology was created, among others to improve the battery replacement process of a moving vehicle. **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/drone-on-a-moving-platform-enabling-autonomous-landing-and-battery-replacement-and-further-flight	CCC-1, FCCC-24
17	Real time earthquake shaking maps for Greece	Technological tool, that records earthquakes of magnitude > 3,8 and provides Peak Ground Acceleration and Rotation to both, the civil protection agencies and the general public. Thus, it becomes easier to assess the seismological risk in a certain area, when the seismological hazard and the population vulnerability are combined. System in operation. Built for Greece but it can be adjusted to other areas if necessary input data are provided. Already in operational mode. **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/real-time-earthquake-shaking-maps-for-greece	CCC-1, CCC-3, CCC-5, CCC-6, FCCC-7, CCC-13, CCC-14, CCC-15, FCCC-16, FCCC-24
18	GIS-based Fire Hazard and Risk Assessment	Multi-layer GIS map system with specific fire hazard and risk assessment implemented in online platform. For development of the maps data are used from FIRMS (NASA), Copernicus, OpenStreetMaps, Google Maps and local information depending on local conditions (emergency response capacity, local specific hazards e.g. minefields). **Link to FIRE-IN e-platform:** https://www.fire-in.eu/challenges-resources/validated-solutions/gis-based-fire-hazard-and-risk-assessment	FCCC-4, CCC-6, FCCC-7, FCCC-12, FCCC-16, CCC-18, CCC-21, FCCC-24
19	XENIOS	Solution in development in a collaborative project funded in Greece. Very high operational value and interoperability. It collects data from various sources and disseminates information to both tourists and the Authorities. Moreover, it will provide	CCC-2, FCCC-4, CCC-5, FCCC-7, CCC-14, FCCC-16, CCC-21, FCCC-23

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
		forecasts for potential natural threats and also alerts for the public via a mobile application. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/xenios	
20	Coordination Center for CIP	The national platform for national CIs and the under development information system aims at the systematic information of the Infrastructure operators for their level of risk after analysis of natural and technological risks and anthropogenic threats. In addition, infrastructure operators are requested to provide pilot reporting of emergency safety and security incidents exceeding the limits of their Infrastructure, through a secure online application, in order to inform the competent authorities and to contribute to the register of security incidents. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/coordination-center-for-cip	CCC-11, CCC-14, FCCC-16
21	Automatic Post Earthquake Damage Assessment	The algorithm is under development in its early stages. Image acquisition and data sharing through drone is nowadays a usual task. The aim of the project is to acquire pre- and post-earthquake images of an area, to compare them and evaluate the damage grade in building level or detect changes in the landscape for possible landslide phenomena. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/automatic-post-earthquake-damage-assessment	CCC-1, CCC-3, CCC-13, CCC-14, CCC-15, FCCC-24
22	Automatic FIRE DAMAGE ASSESSMENT	Estimate as fast as possible areas under fire danger. Identify possible routes of evacuation. Monitor for possible future direction of the fire. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/automatic-fire-damage-assessment	CCC-1, CCC-3, CCC-13, CCC-14, CCC-15, FCCC-24
23	Air Logger - device and software that allows measurement of important moving drone parameters	The device is tailored to CNBOP needs and has been developing continuously. The device with the software is currently used to test drones that have their use in broadly scoped fire protection units. That means drones that are declared to be used in specific conditions like conditions that occur in the time of extinguishing and fire protection need to endure specific requirements (not obligatory right now) like proper velocity (that allows it for operational use), accuracy of telemetry, resist to wind blows, etc. All these parameters can be tested by presented equipment. Currently, we are working on a standard that will set specific rules that the drones need to fulfill. **Link to FIRE-IN e-platform:** https://fire-in.eu/fr/challenges-resources/validated-solutions/air-logger-device-and-software-that-allows-measurement-of-important-moving-drone-parameters	CCC-21
24	Identification and tracking of UAV to safe and secure operational areas/zones	Unmanned Traffic Management (UTM) support designated to safely manage future congested U-space traffic. It allows to detect drones that may violate the operational area, contamination zones - i.e. UAV operate by media, reporters, journalists. Moreover, solution may help to manage a local Unmanned Traffic Management form different uniformed services - fire fighters, police, medics. **Link to FIRE-IN e-platform:** https://fire-in.eu/fr/challenges-resources/validated-solutions/identification-and-tracking-of-uav-to-safe-and-secure-operational-areas-zones	CCC-1, FCCC-24
25	Remote detection (form UAV) of potentially infected people	In the current epidemiological situation, drones can help fight coronavirus. Drones equipped with thermal cameras are able to accurately measure the temperature and catch from the crowd of people with fever - automatically suspected of coronavirus infection. The recipients of technology can be uniformed services: police, city guard, army. In the event of a high risk of infection, the services will not risk knocking directly on the door, unless they are properly prepared. **Link to FIRE-IN e-platform:** https://fire-in.eu/fr/challenges-resources/validated-solutions/remote-detection-form-uav-of-potentially-infected-people	CCC-1, CCC-21
26	ENGAGE IMS/CAD (Incident Management & Computer Aided Dispatch)	Based on a highly modular and reconfigurable S/W platform and a reliable, distributed Event Driven architecture, ENGAGE supports comprehensive incident control and dispatching for Public Safety offering an unmatched combination of speed, reliability, and features adaptive to highly complex communication environments. **Link to FIRE-IN e-platform:** https://fire-in.eu/fr/challenges-resources/validated-solutions/engage-ims-cad-incident-management-computer-aided-dispatch	CCC-3, CCC-11, CCC-14, CCC-15, FCCC-16, FCCC-23, FCCC-24

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
27	G-Sense - Earthquake Rapid Damage Assessment for Buildings	Satways Ltd recently developed the G-sense system comprising of a network of sensor nodes installed in different floors of a building measuring acceleration. The gateway is calculating damage probabilities for every floor following an earthquake event and sends damage alerts to a central command and control software that monitors all G-sense installations in different buildings, the nodes state of health and change the nodes and gateway configuration remotely when required. **Link to FIRE-IN e-platform:** https://fire-in.eu/fr/challenges-resources/validated-solutions/g-sense-earthquake-rapid-damage-assessment-for-buildings	CCC-1, CCC-3, FCCC-4, CCC-5, FCCC-12, CCC-13, CCC-14, CCC-15, FCCC-16, CCC-21, FCCC-23, FCCC-24
28	Dronesbench	The device with the software is currently used to test drones that have their use in broadly scoped fire protection units. That means drones that are declared to be used in specific conditions (it refers only to static ones such as mass, center of gravity and not dynamic such as velocity, slope to the ground, capacity of the battery, time of flight). Static parameters can be tested by presented equipment and they are very important for interoperability because they have a big impact for planning a scenario, mission. Currently, we are working on a standard that will set specific rules that the drones need to fulfil. **Link to FIRE-IN e-platform:** https://fire-in.eu/fr/challenges-resources/validated-solutions/dronesbench	CCC-21
29	Custom drone to measure level of explosive gases like methan	The drone is electrical safe - it means that no spark would come out of the whole mechanism (drone and measuring device) during the flight. Tests are made in order to be safely used in explosives zones. It measures gases and sends parameters in real time to server installed in CNBOP-PIB premises. **Link to FIRE-IN e-platform:** https://fire-in.eu/fr/challenges-resources/validated-solutions/custom-dron-to-measure-level-of-explosis-gases-like-methan	CCC-1, FCCC-24
30	Assistant Volunteer	A highly interoperable technological innovation, that not only connects vulnerable citizens with voluntary organizations and government programmes, but also enables the organizations to train, coordinate and supervise volunteers. Moreover, via this innovation, the government programmes and organizations will be provided with suitable tools and applications for the registration and supervision of volunteers, while they are operating in missions, according to the citizens' needs. The application seems to be in a pilot level and have been tested in an operational level yet. Based on the information provided by the supplier, it is also on a level before entering the market and be properly tested. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/validated-solutions/assistant-volunteer	CCC-6, FCCC-7
31	AIOSAT - Autonomous Indoor and Outdoor Safety Tracking System	In a nutshell, AIOSAT proposes a portable system which provides its position and status information (battery life, communication quality of service and any body parameter monitored, if any) to a portable application held by the brigade leader and a PC based application in the Mobile Coordination Center.In the portable device, GNSS positions are enhanced with EGNOS and fused with position information inferred from IMU Pedestrian Dead Reckoning algorithms and Ultrawideband RF interdistance. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/aiosat-autonomous-indoor-and-outdoor-safety-tracking-system	CCC-3, FCCC-4, CCC-14, CCC-15, FCCC-16, CCC-21, FCCC-24
32	Aerial wild firefighting : Suppression of water loss and Enhancement of crew safety	Our proposed solution is to drop water bags. The principle is to wrap water with a specific envelop ; this envelop is built from an innovative membrane (strong enough during the filling, loading and dropping processes but relativeley weak to predictibly burst and optimally spray when hitting the gournd). Our technology allows a wide range of bag size, from 10 liters to few cubic meters.This innovation enable :1. Total suppression of in-flight water loss.2. Better targetting the focused zone.3. Higher safety for the plane and crew.4. Possibilty to process drop by night.5. Suitable for any military transport airplanes; no need of specific planes.6. Better pooling of aerial wild firefighting capacities in EU. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/aerial-wild-firefighting-suppression-of-water-loss-and-enhancement-of-crew-safety	CCC-1
33	PROFITEX (Providing Fire Fighters with	system that supplies mission-relevant information without overwhelming the fire fighter. The ProFiTex system comprises electronic devices like an infrared camera, localisation sensors and a human-computer interface device integrated into the fire fighters' jacket.	CCC-1

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
	Technology for Excellent Work Safety)	**Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/profitex-providing-fire-fighters-with-technology-for-excellent-work-safety	
34	SAT406CM: physiological monitoring application	enhanced communication capability to serve different applications, yet in the scope of this project, one specific application is developed: monitoring the PLB user's physiological status and reporting that to the Rescue Coordination Center (RCC). **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/sat406cm-physiological-monitoring-application	CCC-1
35	INDIGO (Innovative Training & Decision Support for Emergency operations)	innovative system integrating the latest advances in Virtual Reality, Simulation and Artificial Intelligence in order to homogenise and enhance both the operational preparedness and the management of an actual complex crisis. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/indigo-innovative-training-decision-support-for-emergency-operations	FCCC-24
36	ESCUDO (CBRN Communication and Detection System)	CBRNe, Chemical, Biological, Radiological, Nuclear, Warefare Agents, Detection, Counterterrorism. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/escudo-cbrn-communication-and-detection-system	FCCC-24
37	vieWTerra Evolution	vieWTerra Evolution, vieWTerra Mobile and vieWTerra Base form a combined "GIS & Simulation" suite of products allowing responders to rapidly build a virtual 4D representation (3D synthetic environment+ Time dimension) of any potential Crisis area on Earth, available both on desktop PC (off-line/on-line product) and mobile devices (Web browser application for PC, tablets and smartphones). These solutions provide a Common Operational Picture to both the Command Center and the rescue units out in the field. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/viewterra-evolution	CCC-2, CCC-3, CCC-5, FCCC-7, CCC-11, CCC-14, CCC-15, CCC-18, FCCC-24
38	CRISIS (CRitical Incident management training System using an Interactive Simulation environment)	next generation, advanced video game style interactive simulation training system developed to help emergency service personnel and commanders prepare for crisis scenarios such as train and plane crashes, and terrorist attacks. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/crisis-critical-incident-management-training-system-using-an-interactive-simulation-environment	CCC-13, CCC-15
39	L4S (Learning 4 Security)	"L4S project exploits the reality and the needs of organizations to help their managers and personnel in order to develop key skills and competencies in crisis management area through an innovative, highly involving, effective and easy deployable life-long learning service. Simulation-based learning experiences. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/l4s-learning-4-security	CCC-13, CCC-15
40	E2mC Project	E2mC (Evolution of Emergency Copernicus services) project aims at demonstrating the technical and operational feasibility of the integration of social media analysis and crowd-sourced information within both the Mapping and Early Warning Components of Copernicus Emergency Management Service (EMS). **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/e2mc-project	CCC-13, CCC-15
41	DECONTAMINATION: Cold Plasma at atmospheric pressure	Enriched Non-thermal Plasma Technology Toolbox. This system works through air ionization creating reactive species, that in turn, cause chemical reactions or eliminating virus and bacteria. Using just electricity, this breakthrough technology has the ability to challenge current paradigms in the concept of civilian, i.e. health, food and environment, and military (CBRN) protection & decontamination of hazardous Chemical and Biological agents. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/decontamination-cold-plasma-at-atmospheric-pressure	FCCC-24
42	COPE (Common Operational	integrate COTS solutions and novel technologies to achieve a step change in information flow both from and to the first responder in order to increase situational awareness	CCC-1

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
	Picture Exploitation)	across agencies and at all levels of the command chain he project will realise and trial mobile technologies to support first responders by giving them: - the ability to share ground truth with the COP -increased cognitive situational awareness to enhance decision making -support for multi-agency co-operation and communication -the ability to localise personnel, to navigate and to generate maps -the capability to monitor safety issues, tasking, as well as post crisis audit. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/cope-common-operational-picture-exploitation	
43	CATO (CBRN crisis management: Architecture, Technologies and Operational Procedures)	Open Toolbox for dealing with CBRN crises due to terrorist attacks using non-conventional weapons or on facilities with CBRN material. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/cato-cbrn-crisis-management-architecture-technologies-and-operational-procedures	CCC-18
44	FORETRESS (Foresight Tools for Responding to cascading effects in a crisis)	a) foresight tool to assist decision-makers in understanding the potential effects of their decisions in training environments, b) decision support tool that is user-friendly enough to be employed during a crisis to assist real-time decision making. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/foretress-foresight-tools-for-responding-to-cascading-effects-in-a-crisis	FCCC-10, CCC-18
45	CRISMA (Modelling crisis management for improved action and preparedness)	The CRISMA System facilitates simulation and modelling of realistic crisis scenarios, possible response actions, and the impacts of crisis depending on both the external factors driving the crisis development and the various actions of the crisis management team. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/crisma-modelling-crisis-management-for-improved-action-and-preparedness	FCCC-10, CCC-18
46	IN-PREP: Transboundary training platform	Transboundary training platform: addresses responders from different agencies and countries as it enables them to simulate future scenarios and practice together; training formats which will be applied across agencies and countries so that collaboration efforts transfer into optimal preparedness for crisis. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/in-prep-transboundary-training-platform	FCCC-23
47	IGNIS: simulation tool and training packages	mobile simulation tool and training packages that can be used within the partner countries and across Europe to train fire officers in how to safely, effectively and efficiently command and control large wildfires; financed by DG ECHO. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/ignis-simulation-tool-and-training-packages	FCCC-23
48	SECTOR project (Secure European Common Information Space for the Interoperability of First Responders and Police Authorities)	flexible Common Information Space concept that provides users with "peer-to-peer" type functionalities to dynamically set-up cross-agency collaborative platforms and information spaces, for information and resource sharing across agencies and across borders, as required in a specific crisis situation. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/sector-project-secure-european-common-information-space-for-the-interoperability-of-first-responders-and-police-authorities	CCC-15
49	FIRESENSE (Fire Detection and Management through a Multi-Sensor Network for the Protection of Cultural Heritage Areas from the Risk of Fire and Extreme	automatic early warning system integrating multiple sensors to remotely monitor areas of archaeological and cultural interest for the risk of fire and extreme weather conditions. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/validated-solutions/firesense-fire-detection-and-management-through-a-multi-sensor-network-for-the-protection-of-cultural-heritage-areas-from-the-risk-of-fire-and-ext	FCCC-4, FCCC-16

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
	Weather Conditions)		
50	EVAPREM (Developing an evaluation model to assess prevention measures)	Develop a universal and comprehensive model for evaluating the results of prevention measures implemented by the rescue boards of European countries. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/evaprem-developing-an-evaluation-model-to-assess-prevention-measures	FCCC-12
51	Disaster Alleviation in Real Time (DART)	DART is developed from systems designed for army use. It is nodal and requires no central server. It uses fixed messages (Data Links) to send all data. It is designed to be graphical and require no computer knowledge by the operator. It can use any communications medium. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/disaster-alleviation-in-real-time-dart	CCC-1, CCC-3, CCC-14, CCC-15
52	AquaEye – Handheld Sonar Device	AquaEye® from VodaSafe is an advanced handheld underwater scanner that uses the latest sonar technology as well as Artificial Intelligence to identify human bodies underwater and in waters with poor visibility. AquaEye® can scan 8000 square meters of water area in less than 5 minutes. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/aquaeye-handheld-sonar-device	CCC-1
53	BlowHard - Firefighter Ventilators	Fire department ventilators increase extinguishing success and safety Positive pressure ventilation during firefighting operations has become an increasingly important part of firefighting practice over the years. While ventilation is already accepted and common practice in some countries, it is becoming increasingly important in Europe as well as worldwide, as the benefits are now undisputed and well documented. This is also reflected in the number of different PPV positive pressure ventilators now on the market, as well as the new technologies that are in daily use. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/blowhard-firefighter-ventilators	CCC-1
54	Firstlook360 - Search- & Rescuecameras	MORE RELIABLE AND LOWER COST RESCUE WITH SPHERICAL 360 DEGREE RESCUE TECHNOLOGY - The latest spherical 360degree camera technology produces better search results combined with easier operation, because there are no moving components, the camera is less likely to be damaged and will have a longer service life and incur less repair costs. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/firstlook360-search-rescuecameras	CCC-1
55	NANOSENS ATMON FL - a lightweight, mobile gas detector for UAVs	ATMON FL is a modular, lightweight gas detector designed for UAVs. It can hold up to 6 sensors, each dedicated to a different substance. Thanks to the modular construction, the sensors can be replaced by the user in the field. ATMON FL can be used in a variety of applications, including environmental / pollution inspections and assesment of CBRNE-related situations. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/nanosens-atmon-fl-a-lightweight-mobile-gas-detector-for-uavs	CCC-1, CCC-2, FCCC-4, CCC-5, FCCC-7, FCCC-12, FCCC-16, CCC-21, FCCC-24
56	PS-Bridge - Ultra-Light Bridge for Emergencies	Unique light-weight emergency bridge to help restore vital lifelines in disaster-affected areas. The solution is based on the use of an innovative technology called Tensairity, which combines high-pressure inflatable tubes and metallic elements. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/reviewed-solutions/ps-bridge-ultra-light-bridge-for-emergencies	CCC-1
57	SARUAV - software for AI-based aerial photo analysis in SAR missions / missing person mobility simulation / SAR	The software has 3 main functions: 1) missing person mobility simulation: based on initial information (time and location of Point Last Seen, Intended Destination, Travel Time, local SAR statistics) the program calculates how far a person could have travelled by foot in a given terrain and in a given time. 2) UAV should perform a survey flight (autonomous flight plan based on survey pattern. This kind of flight can be programmed easily on the fly in most commercial drone platforms (for example Yuneec H520E, Autel Evo II series, DJI Phantom 4 series, DJI Matrice series).	CCC-1, CCC-3, FCCC-4, CCC-11, FCCC-12, CCC-13, CCC-14, CCC-15, FCCC-16, CCC-18, FCCC-19, CCC-21, CCC-22, FCCC-23, FCCC-24

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No.	Name of Solution	Short Description	CCCs/FCCCs addressed
	mission coordination	3) SAR Mission planning and coordination - apart from the mobility simulation map, we can use the map in the software to draw points lines and sectors, we can also import GPX files from handheld GPS devices to view a rescuer's path. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/saruav-software-for-ai-based-aerial-photo-analysis-in-sar-missions-missing-person-mobility-simulation-sar-mission-coordination	
58	urbanEXODUS – the large-scale Agent Based Evacuation Model	urbanEXODUS is developed by the Fire Safety Engineering Group (FSEG). Capable of representing human behaviour under a variety of hazards including their effect on the evacuating population, the urbanEXODUS variant of EXODUS, provides large-scale capabilities to support crisis managers to prepare for a likely disaster by examining a variety of plausible evacuation scenarios for the area of interest. The tool provides insights on the evacuation process and performance and allows for informed decisions to be taken during the response phase of a disaster. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/urbanexodus-the-large-scale-agent-based-evacuation-model	CCC-1, CCC-2, FCCC-4, CCC-5, FCCC-7, FCCC-12, FCCC-16, CCC-21, FCCC-24
59	WEARIN CONNECTED FIRST RESPONDERS	PROTECTED FIRST RESPONDERS React immediately to emergencies, while predicting and mitigating risks. SITUATIONAL AWARENESS Improve coordination and response times with real-time, two-way data flow and automatic alerts. BIOMETRIC BASED ALARMS Detect acute stress and automatically generate alarms. EASE OF USE Ensure mobility and comfort with lightweight, integrated devices and centralized power. **Link to FIRE-IN e-platform:** https://fire-in.eu/challenges-resources/reviewed-solutions/wearin-connected-first-responders	CCC-1, CCC-17, FCCC-24
60	Yuneec E20tvx dual camera 640x512 Radiometric IR Thermal and 1080p visible light	This camera is integrated with the gimbal and the Yuneec H520E UAV. The camera has two sensors. They can be used at the same time. The UAV with this camera doesn't exceed maximal take off weight of 2,5 kg. It's light, portable and very cost-efficient. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/reviewed-solutions/yuneec-e20tvx-dual-camera-640x512-radiometric-ir-thermal-and-1080p-visible-light	CCC-1, FCCC-24
62	The Earthquake Suitcase	The Earthquake Suitcase contains a portable earthquake simulator representing the horizontal shaking produced by seismic waves. 3D building models of various response to the shaking are constructed on the simulator surface. One portable accelerometer is mounted on the shake table surface, recording and storing the time histories of the simulated strong shaking. **Link to FIRE-IN e-platform:** https://fire-in.eu/en/challenges-resources/solutions-awaiting-validation/the-earthquake-suitcase	CCC-5, CCC-6, FCCC-7, FCCC-8, CCC-17

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