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Abstract:

This document provides the second strategic research and standardisation agenda to improve fire and rescue capabilities in Europe. It is built on the cycle#2 of Fire-In project outputs. The corpus of the document is built as a policy brief, i.e. it is reduced to 20 pages, with extra material attached in appendix.
In a first part, the document focuses on best practises identified by practitioners; in a second part, it focuses on research and publications; in a third part, on technology and innovations; and in a fourth part on standardization. Each part considers a) the challenges; b) the achievements and c) the way to follow.

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Executive Summary

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 purpose of this report is to synthetize and merge the results from the second cycle of FIRE-IN process, i.e.:

a. The definition of capability challenges expressed by practitioners;
b. The screening of existing resources to address the challenges;
c. The feedback from research and technology providers regarding ability to bridge the gaps.

As a result, the reports guides the European Commission on a second strategic research and standardization agenda that focuses on some key challenges to invest on.

Table 1. FIRE-IN partners

Participant No.	Participant organisation name	Part. short name	Country
1	Pôle de compétitivité SAFE CLUSTER (ex Pôle Pégase)	SAFE	France
2	Ecole Nationale Supérieure des Officiers de Sapeurs-Pompiers – French National Fire Fighter Officers Academy	ENSOSP	France
3	Italian Ministry of Interior, Department of Fire Corps	CNVVF	Italy
4	Bundesanstalt Technisches Hilfswerk	THW	Germany
5	Global Fire Monitoring Center	GFMC	Germany
6	INERIS Development	INEDEV	France
7	Fraunhofer INT	FhG-INT	Germany
8	Fire Ecology and Management Foundation Pau Costa Alcubierre	PCF	Spain
9	Catalonia Fire Service Rescue Agency	CFS	Spain
10	Scientific and Research Centre for Fire Protection	CNBOP	Poland
11	The Main School of Fire Services	SGSP	Poland
12	Council of Baltic Sea States Secretariat	CBSS	Sweden
14	Center for Security Studies	KEMEA	Greece
15	Czech Association of Fire Officers	CAFO	Czech Republic
16	inno TSD	inno	France

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1. Introduction

One of the main objectives of FIRE-IN project is to provide recommendations to develop research and standardization that is aligned with both practitioners' needs and research and technology developers (RTD)' capabilities. Therefore, it can only happen after a full cycle of the project is completed: i) identification of challenges from the practitioners' perspective; ii) screening of existing solutions; iii) consultation with industry and research networks.

The final objective is to provide inputs for the European Commission to build the roadmap of research and standardization in the field of fire and rescue. As the FIRE-IN project is made of three cycles, this deliverable delivers the second cycle's results.

At the end of the first cycle[1], we realized a cross-analysis of the key challenges identified by the Fire and Rescue community, on one hand, and, on the other hand, the findings and the ongoing research and innovation that could potentially address those challenges.

Then, FIRE-IN conclusions were that the top-two subjects still to address were:

- Foster risk tolerance and resilience.
- Boost interaction with the public during crises.

However, much more challenges and R&I promising achievements were also investigated during this first cycle, even if they were not fully presented in that 1st cycle deliverable[1].

In the second cycle, we invited the practitioners to review a wider set of challenges they identified as important and to assess research and innovation products we had identified in regard their applicability to address those challenges[2]. We also invited them to present and discuss best practises they have developed to face the challenges. Those best practises are presented in the first part of this report.

In the second part, we cross the feedback of the practitioners with our cycle#2 screening of solutions[3] to indicate the direction to follow for research.

In the third part, we realize a similar assessment for technology and innovation in regard the result of the request for ideas we disseminated during that second cycle[4].

In the fourth part, we finally address standardization matters in regard the interactions and exchanges we have had with ongoing projects and initiatives, such as the TIC Council (https://www.tic-council.org/), Stair4Security project (http://cen-stair4security.eu/) and others.

[1] S. Lahaye, O. Salvi and J. Sadowska, 'Fire-In D3.5 Final Strategic Research and Standardization agenda #1', Fire-In consortium, July 2019.
[2] C. Gallardo et al., 'Fire-In D1.3 report on current and future common capability challenges (CCCs & FCCCs)#2', Fire-In consortium, July 2019.
[3] G. Walther et al., 'Fire-In D2.3 RDI and standardisation screening report', Fire-In consortium, February 2020.
[4] G. Sakkas et al., 'D3.3 Results of the Request for Ideas: mapping RTOs and Industry potential, response and trends related to Fire-IN CCC/FCCCs #2', Fire-In consortium, June 2020.

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2. Policy and Best practises

2.1. Challenges

On request of the European Commission during the project review, Fire-In consortium produced five Policy Briefs, one per Task Working Group, in January 2020[5].
These Policy Briefs pointed out the key challenges identified by practitioners during two rounds of workshops and also presented best practises they had highlighted.
Some of the challenges identified may indeed not be addressed by any innovation or technology, and, even if research or standardization could support, they are not at the roots of potential solutions. For those challenges, only changes in policies or sharing and upgrading best practises would close the gap.

Most the challenges falling into this category, listed here below, belong to the capability of 'Community involvement', as defined in FIRE-IN matrix of challenges[6]. Others refer to 'Incident Command Organization', sometimes in connection with the 'Knowledge cycle' within those organisations and their capability for 'Pre-planning'.

Community involvement

- High media coverage on response, vs. prevention, drives budget
- Unrealistic high expectation of communities to be fully protected
- Because of the low frequency of disasters, responders, stakeholders and communities are not building tolerance to coexist with these risks.
- The difficulty to involve citizens who are willing to help while a major disaster;

Incident Command Organization (+ *Knowledge cycle* and *Pre-planning*)

- The multiplicity of agencies involved in response, which does not share the same objectives and methods, with a special emphasis for cross-border or international disasters;
- Low frequency of disasters challenges the capacity to build knowledge, competency and interoperability in a scenario with fragmented responsibilities;
- High level of social exigence in case of disasters forces the focus on short-term, known risks, increasing the risk of collapse in front of uncertain, high impact risks;
- Too rigid response organisations are not able to overcome fast evolving situations with a high level of unexpected developments.

2.2. Achievements

During the workshops, practitioners also identified best practices and initiatives that can address those challenges. They are listed below.

[5] Fire-In Consortium, Thematic Policy Briefs for the European Commission, January 2020, https://projectnetboard.absiskey.com/viewdocument/0ec9b5-53e9a8-02ff45-3f6126-000183

[6] S. Lahaye et al., 'Fire-In D1.2 Report on current and future common capability challenges (CCCs and FCCCs) #1', Fire-In consortium, September 2018

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Community involvement

In Europe there are local, regional or wider initiatives to engage with the population, generally to address a specific risk:

- The city of Frankfurt issued a brief information to all relevant households via mail to inform them on their potential flash flood risk and a pre stamped post card to fill in with requests for further information and there is a flood audit from DWA for private households (*Frankfurt Firefighters, Germany*);
- Firefighters and companies involved in building fires' prevention activities at school to explain the risks and what actions to be taken during an emergency (*Estonia*);
- Networks to support prescribed burnings in connection between firefighters, foresters and farmers (*in France and UK*) and courses in the Western Balkans and the South Caucasus to engage communities with alternative (to fire) farming methods (*GFMC*);
- Public warning systems in EU – activity of European Emergency Number Association https://eena.org/document/public-warning-systems-2019-update/

However, the most impacting initiatives pointed out by practitioners, organized at national policy level, come from outside EU:

- After Black Saturday in Australia (179 dead) there was a paradigm change for fire services from responding to fires with ever more resources to engaging the population and placing more responsibility in their hands (preparedness & during crisis); "firewise" or "fire smart" approaches are also very effective in achieving awareness, preparedness and prevention measure (*Australia & USA*);
- School integrated training of how to behave e.g. for earthquakes (*Japan*);

Incident Command Organization

The practitioners also highlighted best practices that deserve being upgraded to improve the collaboration, training or preplanning of response agencies:

- Boost organizations that facilitate the coordination and work between different agencies allowing intercommunications and integrated mechanisms and procedures. (*DG Echo mechanism*);
- Exchange of expertise through study tours, international workshops, cross-border trainings, round table or other joint exercises or pre-planning scenarios have shown great results (*Pau Costa Foundation*);
  On site trainings with near-real conditions (*Madrid Firefighters, Spain*);
- Detailed risk mapping of fire developments to better predict potential evolutions and lower uncertainty (*Catalan Fire Service, Spain*);
- Use the structural triage (rapid assessment of required treatment) as a way to avoid system collapsing. (*University of Udine, Italy* & *ENSOSP, France*)

COVID 19 Best practices

The COVID 19 crisis has fully fall into the spectrum of unexpected-scale disasters with 'high level of uncertainty'. As a result, practitioners' organizations adapted and developed internal trainings and protocols. A lot were disseminated on FIRE-IN platform https://fire-in.eu/single-pages/coronavirus-european-countries-share-their-best-practices.

Just-in-time training raised as a key concept to face such disasters, as FIRE-IN, ENOTICE, NOFEAR, MEDEA and DARENET projects presented during the 18 June 2020 conference https://www.practitionernetworks.eu/

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2.3. Way to follow

Without neglecting research and innovation coming from academics and private companies, the European Commission may play a role in upgrading and empowering best practises developed by practitioners and acknowledged by their Peers across countries.

Regarding community involvement, beyond best practises, there is a need to booster at policy level the Europe and nations' engagement to shift the current focus from response to prevention and preparedness. This policy engagement would cover several activities, such as school programs for risks awareness, resources to promote local communities and volunteers initiatives, thematic parks for risk…

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3. Research and publications

3.1. Challenges

During the first cycle of discussion with end-users of current challenges faced by their organisations in firefighting, FIRE-IN produced a matrix of common capability challenges (CCCs, see Appendix 1). These challenges were further refined and weighted in the second workshop cycle of the project, which resulted in a list of prioritised capability challenges (PCCs, see Appendix 2). Within the solution screening process of FIRE-IN, research and technological solutions to these challenges were identified. Based on this process, a traffic light system was used to identify which capability challenges are not yet properly being addressed and discussed within the research community.
This short analysis will identify research gaps in two ways. Basis for both analyses is the database of 1700 research articles that was developed in the first and second cycle of the solution screening process of FIRE-IN. The first approach to identify research gaps consisted of matching the research activities and findings of these articles with a 2015 publication by NIST (National Institute of Standards and Technology, U.S. Department of Commerce) on how smart firefighting should look like in the future. Keywords from this publication were used to screen the database. In addition to this quantitative approach, a qualitative approach was conducted as well. In the qualitative approach, the 1700 research article abstracts were searched for potential research gaps. These results were categorized and served as an additional overview of research gaps regarding the challenges of firefighters.

3.2. Achievements

3.2.1. Quantitative Approach – First and second cycle results matched against the NIST Smart Firefighting Report keywords

1700 article abstracts screened during the First cycle of FIRE-IN were explored with 84 keywords extracted from the NIST (National Institute of Standards and Technology, U.S. Department of Commerce) Special Publication 1191 'Research Roadmap for Smart Fire Fighting' (Table 2). Some of those keywords were split up and searched separately, e.g. 'Electronic Textiles and Wearable Technologies' was split into 'electronic textiles' and 'wearable technologies'.
The outcome was classified using the traffic-light system that was previously used in FIRE-IN (see table 2). Keywords not found in any abstract were excluded from this system and collected in table 3. Keywords mentioned 1-15 times were marked red, yellow for those mentioned 16-45 times and green for those with 46-100 findings. There were only three keywords found more than 100 times - 'decision making', 'Command and Control' and 'Search and rescue'. Those were excluded as they are not specific enough. In contrast, those never mentioned may have been too specific.
More than half of the keywords were excluded or marked red (60 of 84), their themes can be clustered into new and different technologies such as sensors or computer-based simulations, but also communication and data management and contribution of data. The first three topics in the table (see table 2) are all related to communication technology and sensors and don't have many findings at all. The same applies to the topics 'hardware/software' and 'non-firefighting data user applications'. The topic of 'Interface delivery methods', did not show many findings as well. However, the keyword 'interface' itself has many, which can lead to the conclusion that there is some research, but it is not to be found with the specialized keywords used here, especially if the search only considered the abstracts.

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The topics 'data collection & pre-emergency and post-event', 'real-time data analytics' and 'use of data during an emergency event' are mainly classified as yellow or green. This shows that the ongoing response in a disaster is researched and described comparatively often. Surprisingly, 'pre-incident planning' also has zero findings, especially as prevention and preparedness and also risk assessment were found more often. Training and exercise which can be seen as parts of pre-planning, are also marked yellow. Additionally, although in general new technologies are not being mentioned very often, this does not apply to robotics, unmanned vehicles and Geographic Information Systems (GIS). Those have a high quota in the abstract keyword search, which shows that they are the exemption, especially as they are already used quite often in current firefighting.
In conclusion, there is ongoing, broad research in the field of response, whereas in the field of technologies and electronic tools and gadgets, there seem to be research gaps or at least a potential for further research.

Table 2 Number of research articles from the database that matched the NIST keywords

Keyword	Amount	Keyword	Amount
Communications Technology and Delivery Methods			
Remote Data Communications Technologies	5	Emergency Responder Wireless Communications	3
Sensors as part of personal protective equipment:			
Sensory Support	1	Tracking and Location	6
Wearable Technologies	3		
Mobile Sensors:			
Portable Equipment	4	Unmanned vehicles	24
Robotics	49	Robotic application architecture	4
Stationary sensors:			
Stationary Sensors	1		
Data collection & Pre-Emergency and Post-Event:			
Planning and analysis:			
Capability assessment	11	Inspection	8
Vulnerability	85	Risk assessment	96
Preparedness:			
Resource Deployment	14	Targeted Mitigation	2
Training and Exercises	29		
Response:			
Routing	26	Mobile applications	39
Field application	45	Evacuation	84
Shelter	30	Mass Care	38
Public Warning	27	Public notification	3
Incident Resource Management	60	Multidisciplinary Coordination	3
Operations Dashboard	2		
Hardware/Software:			

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Component Attributes	4	Certification Standards	1
Interoperability	42	Interface Standards	2
Scale of interoperability	8		
Real-Time data Analytics:			
Computer-based Simulation	3	Decision Theory	30
Prevention and Preparedness	41	User experience	21
Use of data during an emergency event:			
Geographic information systems (GIS)	106	Situational awareness	51
Incident awareness	16	Stream and data management	13
Visualisation	4		
Non-fire fighter data user applications:			
Alerting	3	Risk-Based inspection	9
Emergency dispatch	5	Automatic intervention	1
Manual intervention	1		
User Interface Delivery Methods:			
Gesture interface	2	Immersive / augmented reality	1
Wearable computers	1	bio sensors	6
Context aware and situational awareness	8	Mobile devices	23
Delivery methods	6	Human centered design	2
Interface	66		

Table 3 shows the results of NIST keywords with no hits in our database. There are three likely causes for this fact: a) the keywords are too broad or too narrow, b) the database does not cover this field of research, or c) there is very little research currently being done in this area. Further differentiation between these causes is beyond the scope of this research.

Table 3 Keywords from the NIST publication that did not match any research articles from the database

Keyword	Amount	Keyword	Amount
Sensors as part of personal protective equipment:			
Physiological Monitoring and Measurements	0	Electronic Textiles	0
Mobile Sensors:			
Land-based vehicles	0	Air and water craft	0
Data collection & Pre-Emergency and Post-Event:			
Preparedness:			
Pre-Incident Planning	0		
Response:			
Computer-Aided Dispatch	0	Automatic Vehicle Location	0
In-Vehicle Applications	0		

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Use of data during an emergency event:			
Dashboards	0	Data and metadata repository	0
Non-fire fighter data user applications:			
Mass and targeted Notification	0	Transportation: Routing and Signage	0
User Interface Delivery Methods:			
Voice / speech interfaces	0	Eye Gaze	0
Touch and Haptic Interfaces	0	Vibration interfaces	0
Heads-up displays	0		

3.2.2. Qualitative Approach - First and second cycle results screened for future research remarks

As mentioned above, the additional qualitative approach consisted in the first step of search queries regarding research gap remarks and indications (keywords: 'research gap', 'future research', 'further research', 'research needed', 'research needs', 'research demand'). In the second step the resulting articles were acquired as full texts (if possible) and analysed qualitatively to extract hints to future research based on the content of the paper. In a third step the resulting compilation was categorized with meaningful captions which describe the content. In some cases, only one article formed the basis as it had a unique remark on future research needs or existing research gaps, in some cases several research articles had similar indications and thus were combined. This qualitative approach serves as an additional overview of research gaps regarding the challenges of firefighters. Interestingly this approach resulted in more non-technological fields of study and mostly showed research questions regarding ecosystem management, land use management, disaster risk management processes, communication and organizational aspects. The following table (table 4) represents an overview of the identified and categorized research gaps and needs. The appendix (see Appendix 3) holds a more comprehensive list with additional information such as quotes highlighting this research gap as well as the full reference of the respective paper(s).
Additionally, manual search and qualitative examination of overview, review and meta-study articles has been conducted to supplement the findings with broad perspectives and in some cases more current papers than the first and second cycle screening. However, given the scope of the present deliverable, it could only be an addition to the already used dataset described above without being exhaustive. A broader and systematic qualitative study on this matter poses to be a research need in itself.

Table 4

Categories of research gaps and needs based on the qualitative analysis
Need for projection standards and meaningful fire metrics
Understanding wildfire fuel processes
Development of DGVM-fire models and taking vegetation shifts into account

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Assessing trends and shift in anthropogenic processes related to wildfires
Assessing the effectiveness of fire control policies
Dealing with uncertainties of wildfire management
Research on spatiotemporal dynamics and consequences of climate change
Studies on Wildfire and Land-use as coupled system
Improvement of the use of Social Media
Understanding and Interpreting Weather Warnings
Information Sharing and Coordination in Multi-Agency Disaster Response
Research on leadership in extreme events
Research on spontaneous Volunteering in Disaster Management / Community Involvement
Intergovernmental and interorganizational cooperation
Organizational resilience towards extreme weather events
Community involvement and the role of the private sector in building disaster resilience
Research on supply chains of non-profit organizations in crisis management
Establishing trust in Media Communications
Situational Awareness Tools

3.3. Way to follow

This research has used a quantitative and qualitative approach to identify research gaps in future firefighting. The quantitative approach has identified several areas of research that could be boosted in the future: **sensors, computer-based simulations, communication tools, data management** and **contribution of data to firefighting**. The qualitative approach identified more non-technological gaps such as **ecosystem management, land use management, disaster risk management processes, communication** and **organizational aspects.**

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4. Technological innovations

4.1. Challenges

During the two cycles of FIRE-IN, the challenges referring to technologies according to the practitioners' point of view, which could be considered as fields for further consideration towards standardization were the following

Technological Challenges from the 1st cycle	Technological Challenges from the 2nd cycle
• Use technology to assess risks and minimize responder's engagement (TOP CHALLENGE) • Forecast and simulate complex scenarios • Technological tools to support data sharing • Get a clear picture of the risk evolution	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

Based on the outcomes of deliverable D3.3[4] it became obvious that technologies that are already on the market or are in some stage of development can cover all the 27 Common Capability Challenges of the FIRE-IN project.

Capabilities of "Incident Command Organization", "Pre-planning" and "Technology" are already mature in terms of technologies (green level). This practically means that at least the level of widely used technical formal and informal standards (e.g. WMS) are covered by the tools related to these capabilities. However, even for these capabilities some standardization gaps have still been detected, related mainly to operational procedures and protocols.

The capabilities of "Guidance instruments", "Community Involvement", "Knowledge Cycle" and "Information Management" are still developing. Thus, new technological solutions on these fields are also expected in the coming years. Consequently, these capabilities are scarcely covered by standardized tools and procedures.

The technological solutions screened and analysed during both cycles of FIRE-IN in WP2 and WP3 can be roughly classified in the following categories according to their operational functionality:

- Early warning systems for various hazards and risks.
- Real or near-real time applications, for hazard and risk estimation.
- Monitoring, surveillance and early detection through UAVs, robots and satellites.
- Risk communication mainly to the public.
- Software and sophisticated algorithms embedding Artificial Intelligence (AI), machine learning and deep learning.

A significant number of these screened and analysed technologies have high operational value meaning that either they could be used in an operational environment or are already used by first responders and practitioners. Many solutions are also in a phase of being tested or are the outcome of projects and a small amount is on very early stages of development. Regarding interoperability and standards, a significant number of technological solutions has been developed or is in the process of

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development considering the issue of technological standardization and interoperability. **Technologies already screened may follow technical formal standards, but security and society resilience relevant formal standards is a topic which requires further attention and elaboration on behalf of the suppliers.**

Regarding the technological solutions various organizations have published many standards, purely related to technology topics. For example, the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), the European Telecommunications Standards Institute (ETSI), the International Organization for Standardization, the Open Geospatial Consortium (OGC) and the International Hydrographic Organization (IHO) and other organizations have published many technical standards that are related to technological solutions (software, hardware and materials) and are already on the market. Many solutions created by large companies or organizations are already compliant with technical standards issued by the aforementioned organizations but for solutions that are created from smaller manufacturers this information (e.g. covering specific standards) cannot be easily found. A list of technical standards can be found on Appendix (chapter 7).

4.2. Achievements

The traffic light system, introduced as a tool for the evaluation of the FIRE-IN solutions, has been proven a valuable tool for the classification of the technological solutions based on the maturity, operational usefulness, and interoperability items, which are basic steps and specifications towards standardization process. From the solutions that were analysed both in the framework of WP2 and WP3 it was found that many solutions are ready to market with a high TRL (TRL>7 and the majority of TRL=9).

From the "request for Ideas" procedure and other dissemination actions during the project, a significant number of solution providers and other stakeholders was approached. The FIRE-IN e-platform hosts already 50 solutions, 38 of which are technological innovations and submitted during the 2nd cycle. The interest of the community is strong and the network is growing.

Based on the needs and challenges of the practitioners and experts, technological solutions that are in the market should be: (1) useful, (2) simple and easy to use, (3) easy to deploy, integrate and interoperable, (4) robust, easy to transport, light with high autonomy, resistant to harsh conditions, (5) with open access and (6) usable by people with disabilities. The majority of technologies that exist in the market cover a lot of these specifications although issues like easy to use, autonomy, open access and people with disabilities are still in great development and depends on the technology and to its target audience.

The number of technological solutions that point directly to the capability of "Guidance instruments/Standardization" is not high. Materials, hardware and even software that exist on the market should cover specific technical standards but in what extent these technological solutions could cover society related and risk related standards (e.g. CEN/TC 391 Societal and citizen security or ISO 31000 Risk management: principles and guidelines) is not very clear. In addition, the legal framework or some professional standards may not be covered by relevant technologies.

4.3. Way to follow

Based on the work carried so far and the experience gained up to now, the following recommendations are proposed regarding technological aspects.

- In the future, **priority should be given on the "Guidance instruments", "Community Involvement", "Knowledge Cycle" and "Information Management" capabilities that have been marked with yellow in D3.3**[4]. Capabilities that have been marked with green are sufficiently covered by many existing solutions.

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- **Technologies should be able to process data from multiple sources and to provide elements for the prediction and/or evolution of a specific event**. Big data analytics and multi-sensors approach should be cultivated in the technology suppliers. Intelligence, artificial intelligence, machine learning and deep learning are invading the market in fast rhythms. Their results are not always acceptable but in the future these algorithms will be improved.
- **Training to new technologies will be a key element for the future**, both for first responders and the rest of us (general public as well as other stakeholders). As the "easiness of use" is main challenge for first responders, training is a future priority.
- **Technologies should be cost effective**. "Open access" is another key point for first responders. The overall costs (cost of purchase, cost of use, cost of maintenance) of new technologies should be minimized. Even some of their basic elements should be offered for free.
- **Risk communication** is an essential part for the future challenges. How to communicate risk to the general public and stakeholders. What is the optimal way? Technologies can play a significant role in this effort with games, virtual reality, augmented reality applications, social media and mobile devices. Of course, additional actions are required, such as drills in schools, public meetings and enhancing a volunteer approach.
- **Ethics** exist for long time regarding personal and medical data. However, there are gaps in ethics regarding other fields, such as the natural disasters. In what extent should a first responder have access to the personal data of a victim and for how long? At the same time legal and regulatory framework should be the guide for improved response in order to save lives and not a barrier during this process. The optimal balance is a crucial aspect for the future.
- **Procurement and purchase of technological equipment**. These procedures should be simplified and be me less time consuming in order to build capacities and capabilities of the response mechanism.
- **Interoperability and Standardization**. Interoperability between various sectors and level of administration and how this can be addressed from technology is important. **All technological solutions that target operational purposes and first responders should cover at least relevant technical formal standards** published by organizations (e.g. ETSI or OGC standards). The **transformation of professional guidelines to formal standards** will also enhance the internationalization of standard operation procedures as well as other self-protection measures. A first responder can be capable of working in different environments (natural, anthropogenic) and cultures, using equipment (vehicles, software, hardware) that follows the same standards in various countries and levels. Semantics, symbols even colours, should be the same across different actors, sectors, etc. The transformation of guidelines to formal standards will ensure that same procedures are followed by first responders across countries, regions and sectors and are widely accepted.

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5. Standardization

5.1. Challenges

Standardization is a multi-facet issue in the context of fire and rescue innovation. Over the previous three years and the 2 cycles to define the content of the strategic research and standardization agenda of FIRE-IN project, standardization has appeared as:

1. A process to establish the state of the art by consensus among experts and define common terms, methods and solutions within a technical sector,
2. An instrument to facilitate the purchase and use of innovative technologies with the Direct Public Procurement, Public Procurement of Innovation (PPI) and Pre-Commercial Procurement (PCP) (for more details see the § 2.4.3.2 in the pre-cited deliverable D3.5[1]),
3. A procedure to share and give access to good practices among professionals and practitioners.

Over the previous chapters of this report, all three aspects are addressed, and standardization is referred to and cited when it is about, respectively:

- For 1: using a common vocabulary, a common approach for the community involvement in disaster management or for the incident command organization,
- For 2: characterizing the level of maturity of some technologies (TRL) measured by the availability on the market,
- For 3: disseminating largely to the stakeholders and the public good practices.

In the field of fire and rescue, the main challenge is to reduce the distance between the standardization process and the implementation of the standards.
The screening process performed in the two cycles of FIRE-IN and the workshops with practitioners and the interviews carried out in the framework of the request for ideas (RfI pre-cited) have made it clear that practitioners do not have the overview on existing and relevant standards in their business, and might have difficulties to access to the standards, in particular if it is a formal standard that has to be purchased.

For example, at the Stair4Security (S4S) seminar organized on June 16th, 2020 with FIRE-IN and EXERTER representative, the S4S consortium members have explained that their platform could have supported the Covid-19 preparedness and response by giving access to useful and reliable data contained in the standards mentioned on the following slide (See Figure 1).

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Figure 1: Slide presented by the Standard4Security consortium during a workshop with FIRE-IN and EXERTER on June 16th, 2020

Reducing the distance between the standardization process and the implementation of the standards might be translated in two aspects:

- **Dissemination and promotion**: provide digested and targeted information on existing standards to the fire and rescue community, and train and make explicit the content of relevant standards and possibly promote the exchanges of experiences around the implementation of the standard to shift from the theory to the practice.
- **Engagement of practitioners in the standardization process**: provide the opportunity to find and engage with other practitioners who might be interested to develop or revise standards on given topics: this can be very stimulating for practitioners.

5.2. Achievements

Several European projects have taken some actions and initiatives to contribute to standardization in the field of fire and rescues, including security and CBRNe. Among them we can mention: EDEN, ENCIRCLE, RESISTAND, DRIVER…and others. Many good ideas and suggestions have been made but have not percolated through the various stratums between the researchers and standardization experts involved in the European projects and the practitioners on the field.

The main difference today compared to the time of implementation of the previously cited projects is that FIRE-IN provides a unique community of practitioners engaged in contributing to innovation in the field of fire and rescue.
In addition, with the platform in development in S4S project and the e-FIRE-IN platform, there will be many synergies that can overcome the difficulties to disseminate standards to the practitioners and engage them in the standardization process. Indeed, the ontology layer of the S4S platform will provide

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organized information on relevant standards to the practitioners for given topics / themes. This is important to promote standards among practitioners who often ignore their existence.
Besides, a good coordination between S4S and FIRE-IN will provide opportunities to create groups of practitioners interested by the same standards and therefore engage them with other practitioners who might be interested to develop or revise standards on given topics.

The S4S platform appears as a great opportunity to create "user groups of some key standards" (e.g. CEN TS1759) related to FIRE-IN topics, to exchange experiences on the implementation of current standards, collect feedback to prepare the revision of standards and therefore create a dynamic around standardization activity. It will reduce the distance between the "thinkers/experts developing the standards" and the "users".

On the other side, it is necessary to pay attention to potential overlaps between S4S and FIRE-IN, for example the promotion of validated solutions or the provision of specific tools for practitioners. These activities should be coordinated between the two projects and therefore the interactions should be considered with some cross-participation of leaders from the various projects / platforms to minimize the overlaps and avoid possible contradictions or divergences while promoting some solutions.
Also, in terms of governance, an independent group gathering experts from various projects might be created for the "validation" or "promotion" of the solutions since it is important to build trust with the users. There should not be too much lobby nor conflict of interest for the promotion of solutions through the platforms.

5.3. Way to follow

With the current constellation of projects in the field of security, CBRN…, all conditions are gathered to democratize and boost standardization in the field of fire and rescue, and therefore reduce the distance between the development of standards and their implementation by practitioners.

With the strong support of CEN TC391 chairperson, Ms Patricia Compard and her leading role in the Stair4Security project, with the liaison being established between FIRE-IN and this technical committee, and the motivation from several leaders in on-going projects funded under the Community of Users initiative (NO FEAR, DARENET, ENCIRCLE…), the coming months might be used to establish demonstrations of good synergies between FIRE-IN and S4S, by creating practitioner groups on existing standards.
The process could be as follow:

- Select several existing standards relevant for FIRE-IN from CEN TC391 for example,
- Ask FIRE-IN practitioners to exchange their experiences on the implementation of the standards (check the level of dissemination of the standard among practitioners, check its practicality, check its usefulness…),
- Provide feedback to the standardization working group of the relevant CEN TC on the content and on the access to the standards from the point of view of practitioners,
- Assess whether standard updates or guides for implementation are needed,
- If updates are needed, then engage practitioners in the preparation of the new versions of the standards.

By reducing the distance between standardization and the practitioners from FIRE-IN, we might discover that many solutions exists and that they need to be promoted, or that they need to be adapted to the reality of the practitioner daily business. Therefore, this common work from S4S and FIRE-IN could end-up with better standards and a better use of standards.

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6. Conclusion

After the end of the 2nd cycle of identification and verification of gaps in capabilities, it is necessary to identify strategic goals in which it is worth investing and focusing energy in the coming years. As indicated in the previous chapters, there are several gaps that have been identified as possible areas of research and development. However, it is impossible to ignore the pandemic situation that significantly influenced the indication of the priority ones. The crisis highlighted the importance of the work of rescuers and emphasized the importance of international cooperation. The specificity of the situation that the Fire & Rescue community deals with has influenced the appreciation of the importance of new technologies and tools that support us all, but also revealed the need for implementation and use of them. The R&D needs and directions analysis carried out during the FIRE IN 2nd cycle also largely covered and corresponds to the needs that emerged during the pandemic crisis.

Second cycle indicated some areas which need further support of future R&D works such as:

- "community involvement",
- "guidance instruments",
- "knowledge cycle",
- "incident command organization".

It also paid attention to redirect more resources to prevention and preparation phase.

In terms of standardization, it is worth considering increasing efforts in two ways:

1) to make entities aware that their solutions should meet technical and formal norms and standards, and to encourage them to develop and promote solutions facilitating the implementation of norms and standards,
2) to make practitioners aware of existing norm and standards and engage them to standardization process.

Taken in consideration all aspects, i.e. identified gaps and verified challenges, but also influence of pandemic crisis situation, we can point out several crucial topics and strategic goals which FIRE-IN wants to recommend to focus and allocate necessary funding:

- **Open and engaged community empowerment for maintaining resilience - close and appealing cooperation between Fire & Rescue providers and citizens.**
  Also called *Education and awareness raising about the desired attitude of the society and the possibilities of involvement during a crisis situation*

- **Multi-agency trainings with new technology as assurance of enhancement of response interoperability and safety of rescuers.**
  Using joint training not only as a way to facilitate cooperation between agencies but also to become familiar with modern technologies used by others and to engage toward standardization

- **Link standardization process with practitioners**

- **Better prepare to face global change-induced disasters and effects with accurate forecasting and pre-planning.**
  This requires to strengthen tools using innovative technologies such as big data and machine learning.

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7. Appendices

7.1. Appendix 1: CCC matrix

Table 5 FIRE-IN Common Capability Challenges (CCC) matrix

CCC	High flow of effort in hostile environment	Low frequency, high impact	Multi-agency / multi-leadership environment	High level of uncertainty
Incident Command Organization	Focus on sustainability of safe operations	Anticipate vulnerability and communicate to the public	Distribute decision-making	Strategies choosing safe, resilient scenarios, and maintaining credibility
Knowledge cycle	Train specific roles and risks	Organizational learning focusing efforts in key risks and opportunities	Build a shared understanding of emergency and train interagency scenarios	Focus on capacity building towards more resilient societies
Community involvement	Develop public self-protection	Prepare communities for the worst scenario before it happens.		Cultural changes in risk tolerance and resilience
Pre-planning	Pre-plan a time-efficient, safe response, minimizing responder's engagement	Negotiate solutions with stakeholders for anticipated scenarios	Plan interoperability and enhance synergies	Focus on governance and integral risk management
Guidance instruments and standards	Establish procedures and guides	Standardize capabilities in front of pre-established scenarios	Establish an interagency framework	Build doctrine for resilience in emergency services and societies
Information management	Information cycle	Focus key information on decision-making	Define common information management processes between agencies	Provide an efficient, flexible flow of information for a shared understanding
Technology	Use technology to assess risks and minimize responder's engagement	Forecast and simulate complex scenarios	Technological tools to support data sharing	Get a clear picture of the risk evolution

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7.2. Appendix 2: PCCs

Table 6 Overview of prioritized capability challenges (PCCs) identified in the second cycle of workshops

	Description of PCCs	Topic
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
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
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 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
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
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
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
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
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

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9	Maintain situation awareness. Avoid the loss of information with shifts' changes.	Incident Command Organization
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
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
12	Be prepared to provide massive alerts to population.	Community involvement

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7.3. Appendix 3 related to research and publications

Table 7: Extended Table of categories of research gaps and needs ds based upon the qualitative analysis

Categories of research gaps and needs based upon the qualitative analysis	Quotes	References
Need for projection standards and meaningful fire metrics	„A lack of standards has been identified in the definition of some fire metrics, in their computation, and in the way the results are reported […]" (Dupuy et al. 2020, p. 15) "We suggest that the scientific fire community works on deriving common definitions and standards of the fire danger metrics to be reported in future studies. This must include a sound evaluation of the fire danger concept and how to rate this danger." (Dupuy et al. 2020, p. 15)	Dupuy, J.-L.; Fargeon, H.; Martin-StPaul, N.; Pimont, F.; Ruffault, J.; Guijarro, M. et al. (2020): Climate change impact on future wildfire danger and activity in southern Europe: a review. In: *Annals of Forest Science* 77 (2), pp. 326. DOI: 10.1007/s13595-020-00933-5.
Understanding wildfire fuel processes	"This involves important research efforts for understanding fuel processes and predicting fuel load and fuel moisture." (Dupuy et al. 2020, p. 15) "[…] need for more fundamental research to understand the physiological processes driven by water potential in plant and soil that ultimately govern water content dynamics." (Dupuy et al. 2020, p. 16)	Dupuy, J.-L.; Fargeon, H.; Martin-StPaul, N.; Pimont, F.; Ruffault, J.; Guijarro, M. et al. (2020): Climate change impact on future wildfire danger and activity in southern Europe: a review. In: *Annals of Forest Science* 77 (2), pp. 326. DOI: 10.1007/s13595-020-00933-5.

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Development of DGVM-fire models and taking vegetation shifts into account	"[…] evaluation and further developments of these models and of their fire and vegetation components, at both global and regional scales with different degrees of refinement, is certainly a good option to gain new understanding and better prediction capabilities of fire regimes." (Dupuy et al. 2020, p. 16)	Dupuy, J.-L.; Fargeon, H.; Martin-StPaul, N.; Pimont, F.; Ruffault, J.; Guijarro, M. et al. (2020): Climate change impact on future wildfire danger and activity in southern Europe: a review. In: *Annals of Forest Science* 77 (2), pp. 326. DOI: 10.1007/s13595-020-00933-5.
Assessing trends and shift in anthropogenic processes related to wildfires	"Most projection studies do not account for the impact of fire management and socio-economic drivers on fire activity." (Dupuy et al. 2020, p. 16) "There is also critical need to assess the impact of continued land abandonment that may foster increasingly large fires in nonfuel-limited environments. More generally, long-term variations in human-driving fire influences need to be better understood." (Dupuy et al. 2020, p. 16)	Dupuy, J.-L.; Fargeon, H.; Martin-StPaul, N.; Pimont, F.; Ruffault, J.; Guijarro, M. et al. (2020): Climate change impact on future wildfire danger and activity in southern Europe: a review. In: *Annals of Forest Science* 77 (2), pp. 326. DOI: 10.1007/s13595-020-00933-5.
Assessing the effectiveness of fire control policies	"It is of great importance to assess how the fire danger increase might affect the success of these policies […]" (Dupuy et al. 2020, p. 16)	Dupuy, J.-L.; Fargeon, H.; Martin-StPaul, N.; Pimont, F.; Ruffault, J.; Guijarro, M. et al. (2020): Climate change impact on future wildfire danger and activity in southern Europe: a review. In: *Annals of Forest Science* 77 (2), pp. 326. DOI: 10.1007/s13595-020-00933-5.
Dealing with uncertainties of wildfire management		Thompson, M. P.; Calkin, D. E. (2011): Uncertainty and risk in wildland fire management: a review. In*: Journal of*

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		environmental management 92 (8), pp. 1895–1909. DOI: 10.1016/j.jenvman.2011.03.015.
Research on spatiotemporal dynamics and consequences of climate change	"Spatiotemporal dynamics and the consequences of climate change also remain key areas of research, and the degree of uncertainty present in projections of alternative futures will no doubt influence how we characterize and prioritize future risk mitigation efforts." (Thompson & Calkin 2011, p. 1905)	Thompson, M. P.; Calkin, D. E. (2011): Uncertainty and risk in wildland fire management: a review. In*: Journal of environmental management* 92 (8), pp. 1895–1909. DOI: 10.1016/j.jenvman.2011.03.015.
Studies on Wildfire and Land-use as coupled system	"We suggest that future research into fire and land use as a coupled system is necessary to provide pathways to a future where we co-exist with fire as a natural process, and when possible, better plan how and where we build." (Butsic et al. 2015, p. 151)	Butsic, V. ; Kelly, M.; Moritz, M. (2015): Land Use and Wildfire: A Review of Local Interactions and Teleconnections. In: *Land* 4 (1), pp. 140–156. DOI: 10.3390/land4010140.
Improvement of the use of Social Media	Further research is needed to improve the use of social media during natural disasters, environmental disasters, and other environmental concerns. (Finch et al. 2016) "Further research should aim to improve the use of social media in detecting and responding to environmental problems" (Finch et al. 2016, p. 758).	Finch, K. C.; Snook, K. R.; Duke, C. H.; Fu, K.-W.; Tse, Z. T. H.; Adhikari, A.; Fung, I. C.-H. (2016): Public health implications of social media use during natural disasters, environmental disasters, and other environmental concerns. In: *Natural Hazards* 83 (1), pp. 729–760. DOI: 10.1007/s11069-016-2327-8. Ripberger, J.T.; Jenkins-Smith, H.C.; Silva, C.L..; Carlson, D.E.; Henderson, M. (2014): Social media and severe weather: do Tweets Provide a valid indicator of public attention to severe weather risk communication? In:

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	"[…] future research can examine methods to create more accurate ways to interpret real-time data from social media" (Finch et al. 2016, p. 758; Ripberger et al. 2014; Rogstadius et al. 2013).	*Weather, Climate, Society* 6, pp. 520–530. doi:10.1175/WCAS-D-13-00028.1 Rogstadius, J.; Vukovic, M.; Teixeira, C. A.; Kostakos, V., Karapanos, E.; Laredo, J.A. (2013): CrisisTracker: crowdsourced social media curation for disaster awareness. In: *IBM J Res Dev* 57(4), pp. 1–4. doi:10.1147/ JRD.2013.2260692
Understanding and Interpreting Weather Warnings	"[…] research gaps include the topics of understanding, interpretation and use of weather warnings (e.g. Morss et al., 2008)." (Kox et al. 2015, p. 293) "The survey results show that even within one specific group like emergency services the perceptions, needs and capabilities vary considerably." (Kox et al. 2015, p. 300) "More detailed research is needed in this field. Special attention should lie on addressing the consequences of weather and weather warnings." (Kox et al. 2015, p. 300)	Kox, T.; Gerhold, L.; Ulbrich, U. (2015): Perception and use of uncertainty in severe weather warnings by emergency services in Germany. In: *Atmospheric Research* 158, pp. 292–301. DOI: 10.1016/j.atmosres.2014.02.024.
Information Sharing and Coordination in Multi-Agency Disaster Response	"In addition, we discussed a number of directions of further research, including people's inability to identify relevant information under pressure, the empowerment of and control by individuals	Bharosa, N.; Lee, J.-K.; Janssen, M. (2010): Challenges and obstacles in sharing and coordinating information during multi-agency disaster response. Propositions from field exercises. In: *Information Systems Frontiers* 12 (1), pp. 49–65. DOI: 10.1007/s10796-009-9174-z.

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	and the redesign of information sharing processes." (Bharosa et al. 2019, p. 63)	
Research on leadership in extreme events	"[…] future research should determine how leaders identify and establish constraints, structures and opportunities that influence sense-making and performance at such critical points." (Hannah et al. 2009, p. 904) "It will be important for future research to explore differences in effects based on conditions such as: 1) where the leader only is at risk (e.g., the leader is a bomb expert or hostage negotiator and moves his team to safety but goes in himself to diffuse a bomb/situation), 2) where followers only are at risk (e.g., the general in the command post directing attacking units), 3) where both leader and followers are at risk (e.g., a SWAT leader enters a house with his squad), and 4) where only civilians/clients/ patients are at risk (e.g., an emergency room doctor who is not personally at risk but the patient is; or a disaster relief worker that responds to a disaster after the major risk has subsided). These aspects	Hannah, S. T.; Uhl-Bien, M.; Avolio, B. J.; Cavarretta, F. L. (2009): A framework for examining leadership in extreme contexts. In: *Leadership Quarterly* 20 (6), pp. 897–919. DOI: 10.1016/j.leaqua.2009.09.006. Boin, A.; T'Hart, P.; McConnell, A.; Preston, T. (2010): Leadership style, crisis response and blame management. The case of Hurricane Katrina. In: Public Administration 88 (3), pp. 706–723. DOI: 10.1111/j.1467-9299.2010.01836.x.

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	of exposure to risk may contextualize leadership dynamics in unique ways, which in total have not yet been explored in the leadership literature." (Hannah et al. 2009, p. 907) "Because extreme events often involve complexity dynamics, the study of how leaders and followers process and make sense of complexity in extreme and ill-defined contexts will be a useful area of future research" (Hannah et al. 2009, p. 911) "Future research will be important to then investigate the inherent tensions between the adaptability required of organizations at the direct, tactical level, and the needs for administrative control at higher levels of the organization in which they are embedded." (Hannah et al. 2009, p. 913) "An important avenue of research would be to explore various leadership style types across various types of crises to further examine the hypothesized relationships between style, political management strategy, and the political and	

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	policy impacts of crises." (Boin et al. 2010, p. 720)	
Research on spontaneous Volunteering in Disaster Management / Community Involvement	"Future research could consider the applicability of our model to other international and volunteering contexts" (Harris et al. 2017, p. 368)	Harris, M.; Shaw, D.; Scully, J.; Smith, C. M.; Hieke, G. (2017): The Involvement/Exclusion Paradox of Spontaneous Volunteering. New Lessons and Theory From Winter Flood Episodes in England. In: Nonprofit and Voluntary Sector Quarterly 46 (2), pp. 352–371. DOI: 10.1177/0899764016654222.
Intergovernmental and interorganizational cooperation	"Future research can focus more on specific task-related networks such as networks in donation collection and management, networks in immediate recovery, and networks in law enforcement-related activities." "Among them is the lack of electronic information sharing tools as well as the lack of collaboration frameworks detailing roles and responsibilities in interorganizational response settings. Continuing research on this topic by adding more in-depth research on the identified issues, and by extending the scope to further organizations and states, will enable the development of concrete suggestions for enhancing interorganizational response settings."	Kapucu, N.; Arslan, T.; Collins, M. L. (2010): Examining Intergovernmental and Interorganizational Response to Catastrophic Disasters:Toward a Network-Centered Approach. In: *Administration & Society* 42 (2), pp. 222–247. DOI: 10.1177/0095399710362517. Berchtold, C.; Vollmer, M.; Sendrowski, P.; Neisser, F.; Müller, L. & S. Grigoleit (2020): Barriers and Facilitators in Interorganizational Disaster Response: Identifying Examples Across Europe. In: *International Journal of Disaster Risk Science* 11, pp. 46-58. https://doi.org/10.1007/s13753-020-00249-y

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	(Berchtold et al. 2020, p. 57)	
Organizational resilience towards extreme weather events	"Further research is required to understand how organizations can best manage for resilience to extreme weather events by altering underlying features of the organization, including its resources, capabilities and organizational ideologies." (Linnenluecke et al. 2010, p. 28) "Further research is also required to understand whether there are underlying mechanisms of resilience that are transferable to organizations in different sectors or contexts." (Linnenluecke et al. 2010, p. 28)	Linnenluecke, M. K.; Griffiths, A.; Winn, M. (2012): Extreme Weather Events and the Critical Importance of Anticipatory Adaptation and Organizational Resilience in Responding to Impacts. In: *Business Strategy and the Environment* 21 (1), pp. 17–32. DOI: 10.1002/bse.708.
Community involvement and the role of the private sector in building disaster resilience	"New research could also explore private sector involvement from the perspective of communities and community members. What balance of government and private sector involvement do communities and community members prefer? What roles are communities comfortable with firms playing and which ones are less welcome? This would involve a deeper understanding of what factors drive communities to be better prepared for	McKnight, B.; Linnenluecke, M. K. (2016): How Firm Responses to Natural Disasters Strengthen Community Resilience. A Stakeholder-Based Perspective. In: *Organization & Environment* 29 (3), pp. 290–307. DOI: 10.1177/1086026616629794.

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	disaster." (McKnight & Linnenluecke 2016, p. 302)	
Research on supply chains of non-profit organizations in crisis management	"There is a need for more case studies and empirical research in crisis management for not-for-profit supply chains." (Natarajarathinam et al. 2009, p. 547) "Greater strategic planning to explicitly include aspects of cross-sector collaboration is necessary generally" (Simo & Bies 2007, p. 140)	Natarajarathinam, M.; Capar, I.; Narayanan, A. (2009): Managing supply chains in times of crisis. A review of literature and insights. In: *International Journal of Physical Distribution & Logistics Management* 39 (7), pp. 535–573. DOI: 10.1108/09600030910996251. Simo, G.; Bies, A. L. (2007): The role of nonprofits in disaster response. An expanded model of cross-sector collaboration. In: *Public Administration Review* 67, pp. 125–142. DOI: 10.1111/j.1540-6210.2007.00821.x.
Establishing trust in Media Communications	"Further empirical and quantitative studies could investigate ways to develop and maintain trust where parties' agendas compete and in environments where the media are increasingly interactive." (McLean & Power 2014, p. 322)	McLean, H.; Power, M. R. (2014): When minutes count. Tension and trust in the relationship between emergency managers and the media. In: *Journalism* 15 (3), pp. 307–325. DOI: 10.1177/1464884913480873.
Situational Awareness Tools	"[…] further research and development work in this direction can eventually lead to such systems being regularly used in disaster response and management." (Mohsin et al. 2016, p. 323)	Mohsin, B.; Steinhaeusler, F.; Madl, P.; Kiefel, M. (2016): An Innovative System to Enhance Situational Awareness in Disaster Response What are End Users Looking for in Such Systems. In: *Journal of Homeland Security and Emergency Management* 13 (3), pp. 301–327. DOI: 10.1515/jhsem-2015-0079.

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7.4. Appendix 4 related to technologies & standards

Technical and special committees regarding communication and information technologies

CEN committees related to communication and information technologies as well as to societal and citizen security

CEN/TC 353 - Information and Communication Technologies for Learning, Education and Training	https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:580446&cs=15AD42370A941BEC38A49B673D09BFEF6
CEN/CLC/WS ZONeSEC – Interoperability of Security Systems for the Surveillance of Widezones	https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:2341530&cs=14E48275311C34B3A42C277EA8DFC5CAF
CEN/TC 428 – ICT Professionalism and Digital Competences	https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:1218399&cs=1600F0DD849DA04F3E3B900863CB58F72
CEN/TC 391 - Societal and Citizen Security	https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:680331&cs=18422BF6F2CD25C72E8F633D87A8147AB

ETSI committees

ETSI/TC Integrated Broadband Cable Telecommunication Networks (CABLE)	https://www.etsi.org/committee/1392-cable
ETSI/JTC of the European Broadcasting Union (E.B.U.), the European Committee for Electrotechnical Standardization (CENELEC) and ETSI, (BROADCAST)	https://www.etsi.org/committee/1391-broadcast
ETSI/SC Emergency Telecommunications (EMTEL)	https://www.etsi.org/committee/1397-emtel
ETSI/TC Core Network and Interoperability Testing (INT)	https://www.etsi.org/committee/1401-int
ETSI/TC Mobile Standards Group (MSG)	https://www.etsi.org/committee/1404-msg
ETSI/TC SAFETY	https://www.etsi.org/committee/1410-safety
ETSI/TC Satellite Earth Stations and Systems (SES)	https://www.etsi.org/committee/1412-ses
ETSI/Industry Specification Group (ISG) Cross Cutting Context Information Management	https://www.etsi.org/committee/1422-cim
ETSI/ Industry Specification Group (ISG) Augmented Reality Framework (ARF)	https://www.etsi.org/committee/1420-arf
ETSI/Industry Specification Group (ISG) Securing Artificial Intelligence (SAI)	https://www.etsi.org/committee/1640-sai

International Electrotechnical Commission (IEC) committees for relevant electrotechnical equipment

IEC/TC31: Equipment for Explosive Atmospheres	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1232

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IEC/SC31J: Classification of Hazardous Areas and Installation Requirements	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1333
IEC/SC45B: Radiation Protection Instrumentation	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1360
IEC/TC57: Power Systems Management and Associated Information Exchange	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1273
IEC/TC79: Alarm and Electronic Security Systems	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1269
IEC/TC89: Fire Hazard Testing	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1283
IEC/TC100: Audio, Video and Multimedia Systems and Equipment	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1297
IEC/TC108: Safety of Electronic Equipment within the Field of Audio/Video, Information Technology and Communication Technology	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1311
ISO/IEC JTC1/SC36: Information Technology for Learning, Education and Training	https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:3410

CENELEC electrotechnical standards

CLC/SR 89	https://www.cenelec.eu/dyn/www/f?p=104:7:222114259505101::::FSP_ORG_ID,FSP_LANG_ID:1258105,25
CLC/TC 108X	https://www.cenelec.eu/dyn/www/f?p=104:7:222114259505101::::FSP_ORG_ID,FSP_LANG_ID:1257189,25
CLC/SR 124	https://www.cenelec.eu/dyn/www/f?p=104:7:222114259505101::::FSP_ORG_ID,FSP_LANG_ID:2350495,25
CEN/CENELEC/ ETSI/SF-SSCC	https://www.cenelec.eu/dyn/www/f?p=104:7:222114259505101::::FSP_ORG_ID,FSP_LANG_ID:1161932,25
CEN/CLC/JTC 4	https://www.cenelec.eu/dyn/www/f?p=104:7:222114259505101::::FSP_ORG_ID,FSP_LANG_ID:812864,25
CEN/CLC/WS INACHUS	https://www.cenelec.eu/dyn/www/f?p=104:7:222114259505101::::FSP_ORG_ID,FSP_LANG_ID:2449074,25
CEN/CLC/WS SEP-IoT	https://www.cenelec.eu/dyn/www/f?p=104:7:222114259505101::::FSP_ORG_ID,FSP_LANG_ID:2366187,25

ISO/IEC JTC 1 Committees

SC.6 - Telecommunications and Information Exchange between Systems	https://www.iso.org/committee/45072.html
SC.23 - Digitally Recorded Media for Information Interchange and Storage	https://www.iso.org/committee/45240.html
SC.24 - Computer graphics, image processing and environmental data representation	https://www.iso.org/committee/45252.html

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SC.25 - Interconnection of Information Technology Equipment	https://www.iso.org/committee/45270.html
SC.29 - Coding of audio, picture, multimedia and hypermedia information	https://www.iso.org/committee/45316.html
SC.32 - Data Management and Interchange	https://www.iso.org/committee/45342.html
SC.37 – Biometrics	https://www.iso.org/committee/313770.html
SC.38 - Cloud Computing and Distributed Platforms	https://www.iso.org/committee/601355.html
SC.41 - Internet of Things and Related Technologies	https://www.iso.org/committee/6483279.html
SC.42 – Artificial Intelligence (AI)	https://www.iso.org/committee/6794475.html

Security and Resilience topics

ISO committees

Regarding Security and Resilience issues, the ISO/TC 292 has published 38 standards, which can be found in this link https://www.iso.org/committee/5259148/x/catalogue/p/1/u/0/w/0/d/0. Similarly, regarding the sustainability and resilience of cities and communities, the ISO/TC 268 has published 23 standards, whereas 17 are currently under development. The list of standards can be found in the following link https://www.iso.org/committee/656906.html.

CEN committees

Published Standards related to the CEN/TC 391 – Societal and Citizen Security committee can be found on the following link: https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:680331&cs=18422BF6F2CD25C72E8F633D87A8147AB.

Geospatial standards topics

Standards regarding geospatial analysis, created by international standardization bodies, such as the International Organization for Standardization (ISO), the Open Geospatial Consortium (OGC) and the International Hydrograpfic Organization (IHO), should be taken into consideration for further development of current technologies or for future technologies.

The **International Hydrographic Organization (IHO)** has published a significant number of standards regarding maps and their required characteristics and specifications. These standards can be found in the following link: https://iho.int/en/standards-and-specifications.

Furthermore, the **Open Geospatial Consortium**, which is an international consortium of more than 500 businesses, government agencies, research organizations and universities, has published required specifications and technical characteristics for geospatial analysis and mapping, e.g. Web Map Service (WMS). Globally acknowledged, relevant organizations cooperate or are partners in the OGC like USGS, ESRI, NOAA, AIRBUS, GOOGLE etc. and have validated and certified the implementation of these standards, which can be found in the following link: http://www.ogc.org/docs/is.

As far as the **International Organization for Standardization (ISO)** is concerned, the Technical Committee 211 has published 80 standards, whereas 21 more are under development. The standards can be found here: https://www.iso.org/committee/54904/x/catalogue/p/1/u/0/w/0/d/0.

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