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Opportunities and Challenges of ICT in Emergency Processes

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Abstract. The aim of this paper is to examine emergency employees' perception of the possibilities and challenges of the implementation of Information and Communication Technology (ICT) in their daily processes. Therefore, interviews with eight emergency services employees from differing organizational and positional backgrounds were conducted over the course of two separate research projects. These semi-structured personal and group interviews were subsequently transcribed, and analysed using Grounded Theory. The authors come to the conclusion, that changing perspectives on technology in emergency processes could help enable better cooperation between emergency employees and technology. The raising of employee awareness, and the provision of sufficient training, is vital to both further the understanding of technology as non-human actor and to focus on their interconnectedness. This enhanced interaction between human emergency employees and non-human technological systems could lead to the improved exploitation of socio-technical opportunities to increase the overall security of our society. This research paper seeks to draw out lessons for ICT-implementation within emergency services by examining the opinions and perspectives of employees from different emergency organizations. In so far, the findings and recommendations of the article will support efforts made by emergency organizations to integrate Information and Communication Technologies into their existing processes.

Keywords: Information and Communication Technology (ICT), Socio-technical cooperation, ICT in emergency processes.

1 Introduction

Imagine you are on the road and suddenly emergency sirens start to sound out. In these situations, it is often not clear to many road users what to do. While some keep on driving, others slow down, stop completely or even speed up. These different reactions quickly result in a traffic jam, which makes it difficult for emergency vehicles to move forward, and poses an additional risk of accidents. The use of modern traffic management technologies could clarify what needs to be done by all road users, and thus clear the way for emergency drivers to get ahead of the rest of the traffic quickly and safely.

As this example shows, Information and Communication Technology (ICT) possess huge potential to improve the processes of emergency organizations, and to raise their level of security. While the term “Information and Communication Technology” per se comprises a broad field of applications and systems, these various devices are able to fulfil a range of tasks at different stages of an incident. Most especially, the provision of additional information is of great importance to emergency organizations. Better information can lead to an improved situational awareness, and to more appropriate security measures, thus promoting an emergency employee's safety [1]. However, emergency organizations constantly hesitate to implement new technologies, often due to employee doubts and fear, and the emergence of significant organizational challenges. Since the non-usage of a technology [2-3] is also a valid option available to an emergency organization and its employees, human actors must be able to see a definite benefit in implementing technological devices in their processes. Otherwise, they would not see a benefit in changing their existing practices. This paradoxical relationship between emergency organizations and technological systems [4] can be understood as a major obstacle to the exploitation of the potential afforded by technology to emergency organizations.

The aim of this research paper is to, therefore, provide guidance to emergency organizations on how to establish and maintain cooperation between technology and their employees. To address this aim, the authors will investigate the question of how emergency employees perceive the possibilities and challenges connected with the implementation of Information and Communication Technology in their emergency practices. The research problem will be discussed in the context of two different research projects, both focusing on how a new technological system can improve existing emergency processes. While the first device under consideration is a priority system aimed at enabling a faster ride to an accident location, the second is a sensor developed to detect the release of chemical, biological, radiological and nuclear (CBRN) substances.

ICT in the Emergency Management

The National Governor's Association (NGA) has identified four phases of emergency management [5] based on McLoughlin [6]. These are recognized as the traditional four stages of disaster management by various authors in the field, and can benefit in different ways from human interaction with technological systems. The first phase – *mitigation* – refers to the long-term activities undertaken to prevent emergencies or reduce the resulting damage of an emergency. The second phase of *preparedness* covers the short-term activities that are realized before the emergency strikes to enhance the readiness of organizations to respond to it. The third phase is about *response*, and includes activities undertaken immediately after an emergency to provide assistance to those in need. The last phase of *recovery* focuses on short-term as well as long-term activities, put into practice to provide victims with their pre-disaster conditions [5].

Summarizing the findings from various authors [4, 7-10] it can be concluded that technology may be used to support employees at all the different stages of emergency management. In particular, technology can help emergency employees obtain information on: (1) environmental conditions – including causalities, location, cause; (2)

available resources, in terms of employees, skills and equipment; and (3) best practices, involving training, testing and continuing education. This information, together with the technologies themselves, can help emergency employees with (4) appropriate communication and information sharing within their organization, and with other external actors; (5) enhanced situational awareness; and (6) improved decision support. Through these tasks, technology enhances (7) organizational agility for disaster management; (8) the engagement of the public; and (9) infrastructure survivability. The technologies used can be very diverse, and range from coordination, communication or training platforms driven by government agencies to monitoring technologies as sensor network systems.

However, these multiple possibilities are often accompanied by several challenges faced by emergency organizations and their employees during the implementation of new technologies. Following Rogers and Scally [11], these may be summarized under four broad headings: (1) the unlawful use of technology, (2) workforce resistance, (3) training and budget, as well as (4) balance regarding legislation. While the authors focus mainly on police departments as specific kind of emergency organization, their findings may also be applied to other emergency organizations. The first aspect addresses the possibility of the occurrence of cybercrime. Every technology carries with it new vulnerabilities, resulting in the emergence of new entry points for criminals in the critical infrastructure of emergency systems. This can pose a threat to not just the entire organization and its employees, but also society as a whole. The second topic encompasses the impact that new technologies have on the existing practices, beliefs and working culture of an organization. Since the overall mission of emergency employees is to act fast during complex-incident situations, their requirement is for easy-to-use instruments [8]. This is one reason why emergency employees often resist technological changes in their procedures. As third aspect, Rogers and Scally [11] mention the need for employee training, and budgeting by emergency organizations, to enable the successful implementation of a new technology. Enhancing the amount and quality of training could help reduce the skepticism on the part of emergency employees towards change, making them more aware of the possibilities and risks associated with the introduction of new technologies into their processes. Sakurai and Murayama [7] state that the more information technology becomes a part of emergency management, the more IT resources within the organizations are required to address these applications, and to support this dimension. The fourth topic mentioned by Rogers and Scally [11] is the difficult balance required between technology use and human rights. National and international legislation concerning technology use can have a significant impact on the relationship between an emergency organization and the technology available to its employees, as well as on its overall relationship with society. Thus, the general concerns of society raised in connection with data collection and privacy must be considered, when increasing the usage of technology by emergency organizations.

2 Research Design and Methods

The aim of this research paper is to investigate the perspective of emergency employees towards new information and communication technologies, and to determine how they perceive the possibilities and challenges concerning their incorporation into daily routines and processes. Hence, the paper poses the following research question:

How do emergency employees think about the implementation of novel Information and Communication Technology in their daily practices?

To answer this question, the paper draws on empirical material from two different research projects. Both projects focus on how new technological systems can improve existing emergency processes. While in the first project the technology under consideration is a priority system that is supposed to enable a faster ride to an accident location, in the second project the technology investigated is a sensor, developed to detect the release of CBRN-substances in specific contexts. Following the literature, the first ICT tries to improve the phase of response through the introduction of help of a human-to-human communication device. The second tries to improve the mitigation phase with the help of a sensor. In both research projects, the authors interacted with different employees from various emergency organizations located in Vienna. While the topic of the projects had been the specific technologies, the emergency employees in both projects used the openness of the interview method to talk about their perceptions of the use of information and communication technologies in their daily routines. Information collected was merged and analyzed, leading to the findings of this paper.

To obtain their point of view, problem-centered personal and group interviews [12-13] were performed during June and November 2019. In the context of six interview-settings, eight persons were interviewed. Discussion partners ranged from chief-officers to operative employees, as well as employees at the interface between different associations and organizations. Their organizational backgrounds ranged from occupations in fire departments, police departments, rescue services as well as within special units. Seven male participants and only one female were interviewed. The semi-structured interview guide utilized included, on the one hand, case examples that encouraged interviewees to narrate and describe the emergency processes within their organizations in order to identify practices and their interlinkage with Information and Communication Technology, and, on the other, open-ended questions to obtain insights into the challenges faced by emergency employees within the context of existing processes. The interviews in their duration lasted from between 60 to 260 minutes. All of them were recorded and transcribed verbatim. In a final step, the interview data thus collected was analyzed following the approach of Grounded Theory as described by Charmaz [14].

Within the literature, various authors share the opinion that stakeholders such as emergency responders whose behavior is shaped by technology, should be integrated into the processes of technology development and implementation in order to address existing needs and concerns [1, 4, 10]. To give emergency employees the possibility to participate in the process of analysis, the findings of the interviews were presented and further developed in the form of a workshop [15]. The results are presented in this research paper.

The participants gave their written informed consent to their involvement in the study, as well as to the recording of the interviews. The authors gave them the opportunity to withdraw from the study at any time they wanted. Additionally, in order to align further with good scientific practice, the authors signed a confidentiality agreement to protect the participants and their organizations. Thus, they will appear anonymized, and data will only be used if it does not disclose personal information, that makes them identifiable, and if it does not endanger existing security processes.

3 Results

While the interviews initially focused on the daily practices of emergency employees, interview data reveals that they started talking about their relationship with technology on their own. This behavior shows that their opinion of technology has an impact on their daily practices, particularly during emergencies. The interviews shed light on the fact that the most important condition for the implementation of a new technology in daily routines is its acceptance by emergency employees. Although in advanced technological societies, technology is inevitably intertwined with disasters [16], the implementation of specific technological systems and devices in existing processes of emergency management is often accompanied by change [17]. Hence, technology acceptance is contingent on how the organizations and the employees cope with this change. Chan [17] distinguishes three sets of factors that influence the course of technological change and its impact on organizations: technical factors, cultural factors and political factors. While technical factors refer to the nature of technology to be used, cultural factors imply a clash between the assumptions underpinning a certain technology and those held by users within adopting organizations. By political factors, the author refers to the interests at stake in technological change. In order to cope with resistance against change in the workforce, it makes sense to take not only technological but also occupational psychology measures [18]. Nevertheless, technology enables change, but is not its cause. By adapting a certain technology to existing processes, emergency employees, by themselves and through the interaction with the new technology, cause change [19].

While emergency employees are used to changing environments, complex situations and a flexible framework, the interviews showed that they often wish for stability in their overall procedures to reduce this immutable complexity. However, emergency employees are also aware of the fact that technologies can ease day-to-day processes and practices. Our findings show that the interviewees consider Information and Communication Technology at once possibility distinct means by which to improve existing processes, and as a threat to existing processes. These two visions of ICT should not be understood as two opposing perspectives with nothing in between, but as two ends of a straight line upon which the perspective of an employee is situated in the middle, as illustrated in Figure 1. Moreover, it is not like there is one correct understanding of the role of technology in emergency processes. The perspectives are the result of real experiences with technologies and the changes that occur with their implementation. Thus, each perspective has its legitimacy.



Fig. 1. The perspectives of ICT as opportunity and ICT as threat for existing processes can be understood as the two ends of a line.

3.1 ICT as Opportunity for existing Processes

Information and communication technologies have the potential to help emergency employees face the challenges encountered during the course of their daily work. In doing so, technological devices can be understood as being allies of the human user, since they broaden the options available to the emergency employee. Technologies can help users through the *gathering of more information* or by facilitating the sharing of information with other actors in the field. This could lead to a better assessment of the situation by all actors involved, and hence to safer incident handling by emergency workers. In this sense, technology can *secure and expand existing capabilities* of emergency employees. Devices with these possibilities include navigation systems, and sensors collecting data. Moreover, ICT can also *simplify existing processes*, either by facilitating process automation or by interconnecting emergency devices like alert units and navigation systems. While the absence of feelings on the part of the technology is usually taken as being a negative characteristic, in some situations it can be beneficial. The technology assesses a situation along certain parameters, leading to a calculated response output. The recommendations based on this process can assist the employee in decision-making processes, especially when facing an ethical dilemma:

“In the case of major damage medicine, no distinction is made between child, woman and man. Instead, they look at who has the best chance of survival. That means getting the most out of the situation with the least possible resources. And of course, there are a lot of emotions in us and if I have a child somewhere who is five years old and needs resuscitation, then I have to get three staff members there to resuscitate the child. (...) If 30 others would die because of one life saving, then it is of course not reasonable. And then there must be a system behind it that is objective.”

This example illustrates how technology can support the emergency employee, by recommending practices or by announcing them as the best way to handle certain situations. In doing so, *technologies reduce complexity*, allowing emergency employees to focus on other practices. In some cases, technologies even provide support in legal disputes, for example, through accident data storage. This specific technology can help the employees identify prior behavior in traffic situations. Finally, some respondents mentioned that they see technologies in their processes as being playful instruments from which they can gain new insights and learn new skills.

3.2 ICT as Threat to existing Processes

In concurrence with the benefits information and communication technologies can afford, emergency employees in some respects also see it as being their opponent. As they work in highly critical and complex situations, they must not make any mistakes and neither should their equipment. Thus, employees work with instruments with so-called high failure safety and reliability. Technologies often seem *more vulnerable* than manual processes, which is, on the one hand, explained by the specific requirements technologies possess, and the materials they are constructed out of (e.g. need electricity, consists partly of glass) and, on the other, by the lack of insight that users have into the functioning of some technical devices. Moreover, every ICT device implies a new gateway for cybercriminals, through which the device could be attacked or taken over, rendering it useless or even dangerous to emergency employees [20]. Thus, there exists a distinct lack of trust in technology. While already mentioned that the lack of emotions on the part of a device can be helpful to employees in certain situations, in others, it can have negative effects. This is especially true during the phase of alerting, wherein *social and emotional intelligence* enables a human to gain insight into the situation of the affected person(s). In this phase, a lot of uncommunicated information hidden between the lines gets lost when information gathering is done by technology. This could then lead to an incomplete assessment of the situation.

Furthermore, each task performed by the technology seemingly leads to the lack of need on the part of the emergency employee to have this ability. For example, a navigation system enables employees to orientate through the city without necessitating them to know the way on their own. Furthermore, these skills are not used and honed anymore, because they are provided by technology, resulting in them getting lost. This process raises employee's *dependency on technology*. In this respect, it is also understandable that some interviewees had the feeling they could come to be replaced by a technological system one day. After all, when dealing with technical tools, it is not just the emergency employees delegating tasks to the devices, but also the devices shaping users' own practices and knowledge [21]. While technology seemingly makes some skills obsolete, it also *demand new skills* in dealing with it. Hence, through the implementation of technologies the requirements for emergency employees are additionally extended to include the acquisition of skills needed to (1) handle technical equipment, (2) assess technical information, and (3) promote self-confidence and assertiveness. Skills in handling technical equipment implies the ability to operate it properly and to use the technical device in the right way. Moreover, if the employee receives information from a monitoring system, this data must also be applied in practice and their meaning must be understood. This evaluation involves the meaningful integration of the additional information. Thirdly, when interacting with technical devices, the emergency employee needs to do so with a high degree of self-confidence and assertiveness. The interviewees agreed that in emergencies decisions should be made by humans and that technology should make recommendations assisting that process. In practice, however, this means that in some situations, emergency employees must actively reject technological recommendations and assert themselves against them. This needs self-confidence and assertiveness, as well as the continuous questioning of technological

output. To speak up against the system means *taking on even more responsibility*. It is the requirement of these skills, and the provision of training, that deters some organizations from implementing certain technologies with daily workflow processes:

“The selection of vehicles was also made intuitively in the past and since it has been computerized, nobody has really dared to change the computer proposal. So according to the motto: the computer will have thought of something. However, this leads to the fact that the whole thing becomes extremely rigid and it is almost only a decision of the computer, which was not the point of the whole story. (...) The willingness to take responsibility, so to speak, to stand against an established system is very low.”

Additionally, some emergency employees felt that the huge amount of data collected by technologies could also be used against their persons, thus endangering their right to *privacy*. Finally, some interviewees questioned the usefulness of the implementation of yet another technological system in the workplace.

3.3 Organizations in between

Overall, we could see that none of those interviewed were free of any kind of concerns pertaining to the use of information and communication technologies in emergency processes. Similarly, however, not one of the interviewees failed to mention the potential benefits that certain technologies brought to their organizations. Our findings show that, as Rogers and Scally [11] state, the working culture bears influence on whether an emergency employee accepts a certain technology or not. While interviewees from organizations that made use of less technology in their processes seemed more concerned about its impact, those employed in organizations with more implemented technologies referred more frequently to the advantages of ICT. Results from research projects show that the target group of blue light organizations in Vienna is very heterogeneous in their relationship to Information and Communication Technology. Some organizations encourage an open discussion of the implementation of common technologies such as navigation systems, and recommend that their employees use technology only if it is absolutely necessary. Other organizations already discuss the implementation of artificial intelligence and other advanced forms of data collection. Yet others have even started to consider new regulations for the individual use of technology to enable better coverage to promote interconnected emergency communication with society.

4 Recommendations

Our findings concerning the perceived positive and negative effects of information and communication technology implementation shed light on the paradoxical relationship between technology and emergency employees described by Yang et al. [4]. Based on these results, and on the existing literature, this research paper makes three intercon-

nected recommendations to support emergency organizations in implementing technology in their daily processes by focusing their attention on the concerns of their employees.

4.1 Awareness and Training

To meet the changing requirements brought about through the continued interaction with ICT, the implementing organization needs to provide training to emergency employees [7, 11]. While already experts in their field of emergency processes [22], emergency workers would benefit considerably from awareness raising and training based on the use of those technological devices deployed in their daily processes. This training should not just focus on the handling of specific technologies to raise employee confidence, but also on the nature of human-computer interactions and the emerging opportunities and challenges. Before speaking of the implementation of a specific technology, first it needs the awareness of the employees that this ICT addresses an important issue, which requires changes in the existing process. If the employee does not see the need to adapt or change his or her behavior to address new challenges, he or she will reject or even trick the system. Thus, raising awareness includes the need for the acquisition of knowledge about a certain technology, as well as an understanding of the specific topic in focus and its practical implications. Moreover, the implementation of ICT into emergency processes has a remarkable influence on how employees think, act and report on their activities [23]. Training should therefore, also raise an employee's awareness of this influence, with emphasis on positive as well as negative effects. Moreover, the training should help the employee *gain an understanding of how to handle and interact with a particular technology*. This – amongst other variables – could help employees in the formation of a trusting relationship with their technological devices [24]. The achieved increases in levels of awareness and knowledge reduces uncertainties, enables employees to make their own informed decisions about technology use, and allows them to deal with the new form of responsibility arising through the interaction with ICT.

4.2 Technology as Non-Human Actor

Drawing on the ideas of actor-network-theory (ANT) [25-26] from science and technology studies (STS), the authors suggest to reconsider the notion of technology as object. Instead, we recommend the development of understanding that technology is more a non-human actor that assists the emergency employees. When taken as being an actor, technology is not only influenced by humans, but also shapes the practices of humans too. Moreover, from an ANT perspective, technologies are not understood as opponents of the human actors, but as actors within the same network [21]. Drawing on this perspective, technological devices can be seen as having particular strengths and weaknesses. For example, the technological characteristic of being emotion-free can be thought of as possessing both qualities in different situations. While in some complex ethical situations, emergency employees can benefit from the emotion free recommendations of technology [27], in others this emotionlessness can lead to the loss

of important information [28]. As within every team, it is necessary to have a knowledge of the *strengths and weaknesses of each team member*, to enable the best possible cooperation. Furthermore, focusing on technological devices as aids that assist human actors fulfil tasks enables emergency employees to recognize that technologies are not free of mistakes. In consequence, information obtained from these devices has to be extended and supplemented with their individual experiences and tacit knowledge to combine the strengths of both sets of actors in the process. It is expected that this insight would make it easier for emergency employees to question the recommendations made by technology.

4.3 Cooperation through clear Assignment of Tasks

When thinking of technological devices as non-human actors, and of emergency employees as trained experts who interact with these technologies, the last step is to link the skills of both actor groups. To combine the strengths of emergency employees and technology, it is necessary to have clear understanding of assigned tasks. As already suggested by Yang et al. [4], the task of technology is to assist human actors by providing information and facilitating better communication. These tasks would help emergency employees in their decisions, but the decisions themselves should be taken by human actors based on a combination of information, experience, and expert knowledge. This clear assignment of tasks enables organizations to link the skills of both [28]. However, it must be emphasized that, technology needs meaningful human control [29]. Our findings support this aspect, as they demonstrate the need for close cooperation between technology and emergency employees to best meet the requirements of emergencies:

“So, imagine it's a family emergency and you call, and you're very excited. It takes feeling and sense to hear what is there. So not just these facts, but to bring this human element into it. And that human feeling – if I shut that off completely, the decisions are usually worse.”

On the one hand, emergency employees can carry technological information forward, with - for example - their experience and skills in social and emotional intelligence. Thus, the skills of emergency employees are needed to apply the output of the technology in the way it makes sense to the present situation and future decisions. On the other hand, technological devices can support and relieve emergency employees with their informational and communication possibilities. As part of regular trainings, not only the employee can be further educated, also the technology can be continuously developed and improved through the practical implications of the employees using them in their daily practices. Nevertheless, imagining technology as assisting actor, and not entrusted with the task of decision-making, could counteract emergency employees' fear of being replaced by technology. However, this fear is comprehensible since it is intertwined with the role technology has in an organization and does not just affect low skilled employees anymore [30]. The replacement of an emergency employee with a technology would end this process of cooperation, and therefore lead to a loss of skills

and information, poorer situational awareness, and the insufficient addressing of emergency incidents. Thus, it is necessary to *combine human skills and the potential of machine intelligence with the aim of achieving a “human-technology symbiosis”* [29].

5 Conclusion

Changing the perspective of emergency employees towards the usage of technology in emergency processes could help to enable greater cooperation between these actors and technology. To achieve this aim awareness needs to be raised, and training for emergency employees provided, to further the understanding of technology as a non-human actor and shift the focus on to mutual cooperation through the clear assignment of tasks. These recommendations address the challenges emerging from the implementation of technology, when considered from the perspective of emergency employees.

However, to change the perspective through the provision of recommendations is only effective if the certain technology in focus is (1) useful to the emergency organization and (2) has an acceptable level of vulnerability. The best technology is useless if the potential users do not see any sense in its utilization. Therefore, it is important to involve users in the development of technology, to address their needs and do not develop technology for an end in itself. Moreover, the risks posed by technical applications must be as low as possible in order to be attractive to emergency organizations. A system with open vulnerabilities can do more harm than good to the safety and security of an organization, its employees, and society at a time when cybercrime is continuously on the rise. Considering the process of data collection, emergency organizations opting to implement new technologies must examine more closely the topic of privacy, and take into account the various accompanying legal regulations and societal challenges.

The aim of this paper is to provide support to emergency organizations concerning how to implement information and communication technologies in their existing processes. Therefore, it is necessary to understand disasters in advanced technological societies as socio-technical and thus, technology as associated with disasters in many different ways. Insofar as it is not a human decision to incorporate technology into emergency-situations, since they are already inevitably a part of them, it takes humans to set the course of action to produce the best possible cooperation between humans and non-human actors – emergency employees and technological systems – in specific situations and processes. This would make it possible to exploit the socio-technical opportunities to increase the security of our society.

Methodological Considerations

The interviews on which this work is based were conducted in the context of two different research projects, each focusing on specific technologies for emergency procedures. Therefore, the findings could be biased, as they comprise the opinions of emergency employees to that specific technology. The study presents the perspectives of a diverse range of interviewees, each differing in age and work experience. However,

from the eight interview partners only one was female. This could be understood when considering the gender distribution in the field of emergency organizations, which is, especially in the sector of fire and police departments, not balanced. A gender imbalance could lead to a bias, or an overrepresentation of the perspective of male emergency employees, and has to be considered when reading and interpreting the findings. Moreover, the interviewees all work in organizations located in Vienna, so the findings are limited to experiences within an urban area.

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