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Which Factors Govern the Use of Emergency Response Information Systems? Insights from an Ethnographical Study of a Voluntary Fire Department

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Abstract

To realize the digitalization potential of emergency response processes, several information technologies have been proposed that shall support firefighters in their operations. In the incident command process, especially emergency response information systems (ERIS) are supposed to raise the situation awareness and overall efficacy. Despite their theoretical potential, these technologies only slowly disseminate in practice, however. While extant acceptance models can basically explain firefighters' intention to use them, the actual usage so far remained unexplored. To gain an in-depth understanding of the specific domain and its influence on the usage of technologies, we ethnographically observed a voluntary fire department over several years. During its digitalization of command processes, we identified operational specialties like flexibility, organizational requirements like error culture, and social aspects like perceived importance that influence the introduction of an ERIS. These factors shall enrich existing acceptance models and help to better consider the special characteristics of the firefighter domain.

1. Introduction

Improving the efficacy of emergency responders such as firefighters with information technologies is receiving increasing attention in academia and practice. In recent years, significant efforts have been made to digitalize and improve emergency response processes [35, 41]. Despite their significant potential, however, novel information technologies such as emergency response information systems (ERIS), intelligent clothing, or digital maps oftentimes disseminate only slowly in the firefighter domain [39].

This observation seems to apply particularly for the activity fields of incident commanders (ICs), who constantly need to assess the encountered emergency situation and make context-dependent decisions to coordinate the operation [1]. Information technologies reportedly have a significant potential to support the command processes, because the situation awareness – i.e., the perception of the environmental elements, the comprehension of their meaning, and the projection of their development – is a critical determinant for the quality of such decisions [1, 2, 10]. However, extant studies have shown that there exists a significant discrepancy between firefighters' intention to use supporting information technologies and the actual usage of such technologies in command processes [40]. The findings suggest that firefighters are willing to use supporting information technologies if they fulfill domain-specific requirements. Nevertheless, the actual use of such technologies in daily routine remains low.

Next to the acceptance of information technologies, it is hence also necessary to examine their introduction and use to fully understand the constraints prevalent in the firefighter domain. To help achieving this goal, we present the results of a study, in which we observed the introduction of an ERIS to support the command processes of an exemplary fire department. Thereby, we focus on the following research question: "*Which factors influence the introduction and practical usage of information technologies in the firefighter domain?*"

To obtain rich insights into this mostly unexplored field of study and be able to comprehend the background of our observations, we adopted an ethnographical approach. Thereby, one of the authors accompanied the introduction of an ERIS at his voluntary fire department, which resembles a "typical" organizational unit. While the observed fire department is located in Germany, there exist comparably organized departments around the globe. The obtained results contribute to the body of knowledge on the adoption of information technology in the emergency response domain. Our findings particularly suggest that the introduction and actual use of information technology is not only influenced by domain-specific user requirements (which determine the intention to use such technologies), but also by

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additional team-related and organizational factors, which so far have not been considered adequately.

The remainder of the paper is organized as follows: in the next section, we describe the background of our study and discuss related work. In section 3, we provide details of the ethnographical research methodology. The insights gained during our study are discussed in section 4. Section 5 concludes the paper by highlighting the implications and limitations of our study and providing an outlook on future research directions.

2. Background and related work

To establish a basic understanding of the study's background, we briefly describe the firefighter domain and discuss related research.

2.1. Fire departments and their digitalization

Around the world, fire departments are assembled as specialized emergency response organizations. They provide services in non-fault-tolerant, often time-critical situations, which largely dictate the characteristics of their special domain. With respect to the widely applied disaster management cycle [15], fire departments are typically concerned with two phases: preparation and response. Preparation comprises the provisioning of equipment, training the personnel, and defining operation procedures. In the response phase, fire departments provide help in a variety of emergencies. Typical areas of operation are firefighting, technical rescue, and hazardous materials operations [1, 6]. Also, fire departments play a key role in many scenarios of large-scale disasters [15]. Both phases go hand in hand since a successful response particularly depends on good preparation like the concrete design of local processes based on general regulations. Such regulations typically provide basic guidelines for the most important procedures. One of them is the incident command process, since it is crucial for the outcome of the whole operation [1, 2].

Over the last years, several novel technologies have been proposed to digitalize parts of the firefighter work

Figure 1. Exemplary ERIS "Fireboard" [11]

and raise the situation awareness of firefighters. Among them are unmanned aerial or ground vehicles [18, 19], smart protective clothing [4, 30], and many others. A technology to specifically support command processes can be seen in ERIS. They provide a platform to gather, process, and share relevant operational information. As shown in Figure 1, they typically comprise an overview of responding units, the hierarchical command structure, and a situation map of the incident area. From a technological point of view, they can be divided in three evolutionary stages. Basic ERIS require the manual input of data by the user [11, 14]. Advanced systems partly automate this data input and capture real-time information from different sensors like GPS-positions of units or water tank levels [24, 29]. ERIS of the highest stage even automate parts of the decision-making by calculating recommendations and proposing them to the commander [3, 33]. A comprehensive overview of these systems can be found in literature [39, 40].

2.2. Acceptance and use of technologies

The acceptance and use of novel technologies have been extensively researched in the IS literature. The most prominent theories aim to explain it based on the users' attitudes and beliefs toward the technology. A recent examples of this approach is the *Unified Theory of Acceptance and Use of Technology* [37]. It postulates that the users' *Performance Expectancy*, *Effort Expectancy*, *Social Influence* and *Facilitating Conditions* will determine their *Behavioral Intention* and ultimately the *Use Behavior*. These constructs unify findings described in the *Innovation Diffusion Theory*, *Technology Acceptance Model*, and other established theories. Meanwhile, these models have been adapted and applied in several business and consumer domains [38, 40]. Amongst others, they can explain individual and organizational use decisions, utilitarian and hedonic scenarios, and mandatory and voluntary use cases. All these aspects can be further detailed. For example, voluntariness can be divided in several categories [34].

2.3. Related work

To identify related work concerning the acceptance of information technologies in fire departments, we used the results of a broad literature review that we conducted for a prior study. It considered EBSCOhost, ScienceDirect, SpringerLink, AISeL, ACM DL, and IEEE Comp. Soc. DL with search terms like *firefighter* and *fire department*. For ERIS just like most other technologies, we mainly identified studies with a technology-centered point of view. Only a few authors take the user's perspective or specifically address their acceptance of technologies. Multiple works analyzed command processes to design suitable interfaces and implement them in a system architecture [26, 27]. The capabilities of fire departments to adopt information technologies has been researched as well [32]. Multiple works have identified factors for the acceptance of ERIS by firefighters [39]. The integration of these factors into an acceptance model, however, illustrated that there remain certain blind spots to fully understand under which circumstances fire departments use novel technologies like ERIS [40]. While the intention to use can be reasonably well predicted, the factors governing actual usage still can be explained only weakly.

To examine such unexplored and often social phenomena, ethnography has been proven to be a suitable method. In the field of sociology, there exist several ethnographies examining the specialties of emergency responders. Van Maanen, for example, exhibits ethnographic research about police officers [36]. Regarding firefighters, there has been a special focus on wildland firefighting [7, 9] and the role of gender [13, 25]. In Information Systems and Computer Science research, ethnographic methods have been applied to understand firefighter interactions during structure fires to derive design implications [8, 20, 28]. Other areas of application were the temporal effects of information technology in emergency operations [22], the interplay between emergency planning and response [16], and general interactions of first responders with information technology [31]. What comes closest to the focus of the work at hand is an ethnographic study about introducing digital plans in Swedish fire departments [23]. While ethnography therefore seems to be a widely applied and established research method in this domain, we could not identify studies examining the command processes of fire departments. It hence remains unclear how emerging technologies such as ERIS can digitally support the command processes of firefighters.

3. Methodology

To help closing this literature gap, we pursued an ethnographical approach that allowed us to gain in-depth insights into the reality of a fire department and the digitalization potentials of its command processes.

3.1. Research approach

Following Van Maanen's seminal guidelines [36], our goal was to capture first-hand experiences from the firefighter domain. As shown before, such input seems necessary to enhance existing acceptance models that insufficiently explain firefighters' use of technologies. Participatory observations, as included in ethnographic approaches, are especially suited to gain such in-depth insights [36]. For several reasons, we decided to observe the digitalization of command processes in a voluntary fire department. First, despite the publicity of some professional departments (like the FDNY), in many countries most firefighters are volunteers (e.g., 67% in the US, 96% in Germany). Second, one of the authors has been a long-year member of a voluntary department, thus being able to conduct participatory observations. Third, the observed department started a project to digitalize its command processes in 2018. Since command is vital for the overall success of an operation, these processes are of specific interest [1, 2].

The recommendations of Klein & Myers served as another guideline to ensure the rigor of our observation and analysis [21]. For *contextualization*, we described the general domain in section 2, details about the case are given in the next section. The *interaction between researcher and subjects* was collegial. One of the authors is a trained firefighter and has been member of the department prior to this study. Therefore, he could directly participate in all official and social activities. From our point of view, this is the only realistic way to obtain in-depth insights and be able to capture *multiple interpretations* from a voluntary fire department. Main reasons are that the operations occur extremely spontaneously, and most other things happen outside normal office hours of a researcher. However, to rule out biases (*suspicion*), the observations were documented in a diary and frequently discussed with the non-firefighter co-authors. For *abstraction and generalization*, the gathered data was coded, grouped based on common themes, and labeled accordingly. The resulting insights presented in section 4 were linked to theoretical concept wherever possible. Nevertheless, we tried to make our observations unprejudiced and linked them to theory afterward, to also identify contradictions to or gaps in existing theory (*dialogical reasoning*).

3.2. The Haßfurt Voluntary Fire Department

As in many other countries, fire departments are organized on the municipal level in Germany. We studied the Haßfurt Voluntary Fire Department, a fire department that provides emergency services for the 13,500 inhabitants of Haßfurt. Located in Bavaria, Germany, the city is the largest municipality in the rural district Haßberge. On an area of 53 km^2, it is structured into the city center and nine separate city districts.

Although the pure numbers might seem quite small, there are several characteristics that make the city an interesting and challenging area from a firefighter's point of view. Haßfurt is linked to all kinds of traffic infrastructure. The river Main and its adjacent streams flow right through the city. A federal freeway and other busy roads cross its boundaries. The city's regional airport processes more than 10,000 annual aircraft movements. Those traffic routes provide the potential of ship, car, or aircraft accidents, as well as floods and other scenarios. Moreover, the city has several special facilities itself. The historic city center comprises many culturally significant buildings packed closely together. Several schools and retirement homes, as well as the hospital have regional catchment areas. There are multiple buildings near the high-rise threshold as well as industrial plants and warehouses. Large forests and agricultural areas complete the highly diverse cityscape. All these characteristics combined make Haßfurt a rather interesting environment with quite challenging conditions in relation to the small size of the city.

To cope with these challenges, Haßfurt maintains a well-equipped and trained voluntary fire department. Its main fields of duty are firefighting, technical rescue, and hazardous materials operations. The members are volunteers, as it is common in Germany. This means that training and other predictable activities are done in their leisure time, mostly in the evenings. For emergency operations, the firefighters get alerted by pagers or sirens and head to their station to staff the needed vehicles. Over the last years, the department responded to an average of 180 annual incidents with a peak at 300. The 373 volunteers are supported by two fulltime employees in administrative and maintenance issues. The department headquarter houses a command center, several workshops, and a broad spectrum of specialized equipment. Eight smaller fire stations are distributed around the city districts. The department operates 22 vehicles, including engines, ladders, and boats.

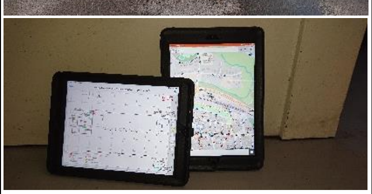
3.3. Digitalization of command processes

Starting in fall 2018, the fire department has begun to continuously improve its incident command (IC) and adjacent command support processes. The introduction of novel IT solutions has been a key aspect of this still ongoing project. Three specific subdomains have been iteratively addressed by now (see Table 1). In the first iteration, the vehicles were equipped with tablets. On these devices, the IC and the squad leaders can access relevant information like building plans and operation guidelines. Besides that, several apps can be used to distribute information amongst the command staff. For example, pictures from different angles of the operation site, situation maps, and so on can be easily shared.

In the second iteration, starting in December 2018, the command center processes were addressed. The command center in the headquarters is staffed in large-scale disasters like blackouts, thunderstorms, or floods. Apart from these special occasions, a regional control center alerts departments and coordinates operations. To support the commanding of large-scale disasters, the command center in Haßfurt was equipped with five PCs and the ERIS Fireboard – a basic system with respect to the categorization of section 2.1. A command support unit (CSU) was formed that is responsible to operate the command center. In multiple training sessions, a standard staffing of six functions was established: Two CSU members answer incoming calls or faxes and generate prioritized tasks based on the information. The IC and the command assistant allocate the available units to these tasks. Finally, two CSU members manage and document communications with responding units, the regional control center, and other institutions.

The most impactful iteration started in March 2020 and concerned the command structures on the site of the operations. A new command vehicle was procured and configured according to the new, digitalized command processes. Amongst others, it contains three computers running the ERIS Fireboard and an exterior display for situation reports. The vehicle responds to any operation of the department. The default staffing was defined with

Table 1. Iterations of the observed project

Iteration	Tablets for command staff	Command center	Command vehicle
Focus	Single unit + communication	Large-scale disasters	All mobile operations
Kick-off	Fall 2018	Winter 2018	Spring 2020
Sample images	 	 	 

three functions: The IC coordinates the operation. The command assistant supports the IC in the field. He acts as an advisor or gets assigned to command a separate sector in larger operations. One CSU member operates the vehicle and establishes a command post with it. His tasks are to look up relevant information, to maintain overviews of responding units and a situation map in the ERIS, and to manage and document the communication on site, with the control center, and other institutions.

4. Key observations

During our study, we gained the following insights why and how the observed fire department introduced an ERIS and integrated it into its command processes. While some results seem to apply to all kinds of fire departments, others seem specific for voluntary ones.

4.1. Emergency management needs flexible guidelines instead of rigid processes.

Amongst firefighters it is widely acknowledged that no incident is like the other and unexpected events can occur in virtually any situation. Over the last years, we observed countless examples for this in Haßfurt: a car standing vertically on its front after an accident, multiple gas containers in what appeared to be a normal vehicle fire, exotic scorpions in a burning apartment, etc. The same applies to the command of an operation. It is hardly possible to estimate the needed means and processes of command at the beginning of an operation. Imagining a BPMN of emergency command processes, there would be endless branching gateways and ad-hoc structures needed to come near a realistic illustration.

Due to this level of uncertainty, fire departments need flexibility in their work. As Denef et al. [8] framed it: the structures of firefighter operations are rigid, but the units acting within these structures are largely independent. This also is the case in Haßfurt, where firefighters organize in teams, squads, and platoons. For some operation types, these units' initial measures are given in standard operating procedures. All measures beyond the initial phase, however, are dependent of the specific situation. Instead of fixed processes, firefighters rely on guidelines like mnemonics, checklists, and regulations. The regulation for command, for example, structures an emergency command process into a circle with three phases: reconnaissance, planning, and issuing of orders [1]. The command staff iterates through this circle multiple times during an operation. Each officer applies it for his/her current situation, the unit(s) under command, and the orders from higher command levels.

This quite basic circle has also proofed to be a solid base to deduce functions and tasks in the digitalized command processes of the observed department. The tablets help squad leaders in their reconnaissance. In the command center, capturing information from telephone and fax supports reconnaissance, the allocation of units is a planning task, and communication supports the issuing of orders. In the command vehicle, all three phases are supported by a single operator. Precise processes are defined in neither of the three areas. Only checklists are provided for certain tasks like launch of the respective devices, available systems including their features, etc. Priority lists define specific tasks that must be executed in any case, for example ensuring communication with the control center. Other tasks are defined as optional and are executed ad-hoc in idle times or on request. Posters provide overviews of the most important tasks that can be requested from the CSU.

The described degree of flexibility in the process must consequently be representable in the used systems, as well. This assessment also corresponds with other studies, in which flexibility has been shown as a major factor for the intention to use an ERIS [40]. We could observe such flexibility in many regards in the ERIS used in Haßfurt. The main functionalities are grouped in freely accessible modules like *resources* to organize units and *operation logs* to protocol important events. There is no defined order in which the modules must be used. While often-used data like properties of local units can be pre-defined, the user can always add new elements at runtime. In the multi-user mode, the tasks can be freely distributed among the users. What requires flexibility of the user, however, is that the system can crash, which we observed a couple of times. In that case, the user will switch to pen and paper as a backup and – if there is time – they will try to solve the problem.

4.2. Command structures must be able to grow and adapt with the operation structures.

From a firefighter perspective, a burning fire has many factors in common with a living creature. It needs air to breath, it consumes flammable materials as food, and it grows. Generally, diffusion or spread is seen as one of the major dangers in any type of emergency operation. Diffusion needs to be prevented or, if it is inevitable, the responding units need to adjust their response according to it. For this reason, emergency operations grow like fires do. Growing operations imply increasing numbers of units. For these additional units, the command structures must be able to grow in an equivalent way. Therefore, German fire departments think in four levels of command. They range from level A, where the squad leader of a single unit commands without support, to level D, where an executive staff acts with numerous support personnel and consultants. Within these levels, the operation can be divided in areal or thematical sectors and sub-sectors. As a rule of thumb, each officer shall have at least two and at most five units or sectors under their command.

The focus on command levels was evident in the observed case, as well. The tablets for the squad leaders support level A, the command vehicle the levels B-C, and the command center the levels C-D. While the levels as such seemed quite clear from the beginning, it was the transition from one level to another that caused problems. In the command center, a Thunderstorm in 2019 showed that the standard staffing of six functions cannot be realized right from the beginning. The voluntary members of the CSU arrive at the station one by one, while the telephones start ringing in the first minute. As a reaction, a preliminary stage was defined, in which the most important tasks are divided among only three functions. In the command vehicle, the suspected emission of explosive gases in an industrial plant in September 2020 demonstrated how fast the standard staffing of three functions can be overwhelmed with a growing operation. At that time, there was no real concept on how to grow. Especially the operator of the vehicle was unable to fulfill all the given tasks (communicate with IC and control center, research the dangers from the emitted gas, define staging areas for approaching units, etc.). Meanwhile, the vehicle gets staffed with four functions for certain types of emergencies. If further growing is needed, additional CSU members from other units get assigned to man functions 5 and 6. Responses to fires in a hospital (2020) and a dormitory (2021) showed a clear improvement.

This ability to grow, which might be referred to as scalability, could in parts be observed in the used ERIS, as well. In the system, the operation can be easily divided into sectors and units can be assigned to them. The numbers of personnel are automatically summed up for the whole operation. Most importantly, there is a multi-user functionality that, however, only works for local networks by default. Looking at the literature, the growing of operations and scalability of used systems has not been of great interest, so far. Most authors do concentrate on specific levels of command, i.e. single units [8], normal-size operations [41], or large-scale disasters [35]. However, the transition from one level to the other is hardly discussed in the literature. Also in practitioner outlets, most of the work seems to be only concerned with the separate levels [1, 2]. The same applies for the acceptance of ERIS, for which scalability has by now not been examined as a relevant factor.

4.3. Lack of error culture is one possible root for a perceived resistance to change.

In operations, trainings, and interactions with other departments, we observed a significant resistance to change among firefighters. While this finding is in line with other studies and practitioner outlets [12, 39], we could also observe some possible roots for this phenomenon. Generally, there seems to be an attitude to never change a running system. Changes might risk the reliability of usual habits and making them right is a time-consuming task. More specific for fire departments is that they feel a strong pressure to appear as competent and infallible in the eyes of the public. It is essential that, in an emergency with lives at stake, people blindly trust their fire department. Therefore, it is quite common among fire departments that mistakes are not discussed in public or in front of outsiders. While this may still appear plausible and reasonable, many departments overdo it. They often do not even internally talk about errors and possible consequences. It appears to us that they confuse the outwardly presented infallibility with an actual one – which can, realistically, not be reached.

This situation can be described as a lack of error culture that is, of course, not a black or white situation. Many departments try to introduce a more open handling of errors. In this regard, the observed case is a pleasant example. The adaption of command processes in Haßfurt was informed by identified and analyzed errors. During the iterative process of improvement, feedback was frequently gathered and openly discussed. Of course, there remained skeptics in the department and even within the CSU that considered the project to be exaggerated for the size of the department or a waste of time. However, with each training or operation, in which improvements over the former status quo got visible, these voices fell silent. Meanwhile, the new processes have become firmly established within the department. The major drawback remains that they are still quite unique in the surrounding area. Most of the neighboring departments observed this “revolution” rather suspiciously than openly interested.

Summing up, the widespread lack of error culture amongst fire departments seems to decline only slowly. The small steps toward a more open attitude seem to be depending on the will and perseverance of individuals. To better understand the interrelationships between error culture and resistance to change as well as their impact on the acceptance and use of technologies, further research is necessary.

4.4. Unveiling experiences or due investments trigger major progress.

Apart from the general existence of an error culture, we could observe two triggers that seem to be needed for substantial progress in a fire department. First and foremost, a firefighter relies on his own experiences. Be it at fighting fires or using hydraulic rescue tools – firefighters seem to learn things best by doing them.

This focus on personal experiences often transfers to decision making. Progress like fundamental process adaptions is often triggered by events that illustrate need for action. Another, more external trigger can be due investments. Typically, publicly funded equipment of a fire department gets replaced on a regular basis. In a voluntary department the replacement cycle of a vehicle can be more than 25 years. On the one hand, whenever the replacement of a vehicle is pending, it triggers the department to get informed about the current state of the art. On the other hand, internally desired progress must often wait for such a due investment, because old equipment cannot be adjusted for the new requirements or there is simply no financial support.

For the command center in Haßfurt, the triggering event was a thunderstorm in 2015, which confronted the department with more than 100 incidents in less than an hour. Until then the command center coordinated large operations for many years, most prominently floods of the river Main. There has always been a long lead time and the situation changed only sporadically. In the 2015 thunderstorm, however, the untrained personnel with their usual paper forms and Excel sheets were totally overwhelmed. Based on this event, the CSU was established, and the command center got its digital upgrade. For the command vehicle, there was an unveiling event, as well. At a structure fire in 2017 with two fatalities the IC could not contact the control center with his handheld radio. For the stronger vehicle radio, he had to run a hundred meters away from the incident area several times. At that time, command support was completely missing in mobile operations. However, in this case the desired technologies could not be integrated into the existing equipment. The command vehicle at that time was an SUV without sufficient space for any computer workstations. Consequently, it needed the procurement of a new command vehicle, that was planned for some years later, as an additional trigger.

Summing up, we observed two triggers to introduce novel technologies in a fire department. First, users must be convinced by own experiences. It seems reasonable to intentionally evoke such experiences in trainings instead of real operations to avoid dangers and not depend on chance. This way, technologies and processes can also be better standardized across the departments. While we observed such approaches in practitioner seminars, technology acceptance literature has not taken this topic into focus. Neither has the second trigger of due investments been researched.

4.5. Personnel is biggest strength and biggest weakness of a voluntary fire department.

On first sight, it appears clear that qualified personnel is scarce in fire departments – just like in most other professions. In voluntary fire departments, however, personnel matters are of a quite unique, two-fold nature. On the one hand, voluntary firefighters do their service as a (very special) hobby besides their actual job. Due to this fact, the members can come from all social groups. They may comprise highly educated and specialized experts of virtually any profession. In that regard, they may even have higher educated personnel than professional departments in certain areas. The experts can be used to address highly complex topics and problems. On the other hand, especially these higher qualified members tend to commute to other cities or are engaged in their actual job during office hours. They are hence less available for emergency operations in these times. Consequently, especially the most important tasks in the initial phase of an emergency response must be comprehensible for any ordinary firefighter and not only a few experts.

The fact that the adaption of command processes in Haßfurt went hand in hand with the introduction of novel information technologies was only possible because the department had multiple IT experts. They implemented specific solutions in the command center and vehicle and the used systems. One example is the administration of continuous VPN connections between the ERIS workstations for remote multi-user access. In Operations, all CSU members take turns on the vehicle. For the less experienced users, there are checklists provided for the most common tasks as well as the handling of the most frequent errors. Besides that, certain routine activities like the transfer of unit status and alarm data from the control center into the ERIS were automated. These are just some of the measures taken to facilitate the work in the command vehicle and in similar form in the command center.

Regarding the used ERIS, most users acknowledge that it is quite intuitive to use but still requires some routine. Especially for the firefighters that do not regularly work with computers in their job, we could observe a noticeable insecurity. However, only by including this group, the staffing of command vehicle and center in Haßfurt can be ensured throughout the day. This demonstrates why processes and technologies in emergency management must be generally designed for the easiest possible handling in operations. This is in line with existing literature, in which ease of use is seen as a major acceptance factor for ERIS and other systems [40]. The question of personnel availability, however, is rarely raised in the literature. One reason might be that voluntary departments are much more affected by this problem than the more often studied professional ones. Nevertheless, voluntary departments are the vast majority in many countries and not all professional departments do have IT experts. Hence, future research must consider the availability of qualified personnel as a non-trivial requirement for digitalization, especially in fire departments.

4.6. Command work must be perceived as important and can be perceived as fun.

As we observed, the common firefighter seems to be a craftsman. He/She likes manual work and to see the results of the actions right away: splash water and the fire goes out, kick in the door and the way is free. In contrast to manual actions, command work is of a more theoretical nature and its results are less visible. The command staff itself may have the power of decision-making as a kind of compensation. The command support staff, however, has theoretical work to do without any apparent benefit. While this applies for all kinds of fire departments, the problem is further increased for the voluntary ones. First, there are very limited options for disciplinary consequences since a volunteer is much less dependent than an employee. Second, the members do the service as a hobby and typically seek a change from their everyday work routine. Especially the ones working with computers all day do not necessarily want to continue this activity in their hobby, while the others do "the real work". It is these people, however, who are best suited for the command support. All in all, motivating firefighters for this kind of work appears to be a difficult task.

One key factor of success in the observed case was to establish an overall understanding of the importance of command and especially command support. The commanders tried to keep the events triggering the process adaption and the expected improvements in the minds of their firefighters. They did so with personal conversation, by mentioning them in meetings and press releases. The establishing of the CSU as a special task force illustrated the topic's significance as well. CSU members obtain incentives like specialized trainings or seminars and the option to "reserve" the command vehicle in an online calendar. In that time, they can assume the operator position despite the common first-come-first-served staffing principle. What might seem like negligible trifles does work much better than monetary incentives in this special domain, since the firefighters work out of conviction. Another motivator we could observe was fun. Especially for younger members, the use of an ERIS can be framed as playing a video game. Amongst some of this group the term of "playing Fireboard" has meanwhile become established.

Be it perceived importance or just fun – especially for voluntary fire departments it is important that the members are motivated and show the desired behavior as result of their own will. While we know of several practitioner publications about motivating firefighters, research has so far largely omitted the topic. In most cases, firefighter information technologies are examined from a technological point of view and human factors are left out. In the literature of technology acceptance in general, however, there are several constructs that might help to map the observed phenomenon. *Job relevance* [5] and *Perceived enjoyment* [17] might be suitable concepts for what we called perceived importance and fun. *Hedonic motivation* [38], *Intrinsic motivation* [37] or various aspects of *Voluntariness* [34] might capture the overall topic. Such human or social factors should receive more attention in future research of firefighters' use of technologies. Our observation indicates that they are essential for the success of such projects.

5. Concluding Remarks

During our ethnography, we could gain in-depth insights into factors influencing the digitalization of command processes in a voluntary fire department. The study has implications for academia and practice alike.

5.1. Implications

From the academic point of view, we elaborated on many specific aspects that characterize the firefighter domain. This complements existing literature that does acknowledge the domain's high specialty but insufficiently explains exactly why it is so special. Our study constitutes a detailed domain characterization with specific focus on the highly important command process. At the same time, we answered our initial research question and identified several factors that influence the introduction and practical usage of new information technologies in the firefighter domain. These add several new perspectives, which enrich extant models explaining the acceptance of / intention to use technologies like ERIS [40]. The first perspective concerns specificities of the command process itself with a high degree of flexibility and scalability in processes, personnel, and systems as important factors. As a second perspective, we found organizational requirements for progress like the introduction of novel technologies, namely an existing error culture, the presence of a triggering event, and due investments. Finally, we identified human or motivational aspects such as personnel availability, perceived importance, and fun. Exactly these soft factors might resemble some of the blind spots of extant acceptance models. Including them may lead to a more holistic understanding of the topic. Next to the firefighter domain, our insights are transferable to other emergency management domains, especially those with comparable volunteer structures. Some findings like the unexpected importance of soft factors for the use of technologies are also relevant for business or private contexts. The gained insights did, however, not only deliver answers but created just as many open questions that may serve as starting points for future research. Some of our own plans will be described in section 5.3.

For practice, we shed light on the phenomena and mechanisms in voluntary fire departments that so far might even have remained hidden for those involved. On the one hand, this concerns the firefighters themselves. The awareness for their own needs and ability to articulate them may be strengthened by our insights. Furthermore, uncovered aspects like the lack of error culture may initiate a rethinking in departments. On the other hand, the vendors of technologies can use our findings to better match their products to the users' needs. Products that better support firefighters during their operations will ultimately raise their efficacy and may save lives in the long run.

5.2. Limitations

When interpreting our results, several limitations should be considered. First of all, we observed a single case (i.e., one fire department). Although our contacts to other departments confirmed most of our assessments, there might still be undiscovered differences. Moreover, our research object was a voluntary department in Germany. While our insights into operational processes will be transferable to professional departments as well, other findings are rather specific for voluntary ones. Also, the insights may only be transferable to countries like the US, where comparable volunteer structures exist. The specific focus on command processes only partly allows for statements about other processes in a department, as well. Also, our approach to provide a broad overview of several aspects prevented a deeper discussion of each aspect on its own.

General limitations associated with the method of ethnography are the lack of quantifiability and the challenge of objectivity. In particular, the researcher was deeply involved as a long-year firefighter. This appeared to be the only realistic way for ethnographic work in a voluntary fire department with spontaneous operations and most other activities in the leisure time. However, to control the rigor of our study, we followed established rules [21]. Frequent discussions with the less involved co-authors were moreover conducted to prevent biased interpretations. The pandemic situation leads to an additional limitation, since there were restricted training conditions and lower incident numbers at times during our study.

5.3. Future Research

As mentioned before, the project of digitalizing the command processes in the Haßfurt Fire Department is still ongoing. We want to continue our observation and try to gather additional insights. With the end of the Corona pandemic, more trainings and an increasing number of incidents can be expected. We also plan to conduct semi-structured interviews with the involved actors. This way, our observations can be complemented with firefighters' subjective perceptions. Another plan is to interview experts from other departments. Our experience makes us assume that the identified insights will largely apply to most fire departments, at least in Germany. Nevertheless, there might be additional factors or alternative interpretations that should be considered. The ethnographical insights may be used to enhance existing models to describe the acceptance and use of information technologies by firefighters. Finally, the long-term appropriation of ERIS after the initial acceptance is of interest. For these endeavors, we hope to provide a suitable starting point with the results of our study.

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