State of Knowledge Management among German firefighters

Andreas Schultz*
Paderborn University
Data management in mechanical engineering (DMB)
andreas.schultz@uni-paderborn.de

Fabian Dotzki
Paderborn University
Data management in mechanical engineering (DMB)
dotzki@mail.uni-paderborn.de

Iryna Mozgova
Paderborn University
Chair of Data management in mechanical engineering (DMB)
iryna.mozgova@uni-paderborn.de

ABSTRACT

This paper introduces the results of a survey that was conducted among German firefighters in 2023 to investigate the current situation of knowledge management. We want to examine which systems and techniques are in use, what the end users' expectations towards knowledge management are, and which requirements a system should fulfill. We focus on all stages of the crisis management circle, from prevention and preparation to the response to an incident as well as recovery.

The goal of this survey is to evaluate firefighters' needs in order to be able to define requirements for a knowledge management system that will be accepted by the users. The exchange of information items between entities (emergency units, authorities, and enterprises) and other IT systems is one important aspect. We identify existing information and knowledge management systems, and means to improve user satisfaction by leveraging users to maintain a system with relevant and up-to-date information and knowledge.

Keywords

Knowledge management, firefighter, emergency management, survey, Germany

INTRODUCTION

During the past decades, crisis management has experienced many changes regarding exterior circumstances and interior preconditions. New and changing legal and administrative regulations hamper the performance of emergency management organizations, digitization puts new requirements on the practitioners' skills (cf. (Sauerland et al., 2020)) and the technical and procedural understanding has to grow constantly. It is challenging to find new (voluntary) personnel as their expectations shift towards work- and family-friendly conditions and the level of skills and knowledge required continues to increase. Since the amount of necessary time is constantly increasing, measurements have to be taken into account to cope with it. There are few publications related to the combination of knowledge management and crisis management, as stated by Anand et al. in their survey study related to knowledge management in contexts of crisis (Anand et al., 2022). They identified 59 publications focusing on knowledge management and disaster management, but factors supporting the development of knowledge management for crisis preparedness is scant. Oktari et al. showcase the positive effects of knowledge management that improves both the effectiveness and performance of operations as well as innovation among users (Oktari et al., 2020). Only few literature can be found that deals with the actual implementation of a knowledge management system for emergency

*corresponding author

services. One older article from Pickles describes the development of a knowledge management infrastructure in Australia but hardly more information about the system can be found (Pickles, 2004). Another description comes from Timm et al. who describe the comparison of different open-source systems to be used as a knowledge and collaboration platform (Timm et al., 2013). Some German fire brigades make use of the Einsatzleiterwiki, which is a software solution that stores incident-relevant information in a wiki. A public instance exists that is accessible on the internet[1]. The usage as a closed system by the Berlin fire department is described in (Ziehr et al., 2017). This shortage in knowledge management research led the authors to perform a survey among German firefighters to find out what their attitudes towards knowledge and knowledge management are.

This survey is one of the first steps in a holistic process of examining knowledge management among firefighters, surveying the current status and needs of emergency personnel regarding knowledge management, and finally developing a system that incorporates the findings. It aims to bridge the gap between research and practice by laying the foundation to develop a system according to the needs of end users. The focus is on the German firefighters, where each federal state (Bundesland) has to govern the emergency management and issue laws and regulations (except civil protection for which the Federal State (Bund) is responsible for) on its own. The vast majority are voluntary firefighters, and in general, the bigger the city, the more professional firefighters are on duty, mostly 24/7. See (Deutscher Feuerwehrverband, 2021) and Figure 6 for details. The results of the survey should be independent of the specific organisation of the participants. Of course, some organisations either have more personal capacities like professional personal who are employed or have motivated voluntary members who are already involved in maintaining a knowledge management systems (KMS). In general, the prerequisites should be similar between fire services, relief organisations or other emergency organisations and a comparability of the survey results is given. In contrast to KMS in a corporate environment, KMS for emergency services can profit from an absent competitive situation which would impede the exchange of information between organisations.

In this evaluation, a methodical approach was followed, guided by the methods recommended in *Umfragen erstellen und auswerten* (Creating and Evaluating Surveys) (Ortmanns & Sonntag, 2023). The central research question is: To what extent is knowledge management bruited in German fire departments, particularly outside of emergency situations, and what are the end users' expectations towards a KMS. The extent of the dissemination and intensity of the use of KMS were examined. The hypothesis was formulated that the spread and use of such systems in German fire departments is currently limited and confined to a few projects. Emergency personnel, although not stated explicitly in literature, wishes for a system to manage their knowledge.

The survey plan was developed in line with the methods suggested by (Ortmanns & Sonntag, 2023). The investigation employed a quantitative survey method, supplemented by the inclusion of some open questions to allow for a broader range of responses. The survey was tested before dissemination internally several times and by few senior firefighters known to the authors. Particular care was taken to reach as many firefighters as possible. To this end, fire department associations in Germany were contacted, and the survey was distributed via social media. The data collection was conducted online with the EU Survey system[2] to make use of a flexible and proven system to ensure maximum reach and user friendliness.

Terms and concepts related to knowledge management often do not have a universally valid definition. Therefore, we provide a disambiguation and distinguish between the terms data, information, and knowledge in the following way, according to (North, 2016; Mozgova et al., 2020) and depicted in Figure 1:

- Symbols are the basic set of available characters (letters, numbers) that, when combined in a syntactical way, form data.
- Data are uninterpreted sets of symbols that do not have a specific meaning until a sense is added.
- Information is data with a context of meaning and an added relationship.
- Knowledge is the result of connected information. Information forms the basis and needs to be interpreted by a human being.

The remaining stairs in 1 refer to a more business-oriented view on knowledge management, which is only partly applicable for emergency management (Duscher, 2010). At least the last step, competitiveness, does not make sense for emergency personnel since there is no need to compete rather than to collaborate.

This paper is structured as follows: At first, we will give an overview of the survey and present our methodology as well as demographic data about our respondents. Then we will examine the knowledge management-related

[1] https://einsatzleiterwiki.de/
[2] https://ec.europa.eu/eusurvey/

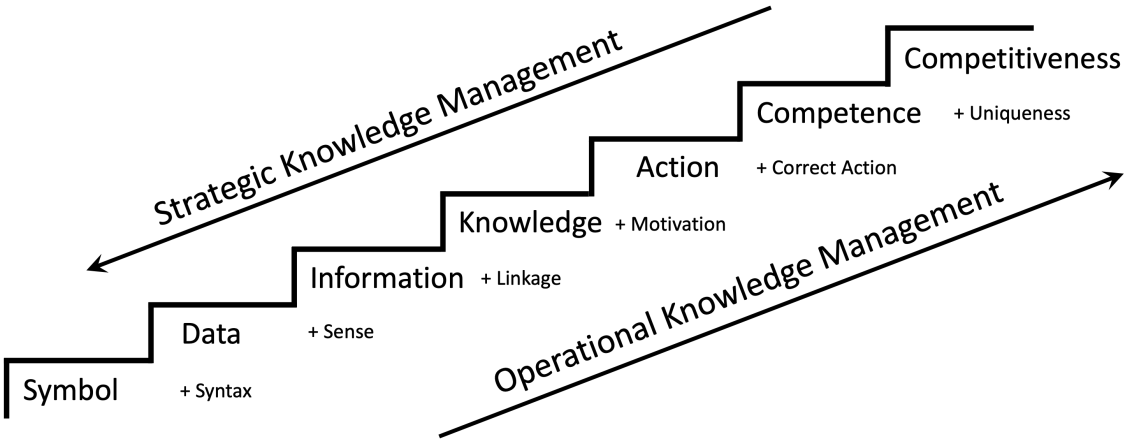

Figure 1. Knowledge staircase according to (North, 2016)

aspects of our survey, where we elaborated on the current status of German fire brigades as well as respondents' requirements and wishes. Next, we present the findings of our survey and deduce aspects that have to be taken into account when developing a KMS for emergency personnel. Finally, a conclusion summarizes our presentation and shows further areas that need to be examined.

SURVEY

The survey was designed to get an overview of current aspects related to knowledge and knowledge management among firefighters, from the beginner to senior experts with decades of experience. The procedure for the whole survey is shown in Figure 2. During creation, the questionnaire was divided into the blocks *statistical data* (8 questions), *information management* (19 questions plus free text fields to clarify answers), *information exchange* (5 questions plus free text fields to clarify answers), and *data maintenance* (21 questions plus free text fields to clarify answers). The survey period was from August 2023 until October 2023. We distributed the survey among both, federal and state fire organizations and via personal contacts with the request to forward it to them, and we posted calls to encourage participation online via Facebook posts and groups. We received a total of 577 responses from firefighters across Germany. Only 5 submissions were empty and excluded beforehand. Since some questions were only shown based on certain previous answers and other questions have multiple answers possible, the number of responses per question might vary. The evaluation is carried out in this paper.

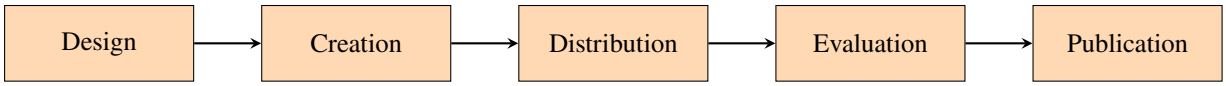

Figure 2. Survey process

We contacted each state fire association (Landesfeuerwehrverband) in Germany but only two replied positively; one declined our request, and the rest did not answer at all. The distribution via Facebook by the DFV[3] is likely location-independent, other invitations to participate via Facebook groups might be filtered more restrictively by Facebook's algorithms. The participants and results of our survey roughly align both with the population's distribution in Germany, as indicated in Figure 3, as well as the distributions of education and expertise among the firefighters. But we do not consider our study fully representative for Germany since the emergency domain differs in each state and we do not have sufficient answers from every state.

Overview

Beginning with demographic data for the subsequent analysis, we asked the participants questions to get an idea of their type and location of engagement, experience in the emergency domain, their IT and leadership skills, and their age and duration of membership. In the following, we considered the current state of information and knowledge

[3] https://www.facebook.com/112willkommen/posts/pfbid02kjfzQVu9T5UNjajxDo9qQ7zQiaheFCE8nAYgqzvMfgBJimWRhp7GAxVc5qmFX5Qjl retrieved August 2, 2023

management in their units. We were interested in exploring how information and knowledge are currently being exchanged among firefighters and the tools they utilize for this purpose. We aligned our survey with information from the DIN ISO 30401 norm, which deals with requirements for KMS in business contexts (Deutsches Institut für Normung, 2022). Another important step in managing knowledge is the exchange of already-available information via Information Management Systems (IMS), respectively KMS. Therefore, we examined the distribution of means to share data between entities (emergency units, authorities, and enterprises) or IT systems. In the last section, we examined the current status and willingness to maintain KMS. We wanted to see whether our participants are already involved in creating knowledge, instructions, or sharing information and how they do it. We asked them to rate several statements regarding the upkeep of knowledge in a KMS, focusing on the amount of time they devote or would devote to maintenance tasks and their preferred tools for these activities.

Detailed Insights

We received a total of 577 valid answers that were taken into account for our validation. Only one answer is not based within Germany; five did not provide their origin. The federal states of North Rhine-Westphalia and Lower Saxony are particularly well represented. City states like Berlin, Hamburg, or Bremen have the lowest numbers of responses. The distribution of responses by state, as shown in Figure 3, does not perfectly match the distribution of the German population across federal states. However, our results are generally in line with the population distribution. A comparison between the actual numbers of firefighters per state with the submitted surveys would have been preferable, but it is difficult to obtain comparable recent numbers for all federal states.

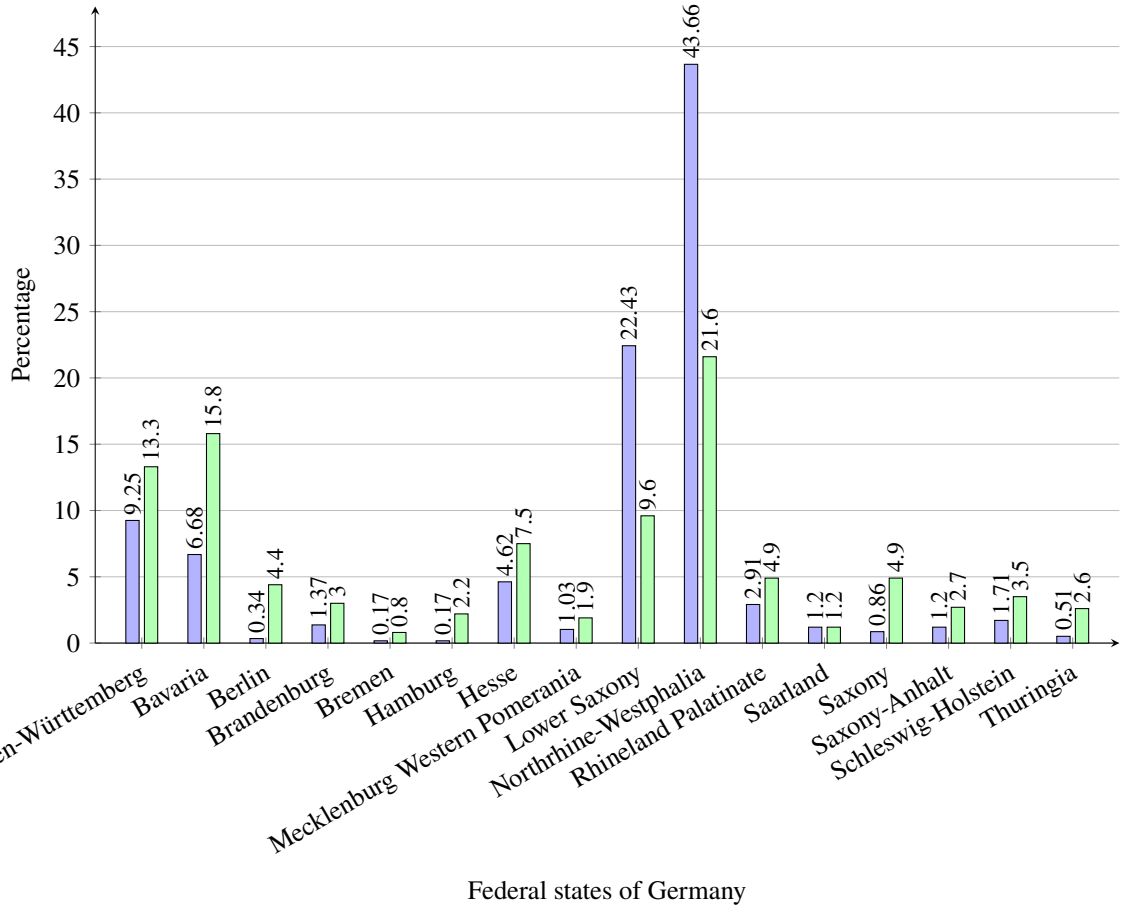

Figure 3. Distribution of survey answers (in blue) compared to inhabitants (in green), data from (Bundeszentrale für politische Bildung, 2023)

The age structure of our participants shows a relatively even distribution across all ages, ranging from 18 to the age at which emergency personnel typically retire. According to the German fire brigade association (Deutscher Feuerwehrverband), the age limit for active duty in emergency services varies from state to state. For instance, in some states, young people can participate with limitations beginning at 16 years old, while in other states, the minimum age is 17 or 18 years old. The upper age limit also shows variation, ranging between 60 and 67 years across different regions (Deutscher Feuerwehrverband, 2017).

The duration of membership of our respondents appears to be evenly distributed across the 10-year categories. Significantly, a number of participants with decades of experience contributed to our survey, providing valuable insights into their extensive knowledge, as depicted in Figure 4.

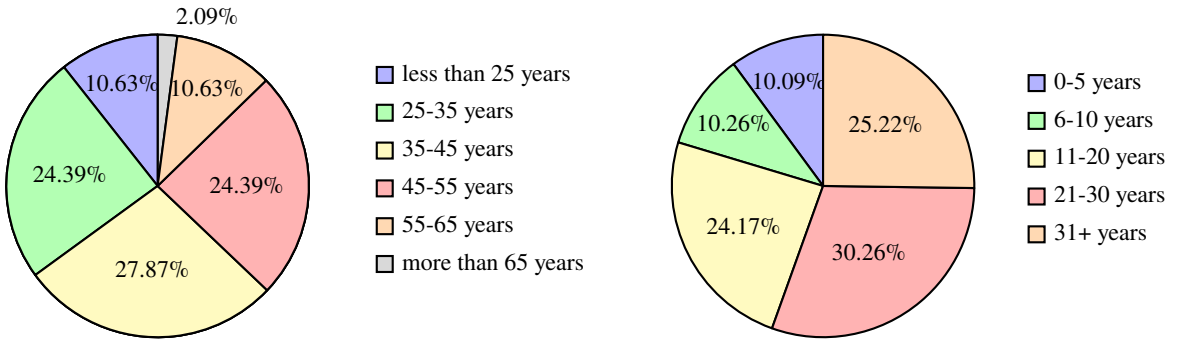

Figure 4. Age (left) and years of membership (right)

The management education of our participants is rather high, and a particular emphasis is on group, platoon, and formation leaders (Gruppen-, Zug- und Verbandsführer), who usually take responsibility for their units and lead operations and organizations (cf. left chart of Figure 5).

We further asked our participants to rate their perceived IT knowledge to get an idea of their skills and to be able to rate their answers in an IT-related context. Although this rating is not objective, it helps us rate comments and attitudes (cf. the right chart of Figure 5).

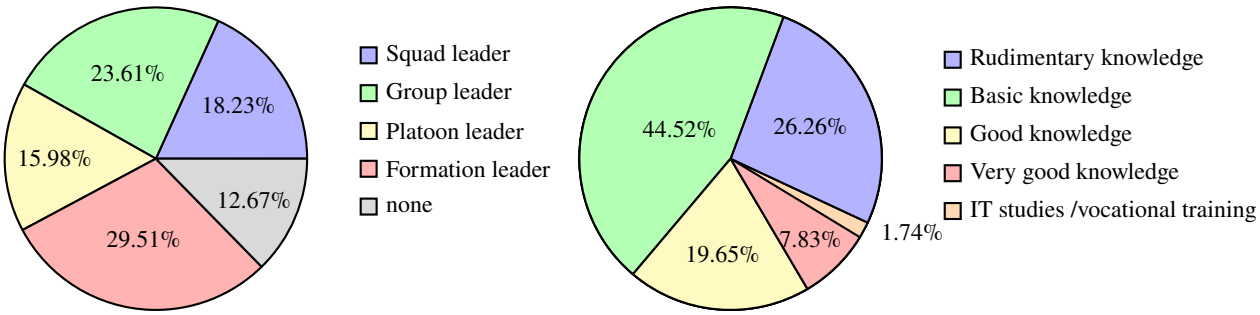

Figure 5. Level of fire department management training (left) and IT knowledge (right)

The vast majority of our participants are doing firefighting on a voluntary basis. This is not a surprise, since of the 1.385 million firefighters in Germany, 1.014 million belong to a voluntary fire brigade. Only 35 thousand firefighters are professional firefighters at governmental institutions, plus another 34 thousand firefighters work for companies. The remaining 301 thousand are members of youth fire departments. Some people also belong to both types of organizations (Deutscher Feuerwehrverband, 2021). The shares can be seen in Figure 6.

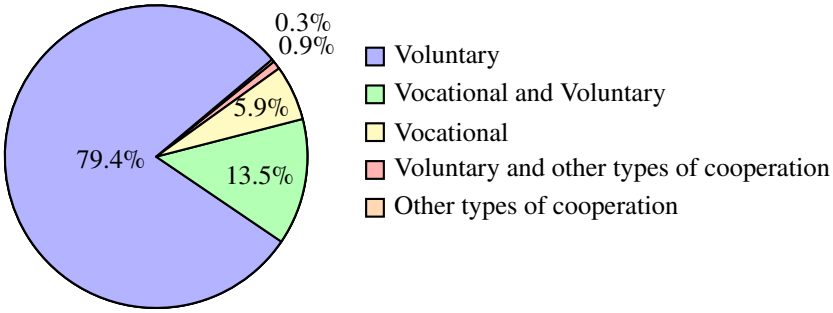

Figure 6. Types of engagement in the fire department

SURVEY EVALUATION

In the following section, we will present the knowledge-management-related aspects. We will begin with a survey of the current status of knowledge management. This includes, according to (Nonaka & Takeuchi, 1995), the acquisition, administration, and dissemination of *information* (cf. Figure 1). This is followed by questions about knowledge management and its distribution, as well as requirements from our respondents.

Information Acquisition, Administration, and Dissemination

Regarding the systems that are in use for information dissemination and the perceived availability of information, we asked the following questions:

How is new information, such as instructions (e.g., service instructions, emergency plans), processes, contact persons, etc., currently distributed in your fire department? (multiple answers possible)

The prevalent means of information management are e-mail, text messaging (such as WhatsApp and Telegram), verbal communication, and notices on a board (see Figure 7). Other platforms, such as a cloud, wiki, or forum, are barely used currently. The participants indicated the following software in the free text field: DIVERA 24/7 (10), Spond (9), Internal area of the homepage / intranet (8), APager (6), Teams (5), Alamos (4), as well as other products with less than three answers per product. The products are presented in detail in the Findings section.

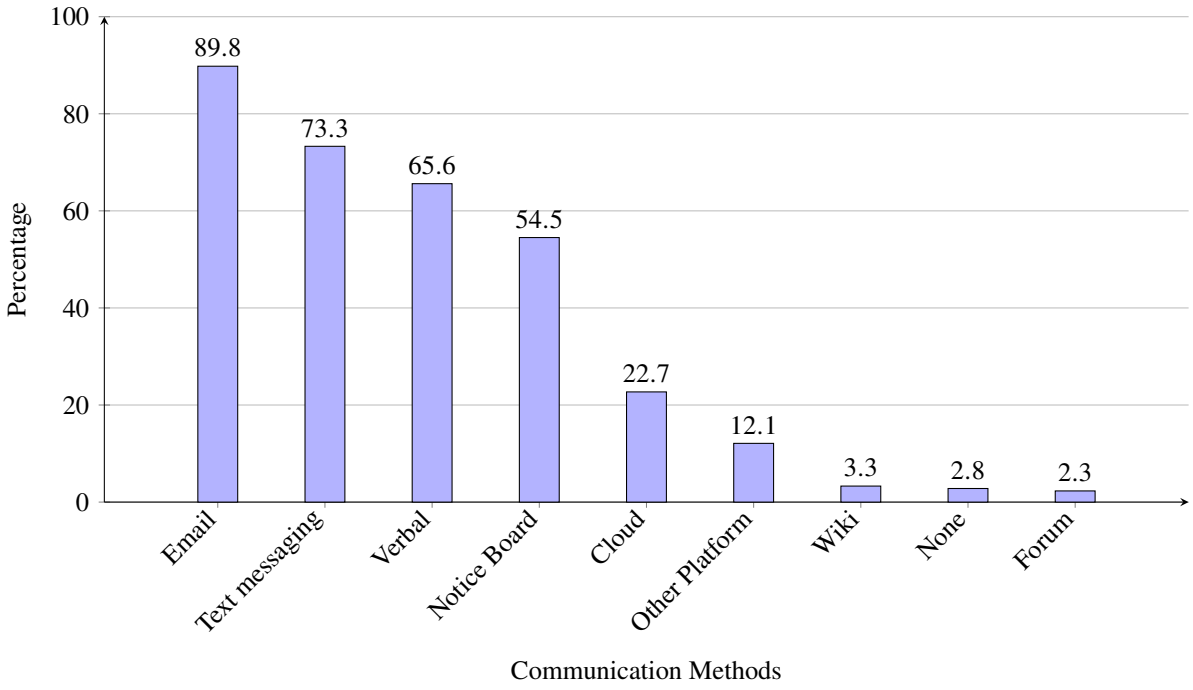

Figure 7. Distribution of communication methods in fire departments (multiple answers possible)

Rating statements towards the current situation of information and knowledge management.

We asked the following questions, the answers to which are shown in Figure 8.

- Question 1: I have the feeling that all current and new information is available to me.
- Question 2: I find it important that information and knowledge are stored in an organized way in my unit.
- Question 3: It is important to me that as much knowledge as possible is available to as many people as possible.
- Question 4: A knowledge management system should provide answers to recurring questions.
- Question 5: A knowledge management system should help to keep the content up-to-date.
- Question 6: The same information must be communicated frequently (e.g., answers to recurring questions).

Remarkably, only 53 percent of the participants stated that they agree, or rather agree, with the claim in Question 1. On the other hand, 32 percent said that they disagree, or rather disagree, with this claim. So, a significant share of the participants perceive a lack of information.

Questions 2 and 3 (cf. Figure 8) relate to the organization and dissemination of information among firefighters. The participants find it important that information is stored in an organized way and, thus, ideally, retrievable with no extra effort. Also, the transparency of information is important to keep personnel informed about everything relevant.

Questions 4 and 5 deal with the features that knowledge management should provide. Here are only two preliminary questions to get a first overview. More requirements and expectations are raised in the course of the survey.

Question 6 revealed other results than expected. Our assumption was that management personnel have to constantly answer similar questions. The response behavior is not as clear as expected but still displays the need to communicate similar information.

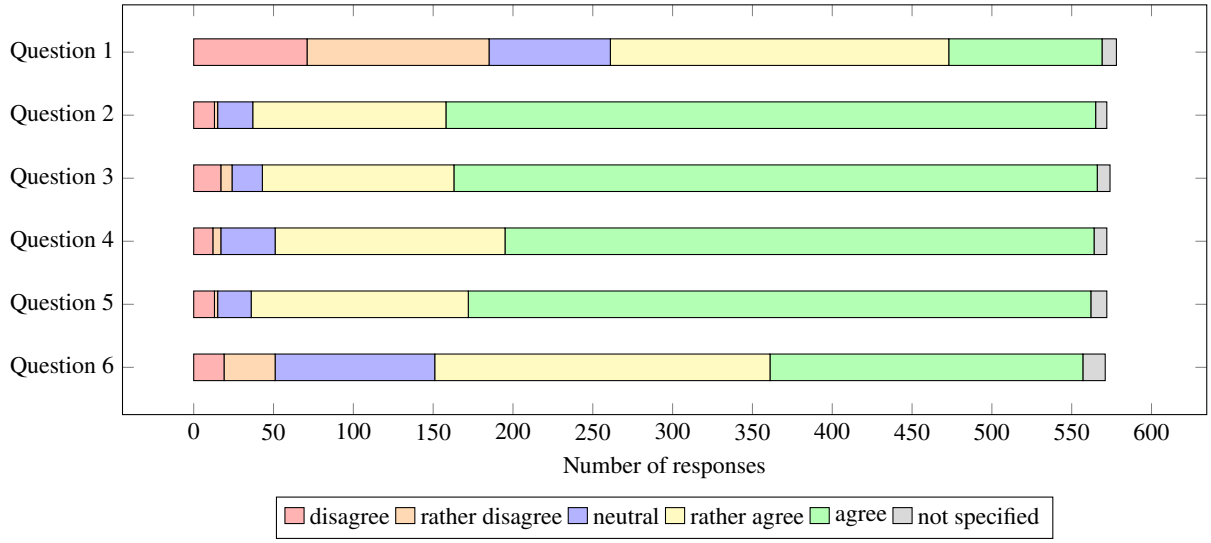

Figure 8. Statements towards information and knowledge management

Knowledge Management

Next, we surveyed the current status of knowledge management. 117 respondents (20.03 %) use a KMS, 343 (58.73 %) do not use a KMS, and 118 (20.21 %) are unsure whether their unit has a KMS in use. All respondents stating 'yes' were then asked which system they use exactly. This gives an overview of many systems that have practical applications. The whole set of software products mentioned throughout the survey is listed in Table 1.

Knowledge management systems in use

We grouped the answers with at least three mentions into the following categories:

- Information management systems / Databases: MP-Feuer (23), FeuerON (19), fireplan (8), Wasserkarte.info (3), 'database' (3) (not further specified)
- Knowledge management systems: Fireboard (19), Alamos (11), Wiki (5) (unclear about the actual usage), DIVERA 24/7 (4), L2R (3)
- Other software (depends on the usage, thus not categorised in one category above): Cloud solutions (18), Teams (3), self-development (3)

Features of knowledge management systems

We asked the participants without a KMS in their unit which features they personally would make use of. 414 would use the KMS for saving data for operations (e.g., hydrant plans or checklists), 411 would use it for providing content for basic and advanced training (e.g., training scripts), and 392 would use the system for saving instructions

for procedures (e.g., clothing exchanges or service directives). With a certain distance, 301 answered ”Storing task descriptions (e.g., tasks as a manager)”, 286 answered ”Saving information about operations (e.g., operation reports)”, and 280 answered ”Managing base data (for promotions, addresses, or equipment maintenance)”.

Subsequently, we asked which functions or contents should be added to or provided by an existing KMS. The answers are partially very generic; others are very specific. We tried to categorize the answers into different, throughout the process evolving, categories that match the meanings of the respondents best.

Many respondents (46) ask for a feature to provide teaching material from existing courses to either have a look at it prior to training or afterwards to refresh the knowledge of an attended course. Another 20 respondents want a KMS to help them harmonize existing teaching material to align and adjust courses' contents to have similar training for all personnel. 9 respondents request a lessons-learned approach to be able to gain knowledge from incidents or risk situations and to inform others about this issues.

Also a regular request is the storage of instructions (29) to have a central position where all applicable instructions can be found. 15 people requested an update mechanism to receive information upon changes in whatever information is stored in the KMS. Another 9 respondents want to record responsibilities and organization charts in a KMS, together with 9 answers that seek to display processes. 5 people want to have an frequently asked questions (FAQ) section, together with another 5 respondents demanding an on-boarding procedure in the KMS. 5 people requested a database of forms.

20 people requested mission-related standardized rules, emergency plans (22) and other maps relevant to an incident.

12 respondents want to store user manuals in a KMS, together with duty roster / appointments (11), equipment and material management (9), personnel administration (8), and training administration (7).

Give an example in which the knowledge management system has contributed or could contribute to solving a problem within the fire department

One respondent reports the necessity of training about 86 fire brigades and their members in their rural district according to a state-wide regulation for vegetation firefighting. The training has to be both theoretical and practical, which requires an enormous amount of effort. The respondent suggests a KMS that helps convey the training content by providing an eLearning course that adapts to the participant's prior knowledge. The course concludes with a test that certifies the theoretical knowledge, which is then applied practically in a second part. Updated material on this topic can be posted in a KMS for former attendees of the course. Likewise, 28 other respondents stated their wish to have standardized implementation of training in a KMS that adapts to the respective management level. The possibility of recovering previously attended courses is demanded, too. Besides, respondents required the standardization of knowledge bases (11) and processes (6), as well as maintaining a set of FAQs (6).

The process of onboarding new personnel is important for 14 respondents who wish to have a place where they can both store information for the people introducing new colleagues to their job as well as a possibility for new people to read up on things about their new place of duty. 4 respondents want to have a place for descriptions of their tasks to facilitate the handover of responsibilities if people in positions change.

11 respondents want to use a KMS to organize their material and knowledge, which was substantiated by others in terms of storing instructions in a sorted way (15), saving information about locations of fire hydrants and other building-related firefighting plans (14) as well as standard operating rules (9). 6 participants requested a facility to store the latest versions of forms in one central place. 13 answers indicated that an important use case would be the management of shift plans and other means to plan events with personnel. 7 people demand a way of centrally informing and being informed of news and updates.

A respondent emphasized the central aspect of a KMS that helps the users avoid unnecessary work. The respondent described that they had to maintain their data every time the program was updated and suggested a central programmer who would take care of this issue instead of dealing with it in every single unit.

Information sharing among different legal bodies

We asked the participants whether they would make use of a KMS that is run by a fire brigade from another municipality. About 83 % answered yes, while only 13 % would not use such a system. 4 % did not answer this question. As mentioned by Duscher, there is no need to compete between different fire brigades (Duscher, 2010), which might be a reason why the exact same percentage of respondents would be in favor of opening their system for members of another fire brigade (83 %), while about 13 % would not, and 4 % did not answer this question.

Sharing of information and knowledge in the line of command

Next, we wanted to know if and how our participants make their knowledge available for others (480), issue instructions (326), and forward information in the line of command (482). We were also interested in the means they use for this, which is plotted in Figure 9. It is apparent that email is the predominant system in all three scenarios of knowledge sharing, issuing instructions, and forwarding information. Verbal communication and text messaging via WhatsApp and Co. are in second and third place, respectively. The notice board is still used by half of our respondents who issue instructions. More digitally advanced systems like clouds, wikis, and forum systems are barely used. The means are complemented by the free text answers where the user referred to Teams (7), Divera 24/7 (7), eLearning like L2R (3), and paper-based notes (3).

We also asked the respondents which digital systems they would like to use to provide knowledge, which is depicted in Figure 9 in the color red. Here, emails are the prevalent means as well, followed by text messaging. The share of people who want to use a cloud is notably higher (58 %) than the current usage of cloud platforms, and the same holds for wikis (30 %) and forums (20 %) as well. We deliberately asked only for digital means of information sharing, which is why verbal and notice boards do not have a value in red. Many free text answers support this hypothesis since only two answers stated that they would like to use analogous means like a notice board.

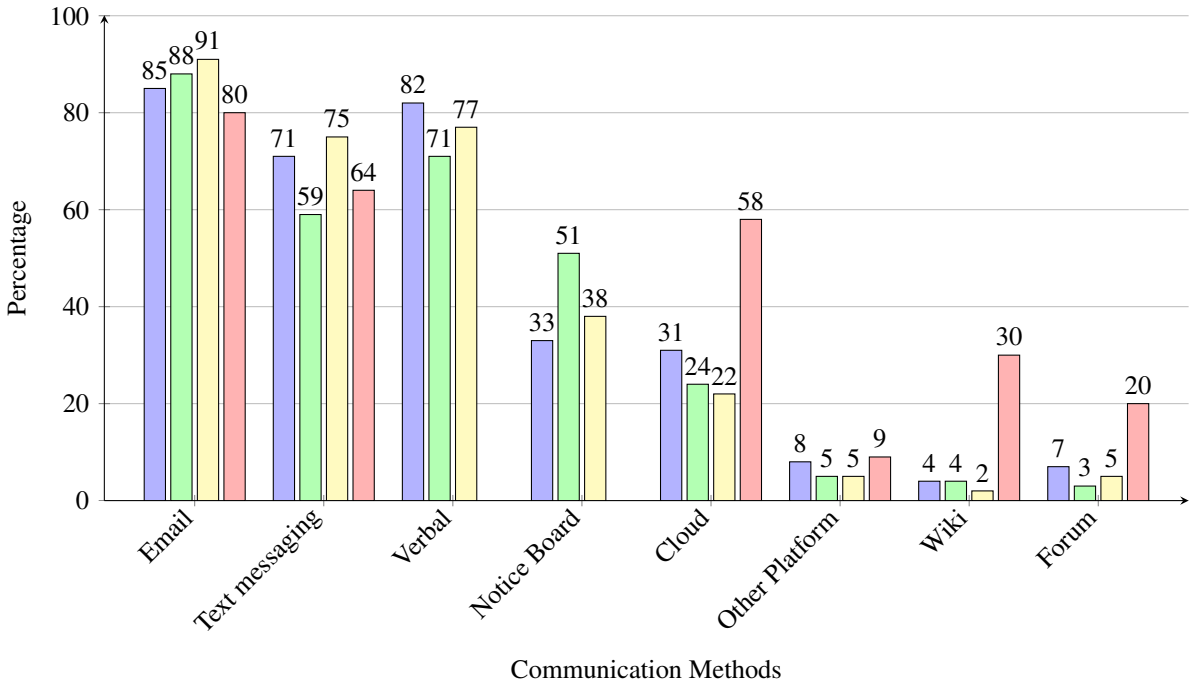

Figure 9. Distribution of means in use for knowledge sharing (blue), instruction issuing (green), information forwarding (yellow), and digital means respondents would like to use (red) (multiple answers possible)

Maintenance of knowledge in knowledge management systems

In the last section of the survey, we covered the aspect of maintaining the KMS. Therefore, we asked the respondents the following six different questions, for which the answers are shown in Figure 10.

- Question 1: It is important to me to be able to access older versions of entries.
- Question 2: It is important to me to be able to integrate / reference / transfer content from external systems.
- Question 3: It is important to me to be able to integrate content from the knowledge management system into other systems.
- Question 4: I would enter information into a knowledge management system myself.
- Question 5: I would have time to keep the knowledge I have entered up-to-date.
- Question 6: The knowledge, information, and instructions I provide are also taken into account in the long term.

Question 1 refers to the possibility for the user to access older versions of a record to keep track of changes and be able to understand its evolution and current status. Questions 2 and 3 deal with the integration of information items from external systems into the unit's KMS as well as referring to information items from other systems to avoid redundancies. Questions 4 and 5 cover the personal perception of both entering information into a KMS and keeping the provided information up-to-date. Question 6 is a more estimating question that refers to information and instruction in general that are issued and distributed by our respondents.

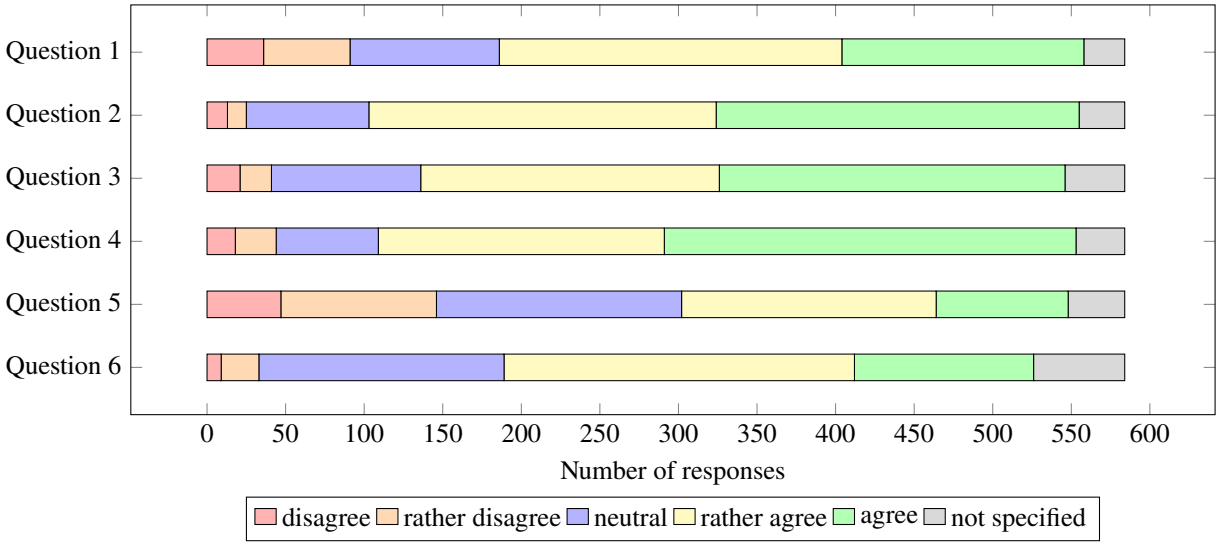

Figure 10. Statements towards information and knowledge maintenance

Final remarks on the topic of knowledge management in fire brigades in general

As the closing question, we asked the participants to write whatever they think they need to communicate to us regarding the survey's realm, which has not been addressed yet.

The most mentioned aspect is the need and requirement to have a KMS that is not only managed and maintained by a central authority (mostly state-wide) but also filled with general content (15). This is supported by the claims that the necessary efforts to run a KMS are quite high (6), as well as interfaces to other systems that are needed (4). 5 respondents explicitly stated user friendliness as an important point.

14 respondents thanked for the survey and expressed their opinion that this topic is important in modern firefighting. 4 also deliberately said that digitization in general is an important topic for the fire brigades, while 3 respondents stressed the need to have a positive balance between effort and effect. 3 respondents stated that current and existing solutions are not used enough, although they exist.

10 respondents reported that the introduction of a KMS in their unit may also be hampered by their current leadership. Some of them might object to a KMS (as something not needed) or refuse to use one because sharing information could endanger their high position (if knowledge is shared more widely). Others might only be reluctant to use digital systems in an environment that has a long tradition and well-established processes. Respondents are also rejecting a KMS because of the high demand to keep it up-to-date (5) and the costs it imposes (5). 3 respondents stated that there is no willingness to share information because others might have unwanted advantages of one's information.

Validity

The results of the survey represent the attitude of the participants towards knowledge management in fire brigades. The participants' distribution is spread across all ages and leadership levels with a tendency towards higher educated leadership levels. Since the call to participate in the survey was only distributed through digital means, this might have impacted our results as we were not able to reach people who do not use any of these means. But on the other hand, these technologies are used by a vast majority of people in Germany (Pokorny & Roose, 2020), and our intention was not to have a representative survey with exact values but to have a first estimation of this extensive topic.

FINDINGS

Although we provided a short description of what we deem an *information* management system and what a *knowledge* management system, many responses expected a KMS to be an all-in-one solution of IMS (master data about persons, equipment, and histories of trainings or incidents), a command support system (used during an emergency to provide plans, files, and procedures), and an actual KMS (dealing with training curricula, maintaining instruction and procedures, lessons learned, and best practices). Especially in the training sector, many respondents seek a system that supports their knowledge management (acquisition, administration, and dissemination).

The answers often focus on incident-related topics and the management of crises like fire hydrant maps, means to store evacuation plans, and standard operating rules for incidents. In addition, the inclusion of non-incident-related topics such as training or the management of administrative knowledge and processes indicates a more holistic view.

As seen in the red bars in Figure 9, the willingness to use digital solutions in the firefighting domain is existent. The users know these systems from other applications and want to transfer them to the fire brigades as well.

It is noteworthy that most respondents want to enter their knowledge into a KMS at first but then do not think that they have enough time to keep it up-to-date (cf. Questions 4 and 5 in Figure 10).

Next, we give a short overview of the most frequently mentioned software products throughout our survey to have a single place where we can relate to them during the presentation of the results. A summary of the software products that have been mentioned throughout our survey and are presented below can be found in Table 1.

- DIVERA 24/7[4] represents a web-based database solution primarily aimed at enhancing efficiency and precision in personnel deployment within the civil protection and disaster relief sectors. This system records, analyzes, and visually presents the availability of emergency service personnel, including firefighters and rescue services, thereby facilitating more effective resource management in emergency situations.
- Spond[5] is a digital solution focused on the administrative management of teams, primarily in sporting environments. Its functionality includes the creation of events and facilitates the exchange of a variety of data forms, such as text, images, and files, within a team setting. It is used to organize groups of several people.
- APager PRO[6], developed by Alamos GmbH[7], represents a mobile solution engineered for the enhancement of emergency alerting, response feedback, and availability planning mechanisms. Utilizing established Google and Apple transmission channels, the system ensures prompt and secure dissemination of alerts and informational messages through push notification technology. This capability is maintained even in scenarios of limited or no internet connectivity. The application further incorporates advanced geospatial features, allowing for precise display and navigation to incident sites. In addition to APager PRO, Alamos GmbH has other software and hardware solutions for alarm systems, visualization tools, and deployment tablets.
- Microsoft Teams[8] is an office application for organizational use, providing a workspace for real-time collaboration and communication. This platform integrates functionalities for meetings, file and app sharing, and allows for a more engaged and effective team environment.
- Fireboard[9], a comprehensive incident command software, is engineered to streamline the management of emergency responses. Integrating a suite of functionalities, it facilitates detailed documentation, resource allocation, and real-time situational analysis. Its modular design allows customization for specific operational needs, encompassing incident command, mapping, communication, and patient management.
- Wasserkarte.info[10] serves as a software tool for maintenance, documentation, and planning. The application offers various features like maintenance planning and automatic data transfer, enhancing the operational efficiency of water supply management.
- L2R[11] is an eLearning platform tailored to the specific needs of personnel in emergency services, including rescue, emergency medicine, and firefighting. Courses can be purchased as well as entered individually.

[4] https://www.divera247.com/ retrieved December 4, 2023.
[5] https://www.spond.com/ retrieved December 4, 2023.
[6] https://alamos.gmbh/loesungen/zusatzalarmierungen retrieved December 4, 2023.
[7] https://alamos.gmbh/ retrieved December 4, 2023.
[8] https://www.microsoft.com/en/microsoft-teams/group-chat-software retrieved December 4, 2023.
[9] https://fireboard.net/ retrieved December 4, 2023.
[10] https://www.wasserkarte.info retrieved December 4, 2023.
[11] https://www.l2r.de/ retrieved December 4, 2023.

- MP-Feuer[12] is an administration software for the fire department, rescue service, and preventive fire protection in Germany. It is established in Germany and has over 7,000 customers. MP-Fire consolidates relevant information into one, easy-to-navigate system, enabling rapid deployment across multiple operational areas.

- FeuerON[13] is a web-based software solution designed for the streamlined and transparent management of critical fire department data. It facilitates the organization of personnel, equipment, reports / incidents, and training registrations. The system offers comprehensive access to relevant data from any location with internet connectivity, enhancing operational efficiency in various areas such as personal data management, equipment and material tracking, report generation, and appointment monitoring. It features an individual rights management system, allowing administrators to control access based on user relevance.

- Fireplan[14] streamlines emergency response through its auto-dispatch and object information features, providing crucial data en route to incidents. It enhances incident management with capabilities like automatic documentation, integrated review and approval processes, and intelligent billing. The software also includes comprehensive modules for reporting, personnel, and equipment management, supporting efficient organization and analysis. Additionally, Fireplan integrates various management aspects such as training, awards, maintenance logs, and scheduling, all within a user-friendly platform.

- MediaWiki[15] is the most prominent example of a wiki system. It is the technical basis for wikis and is therefore an indispensable tool for the community-based collection and dissemination of knowledge. MediaWiki is known for its customizability and is supported by a variety of extensions and skins. It is used in a variety of projects, from large knowledge bases such as Wikipedia to small community initiatives, and features robust syntax, comprehensive user management, and detailed revision histories. MediaWiki is open source, while other wiki systems might be commercial.

CONCLUSION

We have conducted a survey with 577 responses from firefighters from all over Germany and were able to extract new findings from the data, which we will then use to elaborate on the requirements for a KMS. We can conclude that our initial hypothesis, which postulated that the spread and use of *knowledge* management systems in German fire departments is currently limited and confined to a few projects, is true. There are only very few systems in use that can be considered a KMS. This also highly depends on the individual usage of a system like a cloud or Microsoft Teams. *Information* management systems are widely used by fire brigades, as indicated by our respondents, and some examples of these systems are listed above. This survey also revealed aspects that have to be considered when designing and developing a KMS for fire brigades. The need for a system that makes use of an information sharing infrastructure is supported by the answers from our respondents, who seek an easy-to-use system where information is added only once by a superior authority and then all subsequent units can import this information items. Nevertheless, local adjustments and characteristics have to be considered since not everything can be described globally. An integrated solution that also enables the import of information from external systems would be useful to keep the maintenance of the KMS simple and automated. In addition to the insights mentioned above, our survey underscores the importance of a KMS that is applicable in both routine and exceptional operational scenarios. Our findings indicate that firefighters' familiarity with the KMS during regular duties and activities contributes to their ability to use the system effectively, even in stressful situations.

When taking the next steps in designing, developing, and implementing a KMS for emergency organisations, there are many more aspects to be taken into account. One is the rejection by end users who are not familiar with IT or deem it to be unhelpful in their daily tasks. Especially IT systems in use during the response to an emergency pose high requirements to their developers and multiple reasons for rejection (Elmasllari, 2018; Kapalo et al., 2019). Therefore, we focus at the beginning on non-incident scenarios where a KMS can have large effects like time savings, information distribution, and training as well. Nevertheless, the gained knowledge should always contribute to the cirsis management which is the core task of every emergency organisation.

Another aspect that has to be taken into account is data protection, together with data safety and security. In the EU, the General Data Protection Regulation (GDPR) poses high requirements when dealing with personal data (or data that refers to a human person) that have to be respected when developing and operating a KMS (Hüttelmaier et al.,

[12] https://www.mp-feuer.de/ Retrieved December 4, 2023.
[13] https://www.feueron.de/ retrieved December 4, 2023.
[14] https://www.fireplan.de/ retrieved December 4, 2023.
[15] https://www.mediawiki.org/ retrieved December 4, 2023.

Table 1. Combined overview of software categories and functions

Software	Licence	Information Management	Knowledge Management	Other & Collaboration	Communication & Response	Alerting & Management	Administration & Training	Education
DIVERA 24/7	proprietary, 1 unit with up to 50 users free, more need to pay		✓		✓	✓		
Spond	proprietary, free to use			✓	✓			
APager	proprietary, different licenses			✓	✓	✓		
Teams	proprietary, free for non-profit organizations			✓	✓			
Alamos	proprietary, different licenses		✓			✓		
Fireboard	proprietary, different licenses		✓			✓	✓	
Wasserkarte.info	proprietary, free in basic use, more features need to pay	✓					✓	
L2R	proprietary, different licenses		✓					✓
MP-Feuer	proprietary, different licenses	✓					✓	
FeuerON	proprietary	✓					✓	
fireplan	proprietary, different licenses	✓				✓	✓	
MediaWiki	open-source	✓	✓	✓			✓	✓

2021). But also, the security aspect has to be taken into account (Walker, 2012) since many of the data stored is confidential, leading to the need for certain restriction policies.

A broader literature review on KMS in disaster management was performed by Dorasamy et al. Their results state that the terminology related to emergency and disaster management should be standardized to ensure the comparability of different approaches. Also, the differences and similarities between KMS and emergency management information systems should be elaborated upon (Dorasamy et al., 2013). Using standardized procedures as well as interfaces between KMS and third-party systems is an important factor when it comes to implementation. Many fire brigades already use one or another software tool, and interoperability should be possible. As indicated by Wesendrup et al., the six challenges for data management for firefighting in Germany are "cartographic data harmonization, information system (IS) standardization, information gathering from unstructured data, canonical bodies of knowledge, and data-driven firefighting support" (Wesendrup et al., 2019).

Open-source software itself is not required by many respondents in our survey, maybe due to their lack of IT knowledge. But having software that is free to use is important if it is supposed to be used by many, especially smaller fire brigades who cannot afford personnel to run the system for them (Timm et al., 2013).

All together, knowledge management offers great possibilities for modern firefighting to make use of the vast amount of knowledge and high technology. It can speed up actions, keep people informed as well as motivated, and help organizations in transition phases while preventing a loss of knowledge. To be successful, many requirements by end users have to be considered, and satisfaction and acceptance are key success factors for the helpful development and implementation of a KMS.

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