The role of information systems to support disaster management

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Abstract

Society is challenged by various catastrophes, requiring fast and accurate management of information and communication. Handling these challenges needs clearly-defined and well-accepted processes and – most critically – a huge quantity of data, which has to be collected, processed and submitted. In the context of natural catastrophes and public disaster management, governments are challenged. Beyond government involvement, private companies are also forced to react to disasters, establish appropriate procedures, define responsibilities, and make decisions. In such times of emergency, information systems (IS) are important instruments used to improve the efficiency and effectiveness of disaster-handling activities in companies. Furthermore, information systems support companies in their efforts to regain trust, reestablish reputation, and sustain their ability to operate. In this exploratory work, we have investigated how information systems support disaster management in two companies within the passenger transportation industry. Based on interviews, we identified different IS support for disaster management, especially for coordinating activities, processing information, and communicating with stakeholders. We validated the need for training, harmonisation and standardisation of information, as well as ways to manage false news about accidents that may be transmitted via social media.
Keywords: disaster management, emergency management, information systems, organisational challenges, emergency management processes.

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1 Introduction

Society is challenged by various catastrophes: earthquakes, tsunamis, floods, fires, and other natural disasters. When such disasters affect society, fast and accurate management of information and communication is important [1]. In particular, the tsunami that occurred in Asia in December 2004 demonstrated the need for new disaster plans and forecasting systems [2, 3] to increase the efficiency and effectiveness of disaster management efforts [4–7]. To date, research has focused on disasters and their management by governments or NGOs. However, companies are also affected by these crisis events. We focus on the question of how information systems (IS) may support companies in times of disasters or emergencies. We investigate how companies apply IS to support their efforts to manage these events. Therefore, we have developed propositions based on the disaster management literature and have conducted interviews to identify patterns of IS support for disaster management. As a result, we have gained knowledge concerning IS supporting the coordination of activities, processing information, and communication with stakeholders. In addition, we have gained knowledge about the process and cooperation issues in such situations. The rest of this paper is structured as follows: First, we provide an overview covering the background of IS support for disaster management. Second, we explain our methodological approach. Third, we describe the results and draw conclusions. In addition, we present limitations of this research and suggested future research directions.

2 Background

In general, a disaster is defined as "… a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources" [8]. For different reasons, a differentiation between natural disasters (geophysical, hydrological, climatological, meteorological or biological) and disasters having technological or human origins (e.g. complex emergencies, industrial accidents, and transport accidents) is common [8]. Disaster management consequently addresses the structured handling of such events, including four activities: mitigation, preparedness, response and recovery [6, 9]. Mitigation involves actions, taken in advance, to minimise risks [6] and reduce the "degree of long-term risk to human life and property from natural and man-made hazards" [9]. Preparedness describes efforts to guarantee the availability of infrastructure, resources and trained people necessary to tackle a disaster [9]. Response includes "actions taken immediately prior to a foretold event, as well as during and after the disaster event, that help to reduce human and property losses" [6, p. 5]. Finally, the recovery phase sets short- and long-term activities to reconstruct close-to-normal conditions [9]; however, it has been stated that full recovery often cannot be achieved, especially when natural environment has been destroyed [6]. Some authors add communication as an additional phase [10], whereas others integrate

it as the foundation for all of the other phases. The phases form a cycle and have to be encountered by actors involved in disaster management. The four-phase structure is commonly accepted; however, a study investigating academic literature on disaster management in operations research identified 109 articles published between 1980 and 2004, which addressed all four phases, but mainly mitigation (44 articles) [11].

Coordinated and fast response, as well as the collection of and access to different kinds of data, are key to successful disaster management [12, 13]. Information systems support these activities and hence are a natural choice for response activity when critical situations occur. IS involvement extends from geo information systems (GIS) for providing spatial information [13, 14], to logistics systems to support the "humanitarian supply chains" [15], to highly-complex decision support systems. The main task of IS in this situation, however, is to support fast and clear communication with stakeholders [16], including the cooperation of virtual teams and online communities of experts [6, 7], as well as information disclosure to the wider public [16]. Disaster information systems (DIS) [16] or emergency management information systems (EMIS) have been developed to support people in their activities to respond to such situations [6]. These systems are based upon different concepts (open or closed source, network-based or integrated into other systems) and their functionalities are quite diverse [7, 16, 17]. These systems support different phases of disaster management. The mitigation phase relies for example on forecast systems [3, 18]. Systems to train for emergency situations [19, 20] and store information [7] are applied to establish preparedness. In the response phase, systems for coordination [12, 15, 21] and communication [12, 13, 22, 23] have been used. Finally, GIS are necessary to restore the affected area [13, 15]. Especially in the response phase, the power of IS can be used to its full extent to communicate and provide information [7, 12]. However, information systems used in disaster management have to fulfil certain requirements, especially concerning usability, availability, stability and reliability of the information technology [6, 7]. It has become clear that IS used in a time of high pressure need to have a logical and easy to understand user interface for not hindering, the emergency teams [1, 24]. Hence, special emphasis has been placed on design and user interfaces in such systems [4, 14, 24].

In a business context, activities to handle problematic situations are referred to as emergency management. Although mitigation has dominated the literature on information systems in disaster management [11], preparedness, response and recovery [10] dominate business efforts to handle emergencies. Beyond challenges already discussed in disaster management, organisations are forced to sustain normal business in times of emergencies [25], apply risk and reputation management [26], and undertake efforts to handle psychological effects on employees [22]. In addition, the establishment of emergency response teams is an organisational challenge, often investigated, requiring mechanisms to support asynchronous communication of a virtual team inside and outside the company [6]. Clearly, some sectors are more prone to emergencies because their daily business, by its nature, bears risks for people, such as the passenger

transportation sector. Running their business includes caring for their passengers' lives while they are being transported. Transport accidents, which are defined as "technological … accidents involving mechanised modes of transport" [8] affect all passenger transportation forms (air, rail, boat and vehicles) and may lead to severe injuries or even fatalities. The impacts of accidents are experienced by different stakeholders (passengers, their relatives, employees), the accident location (e.g. by destroying buildings), and the company itself. Fortunately, the number of severe transportation accidents is constantly decreasing, especially in the US and the European Union member states [27, 28]. For example, in the US the number of air accidents over the course of 20 years (from 1992 to 2012) decreased by 31%; which has also led to a decrease of injured persons by 39% and fatalities by 55% [27]. The same applies to the number of railroad accidents, which decreased by 58% [27] leading to a decrease by 61% of injured persons and a reduction of 21% of transportation fatalities via railroad [27]. However, decreasing fatality numbers do not exempt passenger transportation companies from their obligations related to emergency management.

For our research, we focus on emergency management in companies and hence define emergency management in accordance with existing definitions [8] as the 'management of resources and responsibilities for dealing with all humanitarian and organizational aspects of emergencies'. Furthermore, we define information systems (IS) as "combinations of hardware, software, and telecommunications networks that people build and use to collect, create, and distribute useful data, typically in organizational settings" [29]. Based on the literature and in line with these definitions, we developed the following propositions:

- P1: Companies rely on IS support for emergency management.
- P2: IS support all four phases of emergency management.
- P3: In times of emergency communication with public authorities, emergency teams and customers are mainly facilitated via IS.

3 Methodological approach

To examine how companies in a specific sector experience the support of IS for emergency management, open qualitative interviews based on rough guidelines were used. The purpose of interviews is to identify relevant issues as seen by the interviewee [30, 31]. Interviewing is a common and appropriate method in exploratory research; however, problems such as ambiguity of language, misunderstandings, and lack of trust may influence the results [31]. By establishing a good rapport between the interviewer and the interviewee, it is possible to encourage the interviewee to formulate ideas on their own and to maintain the momentum in the interview [30]. The interviewer has to react in a flexible way, leading the interviewee without influencing or limiting them [31]. Furthermore, we applied thematic analysis, seeking to develop a sound picture of the specific situation and to evaluate the manifest content of statements. To establish a condensed form of the interview information, it has to be summarized

in a structured way. This means to identify characteristics and develop patterns to be able to compare interviews and determine differences and similarities [32].

We conducted two interviews with representatives from the passenger transportation industry (airline, railroad company) in autumn 2014. Due to the sensitive nature of the information provided, one interviewee expressed the need to sustain anonymity. Thus, we avoided naming the sector in the interview description and used the term 'vehicle' for airplanes and trains alike, with 'stations' indicating both airports and train stations. The interviews were audio-recorded using appropriate technology. Both interviews were conducted in German, transcribed and analysed. Direct quotations have been translated and re-translated to avoid translation errors.

The first interview (I1) was conducted on the phone with an assistant from the customer care centre, who had three years of previous experience on the job and had worked for the company since 2010. Over the course of the interview, the interviewee often expressed uncertainty by adding 'as far as I know' (DQ). The company itself was founded in its current corporate format in 1994, and has 300,000 employees. Approximately 1,600 employees work in the customer care centre, where emergency handling takes place. The interviewee was not able to inform us about the number of employees being trained for emergency handling beyond a basic procedure. The second interview (I2) took place in person in the headquarters of the company and was 20 min. longer than I1. The interviewee is the head of the emergency response department and has held this position for more than 15 years. The interviewee has been working for the company since 1987 in different positions, starting in the customer care department, and was one of the initiators for the development of an emergency response team. The company was founded in 1957 and had experienced many changes in recent years. Refer to Table 1 for an overview of these descriptive characteristics.

Table 1: Description of interviews, interviewees and companies.

Interview	I1	I2
Interview method	Phone	In person
Location	-	Company Headquarters
Duration	25 min.	45 min.
Interviewee		
Position	Assistant, Customer Care	Head of Emergency Response
In the company since	2010	1987
Experience in this position (years)	3	16
Emergencies/disasters managed in this time	3	Some small incidents 2 real emergencies/disasters
Company		
Founded	1994	1957
Employees (approx.)	300,000	6,000
Size of emergency response team (approx.)	1,600	approx. 10–20 people
Other trainings	For crew members	For crew members

4 Results

Both interviews provided information about the sectorial contingencies, the company, processes of emergency management, and IS support in disaster situations. Overall, Interview 2 (I2) was not only longer, but also provided more information. To briefly summarise the results, the processes in both companies were found to be similar in many ways. In both interviews, preparedness and response were the focus of the conversation and recovery was only touched so some extent.

We first describe sectorial contingencies, followed by a brief description of the interviews. We use translated direct quotations when appropriate, quoted with single quotation marks and indicated by (DQ). In this description, we followed a certain structure to enhance readability, which is not necessarily the structure of the interview. This structure includes a differentiation between the organisational and the IS issues, reported in the interviews.

4.1 Sectorial contingencies

In each interview, we asked the interviewee to describe the sectorial contingencies of their industry and to compare them to the other sector. The differences were mainly spatial (where the company operates), but also concerned the available passenger data, which has an enormous impact in emergency management efforts.

The airline industry operates worldwide and crosses large unsettled areas (e.g. the sea). Consequently, these areas are difficult to reach by rescue teams. Moreover, plane crashes affect not only the passengers, but also destroy the area where the accident happens (e.g. buildings or parts of cities). Concerning passengers, airlines have access to some passenger data before the flight starts, especially when flights depart from certain areas. However, passenger data collected via the booking or check-in process has to be revalidated with official authorities in the case of fatalities.

By contrast, the railroad companies operate locally or regionally. When trains cross a border, a cooperation partner is involved, and responsibility is shared between partners, especially concerning the coordination of emergency organisations in the country. Railroads are located close to cities and hence are easier to reach; thus, emergency teams arrive at the accident location more quickly. However, railroads are blocked as long as investigations are being conducted; hence, recovering normal operation (e.g. timetables) is quite difficult. This influences transportation schedules on this specific railroad. Railroad companies very often do not have access to passenger information, unless passengers hold a customer card or reserve a seat. Thus, identification must occur at the accident location or in the hospitals.

4.2 Interview 1 (I1)

Interview 1 was mainly influenced by a recently experienced incident of ‘fake news’ (DQ) on the Internet and subsequently on social media platforms. Hence,

the interviewee reported on the negative impacts of external IS. Furthermore, the importance of IS in times of emergencies and a need for more IS support in training situations was expressed.

In terms of organisational efforts in emergency management, the company invests extensively in preparedness, including emergency processes and plans, developing emergency infrastructure, as well as training personnel. Emergency processes have been developed based on previous emergencies, best practices from the industry, and emergency training institutions and public emergency organisations. The processes are constantly evaluated, and a committee supports decisions concerning changes and re-evaluation. The processes include alerting mechanisms, public relations management, establishment of a crisis squad, involvement of psychological support for victims, relatives and employees, as well as communication rules for the company. The customer care centre is the single point of contact for all emergencies. According to the interviewee, all employees in the customer care centre receive training for emergency situations; thus, they must have the plans 'in their brains' (DQ). Furthermore, approximately 1/3 of the employees receive additional training, and a small, select group is fully and regularly trained. The interviewee reported that three incidents occurred, since he has been working in the company, but was not on duty at this time. However, he expects to handle them 'according to the plan' (DQ).

IS play an important role in the emergency management of this company. All vehicles are connected with a central station to control and alert in case of any irregularities. The call centre is equipped with an EMIS, integrated into the ticketing system. In case of an alert, all employees are informed and immediately receive the appropriate information on their desktops. In addition, members of the crisis squad team are informed, and additional employees are automatically called to duty. The public relations team develops an official text for release to the wider public, provided on the website of the company. In addition, contact numbers, email addresses and relevant information for the relatives of the passengers or potential victims is provided. Internally, all calls are documented and recorded in a database, storing information provided by callers. If available, passenger data is matched to caller data to identify passengers. However, the only valid information about passengers is gained at the accident location from the passengers directly or – in the case of victims – from the official authorities. In addition, IS support the company in emergency training, although the interviewee expressed the need for more IS support in this area, e.g. to have emergency alert drills, test scenarios, or simulations of emergency situations. The interviewee was not aware on how IS are used to cooperate with partners and public emergency organisations.

Concerning drawbacks of information systems, the interviewee emphasised the problematic influence of social media platforms. This includes 'services like Facebook, Twitter or Instagram … allowing users to disclose rumours or real information' (DQ) concerning accidents, often before the company has been informed about it. The employees in the customer care centre have to manage this challenge, verify its truth, and decide how to react. This is time-consuming

and demands resources that are necessary to handle the company's daily business. Thus, the interviewee expressed the 'need for system to identify fake news more easily' (DQ) and communication with other parts of the company to more quickly verify news spread on 'an information system, not under control of the company'.

4.3 Interview 2 (I2)

In this interview, the development of the emergency management plan, processes involved and tasks of these emergency management processes have been described in detail. The 'uncoupling' (DQ) of daily business and emergency handling is one of the main challenges for the company. Furthermore, IS used in times of emergency response have to be 'easy to understand and handle' (DQ), since employees must not be hindered by not understanding the interface. The interviewee expressed needs like establishing standards or standardised platforms for exchanging data in an appropriate way with official authorities and partners. The platform or standard could be created by third party, e.g. insurance companies having an interest in this platform as well.

The interviewee was the main facilitator to establish emergency management in the company, starting in the late 1990s. An internal feeling of 'employees needing to know what to do when something happens' (DQ) and changing legal conditions forced companies in the passenger transportation sector to establish emergency handling. In cooperation with international partners, the company established processes and developed emergency plans. The core emergency response team is rather small, but is augmented by volunteers (approx. 5–10% of employees). Volunteers are trained to assist in case of emergencies; however, crew members in the vehicles obtain special training and participate in drills. The main tasks of the emergency response team are to establish plans and processes as well as to assure that the required infrastructure and resources are provided when necessary. The development of emergency plans has to integrate business, technology and resources (including infrastructure, communication systems, rooms, material and people). For accidents far away from branches of the company, a 'go-team' (DQ) is sent to accident locations to coordinate activities there.

A technical or human error may lead to an emergency, defined as an 'incident, happening in the transportation facility, which will potentially harm or has already harmed people in terms of injuries or death' (DQ). Furthermore, regular incidents (happening occasionally, e.g. evacuation of the vehicles) and emergencies (in rare cases, causing human injuries or death) are differentiated. 'Based on basic principles of expected harm' (DQ), the severity of an emergency is identified, associated alerting codes are used to trigger an automatic alert, and appropriate measures are initiated based on the appropriate emergency plan. An emergency task force has been established that is responsible for initiating contact with people (victims, survivors, relatives of passengers), transportation of people, and collaboration with public authorities at the accident site. After every accident, lessons learnt are discussed and lead to further improvement of the plans. From the interviewee's point of view, good emergency management

leads to increased customer loyalty, whereas poor emergency management may ruin a company's reputation. The interviewee acknowledged the importance of decoupling emergency management from the organisation's daily business in order to sustain the company's operation. Resources in cases of emergency are bound to the emergency handling and not available for the daily business during the 'hot phase' (DQ) of a crisis, which lasts approximately 10–14 days following the incident occurrence. Response processes include stabilisation of normal business routines, early information and psychological assistance for all stakeholders.

The interviewee placed much emphasis on the importance of a 'stable and reliable IT, working properly when an emergency happens' (DQ) as the basis for effective emergency response management. The EMIS were once developed by the company itself, but the current systems have been created by third parties based on the requirements of the company. These systems include databases, which hold passenger information, methods of incident reporting, and details about different systems used in emergency management operations. Thus, data stored in different systems (schedules, passenger lists, routes) must be made available to the emergency response team via a platform or interface. This overarching platform has to be 'easy to understand and handle' (DQ), since employees are only using it in the rare occasion of an emergency. A major challenge for EMIS is to match passengers and worried people calling; hence, associated intelligence has been built into the systems. However, the company still relies on the wisdom of its employees to 'make the final match' (DQ) and provide such sensitive information in the appropriate way. Furthermore, IS support the company in their efforts to inform the wider public about the emergency. The company installs a so-called 'dark site' (DQ) on their website, redirecting website visitors either to information concerning the emergency or to the regular website. Since they experience a high volume of data traffic in times of emergency, they strive to sustain operations and to bypass data, evolving from the user's initial interest in the emergency, to a specific server. Internally, IS for informing employees include the Intranet, email and newsletters. This is necessary to establish confidence in the company and to sustain employees' ability to work, especially for crew members who are often unfit to work due to psychological problems, e.g. anxiety.

Problematic experiences with social media platforms (specifically, Twitter and Facebook) were reported in this interview, as well. However, the company reacted to this situation by monitoring these platforms to be aware of possible fake news as well as emergencies that have not been reported via the official channels. Clarification on such issues relies on 'calling reliable people to find out what is true' (DQ). Required additional support from the IS department was expressed in terms of proactive involvement, e.g. by suggesting new ways to support the emergency response team. Furthermore, a need for technologies such as mobile devices or satellite telephones to avoid media discontinuity and to save time, has been reported. The interviewee emphasised the lack of standardisation and harmonisation in the industry. Standardised interfaces or a standardised platform could support the efficient exchange of data between involved parties.

The technology could be developed by third parties, e.g. insurance companies. Additional standardisation and harmonisation of IS should be realised at the stations and the customer care centres.

5 Discussion

In the interviews, we have found evidence to support our propositions to some extent. First, P1 (Companies rely on IS support of emergency management) has been supported, since both interviewees pointed out that without IS emergency processes, management of these situations will become more complicated and delayed. P2 (IS support all four phases of emergency management) has not been supported, since no evidence for IS support in mitigation was found. This may be due to the fact that emergency management in companies as such does not integrate mitigation, and consequently information systems are not applied for this purpose in emergency management. However, this does not mean that IS do not support mitigation; it only suggests that mitigation is not viewed as part of the emergency management in companies. P3 (In times of emergencies, communication with stakeholders is mainly facilitated via IS) was only partially supported. In both interviews, we noted a lack of trust in information systems that are not under the control of the companies (e.g. the Internet, social media platforms). Hence, companies rely on telephone communication for both incoming calls (of passengers' relatives) and outgoing calls (e.g. for contacting public authorities). In addition, we were able to identify some characteristics of emergency management in the passenger transportation industry. These include the lack of complete passenger information, the need to identify victims to match them with their relatives, as well as a need for more standardisation and harmonisation of information to increase the efficiency and effectiveness of emergency management.

In accordance with literature [4, 24], in both interviews, the user interface of the EMIS was addressed. In one case (I1), the user interface is part of the daily-used ticketing system, and hence the emergency response team is experienced in handling the interface. In the other case (I2), ease-of-use of the interface is required, since the emergency response team uses it only when needed. Concerning training, Interviewee 1 strongly requested more IS support in training and drills, having experienced a lack of sound and regular trainings. By contrast, Interviewee 2 did not express such needs. In Interview 2, the interviewee acknowledged the necessity to decouple emergencies from daily business and the need for standardisation and harmonisation in a way that had not been expressed in Interview 1. This may be due to the fact that Interviewee 2 is more experienced in his job, positioned at a higher level in the company, and more involved in strategic business decisions.

6 Conclusions

Disasters and emergencies affect society, individuals, and companies. As we have seen, disaster management of governments and emergency management in

companies have some similarities, especially concerning their phases and the IS support they employ. The passenger transportation sector has to protect the lives of passengers; hence, emergency management plays an important role. We conducted interviews with two representatives of this sector, identifying some similarities of both companies as well as differences. Both interviewees emphasised the important role of IS. However, one interviewee focused on the possibilities of IS support in training and test scenarios. By contrast, the other expressed the need to standardise and harmonise communication in the entire industry in order to establish more efficient and effective IS support. In addition, it was evidenced that companies do not rely only on IS support in times of emergencies, but also on the wisdom of their employees and on various methods of communication to be able to react in a flexible way. Since this study is exploratory and based on only two interviews, generalisation is not possible. Further research would require additional interviews in order to develop hypotheses that can be tested and validated.

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