Evaluating a Mobile Crisis Response System for the Management of Disaster Volunteers

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Abstract. As part of an ongoing research project, we have designed and implemented a mobile crisis response system (MCRS), which creates a nexus between relief organizations and unaffiliated disaster volunteers. We developed the MCRS using a design science approach and address information management, coordination, and motivation challenges in the context of managing unaffiliated disaster volunteers in crisis response and disaster relief activities. In this research-in-progress paper, we propose a design for the evaluation of the MCRS prototype based on a field experiment, which will be conducted during a joint mission exercise performed by three major German relief organizations. We adapt the enterprise systems success model and suggest evaluating the system quality, information quality, individual impact, and organizational impact of the prototype.

Keywords: Design Science · Design Research · Evaluation · Unaffiliated Disaster Volunteers · Relief Organizations · Field Experiment · Crisis Response · Mobile Crisis Response Systems

1 Introduction

Relief organizations increasingly find themselves confronted with a scarcity of paid relief workers [1] and even growing frequency of man-made crises [2]. Unaffiliated disaster volunteers who participate voluntarily in disaster relief activities, and who often self-organize via social media [3], play an important role in coping with crisis and disaster situations (e.g., by providing goods, services, and time [4]). For example, when more than 80 percent of Thailand's provinces were surprised by a severe flooding crisis in 2011, citizens used social media to disseminate crisis-related information, provide emotional support, and coordinate their collaborative relief efforts, when authorities and official relief organizations were overwhelmed by the impact of the crisis [5]. The benefits of the volunteers' support, however, comes with the challenge of managing them in crisis situations. Unaffiliated disaster volunteers—that is, individuals not affiliated with official relief organizations who engage spontaneously in crisis response activities—are particularly difficult to integrate into the organizational processes and structures of professional relief organizations. One reason for this is the absence of a technical and organizational nexus between relief organizations and unaffiliated disas-

ter volunteers, which leads to various information management, coordination, and motivation issues that hamper the management of unaffiliated disaster volunteers [1, 6]. Motivational issues, for example, can occur with regards to the sustained encouragement of unaffiliated disaster volunteers. A concern frequently voiced by the relief organization officials we interviewed in the context of this study is the high of degree of volatility in the availability of unaffiliated disaster volunteers. While their help is a welcome resource to relief organizations, unaffiliated disaster volunteers are not bound by formal hierarchies and tend to operate on their own schedule, which can result in work being left undone when they leave without notice. By providing a nexus in the form of a technical artifact that connects unaffiliated disaster volunteers and relief organizations, we enable the integration of unaffiliated volunteers into the organizational structures and processes of relief organizations. In doing so, we aim to overcome some of these issues and improve the effectiveness and efficiency of unaffiliated disaster volunteers in crisis response activities.

As part of an ongoing research project, we have designed and developed such an artifact: a mobile crisis response system (MCRS) to support the management of unaffiliated disaster volunteers. It provides unaffiliated disaster volunteers with a central platform they can use to register as volunteers and offer their help with specific tasks. It offers relief organizations a simple interface for managing tasks with which they need help and allows them to receive information provided by unaffiliated disaster volunteers. In contrast to crisis response systems (CRS) typically used by relief organizations [7], we focus on providing a technical platform to connect unaffiliated disaster volunteers with relief organizations and integrate these volunteers into the organizational processes and structures of the relief organizations. We developed the MCRS using a design science approach [8, 9] and seek to answer the following research question: "Does MCRS usage improve the management of unaffiliated disaster volunteers?" Results from earlier stages of our design science approach have been published in [10]. In this research-in-progress paper, we present the design of our evaluation phase, which is based on a field experiment.

The remainder of this paper is structured as follows: Section 2.1 introduces the research problem we address. Section 2.2 briefly describes the proposed artifact. Section 2.3 focuses on the planned evaluation. Section 3 presents our conclusion.

2 Designing a MCRS

We use the design science approach [8] to develop a design for a MCRS that will support the management of unaffiliated disaster volunteers. This paper covers the first five steps of the methodology proposed by [9]: problem identification and motivation, objectives of a solution, design and development, demonstration, and evaluation (see Fig. 1). Thus far, we have generated a conceptual design based on knowledge drawn from theoretical and practical sources. We implemented this design as a responsive web application, which we demonstrated to relief organization employees, experts in the field, and professionals working on similar projects. We refined the artifact based on their

feedback and repeated this procedure several times before reaching a stable state in the artifact development.

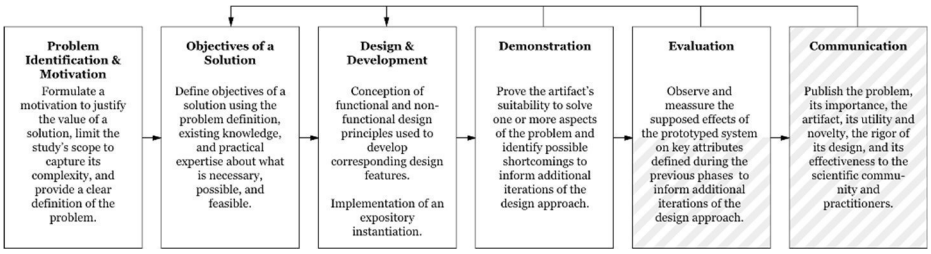

Fig. 1. Research approach; based on the interpretation of [11] of [9]

The following sections briefly illustrate the results of the steps already performed and describe in detail our plans for evaluating the artifact.

2.1 The Problem

We followed a problem-driven approach and conducted open interviews [12] as well as expert workshops [13] with official representatives of the three largest relief organizations in Germany, i.e. German Red Cross, Johanniter-Unfall-Hilfe, and Arbeiter-Samariter-Bund. Similar to organizations like the German Federal Agency for Technical Relief (THW) or UNICEF, the involved relief organizations employ professional full-time helpers, but depend on the support of volunteer helpers, which formally join and affiliate themselves with the organizations. The activity of the organizations involved in our work, however, focuses primarily on emergency services and social services. In this context, unaffiliated disaster volunteers play an increasingly important role in providing additional resources in crisis situations. The goal of this phase was to identify problems arising in the context of managing unaffiliated disaster volunteers in various types of crises and disaster situations. As a result, we defined the problem addressed in this research as follows: There is neither an organizational nor a technological nexus between unaffiliated disaster volunteers and relief organizations, which leads to several information management, coordination, and motivation challenges.

2.2 The Solution

To define the objectives of our solution, we first analyzed research on existing CRS solutions. This allowed us to identify limitations of similar projects and potential challenges for our own solution. In addition, we adopted an empirical approach and conducted semi-structured telephone interviews with the system's stakeholders, i.e. relief organization employees and unaffiliated disaster volunteers, using open-ended questions [12] to develop the conceptual MCRS design. By focusing on both, the relief organizations and the unaffiliated disaster volunteers, we developed a middle ground solution that avoids an overemphasis on the top-down model of disaster management,

which undermines the role of the community [5]. Further, we used user stories to describe the functionality of individual requirements and facilitate discussion about them [14]. These results formed the basis for the next step.

As part of the design and development phase, we derived design requirements for an artifact, which we propose as a solution to the problem identified, by analyzing the data collected in the preceding phases in three consecutive steps: descriptive coding, interpretive coding, and definition of overarching themes, that is, recurring motives [12]. We developed functional and non-functional requirements [15] based on the approach proposed by [16].

In the first step, we derived seven design requirements by integrating the overarching themes identified. Following [16], we then translated these requirements into three general design principles that describe the main functions of the conceptualized system in a generic and abstract manner: improve information management, improve coordination, and maintain engagement. Further, we mapped these principles to 13 concrete design features that would eventually constitute specific ways to implement a design principle in an actual artifact. Those comprise eight functional design features (FDFs) and five non-functional design features (NFDFs). The FDFs are: collect unaffiliated disaster volunteers' data (FDF 1), provide crisis related information to unaffiliated disaster volunteers (FDF 2), provide key performance indicators on volunteer activities to relief organizations (FDF 3), enable data aggregation for analysis (FDF 4), enable the creation of tasks for relief workers to call for support (FDF 5), provide a matching process to recommend tasks to unaffiliated disaster volunteers depending on their skills and qualifications (FDF 6), enable directed communication in the form of task related message boards (FDF 7), and enable broadcast communication in the form of mission-wide notifications and news provided by heads of operations (FDF 8). The NFDFs are: establish different levels of unaffiliated disaster volunteer participation (NFDF 1), enable data privacy (NFDF 2), minimize complexity (NFDF 3), facilitate the provision of insurance to unaffiliated volunteers (NFDF 4), and utilize personal approach (NFDF 5). The core functions of the artifact to address the most important specified design features comprise: a simple registration process; a management interface to create, update, and delete crisis response activities offered to unaffiliated disaster volunteers; message boards to provide a central communication nexus for response activities; and news feeds to distribute official information provided by relief organizations. To improve the coordination of tasks and helpers, we further specify design features for an appropriate matching process that presents available crisis response activities to unaffiliated volunteers who meet potential requirements (e.g., possess a driver's license; have first aid skills). The matching system provides unaffiliated disaster volunteers access to crisis response activities based on their preferences and qualifications. Further, it enables relief workers to prioritize specific activities by recommending them manually to individual volunteers. In addition, we propose features to motivate unaffiliated disaster volunteers during their involvement, such as a low entry threshold for new users, data privacy, and low complexity (for further information on the development of the design features and a more detailed description of the artifact, see [10]).

Finally, we developed an initial prototype of the artifact based on the results of this phase. To account for the unaffiliated disaster volunteers' independence and spontaneity, we implemented a prototype system as a "mobile first" solution by means of a responsive web application with a lightweight user management system. This allows for ad-hoc access using mobile and other devices (e.g., desktop computers). We arranged an expert workshop [13] and asked relief workers to conduct functional tests to demonstrate the artifact to a diverse audience and evaluate its capability for solving the problem. Based on the feedback, we refined the prototype, which will be used in the planned evaluation.

2.3 The Planned Evaluation

This section describes in detail the evaluation phase of our design science approach. Its goal is to measure meaningful characteristics of the artifact and to determine its adequacy for the specified problem [17].

To design the evaluation, we applied the four-step DSR (Design Science Research) evaluation research design method proposed by [18]. We plan to conduct a field experiment [19] to assess the system's quality. The experiment is based on a joint mission exercise which will be performed by the involved relief organizations (German Red Cross, Johanniter-Unfall-Hilfe, Arbeiter-Samariter-Bund). During the exercise, the relief organizations will simulate a crisis scenario under realistic conditions, which are derived from a real natural disaster that took place in a medium-size German city in 2013. During a festival located on the banks of a river, heavy rain resulted in a substantial rise in the river's water level, which in turn caused a rapidly rising flood that confronted the festival's organizers and responsible relief organizations with tremendous challenges. Visitors had to be evacuated from the affected area, and then employees of the relief organizations involved had to manage unaffiliated disaster volunteers who wanted to help with urgent tasks. For example, tents had to be taken down and injured persons provided with care. The situation is ideal for studying the phenomenon of unaffiliated disaster volunteering and to evaluate our artifact.

Within the limits of this mission exercise, we suggest an adjusted post-test only/control group design [20]. Accordingly, we will divide the experiment between two independent groups, the control group and the treatment group. Both groups will perform the same tasks with the same resources. The control group will manage unaffiliated disaster volunteers based on the traditional approach—oral communication—while the treatment group will use the MCRS prototype. Each group will be comprised of three types of participants: relief organization employees responsible for the coordination of the overall mission (i.e., heads of operations); relief workers directly involved in field activities and who are in contact with unaffiliated disaster volunteers; and unaffiliated disaster volunteers who appear spontaneously, are not affiliated with official relief organizations, and engage in self-organized disaster relief activities.

In total, there will be 73 experiment participants: one head of operations, located at a distant command center, who will be directing the operation and coordinating both the treatment and control groups (necessary due to a limitation imposed by the design of the mission exercise that provides the foundation for our field experiment); two

groups of 26 relief workers each (six coordinators and two task forces of ten in each group); and two groups of ten unaffiliated disaster volunteers each. As stated before, both groups of relief workers and disaster volunteers will be given identical assignments comprising various tasks of different natures and complexity and requiring varying degrees of cooperation. Once the experiment is completed, relief workers in the field and unaffiliated disaster volunteers will be asked to complete a survey, and some will participate in follow-up interviews. The head of operations will be interviewed based on differentiated, open-structured questions to analyze the effect of MCRS usage during the evaluation. Figure 2 shows the overall constellation of the experiment.

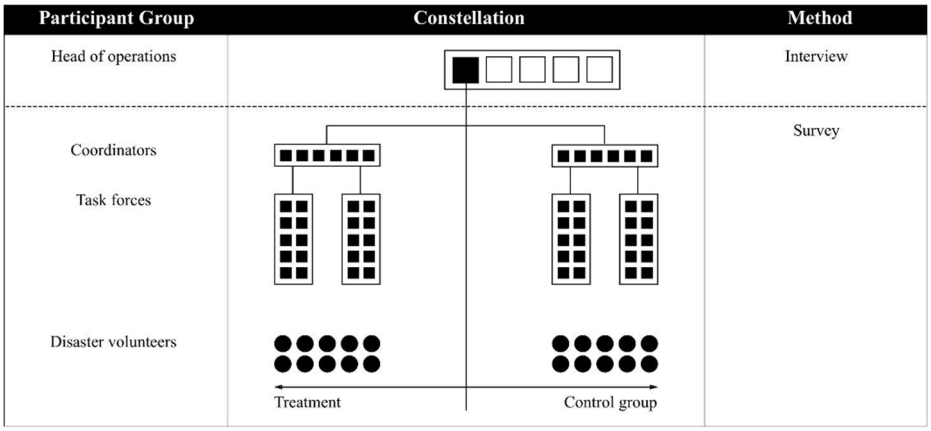

Fig. 2. Experimental Design

The central premise of our artifact's evaluation is to demonstrate that MCRS usage improves the management of unaffiliated disaster volunteers in a crisis context. In other words, we want to prove the success of our proposed design. That is why we use the IS Success Model [21, 22] as a basis for the survey design. In addition to describing a causal/process model of the dependent variable success, the IS Success Model also depicts a measurement model [23]. The model's constructs fit the core elements of the problem identified. Information quality addresses poor information management, individual impact addresses the unpredictable motivation of unaffiliated disaster volunteers, and organizational impact addresses coordination problems. In addition to the adequacy of our solution for the problem identified, we want to understand the artifact's system quality based on the respective constructs. Therefore, we use the proposed constructs as dimensions to design an adequate survey instrument. We adapt the Enterprise

System Success Model proposed by [21] to the context introduced and use it accordingly. For this purpose, we remove measurements that are not relevant for the context of an MCRS and add three additional constructs. The result is a model consisting of four dimensions: system quality (seven measurements), information quality (six measurements), individual impact (seven measurements), and organizational impact (five measurements) (see Table 1). The added constructs are necessary to measure properties that are distinctive for a MCRS and that are not part of a typical enterprise system. Both

matching effectiveness and matching efficiency address the quality of the implemented matching process, which helps to coordinate the accrual of tasks and available helpers. Similarly, we added a construct to determine the prototype's effect on unaffiliated disaster volunteers' motivation to maintain their engagement. We use the term "system" for the MCRS prototype in using the dimension system quality for both experimental groups; the term also describes the traditional system of managing unaffiliated disaster volunteers.

Table 1. Adaption of the *Enterprise System Success Model* [21]

System Quality		Information Quality		Individual Impact		Organizational Impact	
SQ1	Ease of use	IQ1	Availability	II1	Learning	OI1	Organizational costs
SQ2	Ease of learning	IQ2	Usability	II2	Awareness/ Recall	OI2	Staff requirements
SQ3	User requirements	IQ3	Understandability	II3	Decision effectiveness	OI3	Increased capacity
SQ4	System features	IQ4	Relevance	II4	Individual productivity	OI4	Overall productivity
SQ5	System accuracy	IQ5	Format	II5	Matching efficiency*	OI5	Improved outcomes
SQ6	Flexibility	IQ6	Conciseness	II6	Matching effectiveness*		Cost reduction†
SQ7	Integration			II7	Motivation*		e-Government†
	Sophistication†						BP Change†
	Customizability†						

†removed, * added

The treatment and control groups will receive the same surveys. The first survey will be administered to relief workers in the field (i.e., the second type of participants described earlier) and will include all four described dimensions. The second survey will be administered to unaffiliated disaster volunteers (i.e., the third type of participants) and will comprise all but the last dimension, since this group is not part of the organization itself. The additional interviews with both participant types, as well as the open-structured interview with the head of operations, will also be based on these dimensions, but will leave room for additional comments and detailed feedback.

Since the size of the experiment and the number of participants is subject to limitations beyond our control, we plan to conduct qualitative and descriptive analyses of the results to assess the design's success. If the feedback is unsatisfactory, we will revisit the design phase and revise our solution. Otherwise, the design study will enter the concluding communication phase.

3 Conclusion

The focus of this research-in-progress paper is on developing an appropriate evaluation design to determine the artifact's adequacy for the problem of managing unaffiliated disaster volunteers during crisis response activities. To complete the study, we need to conduct the actual evaluation of the prototype. In particular, we need to assess whether the artifact developed, when used as part of managing unaffiliated disaster volunteers, increases the effectiveness and efficiency of collaboration compared to existing methods. To achieve this, we propose a detailed plan for a comprehensive field experiment involving 73 participants from all stakeholder groups. Subsequently, we need to analyze the elicited data to assess the success of our design, which may then inform another

build-and-evaluate iteration. If we can successfully test the appropriateness of the artifact for the problem identified, we can move to the last step of the design study—that is, the communication of our results. We plan to present the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant parties [9]. It is especially important to communicate the results of our research to relief organizations so they can employ an appropriate MCRS and improve the management of unaffiliated disaster volunteers.

To interpret the implications of the evaluation design presented, readers should consider the following limitations of our study. The field experiment will be restricted by organizational constraints of the relief organizations involved, which are ultimately responsible for the execution of the experiment. Hence, we have had to adjust the traditional post-test only/control group design. We are aware that the artifact will not be tested under optimal conditions, but we are certain that the field experiment will contribute considerably to the artifact's improvement. If, however, the evaluation we have described should not suffice, we plan to conduct an additional lab experiment that could, for example, place a stronger focus on the head of operations subgroup (the participant of the first type described earlier).

The proposed design provides a nexus in the form of a technical artifact that connects unaffiliated disaster volunteers and relief organizations. Choosing a more general context could result in different or additional design requirements and principles. We expect, however, that the design could be generalized and applied to contexts, in which groups of volunteers are willing to provide their time and resources to solve simple location-based tasks, which are specified and monitored by a coordinating organization (e.g., UNICEF and Doctors Without Borders). The generalizability of our solution is facilitated by the high degree of aggregation with regards to the functional and non-functional design principles and features.

Finally, [22] have shown that there are few design science studies that evaluate instantiated artifacts using illustrative scenarios, which allow for evaluation of the artifact under realistic conditions. Rather, researchers tend to apply limited technical experiments to test instantiations under laboratory conditions. We hope to contribute to the knowledge base about scenario-based evaluations in IS design studies by proposing an exemplary approach based on a combination of a comprehensive field experiment and a customized measurement framework derived from the IS Success Model.

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