Applying Usability Engineering to Interactive Systems for Crisis and Disaster Management

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ABSTRACT

Crisis and disaster management are increasingly characterized by interactive systems intended to be valuable support for professionals and volunteers in preventing, preparing for, responding to and recovering from major incidents and accidents. Therefore, usability in terms of safe and efficient usage of computer-based solutions becomes a crucial factor for successful crisis and disaster management. In order to ensure usability, it has to be addressed systematically throughout any development process. In this paper, established engineering approaches to crisis and disaster management systems are summarized. Subsequently, resemblances (e.g. diversity of users and devices) and differences (e.g. scalability) between safety-critical contexts of medical device design and crisis management are outlined. Following this, recommendations for applying usability engineering processes to disaster management are derived from standards and guidelines according to medical device design (IEC 62366-1:2015, ISO 14971:2007). Particularly, relationships and interactions between usability engineering and risk managements measures (e.g. hazard-related use scenarios) are described.

Keywords

Usability Engineering, Risk Management, Medical Devices, User-Centered System Design

INTRODUCTION

Information technology varying from wearable devices (e.g. smartwatches, smartglasses) to stationary command and control rooms with multiple screens and various workstations have *"a tremendous potential for increasing efficiency and effectiveness in coping with a disaster"* (Meissner et al., 2002). However, it can only be brought to bear, if users will be able to handle their tasks successfully taking as little time and cognitive load as possible. This is a major challenge because *"an [user] interface is still an intermediary between the user's intent and execution of that intent. As such, it should be considered at best a necessary evil because no matter how fluid, it still imposes a layer of cognitive processing between the user and the computer's execution of the user's intent"* (van Dam, 1997). In the worst case, it could either prevent crisis managers, first responders, volunteers or the general public from using or trusting such computer-based solutions or cause problems resulting in delayed or improper actions.

In this regard, *usability* as *"the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"* (ISO, 1998) is a crucial factor for suitability of interactive system in any safety-critical domain. It has to be addressed and ensured systematically throughout any development process. Necessary measures include context of use analysis, human-machine task allocation, human-machine cooperation, interaction and interface design as well as usability evaluations (Mentler, Reuter and Geisler, 2016).

In the following section, two research questions will be addressed:

1. Which specific engineering approaches have already been applied to the development of crisis and disaster management systems?

2. Could recommendations for applying usability engineering to crisis and disaster management be derived from ones established in the safety-critical context of medical device design? If yes, which are they?

Firstly, the topic of (usability) engineering approaches to interactive systems for crisis management will be introduced by describing background and related work. Following this, characteristics of medical device design related to crisis and disaster management are outlined. These sections are based on systematic literature review and experiences from previous research in the fields of pre-hospital and clinical care (cf. Mentler and Herczeg, 2014; Mentler et al.; 2016) as well as safety-critical human-machine interaction in general (cf. Mentler, Reuter and Geisler, 2016). Subsequently, these recommendations are applied to the domain of disaster and crisis management. Conclusions will be drawn and reflected upon in the last section.

BACKGROUND AND RELATED WORK

In the following sections, basic principles and process model of *usability engineering* covering "*concepts and techniques for planning, achieving, and verifying objectives for system usability"* (Beyer and Holtzblatt, 1998) are described. Afterwards, engineering approaches to crisis and disaster management systems resulting from systematic literature review in ISCRAM Digital Library are summarized.

Fundamental Principles and Process Model of Usability Engineering

Usability engineering, as a concept integrating several measures for ensuring and improving usability of interactive systems, can be traced back to the mid-1980s. Good et al. (1986) defined *usability engineering* as *"a process, grounded in classical engineering, which amounts to specifying, quantitatively and in advance, what characteristics and in what amounts the final product to be engineered is to have"*. According to them, usability engineering processes are characterized by

- defined metrics and levels of usability,
- design solutions analyzed with respect to meeting project goals,
- user feedback incorporated into an iterative design process.

These requirements and the analyze-design-build-evaluate-cycle (see Figure 1) provide the basis for standard like ISO 9241-210 describing the "*human-centred design for interactive systems"* and have been implemented in more sophisticated process models like *Contextual Design* (Beyer and Holtzblatt, 1998), *Scenario-Based Design* (Rosson and Carroll, 2002) or the *Usability Engineering Lifecycle* (Mayhew, 1999).

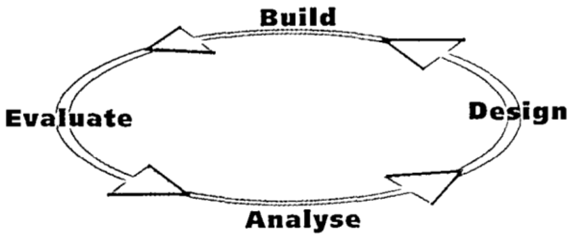

Figure 1. Usability Engineering Paradigm (Butler, 1996)

Both the ISO 9241-210:2010 standard and the previously mentioned design approaches are devoted to interactive systems in general and not particularly to safety-critical ones. For example, ISO 9241-210:2010 *"does [not] address health or safety aspects in detail"*. Rosson and Carroll (2002) state that *"safety has remained a side issue in usability engineering"* and outline how usability engineering techniques could be used to incorporate safety-related aspects. For example, they suggest to represent critical incident reports as scenarios in terms of *"[stories] about people carrying out an activity"* (Rosson and Carroll, 2002).

In any case, usability engineering for safety-critical contexts like crisis and disaster management has to be conducted in due considerations of challenges like extraordinary operational conditions (e.g. heavy rain, time-pressure), dynamic changes of mission parameters (e.g. number of casualties, affected areas) as well as users under high cognitive and physical workload. Apart from this, *"even early prototypes might require advanced levels of hardware and software quality"* (Mentler et al., in press). Therefore, methods from other engineering disciplines (e.g. software engineering, safety engineering) need to be incorporated in user-centered design approaches.

Engineering Approaches to Crisis and Disaster Management Systems

Over the last 20 years, research and development of interactive systems for crisis and disaster management have been increased. A systematic literature review of contributions to ISCRAM Digital Library should give an answer to the question which specific engineering approaches have already been applied by ISCRAM-related research groups to the development of crisis and disaster management systems. Subsequently, its results are summarized.

In January 2017, a *main field search* was conducted in ISCRAM Digital Library (http://idl.iscram.org/) considering data fields for author, title, publication (in terms of proceedings), keywords, abstract, area and conference. *Search terms* were “usability” (23 results), “engineering” (56 results), “usability engineering” (1 result), “user-centered design” (5 results), “user-centred design” (0 results), “human-centered design” (3 results), and “human-centred design” (0 results).

With respect to engineering in general, various approaches could be identified:

- *business process reengineering* (e.g. Charles et al., 2009; Hofmann et al., 2015) *“reevaluating existing internal norms and behaviors before designing a new system. This new evaluation process will address customers, operational efficiencies, and cost”* (Langer, 2016). For example, Charles et al. (2009) applied enterprise modelling approaches and tools to characteristics of humanitarian aid work. In this regards, *business process modelling techniques* have been used by several researchers (e.g. Barthe, Lauras and Benaben, 2011; Ooms and Van Den Heuvel, 2014).
- *resilience engineering* (e.g. Filho et al., 2014; De França et al., 2014) looking *“for ways to enhance the ability of organisations to create processes that are robust yet flexible, to monitor and revise risk models, and to use resources proactively in the face of disruptions or ongoing production and economic pressures”* (Dekker et al., 2008). For example, Filho et al. (2014) analyzed how a command and control center coped with unexpected events (especially large-scale protests) during a major sports event in Brazil.
- *requirements engineering* (e.g. Campbell et al., 2005; Groner and Jennings, 2012) in terms of *“the subset of systems engineering concerned with discovering, developing, tracing, analyzing, qualifying, communicating and managing requirements that define the system at successive levels of abstraction”* (Hull et al., 2011). For example, Campbell et al. (2005) conducted an empirical study in order to investigate how group and task structures affect quality of distributed and asynchronous requirements elicitation.
- *safety engineering* (e.g. Ristvej et al., 2010; Sharpanskykh, 2012) assuring *“adequate safety in advance of the deployment of a system”* (McDermid et al., 2009). For example, Sharpanskykh (2012) proposed a formal method to linking local actors and global characteristics in safety-critical organizations. In this regard, *risk management* in terms of systematic approaches to analyzing, assessing, controlling and monitoring risks is considered by several research groups (e.g. Eckle et al., 2016).
- *software engineering* (e.g. Diirr and Borges, 2013; Glantz, 2014) *“concerned with developing and maintaining software systems that behave reliably and efficiently, are affordable to develop and maintain, and satisfy all the requirements that customers have defined for them”*(ACM, 2006). For example, Diirr and Borges (2013) applied test and quality assurance methods (Formal Technical Review, mutation testing) to emergency plans for response teams.

It is worth mentioning that all of these engineering approaches overlap with user-centered process models to a certain degree but have different priorities and overall aims (e.g. not focussing on users’ need in the first place). According to usability engineering, user-centered or human-centered design, most contributions to ISCRAM focus on one stage of the analyze-design-build-evaluate-cycle (see Figure 1). For example,

- Catarci et al. (2010) described the *usability evaluation methodology* applied during the development of a process management and geo collaboration system for disaster response forces. Their approach comprised controlled experiments, cooperative evaluations with domain experts, tests with external users not familiar with the domain and set-ups of concrete and realistic scenarios (“showcases”).
- Mentler and Herczeg (2013) explained *interface and interaction design* of a tablet-based application for Emergency Medical Services (EMS) dealing with mass casualty incidents (MCIs). They applied the seven design principles of ISO-standard 9241-110 (e.g. suitability for the task, self-descriptiveness) to a mobile and safety-critical context of use considering challenges of designing an application which should to be suitable for users in both regular day-to-day services as well as rare missions with dozens or hundreds of casualties.

Only a few contributions have been devoted to overall usability engineering process models or applied techniques to different stages of development:

- Fischer and Klompmaker (2012) designed an interactive table to support rescue workers. They followed a *user-centered system design approach* and conducted contextual analysis, specified user requirements, designed a prototype, conducted a *"first evaluation"* with domain experts and presented further scenarios.
- Kluckner et al. (2014) summarized the development and evaluation of a graphical user interface *"of a simulation tool in crisis management"* following a *user-centered system design approach*. They referred to context analysis, requirements specification, prototype design and usability tests.

Context analysis, prototype design, usability tests and other usability engineering measures are essential for ensuring safe and efficient usage of interactive systems. As mentioned before, looking for approaches and methods incorporating safety-related aspects in more detail seems to be advisable.

USABILITY ENGINEERING FOR MEDICAL DEVICES

Crisis and disaster management is not the only and not the first safety-critical domain increasingly characterized by interactive systems (e.g. aviation, dispatch centers, healthcare, power supply, transport and logistics). However, knowledge transfer from one domain to another is challenging due to specific characteristics of different contexts of use.

In the following sections, it is explained whether and why standards and guidelines for usability engineering of medical devices should be considered for further improvement of crisis and disaster management systems. Afterwards, fundamental principles of the standards IEC 62366-1:2015 ("Application of usability engineering to medical devices") and ISO 14971:2007 ("Application of risk management to medical devices") are summarized.

Characteristics of Medical Device Design related to Crisis and Disaster Management

The context of use for medical devices bears resemblances to the one for interactive systems in crisis and disaster management with respect to the following aspects:

- diversity of users,
- diversity of devices and applications,
- diversity of operational conditions.

IEC 62366-1:2015 states that *"there can be a wide diversity of such individuals for any particular medical device including: installers, engineers, technicians, clinicians, patients, care givers, cleaners, sales, marketing"*. While some systems and applications (e.g. artificial respiratory equipment) might be used by trained professionals of single or several disciplines only, others might be available for both domain experts and laypeople. These characteristics can be compared to crisis and disaster management requiring

- computer-supported cooperation between professionals of single or several public service authorities and emergency services,
- computer-supported cooperation between professionals and volunteers ("emergent groups").

With respect to *technology*, medical devices range from wearable computing (e.g. smartglasses for surgeons; Mentler et al., 2016) to large-scale devices (e.g. magnetic resonance imaging system). Information systems, decision support systems and training systems are important *applications* (e.g. clinical information systems, electronic health records, simulations; Dahl et al., 2009; Shneiderman, 2011). Some of them might not be usable or not allowed to be used without prior instruction, others, e.g. automated external defibrillators, have to be regarded as *"walk-up-and-use products"* (Bevan and Raistrick, 2011). These classes of devices and applications are relevant to crisis and disaster management as well (Eckle et al., 2016; Parush et al., 2016).

The *diversity of operational conditions* for medical devices is indicated in Figure 2. From temporary installations in the field at night and during snowfall to well-equipped operation rooms with carefully adjusted lighting, heating and workplaces, medical devices must be usable (nearly) anywhere and anytime. The same can be determined in crisis and disaster management. Control rooms, on-site command vehicles, office environments, gathering places or outdoor environments are just a few possible working environments.

Figure 2: Exemplary environments for usage of medical devices

Finally, medical devices need to be applied in many crisis and disaster scenarios (e.g. mass casualty incidents after earthquakes; Garcia-Aristizabal et al., 2015). Nevertheless, their management might impose further challenges not present in medical device design and usage, e.g. long-lasting and spatially extended missions involving several actors at different locations for weeks, months or years. *Scalability*, in terms of the *"ability of a system to accommodate an increasing number of elements or objects, to process growing volumes of work gracefully, and/or to be susceptible to enlargement"* (Bondi, 2000), is a major challenge in developing crisis and disaster management systems affecting their usability as well. The same holds true for *interoperability* in terms of *"accessing relevant data at any time and sharing it across any levels of activities and parties involved in [Humanitarian Crises]"* (Shamoug and Juric, 2011).

Because of the outlined resemblances according to diversity of users, devices and operational conditions, guidelines and standards for medical device design should be considered, if dealing with usability engineering for crisis and disaster management systems. However, because of the outlined differences (e.g. scalability, interoperability) between these contexts of use, this should be done in a careful way.

Fundamental principles of IEC 62366-1:2015 and ISO 14971:2007

While ISO 9241-210:2010 refers to computer-based interactive systems in general (ranging from web sites to process control systems), IEC 62366-1:2015 and ISO 14971:2007 are domain-specific standards taking characteristics of medical devices and their usage into account. They specify

- normal and abnormal use,
- requirements for documenting usability engineering measures (usability engineering file),
- relationship between usability engineering and risk management processes.

Figure 3 shows the relationship between *normal and abnormal use* of a medical device according to IEC 62366-2015. It is worth mentioning that manufactures are only required to *"assess and mitigate risks associated with correct use and use error […]"* (IEC 62366-2015). Abnormal use of a user interface (e.g. criminal offenses, reckless behavior) is out of the manufacturer's scope of responsibility.

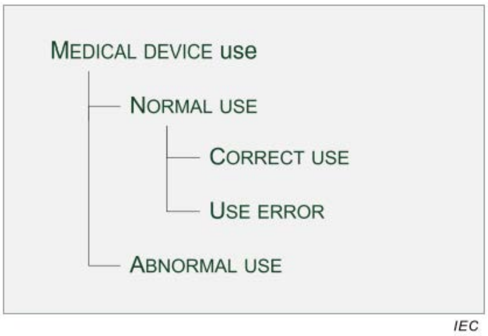

Figure 3: Relationship between normal and abnormal use (IEC 62366:1-2015)

However, manufacturers have to deal with possible use errors which could be caused by perception errors (e.g. failing to recognize a visual element), cognition errors (e.g. applying a wrong measure) or action errors (e.g. pressing a wrong button).

Actions to prevent use errors (e.g. formative and summative evaluations) as well as other measures have to be documented. IEC 62366-2015 states that all *"the results of the usability engineering process shall be stored in the usability engineering file"*. The Food and Drug Administration (2016) recommends a structure for such a usability engineering report. Among others, it should contain:

- descriptions of indented users, use, environments, training and user interface design;
- a summary of known problems with the user interface;
- a hazard and risk analysis;
- a summary of evaluations and details of human factors validation testing.

Relationship and interactions between usability engineering and risk management are described in IEC 62366-1:2015 with reference to ISO 14971:2007 in great detail. In this regard,

- risk management is a *"decision-making process for determining acceptable risk"* (IEC 62366-1:2015) and involves risk analysis, risk evaluation and risk control (ISO 14971:2007);
- usability engineering is a *"design and development process for the user interface to reduce the possibility of use errors that could result in risks associated with usability"* (IEC 62366-1:2015).

It is worth mentioning that this second definition is narrower than other ones in usability engineering and human-computer interaction: it embraces work reengineering and is not limited to user interface and interaction design (e.g. Mayhew, 1999). Introducing new or modified tools in a working environment affects the way users can solve their tasks. That's why procedures and workflows might have to be adjusted but this aspect is not covered in this standard.

Information flows between risk management and usability engineering process involve use specifications, safety-related user interface characteristics, known or foreseeable hazardous situations (e.g. from experience with a previous version), hazard-related scenarios describing use scenarios that could lead to a harm (IEC 62366-1:2015) and results of formative and summative evaluation measures.

USABILITY ENGINEERING RECOMMENDATIONS FOR CRISIS AND DISASTER MANAGEMENT SYSTEMS

In the following sections, recommendations for applying usability engineering measures to crisis and disaster management are derived from the previously described fundamental principles of IEC 62366-1:2015 and ISO 14971:2007. They refer to normal and abnormal use, usability engineering files and the relationship between usability engineering and risk management.

Normal and Abnormal Use

Because crisis and disaster scenarios can vary in many regards (e.g. damages, duration, dynamics, hazards, severity), utility and usability of a specific crisis and disaster management systems can hardly be predicted or even assured in general. While laboratory studies allow for control of many influencing factors, various stressors and influences can not be created intentionally. On the other hand, field studies require a lot of resources (e.g. observers, test devices, access to safety-critical areas) and can only provide insights for certain specific circumstances. Therefore, manufactures (e.g. software developers or usability engineers in research groups) should specify the intended use of their applications.

Defining a normal use would require to deal with potential use errors, too. Therefore, improved design solutions for error control, error correction and error management as means for error tolerance of interactive systems would be necessary and support users under high cognitive and physical load.

Abnormal uses in terms of intentional acts or omissions might be hard to prevent but manufacturers could try to describe under which circumstances their applications might not be usable in the intended way. Addressing system boundaries explicitly could be both a starting point for improvements and a facility to better match users', designers' and systems' mental model (Herczeg, 2014).

Usability Engineering File

Documenting essential characteristics of the context of use (intended users, use, environments, training and user interface design principles) as well as evaluation results should be mandatory for crisis and disaster management systems because it would ease third-party audits from usability experts and support accident analysis with respect to interaction problems.

Furthermore, it could guide both manufacturers (e.g. software developers or usability engineers in research groups) and domain experts not familiar with usability engineering measures in great detail. As stated by Mentler and Herczeg (2014): *"Managers and decision makers of [Emergency Medical Services] EMS providers often have a professional medical background but are not human factors and ergonomics experts"*. Comprehensive usability engineering reports could become an alternative means of understanding.

Usability Engineering and Risk Management

Dealing with known or foreseeable hazardous situations as well as describing hazard-related scenarios could improve usability of crisis and disaster management systems because these measures would require designers and developers to deal with "Doyle's Catch" (Alderson and Doyle, 2010): *"Computer-based simulation and rapid prototyping tools are now broadly available and powerful enough that it is relatively easy to demonstrate almost anything, provided that conditions are made sufficiently idealized"*.

However, crisis and disaster management offer conditions far away from being ideal for computer-based interactive solutions. Time- and safety-critical circumstances put high requirements on users, technology and their interaction respectively cooperation. Therefore, usability engineering and risk management processes should be aligned in order to ensure safe and efficient human-computer interaction even under extraordinary circumstances. Techniques of resilience and safety engineering (see the previous section) could be a valuable addition helping a system to become *"SURE (Safe, Usable, Reliable, and Evolvable)"* (Palanque et al., 2007).

CONCLUSION

Systematic development of crisis and disaster management systems is both crucial and challenging. As a systematic literature review reveals, several engineering approaches have been used by ISCRAM-related research groups. *Business process reengineering* and *business process modelling techniques*, *resilience engineering*, *requirements engineering*, *safety engineering* and *risk management measures*, *software engineering* and *usability engineering* overlap to a certain degree but have different priorities and overall aims. Usability is is a crucial factor for suitability of interactive system in crisis and disaster management. Usability engineering measures are essential for ensuring safe and efficient usage. In order to incorporate safety-related aspects more carefully, approaches and methods from other safety-critical domains should be considered. Because the context of use for medical devices bears resemblances with respect to diversity of users, diversity of devices and diversity of operational conditions, fundamental principles of domain-specific standards and guidelines should be considered. Because there are differences (e.g. scalability, interoperability) between these contexts of use, this should be done in a careful way. Concepts like the distinction between normal and abnormal use, usability engineering files and risk management incorporation could be valuable complements to commonly used general or user-centered engineering approaches in crisis and disaster management. Nevertheless, further research is necessary on knowledge transfer between safety-critical domains. Finally, formative and summative evaluations of prototypes developed according to the mentioned concept have to be conducted in order to demonstrate their importance.

REFERENCES

ACM. (2006) Software Engineering. http://computingcareers.acm.org/?page_id=12.

Alderson, D. L. and Doyle, J. C. (2010) Contrasting views of complexity and their implications for network-centric infrastructures, *IEEE SMC—Part A*, 40, 839–852.

Barthe, A. M., Lauras, M. and Benaben, F. (2011) Improving the design of interoperable platform through a structured case study description approach: Application to a nuclear crisis. *Proceedings of the 8th International ISCRAM Conference*, Harbin, Heilongjiang, China.

Bevan, N. and Raistrick, S. (2011) ISO 20282: Is a Practical Standard for the Usability of Consumer Products Possible? *Design, User Experience, and Usability. Theory, Methods, Tools and Practice (Lecture Notes in Computer Science*, 119-127, Springer, Berlin.

Beyer, H. and Holtzblatt, K. (1998) Contextual design. Defining customer-centered systems, Morgan Kaufmann, San Francisco.

Bondi, A. B. (2000) Characteristics of scalability and their impact on performance. *Proceedings of the 2nd international workshop on Software and performance*, Ottawa.

Butler, K. A. (1996) Usability engineering turns 10. *interactions*, 3, 1, 58-75.

Campbell, C. L., Van De Walle, B. A. and Deek, F. P. (2005) Asynchronous negotiation and collaboration of software requirements for an emergency response information system: An empirical investigation, *Proceedings of ISCRAM 2005 – 2nd International Conference on Information Systems for Crisis Response and Management*, Brussels.

Catarci, T., De Leoni, M., Marrella, A., Mecella, M., Bortenschlager, M. and Steinmann, R. (2010) The WORKPAD project experience: Improving the disaster response through process management and geo collaboration, *Proceedings of ISCRAM 2010 – 7th International Conference on Information Systems for Crisis Response and Management: Defining Crisis Management 3.0*, Seattle, WA.

Charles, A., Lauras, M. and Tomasini, R. (2009) Learning from previous humanitarian operations, a business process reengineering approach, *Proceedings of ISCRAM 2009 – 6th International Conference on Information Systems for Crisis Response and Management: Boundary Spanning Initiatives and New Perspectives*, Gothenburg.

Dahl, Y., Alsos, O. and Svanæs, D. (2009) Evaluating Mobile Usability: The Role of Fidelity in Full-Scale Laboratory Simulations with Mobile ICT for Hospitals. Human-Computer Interaction. New Trends, *Human-Computer Interaction. New Trends*, Berlin.

De França, T., Nolasco, D., Tavares, R., Gomes, J. O. and De Paulo, V. R. (2014) A critical insight of the pope's visit to Brazil for the world youth day: Resilience or fragility?, *ISCRAM 2014 Conference Proceedings – 11th International Conference on Information Systems for Crisis Response and Management*. University Park, PA.

Dekker, S., Hollnagel, E., Woods, D. D. and Cook, R. (2008) Resilience Engineering. New directions for measuring and maintaining safety in complex systems. https://www.msb.se/Upload/Kunskapsbank/Forskningsrapporter/Slutrapporter/2009%20Resilience%20Engineering%20New%20directions%20for%20measuring%20and%20maintaining%20safety%20in%20complex%20systems.pdf.

Diirr, B. and Borges, M. (2013) Applying software engineering testing techniques to evaluate emergency plans, *ISCRAM 2013 Conference Proceedings – 10th International Conference on Information Systems for Crisis Response and Management*, Baden-Baden.

Eckle, M., Albuquerque, J.P., Herfort, B., Zipf, A., Leiner, R. and Wolff, R. (2016) Leveraging OpenStreetMap to Support Flood Risk Management in Municipalities: A Prototype Decision Support System, *ISCRAM 2016 Conference Proceedings – 13th International Conference on Information Systems for Crisis Response and Management*, Rio de Janeiro.

Filho, A., Sobral, A., Passos, C., Arce, D., Bianco, G. and Rodrigues, J. (2014) C2 Center dealing with the unexpected: Resilience and brittleness during FIFA confederation cup, *ISCRAM 2014 Conference Proceedings – 11th International Conference on Information Systems for Crisis Response and Management*, University Park, PA.

Fischer, H. and Klompmaker, F. (2012) Enriching disaster control management based on human-centered design, *ISCRAM 2012 Conference Proceedings – 9th International Conference on Information Systems for Crisis Response and Management*, Vancouver, BC.

Food and Drug Administration (2016) Applying Human Factors and Usability Engineering to Medical Devices. http://www.fda.gov/downloads/MedicalDevices/…/UCM259760.pdf

Garcia-Aristizabal, A., Polese, M., Zuccaro, G., Almeida, M. and Aubrecht, C. (2015) Improving emergency preparedness with simulation of cascading events scenarios, *ISCRAM 2015 Conference Proceedings – 12th International Conference on Information Systems for Crisis Response and Management*, Kristiansand.

Glantz, E. J. (2014) Community crisis management lessons from Philadelphia's 1793 epidemic, *ISCRAM 2014 Conference Proceedings – 11th International Conference on Information Systems for Crisis Response and Management*, University Park, PA.

Good, M., Spine, T. M., Whiteside, J. and George, P. (1986) User-derived impact analysis as a tool for usability engineering, *CHI '86 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, New York, NY.

Groner, N. and Jennings, C. (2012) Describing pipeline emergency response communications using situational awareness informational requirements and an informational flow analyses, *ISCRAM 2012 Conference Proceedings – 9th International Conference on Information Systems for Crisis Response and Management*, Vancouver, BC.

Herczeg, M. (2014) Prozessführungssysteme. Sicherheitskritische Mensch-Maschine-Systeme und interaktive Medien zur Überwachung und Steuerung von Prozessen in Echtzeit, de Gruyter Oldenbourg, München.

Hofmann, M., Betke, H. and Sackmann, S. (2015) Automated Analysis and Adaptation of Disaster Response Processes with Place-Related Restrictions. *ISCRAM 2015 Conference Proceedings – 12th International Conference on Information Systems for Crisis Response and Management*, Kristiansand.

Hull, E., Jackson, K. and Dick, J. (2011) Requirements Engineering. Springer, London.

International Standard 14971 (2007) Medical devices – Application of risk management to medical devices.

International Standard 62366-1 (2015) Medical devices – Part 1: Application of usability engineering to medical devices.

International Standard 9241-11 (1998) Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability.

International Standard 9241-210 (2010) Ergonomics of human-system interaction - Part 210: Human-centred design for interactive systems.

Kluckner, S., Heintze, K. E. and Wendt, W. (2014) Designing for the user: Tailoring a simulation software interface to the needs of crisis managers, *ISCRAM 2014 Conference Proceedings – 11th International Conference on Information Systems for Crisis Response and Management*, University Park, PA.

Langer, A. M. (2016) Guide to Software Development, Springer, London.

Mayhew, D. J. (1999) The usability engineering lifecycle. A practitioner's handbook for user interface design, Morgan Kaufmann Publishers, San Francisco.

McDermid, J., Thomas, M. and Redmill, F. (2009) Professional Issues in System Safety Engineering, *Safety-Critical Systems: Problems, Process and Practice*, Springer, London.

Meissner, A., Luckenbach, T., Risse, T., Kirste, T. and Kirchner, H. (2002) Design Challenges for an Integrated Disaster Management Communication and Information System, *First IEEE Workshop on Disaster Recovery Networks (DIREN)*. http://www.comet.columbia.edu/diren/.

Mentler, T., Berndt, H., Wessel, D. and Herczeg, M. (In Press) Usability Evaluation of Information Technology in Disaster and Emergency Management, *First IFIP Conference on Information Technology in Disaster Risk Reduction (ITDRR 2016)*, Sofia.

Mentler, T. and Herczeg, M. (2013) Applying ISO 9241-110 dialogue principles to tablet applications in emergency medical services, *ISCRAM 2013 Conference Proceedings – 10th International Conference on Information Systems for Crisis Response and Management*, Baden-Baden.

Mentler, T. and Herczeg, M. (2014). Human Factors and Ergonomics in Mobile Computing for Emergency Medical Services, *Proceedings of the 5th International Conference on Applied Human Factors and Ergonomics*, Krakow.

Mentler, T., Kappel, J., Wünsch, L. and Herczeg, M. (2016). Photo-enriched Documentation during Surgeries with Google Glas, *i-com*, 15, 2, 171–178.

Mentler, T., Reuter, C. and Geisler, S. (2016) Introduction to this Special Issue on "Human-Machine Interaction and Cooperation in Safety-Critical Systems", *i-com*, 15, 3, 219–226.

Ooms, D. and Van Den Heuvel, W.-J. (2014) If every nail looks different, you need different hammers: Modeling civil-military interaction. *ISCRAM 2014 Conference proceedings. Book of papers : 11th International Conference on Information Systems for Crisis Response and Management*, Pennsylvania.

Palanque, P., Basnyat, S., Bernhaupt, R., Boring, R., Johnson, C. and Johnson, P. (2007). Beyond usability for safety critical systems. How to be SURE (Safe, Usable, Reliable, and Evolvable)?, *CHI '07 extended abstracts*, San Jose, CA.

Parush, A., Springer, A., Livkind, R., Laendler, S., Solomon, T. and Nicola, A. (2016) Simulator and Game-based Multi-level Training of Cognitive Skills and EMS Teamwork in Multi-casualty Incident Management, *ISCRAM 2016 Conference Proceedings – 13th International Conference on Information Systems for Crisis Response and Management*, Rio de Janeiro.

Ristvej, J., Lovecek, T. and Kampová, K. (2010) eSEC – Competency based e-portal of security and safety engineering, *Proceedings of ISCRAM 2010 – 7th International Conference on Information Systems for Crisis Response and Management: Defining Crisis Management 3.0*, Seattle, WA.

Rosson, M. B. and Carroll J. M. (2002) Usability engineering. Scenario-Based development of human-computer interaction. Academic Press, San Francisco.

Shamoug, A. and Juric, R. (2011) Addressing interoperability through the semantic of Information Highway in managing responses in Humanitarian Crises. Proceedings of the 8th International ISCRAM Conference, Harbin, Heilongjiang, China.

Sharpanskykh, A. (2012) An agent-based approach for safety analysis of safety-critical organizations, *ISCRAM 2012 Conference Proceedings – 9th International Conference on Information Systems for Crisis Response and Management*, Vancouver, BC.

Shneiderman, B. (2011) Tragic Errors. Usability and Electronic Health Records, *interactions*, 18, 6, 60–63.

van Dam, A. (1997) Post-WIMP User Interfaces. *Communications of the ACM*, 40, 2, 63–67.