Simulation and Analysis of Mass Casualty Mission Tactics: Context of Use, Interaction Concept, Agent-Based Model and Evaluation

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ABSTRACT

Mass casualty incidents (MCIs) cannot be managed with existing resources from operational area. The key to MCI management therefore is the efficient use of the few own resources as well as resources from neighboring administrative units by local medical mission commanders. This paper suggests a computer-based modeling and simulation system with a user- and context-adequate interface for testing local MCI mission tactics with realistic spatial and temporal availabilities of rescue units and hospitals in the vicinity of an accident site. From an organizational point of view, the tool could contribute to a holistic quality management approach for improving MCI management by facilitating site-specific resource deployment, mission structure, and patient evacuation planning. This paper describes the interaction concept of a resource planning application and envisions its usage in training courses, in breaks of leading personnel and for elaborating local preparedness plans.

Keywords: Interaction Concept, Mass Casualty Incident, Modelling, Simulation, Think Aloud

1. INTRODUCTION

Full-time and volunteer staff is operating in relief organizations such as German Red Cross in order to ensure Germany’s medical civil protection on duty for federal, state and local authorities. In addition to regular emergency medical services (EMS) facing small daily-happening incidents, they provide medical civil protection facing larger crisis scenarios. A mass casualty
incident (MCI) is defined as: “an emergency with a larger number of injured, diseased or affected people that cannot be managed with existing resources from the operational area” (BBK, 2013). In disaster medicine, special mission tactics apply, such as a triage workflow assigning triage categories (T1–T3) to each patient. Since such missions occur quite seldom, both regular emergency medical service staff and voluntary personnel lack of routine in accomplishing such situations. This can result in sub-optimal handling of MCIs. Practitioners and experts therefore desire improved resource planning across county boundaries as well as improved training for decision makers (DRK, 2012).

For strengthening MCI mission accomplishment, mission workflows could be enhanced by new interactive systems as e.g. tablets for assessing triage categories. However, with new technology also new uncertainties for responders appear (Ellebrecht & Kaufmann, 2015). Instead of the response phase, the preparedness phase of MCIs could be enhanced by the use of interactive modeling and simulation systems and applications that allow testing of mission tactics while taking into account local constraints on medical rescue resources and hospitals. The main requirements for such tools are: (1) less effort compared to e.g. organization of field trainings; (2) trustworthy analytical predictions which can be validated against base data; and (3) intuitive user guidance to assure user acceptance (Sautter et al., 2015).

Such simulation tools should be used regularly by leading personnel in civil protection to discuss and elaborate different tactical options under local boundary conditions such as available resources and hospital capacities (Sautter et al., 2014a). Users have to be able to both express their simulation needs and process the resulting data in a way that is as compatible with their current workflows, procedures and organization as possible.

Nowadays, most simulation tools are operated by simulation experts, e.g. in the domain of logistics. A simulation based analysis has been done for the capacity of the planned new underground railway station “Stuttgart 21” (SMA und Partner AG, 2011), which raised an enormous public dialogue (stuttgarter-zeitung.de, 2015). Hence trust in model and modeler is crucial and users need to be aware of uncertainties they deal with. Unfortunately, the civil protection is a particularly critical usage context for interactive information systems (Nestler, 2014). Therefore designing systems that accept parameter inputs and show the results in an adequate manner for non-expert users in the field of modelling is challenging for designers of interaction concepts (Sautter et al., 2012).

This paper presents the findings of a Human-Computer Interaction (HCI) study that was performed in the scope of the CRISMA research project. The technical goal of the study was to design and prototypically develop a resource management planning support tool for medical civil protection professionals in Germany. This is a special case of a more generic quest for „analytical simulation software that can be safely used by users with low affinity for information systems and next to no understanding for capabilities and limitations of the simulation models“. From a medical civil protection point of view, the main research question was: “how to mitigate uncertainty in MCI missions by local-specific preparedness regarding mission tactics and resource planning?”

The work has been structured as follows: first, we built an understanding for the German medical civil protection organizations and their decision-support needs. This was mainly achieved through a combination of literature review, interviews with key personnel of the German Red Cross, and participation in field trainings. The main results of this work, which are in particular local-specific scenarios, relevant indicators, and a description of the context of use, are summarized in the sections 3, 4 and 5 respectively.

In parallel to this work, we have gradually designed and evaluated the human-machine interaction concept (section 6), the underlying resource models (section 7) and the prototype
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