Driving Innovation in Crisis Management for European Resilience

D934.13 – EXPERIMENT 44 DESIGN AND REPORT

SP93 - SOLUTIONS

DECEMBER 2017 (M44)

This project has received funding from the European Union's 7th Framework Programme for Research, Technological Development and Demonstration under Grant Agreement (GA) N° #607798

Project information

Project Acronym:	DRIVER+
Project Full Title:	Driving Innovation in Crisis Management for European Resilience
Grant Agreement:	607798
Project Duration:	59 months (Sept. 2013 - April 2020)
Project Technical Coordinator:	TNO
Contact:	coordination@projectdriver.eu

Deliverable information

Deliverable Status:	Final
Deliverable Title:	D934.13 – Experiment 44 Design and Report
Deliverable Nature:	Report (R)
Dissemination Level:	Public (PU)
Due Date:	December 2017 (M44)
Submission Date:	31/01/2018
Sub-Project (SP):	SP93 - Solutions
Work Package (WP):	WP934.1 – Solution Legacy
Deliverable Leader:	DLR
Reviewers:	Michael Löscher, ARTTIC Peter Petiet, TNO
File Name:	DRIVER+_D934.13_Experiment 44 Design & Report.docx

Revision Table

Issue	Date	Comment	Author
V0.1	14/03/2016	First draft (document structure)	Sandra Detzer, DLR
V0.2	31/03/2016	Contribution to Section 2.2.2	Gaby Gurczik, DLR
V0.3	01/04/2016	Contribution to Section 2	Sandra Detzer, DLR
V0.4	01/04/2016	Contribution to Section 2.2.2	Gaby Gurczik, DLR
V0.5	04/04/2016	Contribution to Section 2.2.	Gaby Gurczik, DLR
V0.6	05/04/2016	Contribution to Section 2	Gaby Gurczik, DLR
V0.7	06/04/2016	Contribution to Section 2.3.	Gaby Gurczik, DLR
V0.8	06/04/2016	Merging changes	Sandra Detzer, DLR
V0.9	07/04/2016	Contribution to Section 2.3.1.	Gaby Gurczik, DLR
V.10	08/06/2016	Contribution to Sections 1 & 2 & 3 & 5, merging changes	Gaby Gurczik, DLR Sandra Detzer, DLR Michael Middelhoff, WWU
V0.11	09/06/2016	Contribution to Sections 1 & 2 & 3 & 5, merging changes	Gaby Gurczik, DLR Sandra Detzer, DLR Michael Middelhoff, WWU
V0.12	10/06/2016	Contribution to Sections 1 & 2 & 3 & 5	Gaby Gurczik, DLR Sandra Detzer, DLR Michael Middelhoff, WWU
V0.13	13/06/2016	Proof reading (all sections)	Sandra Detzer, DLR
V0.14	22/06/2016	Proof reading (all sections)	Michael Middelhoff, WWU Gaby Gurczik, DLR Sandra Detzer, DLR
V0.15	30/06/2016	Peer review (all sections)	Adam Widera, WWU
V0.16	06/07/2016	Peer review (all sections)	Konstanze Lechner, DLR
V0.17	11/07/2016	Contributing to all sections according to the reviews	Gaby Gurczik, DLR
V0.18	12/07/2016	Quality check	Sandra Detzer, DLR
V0.19	06/12/2017	Formatting according to new template finalized and sent to reviewer	Gaby Gurczik, DLR
V0.20	12/12/2017	Review	Michael Löscher, ARTTIC

Issue	Date	Comment	Author
V0.21	18/12/2017	Revised version sent to reviewer	Gaby Gurczik, DLR
V0.22	09/01/2018	Revised version sent to reviewer	Gaby Gurczik, DLR
V0.23	12/01/2018	Final review	Michael Löscher, ARTTIC
V0.24	18/01/2018	Final reviewed version	Gaby Gurczik, DLR
V0.25	26/01/2018	Final check and approval for submission	Tim Stelkens-Kobsch, DLR, Quality Manager
V0.26	31/01/2018	Final check and approval for submission	Peter Petiet, TNO, Project Director
V1.0	31/01/2018	Submission to the EC	Francisco Gala, ATOS

The DRIVER+ project

Current and future challenges due to increasingly severe consequences of natural disasters and terrorist threats require the development and uptake of innovative solutions that are addressing the operational needs of practitioners dealing with Crisis Management. DRIVER+ (Driving Innovation in Crisis Management for European Resilience) is a FP7 Crisis Management demonstration project aiming at improving the way capability development and innovation management is tackled. DRIVER+ has three main objectives:

1. Develop a pan-European Test-bed for Crisis Management capability development:
    - Develop a common guidance methodology and tool (supporting Trials and the gathering of lessons learned.
    - Develop an infrastructure to create relevant environments, for enabling the trialling of new solutions and to explore and share Crisis Management capabilities.
    - Run Trials in order to assess the value of solutions addressing specific needs using guidance and infrastructure.
    - Ensure the sustainability of the pan-European Test-bed.
2. Develop a well-balanced comprehensive Portfolio of Crisis Management Solutions:
    - Facilitate the usage of the Portfolio of Solutions.
    - Ensure the sustainability of the Portfolio of Solutions.
3. Facilitate a shared understanding of Crisis Management across Europe:
    - Establish a common background.
    - Cooperate with external partners in joint Trials.
    - Disseminate project results.

In order to achieve these objectives, five sub-projects (SPs) have been established. **SP91 *Project Management*** is devoted to consortium level project management, and it is also in charge of the alignment of DRIVER+ with external initiatives on crisis management for the benefit of DRIVER+ and its stakeholders. In DRIVER+, all activities related to Societal Impact Assessment (from the former SP8 and SP9) are part of SP91 as well. **SP92 *Test-bed*** will deliver a guidance methodology and guidance tool supporting the design, conduct and analysis of Trials and will develop a reference implementation of the Test-bed. It will also create the scenario simulation capability to support execution of the Trials. **SP93 *Solutions*** will deliver the Portfolio of Solutions which is a database driven web site that documents all the available DRIVER+ solutions, as well as solutions from external organisations. Adapting solutions to fit the needs addressed in Trials will be done in SP93. **SP94 *Trials*** will organize four series of Trials as well as the final demo. **SP95 *Impact, Engagement and Sustainability***, is in charge of communication and dissemination, and also addresses issues related to improving sustainability, market aspects of solutions, and standardization.

The DRIVER+ Trials and the Final Demonstration will benefit from the DRIVER+ Test-bed, providing the technological infrastructure, the necessary supporting methodology and adequate support tools to prepare, conduct and evaluate the Trials. All results from the Trials will be stored and made available in the Portfolio of Solutions, being a central platform to present innovative solutions from consortium partners and third parties and to share experiences and best practices with respect to their application. In order to enhance the current European cooperation framework within the Crisis Management domain and to facilitate a shared understanding of Crisis Management across Europe, DRIVER+ will carry out a wide range of activities, whose most important will be to build and structure a dedicated Community of Practice in Crisis Management, thereby connecting and fostering the exchange on lessons learnt and best practices between Crisis Management practitioners as well as technological solution providers.

Executive summary

The purpose of this report is to provide detailed insights into the DRIVER+ Experiment 44 (EXPE44) (including its scope, goals, activities, evaluation approach, results and lessons learned. This EXPE44 was organised and held before DRIVER+ suspension. Identified drawbacks and gaps from EXPE44 are described and will be integrated into forthcoming Trials.

The EXPE44 is related to the impact of the transport system on the efficiency of professional responders. The transportation system is a crucial infrastructure and of outstanding importance for the mobility and supply of persons and goods. Anyhow, the transportation system often collapses first in crisis situations. This in turn affects professional responders, who depend on functioning and reliable transport infrastructures to e. g. reach corresponding action places, to ensure evacuation or to provide the affected population as well as logistics planning with goods and services. EXPE44 captures this issue and deals with logistics and transport management topics that are related to the performance of the relief chain design, planning, and execution as well as the strategic transport and efficient routing. To measure the performance and to identify bottlenecks and improvement potentials, DLR and WWU provided a solution for the experiment which is able to model and simulate several relief chain setups. That solution involves special complementary tools (KeepOperational, U-Fly, ZKI-Tool, HumLog) with each tool having its specific contribution and benefit from interworking on different levels. In order to reduce complexity, a simplified network and relief operation was modelled and performed in the experiment. The combination of one specific crisis scenario (flood in the city of Magdeburg), the network of one relief organization (THW) and the supply of different types of (relief) goods/persons (sandbags, food, volunteer units) was used to test several configurations, like effects of prepositioning or different transportation modes. The whole relief chain from procurement up to the distribution in the last mile was depicted.

The scenario design was based on real data recorded by THW during the operations on the Elbe river flooding event in the city of Magdeburg, capital of the Federal State Sachsen-Anhalt in Germany, from June 2013. Within the experiment, the scenario was performed as a table top exercise at the THW platform in Neuhausen (Germany) where a series of simulated use cases performed by THW practitioners provided insights in improvement potentials by analysis of current logistics and traffic situation as well as by simulating the transport of resources. The preparation started several months before and contained a series of interviews with the THW, the design of a general simulation environment, the development of a case-specific simulation model as well as the integration of the involved tools. In total, 19 persons participated in the three-day experiment. The provided tools were operated by the THW practitioners itself with support of the solution providers. The practitioners were split into three groups: a ‘Control Centre’, a ‘Tool Group’ and a ‘Control Group’ to ensure comparability to the regular THW operation process. The conducted use-cases gave evidence concerning e.g. the efficiency and capacity of storage and transport of resources by covering several realistic situations such as: establishment of a sandbag packing station including the ramp up and maintenance of necessary resources and services (e.g. fleet management, assembly of sand bags, and especially staff management); provision of drink/food supplies for staff and confined population in operational area; transformer station in danger of being flooded has to be secured by sand bag dams. In this context, the ultimate goal of EXPE44 was to validate the performances of both groups and to gather feedback on the solution. For instance, a research question was to test, how the tools are able to support the practitioners work and how this leads to an improved operation process.

The evaluation of the results of the experiment depicted that the provided tool suite was seen as a suitable solution for transport and logistic demands in Crisis Management by THW practitioners. The experiment showed that the usage of the tools can lead to an improved operation process regarding time saving and better situational awareness. But, according to the experiment results, two main criteria must be met, in order to state the solution useful in Crisis Management. First, a solution is only useful in certain situations e.g. rural area, nationwide operations and a wide range of available (routing) alternatives. If and which impact the tools might have in other areas, esp. in comparison to already used tools, cannot be stated based on the experiment results. Second, efficient usage of the solution requires experienced operators.

Table of Content

List of Figures

List of Tables

List of Acronyms

Acronym	Definition
ABM	Agent-based modelling
CIS	Common Information Space
CM	Crisis Management
CoW	Collaborative WorkSpace
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V.
EAL	Einsatzabschnittsleitung (command and control centre)
EC	European Commission
EmerT	Emergency mobility of rescue forces and regular Traffic
ETC	European Transport Conference
EU	European Union
EXPE40	Experiment 40
EXPE44	Experiment 44
FL	Institute of Flight Guidance
KatSL	Katastrophenschutzleitung (emergency response centre)
KPI	Key Performance Indicator
PoS	Portfolio of Solutions
SCM	Supply Chain Management
SUMO	Simulation of Urban Mobility
TEL	Technische Einsatzleitung (technical command and control centre)
THW	Technisches Hilfswerk (Federal Agency for Technical Relief)
TS	Institute of Transportation Systems
UTM	Universal Transverse Mercator
WWU	University of Münster
ZKI	Center for Satellite based Crisis Information

1. Introduction

This document is a report of the conducted experiment 44 "Transport & Logistics Support" (EXPE44) and provides insights into the results. The EXPE44 was conducted on THW's platform in Neuhausen (Germany) with 19 participants (including 11 practitioners from THW) from 07-09/03/2016. Participants of the experiment were DLR (experiment leader and solutions provider), THW (platform provider and host) and WWU (solution provider). The experiment is part of the second round of experiments planned in DRIVER.

1.1 Motivation

SP93 aims to support the bridging of various identified gaps in Crisis Management. The overall objective of the experiment "Transport and Logistics Support" is to highlight and illustrate the benefits of the logistics and traffic management tools during the planning and response phase for crisis managers.

The experiment 44 deals with different supply chain, logistics and transport management topics that are related to the performance of the network design and planning, the strategic transport and efficient routing. These topics will be addressed during different phases of Crisis Management whereby the assistance of professional logistics crisis managers is required. Therefore, different tools that are able to model and simulate several relief chain setups are provided in order to measure the performance and to identify bottlenecks and improvement potentials. The whole relief chain from procurement up to the distribution in the last mile will be illustrated.

The experiment focused on the following gaps:

- Demand and needs assessment.
- Capability and capacity mapping.
- Tools for tasking and resource management.

The scenario design was based on real data recorded by THW during the operations on the Elbe river flooding event in the city of Magdeburg, capital of the Federal State Sachsen-Anhalt in Germany, from June 2013. After continuous rainfall over several days the major rivers and its tributaries of Southern and Eastern Germany have reached their banks and are in danger of flooding adjacent areas. The city expects the prospect of a major flooding of large parts of the city area and has started emergency preparations for the event. The civil protection agency identifies the endangered areas and affected population as well as the critical infrastructure of the city.

The scenario was a purely table top exercise therefore it was based on a simulated realistic crisis scenario. The data used are either archive/recorded data (e.g. satellite imagery, aerial imagery) or simulated data. A series of simulated use cases/tasks, conducted by THW practitioners, provided insights in identifying bottlenecks, cascading effects and improvement potentials by analysis of current logistics and traffic situation as well as by simulating the transport of resources. The conducted simulations will also give evidence concerning e.g. the efficiency and capacity of storage and transport of resources.

The experiment activities have been subdivided into five inter-related segments. Each segment included sequential THW related micro-tasks, which occur during a flood on a regular basis. The THW practitioners had to coincidently solve the tasks in two different groups: one group used the solutions from the DRIVER repository while the other group figured as a control group tackling the tasks in classical manner. After each segment, the execution of the tasks had been compared to each other. The tasks covered - but were not limited to - the following situations:

- Establishment of a sandbag packing station including the ramp up and maintenance of necessary resources and services: fleet management, assembly of sand bags, and especially staff management.
- Provision of drink/food supplies for staff and confined population in operational area.
- Evacuation of endangered persons.
- Protection of a transformer station which is in danger of being flooded and has to be secured by sand bag dams.

Within this framework, parts of the population additionally try to leave the affected area on their own caused by warnings of the Civil Protection Agency. Therefore, additional pressure is put on the road network.

The underlying hypotheses behind the experiment are:

- The demonstrated set of solutions will lead to increased effectiveness of the relief operation during a crisis situation.
- The demonstrated set of solutions will facilitate the completion of tasks for crisis managers.

DLR and WWU provided technical IT tools (displayed in Figure 1.1: KeepOperational, U-Fly/3k, ZKI-Tool, HumLog) for the experiment whereby each solution brought its contribution and the benefit from working on different levels was tested and evaluated. The connection between the solutions was realized by using the one's information output as input for the other tool and vice versa.

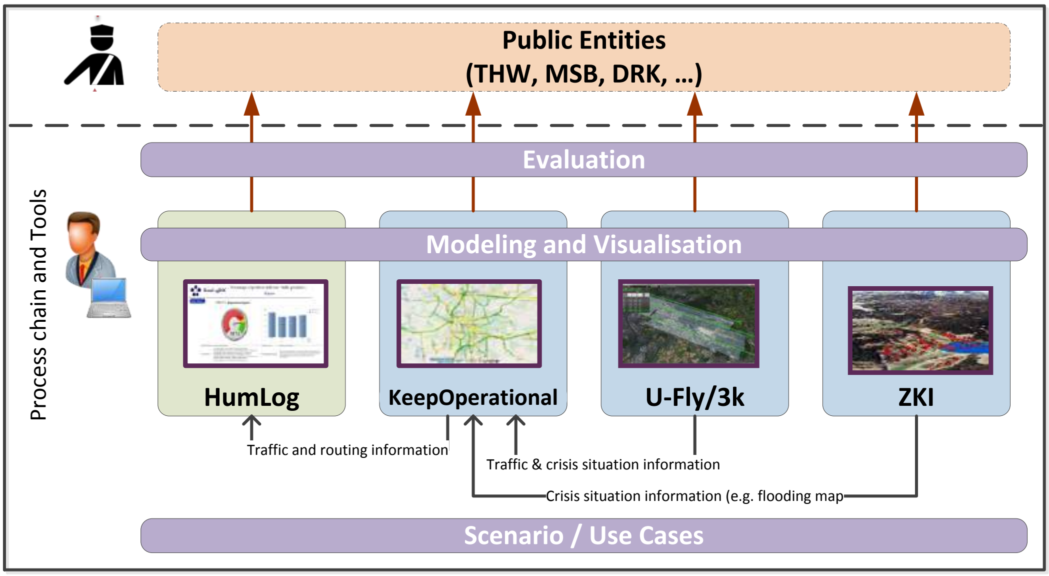


Figure 1.1: Experiment tool set-up

Together with the end-users, a set of evaluation criteria was identified. These so called Key Performance Indicators (KPIs) were for instance "effectiveness", "complexity", "handling", "feasibility" and "benefits".

In order to address those KPIs, the experiment aimed to provide answers to questions, such as: "Does the provided solution lead to increased effectiveness (e.g. time savings) in completion of tasks?", "Are tool functionalities too complex to use?", "How was the training of solution?", "How was the solution provider support during the execution?", "Would you use the solutions in real operation?". The questions were asked during the feedback rounds and in the subsequent questionnaire (see section 4).

1.2 Scope

For preparation of experiment 44 several Face-to-Face Workshops and telephone conferences with the EXPE44 participants were held (see section 3.2.1). Besides, regular jour fixes and meetings within the participating organization took place.

Although DRIVER+ is a demonstration project, additional design, integration, and adjustment work of the solutions were necessary to fit to the experiment scenario, experiment design and with each other. Although the DLR components have been already connected in EXPE40, the focus in EXPE44 was another and adaptions were necessary (e.g. including organization-specific vehicle fleet, and integrating GeoPDFs from ZKI, programming of custom road adaptation module etc.). For the WWU tool suite it was necessary to generate organization- and scenario-specific models (process models and a simulation model), which was based on the HumLogEM (application of a reference model) and HumLogSIM (application of a simulation environment). Both artefacts follow an Action Design Science approach and thus include the involvement of both a rigor (research community) and a relevance (practitioner community) cycle. Besides, a connection between WWU and DLR systems was never established before. Furthermore, the solutions had to be adapted to the scenario (e.g. cartographical material from the scenario disaster area, integrating points of interest related to the scenario such as the sand bag stations, scenario specific capacities etc.

After the three-day experiment execution, the work on the detailed experiment report started, which includes resources for experiment analysis (including a simulation study according to the guidelines 3633 by The Association of German Engineers), evaluation of the experiment and for writing the report.

Furthermore, the preparation of the debriefing workshop started in April and the workshop took place in June. Moreover, a debriefing questionnaire was designed and sent to the THW practitioners in preparation of the workshop.

All in all, the preparation and realisation of the Experiment 44 followed the six-step approach of DRIVER+ experimentation illustrated in Experiment Design Manual (see Figure 1.2).

Figure 1.2: Experimental methodology

1.3 Document structure and related documents

The document is structured as follows:

- Section 2 "State of the Art" describes briefly the background of transport and logistics management in CM.
- Section 3 "Experiment and scenario design" describes the overall goals and expected outcomes, the experiment design including the participating organisations, their solutions / tools, the experiment platform as well as the preparation timetable. Moreover, the scenario design is described. Therefore, the story of the experiment is illustrated together with the assumptions made by describing the disaster area and initial situation. Also, the evaluation approach with respective metrics is elaborated.
- Section 4 "Results and Insights" describes the results of the experiment for each tool.
- Section 5 "Lessons Learned" lists the elaborated lessons learned recovered during the preparation and execution of the experiment. Moreover, gaps which were identified from the practitioner's perspective are included as well. In addition, problems in designing the experiment and the scenario are indicated. Also different perspectives (logistics, technical requirements, provision of operational personal) were taken into account.
- Section 6 "Conclusion" completes the report by summarizing the major outcomes and describes the added value for DRIVER+ and the further use of the results within the project, including contribution and solution for design of forthcoming experiments elaborated by the outcomes and lessons learned.

2. State of the art

Crisis situations like Europe-wide power failure, floods or earthquakes can have devastating impacts and can affect large areas. They require numerous safeguards to protect people, buildings and infrastructures. Also, chemical accidents, fires or incidents at major events place enormous challenges on the involved organisations.

Existing projects offer a variety of solutions most of which deal with the provision of relevant information for private users or for organisations and operators in charge of highly specialised use cases. Moreover, current solutions differ very much on their operating range within Crisis Management cycle (Figure 2.1).

Figure 2.1: Crisis Management cycle (according to (1))

Mostly, the Preparedness and Response phases are of particular interest for R&D. For example, the project ELITE ((2)) aimed to establish a web-based 'living document' for knowledge gathering, categorisation, analysis and evaluation. The intention was post-crisis lessons learning and use of this learning in practice to define the need of a Community of Practice (CoP) for crisis response. In contrast, the CRISMA project ((3)) developed a simulation-based decision support system, for modelling Crisis Management, improved action and preparedness. The CRISMA System facilitates simulation and modelling of realistic crisis scenarios, possible response actions, and the impacts of crisis depending on both the external factors driving the crisis development and the various actions of the Crisis Management team. Another project in the context of Preparedness is FORTRESS ((4)). Given the increasing interdependencies between different infrastructural sectors and between different countries, FORTRESS aims to improve Crisis Management practices by identifying the diversity of cascading effects due to the multiple interrelations of systems and systems of systems, and by designing an incident evolution tool that will assist in forecasting potential cascading effects. Within the *Response* Crisis Management phase*,* projects such as KOKOS ((5)) invent methods, technical concepts and IT tools to involve the active participation of the general public for self-help activities and communities integrated in processes of authorities. To enable the interoperability between first responders and police authorities during crisis situations or disasters, the projects SECTOR and EPISECC ((6); (7)) aim at establishing a secure European common information space (CIS). The CIS should give continuous and shared access to all necessary data and information, besides the use of collaboration process models to support coordination and cooperation between the organisations.

Considering the research done in the projects mentioned above as well as from further literature reviews and from discussions with practitioners, we found out that the following aspects are crucial for logistics and traffic management especially with regard to the CM cycle phase 'crisis response':

- Tools for tasking and resource management.
- Demand and needs assessment.
- Capability and capacity mapping.
- Analysing current logistics and traffic situations.

- Providing real time information.
- Infrastructure assessment.
- Forecasting potential bottlenecks.
- Tools for effective route planning.

Therefore, the DRIVER+ experiment EXPE44 aims to highlight and illustrate the benefits of a logistics and traffic management tool-suite that provides relevant information for crisis managers to cope with challenges within the logistics chain during the planning (preparedness) and response phase. In order to achieve this objective, three different topic areas operate together within the experiment EXPE44: Logistics, Traffic Managements as well as Satellite and Airborne Imaging. In the following, the state-of-the-art for the respective subjects is described in connection with crisis situations.

2.1 Logistics in Crisis Management

Although all humanitarian operations depend on their logistics activities, it is hard to find a generally agreed upon definition of logistics in the context of disaster relief. An appropriate definition can be identified reflecting the findings in the area of so-called humanitarian logistics (HumLog). (8) defines HumLog as the "process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods, materials and equipment as well as related information, from point of origin to point of consumption for the purpose of meeting the beneficiary's requirements" ((8), p. 61). This definition combines different aspects of previous research (e.g. (9), (10), (11)). Regarding the flows within the supply chain, it has to be noticed that the common known supply chain flows, material and information flow, have to be extended for the HumLog context. The flow of personnel has to be added to the material flow as well as knowledge and skills to the information flow ((12), p. 246). Secondly, the typical supply chain actors of humanitarian and commercial supply chains differ significantly. For example, commercial supply chains have to deal with customers, who demand goods and are willing to pay for their product. Whereas in humanitarian supply chains the financial support is mainly covered by donations which basically mean that the donor pays for goods or services which are delivered to the beneficiaries ((13), p. 2). Finally, the product life cycle in commercial supply chains does not match the disaster management cycle of humanitarian organizations ((12), pp. 246-247). A table including the key differences was developed by Widera and Hellingrath who considered main contributions from former research ((9), (13), (14), (15)) and is depicted in Table 2.1.

Table 2.1: Main differences between humanitarian and commercial logistics

Category	Commercial Supply Chain	Humanitarian Supply Chain
Range	From supplier to customer	From donors and suppliers to beneficiaries
Actors	Known, with aligned incentives	Multiple in nature, with misaligned incentives
Customer	End-user = Buyer	End-user (Beneficiary) ≠ Buyer (donor)
Supplier	Supplier, known in advance generally	Supplier and/or donor uncertain and multiple
Environment	More and more volatile	Highly complex, volatile and unstable
Shelf life	Some years, but tends to shorten	Some weeks to some months in total, depends on type of crises
Supply Chain Driver	Purchasing power-based demand: relatively stable and predictable	Beneficiaries' needs: relatively uncertain and unpredictable in terms of timing, location, type, and size

Category	Commercial Supply Chain	Humanitarian Supply Chain
Lead Time	Determined by the supplier manufacturer-DC-retailer chain	Approximately zero lead time requirements
Distribution Network Configuration	Well-defined methods for determining number and locations of distribution centres	Challenging due to the nature of the unknowns (locations, type and size of events, politics, and culture), and "last mile" considerations
Information System	Well-defined, advanced technology	Information often unreliable, complex, incomplete or non-existent

To summarize the key findings: Humanitarian supply chains are driven by their goal of saving lives and reducing human suffering. The role of donors as buyers and beneficiaries as end-user is of high importance for the supply chains ((9)). Furthermore, the characteristics of disasters and other influence factors create highly volatile and complex environments for the humanitarian supply chains which might result into partly temporary and unknown supply chain designs ((13), p. 2; (16), p. 1009). This is empowered by the relatively unstable, uncertain and unpredictable needs of the beneficiaries ((14), p. 135). The focus of these supply chains lies on the areas procurement and distribution ((8), p. 63). Overall, it can be concluded that this disparity between humanitarian and commercial supply chains induces a restricted transferability of existing Supply Chain Management (SCM) concepts to HumLog ((12), p. 246). This applies also to existing simulation concepts. Due to the uniqueness of HumLog supply chains, a restricted transferability of current concepts exists resulting into a need for a bilateral analysis of simulation and HumLog.

The relevance of humanitarian logistics for the research community has risen significantly over the previous decade. Particularly, during the span from 2008 to 2011, the number of journal publications per year increased from around 10 to 40 ((17), p. 129; (18), p. 105). Furthermore, former literature reviews emphasize the pivotal role of simulation for humanitarian logistics (cf. (19); (17); (18)). Modelling and simulation is the most used research methodology in the analysed journal publications by Kunz and Reiner ranging from 1993 to 2011 with 46 % ((17), p. 129). The papers mainly deal with topics related to infrastructure decisions, as, for example routing problems (cf. (20); (21)), scheduling problems (cf. (22)) or facility location problems (cf. (23)). These results have been justified by the findings of our literature review, which we conducted based on the concept of vom Brocke et al. ((24), pp. 7–10) and Webster and Watson ((25), pp. 15-18). The following four research databases: EBSCOhost, Google Scholar, JSTOR and ScienceDirect were used to find relevant scientific sources. We detected in the 28 analysed sources a nearly equal distribution between the topics optimization models, Operational Research/Management Science (OR/MS) modelling and simulation, whereas decision support systems (DSS) have only been addressed in three articles.

Simulation modelling frameworks have been used concretely only in a few cases as the categorization of the sources depicts. (26) illustrated the appropriateness of a system dynamics (SD) methodology as a tool for humanitarian decision makers to understand the effect of their decisions on humanitarian operations. By developing distinct cases, they showed that the SD paradigm has the capacity to represent the dynamic complexity of humanitarian operations. Peng and Chen developed a SD model to describe the processes of delivering emergency supply (cf. (27)). They highlighted that simulation results can have a significant impact on the supply chain risk management of humanitarian organizations. Das introduced an agent-based modelling (ABM) framework for integrating stakeholders' interests (cf. (28)). They conclude that ABM is a good tool for analysing the effects of resource allocation. It allows to investigate the effects of transport measures and to understand the mechanisms of demand management in a dynamic environment ((28), p. 282). A multi-method model has only been discussed in one of the sources. Xanthopoulos and Koulouriotis used discrete-event and agent-based facets to investigate the vehicle routing problem during relief distribution operations in a post-disaster environment (cf. (29)). The usage of this simulation tool showed that significant insights can be obtained concerning the routing selection ((29), p. 181).

It can be concluded that several gaps exist in the research of simulation in the context of humanitarian logistics. Although researchers consider simulation as a vital instrument for their research problems, a bilateral analysis of both areas is missing assessing possible application areas and a deeper analysis of possible advantages. Moreover, the conceptualization and use of multi-method simulation environments has not been examined in detail yet. Most of the approaches and tools concentrate only on the application of one modelling framework, for example SD.

2.2 Transport management in Crisis Management

Transport Management in the context of natural hazards and Crisis Management is one of the most under examined subjects in the research field. Despite that, the transport system is particularly vulnerable during crisis events (for example floods and earthquakes) and therefore mostly collapses first. Since the road system is of outstanding importance for the mobility of the population as well as their providing with goods and services, authorities and organisations with security responsibilities (BOS) – e.g. police, fire and rescue services – depend on a functioning road network to reach their assembly areas.

During large crisis, the German Federal Agency for Technical Relief (THW) for example sends service units to the affected areas from all over Germany. That entails gathering requested units in convoys each of which commonly consists of 15-20 vehicles – most of them trucks – sometimes pulling trailers with heavy equipment. Therefore, functioning (i.e. passable and safe) roads are a necessary precondition for the provision of the units. Currently, the THW only uses open access programs such as Google Maps, in order to guide units to the desired destination. However, a drawback of these programs is that they do not feature real time information such as the dimensions of already inundated zones and demolished infrastructures (e.g. road blockages or closures), or the height and bearing capacity of bridges in the affected area.

Since all of this information may lead to an adjustment in the optimal routing, its consideration is particularly relevant when guiding vehicles through an affected area.

Therefore, the prerequisite for the assessment and guarantee of the functionality of the traffic and transport system is a traffic situation report which is based on current traffic and infrastructure data. To generate real time information during crisis situations, video analytics are currently preferred ((30), (31)). Even though they provide detailed insight in actual situations, typical optical sensor characteristics such as their limited detection range and field of view, their dependence on weather and visibility conditions or on shading and masking effects, as well as the lenses' high vulnerability to pollution have considerable influence on the achievable quality of the results ((32); (33)). Moreover, video sensing systems are locally deployed and therefore, are dependent upon power supply. Accordingly, the default risk in crisis situations is extremely high, often leading to a total collapse of both infrastructure and sensing system. Since video sensing systems are costly, they are mostly installed at critically endangered infrastructures like bridges and tunnels. Road-related real-time information is, however, mainly gathered by likewise locally available traffic sensor systems such as induction loops and radar detection. As these sensing systems cover primarily main routes (e.g. highways, major urban streets), they do not recognize significant volumes of traffic flow in the lower-category network which might occur due to potential road blockages or closures at unpredictable points in the network during disaster situations. In result, unreliable traffic situation reports complicate the work of the involved organisations. To prevent outdated and incomplete traffic situation reports, the classical sensing systems are currently supplemented by additional data sources such as airborne and satellite imaging in case of crisis situations (cf. section 2.2.3).

2.3 Satellite-based imagery in Crisis Management

The application of Earth Observation based on optical and radar satellites in the context of natural hazards and Crisis Management has advanced at an unprecedented rate during recent decades ((34)). Since the year 1999, several international space agencies have signed the International Charter "Space and Major Disasters" to develop a unified system of space data acquisition and delivery for authorities and decision-makers in disaster affected areas ((35)). At an early stage of the Charter mechanism it was agreed that the delivery of plain satellite imagery should be extended to the provision of analysis results, respectively ready to use information products, such as maps ((36)). This was the starting point of the development of satellite-based rapid mapping capacities all over the world, aiming the rapid provision of crisis relevant information through applying digital image analysis, respectively remote sensing techniques and digital cartography (GIS). In this field, the UNOSAT Rapid Mapping service (since 2003) and the Center for Satellite Based Crisis Information (ZKI) of the German Aerospace Center (DLR) (since 2004) can be mentioned ((37); (38)). In the last several years satellite-based mapping activities and services have been developed and applied in the EU-program Global Monitoring for Environment and Security (GMES), such as the projects SAFER, G-MOSAIC and G-NEXT, and are continued on an operational basis in the successor projects of the EU Copernicus program ((39), (38)). Satellite imagery can be applied for several types of natural disasters and offer a great potential for disaster management support, such as planning logistics of relief organizations in the field immediately after, for example, an earthquake or tsunami event ((40); (41); (36)). Major subject of further developments and research in this field include the improvement of the accessibility of civilian and commercial satellite imagery (e.g. though the development of data relay systems) and to further align satellite-based crisis mapping and derived information to end-user’s needs, i.e. overcoming organisational (data quality, data sharing), economical (cost benefit analysis) and technical (software/hardware) challenges ((42); (43)).

2.4 Airborne imagery in Crisis Management

To gather data and information on damaged infrastructure as well as traffic data, (historical) airborne imagery data was provided for the execution of the experiment. Airborne imagery in Crisis Management in general as well as the characteristics of the specific system U-Fly/3k were extensively demonstrated and described in EXPE40. Further information about the use of U-Fly/3k in Crisis Management can be found in D430.22 – Experiment 40 Design & Report from the DRIVER+ project before suspension.

3. Experiment and scenario design

In the following sections, the goals of the experiment and their expected outcomes are given. Moreover, the experiment and scenario design are described. This includes the description of the experiment setup including involved organizations and their respective roles in the experiment and as well an overview of the provided solutions. Furthermore, the scenario with the associated activities of EXPE44 and schedule plan is described.

3.1 Goals and expected outcomes

3.1.1 Goals & hypothesis

The aim of experiment EXPE44 has been the highlighting and illustration of the benefits of a logistics and traffic management solution that provides relevant information for crisis managers to cope with challenges within the logistics chain during the planning and response phase of CM. Specifically, the considered solution involves:

- A logistics framework that will assist decision makers in identifying and reacting coherently to future and emerging threats and crisis situations, including the elaboration of recommendation actions to logistics stakeholders and public entities.
- A transport management tool suite that will assist decision makers in managing efficiently the required rescue logistics and the nearby traffic flow even under extreme conditions, thereby enabling emergency services to rapidly reach the locations where they needed.
- A demonstration of the usability and benefit provided for end-users (emergency services).

A pre-defined set of all in all five goals was established (the goals are operationalized in section 3.1.2):

- Goal#1: Validation and demonstration of solution features.
- Goal#2: Validation of interoperability between the solutions.
- Goal#3: Evaluation of the tools' performance.
- Goal#4: Preparation for upcoming experiments.
- Goal#5: Identification of gaps (lessons learned).

These general goals are later on specified in form of specific objectives (cf. section 3.1.2). Research objectives are statements of what researchers intend to deal with in a study and flow directly from the research object which is commonly formulated by one or more research hypothesis. Hypotheses are statements on the relationship between two or more variables which, however, a researcher makes about the potential outcome(s) of a study. The underlying hypotheses behind the given experiment EXPE44 are:

- Hyp#1: The demonstrated set of solutions will lead to increased effectiveness of the relief operation during a crisis situation.
- Hyp#2: The demonstrated set of IT solutions will facilitate the completion of tasks for crisis managers.

Hypotheses are empirically verifiable. Nevertheless, they intend to describe overall outcomes. Therefore, the objectives aim to break down the variables in the hypothesis to give the study more focus and to split the research problem into specific and measurable subdivisions.

The following investigation aims to evaluate the objectives given in section 3.1.2 by the use of evaluation metrics (cf. section 3.4.2). The verification of the hypotheses is achieved when all the objectives are evaluated and thus, all the goals defined above are reached.

3.1.2 Expected outcomes

The experiment analysis was based on a set of predefined objectives. For each goal one or more basic experiment objectives were defined by the involved tool suite providers WWU and DLR, whereas each objective was additionally subdivided into several expected outcomes which were identified from the professional's expectations (cleared within 3rd EXPE44 Workshop, cf. section 3.2.1). The expected outcomes can be understood as success criteria which are adapted to the specific scenario, the tool suites and the platform used in the experiment.

To evaluate if the outcomes match the expectations of the professionals, evaluation metrics were defined (cf. section 3.4.2).

The outcomes are expected to be direct results from the experiment (see Table 3.1, Table 3.2, Table 3.3, Table 3.4, and Table 3.5).

Table 3.1: Goal 1 and expected outcomes

Goal#1: Validation and demonstration of solution features		
Objective#1.1	**Validation and evaluation of transport management solutions**	
	Outcome#1.1.1	Different routing options are provided
	Outcome#1.1.2	Information about the current traffic situation and traffic infrastructure are provided
	Outcome#1.1.3	Blocked roads can be easily identified
	Outcome#1.1.4	Based on a current situation a traffic forecast can be provided
Objective#1.2	**Validation and evaluation of different logistics solutions**	
	Outcome#1.2.1	Bottlenecks in demand fulfilment are identified
	Outcome#1.2.2	Fulfilment schedule is available
	Outcome#1.2.3	Alternative schedules are available
	Outcome#1.2.4	Dependencies between different demands are considered
	Outcome#1.2.5	Input of demand and resources
Objective#1.3	**Validation and evaluation of new map products for situation awareness**	
	Outcome#1.3.1	The imageries provide a faster situation awareness for the transport and logistics support
	Outcome#1.3.2	All products prepared by ZKI could be executed and used without any technical problems on the provided hardware and software infrastructure.
Objective#1.4	**Integration of aerial/satellite imagery and traffic management components in one common interface.**	
	Outcome#1.4.1	The common interface provides improved and faster situation awareness for logistics and transport support.

Table 3.2: Goal 2 and expected outcomes

Goal#2: Validation of interoperability between the solutions		
Objective#2.1	**Assess whether the interoperability of HumLog and KeepOperational is sufficient**	
	Outcome#2.1.1	The tools working seamlessly together
Objective#2.2	**Assess whether the interoperability of U-Fly/3k and KeepOperational is sufficient**	
	Outcome#2.2.1	The tools worked seamlessly together
Objective#2.3	**Assess whether the interoperability of ZKI-Tool and KeepOperational is sufficient**	
	Outcome#2.3.1	The tools worked seamlessly together

Table 3.3: Goal 3 and expected outcomes

Goal#3: Evaluation of the tools' performance		
Objective#3.1	**Assess whether the provided tool suites are a valuable support in CM**	
	Outcome#3.1.1	The tools support decision making process
	Outcome#3.1.2	The tools ensure a faster situational awareness
	Outcome#3.1.3	The tools allow a faster completion of tasks
	Outcome#3.1.4	The tools are useful for end-users in CM
	Outcome#3.1.5	The tools are suitable for end-users in CM

Table 3.4: Goal 4 and expected outcomes

Goal#4: Preparation for upcoming experiments		
Objective#4.1	**Assess which tool features might provide a contribution to further experiments**	
	Outcome#4.1.1	Potential contributions are identified

Table 3.5: Goal 5 and expected outcomes

Goal#5:Identification of gaps (lessons learned)		
Objective#5.1	**Identify improvement potentials**	
	Outcome#5.1.1	Lessons Learned are recorded and evaluated
	Outcome#5.1.2	Missing / desired / not required functionalities are identified to optimise tools
	Outcome#5.1.3	Bugs in tool suites are recognised

3.2 Experiment design

3.2.1 Framework

In the preparation phase of the experiment, four workshops/meetings were held from June 2015 to February 2016 besides internal jour fixes and regular Telcos to synchronize tasks (see Figure 3.1). Mainly, following topics were discussed in the workshops:

- The contribution of the participants.
- The combined usage of the solutions, incl. interfaces and complementarity.
- The goals and outcomes of the experiment.
- Scientific experimentation hypotheses.
- The scenario of the experiment.
- The concept of procedure including evaluation criteria.

The first workshop (June 2015) served to clear the focus of the experiment and the contributions of the solution providers and platform provider. Solution/platform descriptions were collected from all partners foreseen to contribute to the experiment in order to get an overview of the solution/platform main functionalities, scope (CM phases, target body) and basic technical information (licensing, maturity, software platforms, inputs and outputs). The second workshop (August 2015) had to be carried out as teleconference and had to be divided into several sub telco's with solution providers and the platform provider to present the transport and logistics division of the platform providers, the solutions, and to discuss first requirements from both perspectives. In the third workshop (October 2015) the interaction between the solutions, the methodology as well as the goals and outcomes were discussed and the first draft of the scenario was developed, which was finalized in the fourth workshop (February 2016) including the concept of procedure as well as methodology and evaluation criteria.

From 07–09/03/2016, the actual execution of the experiment was conducted together with all participants at the THW premises. The experiment was designed as a table top exercise based on a simulated realistic crisis scenario representing the Elbe flood from 2013 in Germany. The experiment was carried out by voluntary professional THW staff. For the processing of the scenario, the THW staff was divided into two groups each of which worked simultaneously on the same tasks but one with and one without tool suite support.

In the debriefing workshop, the results of the experiment were presented, a final feedback was given and the contribution to upcoming experiments was discussed. Until the debriefing workshop, no completed debriefing questionnaire was send back. After the debriefing workshop, the experiment consortium received two completed questionnaires. Therefore no additional feedback, besides the large number of comments collected during the experiment, could be considered in the debriefing workshop.

First results of the experiment were published in two conference papers ((44); (45)).

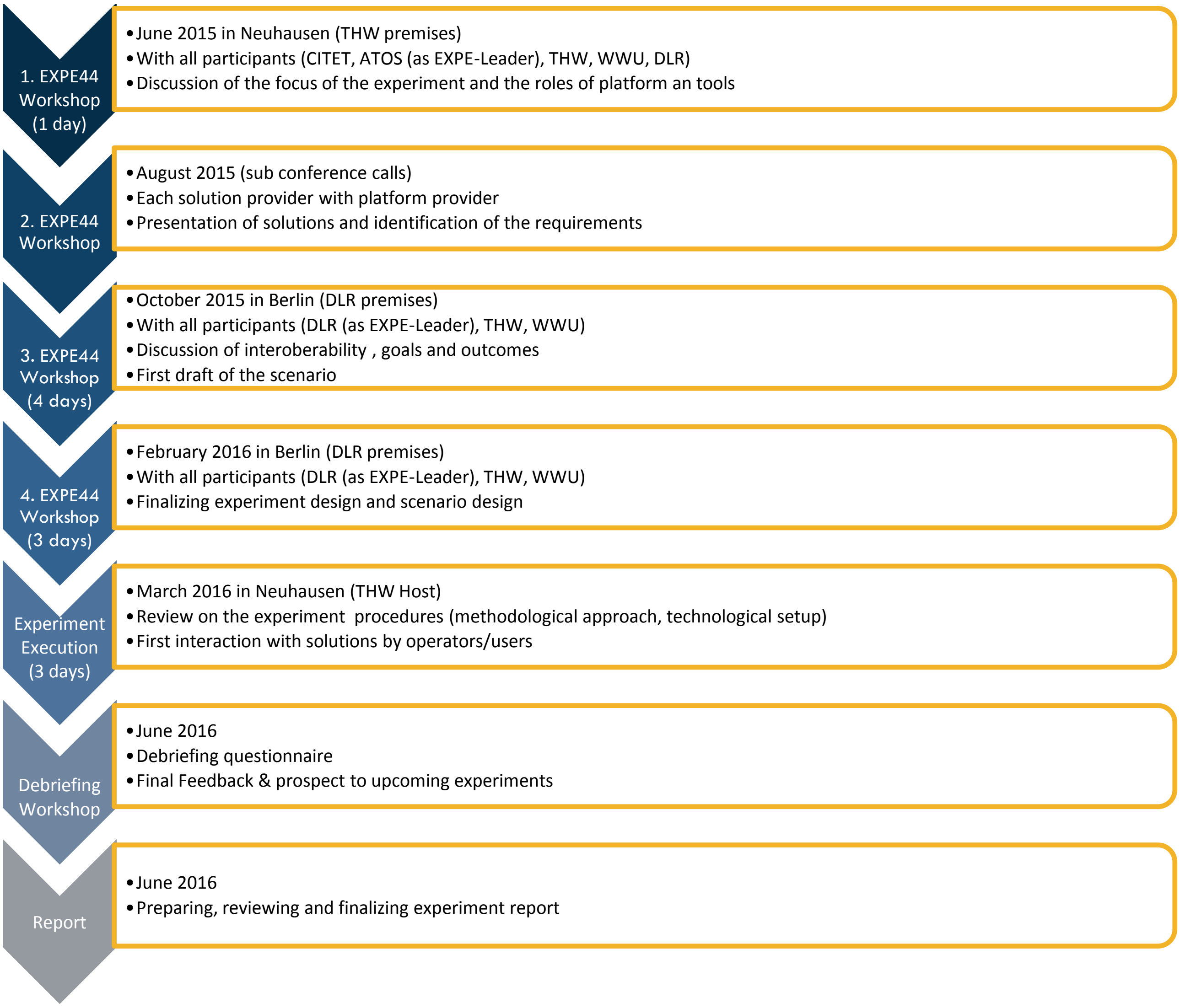


Figure 3.1: Progress EXPE44

3.2.2 Involved organizations

Participants of the experiment were:

- **German Aerospace Center (DLR)** with several Institutes (Transportation Systems, Center for Satellite Based Crisis Information (DFD – ZKI) and Flight Guidance) as experiment leader and solutions provider.
- **University of Münster (WWU)** with its Department of Information Systems as solution provider.
- **Federal Agency for Technical Relief (THW)** as platform provider and host.

In total 19 persons (six DLR personnel, two WWU personnel and 11 THW personnel including the practitioners) participated at all three exercise days.

In Table 3.6 the organization involved and their role in the experiment are listed and described.

Table 3.6: Participants and roles

Role	Organization	Involvement	Performance expectations	Validation objectives
Dissemination	Pole Risque	Coordination and regulations for DRIVER+ dissemination activities	Coordination and contribution to PR activities	
End-user	THW	Expert Input Provide Practitioners	Contribution to evaluation of the provided solutions and professional THW practitioners	Validate operational suitability and usability of the provided solutions for CM
Experiment Leader	DLR	Coordination of experiment execution	Coordinate experiment activities	
Method support	JRC	Methodological expertise in experiment design and validation	Contribution to the experiment design and scenario plan in order to ensure the consistency with the technical requirement and the experimental procedure for DRIVER	Assist in experiment design methodology
Platform Provider	THW	Provide Platform	Contribute platform for experiment execution and contribute expert knowledge for scenario development	Assist in scenario design and platform
Solution Provider	DLR	Provides solutions used in the experiment	Contribution of KeepOperational, ZKI-Products and U-Fly/3k	Assessment of tool performance and tool interoperability
Solution Provider	WWU	Provides solutions used in the experiment	Contribution of HumLog	Assessment of tool performance and tool interoperability

The solutions presented and evaluated in EXPE44 were operated by the THW practitioners who were supported by the system operators of the solution providers. The THW practitioners were introduced to the provided solutions by one-day training. During the experiment, the practitioners used the solutions to complete the tasks and provided feedback on the solutions regarding the usability and suitability as well as possible added value for CM.

In the experiment execution, several personnel of the involved organizations participated and performed different tasks/parts. In Table 3.7, the tasks and experiment staff members are listed.

Table 3.7: Participants and Code of conduct

Tasks/Role	Description	Responsible person
Advisor of the groups	Guide the working groups	THW staff
Exercise instructor	Communicate the tasks to the practitioners	THW staff
Experiment leader	Leader of the experiment	DLR
Minute taker	Take minutes of feedback round, flash feedback and lessons learned round	DLR staff
Moderator (general)	Moderation: • General moderation • Feedback and lessons learned rounds • Segment discussions • Presentation of project, experiment and solutions	DLR/WWU/THW staff
Observer of the groups	Observe the practitioners during the exercise regarding several aspects	DLR/WWU staff
Photo & film	Take pictures and videos	DLR staff
Platform provider	Take care of • Experiment participants • External quests	THW staff
Questionnaire	Implement the questionnaire	DLR Staff
Technical supervisor	Contact person for technical questions/problems which occur during the execution	System operators of the involved solutions
Trainer of tools	Train the practitioners with the provided solutions	System operators of the involved solutions
Practitioners	Perform the experiment tasks Be available for questions	Professional THW practitioners (8 practitioners)

Before the exercise could start a training of the practitioners was necessary in order to familiarize the practitioners with the solutions. During the experiment, the practitioners operated the solutions and were assisted by the solution providers.

3.2.3 Solutions

The following systems as described in Table 3.8 were used, validated and demonstrated within the experiment. In sections 3.2.3.1 to 3.2.3.4 the solutions are described in detail separately.

Table 3.8: Description of solutions

Solutions	Short Description	Experiment Contribution
DLR Tool-Suite		
KeepOperational	A web-portal developed of the German Aerospace Center (DLR). With KeepOperational it is possible to visualize the current traffic situation using different traffic sources. The traffic data can be used as basis to simulate and predict traffic and for supporting the decision process for traffic management actions (e.g. routing) in case of an incident. KeepOperational also involves SUMO – a microscopic and open source road traffic simulation.	Provides transport and traffic information for emergency services (e.g. current traffic situation, routing advice, traffic prediction, scenario modelling, Presentation of the timely reachability in dependency of the current traffic situation, display of aerial images)
U-Fly/3K	A ground control station (GCS) for Remotely Piloted Aircraft (RPV). The capabilities include mission planning and evaluation for single RPAS or swarm formations. U-Fly receives aerial sensor data, processes and evaluates sensor data, and dynamically adapts RPAS missions to newly received information. The 3K camera system is integrated into the RPV D-CODE and sends down georeferenced images and derived image products to the GCS.	Provision of airborne imagery data. Information on damaged infrastructure can be extracted from the gathered data and traffic data can also be extracted.
ZKI-Tool	The Center for Satellite Based Crisis Information (ZKI) presents a service of the German Remotes Sensing Data Center (DFD) at DLR. It provides a 24/7 service for the rapid provision, processing and analysis of satellite imagery during natural and environmental disasters, for humanitarian relief activities and civil security issues worldwide	Provision of flood impact information, e.g. water masks or affected infrastructures derived from aerial and satellite imagery; it will be used as an input for tools on traffic management and logistics support (e.g. KeepOperational) Additionally, provision of 3-D visualization and GeoPDF in order to do own measurements at THW
WWU Tool-Suite		
HumLog	HumlogEM is a modelling tool able to support various modelling languages. It can be used for the application of reference models as well as for model reporting and pattern search. HumLogSIM is an AnyLogic-based simulation environment allowing a multi-method (discrete event, agent based, system dynamics) simulation.	The network structure and the logistics processes of one relief chain, represented by one DRIVER end-user, will be mapped. The results will be organization-specific process models considering all relevant organization levels (lanes), like distribution hubs, and involved supply chain partners (pools), like logistics service providers. The process models will be then used to adjust the existing humanitarian logistics simulation environment in the simulation model in AnyLogic.

In Figure 3.2 the experiment architecture of EXPE44 is displayed. ZKI extracts crisis information from satellite and aerial imagery (e.g. flood layers, flood impacts) and provides on the one hand 2-D and interactive 3-D cartographic solutions (map products and video animations) for the THW practitioners in order to provide situational awareness, support damage and needs assessment and to facilitate decision making processes. On the other hand, the extracted crisis situation information was shared to KeepOperational. The airplane flew in advance of the experiment over the affected area to collect airborne imagery. The imageries and extracted traffic and crisis information can be sent to KeepOperational. KeepOperational uses the provided information of U-Fly/3k and ZKI-Products as well as traffic data information from other sources to provide for example route options for emergency vehicles by considering current traffic infrastructure, information of the traffic situation and infrastructure or a traffic prediction & simulation. The gathered traffic and routing information can be shared with the logistics support tool HumLog which provides a multimethod simulation environment evaluating different scenarios and network settings (e.g. material flow calculation, procurement analysis, scheduling, bottleneck analysis, cascading effects).

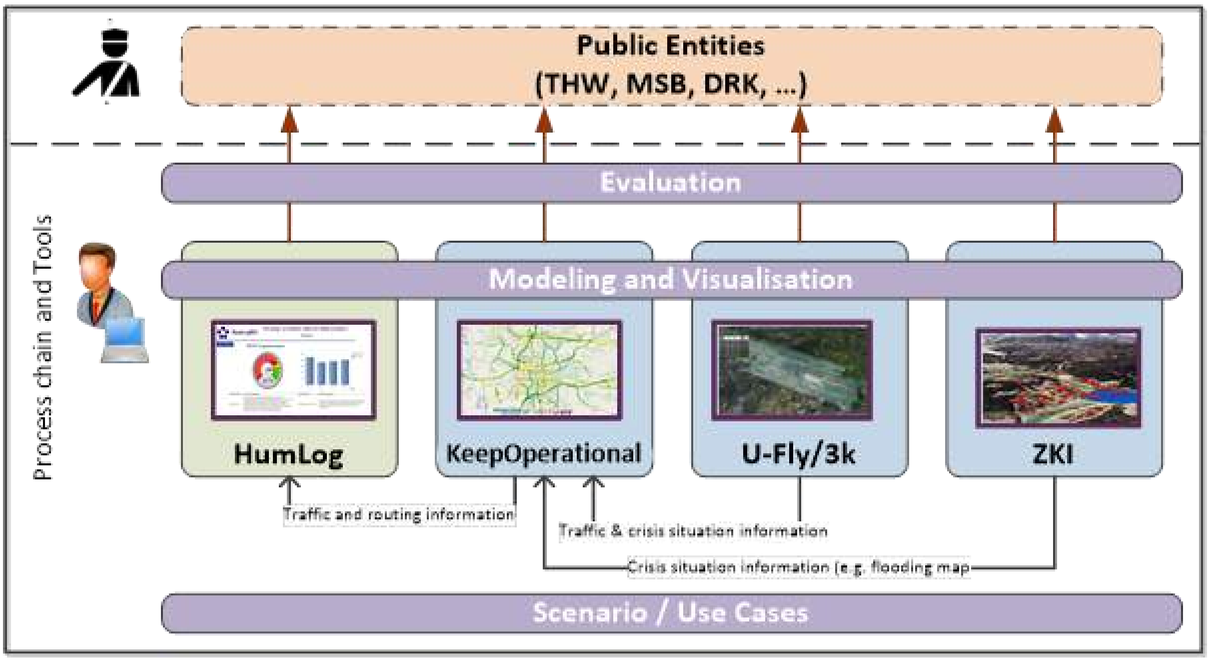


Figure 3.2: EXPE44 Architecture

3.2.3.1 KeepOperational

Considering traffic management actions (e.g. routing) as vital prerequisite for supporting the decision-making process in disaster response activities, the web-portal KeepOperational contributed a visualisation of the current traffic situation using different traffic sources to the experiment EXPE44. Based on the current traffic situation, transport and traffic information for emergency services such as routing advice, alternative routing proposal, traffic forecast, timely reachability in dependency of the current traffic situation or display of aerial images were features provided for the experiment. In order to optimize existing routing functionalities in hazard areas, flood extent information (flood masks) based on satellite data sets were included in KeepOperational from ZKI-Tool (cf. section 4.4). The flood masks were used to highlight roads that are possibly impassable due to flooding. Thus, routing functionalities could be better adapted to the current hazard situation. A direct data exchange between HumLog and KeepOperational was not implemented for rehearsal, but will be considered within the final experiment in June.

From DRIVER experiment EXPE40 which was performed in September 2015, end-user change requests were considered in KeepOperational as well including[1]:

- Display of blocked roads / road closures.
- Consider different types of vehicle and taking vehicle information into account.
- Only one interface for transport related tools.

The KeepOperational web interface is separated in 4 sections as illustrated in Figure 3.3.

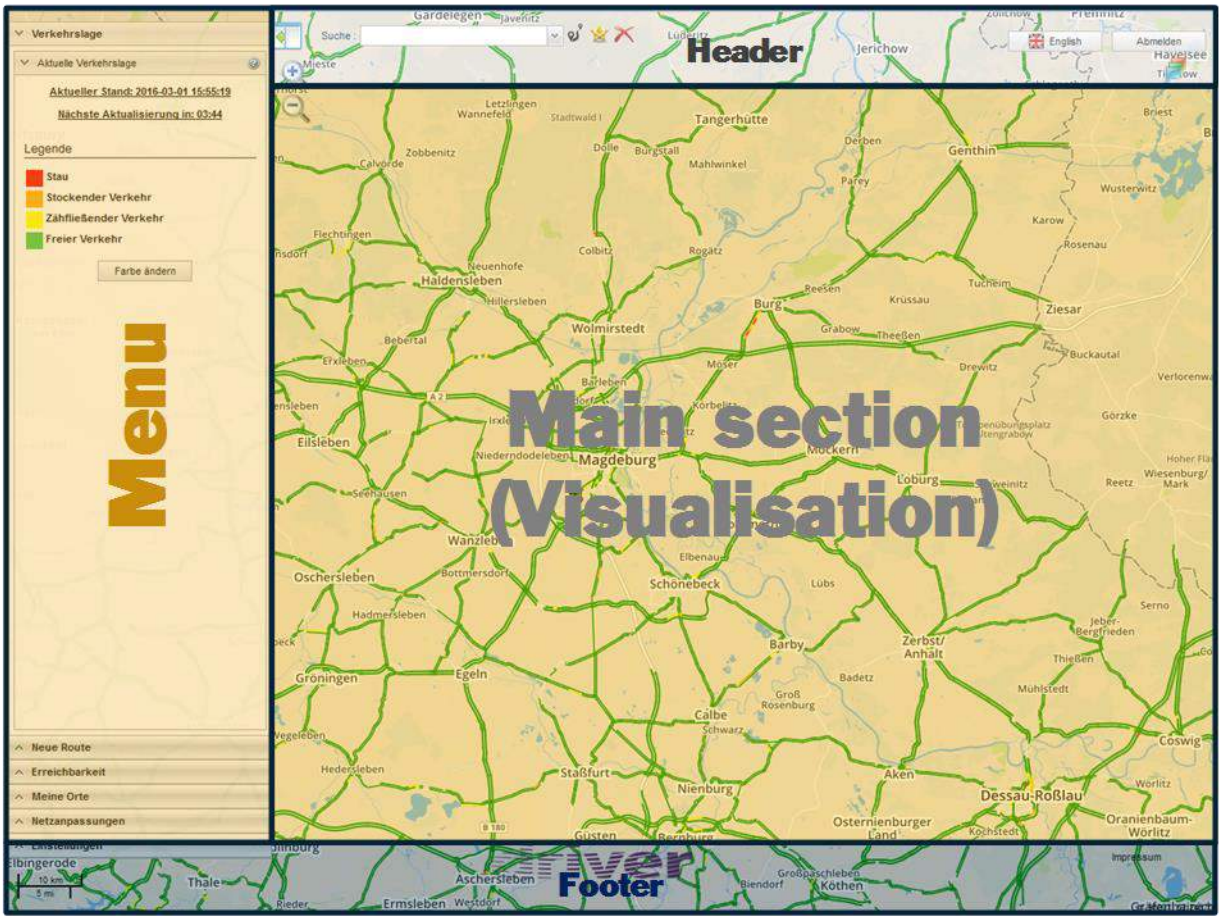


Figure 3.3: KeepOperational web interface

The header includes a search mask (e.g. for address and POI search), language change (German or English) as well as logout button. The footer displays as the header static content (e.g. DRIVER logo), the imprint and the current position of the cursor within the map as coordinates on the bottom right as well as the map scale on the left. The main section allocates the visualisation of dynamical, geo-referenced content. Additionally, it contains the control elements: zoom function ('+' / '-') and layers (differentiated according to base layers and overlays). Whereas base layers are meant to be geographical maps or aerial imagery, overlays imply further geo-referenced content as current traffic situation display, weather report or label display (designations of states, cities, rivers, lakes etc.). Within menu range, different functionalities are listed.

Combining different data sources, KeepOperational enables optimal routing in consideration of the current traffic situation as well as different routing options. Therefore, the user can select the following functionalities within menu range:

[1] Geister, D., et al, D430.22 - Experiment 40 Design & Report, 2016

- Target searching (e.g. points of interest).
- Starting point / destination search.
- Routing as a function of: (typical) day of the week, date, time, transport mode, convoy mode, current traffic / hazard situation.
- Provision of up to 3 routing alternatives for each origin-destination.
- Isochrones as a function of velocity, i.e. timely reachability of specified points in the map depending on the maximum speed.
- Display of road closures / blocked roads due to hazard situation as well as their consideration related to routing.
- Favourites / POI management.
- User profile.

A user manual[2] for KeepOperational was prepared in advance and disseminated to the THW-users during the exercise (see Figure 3.4).

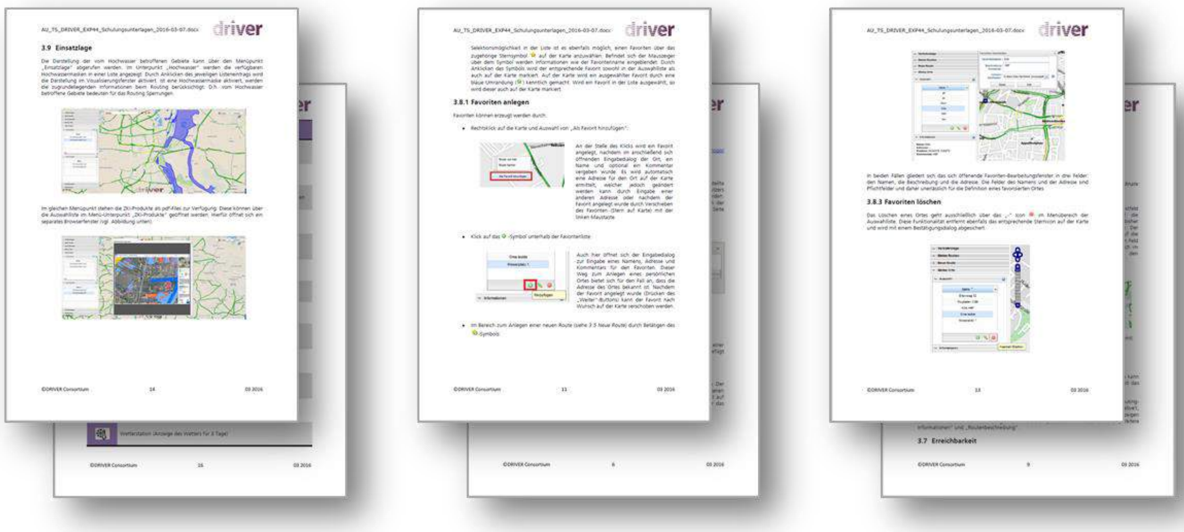


Figure 3.4: Instruction manual for KeepOperational

As already shown in the state-of-the-art (cf. section 2), THW is currently using standard software such as GoogleMaps for their routing queries. In contrast, KeepOperational contains not only classical routing, but also hazard situation related information and support functionalities. Table 3.9 summarizes the main differences between both tools.

Table 3.9: Comparison of GoogleMaps and KeepOperational

No	Content	GoogleMaps	KeepOperational
1)	Target search.	✓	✓
2)	Starting point / destination search.	✓	✓
3)	Routing options:		
	• Typical day of the week.	✓	✓
	• Date and time.	✓	✓

[2] This user manual is available on the internal DRIVER+ Collaborative Workspace (CoW) and is highly likely also available on the future online Portfolio of Solutions (PoS). It is also available on request and please send your request to coordination@projectdriver.eu.

No	Content	GoogleMaps	KeepOperational
	• Vehicle category (car, van, truck, heavy truck, with/without trailer etc.).	✘	✓
	• Convoy mode.	✘	✓
	• Current traffic situation.	✓	✓
	• Current hazard situation (e.g. blocked roads due to flooding etc.).	✘	✓
4)	Alternative routes.	✓	✓
5)	Isochrones.	✘	✓
6)	Road closures (e.g. roadworks).	✓	✓
7)	(Spontaneous) custom road adaptations.	✘	✓
8)	Hazard situation expansion (e.g. flood, fire etc.).	✘	✓
9)	Bookmark management.	✘	✓

3.2.3.2 HumLog

The imminent and high demand of material and labour caused by crisis events, as it has been simulated in the experiment, increases the planning complexity compared to regular commercial supply chains. Within a short period of time a series of demands occur, which have not been known beforehand. It is therefore necessary to allocate available resources fast and efficiently to fulfil demands according to their urgency and prospected progression. The high uncertainty during the crisis situation makes it difficult to predict the near future, which in return affects the decision capabilities of crisis responders. To overcome this, simulations can be used to analyse what-if scenarios under different conditions. Simulations can either be used to test the current network under fictive future events, which enables long-term strategic design decisions on the humanitarian supply chain, or to predict the outcome of operational decisions and thereby allowing to compare courses of action. A simulation solution like HumLogSim is a decision support for crisis managers to lay out a humanitarian supply chain and to test such networks under fictive scenarios, which might as well resemble the real world.

The HumLog solution developed by the WWU comprises three components:

1. HumLog[em].
2. HumLogBSC.
3. HumLogSim.

All of these have been used during the experiment preparation and its execution. HumLog[em] is a component used to model humanitarian supply chain processes, including the actions in logical and sequential order, as well as important information and data for such activities. HumLogBSC is a balanced score card approach for the performance measurement of humanitarian supply chain processes and hence influenced the design of the simulation model in HumLogSim. Accordingly, HumLog[em] and HumLogBSC were applied during the experiment preparation and HumLogSim in its execution. We will therefore focus on the simulation and the experiment results for this report.

The current state of practice in crisis events is dependent on the experience of the crisis managers. They need to request resources and gather information for their situational awareness mainly by direct communications with local entities or superiors in the THW hierarchy. This is a time consuming process and it is difficult to create a complete situational overview of resources and their availability over time.

HumLogSim[3] is designed to support the decision maker by providing simulated outcomes of his decisions. Thereby it makes use of the valuable experience and adds to this by giving the possibility to test options, which is not possible in real life during a crisis event.

HumLogSim contributed to the experiment with a simulation environment of the affected area in Magdeburg. The key features for this scenario were the fulfilment of demands, taken from the tasks given during the experiment, and the allocation of available resources. The required information on resources and the THW network was collected in collaboration with the THW. Based on this information, HumLogSim executed the demand fulfilment under the restrictions of the resource capacities and the THW network. During the experiment, the THW network was considered as a static structure, causing that all demands share this resource in order to be fulfilled. In the situation of two or more simultaneous demands, HumLogSim simulated all at once in order to account for the dependencies between all current demands. The result was a detailed schedule of all transports to and within Magdeburg, which would be needed to complete the tasks. In case of critical bottlenecks in the calculation, the demand was not fulfilled in time. Decisions makers could then reallocate resources to create an alternative schedule and then were able to compare all options. Instead of only making a decision on the next actions, the team supported by HumLogSim furthermore had a detailed plan of what is expected to happen. Besides a decreased uncertainty for the demand fulfilment, this also added to the overall situational awareness of crisis managers.

Figure 3.5 shows a screenshot from the simulation environment with a map of the affected area in Magdeburg. During the simulation, the user can see the transports, routes and types of vehicles. It is possible to change the simulation speed at runtime in order to follow single transports or to fast-forward to the final result. The highlighted area shows a current transport with the calculated rout as red lines. Additionally, the single THW locations in the area are shown as warehouses, as they store or request material. By selecting one of them, in this example the sandbag filling area from the experiment scenario, the current inventories and unfulfilled backorders are shown on the top. For experiment purposes, the user can make small variations to some stock values on the right. The final simulation results, including detailed transport schedules, are automatically exported to excel spreadsheets for further investigations.

[3] A user manual on HumLogSim is available on the internal DRIVER+ Collaborative Workspace (CoW) and is highly likely also available on the future online Portfolio of Solutions (PoS). It is also available on request and please send your request to coordination@projectdriver.eu.

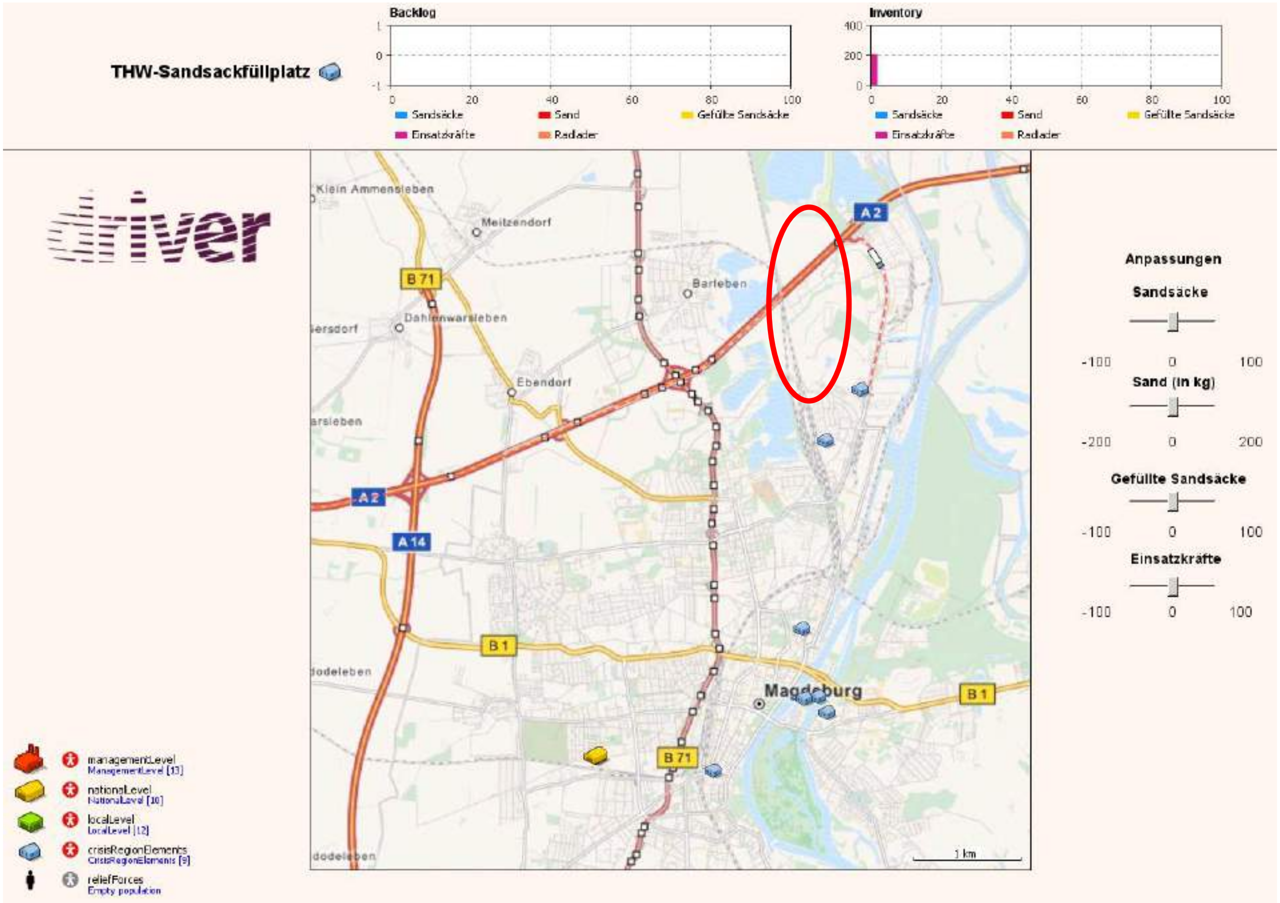


Figure 3.5: HumLog Simulation Environment

Crisis events have a significant impact on the infrastructure in the affected area. Higher traffic volumes due to the active relieve organizations and civilians, as well as damaged and blocked roads effect the transport management. This effects for example the routing of transports, which is considered by KeepOperational and is to be integrated with HumLog. For the EXPE44, HumLogSim simulated the transport schedule based on the regular infrastructure, disregarding potential effects by the crisis event. Crisis managers were able to check the schedule provided by HumLogSim with the available routing options given by KeepOperational. In addition, it is planned to add a direct technical integration that allows HumLogSim to make use of the routing capability of KeepOperational. This will result in a detailed schedule of transports, which adheres to the current traffic and infrastructure situation.

3.2.3.3 ZKI-Tool

Considering situational awareness as an important aspect and premise of the decision-making process in disaster response activities, the main contribution of ZKI included the provision of crisis information, i.e. information on disaster extent and impacts. Thus, major motivation of the ZKI involvement in this experiment was to facilitate logistics-related decisions and activities through the provision of reliable, timely and spatial crisis information derived from satellite and aerial imagery.

Solution functionalities deployed by DLR's Center for Satellite Based Crisis Information – in the following termed as "ZKI-Tool" – included the derivation and provision of geographic vector layers (cf. Table 3.10) and the creation of different map products. Vector layers were acquired from existing databases (Federal Agency for Cartography and Geodesy, BKG), respectively extracted from aerial and satellite imagery using digital image analysis. Flood extent information (flood masks) have been derived through semi-automatic image analysis based on five different satellite data sets which were used within the former ZKI-activation

ZKI-DE 005 – floods in Germany.[4] Main purposes of vector layer derivation was to share them to the other DLR solution KeepOperational, in order to optimize existing routing functionalities in hazard areas, and in particular to create different 2-D and 3-D map products to be directly used by the end-user organization THW.

Table 3.10: Geographic vector layer created by ZKI

No	Data set	Purpose	Data sources
1)	Flood masks	Map production, data sharing	TerraSAR-X, acquired on 06.06./10.06./12.06.2013 RadarSat, acquired on 08.06.2013 Pléiades, acquired on 10.06.2013
2)	Reference water level	Map creation	Federal Agency for Cartography and Geodesy (© GeoBasis-DE / BKG 2014)
3)	Infrastructure (power station, road network, building footprints)	Map creation	
4)	Affected (flooded) roads and buildings	Map creation	Flood mask as derived from Pléiades data & 3)
5)	Building heights	Map creation	Aerial imagery, acquired on 05.11.2015

Three different map products have been created for the experiment: a KMZ product, a GeoPDF and a 3D-PDF as well as 3D viewer product. The products differ in their functionalities and handling and are further characterized in Table 3.11, and illustrated in Figure 3.6, Figure 3.7, Figure 3.8 and Figure 3.9. Common features in all map products are capabilities / solutions for measuring distances, configuring maps view and content and a general low demand for hardware and software resources. User manuals[5] for all three map products were prepared in advance and disseminated to the THW-users during the exercise (Figure 3.10).

A video animation of the hazard area was created in addition to the three map products, in order to demonstrate 3-D visualization techniques. Underlying datasets of the animation were obtained from the flight acquisition conducted on 05/11/2015, i.e. image mosaics and derived digital elevation models. The video was created with a 3-D geo-visualisation software (Eternix Blaze Terra) and disseminated in MP4 and Windows Media Video format.

Table 3.11: Key characteristics of ZKI map products

Characteristic	KMZ-product	GeoPDF	3D-PDF/viewer
Software required (free software)	GoogleEarth	Adobe Acrobat Reader	Adobe Acrobat Reader / scene viewer (free of charge)
Internet access required	Yes	No	No
2-D / 3-D display of scene	2-D & 3-D	2-D	2-D & 3-D
Turn on / off layers	Yes	Yes	Yes
Navigation (rotating,	Intuitive	Intuitive	A bit cumbersome

[4] https://www.zki.dlr.de/article/2373

[5] These user manuals are available on the internal DRIVER+ Collaborative Workspace (CoW) and are highly likely also available on the future online Portfolio of Solutions (PoS). These are also available on request and please send your request to coordination@projectdriver.eu.

Characteristic	KMZ-product	GeoPDF	3D-PDF/viewer
panning, zooming)			
Adding / Editing comments	Limited	mature	mature
2-D and 3-D measurements	Limited (2-D / 3-D) but intuitive	Mature (2D)	Mature (2-D), cumbersome (3-D)
Print functionality	Limited	Mature	Mature

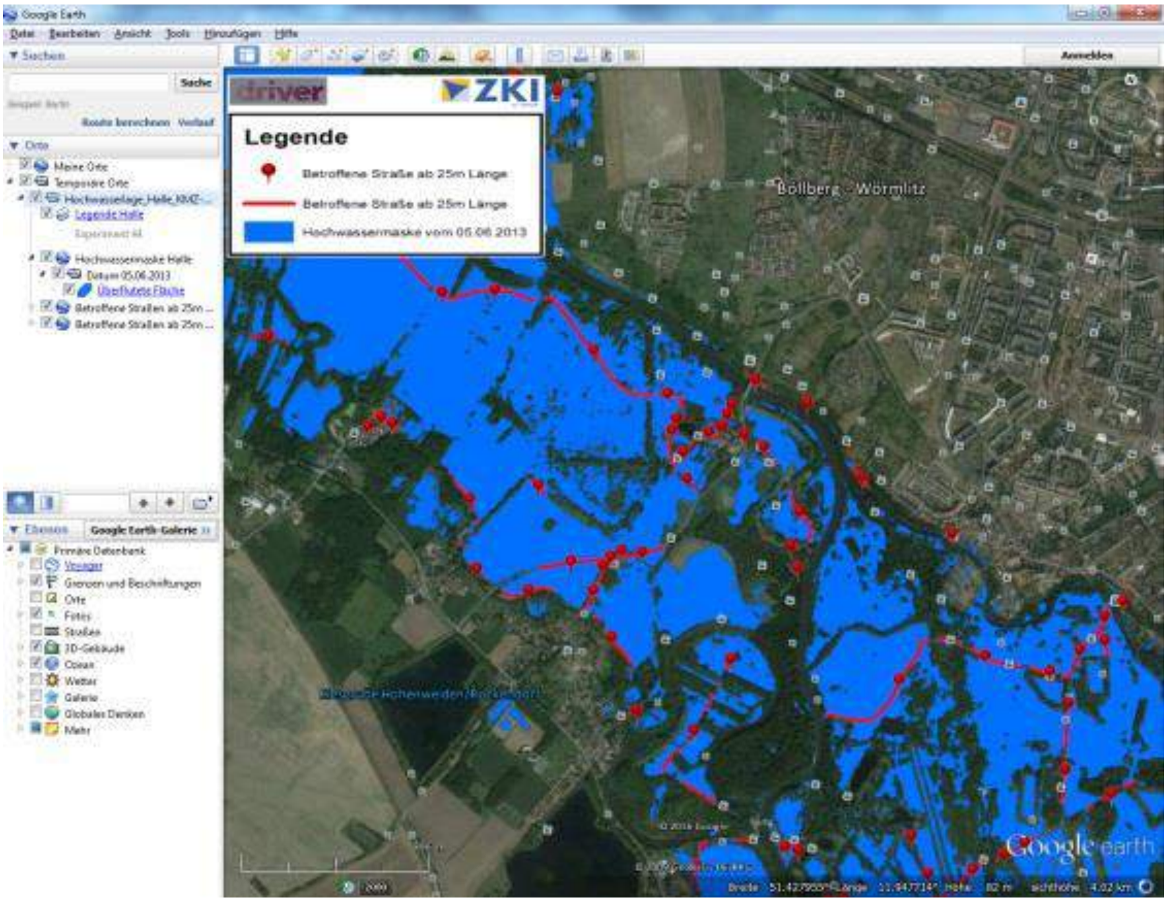


Figure 3.6: KMZ product

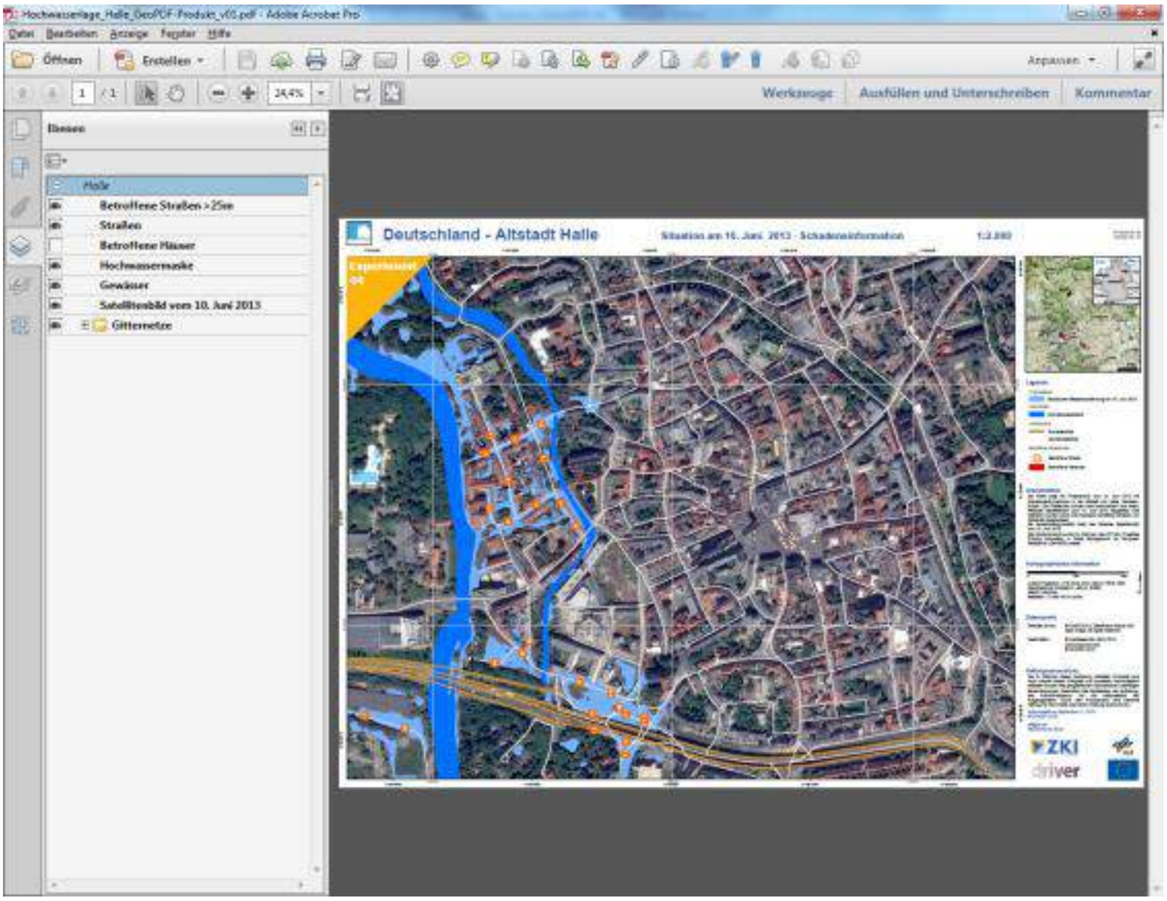


Figure 3.7: GeoPDF product

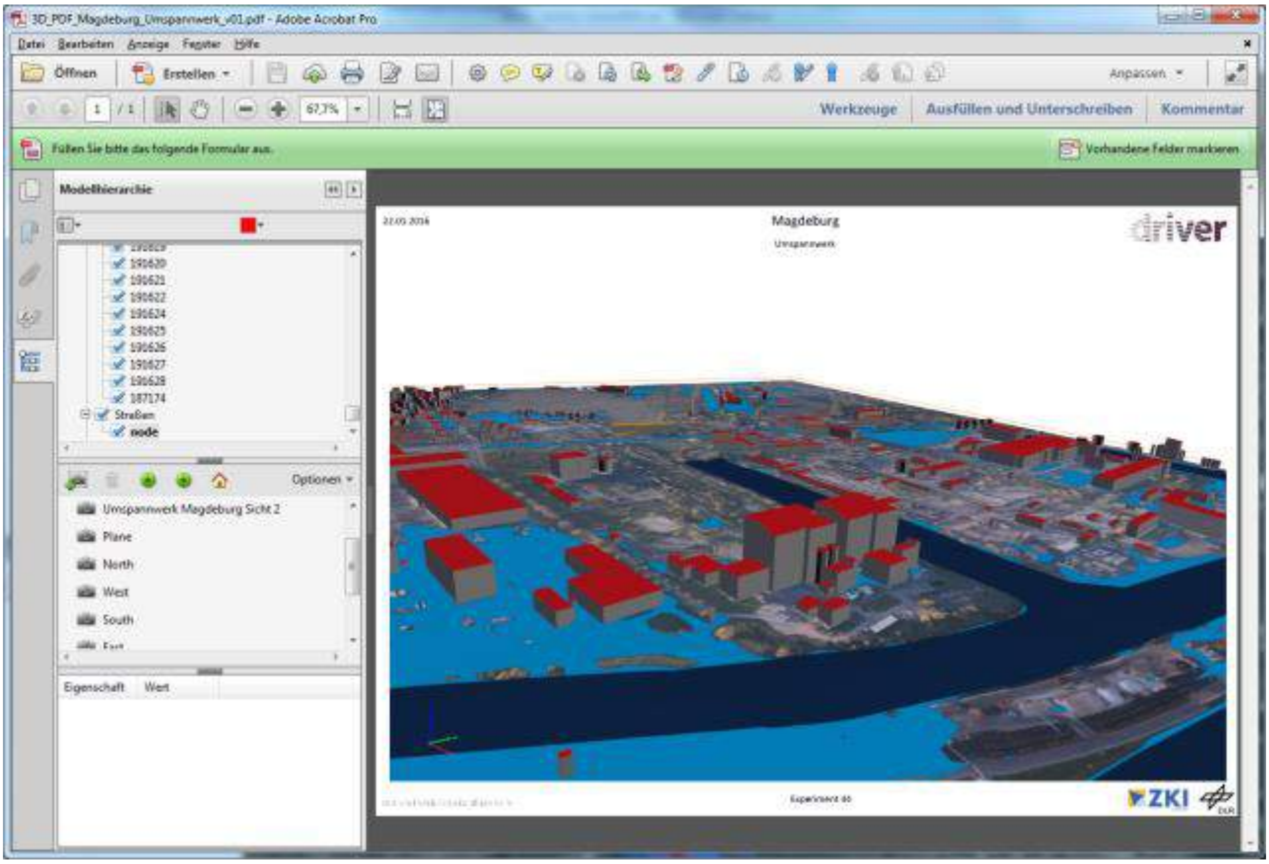


Figure 3.8: 3-D-PDF product

Figure 3.9: Video animation

Figure 3.10: Impression of instruction manuals for GeoPDF (left), 3-D-PDF (middle), KMZ-product (right).

3.2.3.4 U-Fly/3k

In the EXPE44 the system U-Fly/3k was merely simulated because the system was already extensively demonstrated in EXPE40. The simulated data used were gathered in advance by a real flight over Magdeburg in October 2015 (see Figure 3.11).

Figure 3.11: left – four flight stripes of the area of interest,
centre – aerial images of river Elbe, right – aerial images of flight stripe METRO parking area

During the experiment, the system U-Fly/3k was used to demonstrate the benefit and its usage and the interoperability with KeepOperational which uses the aerial images of U-Fly/3k for transport management related information.

3.2.4 Experiment platform

Experiment 44 was the first experiment that took place on THW's platform in Neuhausen. The premises near Stuttgart are those of one of two training academies that THW runs in order to train and educate its full time and volunteer staff. Time slots for experiments therefore have to be booked well in advance in order to fit into the training academies' tight schedule. Commonly every week of the year, the THW premises are fully booked with different trainings and educational programs. Experiments, such the ones in DRIVER, are additional events that can only be accommodated if there are free time slots.

3.2.4.1 Logistics (airport, train station pick up)

Neuhausen is located on the outskirts of Stuttgart, in the South of Germany. It is easily reached by train, plane, car as well as public transportation. It is tradition at the Neuhausen training academy that foreign guests get picked up at the airport or train station – this also applied to all guests for experiment 44.

Both locations (Neuhausen and Hoya) feature between 65 and 83 single bedrooms allowing participants to stay on the premises close to the class rooms. This was also an advantage during the experiment as the participants were able to stay longer in order to make up for slight delays.

All meals can be consumed in the cafeteria also located on the premises, which allowed for a quick transition between the experiment and the breaks.

3.2.4.2 Technical requirements (resulting in upgrade needs detailed in section 6.1)

The technical requirements of the different tool owners were marginal. Since all tools ran online, THW had to provide a stable internet connection, which already exists on the platform in Neuhausen. Since THW computers run on the German Federal Government's network, it had to be insured that all experiment activities take place outside of the official network. This was ensured through the usage of standalone laptops, on which programs such as google earth were downloaded.

What turned out to be very helpful was the use of smart boards that allowed all tool activities to be displayed and recorded. Although there were no guests present during the experiment, projecting the tool screen on the smart board allowed all participants to observe how the "tool group" used the tools in order to solve the problems they were faced with.

3.2.4.3 Providing operational personnel to test the solutions

THW can provide full time staff as well as practitioners to test the solutions in DRIVER. However, the sampling of suitable test persons is a challenging task. In order to make the selection easier, general categories have to be defined for each experiment.

In preparation of the experiment, the following selection aspects were considered:

- Which unit will most likely use the tool during a CM operation?
- Once the unit has been identified, which level of operational personal should be engaged in the experiment (basic volunteer, squad leader, platoon leader…)?
- How much operational experience should this individual have?
- How open minded do the test persons have to be in order to explore potential benefits?
- Should the participants have a background in a specific field of interest (technically savvy, blue/white collar etc.)?
- In which language will the experiment be conducted?
- Should the participants be male/female, age, from different regions of Germany etc.?
- Which priority does each aspect have?

While writing the scenario in which the usage of all three solutions was embedded, it became apparent that the test personnel would have to take on different roles in the Crisis Management process (platoon leader, logistics manager and high-level decision maker). This is due to the fact that the different solutions provide a variety of benefits at different levels and in different situations. In order to show the synergy of all solutions in one Crisis Management scenario, THW decided to select operational personnel that is highly experienced and trained to take on different roles. Furthermore, it was important to select individuals that are open minded enough to test tools of different maturity levels. Crisis managers, in THW's experience, have a tendency to quickly judge solutions according to their applicability in the field. This is due to the fact, that Crisis Management personnel commonly perform exercises and not experiments.

The main focus of exercises is to train already established practices or equipment (commonly already available on the market). Experiments on the other hand side are supposed to test rather immature tools and developed hypotheses in a controlled environment. Test persons have to be aware of this difference in order to participate in a constructive way.

Another factor is that THW practitioners are, compared to full time staff, not always available – compared to THW full time staff. They commonly take time off from work in order to participate in the experiments. It hence requires some effort to identify enough THW volunteer personnel that is available during the experimentation phase.

Experiments involving the use of tools unfamiliar to the test persons require some form of training/briefing/instruction. As noted during the experiment, it takes a significant amount of time until the practitioners feel savvy enough to use the tools in order to solve the tasks given to them. This in turn has implications for the sampling process, as ensuring that the previously trained personnel is also available for the actual experiment is quite challenging.

Since all experiment 44 partners are based in Germany, the language spoken during the preparation and execution phase was German. This not only made communication easier but also allowed THW to select test persons from a larger group. If the experimentation language had been English the pool would have been much smaller and it can be anticipated that limited language skill would have had an influence on the results.

The combination of all of these aspects has led to the selection of eight male THW practitioners, ages between 31 and 53, from Bavaria, Baden-Württemberg, Berlin, Saxony and North Rhine Westphalia.

Even though the experiment has provided all participants with valuable results, THW believes that for future experiments it could be useful to strive for selecting at least one female participant. A heterogeneous test group might produce a richer outcome. However, it needs to be kept in mind that Crisis Management is primarily male dominated. Only about 14% of THW practitioners are female. The experiment partners agreed that qualification should always outweigh the gender aspect in order to ensure that the experiment can take place and generate valid results.

3.2.5 Experiment schedule

The experiment schedule is included in Annex 4. The experiment was performed in two rooms (one small room and one large room) of THW premises. The large room was divided into three areas: Tool Group (Practitioners with provided DRIVER+ solutions), Control Group (Practitioners without provided DRIVER+ solutions) and Control Centre. The Control Centre was always communicating with the two groups and offered information or ordered tasks.

On the first the day both rooms were used for the training of the solutions and on the following days only the large room was needed for the execution of the task (see Figure 3.12).


Figure 3.12: Large room (left hand side) and small room (right hand side)

During the execution, the large room was divided into three areas: Tool Group (practitioners with provided DRIVER+ solutions), Control Group (practitioners without provided DRIVER solutions) and Control Centre (see Figure 3.13).



Figure 3.13: Tool Group, Control Group, Control Centre

3.3 Scenario design

The scenario[6] was based on a river flooding event in the city of Magdeburg, capital of the Federal State Sachsen-Anhalt in Germany. After continuous rainfall over several days the major rivers and its tributaries of Southern and Eastern Germany have reached their banks and are in danger of flooding adjacent areas. The city expects the prospect of a major flooding of large parts of the city area and has started emergency

[6] A full scenario description (in German) is available on the internal DRIVER+ Collaborative Workspace (CoW). It is also available on request and please send your request to coordination@projectdriver.eu.

preparations for the event. The civil protection agency identifies the endangered areas and affected population as well as the critical infrastructure of the city.

The scenario was a purely table top exercises. Therefore, the scenario was completely simulation-based. The data used are either archive/recorded data (e.g. satellite imagery, aerial imagery) or simulated data. A series of simulated use cases which depended on each other were designed and subdivided into five segments containing THW related micro-tasks, which occur normally during a flood:

- Segment 1: Reporting Office (Set Up).
- Segment 2: Transformer Substation (Exploration).
- Segment 3: Sandbags (Demand).
- Segment 4: Sending units.
- Segment 5: Supply.

For the processing of the scenario the THW staffs was divided into two groups each of which worked simultaneously on the same tasks but one with and one without tool suite support. After every segment, the execution of the tasks had been compared to each other in order to:

- Compare and analyse the results in both working groups.
- Discuss the benefit and usage of the provided solution to complete the tasks.
- Gain feedback.
- Update all practitioners with the same information to ensure a common initial position before starting the next segment.

3.3.1 Scenario assumptions

This section describes the initial "virtual reality" of the experiment situation.

3.3.1.1 Disaster area

The area of action is Magdeburg (see Figure 3.14). The city is located at the river Elbe in the north-east of Germany. Magdeburg is the capital of the federal state Saxony-Anhalt and inhabits 238,212 residents.[7] In 2002 and 2013 Germany was affected by serious flood catastrophes. One of the concerned cities had been Magdeburg, which was affected in both years. During the flood THW was on-site and supported the city of Magdeburg with their practitioners. Moreover, appropriate data (satellite imagery and traffic data) was available.

[7] http://www.magdeburg.de/Start/B%C3%BCrger-Stadt/System/Volltextsuche-SOLR/index.php?La=1&NavID=37.871&object=tx|37.12715.1&FID=37.12715.1

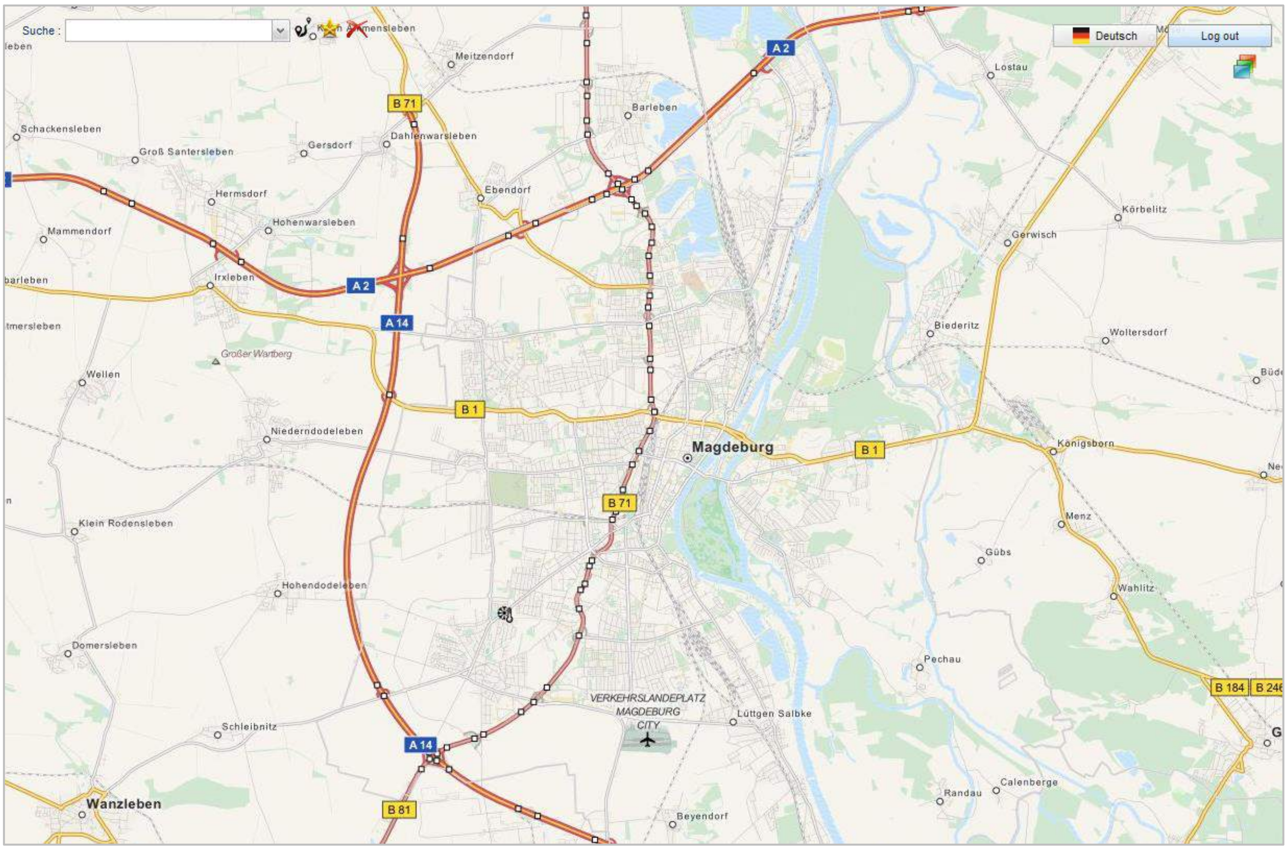


Figure 3.14: Area of Interest

3.3.1.2 Initial situation

After continuous rainfall over several days the major rivers and its tributaries of Southern and Eastern Germany have reached their banks and are in danger of flooding adjacent areas (see Figure 3.15).

The federal state of Sachsen-Anhalt (Eastern Germany) has announced the highest alert for flood warning and starts preparations for severe flooding.

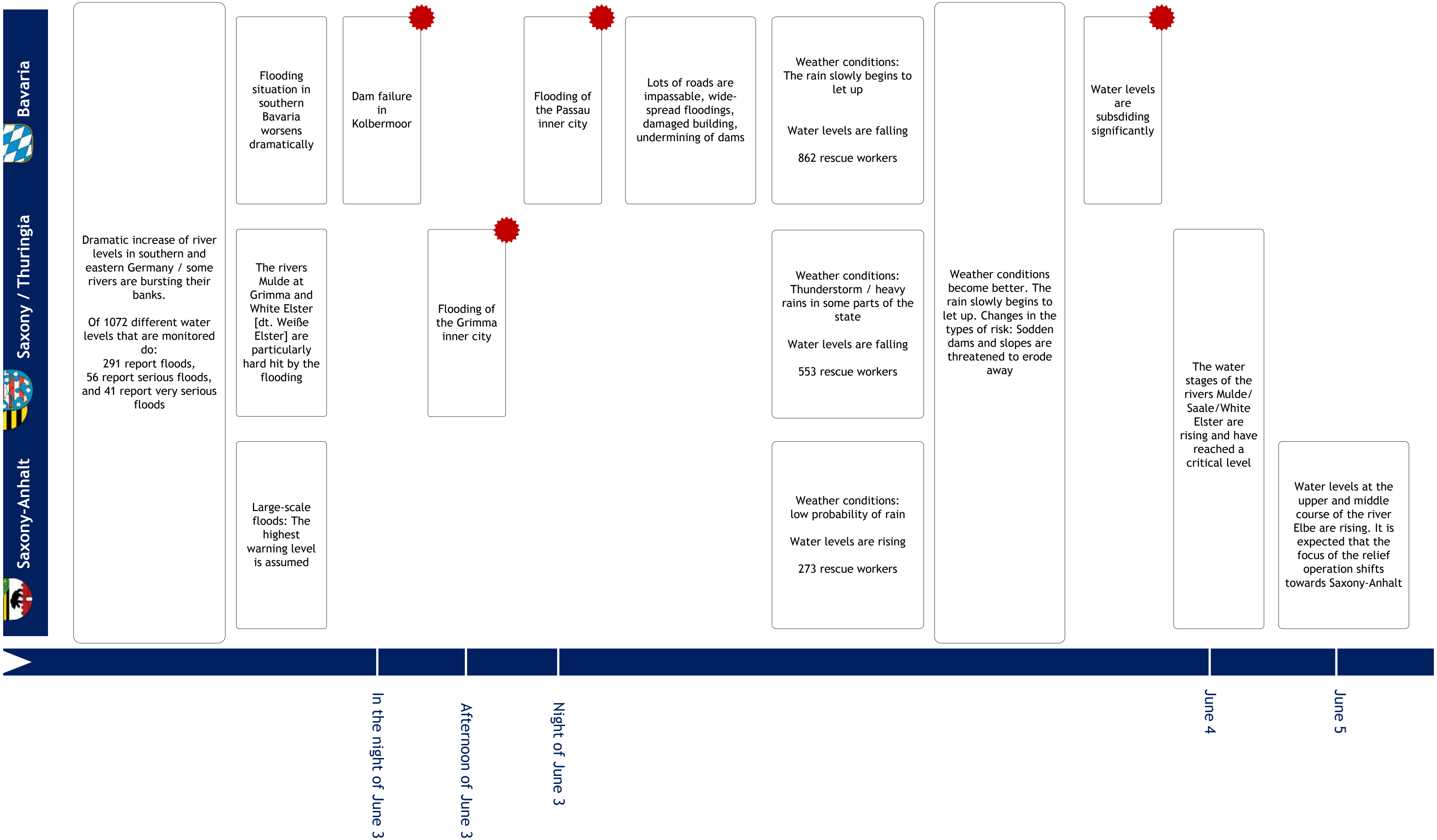


Figure 3.15: Timeline Initial situation

The state capital of Magdeburg expects to face a major flooding of large parts of the city area and has started emergency preparations for the event (preparation time: 24h) – see Figure 3.16. The civil protection agency identifies the affected population and critical infrastructure. It has requested support to receive real-time areal and satellite images for identification. Currently 291 of 1,072 water gauges in Germany register high flood, thereof great flood at 56 water gauges and huge flood at 41 water gauges. THW is preparing for the continuation of the support of the most affected federal states/counties/municipalities.

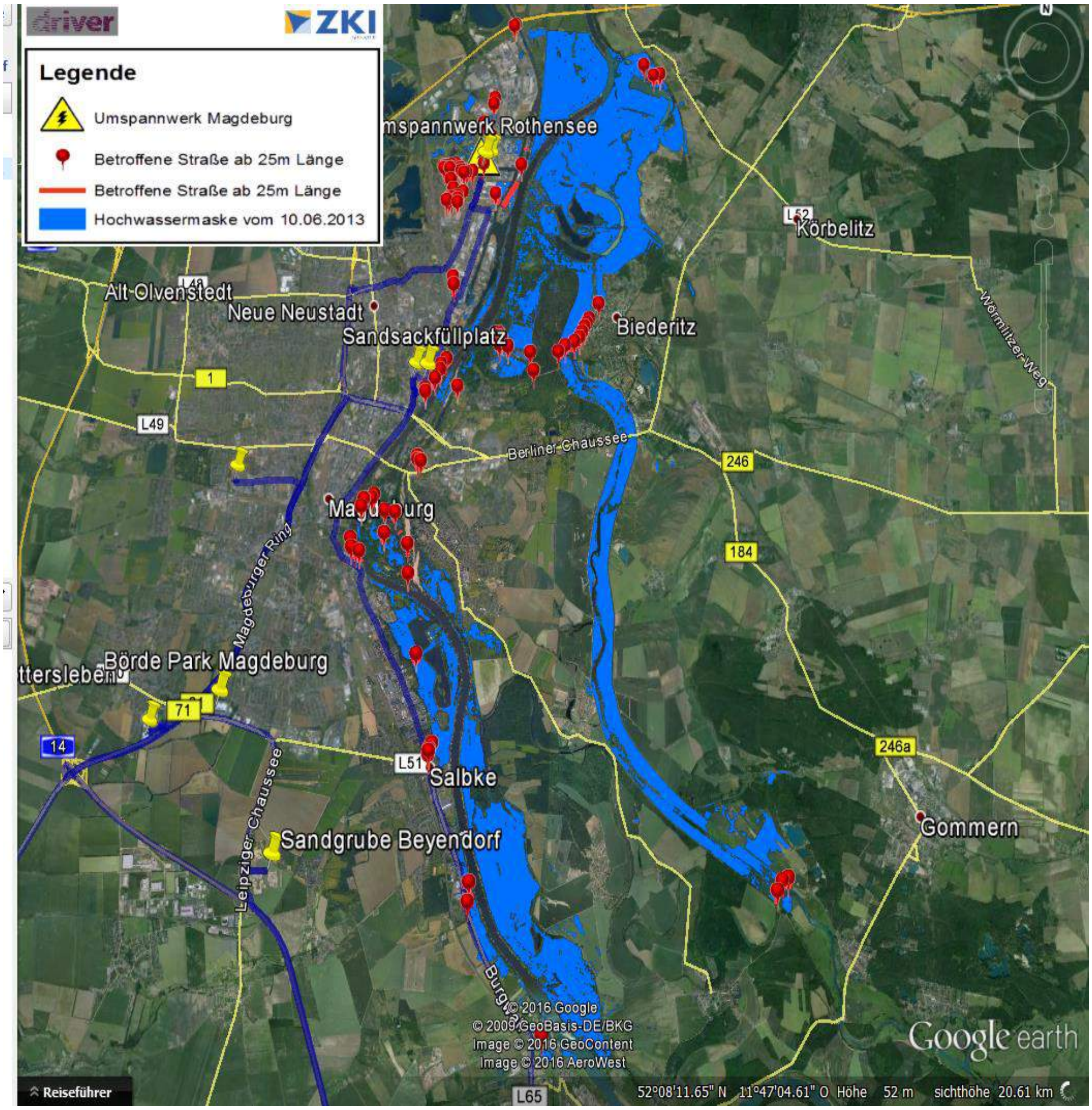


Figure 3.16: Disaster area in Magdeburg

3.3.2 Scenario description

The scenario and the associated experiment activities have been subdivided into five segments which are based on each other. Each segment includes sequential THW related micro-tasks, which occur normally during a flood. The THW practitioners had to solve coincident the tasks in two different groups. After every segment, the execution of the tasks had been compared to each other. The information to the participants was given by the Control Centre. The timeline of the scenario is shown in Figure 3.17.

Day	Segments	Task		Duration	Time
Day 1	Segment 1	T1.1	Installation of a reception centre	1h	09:00 - 09:50
Day 1	Segment 1	T1.2	Installation and operation of an EAL		
Day 1	Segment 2	T2.1	Protect transformer station Rothensee against the floods (Exploration)	2:30h	09:50 - 12:20
Day 1	Segment 2	T2.2	Protect transformer station Rothensee against the floods (state needs)		
Day 1	Segment 2	T2.3	Exploration results		
Day 1	Segment 2	T2.4	Installation of sandbags		
Day 1	Segment 2		Feedback & current situation		
Day 1	Segment 3	T3.1	Deliver sandbags to Magdeburg (Demonstration)	1:30h	13:00 - 14:30
Day 1	Segment 3	T3.2	Deliver sandbags to Magdeburg		
Day 1	Segment 3	T3.3	Provide vehicles / equipment		
Day 1	Segment 3		Feedback & current situation		
Day 1	Segment 4	T4.1	Sending units to Magdeburg (Demonstration)	1:35h	14:45 - 16:30
Day 1	Segment 4		Feedback & aktuelle Lage		
Day 2	Segment 5	T5.1	Pick up drinks	2:10h	08:10 - 10:20
Day 2	Segment 5	T5.2	Ensure availability of sandbags / steady working flow		
Day 2	Segment 5	T5.3	Ensure supply of sand and personal resources		
Day 2	Segment 5		Feedback		

Figure 3.17: Timeline scenario

The tasks address different functionalities of the provided tool suites in order to demonstrate the benefits under changing requirements. In Table 3.12, Table 3.13, Table 3.14, Table 3.15, and Table 3.16, the segments and tasks are briefly described.

3.3.2.1 Segment 1: Reporting Office (Set Up)

Table 3.12: Segment 1 – Reporting Office (Set Up)

Segment 1: Reporting Office (Set Up)	Duration: 30 Minutes
Task 1.1: Installation of a reception centre [dt. Meldekopf / Lotsenstelle]	
Description:	Organizing and operating a reception and guide centre to welcome rescue forces of volunteer fire brigades on behalf of the Magdeburg fire service.
Information to participants	Description of initial situation Supporting the fire service of Magdeburg by organizing and operating a reception and guide centre at the B81 at the METRO parking area. The section group of the local branch of Magdeburg has to be relocating as fast as possible to the METRO (Werner von Siemens Ring 9, 39116 Magdeburg Coordinate 32U E:76599 N:72869).
Expected outcomes	Location is found (sign in map) Estimated travel time is indicated Reception centre installed (visible by a sign)
Solutions	KeepOperational
Duration:	15 min
Task 1.2: Installation and operation of an EAL	
Description:	Organizing and operating of an EAL THW in Schönebeck (Stadionstraße Ecke Magdeburger Straße).
Information to participants	Supporting TEL Magdeburg by organizing and operating of an EAL THW. FK Magdeburg provides immediately readiness for action for at least seven operating days 24 hours shift duty. The EAL THW refers to staging area Schönebeck (32U E:686345 N: 5766051).
Expected outcomes	• Location is found (sign in map) • Estimated travel time is indicated • EAL is installed (visible by a sign)
Solutions	KeepOperational

Segment 1: Reporting Office (Set Up)	Duration: 30 Minutes
Duration:	15 min

3.3.2.2 Segment 2: Transformer Substation (Exploration)

Table 3.13: Segment 2 – Transformer Substation (Exploration)

Segment 2: Transformer Substation (Exploration)	Duration: 2:15h
Task 2.1: Protect transformer station Rothensee against the floods (Exploration)	
Description:	The transformer station Rothensee, has to be protect by all means in order to ensure power supply of the inhabitants in the region of Magdeburg. Moreover, the radio mast is feed with electricity by the transformer station Rothensee. An exploration of the area is needed.
Information to participants	Three days later. All local branches in the Magdeburg region are on-call duty and subordinated to EAL THW Schönebeck. Implementation of an exploration to the transformer station Rothensee. Main focus of the exploration is the identification of possible sandbag installations to protect the transformer station from invading water.
Expected outcomes	• Operation file (Einsatzhandakte) / Humlog is fitted to relevant information • Location is found (sign in map) • Estimated travel time is indicated • Order issued to local branch and the unit was routed
Solutions	KeepOperational, HumLog, ZKI-Tool, U-Fly/3k
Duration:	1:20h
Task 2.2: Protect transformer station Rothensee against the floods (state needs)	
Description:	The transformer station Rothensee, has still to be protect by all means – Stating needs to protect the transformer station.
Information to participants	A large area of the K1170 (August Bebel Damm) is already overflowed. The river Elbe already flooded areas westwards to the transformer station. Overtures are only passable by vehicles that are capable of fording (Minimum allowed fording depth: 30 cm). Without immediate installation of sandbags the transformer station will be overflowed within one hour. For urgent measure are 200 m x 2 plies (= 1200 Sandbags) sufficient. In probably 24h the transformation station will be flooded and has to be disconnected.
Expected outcomes	• Results exists (Number of sandbags, needs of sand, working hours) • Optional: Provident reflection to demand for vehicles, delivery etc.
Solutions	KeepOperational, HumLog, ZKI-Tool
Duration:	20 min
Task 2.3: Exploration results	
Description:	The results of the Exploration are available.
Information to participants	Results from Exploration: The Transformer station can be only protecting, if a sandbag dam (length: 160m, height: 50 cm) will be built within the next 24 hours. To that end, 51,500 empty sandbags and 1,800 t sand are needed for filling. For the filling of 51,500

Segment 2: Transformer Substation (Exploration)	Duration: 2:15h
	sandbags 860 working hours are required. The installation of the sandbags requires 860 working hours.
Expected outcomes	• Transferred data were recorded (Maps/Humlog) • Sandbags were requested at the local branches (phone call)
Solutions	KeepOperational, HumLog, ZKI-Tool, U-Fly/3k
Duration:	20 min
Task 2.4: Installation of sandbags	
Description:	Transformer station Rothensee shall be protected by all means in order to ensure power supply for the inhabitants in the region of Magdeburg as well as for the radio mast of Rothensee.
Information to participants	Install immediately a sandbag dam to protect the transformer station against the invading water. For these purpose, the EAL keep a technical unit water damage pumps, technical unit EAL, technical unit TEL, two rescue groups as well as logistics and transport elements to transport sand and bags at call available. One THW sandbag filling station is established in "Wissenschaftshafen"; Peter-Paulstraße, Ecke Theodor Koslowskistraße Coordinate: 32U 681739 5780369.
Expected outcomes	• Updating situation map to staging area Schönebeck is carried out (sign in map) • Updating situation map to Sandbag filling station is carried out (sign in map) • Updating of data is carried out (operation file /HumLog)
Solutions	KeepOperational, HumLog
Duration:	15 min

3.3.2.3 Segment 3: Sandbags (Demand)

Table 3.14: Segment 3 – Sandbags (Demand)

Segment 3: Sandbags (Demand)	Duration: 1h
Task 3.1: Deliver sandbags to Magdeburg (Demonstration)	
Description:	Change of area of responsibility: The lower management level is exhausted. The practitioners move up to TEL and KatSL This task is a Demonstration and the practitioners receives mainly information
Information to participants	Change of area of responsibility The EAL THW Schönebeck request the TEL MD for: • Request 1: ○ Situation: situation report segment 2 ○ To protect the transformer station, 52,000 empty sandbags and 1,800t sand are needed ○ Delivery address is the sand mine "Wissenschaftshafen" • Request 2: ○ The TEL received a further request of EAL THW Schönebeck: Additional demand of 600,000 empty sandbags and 15,000t sand. ○ The FaBe in the TEL MD get the order to clarify the availability of empty sandbags at THW. ○ THW-FaBe checks the availability of empty sandbags

Segment 3: Sandbags (Demand)	Duration: 1h
	Results of nationwide sandbag availability at THW
Expected outcomes	• No outcomes expected, just information
Solutions	HumLog, KeepOperational (Routing as input for HumLog)
Duration:	25 min
Task 3.2: Deliver sandbags to Magdeburg	
Description:	The TEL receives the order to identify sand mines which suits the requirements.
Information to participants	THW receives the order to transport the required 800,000 sandbags within the next 24h to Magdeburg (Information via phone): Priority 1: Delivery of 60,000 sandbags to "Wissenschaftshafen" has to be made within the next 5 – 7 hours. Priority 2: Delivery of the remaining 740,000 sandbags to the sand mine Beyendorf
Expected outcomes	• Results should be: filling is not doable in the given time. Justification has to be provided (how many volunteer´s working hours are needed and how long does this take?).
Solutions	HumLog, KeepOperational (Routing as input for HumLog)
Duration:	20 min
Task 3.3: Provide vehicles / equipment	
Description:	The EAL receives the order to identify sand mines that can provide 12,500t sand within the next 24 hours.
Information to participants	Results (communicated by phone): The SEB Sand mine Beyendorf can provide the demanded sand 24h/seven days/per week. However, it is not possible to load and transport the sand with own resources. For this, 4-wheel loader (of them 2 with pallet forks) and 12 tippers/dump trucks for 24 hour transportation are needed. Address: Zum Anker, 39122 Magdeburg.
Expected outcomes	• Addresses are recorded. • Scheduling is finalized (Where are the vehicle from? When do the vehicles arrive?)
Solutions	HumLog, KeepOperational (Routing as input for HumLog)
Duration:	15 min

3.3.2.4 Segment 4: Sending units

Table 3.15: Segment 4 – Sending units

Segment 4: Send units	Duration: 1:10h
Task 4.1: Sending units to Magdeburg (Demonstration)	
Description:	The technical adviser of the TEL receives the order to provide the needed vehicles/equipment and personnel for 24 hours duty until 18 o`clock.
Information to participants	The units have to register in Magdeburg at the staging area Schönebeck at the reception centre. Readiness for action is from 8 a.m. The Next day: The technical unit Evacuation are ready for use at 8 a.m. at the sand

Segment 4: Send units	Duration: 1:10h
	mine Beyendorf and start with the loading of loose sand and filling of onsite existing sand bags filling machines. The City of Magdeburg has provided 200 citizens to help THW by filling sandbags under the guidance of competent THW staff. Those accomplish to fill and palletise about 100,000 sandbags in one hour. At 9 a.m. THW can start to transport the filled and palletised sandbags to the stated incident scenes. Practitioners receives additional information about • the units posted to Magdeburg • incident scenes with demand of sandbags • the shift operation • catering
Expected outcomes	• Information are recorded • Date, when sandbags are filled, is communicated • Incident scenes are recorded • Results of the calculation are available
Solutions	HumLog, KeepOperational
Duration:	1:10h

3.3.2.5 Segment 5: Supply

Table 3.16: Segment 5 – Supply

Segment 5: Supply	Duration: 1:15h
Task 5.1: Pick up drinks	
Description:	Change of area of responsibility: Now, the practitioners are logistics leader. Collecting and Transporting drinks.
Information to participants	Change of area of responsibility The logistics leader of the staging area receives the order to collect every morning between 9am and 9.10 am REWE Großverbraucher Services der REWE Zentral AG zum Fischmarkt 1 a, 04158 Leipzig 20 pallets beverages and to bring them to the staging area.
Expected outcomes	• Information are recorded in the map • Routing results are available • Vehicles are identified • Timing was satisfied
Solutions	KeepOperational
Duration:	25 min
Task 5.2: Ensure availability of sandbags / steady working flow	
Description:	Five incident scenes have to be delivered. Ensure availability of sandbags / steady working flow
Information to participants	Transport routes and marching time has to be considered for the logistics of the transport of sandbags and the following smooth installation. By all means, it has to be ensured that at any time filled sandbags are available at the incident scene. Display the

Segment 5: Supply	Duration: 1:15h
	necessary execution.
Expected outcomes	• Forces and mean planning exist • Timeline exist
Solutions	HumLog, KeepOperational (Routing as input for HumLog)
Duration:	40 min
Task 5.3: Ensure supply of sand and personal resources	
Description:	Provision the sand mine “Wissenschaftshafen” with sufficient personal resources and sand in order to guarantee the safeness of the transformer station for 24 hours.
Information to participants	For 52,000 sandbags, which are necessary to ensure the safeness of the transformer station for 24 hours, are 50 practitioners needed, who have to be relieved every 3 hours. Additional information to calculate the shift schedule.
Expected outcomes	• Calculation and results are available • Shift schedule is available
Solutions	HumLog, KeepOperational (Routing as input for HumLog)
Duration:	50 min

3.4 Evaluation approach and metrics

The aim of EXPE44 has been the highlighting and illustration of the benefits of a logistics and traffic management solution that provides relevant information for crisis managers to cope challenges within the logistics chain during the planning and response phase of CM. This included the consideration of the following tasks during the experiment:

- (Tool-)Functionality demonstration.
- Information gathering.
- Situation assessment.
- Decision making.
- Tasking and resource management.
- Performance assessment.

3.4.1 Evaluation methodology

Both qualitative and quantitative data have been collected. Qualitative data describe the participating THW practitioners’ feedback and thoughts concerning the usability of the provided solutions. For instance, the debriefing questionnaire and comments from the discussions are considered as qualitative data. Quantitative data such as logistics data quality, routing quality and processing times to handle the different tasks are used in conjunction with the qualitative data to assess the experiment objectives (cf. section 3.1.2). The resulting data from questionnaires are subjective, whereas time measurements to identify and to compare the performance of processing tasks with and without tool support are considered as objective data.

The following assessment methods and techniques were used:

- Time Measurement.
- Flash Feedback.
- Feedback from discussions.
- Observation.
- Data logging.
- Tailor-made questionnaires.

In case of the questionnaire, two tailor-made questionnaires were considered: one questionnaire directly after the experiment (Annex 2), one questionnaire three months after the experiment (Annex 3).

Table 3.17 provides a short description of the metrics and time of application of these methods.

Table 3.17: Methods and metrics

Method	Metrics	Completed
Recording processing times	Gather information on the performance of the THW practitioners with/without tool suite while performing the experiment scenario	During experiment run
Flash Feedback	Record participants' opinions of the tool suites' usability and handling under processing with reference to the specific tasks	After each completed scenario segment
Feedback from discussions	Record participants' opinions of the tool suites' usability and handling under processing	After each experiment day
Observation	Note observations made by external observers (one for each group with/without tool suite)	During experiment run
Data logging	Gather information on the notebooks where the tools are installed (using screen records) as well as video recording	During experiment run
Questionnaires	Assess participants' ratings of the benefits of the tool suites as well as of the usability, effectiveness and suitability	One questionnaire directly after the experiment run, one questionnaire three months after experiment run

Some data were recorded using electronic devices, whereas the questionnaire is a paper-and-pencil instrument. Some analyses were qualitative or purely descriptive, but quantitative statistical analyses using well established methods are performed as well. The inputs to the analyses were the logged experiment data (e.g. processing times), the observation results, the questionnaire and flash feedback responses. Given the scope and the design of the Trials with only a small sample size and therefore reduced statistical power, most analyses were descriptive or were using non-parametric tests.

The first questionnaire was semi-structured (see Annex 2). Some questions were open questions with a text box or Likert-Scale and some questions implied closed questions. The questionnaire was handed out after the experiment execution. The questions relate to the solutions and not to the whole experiment. All 10 THW participants answered the questions under the perspective of their role. Hence, we received four completed questionnaires from the tool group perspective, four completed questionnaires from the control group perspective and two completed questionnaires from the control centre perspective. The questionnaire is included in Annex 1.

The second questionnaire (see Annex 3) was send to the practitioners after three months of the experiment and focused a final feedback and remarks, which may come up during the three months. With one exception, all questions were open questions with text boxes. Until the finalisation of this document, we received two completed questionnaires. Therefore no additional feedback, besides the large number of comments collected during the experiment, was considered for the evaluation.

3.4.2 Evaluation metrics

To evaluate the performance and added value of each provided solution in the experiment and thus, to evaluate if the outcomes match the expectations of the professionals, the three evaluation metrics "benefits", "usability" and "suitability" were used.

3.4.2.1 Benefits

Benefits directly relate to tool functionalities (so called features) which are tool-specific and therefore, are different from tool to tool. To find out if the provided tool functionalities are beneficial for the professionals, and thus, if they liked the features for their daily work, they were asked to rate each feature on a scale of 1 ("very good") to 5 ("poor") respectively 6 ("I cannot assess").

3.4.2.2 Usability

The international standard, ISO 9241-11, provides guidance on usability and defines it 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.[8] This definition translates into the following key performance indicators (KPI):

- **Effectiveness** (can the users complete tasks, achieve goals with the product, i.e. do what they want to do?).
- **Efficiency** (can users finish tasks faster with the help of the product?).
- **Satisfaction** (does the product meet the users' requirements?).

To evaluate the KPI "effectiveness", the professionals were asked the following question: "Could you manage the tasks more easily with the proposed solution?" which they should simply answer by yes or no.

To evaluate the KPI "efficiency", the professionals were asked the following two questions: "Would you say that you could finish the tasks faster with the help of the provided solution?" and "Was faster situation awareness possible?" which they should both simply answer by yes or no.

To evaluate the KPI "satisfaction", a bunch of sub-indicators identified from professional's requirements during the 3rd EXPE44 Workshop (cf. section 3.2.1) was defined: traceable, comprehensible, clear, intuitive, manageable (related to handling), reliable. The professionals were asked to rate each sub-indicator on a scale of 1 ("very good") to 5 ("poor") respectively 6 ("I cannot assess").

[8] Quelle: http://www.usabilitynet.org/management/b_what.htm

3.4.2.3 Suitability

The quality criteria suitability is defined as: The quality of having the properties that are right for a specific purpose.[9]

To find out, how suitable the practitioners assess the provided features in the process of Crisis Management, the following sub-indicators (also identified from professional's requirements during the 3rd EXPE44 Workshop; cf. section 3.2.1) were defined: useful, detailed, up-to-date, beneficial, and innovative. The professionals were asked to rate each sub-indicator on a scale of 1 ("very good") to 5 ("poor") respectively 6 ("I cannot assess").

3.4.3 Evidence

During the experiment, different quantitative and qualitative data have been collected. These data were collected either during or directly after the execution of an experiment step. In Table 3.18 all collected evidence is listed.

Table 3.18: Collected data

Category	Data Types	Data Format
Quantitative	Processing times	.xls
Quantitative	Routing information (link list, duration, length, number of alternative routes)	.xls
Qualitative	Flash feedback and feedback from discussions	.doc
Quantitative	Data logging	.jpeg (screen records) .wmv (video)
Qualitative	Observations	.doc
Qualitative	End-user questionnaire	.pdf

9 https://www.vocabulary.com/dictionary/suitability

4. Results and Insights

In this section, the main results of EXPE44 are presented. Based on the results, identified gaps from the experiment and potential improvements are summarized in the following section 5.

4.1 Overview

In EXPE44, quantitative and qualitative data was recorded and analysed. Both quantitative and qualitative analysis showed that the professional responders have a great interest in the provided solutions and stated and added value in using them.

The results from the quantitative data show on the one hand that the practitioners see the provided solutions as a suitable solution for transport and logistics demands in Crisis Management and on the other hand that some improvements have to be implemented with regard to technical and functional aspects to guarantee more reliable and feasible solutions. Although, the solutions cover relevant demands in Crisis Management, the practitioners express that not all features are obligatory worthwhile for THW related tasks but could be interesting for other professional responders (e.g. police, firefighters, etc.).

It was stated by the practitioners that the proposed solutions are beneficial for the THW daily work regarding the following aspects:

- Performing operation in unknown areas.
- Performing tasks with considerable calculation effort.
- Performing nationwide operations.
- Performing complex tasks with many alternative decision choices.

It was also stated that the usage of the provided solutions makes only sense for practitioners dealing with management and communication tasks. During the experiment it was noticed, that the usage of the solutions below this level is not helpful for the practitioners and would make no sense because tool operators are not available for other activities.

The practitioners mentioned that the usage of the proposed solutions in real operation would advance if the solutions were connected to each other. Preferable is one user interface where all solutions are connected to each other as well as automatic database matching.

At the beginning, it was noticed that the tool group compared to the control group needed more time to complete the given tasks. Especially in performing easy and common tasks they are used to. Main reason for the time delay is, that the practitioners are and not familiar enough in operating the solutions and had not enough experiences in using them effectively. They are used to solve the tasks with other tools. But the more difficult the tasks and the more familiarized the practitioners were in using the solutions, the faster the tool group was in solving the tasks (see Figure 4.1, T2.3 & T3.1). A learning curve was measurable in the short time. In summary it can be said, that the tasks can be processed more quickly with the use of the tools. However, this requires experienced tool operators. The same results eventuated by the qualitative data analysis. Hence, the hypotheses can neither be confirmed nor denied since the scope and size of experiment is not representative. Besides, the control group's behaviour was not as expected. Due to their expertise, they solved tasks in ways that were not intended by the THW professionals who helped to design the scenario and tasks. For instance, when solving task T2.1 the control group did not determine neither the route nor the travel time since they said that their role in this task would practically delegate this subtask directly to the staff in the field. That influenced the experiment and thus, the results, as the control group's processing times where significantly shorter than they de facto should have been. Therefore, the comparison of the results of the two groups is misleading to a certain extent.

		Start time	End time	Time difference	Start time	End time	Time difference
Tasks	**LTG-Infos**	**Control Group**			**Tool Group**		
T1.1	09:18	09:23	09:34	00:11	09:23	09:35	00:12
T1.2	09:48	09:53	09:59	00:06	09:53	10:01	00:08
request closed roads				03:00			
T2.1	10:07	10:07	10:15	00:08	10:07	10:18	00:11
T2.1	10:18	10:22	10:42	00:20	10:22	10:39	00:17
T2.2	10:42	10:45	10:52	00:07	10:45	not logged	-
T2.3		10:52	11:07	00:15	10:52	11:09	00:17
T2.3	11:07	11:09	11:21	00:12	11:09	11:14	00:05
T2.4		11:21	11:40	00:19	11:21	not logged	-
Flash Feedback		11:40	11:50	00:10	11:40	11:50	00:10
T3.1	13:18	13:19	14:07	00:48	13:19	13:48	00:29
T3.2	14:07	14:11	14:27	00:16	14:11	14:27	00:16
Flash Feedback		15:00	15:30	00:30	15:00	15:30	00:30
T3.3	15:44	15:48	15:55	00:07	15:48	16:14	00:26
T4.1	16:16	16:17	16:18	00:01	16:17	16:18	00:01
T4.1		16:18	16:34	00:16	16:18	not logged	-

Figure 4.1: Time comparison between Control Group and Tool Group

The results from the qualitative data approve the results from the quantitative analysis. The professional responders declare a potential for the transport and logistics support tools. All questionnaires would use them in real Crisis Management scenarios. Nevertheless, the provided solutions are not perfect. On average, the solutions have been evaluated from all ten questionnaires as good and some suggestions for modification regarding suitability/relevance, usability and effectiveness were given, except of U-fly/3k. The U-Fly/3k solution had not been operated and evaluated in detail by the practitioners in EXPE44, because the system was already tested and evaluated in EXPE40. The results' regarding usability differs between the proposed solutions. The operating of HumLog was not seen as easy and the usage was assessed between good and partly (on the range "very good – good – partly – fair – poor – I cannot assess"). It has to be remarked, that the tool group assessed the usability inferior compared to the other two groups, who did not use the tool.

The use of ZKI-Products and KeepOperational were evaluated between very good and good. This difference in the usability is justified by the fact, that, HumLog is not designed for everybody to use this system more or less easily compared to KeepOperational and ZKI-Products. Normally the system should be used by the system operator or by an experienced user. The suitability and relevance was seen for all solutions. But it has to be mentioned, that the level of suitability/relevance differs between the features of the provided solutions. Besides the suitability is addicted by certain circumstance (see results from quantitative analysis).

The effectiveness was only asked for KeepOperational. Mainly all questionnaires (two questionnaires did not answer the question) confirm, that they could manage the tasks more easily, that they could finish the tasks faster and that situation awareness was given faster. Although, if these results are not similar to the notes of the observer (see Figure 4.1 and quantitative results). But the THW practitioners stated in the flash feedback that they would be more effective with the tools if they would be more familiar with them. Main remarks of the practitioners were that they would prefer to use a mobile application instead of a laptop during the operation and one Interface where all tool functionalities are combined should exist. Furthermore, the handling of the solutions should be easy and the data have to be topical, be reliable and always available, also under bet weather conditions.

Two major aims to evaluate the performance and benefit of the provided tool-suites during the experiment were: a technical aim (summarized under "Goal#1 – validating and demonstrating solution functionalities", respectively "Goal#2 – validating of interoperability between the solutions") and a more user-oriented aim considering also aspects of product handling and overall experiences ("Goal#3 – Measurement of Tool performance"). A third aim which is less pronounced but nonetheless significant focussed on the experiment processing and its impact on future Trials. Thus, the last two goals were intended to gain experience and to prepare for further experiments ("Goal#5 – identification of gaps (lessons learned)" and "Goal#4 – preparation for upcoming experiments"). In the following sections, the results regarding Goal#1 to Goal#3 are presented for each solution. Results in context of Goal#4 and Goal#5 are separately listed within section 6 and 7.

The feedback questionnaire, which was send to the THW practitioners three months after the experiment confirms the results made during the experiment. After three months, the practitioners are still interested in the provided solutions and would still use them in real Crisis Management situations. No extra remarks were submitted.

4.2 KeepOperational

Regarding the defined goals (see Table 3.1 - Table 3.5 in section 3.1) three major aims can be associated with the evaluation of the performance and added value of the KeepOperational tool:

- Validating and evaluating solutions for traffic analysis and routing (cf. objective#1.1).
- Testing of interoperability between KeepOperational and the other tools (cf. objective#2.1 – 2.3).
- Assess whether the provided tool suites are a valuable support in CM (cf. objective#3.1).

Objective#1.1 was specified by four expected outcomes addressing different features of the KeepOperational tool: routing including routing options, traffic situation report, display of blocked roads, traffic forecast. Since traffic forecast was not implemented, only the expected outcomes #1.1.1 to 1.1.3 can be regarded as fully fulfilled. To get a first impression of what the THW-practitioners think about the tool and its features, they were asked to evaluate their working experience on the tool-suites on a scale of 1 ("very good") to 5 ("poor") respectively 6 ("I cannot assess") within a questionnaire handed out subsequent to the execution. The general assessment of the provided tool features in case of KeepOperational tool (cf. in Figure 4.2) shows that the practitioners liked the features rating them no worse than grade "good". Especially the depiction of the current traffic situation as well as (road) closures has been highly rated.

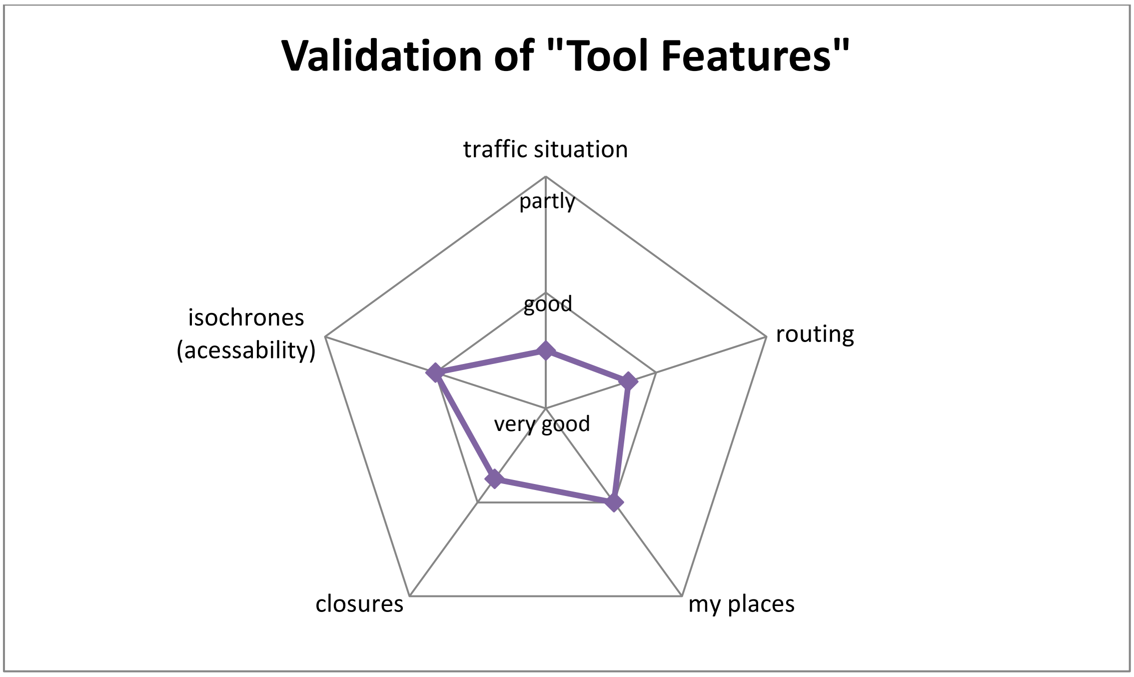
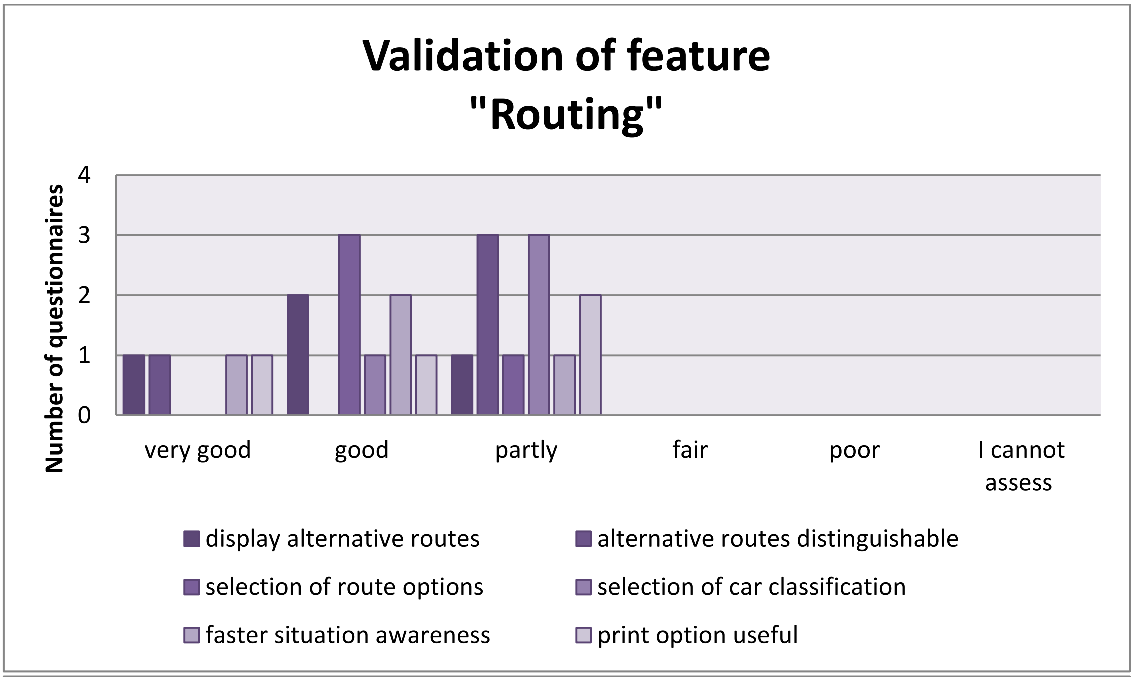


Figure 4.2: Validation of KeepOperational "Tool Features"

The results indicate that the practitioners were mostly satisfied with the provided features. To get a deeper insight, the practitioners were asked to assess some more specified functionalities (so called features) related to the goals and objectives (cf. section 3.1). The results regarding the features "routing" and "(road) closure" are depicted in Figure 4.3 as the practitioners were mostly interested in those two features. . As the evaluation is based on 4 replies (group size was 4 persons), the experiment rather indicates a tendency. Bearing that in mind when having a closer look into the results of the validation of the feature "routing", most of the practitioners rated the "display of alternative roads", the "selection of route options" as well as the “faster situation awareness” as “good” whereas the perceptibility of alternative routes (“alternative routes distinguishable”), the “selection of car classification” and the “usefulness of print option” were merely assessed with “partly”. Since especially the last two functionalities were implemented in a very rough way just to give an impression of what might be possible within the experiment, the results show that these functionalities were generally requested by the practitioners but were insufficient executed in the tool. Therefore, more effort should be devoted to the functionalities future design. A similar picture emerged in terms of the feature “(road) closure” where the specified criteria were rated with an overall “good”.



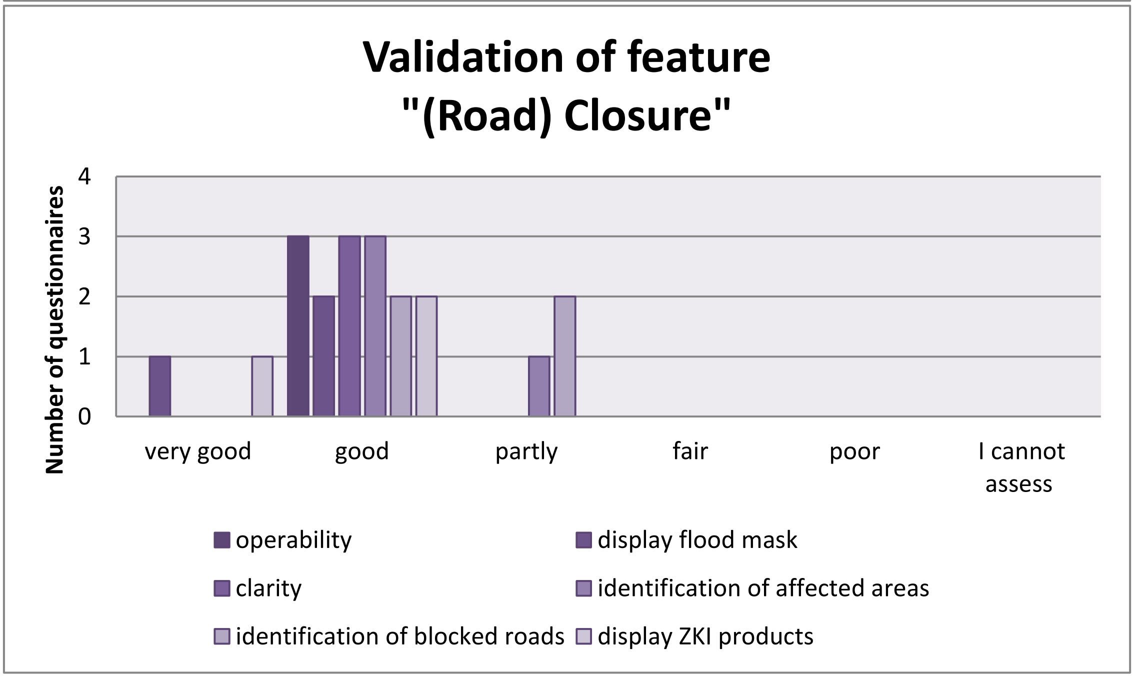


Figure 4.3: Validation of KeepOperational functionalities “routing” and “(road) closure”

Regarding the evaluation of the performance and added value of tool KeepOperational (cf. section 3.4.2) and its related KPIs “Effectiveness”, “Efficiency” and “Satisfaction”, all four practitioners answered the question “Could you manage the tasks more easily with the proposed solution?” with “yes” and therefore confirmed the effectiveness of the KeepOperational tool (although they had some problems in using the provided tool due to their lack of knowledge with the handling). The KPI “Efficiency” was confirmed as well. Again, all four practitioners answered both related questions clearly with “yes” (1. Would you say, that you could finish the tasks faster with the help of the provided solution?; 2. Was situation awareness possible to be achieved faster?). However, some practitioners named system crashes as restriction as well as the assumption that the features might be more effective in case of usage in foreign environment or at long distances.

To further explore these results, observations were made during the experiment. The observations reinforce the results above only partially. Especially at the beginning of the experiment, the practitioners had problems in using the provided solutions due to being not familiar enough with such tools and due to system crashes. Normally, the practitioners use solely telephones or if internet connection is available GoogleMaps. Therefore, they needed more time for solving the tasks at the beginning. With the ongoing experiment, they became more confident with the features – the corresponding routing query times dropped simultaneously (cf. Table 4.1). However, the tool allowed the practitioners to find routings with lower travel times and shorter route length combined with a higher reliability due to exact and up-to-date flooding masks as well as different traffic data sources.

All in all, it was obvious that the more complex the tasks were, the easier it was for the volunteer group handling the tools to complete the assigned tasks.

Table 4.1: Recorded processing times in context of routing query

Task	routing query [hh:mm:ss]		travel time [hh:min:ss]		route length [km]	
Tool	without	with	without	with	without	with
T1.1	00:03:30	00:06:00	00:14:00	00:04:00	7	7
T1.2	00:01:30	00:08:30	00:24:00	00:19:00	27	24
T2.1	-	00:08:00	-	00:19:00	-	29
T2.2	-	00:05:00	-	00:23:00	-	27
T2.3	-	00:05:00	-	00:04:00	-	5
T2.4	no routing tasks					
T3.1						
T3.2						
T3.3						
T4.1						
T5.1	processing cancelled					
T5.2						
T5.3						

The benchmark of the KPI “Satisfaction” (cf. section 3.4.2) is presented in Figure 4.4. Especially high rated was the reliability of the tool. Hereby, the practitioners emphasized the reliability in context of routing through flooded areas which is not integrated in state of the art tools such as GoogleMaps (cf. also section 2). Moreover, KeepOperational is based on different data sources as depicted in the report of EXPE40.

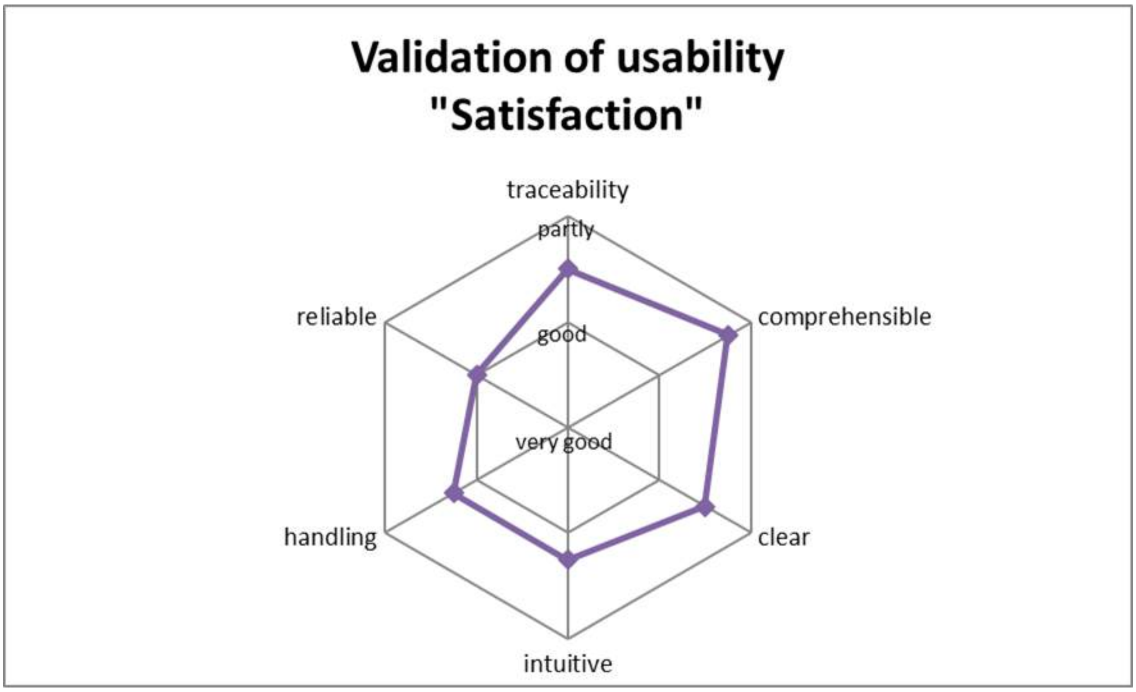


Figure 4.4: Qualitative evaluation of KeepOperational using benchmark criteria "satisfaction"

Regarding the quality criteria "Suitability" (cf. section 3.4.2), the results are displayed in Figure 4.5. In most parts, the practitioners rated the suitability of the KeepOperational tool on the range "very good – good – partly – fair – poor – I cannot assess" between "good" and "partly" with tendency of "good".

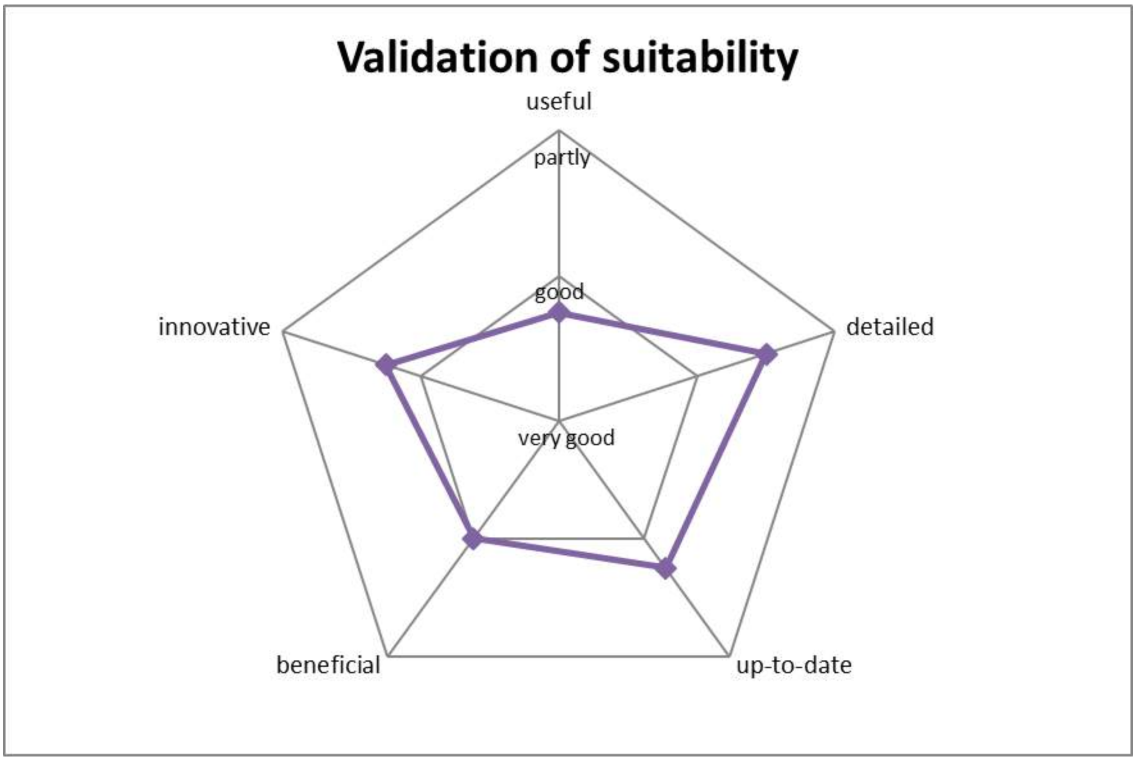


Figure 4.5: Qualitative evaluation of KeepOperational using benchmark criteria "suitability"

The **objectives#2.1 to 2.3** (testing interoperability between tools) were not components of the questionnaire due to their functional nature. Moreover, objective#2.2 (interoperability between U-Fly/3k and KeepOperational) was already tested within EXPE40. In EXPE44 it was solely a simulated part of the scenario, but not in focus of a qualitative or quantitative analysis. For additional information please refer to the corresponding report of EXPE40. Objective#2.3 has been fully reached since ZKI features were directly integrated in KeepOperational (see section 4.4). However, objective#2.1 could not be tested as the integration of HumLog was not finalized until the experiment.

4.3 HumLog

As presented in section 3.1, the evaluation of the experiment is structured according to a set of goals and expected outcomes and is based on the evaluation metrics presented in section 3.4.2. In the following, we will discuss the experiment results in line with the objective from the perspective of the HumLog solution. Within goal 1 "validation and demonstration of solution features", HumLogSim focused on the **objective#1.2 "validation and evaluation of different logistics solutions"**. As mentioned above, HumLogSim calculates a complete fulfilment schedule listing all transports required to fulfil all demands simultaneously, given the available resources. Table 4.2 shows an excerpt of a transport schedule for the delivery of 1000 sandbags to Magdeburg. The tool selects the best resource locations first and assigns them to the demand. In this example, it will take about 42 minutes to have all sandbags delivered to the destination.

Table 4.2: Example HumLogSim Transport Schedule

Departure Location	Arrival Location	Product	Amount	Arrival Time	Duration (Days, Hours, Minutes)
Branch Magdeburg	Sandpit Beyendorf	Sandbag	150	06:40:00	0,0,10
Branch Calbe	Sandpit Beyendorf	Sandbag	150	06:52:00	0,0,22
Branch Oschersleben	Sandpit Beyendorf	Sandbag	150	06:56:00	0,0,26
Branch Haldensleben	Sandpit Beyendorf	Sandbag	150	06:58:00	0,0,28
Branch Staßfurt	Sandpit Beyendorf	Sandbag	150	06:58:00	0,0,28
Branch Burg	Sandpit Beyendorf	Sandbag	150	07:08:00	0,0,38
Branch Bernburg	Sandpit Beyendorf	Sandbag	100	07:12:00	0,0,42

A bottleneck would become visible if the total time exceeds the latest acceptable time or if the total amount available is not sufficient. Crisis managers can then conclude that given the current resources, the objective cannot be achieved in time. One option to overcome a bottleneck would be to request further resources from the THW network or other sources. A new simulation would then result in an alternative schedule. Changes to the demand and available resources can be performed between each simulation if necessary. Although the tool is already capable of identifying bottlenecks and to present detailed schedules, crisis managers addressed the need that the results should be extended by summaries and overviews.

Regarding the "validation of interoperability between the tools", stated by goal 2, HumLog and KeepOperational are planned to exchange routing information to fulfil **objective#2.1 "Assess whether the interoperability of HumLog and KeepOperational is sufficient"**. Yet in the project schedule it was not planned to have the technical integration until the conducted experiment. But, since the integration is completely realized on a technical level, it can be completed and tested outside of an experiment scenario. An interface has been developed, which replaces the HumLogSim routing by the routing service offered by KeepOperational. It is therefore possible to consider the current traffic situation within the simulation and calculation of transport schedules. This will increase the accuracy of the simulation by adding further real world information to the simulation model. Yet the interface is open for testing.

Goal 3 addressed the "Evaluation of the tool's performance" and therefore has the **objective#3.1 to "Assess whether the provided tool suites are a valuable support for CM"**. Overall the crisis managers evaluated HumLog as "good (2)" (on a five-step scale from "very good (1)" to "poor (5)"). Figure 4.6

presents a general assessment of the tool in different dimensions on the same scale. The “satisfaction” sub-indicators presented in section 3.4.2.2 were complemented for HumLog to allow a more differentiated analysis of the usability of the three HumLog components HumLog[em], HumLogBSC and HumLogSim. Besides the in average good results, one can identify tendencies in the answers. On the good side, the assessment shows that HumLog is perceived as very fast, reliable and as a novelty, offering value to crisis managers. Contrarily, the complexity of the simulation affects the use of HumLog, as it is perceived a complex tool and not very intuitive to use. This matches with the feedback that the presentation of results can be improved by additional summaries. One has to keep in mind, that the crisis managers only had short introduction and training. A real world application would also require a trained tool operator within the Crisis Management team.

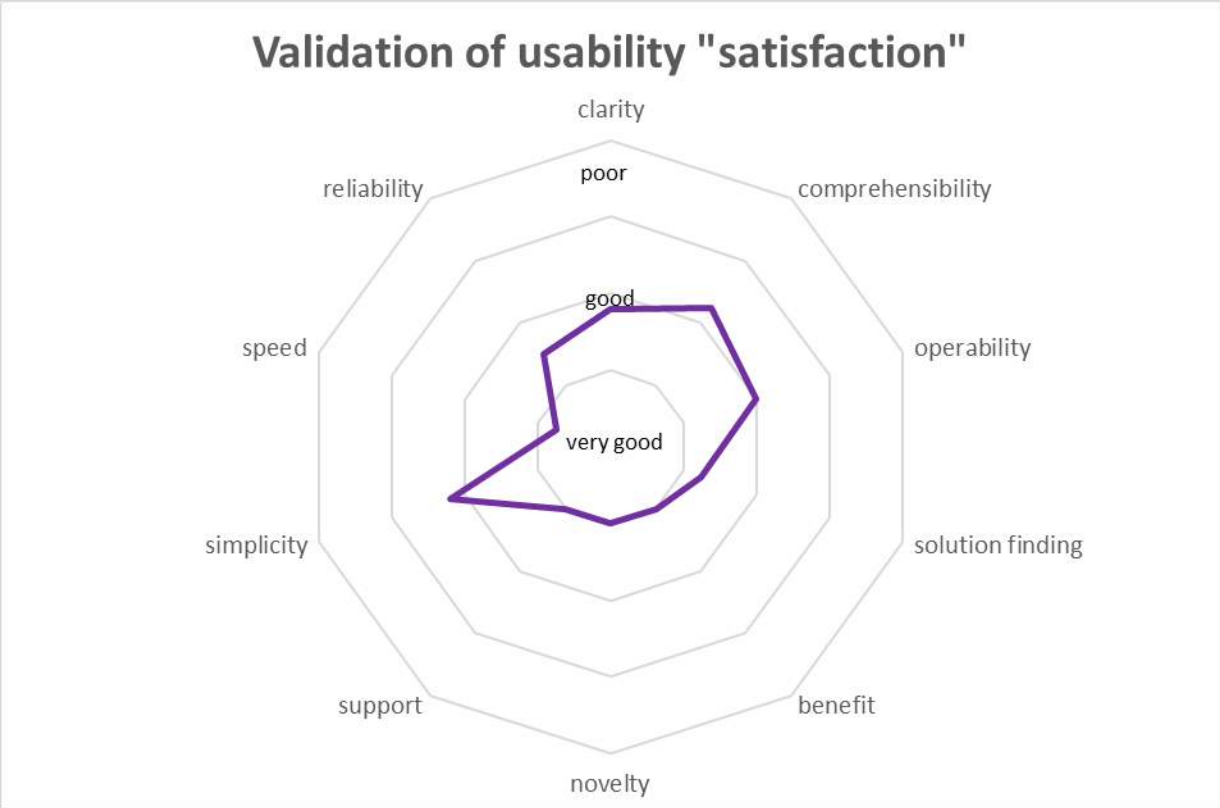


Figure 4.6: Qualitative evaluation of HumLog

Further assessments addressed the different planning capabilities of HumLog, which are used in the simulation in order to compute the result. These cover a simultaneous execution of the routing, procurement, demand, resource and human resource planning. Figure 4.7 highlights that all planning tasks are perceived as a good representation of the real-world planning and that they assist crisis managers in their work. Especially the routing and illustration of the routes to the crisis managers by the solution were very helpful to increase the situational overview. The above-mentioned integration with KeepOperational will most likely further increase this benefit.

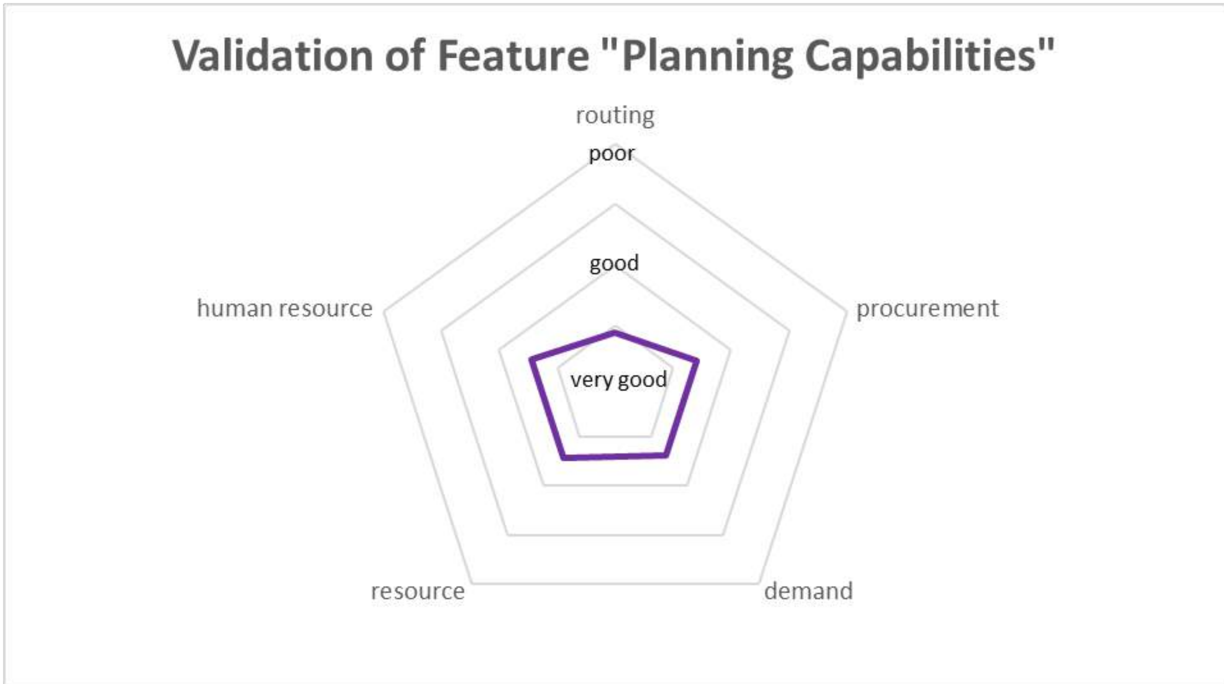


Figure 4.7: Evaluation of HumLog planning capabilities

Finally, the evaluation posted questions regarding the overall methodology presented by the HumLog solution (see Figure 4.8). Instead of addressing specific features and functionalities, they assess the level of acceptance among professionals. Every respondent answered to be able to achieve a better result in shorter time using HumLog and that such a solution like HumLog should be used in the future.

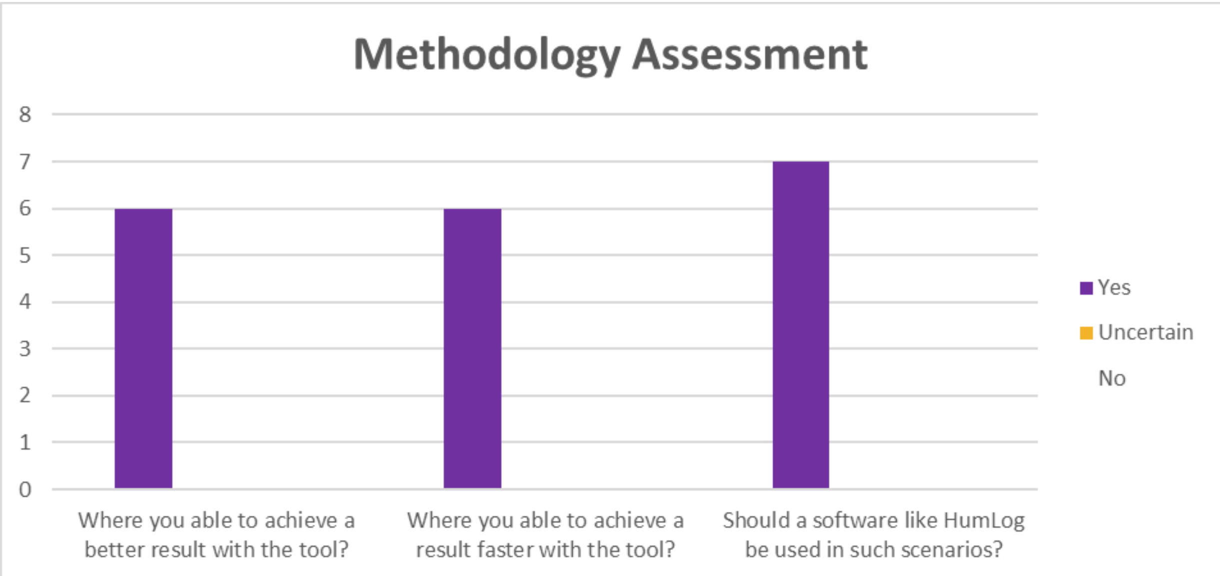


Figure 4.8: HumLog Methodology Assessment

4.4 ZKI-Tool

Regarding to Goal#1 it was of particular interest that all products prepared by ZKI could be executed and used without any technical problems on the provided hardware and software infrastructure. Due to the fact that only low hardware and software (free software) requirements do exist for the map products, no technical problems were expected in advance of the experiment regarding:

- Performance and quality of rendering and solution usability.
- Software (version) conflicts or inappropriate hardware settings.

Regarding Goal#3 it was of particular interest to provide functionalities that really support Crisis Management and logistics related decisions/activities ("Objective#3.1: - Assess whether the provided tools are a valuable support in CM"). Furthermore, it was expected that user feedback, which were either collected during oral discussions or by questionnaires, provide a better understanding on how tools (respectively functionalities) could be further adjusted and improved in order to better align them to end-users' requirements (See "Objective#3.1: - Assess whether the provided tools are a valuable support in CM").

As no problems did occur with installing and running of the all three map products as well as the video animation, Goal#3 can be regarded as fully fulfilled. Focusing on the user perspective, the experiment did provide several findings on how the ZKI-Tools can support Crisis Management, and on further developments. However, it turned out during the experiment, that the underlying storyline of the scenario did only provide limited space and time, where the map products could have been exhaustively explored and effectively applied. Thus, end-user feedback related to the map products fell a little bit short of expectations. However, a lot of valuable feedback and suggestions for solution optimisation have been collected in several discussions in advance, during and in the aftermath of the experiment.

4.4.1 The value of space- and airborne crisis information for logistics support

Even though the map products were only marginally applied during the experiment, a lot of insights and feedback concerning the map products as well as the geographic vector layers (particularly flood masks) have been obtained. The flood masks extracted from satellite imagery played a key role in situational awareness during the flood scenario, and several potential and synergies to other solutions are directly and indirectly connected with provided flood masks.

The masks were used to highlight roads that were possibly impassable due to flooding. This information was not only part in the map products, but also crucial for the DLR-solution KeepOperational that was frequently applied throughout the experiment. Thus, routing functionalities could be better adapted to the current hazard situation.

Flood layers, which were also displayed in KeepOperational, were directly copied by hand on analogues topographic map used by the THW during the experiment. In contrast, the control group had to obtain the same hazard (flooded areas, inundated roads) through time-consuming telephone conversation; furthermore, participants of the control group admitted in the aftermath of the experience that they would have also contacted the federal police of Germany to conduct a flight survey. However, also in this case, a further processing step would have been required to extract flood mask from raw image data, in order to rapidly update road networks in a larger area.

The ZKI-Tool, i.e. the extracted flood masks, did not only serve as an important input for the routing and navigation solution KeepOperational, other synergies have been identified with regard to the HumLog tool. The maps were used to roughly estimate the distance or area that needs to be protected with sand bags near the transformer station Rothensee. This means that the measurement results obtained from the map product provide a key input for the HumLog tool. Even though these digital measurements can be conducted faster and are safer compared to field-based assessments, they cannot fully replace them. However, a great value of earth observation hazard based hazard maps can be seen in the better coordination of field observations.

4.4.2 Suggestion for solution optimisation

There have been addressed several possibilities to optimize and improve solution functionalities, which have been raised during the solution presentation (in advance of the experiment), during and in the aftermath of the experiment.

Regarding the 3-D-PDF product, it was criticised that measurements considered only air-line distances and were not aligned to the topography of the land surface. Furthermore, it was mentioned, that an additional display of contour lines as well as elevation values during mouse-over would facilitate product handling and can easily be solved by the solution provider. A point that applies to the 3-D and Geo-PDF includes the wish of having the opportunities to change the coordinate systems between geodetic (UTM) and geographic formats (decimal degrees, degrees, minutes and seconds). This issue can also be easily solved.

These three improvements were solved with the 3D scene viewer and introduced during the debriefing workshop.

A general point that was raised several times includes the aim for flood forecasting, which would overcome two problems:

- The limited temporal availability of space-borne and aerial acquisitions and thus, derived flood masks.
- The fact of not having the possibility to forecast the flood area.

End-users mentioned that they cannot simply rely on navigation and emergency routing that is based on flood masks which are perhaps several hours old. Some streets that were not highlighted as "impassable" with the flood mask could have been inundated when the tool is actually applied. Furthermore, this applies also for needs assessment, as protection measures need to be planned in advance. As no tool can provide hydraulic flood modelling, which would require a lot of different data sets, a straight-forward solution which was discussed to include the extrapolation of the flood mask that is aligned with the observed, respectively expected change of the water level (at a certain gauge) and a digital elevation level.

Furthermore, the end-user is requesting information on inundation depth, in addition to the spatial extent. In combination with the above-mentioned wish for forecasting, inundation depth would help to better estimate the amount of sandbags (sandbag height) used for protection measures. Additionally, if depth information can be provided in a high vertical accuracy (+/- 1-2 dm), it would help to better estimate the cross-country mobility with emergency vehicles. If the accuracy is lower, indentation depth can be also used to better estimate potential flood damages and to evaluate the accessibility of affected areas. The derivation of inundation depth is currently subject of research within ZKI.

Although, the added value of the map products could only partly be demonstrated during the experiment, there has been obtained valuable feedback concerning the principle use of the map products as well as the geographic vector layer. As the measurement function in the 3-D PDF product still has some limitations, the GeoPDF, which is generally easier to apply, was mainly applied during the experiment. In general map products were mainly used for needs assessments. Geographic vector layers (flood masks, inundated roads) were predominately used to support navigation capabilities and situational awareness and situational briefing (both functions provided via KeepOperational).

In the questionnaire, the THW practitioners stated the GeoPDF as the most useful solution of the three provided ZKI products in the experiment. The handling of the ZKI products was perceived as unfamiliar by the THW practitioners but easy to learn and with more practice easy to handle (see Figure 4.9). Obviously from the responses to the questionnaire was, that the practitioners would definitely use the solutions in real Crisis Management situation – in preference the GeoPDF.

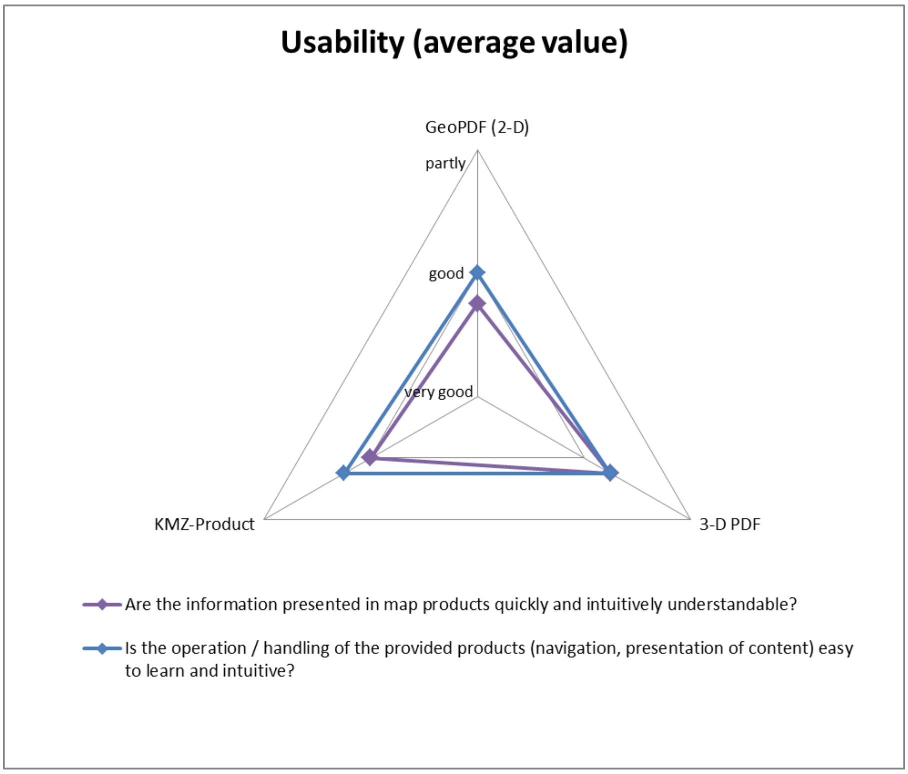


Figure 4.9: Validation of usability

4.5 U-Fly/3k

The experiment confirmed the added value of the system in Crisis Management and the interest for professional responders (Goal#3). This was endorsed by the questionnaire and the feedback sessions. The practitioners stated the features situational awareness and visualisation mainly as very good and helpful.

The Goal#2 (Objective#2.2: Assess whether the interoperability of U-Fly/3k and KeepOperational is sufficient) has already been assessed in EXPE40 and could be approved for a different region in EXPE44.

5. Lessons learned

In the following sections, the lessons learned of the experiment are pointed out and potential measures for improvement are presented. The section is divided in three subcategories: Organization/Logistics, Design of scenario & experiment and Technical aspects.

5.1 Organisation / logistics

The experiment showed that:

- F2F meetings and regular agreements are one major issue in the preparation phase of an experiment. Preparation workshops and frequent teleconferences help to facilitate a common understanding of the experiment and ensure satisfactory results. Besides a preparation time of at least 6-9 months – depending on size, scenario and participants – appeared to be sufficient for planning and definition.

Improvement proposal: At least one rehearsal should be included in the preparation phase of an experiment.

- Personnel and financial costs should not be underestimated. The preparation & execution of an experiment is very personnel and time consuming. It has to be mentioned, that the preparation and the execution of the experiment did more personal resources require than expected/planned. This in turn affects the resources/budget available in the project.
  - For example: In total two more persons had been needed for DLR and WWU duties during the rehearsal (one person for control centre (DLR) and one observer (WWU)).

Improvement proposal: The scenario has to be smaller, so that less participants and practitioners are needed.

- During the experiment the technical equipment (internet connection, power stations and hardware) provided by THW worked well. But it has to be remarked, that some of the provided solutions had technical problems in their performance (the list of bugs is attached in the annex (German version)). Considering this, following potential measures for improvement were identified:

Improvement proposal: A check of technical conditions (e.g. firewall restrictions, using solution in an external net) should be done in advance.

- The acoustic level with different working groups should be considered. It has to be remarked, that following had been noticed during the exercise:
  - When a lot of people spoke at once it was difficult, especially for the control centre, to listen to the phone and to conduct the tasks. This should be considered in respect of, that it is envisaged to invite guests to the experiment.
  - The volunteer groups could hear what the control centre spoke at the phone. In fact, the phone was useless and the groups could listen in on what the control centre told the other group. Consequently, the comparability of the groups is not ensured.

Improvement proposal: The groups should be spatially separated. Moreover, only DRIVER+ Consortium members (max. 5 people) should be invited to minimize the acoustic disturbance.

- The language barrier should be considered: EXPE44 is conducted in German, because the participants are German. If we invite international guests, we need either (a) simultaneous translation or (b) English speaking practitioners.
  - (a) This needs more effort (e.g. practitioners have to say, what they do, someone translates this in order that guests know what is happening) and could lead to acoustic disturbances distracting the practitioners.
  - (b) The number of English speaking THW practitioners, who are available and experienced enough to participate at the experiment is limited.

- Furthermore, it has to be mentioned, that the solutions had to be adapted to the scenario. Therefore, a lot of time is needed and the scenario should be defined in detail before the experiment date. Most time was spent in the preparation of EXPE44 due to: Data acquisition, integration of the data in the system, technical adaptions (e.g. creating flood mask, Interoperability of the solutions…).
- One remark is that THW Crisis Management personnel commonly perform exercises, where they train already established practices or equipment. They are not accustomed with experiments, where they test rather developing solutions (like the provided solutions) and perform in a controlled environment, which simplifies a number of details to a certain extent. Therefore, it took some time to make them aware of the differences in order to participate in a constructive way.
- Another remark is that the test persons were unfamiliar with the kind of provided solutions. Normally, they use only telephone/ radio. Therefore, some form of training/ briefing/ instruction was required. Finally, it took a significant amount of time until the practitioners feel knowledgeable enough to use the solutions in order to solve the given tasks. This, in turn, has implications for the sampling process of suitable practitioners.
    - Training the solutions before the experiment is important to receive valuable feedback. During the experiment it was shown that, a one Day Training for all solutions was not enough for the practitioners to use the solutions faultless.

      Improvement proposal: Providing practitioners access to the solutions (in advance) in order to validate them further on →THW would be interested.

- The planning of the experiment showed that the scheduling and designing of the experiment has to be considered very carefully due to platform availability, technical delays, scenario creation and availability of participants.

5.2 Design of scenario & experiment

The solutions used in the experiment are developed by different partners. Thus, much integration work was necessary. The DLR system is a combination of multiple components with varying purpose, all developed or utilized in different institutes of DLR. Although, the DLR components have been already connected in EXPE40 the focus in EXPE44 was another and adaptions were necessary. A connection between WWU and DLR systems never exists before.

Furthermore, the solutions had to be adapted to the scenario. Therefore, a lot of time for e.g. data acquisition, integration of the data in the system, technical adaptions, creating flood masks, was needed.

Due to the fact that the proposed systems focus on different levels and phases in Crisis Management a lot of effort was needed to create an appropriate scenario and experiment design that is suitable for all. On the one hand, a scenario and experiment design had to be developed that ensure the objective of the experiment and is realizable with the platform provider (e.g. suitable and available THW practitioners) as well as solution providers. And on the other hand, the proper contribution of the participants had to be coordinated regarding the experiment design and to each other.

THW Crisis Management personnel are not accustomed with experiments, where they test rather developing solutions (like the provided solutions) and perform in a controlled environment, which simplifies a number of details to a certain extent. Therefore, the scenario had to be designed in close cooperation with the platform provider who has the professional know how.

Another factor is that THW practitioners are, in contrast to full time staff, not always available. They commonly take time off from work in order to participate in the experiments. Hence, it requires some effort to identify enough THW volunteer personnel that is available during the experimentation phase.

To sum up, the experiment showed that:

- The planned scenario was not realizable one-to-one. Reasons for that were:
    - Practitioners in the Control Group were too familiar with the tasks. Besides they had a lot of practical experience with flood crisis situations. Therefore, they completed some tasks in a way

which is not consistent to common processes (and which was therefore even not foreseen by the THW professionals who helped to design the experiment scenario). As a result, the control group was considerably faster in handling the tasks than the Tool Group.
    - Furthermore, the area of responsibility of the practitioners changed during the exercise. In some tasks, it allowed the practitioners to delegate the tasks to another work level. Thus, they did not complete the task.
    - Practitioners in the Tool Group had been also very experienced but they had problems in using the provided solutions. They had not been familiar enough with the solutions. Therefore, they needed more time in solving the tasks.
    - The comparability of the groups was not ensured due to the above-mentioned points.
- Some tasks and functionalities were repeated often in order to see the learning effect. During the exercise, it was noticed that the discussion and feedback rounds provided more valuable results than the validating of repeating tasks/functionalities.

Improvement proposal:
- Adapting and shorting the scenario. Focusing on three main topics (situational awareness, routing and logistics).
- Optional: Additional rehearsal to test adaptions. This depends on the availability of time and resources.
- Consider if less experienced practitioners or experienced practitioners should be invited for the experiment. This depends on the purpose of the experiment.
- Keeping feedback and discussion rounds.

- The usage of the provided solutions makes only sense for practitioners dealing with management and communication tasks. During the exercise it was noticed, that the usage of the solution above this level is not helpful for the practitioners and would make no sense (e.g. to use the Solutions Internet connection is necessary, but in the field internet connection is not always give). This should be considered for the scenario design for other experiments.
- To create a scenario which suits to all solutions, the application field of the solutions should be considered. It has to be remarked, that HumLog is more eligible at the strategical level and is designed to be used from specially trained staff. This is quite different from KeepOperational and ZKI-Tool, which can be operated from all and can be used at strategical or operational level.
- After the experiment execution it was noticed, that for developing the scenario design they choice of involved participants are crucial. Open minded practitioners and solution providers have to be involved in the scenario design. E.g. the usage of HumLog was matched to the EXPE44. The EXPE44 have changed the way in which the solution is normally used. Therefore, the experiment does not display the common usage of Humlog. In retrospect not unsatisfactory, because the solution provider did not expect that this work and it worked well, but balance needs to be found.
- The EXPE44 showed that, replaying a real catastrophe, which already occurred in the region, is reasonable and should be considered in future experiments scenario designs in order to e.g. ensure realistic conditions, realistic data and realistic extent. The replay of a real catastrophe could be added by fictional cascading events. At least, a scenario should be chosen which is realistic to the region or rather could probably occur.

5.3 Level of representativeness/limitations

The limitations of this experiment are limitations generally found in comparable V2 maturity level experiments (46) and also related to any in-field experiment. In general, the maturity assessment dictates the nature of the evaluation and therefore the level of representativeness and limitations. In this experiment, the following limitations were identified:

- The results of the experiment are representative for logistics and transport management task processing under test on the level of a simulated crisis. Implications are limited to overall conditions, traffic conditions and events similar to this evaluation experiment.
- Only some data regarding different application cases can be gathered. Within experiment scenario only a small number of possible use cases can be considered.
- Due to the limited time, the experiment scenario was only executed once. The multiple execution of the experiment could increase significance of the results (e.g. logistical data quality, routing quality, processing time).
- The participating THW practitioners may not feel able to give an opinion, because they have not used the system in operative business and were not accustomed to work with the solutions before.
- Another limitation is the limited number of participating professional responders used in the evaluation that may influence the weight of the collected results.

6. Conclusions

Even though not everything worked out as it was envisaged, the execution of the experiment can generally be considered as a success. All steps of the experiment could be executed according to the scenario, even if the last day was rescheduled. The spontaneous change in the schedule did not influence the objectives of the rehearsal on the contrary it additionally enabled to collect further important suggestions from the practitioners regarding scenario and experiment design. Therefore, not only the solution functionalities had been validated by the practitioners also the whole experiment. All in all, the experiment can be seen as a success, because:

- All proposed solution functionalities were demonstrated and validated by the practitioners.
- The practitioners provided a lot of feedback which is helpful on the one hand for experiments in DRIVER+ and on the other hand to improve the functions for a more suitable solution for crisis managers.
- The experiment provided a lot of information regarding scenario design, experiment design, technical aspect and organization for the execution of experiments.
- The evaluation approach and the applied metrics were discussed thoroughly and proved to be adequate for the experiment.
- Experiment goals, except goal#2, could be achieved.

The main conclusion is that the THW practitioners see the provided solutions as a suitable solution for transport and logistics demands in Crisis Management. However, some improvements regarding technical and functional aspects are required to provide and guarantee more reliable and feasible solutions. The experiment showed that, the usage of the solutions can lead to an improved operation process regarding time saving and ease of use. But, according to the experiment results two main criteria must be met, in order to state the solutions as useful tools in CM:

- The solutions are only useful in certain situations e.g. rural area, nationwide operations and a wide range of available (routing) alternatives. If and which impact the solutions might have in other areas, esp. in comparison to already used tools, cannot be stated based on the experiment results.
- For an efficient usage of the solutions, experienced solutions operators are needed.

Although, the solutions cover relevant demands in Crisis Management, the practitioners express that not all features are obligatory worthwhile for THW related tasks but could be interesting for other professional responders (e.g. police, firefighters, etc.).

Furthermore, the experiment made clear, that the field inspections of the area of interest by a THW personal cannot be compensate by an IT-Tool. IT-Tools should not and do not absolve from thinking.

All in all, it can be stated, that the proposed solutions can generate an added value in CM in certain situations. For future experiments, the solutions can be utilized alone or in combination. Furthermore, the solutions are adaptable to changing circumstances/crisis situations (e.g. forest fire) A combination of all solutions is very appealing, because three areas could be covered: situational awareness, logistic and transport. The usage of the solutions depends on the experiment area, size and objectives.

Finally, it has to be remarked that the planning as well as the execution of those experiments is very personnel and time consuming due to various tasks (adapt solutions to the scenario, matching process, bringing together solutions, set-up and execute the experiment, train practitioners, develop questionnaires, evaluate the solutions and the experiment etc.).

References

1. **Kandel, N.** Disaster and Crisis Management. *International Seminar on Safety Leadership, Disaster & Crisis Management.* [Online] March 26, 2013. [Cited: April 04, 2016.] http://de.slideshare.net/nirmalkandel/disaster-and-crisis-management.

2. **Project ELITE.** Elicit to Learn crucial post-crisis lessons. [Online] project period: 2013 – 2014. [Cited: April 04, 2016.] http://www.elite-eu.org/index.html.

3. **Project CRISMA.** Modelling crisis management for improved action and preparedness. [Online] project period 2012 – 2015. [Cited: April 04, 2016.] http://www.crismaproject.eu/ and for final results http://www.crismaproject.eu/CRISMAbook.htm .

4. **Project FORTRESS.** Foresight Tools for Responding to cascading effects in a crisis. [Online] project period: 2014 – 2017. [Cited: April 04, 2016.] http://fortress-project.eu/ .

5. **Project KOKOS.** Unterstützung der Kooperation mit freiwilligen Helfern in komplexen Schadenslagen (KOKOS). [Online] project period: 2015 – 2018. [Cited: April 04, 2016.] http://kokos.wineme.fb5.uni-siegen.de/ .

6. **Project SECTOR.** Secure European Common Information Space for the Interoperability of First Responders and Police Authorities. [Online] project start: 2014. [Cited: April 04, 2016.] http://www.fp7-sector.eu/.

7. **Project EPISECC.** Establish a Pan-European Information Space to Enhance seCurity of Citizens. [Online] project period: 2014 - 2017. [Cited: 12 06, 2017.] https://www.episecc.eu/.

8. **Blecken, A.** *Humanitarian Logistics: Modelling Supply Chain Processes of Humanitarian Organisations.* s.l. : Bern et al.: Haupt Verlag, 2010.

9. **Beamon, B. M.** *Humanitarian Relief Chain: Issues and Challenges.* San Francisco, USA : 34th International Conference on Computers and Industrial Engineering, 13.-16. November 2004.

10. **Kovács, G. and Spens, K. M.** Humanitarian logistics in disaster relief operations. *International Journal of Physical Distribution & Logistics Management.* 2007, Vols. Vol. 37(2), pp. 99–114.

11. **Thomas, A. S. and Kopczak, L. R.** From Logistics to Supply Chain Management: The path forward in the humanitarian sector. [Online] 2005. [Cited: June 02, 2015.] http://www.fritzinstitute.org/pdfs/whitepaper/fromlogisticsto.pdf.

12. **Widera, A. and Hellingrath, B.** From Process Analysis to Performance Management in Humanitarian Logistics. *Managing Humanitarian Supply Chains: Strategies, Practices and Research.* 2013, Vol. Literature Series: Vol. Economics and Logistics, 1st ed., pp. 244–264.

13. **Charles, A., Lauras, M. and Tomasini, R.** *Learning from previous humanitarian operations, a Business Process Reengineering approach.* Gothenburg/Sweden : 6th International ISCRAM Conference, 2009.

14. **Mays, R., Racadio, R. and Gugerty, M.** *Competing Constraints: The Operational Mismatch between Business Logistics and Humanitarian Effectiveness.* s.l. : IEEE: Global Humanitarian Technology Conference (GHTC), 2012.

15. **Walton, R., Haselkorn, M. and Mays, R.** Defining "Fast": Factors Affecting the Experience of Speed in Humanitarian Logistics. *Proceedings of the 8th International ISCRAM Conference.* 2011.

16. **Jahre, M., Jensen, L.-M. and Listou, T.** Theory Development in Humanitarian Logistics: a Framework and Three Cases. *Management, Research News.* 2009, Vol. Vol. 32, No. 11, pp.1008-1023.

17. **Kunz, N. and Reiner, G.** A meta-analysis of humanitarian logistics research. *Journal of Humanitarian Logistics and Supply Chain Management.* 2012, Vol. 2(2), pp. 116–147.

18. **Leiras, A., et al., et al.** Literature review of humanitarian logistics research: trends and challenges. *Journal of Humanitarian Logistics and Supply Chain Management.* 2014, Vol. 4(1), pp. 95–130.

19. **Celik, M., et al., et al.** Humanitarian logistics. *Tutorials in Operations Research.* s.l. : pp. 18-49, 2012.

20. **Özdamar, L.** Planning helicopter logistics in disaster relief. *OR Spectrum.* 2011, Vol. 33(3), pp. 655-672.

21. **Trautsamwieser, A., Gronalt, M. and Hirsch, P.** Securing home health care in times of natural disasters. *OR Spectrum.* 2011, Vol. 33(3), pp. 787-813.

22. **Hu, Z.-H.** A container multimodal transportation scheduling approach based on immune affinity model for emergency relief. *Expert Systems with Applications.* 2011, Vol. 38(3), pp. 2632-2639.

23. **Mete, H. O. and Zabinsky, Z. B.** Stochastic optimization of medical supply location and distribution in disaster management. *International Journal of Production Economics.* 2010, Vol. 126 (1), pp. 76-84.

24. **vom Brocke, J., et al., et al.** Reconstructing the giant: On the importance of rigour in documenting the literature search process. *Proceedings of the 17th European Conference on Information Systems.* 2009.

25. **Webster, J. and Watson, R. T.** Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly.* 2002, Vol. 26(2), pp. 13-23.

26. **Besiou, M., Stapleton, O. and Van Wassenhove, L. N.** System dynamics for humanitarian operations. *Journal of Humanitarian Logistics and Supply Chain Management.* 2011, Vol. 1(1), pp. 78-103.

27. **Peng, M. and Chen, H.** Post-seismic supply chain risk management: A system dynamics disruption analysis approach for inventory and logistics planning. *Computers & Operations Research.* 2014, Vol. 42, pp. 14-24.

28. **Das, R. and Hanaoka, S.** Relief inventory modelling with stochastic lead-time and demand. *European Journal of Operational Research.* 2014, Vol. Issue 3, Vol. 235, pp. 616 – 623.

29. **Xanthopoulos, A. S. and Koulouriotis, D. E.** A Multi-agent Based Framework for Vehicle Routing in Relief Delivery Systems. *Humanitarian and relief logistics - Research issue, case studies and future trends.* 2013, pp. 167-182.

30. **Project RETISS.** Real Time Security Management System. Erfahrungen und Anwendungsempfehlungen. [Online] project period: 2010 – 2013. [Cited: April 04, 2016.] http://www.bast.de/RETISS/DE/Downlad/erfahrungen.pdf?__blob=publicationFile.

31. **Project SECUR-ED.** Secured Urban Transportation – A European Demonstration. [Online] project period: 2011 – 2014. [Cited: April 04, 2016.] http://www.secur-ed.eu/.

32. **Reulke, R., et al., et al.** Long-term Investigations of Quality and Reliability of the Video Image Detection System m3. *International Workshop on Traffic data Collection & its Standardization (IWTDCS 2008).* 2008.

33. **Döge, K.P.** *Videodetektion im Straßenverkehr. Signalmodelle und Analyseverfahren.* München : Oldenbourg Verlag, 2013.

34. **Huh, O. K., Roberts, H. H. and Rouse, L. J.** Remote sensing of coastal environmental hazards. *Earth and Atmospheric Remote Sensing.* 1991, Vols. Proceedings of SPIE, 1492, pp. 378-386.

35. **The International Charter Space and Major Disasters (International Charter).** The Internation Charter. [Online] 2016. [Cited: March 24, 2016.] http://www.disasterscharter.org.

36. **Voigt, S., et al., et al.** Satellite image analysis for disaster and crisismanagement support. *IEEE: Transactions on Geoscience and Remote Sensing.* 2007, Vol. 45 (6), pp. 1520-1528.

37. **United Nations Institute for Training and Research (UNITAR).** UNITAR's Operational Satellite Applications Programme – UNOSAT. [Online] 2016. [Cited: March 24, 2016.] https://www.unitar.org/unosat/.

38. **Center for Satellite Based Crisis Information (ZKI).** About the Center for Satellite Based Crisis Information (ZKI). [Online] 2016. [Cited: March 24, 2016.] https://www.zki.dlr.de/mission.

39. **European Commision (EC).** Copernicus Emergency Management Service – Mapping. [Online] 2015. [Cited: November 11, 2015.] http://emergency.copernicus.eu/mapping/ems/emergencymanagement-service-mapping.

40. **Oesch, B.** *Fernerkundung und Naturgefahren – Methoden für Risk/Disaster Management und Humanitäre Einsätze. Report for the Direktion für Entwicklung und Zusammenarbeit.* Switzerland : University of Bern, 2001. p. 88.

41. **Pesaresi, M., Gerhardinger, A. and Haag, F.** Rapid mapping assessment of built-up structures using VHR satellite data in Tsunami affected areas. *International Journal of Remote Sensing.* 2006.

42. **Gregory, M., et al., et al.** Commercial optical inter-satellite communication at high data rates. *Optical Engineering.* 2012, Vol. Vol. 51, No 3, pp: 031202-031202-7.

43. **Römer, H., et al., et al.** Using airborne remote sensing to increase situational awareness in civil protection and humanitarian relief - the importance of user involvement. *Remote Sensing and Spatial Information Sciences.* ISPRS Annals of the Photogrammetry, 2016.

44. **Detzer, Sandra, et al., et al.** *ASSESSMENT OF LOGISTICS AND TRAFFIC MANAGEMENT.* Barcelona : European Transport Conference, 2016.

45. **Widera, Adam, et al., et al.** *Integrated Logistics and Transport Planning in Disaster Relief Operations.* s.l. : ISCRAM 2017, 2017.

46. **EUROCONTROL.** European Operational Concept Validation Methodology (E-OCVM). Version 3.0, Volume I. . [Online] 2010. [Cited: April 07, 2016.] https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf .

47. **Project PROTECTRAIL.** The Railway-Industry Partnership for Integrated Security of Rail Transport. [Online] project period: 2010 – 2014. [Cited: April 04, 2016.] http://www.protectrail.eu/.

Annexes

Annex 1 – DRIVER+ Terminology

In order to have a common understanding within the DRIVER+ project and beyond and to ensure the use of a common language in all project deliverables and communications, a terminology is developed by making reference to main sources, such as ISO standards and UNISDR. This terminology is presented online as part of the Portfolio of Solutions and it will be continuously reviewed and updated[10]. The terminology is applied throughout the documents produced by DRIVER+. Each deliverable includes an annex as provided hereunder, which holds an extract from the comprehensive terminology containing the relevant DRIVER+ terms for this respective document.

Table A1: DRIVER+ Terminology

Terminology	Definition	Comment
Crisis Management	Holistic management process that identifies potential impacts that threaten an organization and provides a framework for building resilience, with the capability for an effective response that safeguards the interests of the organization's key interested parties, reputation, brand and value creating activities, as well as effectively restoring operational capabilities. Note 1 to entry: Crisis management also involves the management of preparedness, mitigation, response, and continuity or recovery in the event of an incident, as well as management of the overall programme through training, rehearsals and reviews to ensure the preparedness, response and continuity plans stay current and up-to-date.	
End-users	Individual person who ultimately benefits from the outcomes of the system	
Evaluation	Process of estimating the effectiveness, efficiency, utility and relevance of a service or facility	
Exercise	Process to train for, assess, practise and improve performance in an organization Note 1 to entry: Exercises can be used for validating policies, plans, procedures, training, equipment, and inter-organizational agreements; clarifying and training personnel in roles and responsibilities; improving inter-organizational coordination and communications; identifying gaps in resources; improving individual performance and identifying opportunities for improvement; and a controlled opportunity to practise improvisation.	
Experiment	Purposive investigation of a system through selective adjustment of controllable conditions and allocation of resources.	
Experiment design	Systematic methodology for collecting information to guide improvement of any process	
Lesson Learned	Lessons learning: Process of distributing the problem information to	

[10] Until the Portfolio of Solutions is operational, the terminology is presented in the DRIVER+ Project Handbook and access can be requested by third parties by contacting coordination@projectdriver.eu.

Terminology	Definition	Comment
	the whole project and organization as well as other related projects and organizations, warning if similar failure modes or mechanism issues exist and taking preventive actions.	
Portfolio of Solutions (PoS)	A database driven web site that documents the available Crisis Management solutions. The PoS includes information on the experiences with a solution (i.e. results and outcomes of Trials), the needs it addresses, the type of practitioner organisations that have used it, the regulatory conditions that apply, societal impact consideration, a glossary, and the design of the Trials.	
Scenario	Pre-planned storyline that drives an exercise; the stimuli used to achieve exercise objectives	
Trial	An activity for systematically finding and testing valuable solutions for current and emerging needs in such a way that practitioners can do this in a pragmatic yet systematic way.	

Annex 2 – EXPE44 Questionnaire

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Driving Innovation in Crisis Management for European Resilience

Questionnaire EXP44

Questionnaire to THW Volunteers

Instructions

In the following questionnaire feedback on the experiment 44 "Transport and Logistic Support" will be collected.

Please respond carefully and as accurately as possible.
Please do not leave any question unanswered.

Your information will be treated confidentially.
If you have questions you can always contact a member of the DLR staff.

Optional details:

Organization:	THW
Role in Experiment:	
Years of Experience:	
Date:	

1 23/05/2016

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Evaluation of KeepOperational

A) Assessment of provided solution

Please assess the solution KeepOperational.

1. How do you like the provided solution - all in all?					
very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
○	○	○	○	○	○

2. Please rate the following criteria for KeepOperational.						
	very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
Content / Information						
useful	○	○	○	○	○	○
detailed	○	○	○	○	○	○
up-to-date	○	○	○	○	○	○
replicable	○	○	○	○	○	○
benefit	○	○	○	○	○	○
comprehensible	○	○	○	○	○	○
Usability						
navigation	○	○	○	○	○	○
structure	○	○	○	○	○	○
load time	○	○	○	○	○	○
clarity	○	○	○	○	○	○
intuitiv	○	○	○	○	○	○
handling	○	○	○	○	○	○
Other						
coloration	○	○	○	○	○	○
reliability	○	○	○	○	○	○
novelty	○	○	○	○	○	○
font	○	○	○	○	○	○

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

3. Please answer the following questions.
If you reply a question with No, please write a note in the comment field.

	Yes	No
Could you manage the tasks more easily with the proposed solution?	☐	☐
Would you say that you could finish the tasks faster with the help of the provided solution?	☐	☐
From your perspective, would the provided features be helpful in crisis management?	☐	☐
Was a faster situation awareness possible?	☐	☐
Should be a software, like KeepOperational, instituted in crisis management?	☐	☐

Comment field:

4. What aspects/functionalities of the provided solution did you find too complex for everyday use? Please name them.

5. What aspects/functionalities of the provided solution did you find helpful for THW missions? What additional features could you imagine?

6. Could you imagine to use the proposed tool in real CM scenarios? If no: What concerns do you have with using the provided solution in real CM scenarios?

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

7. Do you have any further suggestions/remarks on the provided solution? Do you expect more functionalities and/or information?

Please rate the following functionalities of KeepOperational.

8. How do you assess the functionalties shown in the experiment?

	very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
traffic situation	○	○	○	○	○	○
routing	○	○	○	○	○	○
my places	○	○	○	○	○	○
closures	○	○	○	○	○	○
accessibility	○	○	○	○	○	○

9. Please rate the following criteria for the functionality „traffic situation".

	very good (1)	good (2)	partly (3)	less (4)	poor (5)	comment field
display traffic situation	○	○	○	○	○	
clarity	○	○	○	○	○	
color map display	○	○	○	○	○	

10. Please rate the following criteria for the functionality „routing".

	very good (1)	good (2)	partly (3)	less (4)	poor (5)	comment field
display alternative routes	○	○	○	○	○	
alternative routes distinguishable	○	○	○	○	○	

driver 4 23/05/2016

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

selection of route options	◯	◯	◯	◯	◯	
selection of car classification	◯	◯	◯	◯	◯	
faster situation awareness	◯	◯	◯	◯	◯	
print option useful	◯	◯	◯	◯	◯	

11. Please rate the following criteria for the functionality „my places".

	very good (1)	good (2)	partly (3)	less (4)	poor (5)	comment field
creating favorites	◯	◯	◯	◯	◯	
favorites visible in map	◯	◯	◯	◯	◯	

12. Please rate the following criteria for the functionality „closures".

	very good (1)	good (2)	partly (3)	less (4)	poor (5)	comment field
operability	◯	◯	◯	◯	◯	
display flood mask	◯	◯	◯	◯	◯	
clarity	◯	◯	◯	◯	◯	
identification of affected areas	◯	◯	◯	◯	◯	
identification of blocked roads	◯	◯	◯	◯	◯	
display ZKI products	◯	◯	◯	◯	◯	

13. Please rate the following criteria for the functionality „accessibility".

	applies (1)	rather correct (2)	partly (3)	rather not correct (4)	not correct at all (5)	comment field
Is the advice helpful?	◯	◯	◯	◯	◯	
Illustration clearly visible?	◯	◯	◯	◯	◯	
Size of area sufficient?	◯	◯	◯	◯	◯	

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

B) Evaluation of support

14. How did you like the training before the experiment?					
very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
◯	◯	◯	◯	◯	◯
Comment field:					

15. How did you like the assistance during the experiment?					
very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
◯	◯	◯	◯	◯	◯
Comment field:					

Comment field

Space for additional remarks

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Evaluation of ZKI products

16. Which of the provided ZKI products did you find most helpful or did you use mainly during the experiment?		
GeoPDF (2-D) ☐	3-D-PDF ☐	KMZ-Product ☐

17. Are the information presented in map products quickly and intuitively understandable?						
	very good (1)	gopod (2)	partly (3)	less (4)	poor (5)	Suggestions for improvements
GeoPDF (2-D)	◯	◯	◯	◯	◯	
3-D PDF	◯	◯	◯	◯	◯	
KMZ-Product	◯	◯	◯	◯	◯	

18. Is the operation / handling of the provided products (navigation, presentation of content) easy to learn and intuitive?						
	very good (1)	gopod (2)	partly (3)	less (4)	poor (5)	Suggestions for improvements
GeoPDF (2-D)	◯	◯	◯	◯	◯	
3-D PDF	◯	◯	◯	◯	◯	
KMZ-Product	◯	◯	◯	◯	◯	

19. Could you imagine to reuse the proposed products in real CM scenarios to support the situation assessment and operation planning?				
	yes (1)	uncertain (2)	no (3)	remarks
GeoPDF (2-D)	◯	◯	◯	
3-D PDF	◯	◯	◯	
KMZ-Product	◯	◯	◯	

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Comment field

Space for additional remarks

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Evaluation Ufly / Aerial images

20. Please rate the following criteria for the functionality „ Ufly / Aerial images".

	very good (1)	good (2)	partly (3)	less (4)	poor (5)	Comment field
situation awareness	○	○	○	○	○	
visualisation	○	○	○	○	○	

Comment field

Space for additional remarks

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Evaluation of HumLogSim

A) Assessment of provided solution

21. How do you like the provided solution - all in all?					
very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
○	○	○	○	○	○

22. Please rate the following criteria for HumLogSim.						
	very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
clarity	○	○	○	○	○	○
comprehensibility	○	○	○	○	○	○
usability	○	○	○	○	○	○
solution finding	○	○	○	○	○	○
benefit	○	○	○	○	○	○
novelty	○	○	○	○	○	○
assistance	○	○	○	○	○	○
simplicity	○	○	○	○	○	○
expedition	○	○	○	○	○	○
reliability	○	○	○	○	○	○

23. Please rate functionalities shown in the experiment.						
	very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
route planning	○	○	○	○	○	○
procurement planning	○	○	○	○	○	○
demand planning	○	○	○	○	○	○
ressource planning	○	○	○	○	○	○
personnel planning	○	○	○	○	○	○

24. Which additional functionalities or features could imagine? Please describe them briefly.

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

25. Which functionalities of the provided solution should be improved or removed from your point of view? Why?

26. Please answer the following questions. If you reply a question with No, please write a note in the comment field.		
	Yes	No
Could you manage the tasks more easily with the proposed solution?	☐	☐
Would you say that you could finish the tasks faster with the help of the provided solution?	☐	☐
Should be a software, like HumLogSim, instituted in crisis management?	☐	☐
Comment field:		

B) Evaluation of support

27. How did you like the training before the experiment?					
very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
○	○	○	○	○	○
Comment field:					

DRIVER Experiment 44
Questionnaire for THW Volunteers

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

28. How did you like the assistance during the experiment?					
very good (1)	good (2)	partly (3)	less (4)	poor (5)	I cannot assess
◯	◯	◯	◯	◯	◯
Comment field:					

Comment field

Space for additional remarks

Annex 3 – EXPE44 Feedback Questionnaire (in German, three months after)

Feedback Questionnaire EXP44

3 Monate sind seit dem Experiment 44 "Transport and Logistic Support" vergangen und die Teilnehmer des Experimentes gehen ihren gewohnten Tätigkeiten nach. In der Zeit konnten die Teilnehmer das Experiment und die zur Verfügung gestellten Tools verarbeiten. Möglicherweise sind dem einem oder anderen Ergänzungen, Fragen usw. gekommen, die während des Experiments oder der Feedbackrunden nicht zur Sprache kamen oder die Ansicht auf die Tools hat sich geändert. Dieser Fragebogen erlaubt ein letztes Feedback zum Experiment 44 rückblickend nach 3 Monaten.

1. Welche der Funktionalitäten von den zur Verfügung gestellten Tools sind Ihnen noch bekannt?

2. Welche von den genutzten Funktionalitäten fänden Sie für den operativen Einsatz hilfreich?

3. Können Sie sich weiterhin vorstellen, die vorgestellten Tools im operativen Einsatz zu verwenden? Wenn nein, welche Bedenken haben Sie?

4. Was muss ein Tool können (z.B. Funktionalitäten), um Sie bei Ihrer Arbeit in einer Krisensituation zu unterstützen bzw. dass sie es verwenden?

5. Finden Sie, dass Experiment zu lang, zu kurz oder in etwa genau richtig war?

- ◯ Viel zu lang
- ◯ Zu lang
- ◯ In etwa genau richtig
- ◯ Zu kurz
- ◯ Viel zu kurz

Annex 4 – EXPE44 Experiment Schedule

Experiment schedule

Time	Topic	Tasks	Duration
07.03.2016 – DAY 1			
10:15 – 11:00	Setup	Setup of the experiment	45min
11:00 – 11:30	Test	Technical tests	30min
11:30 – 14:00	Launch + Briefing	Introduction of the experiment, introduction of participants, presentation of solutions	2:30h
14:45 – 16:45	Training	Training of the used solutions in the experiment with the practitioners (THW staff)	2h
16:45 – 17:30	Questions	Time for questions	45min
08.03.2016 – DAY 2			
08:00 – 09:00	Briefing	Morning briefing	1h
09:00 – 16:30	Segment 1 – Segment 4 Introduction	Execution of tasks in segment 1 - segment 4 including short feedback session (flash feedback & discussion) after every segment	06:45h
16:30 – 18:00	Feedback & evaluation	Big Feedback & evaluation session	1:30h
09.03.2016 – DAY 3			
08:00 – 08:10	Briefing	Morning briefing	10min
08:10 – 10:20	Segment 5	Execution of tasks in segment 5 including Short feedback session of SEG 5 (flash feedback & discussion)	2:10h
10:20 – 12:00	Removal	Removal of experiment setup	1:40h
13:00 – 15:00	Lessons Learned	Interviews of experiment participants (practitioners & observers)	2:00h

It has to be remarked, that the schedule at day 3 was changed. During day 2 it was noticed that the original plan of day 3 makes no sense due to repetitive tasks and features. It was decided unanimously to use the time slot of segment 5 for group discussion regarding upcoming experiments and suggestions for tool optimisations.