PFG 2010 / 6, 489 – 497
Stuttgart, Dezember 2010

Article

Applying Advanced Techniques to the Dissemination of Satellite Based Crisis Information

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Keywords: Satellite based crisis information, DeSecure, interactive 3D environments, web mapping

Summary: Two approaches for the dissemination of satellite based crisis information have been developed within the DeSecure project: dissemination in 2D web clients and interactive 3D near real time scenarios. Compared to printed maps, the advantages of these new approaches are the possibility of interactive exploration as well as near-real-time updates of the information provided. This paper analyzes the potential users, their requirements, the mission scenarios, and describes the solutions developed.

Zusammenfassung: *Neue Ansätze für die Verbreitung satellitenbasierter Kriseninformation*. Im Projekt DeSecure wurden zwei neue Ansätze für die Verbreitung satellitenbasierter Kriseninformation entwickelt: Die Verbreitung unter Nutzung von interaktiven 2D Kartenanwendungen sowie über Nah-Echtzeit 3D Szenarien. Diese neuen Ansätze haben gegenüber der bereits etablierten Veröffentlichung über gedruckte Karten einige deutliche Vorteile. So kann u. a. die Information einerseits interaktiv exploriert werden und andererseits besteht die Möglichkeit der Aktualisierung in Nah-Echtzeit. In diesem Artikel werden die potentiellen Nutzer und deren Anforderungen sowie entsprechende Einsatzszenarien analysiert und die entwickelten Lösungen beschrieben.

1 Introduction

Today, the dissemination of satellite based crisis information using printed maps is well established by most of the leading organizations involved in emergency mapping (e. g., Centre for Satellite Based Crisis Information (ZKI), SERTIT, MapAction). DeSecure is a joint research project with the objective of improving satellite based crisis information (SBCI) workflows. The entire production cycle of e. g., data access, information extraction and dissemination was analysed during the project duration from 2007–2010.

This paper describes two approaches for disseminating crisis information to the user. The first approach addresses the application of recent web mapping technologies to satellite based crisis information (SBCI) to ensure that continuously updated data are delivered to the user. In the second one, modern interactive 3D visualization software is applied for communicating information during a crisis. Combining the advantages of web mapping technologies with the intuitive understanding of 3D virtual worlds, the focus of our research was on developing a concept for implementing earth observation and GIS data in virtual environments and improving the user interfaces to allow for fast and easy information access.

Since 2003, the ZKI of the German Aerospace Center (DLR), the leading German provider of satellite based crisis information (SBCI), has delivered such SBCI maps to customers engaged in emergency response and/or relief activities. These maps provide detailed and highly valuable information. A printed map has specific advantages. The information they contain is distinctly arranged and focuses on a specific topic. Printed maps allow orientation as well as measurement. They are high-

 www.schweizerbart.de
DOI: 10.1127/1432-8364/2010/0070 1432-8364/10/0070 $ 2.25

ly suitable for in-field operations, primarily in environments where electronic infrastructure is not available or damaged. Furthermore, a map is a well-known medium familiar to most people. In contrast to these advantages, printed maps have major disadvantages, particularly in the context of the dissemination of satellite based crisis information: Maps are outdated at the time of printing. This lack of timeliness comes along with limited updating options. An update means the creation of a new map, a new print-out and physical delivery to the user. Moreover, a map is static and thus does not support user-driven generation of new information through the interactive exploration, analysis and synthesis of information provided in an interactive environment (MacEachren & Kraak 1997). Furthermore, a user always needs to decode a map for example; the existence of contour lines in a map does not necessarily mean that every user is able to generate the correct idea of the topography of a certain site. Thus, creating a mental map of a certain region by decoding a topographic map might be difficult, because the user needs to first learn/acquire these skills, which would not be necessary using a virtual 3D environment (cf. Häberling 2006). The development and rendering of complex 3D visualizations are normally very time consuming. Recent developments in the real-time 3D sector, e. g., using game engines for visualizations will in the near future allow utilization even in time-critical environments (Fritsch & Kada 2004). In DeSecure Tüngerthal (2009) demonstrated the visualization of a fictive crisis scenario using the CryEngine. Within DeSecure such advanced techniques were applied to disseminate SBCI.

2 Potential User and Mission Scenarios

Maps containing SBCI are mostly used to disseminate information to relief organizations, operational centers, on-site crisis teams and the public. Therefore, potential users of interactive 2D and 3D crisis maps are organizations dealing with crisis situation, the public and the media. These users need precise, up-to-date and easy-to-understand information at hand. Web mapping services and interactive 3D environments deliver permanently updated data to the user in near-real-time, and they offer the possibility to interactively exploit this data to create new information.

Due to the anticipated lack of infrastructure in a crisis region the focus of this work is mostly on supporting teams in operational centers. Some of the possible applications scenarios are

- pre-disaster mission briefing,
- real-time team/crisis management
- common operational picture (COP)
- post-disaster analysis
- training of crisis response teams

During a crisis event such new visualization techniques will help to coordinate different relief organizations and to communicate with on-site teams. Decision making will be supported even in very stressful environments. Interactive 3D real-time scenarios can help to obtain a common operational picture of all the organizations and persons involved, which in turn facilitates crisis operations and the coordination of on-site teams.

3 New Approaches for the Dissemination of Satellite Based Civil Crisis Information

3.1 *Web Mapping Component*

Dissemination of spatial information through interactive web clients is well established (Mitchell et al. 2008), except for the dissemination of SBCI. What are the requirements for this task?

An analysis of SBCI user requirements (DeSecure Consortium 2009) reveals the need for tools that enable the exploration of the information provided (e. g., zoom in/out, pan, layer switch on/off, identify, print). Most of today's web mapping clients (e. g., OpenLayers, Mapbender or ESRI's Sample Flex Viewer) already provide these functions by default. The challenge in providing SBCI through interactive web clients is the configuration of the client and the underlying services in a reliable, fast and easy way. A common development scenario for a web mapping component, e. g., in the public sector, needs from several days to weeks before a client is made available online. However, a web mapping client for the dissemination of SBCI has to be published within a very short time frame. From the user's point of view, a reference product based on pre-disaster satellite imagery has to be delivered within the first eight hours, and a damage assessment product within 36 hours after the outbreak of the event. (DeSecure Consortium 2009). Due to the general limitations of satellite imagery acquisition (satellite commanding, orbit specifications, weather conditions), these user requirements can often not be met. The ZKI aims to deliver crisis products within eight hours after acquisition of the specific satellite imagery has been completed. In this context knowing the requirements of the specific producers of SBCI is of major importance for building an adequate solution for very fast dissemination of web mapping clients. Analysis of the technical and human resources framework at ZKI (DeSecure Consortium 2010) shows that there is a need for quick and easy web service compilation, smooth performance of the services, and user-specific configuration of web mapping clients using a content management system (DRUPAL).

This analysis leads to a solution mainly based on ESRI technology. In addition, the CMS DRUPAL has been customized. An adapted version of the ESRI Sample Flex Viewer was chosen as web client (see Fig. 1), due to the easy configuration via XML, the functionality, and a widget concept which enables easy and modular customizing and satisfies ergonomic aspects. Furthermore, the CMS DRUPAL was augmented by two user interfaces supporting the process of client configuration (registration of services and configuration of the client). This technical framework enables the dissemination of SBCI via web clients at ZKI in a fast and easy way, as follows (see Fig. 2).

In the first step a copy of the map documents (mxd) from the map production process is configured for the specific service. All settings that are made in the map document are handed over to the service. This includes, e. g., deleting redundant content, setting maximum or minimum extent, as well as adapting symbology, if needed. A structured approach in the creation of the origin map document in the map production process minimizes the effort of this service-specific configuration.

The configured map documents are then published as a web service. Using ArcGIS Server the needed data could be published as services within a few clicks supporting several interfaces (e. g., REST, SOAP, WMS, WFS, WCS, KML). Good performance of the ArcGIS Server services is guaranteed by following the ESRI recommendations for capacity planning (see, e. g., Peters 2007). The URLs to the REST, and if needed to other interfaces of the published services, are registered in the Content Management System (DRUPAL). When service registration is completed, a client could be configured in about three minutes using the implemented client configuration user interface. The CMS also supports the

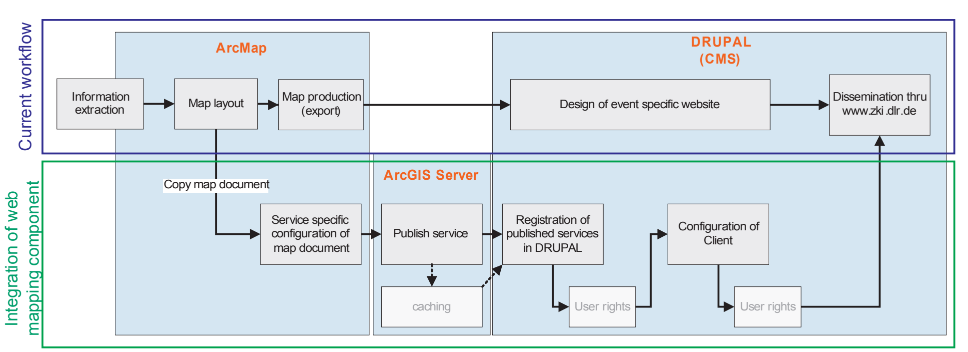

Fig. 1: Workflow of the solution for a web mapping client compilation at ZKI.

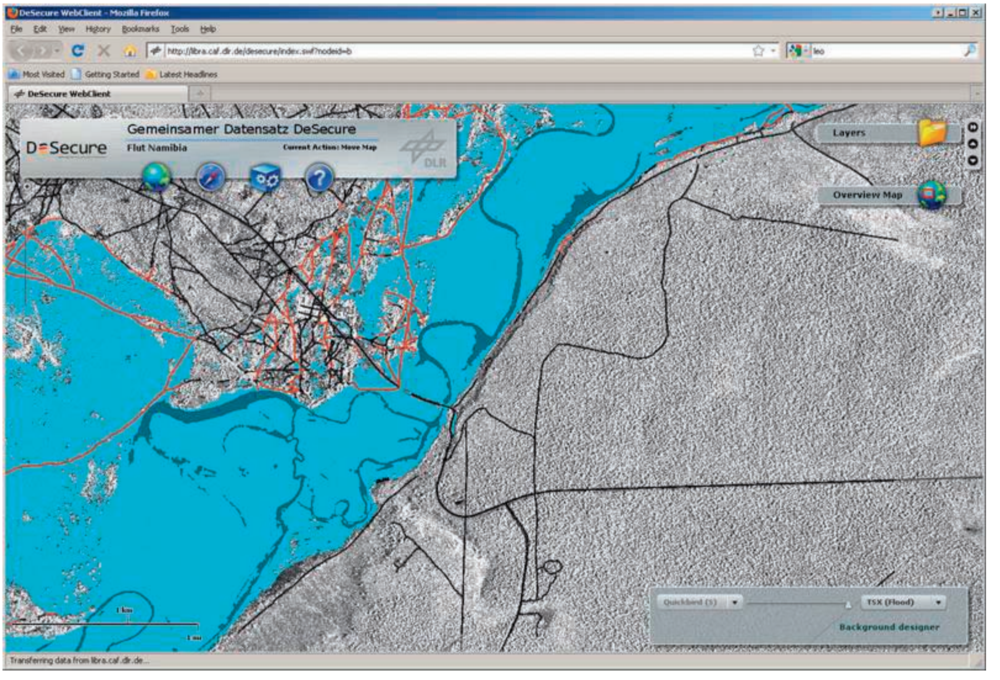

Fig. 2: Screenshot of a ZKI Web Client for the Namibia flood, Caprivi region 2010 (an adapted version of the ESRI Sample Flex Viewer).

definition of access rights for services and client configurations. Thus, after login a user is able to access services and clients via the CMS (ZKI home page), where appropriate access rights have been granted. When a client is activated by a user, a configuration XML is dynamically generated in the background according to the configuration settings and passed over to the Flex client. Updating the client (e. g., adding new services, functions) can also be performed with a few clicks using the implemented configuration interface.

3.2 *Interactive 3D Real-time Scenarios*

3D real-time virtual environments come closer to how we normally see the real world (cf. Slocum et al. 2000) and thus enable even the non-expert (regarding geo-science, cartography, etc.) to navigate easily. Many decisions of stakeholders are based on spatial information (cf. O'Connor 2007). Interactive visualizations in virtual geographic environments (VGE) help people to navigate and understand the information inherent in spatial data sets (cf. O'Coill & Doughty 2004).

Decision making in a distributed team is easier if all work at the same knowledge level, with the same understanding, and roughly the same view of the affected area. According to Lin & Zhu (2006, p. 228) the accessibility of a virtual environment and the ability to share multi-user environments which enable geo-collaboration are key features of virtual geographic environments. Permanently updated geo- and 3D-information assures that the most recent information is available for decision making as soon as possible.

The application of virtual geographic environments or 3D GIS in the civilian crisis management sector is under development, and still not common in operational use in situation rooms. Tiede & Lang (2010) show the value of analytical 3D views also in the context of a simulated crisis exercise. The French joint emergency management operational center (COGIC) uses a 3D visualization system for emergency mapping (see COGIC 2010).

Many of the related initiatives of the European Union like ORCHESTRA (an open service architecture for risk management) and OASIS (open advanced system for disaster and emergency management) are still restricted to 2D (ZLATANOVA 2008). However, ZLATANOVA (2008) states that large amounts of 3D data are increasingly available, that disaster management users are prepared to use this data, and that 3D is considered important by the user. The main goal is to support and facilitate the process of decision making.

For a first overall test DLR used the Leica Virtual Explorer to show some basic applications during two real-time exercises in 2006 and 2007 (GNEX'06 and GNEX'07) within the GMOSS (Global Monitoring for Security and Stability) network of excellence (VOIGT et al. 2009). Within DeSecure DLR collected user requirements in face-to-face interviews with THW (the German Federal Agency for Technical Relief) staff and at an International Search and Rescue Advisory Group (INSARAG) training session. The interviews revealed that 3D information is needed and already used (e. g., Google Earth) from time to time by crisis teams. Such systems could help in the planning and acquisition phases. But the users also stated that too realistic information could lead to misinterpretation because the user might accept the presented virtual information as true without questioning the reliability of the underlying data (TÜNGERTHAL 2006). The collected user requirements were integrated into a requirements catalogue. Based on the experience gained, a market analysis was conducted and Skyline TerraExplorer was selected as the most appropriate commercial software product at that time. Advantages of the Skyline software are very high 3D performance based on a former game engine, collaboration services, streaming server availability, connectors/importers for various GIS, and the availability of remote sensing data.

Skyline TerraExplorer (see Fig. 3) was used in a client-server installation and tested during several selected crisis scenarios. Firstly, a virtual environment of the Pakistan earthquake in 2005 was created to test the potential of the software. One goal of 3D virtual environments is to guide potential users as well as possible and to avoid their getting lost in a too complicated virtual environment and missing important information (cf. MENG 2003). The built-in user interface of Skyline TerraExplorer could become quite confusing and the user has either to search the data sets in a tree structure or follow a strict guideline on how to structure the various data sets. This is not appropriate for emergency situations. Therefore, several additional tools were developed to facilitate the handling of Skyline TerraExplorer to give even the non-expert an easy-to-use virtual environment which according to TUFTE (2007) gives to the observer the greatest number of ideas in the shortest time. In order to guide the user through the virtual environment, two extensions were created, a "visibility manager" for a clear overview of information layers and a "location manager" for fast and easy navigation to selected places. In addition, a connec-

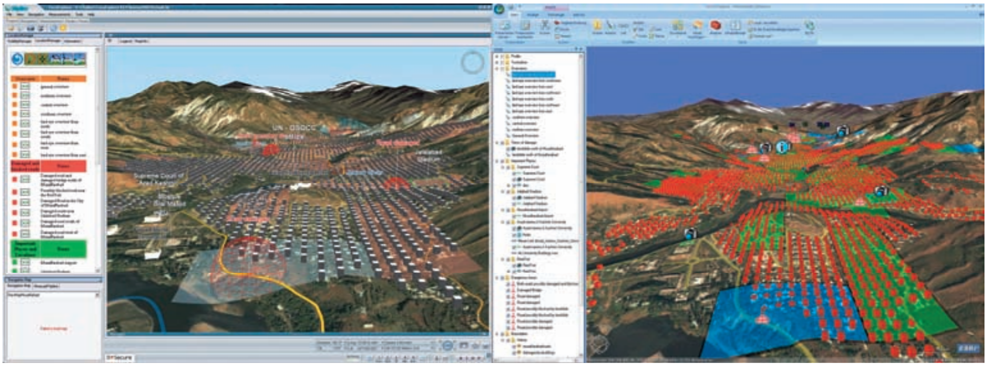

Fig. 3: Virtual Environment of the Pakistan 2005 earthquake. Left: Skyline TerraExplorer; Right: ArcGIS Explorer.

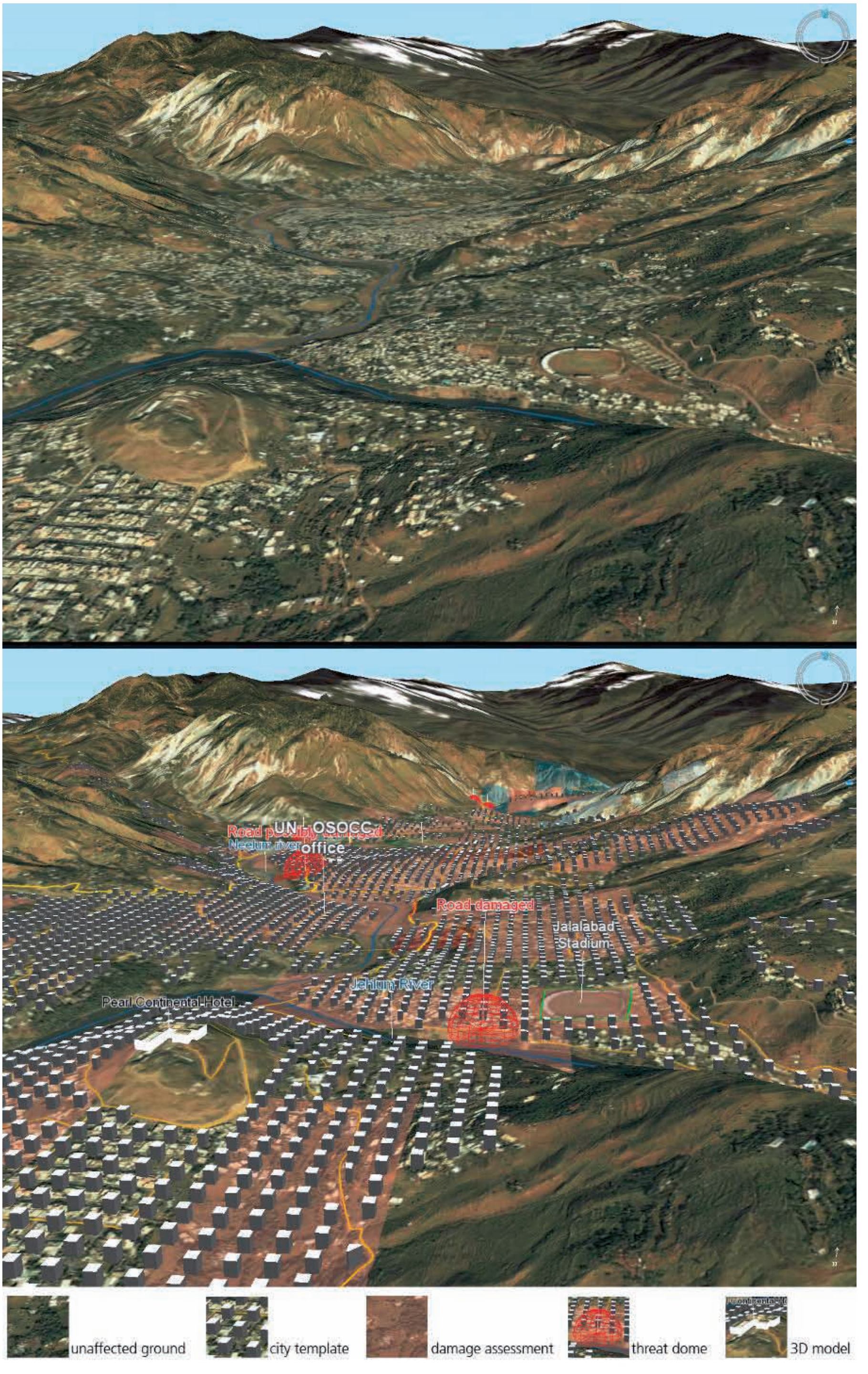

Fig. 4: Development of the virtual Pakistan 2005 scenario according to the phases of the process concept. *Upper image*: Phase 2 – basic scenario with satellite data only; *lower image*: Phase 4 – construction of 3D objects such as threat domes and text labels.

tor to Google Maps was created to allow the exploitation of other sources. Based on user requirements a static map legend using the existing ZKI layout was also added (cf. WODITSCH 2010).

Based on the experience described above, a concept for a process chain to create interactive 3D virtual environments was generated using the Pakistan 2005 scenario. This concept was tested during a second DeSecure crisis scenario, the Okavango flooding in 2009, and in a third real-time crisis exercise during the Assessment Mission Course 2009 in Cyprus (LIMES project, cf. GSTAIGER et al. 2009) The process chain was modified as necessary and a timeline was derived during those scenarios.

The concept consists of four steps (see Fig. 4):

1. 3D oriented geo- data pre-processing
   Availability: recurring during all following steps
2. Basic scenario – e. g., only basic geo-information for a first orientation
   Availability: within 2–3 hours online or on DVD ready for the on-site teams before deployment
3. Crisis scenario – containing the basic scenario, additional vector data, on-site data, 3D objects
   Availability: within 3–7 hours online or on DVD
4. Update – permanent update of geo-data, adding new data sets, e. g., results from other geo-processing/classifications
   Availability: > 7 hours online

All tests during the exercises showed that the basic VGE could be created during the given time frame in phase 2, provided that earth observation data sets are available. Also, the crisis scenario with updated information, additional 3D objects and improved vector data as well as classified information could be delivered within seven hours of phase 3.

The concept of the process chain was also applied to other freely available 3D software packages such as ArcGIS Explorer and OSSIM Planet. Neither is comparable to Skyline in terms of speed, multi-users and collaboration services. The ArcGIS Explorer has advantages because of its simple user interface and its close integration into the ESRI software environment and thus it could easily connect to a variety of GIS services. The already developed virtual 3D crisis scenarios will also be applied to this software.

During the exercises collaborative work within the 3D interactive virtual world was realized using standard PC workstations. Four partners, the ZGIS in Salzburg, Joanneum Research in Vienna, EURAC in Bozen and DLR Oberpfaffenhofen worked simultaneously in the VGE, added new datasets and "discussed" online in a collaborative session inside the VGE. For presentation purposes mobile computers with slow graphics hardware were used. A streaming feature server using Skyline or Leica software (during GNEX)) was installed at DLR and the virtual environment was streamed both via internal high bandwidth LAN connections as well as via relatively slow internet wireless LAN connections.

The minimum requirements to use real-time 3D crisis scenarios are LAN or W-LAN connections, standard PC workstations or laptops. Recent research initiatives try to establish ad-hoc networks even on-site in the emergency region (FRASSL et al. 2010, OASIS CONSORTIUM 2005).

The next step will be the generation of an operational generic process chain applicable to different real-time 3D packages to create and update 3D VGEs automatically from available remote sensing and other geo-data sets. Integrating web mapping and a web-feature service as described above is one of the future key elements to ensure up-to-date satellite based information availability also in interactive virtual 3D environments.

4 Conclusion

Dissemination of satellite based crisis information in a timely manner during a crisis is crucial for relief organizations and teams in situation rooms to support rapid and reliable decision making. The experience gained in DeSecure concerning the development of new dissemination channels for satellite based crisis information can be summarized as follows:

- The information provided by both 2D web-mapping products and 3D environments can be interactively explored and exploited by the user and thus new information can be generated.
- Digital mapping products can be updated either permanently or when new information/maps are available. Thus the most up-to-date product can always be delivered.
- Time consuming decoding of map information will be reduced to a minimum, which accelerates the decision making process based on the same high quality information.
- Supplementary, 3D interactive environments support situation rooms and very likely enable the staff in charge to intuitively understand the on-site environment and geography.
- Decision making will be conducted on a more consolidated basis, e. g., teams in situation rooms as well as on-site teams can now share a common operational picture (COP) without having to decode the information from printed maps.
- Because the authors work in close cooperation with the ZKI, the 2D and 3D solutions developed can be constantly tested during real crisis scenarios and further improved.

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Manuskript eingereicht: Juni 2010
Angenommen: September 2010