VALIDATION OF THE MANAGEMENT OF PAST CRISIS AND DISASTERS

Georg Neubauer, Alexander Preinerstorfer, Stefan Schirnhofer, Heinrich Humer

AIT Austrian Institute of Technology GmbH
georg.neubauer@ait.ac.at, alexander.preinerstorfer@ait.ac.at, stefan.schirnhofer.fl@ait.ac.at, heinrich.humer@ait.ac.at

Gerald Lichtenegger, Wolfgang Vorraber

Graz University of Technology
gerald.lichtenegger@tugraz.at, wolfgang.vorraber@tugraz.at

Harold Linke

HITEC Luxembourg
harold.linke@hitec.lu

Giovanni Tusa

IES Solutions
g.tusa@i4es.it

Roman Gruener, Carsten Dalaff

German Aerospace Center DLR
roman.gruener@dlr.de, carsten.dalaff@dlr.de

Snjezana Knezic

University of Split
snjezana.knezic@gradst.hr

Manfred Blaha

Public Safety Communication Europe Forum
manfred.blaha@psc-europe.eu

Keywords

Interoperability, inventory, key indicator, requirements, crisis and disaster management, affected infrastructures

Abstract

Interoperability of stakeholders is a predominant requirement of crisis and disaster management. Within the EU-project EPISECC a concept of a common information space is under development in order to facilitate European crisis and disaster management. A pre-requirement to set up such an information space is the in depth analysis of the management of past disasters with focus on interoperability. For this purpose an inventory on the management of selected past disasters was developed. The information for the inventory was achieved by systematic expert interviews using specifically developed online questionnaires. Multiple crisis and disaster managers that are active nationally, internationally or on both levels were interviewed in order to obtain the necessary information. Selected results obtained by this inventory are described in the frame of this paper.

1. Introduction

Adequate information exchange between different actors involved in crisis and disaster management is an imperative requirement necessary for efficient and adequate execution of processes of stakeholders such as first responders in all phases of the crisis management cycle. In the past it turned out that mainly, but not only, cross border information exchange was hampered during the management of past, large scale European disasters. In order to improve the situation a multitude of European projects were launched dealing with approaches dedicated to optimize interoperability. Examples of such European projects are REDIRNET (Redirnet, 2016), SECTOR (Sector, 2016) and SECINCORE (Secincore, 2016), an example of a national project is the Austrian project INKA (Inka, 2016; Lichtenegger, 2015). A pre-requirement of most of these projects is to analyze the strength and weaknesses of process execution that took place in past disasters. In the frame of the project EPISECC (FP7-SECURITY, grant no. 607078) a specific data model was set up in order to develop an inventory on how past disasters were managed. This data model and the inventory were already described in detail in (Neubauer, et al., 2015), this paper included the results of more than 40 interviews performed with European crisis managers by applying the inventory.

2. Methodology

2.1. The data model and the applied tool

EPISECC is aiming at improving the collaboration and the interoperability among first responder organisations, police authorities and other stakeholders in large scale disaster situations. The key element, a concept for a common information space, is developed and validated within the project. Therefore, a pan-European inventory of past critical events/disasters and their consequences focusing on the performance of processes, the data exchange and the organizational boundaries was developed. A detailed description of the following, shortly summarizing chapter can be found in (Neubauer, et al., 2015). The inventory was filled with relevant information in four essential steps: First the data model was developed, which is the starting point for analyzing the management of past critical disasters. It consists of relevant areas of information, such as tools, processes or data (Huebner, et al., 2015). Within these areas, specific fields of information are defined (e.g. process type, process name in case of the area of information “process”) which include all information provided by stakeholders. In order to ensure that the inventory is filled with useful knowledge, stakeholders such as the Austrian Red Cross or the German Federal Agency for Technical Relief (THW) were incorporated to provide questions on missing and relevant information related to disaster management with focus on interoperability, understood as the ability to exchange information between different systems (Delprato, O'Brien, Nuessler, & Bousema, 2014) and efficiency. Since answers to such generic questions would be mainly descriptive and are not directly suited to be quantified and compared with available information, a step by step process described in (Neubauer, et al., 2015) was developed to convert a generic question into “subquestions” which are answerable using only predefined fields of information. This led to the development of an online questionnaire and to final interviews of crisis managers with focus on, but not limited to the strategic level in order to identify and analyze relevant information on the management of past disasters.

2.2. Data provision - selection of interviewees

At the current stage 49 representatives from organizations involved in crisis and disaster management provided information for the inventory. A majority of 78 % of these organizations declared themselves to be governmental, 14 % were NGOs and the others were distributed over other categories. Many partners of the FP7 project EPISECC were involved in the provision of data for the inventory leading to a good distribution of organizations that were interviewed all over Europe. In total, organizations came from 19 out from 28 member states, in addition organizations from Norway, Iceland and Israel were interviewed. On the other hand, it has to be stated that the distribution over the European countries is far from being equal. For instance, 17 interviews were performed in Austria, 5 in Italy and 5 in Croatia. This distribution has impact on the general representativeness of the inventory data in a pan-European context. Another approach to analyze the type of organizations being interviewed is demonstrating that 33 % of the organisations providing information are acting predominantly in the civil protection / crisis management domain, the second largest category is fire rescue services (19 %). Emergency Medical Services reach 13 %, whereas the category Police obtains 11 %, the remaining 24 % belong to other type of organisations.

The project partners approached more than 100 persons from different European organizations and convinced about 50 % of them to perform interviews. Sending the questionnaire link to stakeholders turned out not to be a successful approach due to the complexity of the questionnaire, it is more promising to perform the interviews face to face or via web meeting. However, several stakeholders added data to their existing electronic questionnaires alone, after having been introduced to the questionnaire during the initial session.

3. Results

The results of the inventory belonging to different main categories, i.e. organisation and disaster can be combined and analysed in a multitude of ways. In the next sections selected results of the analysis are presented. We do not intend to show all possible evaluations arising from the data obtained so far, but to give some selected examples demonstrating the possibilities of the inventory.

3.1. The quality of information exchange

One of the major targets of the inventory was to find an adequate measure in order to quantify the quality of interoperability. An indicator for interoperability was therefore developed (see also Neubauer, et al., 2015). This indicator is described as

$$KI_{Int} = [0{,}5 \cdot (1 - T_{suc}) + 0{,}5 \cdot (1 - T_c)] \cdot \left[\frac{D_{Tr-is}}{D_{Tr-id}} \cdot \frac{D_{Us-is}}{D_{Us-id}}\right] \quad (1)$$

where

KI_{Int} **Key Indicator for Interoperability** (Value between 0 and 1, 0 = Worst Case, 1 = Best Case) (Moderate Impact of time dimension)

T_{suc} Normalised Time for setting up an information exchange channel, e.g. a frequency channel for communication (Value 0 ideal case = no time for setting up channel, value 1 worst case = worst case time to set up channel, depending on expectation of stakeholder)

T_c Normalised Time for exchanging or provision of information (Value 0 ideal case = no time needed for the process of information exchange (ideal, not possible, the shorter, the better), value 1 worst case = worst case time for exchanging information, depending on expectation of stakeholder)

D_{Tr-is} Data transmitted real status (is); (Value 100 best case = all required data transmitted, value 0 worst case = worst case, no required data transmitted)

D_{Tr-id} Data transmitted ideal (id); always 100 (100%), all expected data transmitted

D_{Us-is} Data understood real status (is); (Value 100 best case = all data transmitted understood, value 0 worst case = worst case, no required data understood; understood means understanding the meaning)

D_{Us-id} Data understood ideal (id); always 100 (100%), all expected data understood

The formula quantifies the process of information exchange and consists of four variables, which measure the efficiency of setting up an information exchange channel, the efficiency of exchanging or provision of information, the amount of data transmitted and finally the amount of data understood. In total 169 information exchange processes were analyzed, whereby values from 0,392 up to 1 (0 is the worst case, 1 the best case) were reached. This indicates that information exchange was limited in the worst 10 cases (see Figure 3-1), but was judged to be at least good in all other cases. In Figure 3-1 four adequate classes were formed to get a better overview of the distribution of the indicators' values. Obviously there is a high number of good interoperability indicators ($KI_{Int} = 1$). Based on the experience gained while performing interviews it can be stated that this value was often chosen for processes where face-to-face communication was the dominating form of interaction. As long as actors spoke the same language, very often best grading was given for these types of processes. However, in some cases it could have happened that the meaning of the terms of the key indicator were not communicated adequately and/or not correctly understood by interviewees. One has to be cautious when looking at key indicators reaching optimum grading.

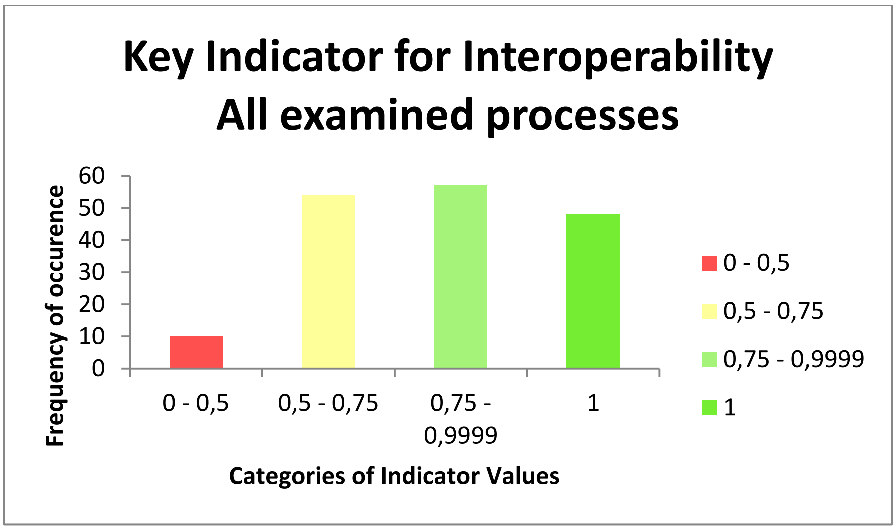

Figure 3-1: Variability of Interoperability Indicators for all examined sub-processes

The weighting of the above named four factors has not been considered yet. While in (1) the variables D_{Tr-is} and D_{Us-is} influence the interoperability indicator in each case by one third, the variables T_{suc} and T_c influence it just by one sixth due to the addition performed in (1). Another approach to calculate an interoperability indicator would be the following:

$$KI_{Int-2} = [(1 - T_{suc}) \cdot (1 - T_c)] \cdot \left[\frac{D_{Tr-is}}{D_{Tr-id}} \cdot \frac{D_{Us-is}}{D_{Us-id}}\right] \qquad (2)$$

where

KI_{Int-2} **Key Indicator for Interoperability-version 2** (Value between 0 and 1, 0 = Worst Case, 1 = Best Case)

(Higher Impact of time dimension)

Here the addition in the first term was replaced by a multiplication, which causes an impact of each factor of one quarter, each. This leads to worse interoperability indicator values compared to formula (1), since $a \cdot b \leq \frac{a+b}{2}$ for $(a, b) \in [0,1]$. The average Interoperability Indicator value decreases from the original version $\overline{KI_{Int}} = 0.79$ to the modified version $\overline{KI_{Int-2}} = 0.74$. For instance, the number of cases below 0.5 increases from 10 to 34.

3.2. Requirements from stakeholders

In order to analyse the narrative description of requirements to improve disaster management and problems faced in disasters, the nine categories shown below were introduced: detection (D), human & physiological aspects (HUP), interoperability (INT), other aspects (O), prediction (Pr), resources (R), training & education (Tr), technical solutions (TS) and standardisation (Sta, including Standard Operating Procedures).

Each requirement given in the input field of the questionnaire was assigned to one of the above given categories. It has to be pointed out that in the majority of cases more than one requirement was provided. In total 79 requirements were collected. Figure 3-2 gives an overview on the number of requirements sorted according to categories.

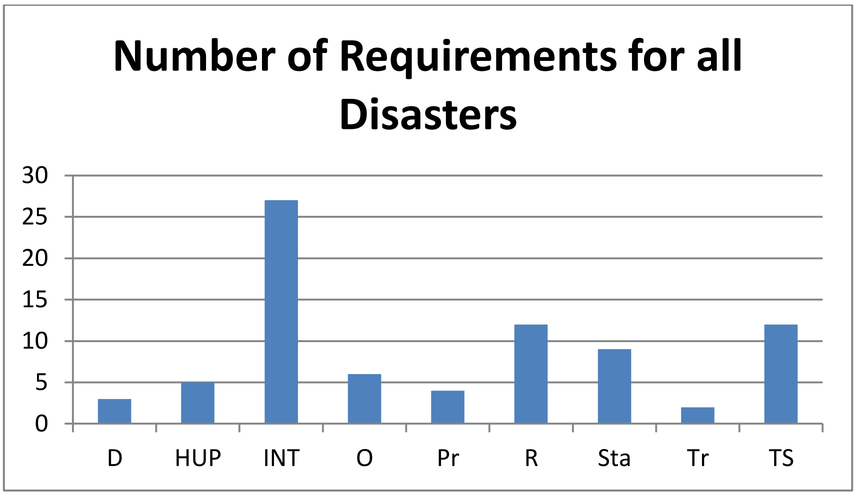

Figure 3-2: Number of requirements according to categories in all examined disasters

This result can be seen as contradiction to the rather good interoperability indicators shown in Figure 3-1. Although final conclusions cannot be made at this stage, it has to be taking into account that the interoperability indicator is focusing on very specific sub-processes in crisis management, whereas requirements and problems specified by stakeholders are often related to higher, more generic process levels.

3.3. Affected Infrastructures

The field of information “Affected Infrastructures” appears in the online questionnaire as a multiple choice field (this is independent from the requirements discussed in chapter 3.2). From a total of 45 entries to different disasters, the field “Affected Infrastructures” was selected 37 times. The selectable infrastructures are Transportation, Communication, Energy, Health and Other; in case Other is selected, the type has to be specified in a free text field. The most frequent entries in the free text field were: Water Supply (35%) and Buildings (44%). As one can see in Figure 3-3, the infrastructure Transportation is the most frequent affected with a probability of being affected of over 90% and Health is the least affected infrastructure having a probability of 35%.

If the disasters are split up in different categories (Complex, Hydrological, Geological, Climatological and Technological), a dominance of Transport as affected infrastructure for all categories can be seen. All infrastructures specified above have been especially heavily affected by Geological disasters. While in general an infrastructure is affected to 58%, for geological disaster this number increases to 96%. In 80% of cases all infrastructure categories were affected. Additionally it must be noted that the distribution of the affected infrastructures for Hydrological disasters is very similar to the distribution of all examined disasters.

3.4. Other results

Since the analysis of the inventory is far from being completed, only a few additional remarkable results are going to be discussed. A possible field of interest is for example “Duration of the response phase”, which is calculated by the difference between the two fields of information

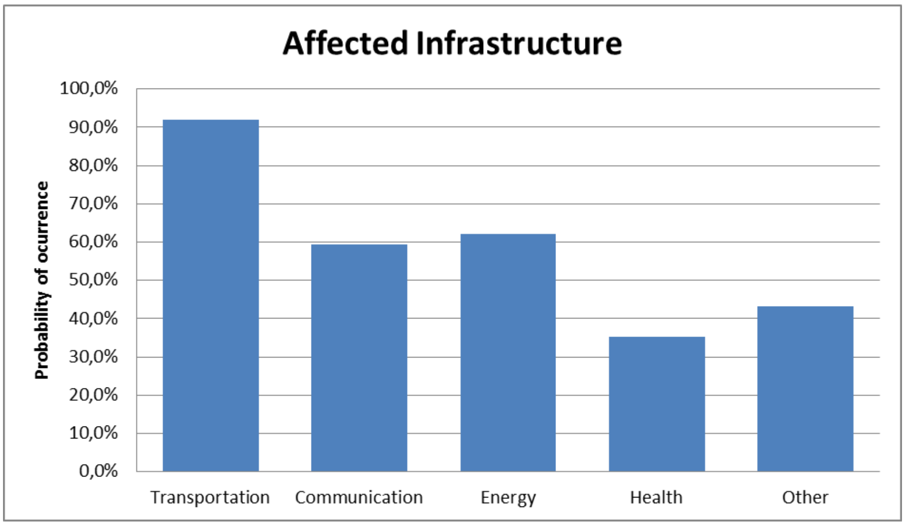

Figure 3-3: Type of Infrastructures affected in all examined disasters

"Response phase end date" and "Response phase start". An analysis of all examined disasters shows an average duration of the response phase of 15.7 days, with a minimum of less than one day and a maximum of 82 days. Furthermore it can be said that natural disasters (hydrological, geological, and climatological) require a remarkable longer response phase which averages 20.7 days, than technological and non-specific disasters with an average response phase duration of 2.7 days. It has to be mentioned that not all interviewees provided information on the duration of the respective disasters.

The field "Degree of Interaction" describes the degree of interaction between - in a certain process - associated organizations with possible values between 0 (no interaction) and 10 (very intensive interaction). The collaboration between the organisations was mostly very intensive, in 79% of all cases a degree of interaction value of 8, 9 or 10 was chosen. A correlation between the interoperability indicator and the degree of interaction can be excluded, since the correlation coefficient is -0.03.

An analysis of the communication media used during cooperation with another organisation showed a high usage of the public services GSM (which was chosen in 98% of cases), MAIL (84%) and Public IP (75%), contrary to the dedicated services, where TETRA was the most used service with a usage in 18% of the cases.

4. Discussions and conclusions

The results obtained using the questionnaire developed within EPISECC can be used to draw some preliminary conclusions on the management of past European disasters. For instance, requirements and problems of stakeholders that arose predominantly in the response phase of disasters show that in the majority of examined events, requirements were mainly related to interoperability. This supports the raised claims on improved information exchange both on cross border as well as national level. In addition, the analysis of these requirements provides detailed insight in problems faced while managing different types of disasters such as flooding or forest fires. Concerning the topic of interoperability, a lack of an operational picture was expressed several times in case of hydrological events. In some contrast to all other type of disasters, improvements related to detection are expressed in case of geological events. The results of the inventory demonstrate clearly (details not shown here) the large diversity of tools as well as standards & procedures used by European crisis managers. This lack of standardization is again in line with the interoperability related constraints described above. The rather high values of the interoperability indicators achieved in more than 160 communication processes do not seem to support this trend. However, one has to take into account that interviewees were free to select very specific communication sub processes that occurred in past disasters that may not show challenges that arose during other information exchange processes taking place during the same disaster. For instance, only very limited insight could be gained on cross border information exchange. In such situations the probability of language, procedural as well as cultural barriers is much higher compared to intra national communication.

In conclusion, the analysis of the 47 interviews provides a fairly good insight into the challenges European crisis management is facing. Although the interviewees represent organisations from 19 out of 28 member states of the European Union the number of interviews is yet not enough to claim EU wide validity for the conclusions drawn so far. The methodology applied to develop the inventory turned out to be a very suitable approach, having the potential to be used on European level in case the inventory would be used by several European countries to document the level of cooperation. Currently, the project team is applying the inventory to analyse the quality of interoperability with specific focus on the refugee and migration crisis currently challenging Europe.

5. References

Delprato, U., O'Brien, T., Nuessler, D., Bousema, A. (2014). ESENET: An Outlook for the Future of Emergency Services in Europe. *Proccedings of the 9th Future Security Conference*, Berlin, 489-498.

Huebner, K., Dalaff, C., Delprato, U., Vorraber, W., Lichtenegger, G., Neubauer, G., Jager, B., Preienrstorfer, A.,rstorfer, A. (2015). Towards a Pan-European Information Space., Proceedings of the ISCRAM 2015 conference

Inka. (2016, April 25). *Interoperabilität zwischen zivilen und militärischen Organisationen im Katastrophenmanagement*. Retrieved from http://www.inka-project.at/

Lichtenegger, G. Vorraber, W. Gojmerac, I. Sporer, A. Brugger, J. Exner, E. Aschbacher, H. Christian, M. Vössner, S. (2015). Identification of Information Gaps in Civil - Military Cooperation in Disaster Management. *International Conference on Information and Communication Technologies for Disaster Management*. Proc. 2015 IEEE International Conference on Information and Communication Technologies for Disaster Management

Neubauer, G., Preinerstorfer, A., Jager, B., Humer, H., Lichtenegger, G., Vorraber, W., Linke, H., Gruener, R., Dalaff, C., Hübner, K., Knezic, S. Blaha, M. (2015). A Methodology to Anlayse Interoperability in Crisis and Disaster Management. *IDIMT 2015: Information Technology and Society Interaction and Interdependence*, 23nd Interdisciplinary Information Management Talks, Trauner Verlag, 23-30.

Redirnet. (2016, April 25). *Emergency Responder Data Interoperability Network*. Retrieved from http://www.redirnet.eu/

Secincore. (2016, April 25). *Secure Dynamic Cloud for Information, Communication and Resource Interoperability based on Pan-European Disaster Inventory*. Retrieved from http://www.secincore.eu/

Sector. (2016, April 25). *Secure European Common Information Space for the Interoperability of First Responders and Police Authorities*. Retrieved from http://www.fp7-sector.eu/