A METHODOLOGY TO ANALYSE INTEROPERABILITY IN CRISIS AND DISASTER MANAGEMENT

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Abstract

Interoperability of stakeholders is an imperative requirement of nowadays crisis and disaster management. Within the European Commission funded FP7 project EPISECC a concept of a common information space is developed in order to assist in the improvement of the European crisis and disaster management. A basis of the development of such an information space is the profound analysis of the management of past disasters with specific focus on interoperability and efficiency of applied processes. In order to perform such an analysis an inventory on the management of selected past disasters was developed. The information for the inventory is obtained by systematic expert interviews using online questionnaires. Multiple crisis and disaster managers that are active nationally, internationally or on both levels are interviewed in order to obtain the required information. The methodology behind this inventory is described in the frame of this paper.

1. Introduction

More than in other societal affairs, "resilience of societies" has obtained a special validity in disaster management. Albeit definitions differ along heterogeneous interpretations, the capacity of a society to get over the impact of a natural or a human-induced hazardous event builds the essence. Frequently, the availability of disaster management agencies to establish synchronised response and recovery procedures might be decisive for harmonised efforts and bundled resources (Iannella, 2007). A seamless and robust information exchange has been considered as vital for coordinating disasters relief efforts including various actors at different institutional stages in an efficient way. Evidence highlighting the role of information was provided by the World Disaster Report (2005) which stated "information alone can save lives."

Indeed, in certain circumstances, when time is tight and decisions are urgently required, processes of disseminating information wherever required in a way that it can be understood are critical success factors for ensuring the security of citizens and maintaining the resilience of the society.

As elaborated by Sagun (2009), two major channels of information flow have been considered as pertinent for managing a disaster

(a) intra-organisational – within an organisation and

(b) inter-organisational – between various organisations.

Considering the citizens' communication needs, there is the obligation to establish a bidirectional information exchange, in fact from people to organisations and from organisations to people. From an organisational view, communication results from the necessity to prepare and coordinate the deployment of resources. However, during disastrous events the communication and information exchange capabilities are often compromised or destroyed, either by the catastrophe itself or due to events and effects in its aftermath, like overload and congestion. In such situations, it is absolutely essential to compensate intermitted information flow by reconditioning reliable communication rapidly. Although, maintaining an intact information and communication technology (ICT) infrastructure during an event is challenging by itself, the interoperability between systems of the different actors involved poses an added crucial point (Weiser, 2007). Frequently, a lack of information inhibits the capability of responsible agencies to respond appropriately resulting in inconsistencies of measures, redundancies in the deployment of resources and gaps in the

situational awareness. Access to information, communication with other rescuers and stakeholders as well as the availability of resources are key factors to minimize damage and loss of life. Multiple challenges have to be encompassed: language and cultural barriers, know-how levels, organisational and especially technical barriers e.g. in voice and data communication as well as in automated data exchange.

Special attention to interoperability, understood as the ability to exchange information between different systems (Delprato et al., 2014), has been paid by the ESENet Project, where an assessment of the different interoperability layers, and of the interoperability during certain events was provided (ESENet, 2014).

The project EPISECC is aiming at developing a concept of a common "European Information Space". This information space is dedicated to become the key element in a future integrated pan-European crisis and disaster response capacity. Besides the development of a common Taxonomy and an ontology model, aimed at addressing the Semantic Interoperability issue, EPISECC will focus on the establishment of Interoperability at Physical (i.e. network) and Syntactical (i.e. automated information exchange) levels. One of the main purposes of the developed inventory, is to allow analysis of interoperability at all levels.

2. Methodology

2.1. The data model

A mandatory pre-requirement for the development of a pan European information space is a profound analysis of past disaster responses with focus on interoperability and efficiency solutions and issues of disaster management. For this purpose an inventory was developed within EPISECC. The general concept, structure and ideas of the 'Architecture of integrated Information Systems' (ARIS) served as starting point for the development of the data model of the inventory (Scheer, 2002). In general terms, the structure of the EPISECC data model consists of main areas, such as data, processes, tools and business models (Huebner, et al., 2015). In addition to these, additional areas of information such as initiator, actor or disaster groups were included in the EPISECC data model. The areas of information were assigned to the four overarching main information units which are Interoperability, Disaster, Organisation and Crisis and Disaster Management Cycle (see Figure 1).

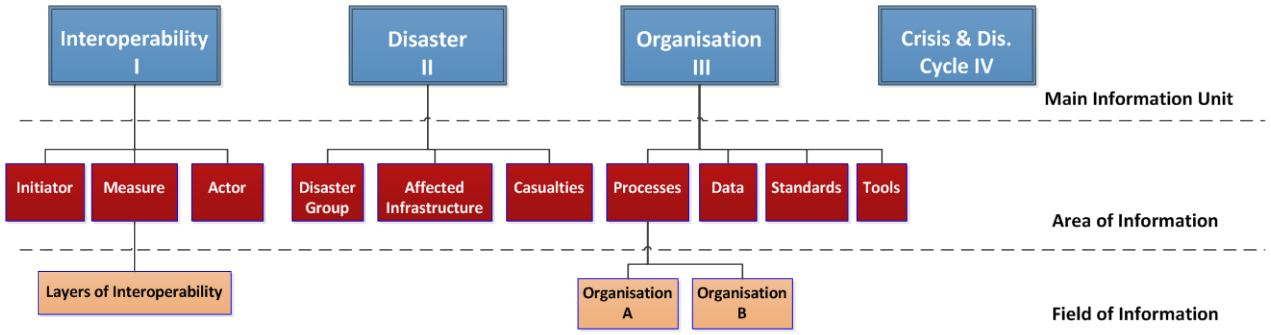

Figure 2-1: Levels of information of the EPISECC data model

On a lower level, each area of information is subdivided in multiple fields of information such as data type or data language in case of the area of information "data". The whole structure of the

different levels of information is called template in the EPISECC project. The template can be considered as the taxonomy of the included fields of information. The data model encompasses in addition to the taxonomy the logic combination of the different fields of information.

The data model is the starting point for analysing the management of past critical disasters. The method of finding relevant information for the inventory of EPISECC goes from the data model over identifying relevant questions together with selected stakeholders being active in disaster management, the development of an online questionnaire up to final interviews of crisis managers with focus on the strategic level in order to identify and analyse relevant information on the management of past disasters (see Figure 2). In the following chapters this process is discussed in detail.

2.2. Identification of questions

After having developed the data model, questions being relevant for the inventory were collected from stakeholders such as the Austrian Red Cross or the German Federal Agency for Technical Relief (THW). For this purpose stakeholders were asked to provide questions on missing relevant information related to disaster management with focus on the response phase on one hand and interoperability and efficiency on the other. The arising so called pre-questions were aimed at showing what the users would like to have answered by the inventory. The result of the interviews on these pre- questions showed the broad scale of interests of stakeholders in such an inventory on the management of past disasters.

The project team considered all pre-questions suggested by stakeholders as a priori relevant. Nevertheless, it was necessary to restrict the number of questions based on their relevance for EPISECC. Using a specifically designed ranking process, the project team selected 29 questions out of a total sample of about 140 to be implemented in the questionnaire. The ranking process was designed in order to highlight the questions which were more relevant from the perspective of interoperability and efficiency in disaster response. The questions being most representative from this perspective are shown in Table 1.

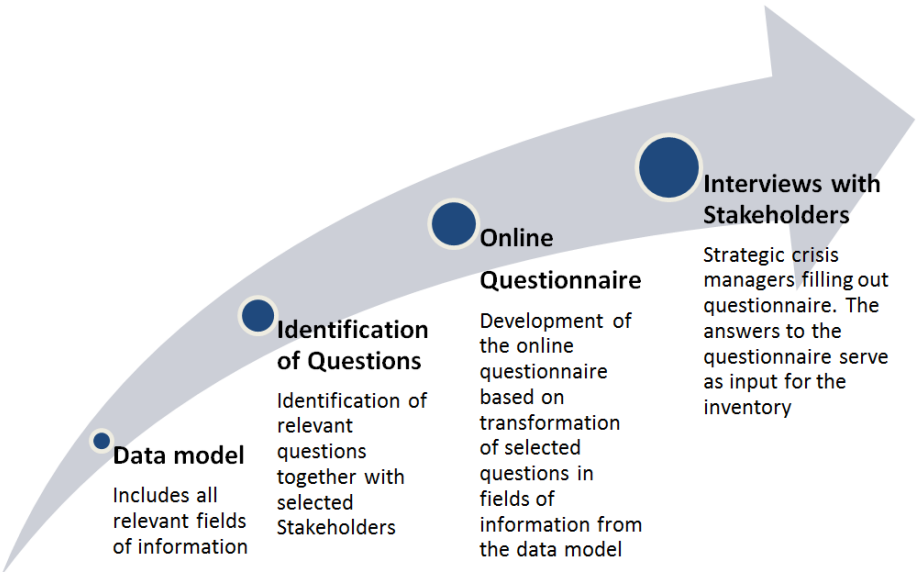

Figure 2-2: Method for data gathering for the inventory

Questions for the EPISECC inventory
What information/data were exchanged in a specific country during a specific type of disaster? How many sources for information were used? How were information saved and exchanged?
How fast could alternative solutions after the collapse of communication tools be provided?
Who alerts partner emergency services? How long time does it take?
Overcoming of language barriers: e.g. how was the collaboration between local and international operational commanding units working?
Which information should be available at which level at which time in each country? Similar information available in country A and B are needed at what level in country A and what level in country B?
How can the communication with another country be realised? Are frequencies provided and predefined radio channels?

Table 1: Examples of selected questions to be implemented in the EPISECC inventory

2.3. Transformation of questions in fields of information of the data model

Generic questions such as those shown in Table 1 would, in case they are answered directly, trigger narrative answers being only comparable to a limited degree making therefore systematic analysis and quantifiable answers hardly achievable. In order to overcome these limitations, the generic questions asked by the selected stakeholders need to be transformed applying the process described in chapter 2.3 to information elements that can be implemented in the online questionnaire. For this purpose we applied a step by step process. A simplified version of this process is shown in Table 2:

First step	To identify key terms (typically substantives and verbs) in the questions
Second step	What key terms from the questions are missing in the data model of the inventory? Identify a place for the additional key terms (corresponding to fields of information) in data model
Third step	Recompose the questions using all necessary fields of information

Table 2: Simplified process for transformation of question

To give an example, the transformation process of the first question of Table 1 is shown in Table 3:

Selected Question	What data of a specific data type were exchanged in a specific country during a specific disaster?
Key Terms	Data, data type, exchanged (synonym for interoperability, fields of information selected: initiator, actor, measure), country (synonym for spatial scope), disaster (selected fields of information: disaster generic group, disastergroup, disaster main type, disaster sub type, start, end)
Missing key terms	Identification number of the disaster
Transformed questions on fields of informations of the data model	Identify disaster (generic group, group, main type, sub type, start, end, identification number) Identify the initiator of the data transmission (e.g. name, stakeholder type, type of responsibility, acting as focal point) Identify the actor (recipient) of the data transmission (see above) Identify layer of interoperability (necessary?) Identify data (data resource name, content, type, language) Identify spatial scope

Table 3: Example of a transformation process of a generic question

2.4. The inventory database

EPISECC uses the expert system Emikat as basis for its inventory. Emikat is a product of AIT Austrian Institute of Technology GmbH and is currently operational in several customer and research based projects since 2001. Originally, Emikat has been developed to model emission inventory related entities and processes. That's where its German name *Emissions Kataster* (emission cadaster) originates from. Emikat is able to model different kinds of scenarios and automatically derive its implications in terms of emissions. On the technical level Emikat is a typical "Client-Server" solution as can be seen in Figure 3. The Java-based Web Start client can be downloaded from the Emikat website (http://www.emikat.at). It uses encrypted Simple Object Access Protocol (SOAP) web services technology to communicate with the servers which are hosted by AIT in Austria. Emikat is designed to administrate multiple customers in parallel. This approach allows multiple customers to share infrastructure and parts of their data but maintain separated working spaces to keep their critical business data. AIT will reuse administrative data and basic application modules and provide dedicated workspaces and user accounts for the EPISECC project.

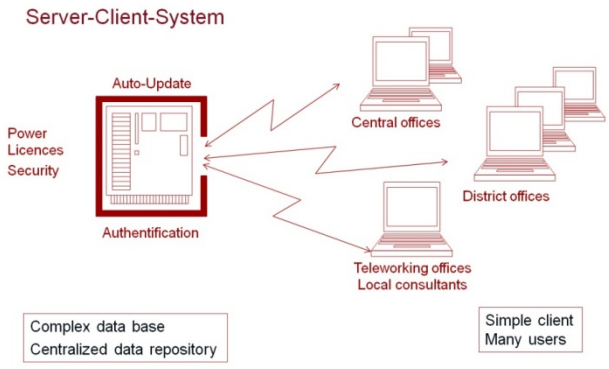

Figure 2-3: Emikat Client-Server Structure

3. Analyses of the information obtained from stakeholders

3.1. Interface to stakeholders – the questionnaire

To receive the necessary input for the inventory database a questionnaire has been created. The questionnaire is addressed to different type of respondents from crisis and disaster management, such as the Bavarian Red Cross. The questions are grouped in different sections, according to their topic / focus (e.g. information on the organisation, on the disaster, on the adopted interoperability processes and measures, and so on). In Figure 4 we show as an example the page with questions related to disasters from the EPISECC questionnaire.

3.2. Implemented key indicator on interoperability

Key indicators (KI), which are dedicated to replace intuitive opinions by verifiable data, are used in addition to the quantifiable and therefore comparable answers to the transformed questions, and add a few representative metrics to the overall analysis. These key indicators are calculated by specific mathematical formulas. Answers from the questionnaires serve as input for these equations. As stated in (Engelbach, et al., 2014) these indicators can be absolute values or ratios. To find suitable key indicators on aspects of crisis and disaster management such as interoperability and efficiency a literature review was performed. Several indicators from literature are integrated in EPISECC such as the Delivery Data Reliability Index from (Santarelli, Abidi, Regattieri, & Klumpp, 2013) or the Process Cost Indicator (Davidson, 2006).

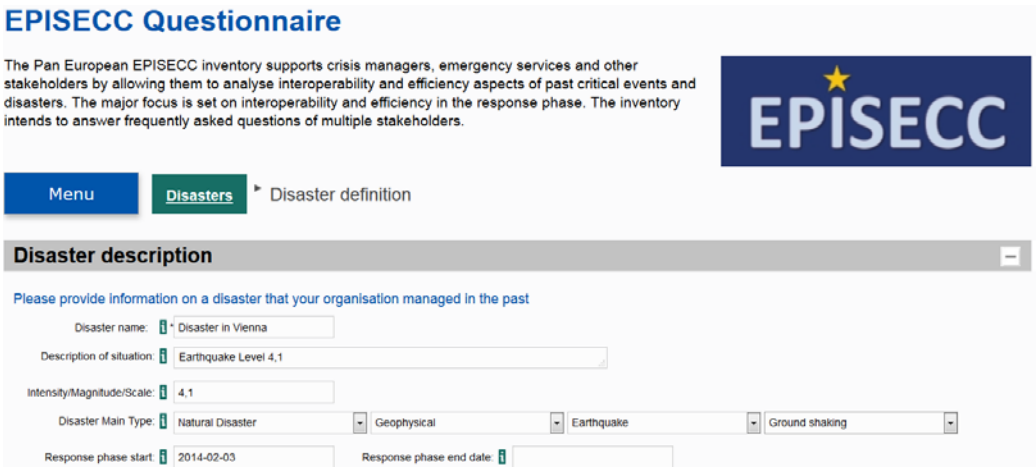

Figure 3-1: Example of a page of the EPISECC questionnaire

Although multiple publications on interoperability exist, we did not identify literature containing a key indicator for interoperability in crisis management suitable for our purposes. Therefore the following indicator has been established:

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

where:

KI_{Int}	**Key Indicator for Interoperability** (Value between 0 and 1, 0 = Worst Case, 1 = Best Case)
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)
D_{Us-id}	Data understood ideal (id); always 100 (100%), all expected data understood

The indicator is based on several assumptions, e.g. giving the time to set up an information exchange channel the same weight as the time to exchange the information can be seen as first approach. Future experiences might allow using more specific weighting factors, for instance weighting factors depending on type of disasters (slow or fast onset). In addition, the indicator could be sharpened by including additional impact factors such as time requested to identify a communication counterpart. However, the four imperative factors of communication, i.e. time to set up a communication channel, time requested to communicate, amount of data transmitted as well amount of data understood are already included.

4. Outlook

Currently the EPISECC questionnaire is finalised and the evaluation of the first interviews of stakeholders is performed, analysis is ongoing and software implementation is finalised. During the next few months further interviews will be performed with multiple stakeholders that are nationally and/or internationally engaged in the crisis and disaster management community. The interviews will encompass a large scale of crisis managers such as experts from United Nations as well as from the European Union and Member States. In case of recommendations from the experts some adaptations of the inventory's architecture will be implemented in order to enhance acceptance of the inventory by stakeholders. The focus of the interviews is set on strategic operations in the response phase of the crisis and disaster management cycle (Lumbroso 2007). The content of the inventory is supporting the development of the common information space due to the identification of both best practices as well as shortcomings related to interoperability and efficiency of applied crisis management processes.

The inventory also offers the possibility to provide responses to specific questions posed by stakeholders in crisis management. The large number of possible combinations of the fields of information of the questionnaire allows achieving new knowledge in the domain. The EPISECC inventory allows also the implementation of additional key indicators. The interoperability key indicator presented in chapter 3.2 is a new developed measure from EPISECC and might be extended by additional indices in case of necessity.

5. References

Davidson, A. (19. May 2006). Key Performance Indicators in Humanitarian Logistics. *Engineering Systems Division*.

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

Engelbach, W., Frings, S., Molarius, R., Aubrecht, C., Meriste, M., & Perrels, A. (2014). Indicators to compare simulated crisis management strategies. *International Disaster and Risk Conference.* Davos.

Esenet (2014). ESENet – Emergency Services Europe Network, http://www.esenet.org/

Huebner, K., Dalaff, C., Vorraber, W., Lichtenegger, G., Delprato, U., Neubauer, G., Preinerstorfer, A. (2015). Towards a Pan-European Information Space. *The 12th International Conference on Information Systems for Crisis Response and Manageme.* Kristiansand, Norwegen (in press).

Iannella, R., Robinson, K. and Rinta-Koski, O. (2007) "Towards a Framework for Crisis Information Management Systems (CIMS)", 14th Annual Conference of the International Emergency Management Society (TIMES), 5th -8th June 2007, Trogir, Croatia.

International Federation of Red Cross (2005). World Disaster Report.

Layers of Interoperability – Introduction and Definitions, ESENet – FP7 Grant agreement number 313013, 2013.

Lumbroso D (2007). Review report of operational flood management methods and models, FLOODsite Consortium, Delft, 2007

Sagun, A., Bouchlaghem, D., Anumba, C.J. (2009). A scenario-based study on information flow and collaboration patterns in disaster management, Disasters, 33, 2, pp. 214–38.Santarelli, G., Abidi, H., Regattieri, A., & Klumpp, M. (2013). A performance measurement system for the evaluation of humanitarian supply chains. *24th. Annual Conference of the Production and Operations Management Society.*

Scheer, A. (2002). *ARIS - Vom Geschäftsprozess zum Anwendungssystem.* Berlin: Springer.

Weiser, P. J. (2007) "Communicating During Emergencies: Toward Interoperability and Effective Information Management," Federal Communications Law Journal: V ol. 59: Iss. 3, Article 5. Available at: http://www.repository .law.indiana.edu/fclj/vol59/iss3/5