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Crisis Management

Theory and Practice

Edited by Katarina Holla, Michal Titko and Jozef Ristvej

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Meet the editors

Dr. Katarina Holla gained her PhD degree with the thesis "Risk Assessment of Industrial Process" at the Faculty of Security Engineering, University of Žilina, in Žilina. Since 2014, she has been appointed the Vice-dean for the International Relations and Marketing of the Faculty of Security Engineering. Her research is mainly focused on the area of major industrial accident prevention (risk assessment and treatment) and crisis management cycle phases where she has already implemented semi-quantitative and quantitative methods for risk assessment developed within R&D projects. This complex model for risk assessment is now being used by several companies in Slovak Republic for the creation of safety documentation. She has published more than 82 research papers and 7 books in Slovak and English language. She has delivered special invite presentation at the Northumbria University in Newcastle, University of Cardiff and University of Economics in Prague. She obtained specialized skills in the area of major industrial accident prevention (Seveso III Directive (specialist)), transport of dangerous goods (safety advisor) and health and safety at work issues (safety advisor for companies). She has participated in 7FP projects (e.g., COBACORE) and attended several scientific conferences (in Tokyo, the USA, Korea and other EU member states).

Dr. Michal Titko graduated from the Faculty of Security Engineering, University of Žilina, where he also completed his PhD degree study in Crisis Management. Currently, he is an Assistant Professor at the Department of Crisis Management at the Faculty of Security Engineering. His research is focused on crisis planning, assessment of the critical infrastructure element vulnerability and assessment of the societal resilience and vulnerability to the impacts of disasters. Vulnerability and resilience assessment of the society was his main task within the FP7 project (RAIN-Risk Analysis of Network Infrastructure in response to extreme weather). In addition, he was a co-investigator of another FP7 project (COBACORE (Community-Based Comprehensive Recovery)) and a co-investigator of several national projects. He is the author and co-author of more than 35 papers.

Dr. Jozef Ristvej gained his PhD degree in Crisis Management in 2007 at the University of Žilina, Slovakia, Europe. Since that time, he has received postdoctoral position as an Assistant Professor and in 2014, after successful habilitation, he has received position as an Associate Professor at the Department of Crisis Management, Faculty of Security Engineering, University of Žilina. Since October 2014, he has been the Vice-Rector for the International Relations and Marketing at the university. In 2007, he participated in ISCRAM Crisis Management Summer School for PhD degree students. In 2010, he received the Ruth Crawford Mitchell grant to support a Visiting Scholars appointment at the Center for Disaster Management, Graduate School of Public and International Affairs, University of Pittsburgh.In his work, he focuses on supporting the information systems in the area of the decision-making process in crisis management. For the year 2012, Dr. Ristvej was selected by the European Commission as the Erasmus Staff Ambassador for the 25th anniversary of the Erasmus Programme. He is a member of the editorial board of the *Infotechnology* journal in Lithuania, and in 2012, he was a member of ISCRAM 2012 Conference organizing committee. He is an author of several papers in Europe and abroad. He is a member of several scientific project teams as well as of the ISCRAM Association in Brussels (Information Systems for Crisis Response and Management) and the Society for Science and the Public, in Washington DC.

Contents

Preface

The last century brought people the most extensive development and progress, however, also enormous suffering almost all over the world. Now, we are living in a new millennium, and the scientific and technical progress is changing the lives of the people and is making it easier. On the one hand, it is bringing more and more flawless technologies and means to all areas of the society. But on the other hand, it is bringing a lot of crisis events we are not prepared for, and we have to cope with them immediately and in a way in which we can solve them at the moment.

The crisis management is one of the basic pillars for solving crisis events. It is an inter-disciplinary scientific specialisation that has passed significant changes since the last century. In the twentieth century, which was marked especially by crisis events of the military character, the attention was drawn to creating different tools of prevention and crisis planning than today. The current century is characterised by crisis events of a different character. The climatic changes, industrial accidents, cyber security, economic security and security and safety of people and citizens are coming to the foreground.

The crisis events can be classified according to several criteria. According to their sources, we divide them into anthropogenic ones and those that are independent of the people's will. The anthropogenic crisis events can be the sociogenic, technogenic, agrogenic and combined ones and those independent of the people's will can include the volcano activities, earthquakes, landslides, the meteorological and cosmogenic phenomena. The lessons learned that are based on analysing the crisis events bring the best knowledge for prevention. On the basis of these analyses, we can implement the preventive tools to practice and minimize potential loses.

Various sources bring a different interpretation of the crisis management cycle. Based on an analysis of several of them, the most understandable interpretation states its four phases: the prevention, preparedness, reaction and recovery. The prevention that is part not only of the theoretical model of the crisis management but also of the practical utilisation in the companies is the dominant idea of the crisis management and the basic pillar of preventing the development of the crisis phenomena—both anthropogenic ones and those that are independent of the people's will. We can say the more effective the prevention is the less power and means we have to invest to the preparation for solving the crisis phenomena, which is ensured by crisis planning. In spite of all of that, the crisis events permanently develop due to various causes and the probability of their occurrence cannot be reduced to zero. Therefore, every phase of the crisis management cycle as well as the individual tasks that are carried out in its framework is important.

This book contains a few views at the theory and practice of the crisis management nowadays. It shows its specifics, analysis crisis events from the past, present case studies, new solutions and characterises the tools for solving the crisis events that are discussed in individual articles within different fields of social life. From the point of view of its content, the publication is divided into three parts: Technologies and Information Systems in Crisis Management, Crisis Management in Organizations and Economics and Crisis Management in Theory and Practice.

We believe the articles in this publication will be a valuable contribution for the reader and will provide space for identifying the problems and their solutions in the theory and practice of the crisis management.

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Section 1

Technologies and Information Systems in Crisis Management

Chapter 1

Urbanization and Crisis Management Using Geomatics Technologies

Rifaat Abdalla

Additional information is available at the end of the chapter

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Abstract

Substantial work has been done by Geospatial Information and Communications Technology (GeoICT) and Disaster Management communities to evaluate and develop tools and applications that integrate the complex interrelationships that are required for adequate preparedness, planning, mitigation, response, and recovery from extreme situations. GeoICT technologies have contributed and are contributing to saving life and property throughout the globe. Over the past decade, extensive research has resulted in more advanced GeoICT technologies. This has helped to maximize the demand for these tools, with a noticeable pattern of adoption and expanding user community. This chapter provides an overview of selected rising stars in GeoICT technology and their applications in disaster management. This discussion evaluates the trends in technology development, with emphasis on data collection, processing, and visualization.

Keywords: GeoICT technology, emergency management, resilience

1. Introduction

The concept of GeoICT attempts to utilize telecommunications technologies to link between various geospatial technologies including Geographic Information System (GIS), Remote Sensing, Global Positioning system (GPS), Photogrammetry, Computing, the Internet, Databases and Visualization Systems. As the name suggests, it integrates various domains of knowledge that require specific skills and abilities to synthesize and integrate. Over the past decades, extensive research on utilizing GIS has resulted in many new technologies. As the name suggests Visualization Systems, integrates various domains of knowledge that require specific skills and abilities to synthesize and integrate. Over the past decades, extensive

research on utilizing GIS has resulted in many new technologies. The usage and request of these technologies have vigorously endorsed the way that GIS and other integrating spatial technologies attempt to find ways and means to determine incongruence and heterogeneity of information from numerous sources, specifically for disaster management. In this way, the integration of different geospatial technologies, supported by advanced Information and Communications Technology (ICT) infrastructure is one of a kind technology-based approach for securing straightforward and useful access to information over various platforms, specifically for disaster management applications. This has made GeoICT integration and, to some extent, its interoperability, as a focal innovative work activity. This convenience of interoperating GIS-based spatial technologies remains the focal point with the objective to have a viable framework, which inevitably relies on how well we are able to handle different circumstances.

Natural disasters are among humanity's most costly, deadly, and dreaded occurrences [1]. Jie et al. [2] have characterized natural disasters as an occurrence that has an enormous effect on the general public. Despite what might be expected, there is no solid definition for natural disasters, as the recognition and elucidation differ with the perspective between the audiences. For example, disaster or emergency, perception varies between social scientists, natural scientists, and information technologists; each of them has a particular field of interest and a special recognition to disasters. Despite that, the typical issue to all catastrophic scenarios is that: floods leave behind a trail of death, with many injured and significant loss in economy.

Disaster management is an applied science, which attempts to use systematic observation [3], monitoring, and analysis of environmental parameters to reduce or eliminate the loss that might occur. However, monitoring and analysis of environmental parameters for the purpose of disaster management cannot be easily documented in a flow chart, since disasters are nonlinear processes [4]. In any case, the disagreement in the definition of tragedy certainly reflects on the approaches that disasters are managed.

Disaster management is an applied science, which endeavors to utilize systematic perception, monitoring, and examination of fundamental parameters to lessen or dispose of the misfortune that may happen. Nonetheless, observation and consideration of environmental parameters with the end goal of disaster management is difficult to be recorded in a simplified project flow chart since catastrophes are nonlinear processes [5]. Regardless of these considerations, the different circumstance about the meaning of disaster has unquestionably mirrored no understanding in the ways that disasters are overseen. What was agreed upon are the phases of disaster management cycle, which are mitigation, preparedness, recovery, and response as shown in **Figure 1**.

Geospatial technologies support a cost-effective means for spatial data acquisition, processing, and presentation for the application of emergency management [6]. Nevertheless, planning a geospatial information application requires an in-depth, detailed information, and analysis of the constituents of the event, be it disaster management or emergency situation, under each of the mentioned stages.

Figure 1. Disaster management cycle.

2. Methods

The method for conducting this work involved reviewing the state-of-the-art GeoICT systems, supported by urban case study, that attempts to address emergency management issues in the City of Jeddah, Saudi Arabia, based on evaluation of data products and applications for the use of GeoICT. This has been investigated from the perspectives of acquisition systems, processing systems, and presentation and visualization systems. Current geospatial technologies have significantly evolved to provide geodata and geoprocessing such as routing and geocoding. The emergence of advanced, sophisticated technologies such as sensor webs, Internet of Things (IoT), and advanced Web mapping protocols have made day-to-day activities simpler and easy, such as Google Maps. As a result, many new platforms are integrated using advanced telecommunications protocols and infrastructure. As such, significant numbers of applications have been rapidly developed. This section discusses these developments from the perspective of GeoICT integration for the purpose of data acquisition, processing, and presentation. It specifically addresses the user interest in these technologies and the capabilities provided by each of the researched themes.

Geospatial information coordination is the procedure that includes gathering information from various sources at different accumulation modes and bringing these data together in a sizeable database to give complete information environment to preparing, displaying and perception.

Light Detection and Ranging (LIDAR) is a surveying technique that measures the distance of an object known as a target by sending laser pulses to hit the target and return to the transmitter. LIDAR is an acronym for Light Detection and Ranging (sometimes Light Imaging, Detection, and Ranging), was initially a blend of light and radar. LIDAR is used to make high-determination maps with applications. LIDAR is also called as laser filtering and 3D checking; with earthbound, airborne, and portable applications, the airborne LIDAR Bathymetric technological framework includes the estimation of time of flight of a flag from a source to

its arrival to the sensor [7]. According to [8], unmanned aerial vehicles (UAVs) are currently being utilized with laser scanners in addition to other remote sensors, as a more conservative strategy to filter smaller territories.

UAVs, generally known as "drones," are little-to-medium-sized flying machines that automatically fly, without human pilots' intervention. The majority of UAVs are remotely guided [9]. They are checked and worked from ground stations that give full insights about the UAV flying data, including flying way, height, information accumulation, and time stamping different information items obtained from the UAV, which is recorded, installed, and additionally transmitted to the ground control station. In any case, there is another kind of UAV, which is known as self-governing UAV [10].

Autonomous Underwater Vehicles (AUVs) are automated frameworks that are equipped to perform tasks submerged underwater, utilizing their outline and their application [11]. AUVs are an improved version of the long referred marine information gathering innovation known as remotely operated vehicles (ROVs). The ROV is linked to the base station's locally available vessels, where it sends information and gets directions over wired corresponse conventions. In particular, they can plunge, float, or skim in shallow or deep waters, completely autonomous of any human steering or control [12]. Indicated that AUVs advancements have reformed the path in which hydrographic looking over is directed and the methods for delivering hydrographic information items, for example, profundity soundings and sweep symbolisms of the ocean depths. The UAV systems, as shown in **Figure 2**, are utilized as a part of complex applications for the observation, upkeep, and establishment of submerged framework, for example, media transmission links and submerged oil and gas pipelines, and typical citizens' areas. **Figure 3** shows the AUV platform for underwater collection.

Courtesy of Heikki Saari/VTT, "Novel MEMS and Piezoactuated Fabry-Perot spectral imagers for atmospherics studies"38th Annual European Meeting on Atmospheric Studies by Optical Methods , , "Fabry-Perot Interferometer Hyperspectral Imaging Technology Transfer to Space Applications"8th ESA Round Table on Micro and Nano Technologies for Space Applications, Jere Kaivosoja/MTT, "UASI Potato Monitoring flight campaign preliminary results"Finnish Remote Sensing Days 2012

Figure 2. Different UAV types.

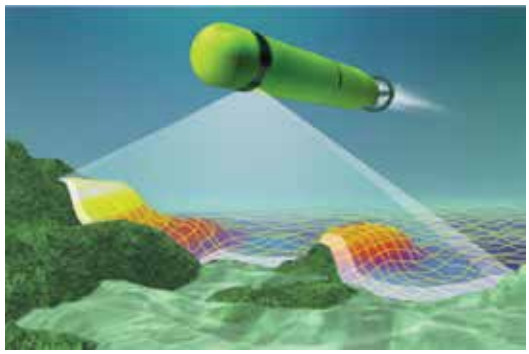

Figure 3. AUV platform, image courtesy to (http://www.mbari.org/).

The expression "sensor-web" has risen as of late as a system of sensors for natural checking is constructed associating distinctive ecological administration hubs [13]. Described as a detecting framework that uses the Internet to communicate with exceptionally small sensors in the field and sends estimations over the system to committed servers that take into account information

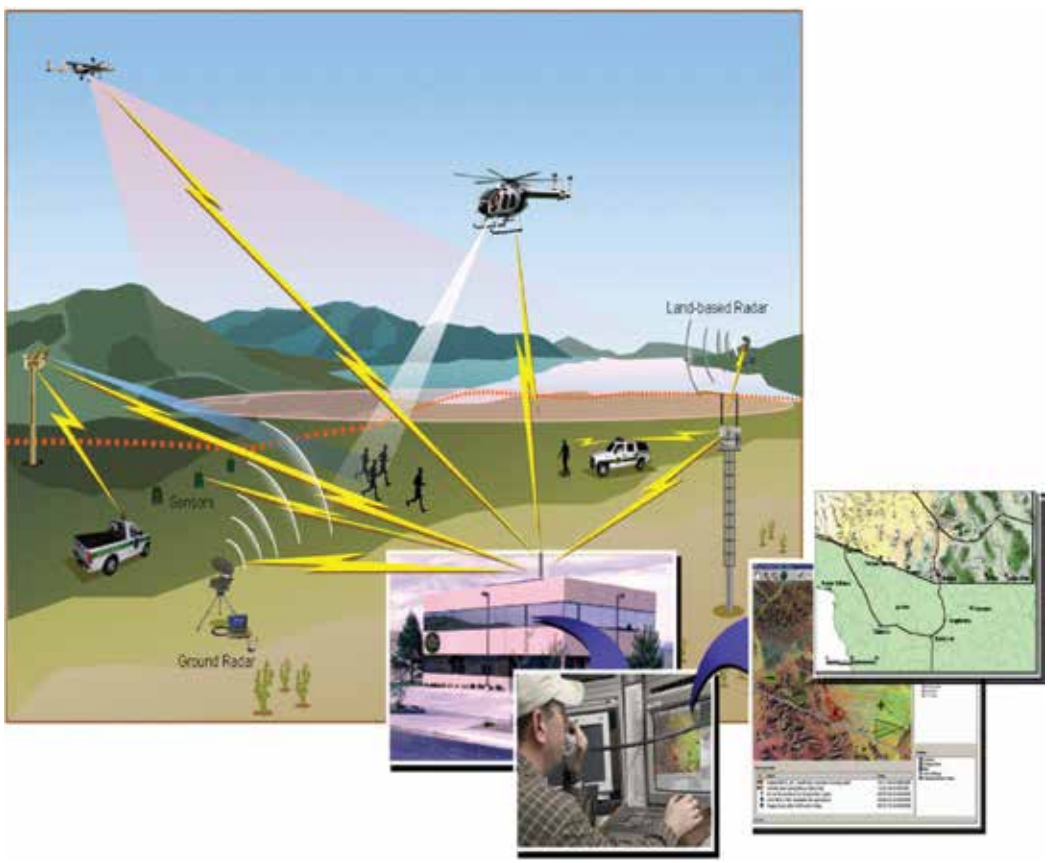

Figure 4. Sensor-network scenario in emergency operations center (EOC). (image courtesy of sensors online magazine (http://www.mbari.org/)).

administration, handling, and investigation. The key normal for sensor web is that the system of sensors are connected and cooperate, and a brought together the framework. Every hub in the system speaks to the spatial element and discuss remote premise with the server and with each other hub in the system. [14] The OGC standard for Sensor Web Enablement is discussed where every hub is spoken to by a sensor equipment that gives single estimation and can be connected to the sensor web over the system [15]. **Figure 4** shows the concept of Sensor Web application in emergency management operations.

3. The concept of urbanization crisis management

Environmental disasters are known to be devastating in many ways. The risk impact can be ascertained depending on the magnitude of hazard. In the past, the impact from environmental emergencies such as floods, earthquakes, tornados, and heat storms was enormous, specifically in urban centers, where the density of the population was higher and the possibilities for response were somewhat traditional in coping with such events.

Todays' technology has significantly contributed toward saving lives and properties. Specifically, they are known as spatial technologies (GIS, GPS, Remote Sensing and Photogrammetry). The strength of these technologies stem from the fact that it offers detailed information on location in terms of positioning, visualization, simulation, and measurements for various applications.

The development of the Internet has added to the spatial technologies, specifically to the GIS domain allowing for what is known as web services for data processing, modeling, and visualization. This has provided a unique opportunity for exploring issues related to interconnectedness between various geospatial elements as well as allowing for simultaneous access and sharing of data. This is crucial for emergency management as it requires rapid and effective response through being prepared for such exigencies.

The idea behind this research project was to provide lively application and solution for applied issues that touch everyone's life in the community. By carrying out the first phase of the project, this chapter has attempted to lay out the foundation framework for the second phase. The study conducted involved data sharing, meetings, and interviews with selected number of decision-makers to analyze the gaps in the current use of technology as well as to provide an insight of what could be done by adopting advanced technologies.

There are many challenges for researchers working in this field including the challenge of getting the data in addition to getting useful feedback from some of the personnel involved in the field. However, the role of research is to provide solutions to these problems as we have done in the first phase and what we continue to do in the second phase is to provide as comprehensive coverage of the problem as possible.

4. Urbanization and emergency management

Many researchers including [17, 18] have provided comparative study models for emergency management. This model is unique as it addresses emergency management between two

large metropolitan centers to examine the role and advancement in GeoICT, which provides an insight on how ICTs can help effective decision-making and enhance the rate of return in spending.

The role of GeoICT in emergency management is characterized by the effective utilization of GeoICT data to provide decision-making models [19]. A framework for using GeoICT in disaster management may consist of:

Development of online interactive hazard maps, categorized by natural hazards, such as floods, earthquakes, dust storms, pandemic potential, and any other potential hazard based on hazard identification strategy for the city.

Development of online risk identification interactive maps, including categorization and prioritization of risks for the city based on what was identified in the risk assessment models.

1. Building various what-if simulation preparedness scenarios that can help decision-makers to optimize the response they need to provide a solution for stakeholders involved.
2. Preparation of potential response policies and procedures that define the role and responsibilities of various departments involved in responding to various risks and examination of their capabilities and responsibilities dealing with each and every risk or threat identified.
3. Advanced integrated visualization systems that provide online 2D, 3D, and 4D visualization of identified risk and response operations, which might be of help for planning groups that are dealing with enhanced emergency response operations.
4. Interactive online mapping with accurate GPS identification of the extents and limits of most vulnerable communities and identification of their type of vulnerability identified whether due to topography or other reasons.

These are the main functions where GeoICT can be used as a utility for emergency management. It has been determined that many of these items listed on the framework are either ready or being developed by the concerned authority, and are discussed in the following sections.

4.1. Decision-making models

The disaster management decision-making models are solely administrated by the Civil Defense Directorate, which is a department of the Ministry of Interior. They work on providing preparedness, planning, and response operations in the City of Jeddah. Many other departments help with providing access to updated data and information related to various alternatives dealing with specific risks. Recent study by Samad et al. [9] indicated that the City of Jeddah has some gaps in the use of early warning technology that can be used for preparedness and response. This was illustrated in the 2009 flooding event that struck the city. It was also found that the Civil Defense Authority was lacking both the policy as well as the level of adoption for the use of technology in locating causalities. This has initiated the need for

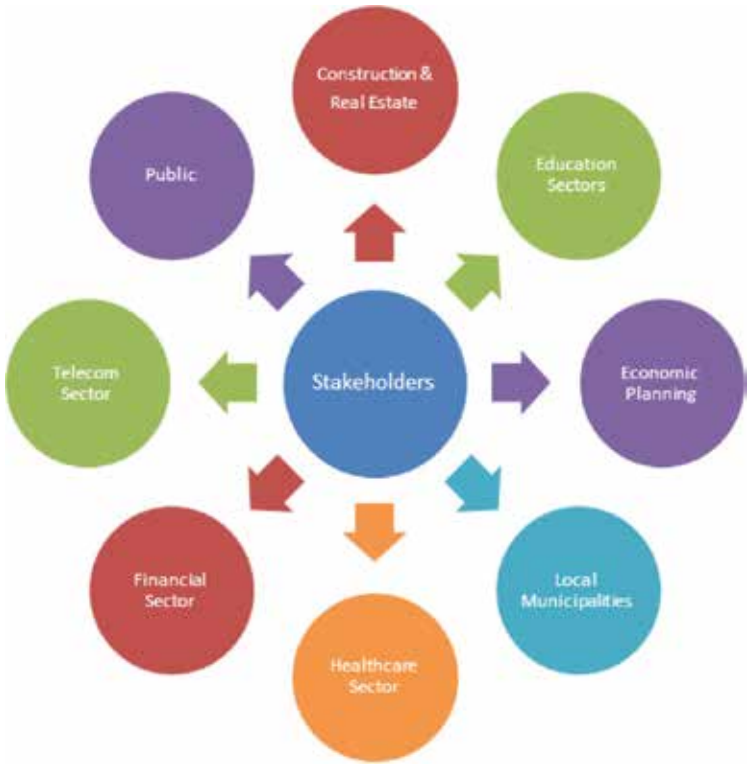

Figure 5. Stakeholders of emergency management systems.

expedited protocols that help with natural hazard communication and reporting, where the GeoICT stands out as a very effective tool to address gaps identified from historical events. **Figure 5** shows typical emergency management stakeholders.

5. Geomatics-based enhanced framework

Many researchers including [16, 17] have provided comparative study models for emergency management. This model is unique as it addresses emergency management between two large metropolitan centers to examine the role and advancement in WebGIS, which provides insight on how technology can help effective decision-making and enhance the rate of return on spending.

Effective emergency management is characterized by the effective utilization of WebGIS data to provide effective decision-making models [18]. A framework for using this technology in disaster management may consist of:

- Development of online interactive hazard maps, categorized by natural hazards such as floods, earthquakes, dust storms, pandemic potential, and any other possible danger based on hazard identification strategy for the city.
- Development of online risk identification interactive maps, including categorization and prioritization of risks to the city based on what was identified in the risk assessment models.
- Building various what-if simulation preparedness scenarios can help decision-makers to optimize the response that they need to provide a solution for stakeholders involved.
- Preparation of potential response policies and procedures that define the roles and responsibilities of various departments involved in responding to various risks and examination of their capabilities and responsibilities dealing with each and every risk or threat identified.
- Advanced integrated visualization systems that provide online 2D, 3D, and 4D visualization of identified risk and response operations, which might be of help for planning groups that are dealing with enhanced emergency response operations.
- Interactive online mapping with accurate GPS identification of the extents and limits of most vulnerable communities and identification of their types of vulnerability identified whether due to topography or other reasons.

These are the main functions where the technology can be used as a utility for emergency management. It has been determined that many of these items listed in the framework are either ready or is being developed by the concerned authorities in the city.

6. Case study

A case study was used to demonstrate the application of GeoICT Technologies in the City of Jeddah, as one of the largest urban centers in the Arabian Peninsula. The objective was to assess the use of GeoICT in disaster management in an urban setting. Jeddah is the largest city in the province of Makkah and the largest port of the in the Kingdom of Saudi Arabia. It is the second largest city in the country and located in the Red Sea coast in the western side of the Kingdom. The city is spread north–south with estimated area of 5460 km^2 [19] and an estimated population at 2,801,481 [20]. Jeddah is located in a coastal plain [21, 22] The city elevation is 12 meters and is known to be a part of the lower Hijaz Mountains in what is geographically known as Tehama Hijaz region [23]. The area is prone to many natural hazards [24]. As part of the regional system [25, 26], it is of dry climate [27] with temperature ranges from 15°C in winter to 43°C during afternoons of summer. Jeddah is home to many international organizations, and it is an active business center. **Figure 6** shows the location of the City of Jeddah in relation to the Kingdom of Saudi Arabia. The city has experienced many recent flood disasters in 2009 and 2011 [21, 23, 27–29]. There are many motivational factors that make people to prefer coming to Jeddah [30] these factors adds to the vulnerability of people in emergency situations.

Figure 6. Map of Saudi Arabia, showing the City of Jeddah.

7. Findings

An assessment has been carried out on the level of adoption of GeoICT technology for disaster management, where data have been collected from government authority, that is, the City of Jeddah and a private vendor. Historically, there have been numerous issues identified with data sharing and data collection as suggested by Lee [31]. It was a cumbersome task to evaluate the application of GeoICT technology, based on getting the geospatial data for this research. However, we were able to obtain shapefiles to assess the administrative boundaries for the City of Jeddah, including provincial boundaries, district boundaries, and municipal boundaries, including the Red Sea administrative boundaries for the City of Jeddah, as shown in **Figure 7**. The transportation dataset provided shapefiles for street centerline and street

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curb for the whole city of Jeddah. The Environment dataset provided shapefiles for streams as extracted from the Radar, as well as floodplains layer showing the natural drainage system for rainfalls across the City of Jeddah. The Tourism dataset contained shapefiles for point features of public facilities. This was helpful with another privately created dataset for Points of Interest for the City of Jeddah. A digital elevation model in the form of Aster data was used for providing the required elevation information for the study area. Most of the datasets used were provided by the City of Jeddah, and it was in accordance with the guidelines provided by Pew and Larsen [32] who provided guidance by identifying potential layers. **Figure 3** shows details about the City of Jeddah geospatial data repository.

A major characteristic of the evolving GeoICT systems is their ability to investigate the level of details and the validity of sources for emergency management, based on the scope, purpose, and application. This scalability provides added value advantage to the user community. This is supported by the flexibility of the advanced system regarding hardware integration and software processing capabilities, backed by cloud-based data storage or a level of data distribution over a specific data management protocols. Advanced GeoICTs are also robust. This strengthens the process of data collection, processing, and manipulation.

The expected major trends for the near future is the expansion of adopting more UAV and AUV systems and integrating data sharing from these platforms with real-time image processing systems. The original features of integrated data systems regarding sophisticated on-the-fly quality assurance modules, processing, and transmission of data are growing. The quality of

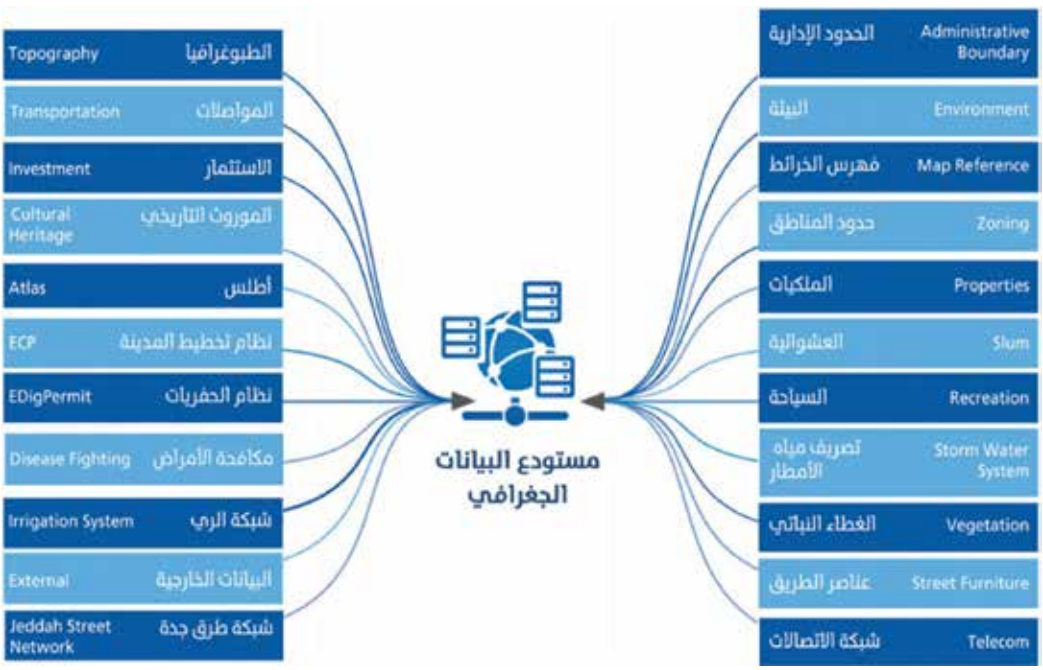

Figure 7. The City of Jeddah. (geospatial data repository source (www.jeddah.gov.sa)).

sensor data, infrared data collection, and on-the-fly decision support is increasing. It is expected that real-time processing and quality control (QC) modules as well as automated data flow will further shorten the production cycle, minimize the human interaction, and will consequently enable a smooth transfer of integrated data systems to many platforms.

The need for adopting advanced GeoICT is supported by the growing user community with diverse applications requirements. In the field of disaster management, GeoICTs are getting a broader user community because of the less technical expertise required and the expanded public participation in disaster management. Between voluntary or crowdsourcing data products, to substantial involvement in the response operations to disaster and emergency management, all these are supported by the trend in ubiquitous, robust, and affordable computing.

The indicators of efficient use of technology in both public and private domains, in the field of disaster and emergency management support are justified by the availability of systems and the practical use of these systems, as well as by the ability of upgrading technology infrastructure, as the case with various emergency management authorities. Data and procedures standardization and mature policies are among the essential factors for advancing the role of GeoICT in emergency management. ICT infrastructure and open, transparent systems are primary factors in developing advanced procurement policies and fostering interoperability between disaster management sectors. However, the challenges relating to the system security and interoperability remain. However, they do not significantly impact the use of this technology.

8. Conclusions

Based on the reviewed technologies and the case study used in this research, it can be concluded that disaster and emergency management operations in urban environments rely heavily on leading Geomatics Technologies. These technologies have maximized the planning and response operations and contributed to saving life and property in many situations, including but not limited to coastal zone tsunamis and earthquakes. The fast pace of development in advanced computing have significantly contributed to disaster management by providing more robust telecommunications, and through growing utilization of the technology, based on a broader standardized user base, and less required technical expertise. The rapid growth in GeoICT has helped disaster management community by expanding public participation along with first responders' advanced capabilities of responding to extreme situations. Geomatics has been instrumental in providing effective approaches and tools for dealing with crisis management from the point of view of urbanization.

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Chapter 2

Position Tracking and GIS in Search and Rescue Operations

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Additional information is available at the end of the chapter

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Abstract

Geographical information systems can be useful in supporting an operational or situational picture in emergency situations. One particular use case is to keep track of moving personnel in the field. This has proven to be useful for safety (of rescue personnel), as well as for monitoring, planning and documentation of operations in the field. In this chapter, we define some concepts of tracking information, and tell the story how enthusiasts from the radio-amateur and red-cross communities developed and applied position tracking to search and rescue services in Norway. Based on years of experience from this work we discuss some issues related to how systems could deal with such spatiotemporal data in emergency and SAR situations.

Keywords: GPS tracking, SAR, GIS, volunteers, situational awareness, operational picture

1. Introduction

In emergency situations like *search and rescue* (SAR) operations or disaster response, it is essential that decision makers have correct and relevant information in a timely manner. SAR and other emergency management may involve a rather ad hoc organisation, and may depend on effort from various volunteers, amateurs and experts in different fields. Typically, different organisations (agencies) and different cultures are involved, using different tools and collaboration patterns. It may be challenging to establish a common understanding of the situation and to coordinate the effort in an efficient and effective manner while at the same time not

compromising the safety of the involved personnel [1]. The information should therefore be correct, precise and easily understandable by the different actors. At the same time an information overload should be avoided.

In this context geographical information systems (GIS) are known to be useful in visualising information and presenting it on a digital map. This is essentially what has also been done manually before the digital age, using printed maps and drawing lines, areas and symbols on them. Visualisations on maps could be a part of a *common situational* or *operational picture*. Examples of geographical information in this context include positions and movements of resources working in the field, e.g., search teams, vehicles as well as observations of interest.

This chapter is a case study on how voluntary organisations in Norway (primarily the radio amateur association and the Red Cross) have explored using position tracking in land-based search and rescue operations. The materials are mostly the author's own experiences along with statements from participants as well as an interview. A system has been developed based on VHF radio communications and open source software. Since 2009, tracking has been used in several real incidents and some lessons were learnt from this experience. This story was earlier presented in [2].

We have observed that tracking and visualisation on maps reduces stress in the command centre or command post. It reduces the need for verbal communication with teams in the field. It can contribute to an improved situational awareness. It has been pointed out that that it addresses three issues: (1) the safety of search and rescue personnel, (2) need for coordinating resources and monitoring the operation and (3) post-operation analysis, planning and documentation. Offering a service like this may free operation commanders and SAR experts from technical tasks.

The rest of the chapter is structured as follows: Section 2 describes some background and related works and describes the role of volunteers and radio amateurs in particular in Norwegian land-based SAR. In Section 3 we describe some concepts of tracking as well as the design and implementation of a tracking system. This includes a tracking device and an application to process and display positions on digital maps. Then in Section 4 we describe experiences from using the system in real search and rescue operations. In Section 5 we look deeper into some lessons we have learned and issues we have encountered in the project like annotating the spatial information, connectivity, etc. In Section 6 we conclude.

2. Background

Information system support for emergency response [3] is an active field of research and development. Here, spatial data and geographical information systems (GIS) play an important role in helping increase the *situational awareness* [4, 5]. This includes location of incidents, affected areas or buildings, location of rescue teams, victims, shelters, etc.

A known issue is how to establish a common *situational* or *operational picture* [6–8]. In the literature, this concept has several definitions. The focus could be on creating a common

understanding of the incident across multiple organisations and cultures participating in the decision making, or on the information systems supporting decision making. When focusing on information systems it is helpful to define and standardise a conceptual model for the information. In [9] the author develops such a model for dynamic, operational information from which database schemas can be derived. They distinguish between (1) *situational information* which is about the incident and its effect and (2) *operational information* which is about active responses, processes, people and organisations involved. They also distinguish between *static information* that exists prior to incidents like maps, roads and buildings and *dynamic information* which is produced during an incident. Dynamic operational information includes incidents, events, threatened areas, causalities, teams or vehicles. Some of the information can be *spatiotemporal*, i.e., it contains points in both spatial and temporal dimensions. For instance, spatial position of objects may change at particular time instants. Through spatiotemporal analysis one could derive trajectories of moving objects. A data model for trajectories in particular is explored, e.g., in [10].

2.1. Search and rescue

For search and rescue operations a number of information system tools exist for planning, coordination and decision support. The usefulness of GIS in SAR (as well as in emergency response in general) is well documented (see e.g. [11–13]). Advantages include having more updated maps, being able to easily connect between planned and documented efforts, to see areas that are searched or not searched and to integrate information from multiple sources. Another advantage which is mentioned in literature is the ability to keep track of rescuers which is the focus of this chapter.

GIS tools can also be used to apply search theory and statistical models to help planning the effort and increase the chances of success [14, 15]. One could use such tools [12, 16] to visualise the probability of finding the lost person, for example, distance circles may be drawn around the initial planning point (IPP) of the operation, which often is based on the last known position (LKP) of the missing person. [17] evaluates such probability models, more specifically where distance from the IPP determines the probability of success, where the terrain determines the probability (watershed model) and a combination of these two which seems to be a promising approach. The Bicycle Wheel Model [18] is a well-known application of such search theory in land-based SAR. It can easily be visualised and combined with tools to draw search areas, points or interest, to manage teams and missions, to write operation logs and to track the position and movements of search teams.

There are few commercially available land SAR tools and they are often not generally available since they often are designed for specific agencies or countries, are based on proprietary technology, etc. Examples include the Canadian SARPlan [15], the British SARMan [19], or Norwegian SARA [20] used by the Norwegian Joint Rescue Coordination Centre (JRCC).

The work described here focuses on one of the many parts of a GIS-based information system for SAR, namely position tracking of teams, vehicles, etc. Several commercial applications exist providing tracking or fleet maps, often proprietary and limited to single technologies like, e.g., Tetra. We are primarily using amateur radio APRS tracking. SARtrack in New Zealand

[21] has some similarities with our work, but some aspects of search planning are supported as well. Our system aims to be an extensible platform where such functionality may be added as well as alternative data sources. Our project is focused on open source software, it is web-based and open, while most other solutions require platform-specific programs to be installed on desktop or laptop computers.

2.2. Voluntary rescue services in Norway

Norwegian rescue services are organised as a cooperation between government agencies, voluntary organisations and private companies being able to contribute. Two Joint Rescue Coordination Centres (JRCC) has the overall responsibility for coordination of operations. Land-based SAR operations are usually led and coordinated by the Local Emergency Management Authority located at police districts. In a typical land-based SAR operation a temporary command centre (or command post) is established close to the location of the incident. The effort is coordinated by an operations leader which is a representative from the police force.

If approved by the JRCC voluntary personnel may be contacted and asked to help. Most voluntary organisations participating are members of the Norwegian Forum for Rescue Organisations (FORF), an umbrella organisation. Voluntary organisations may be specialists or experts on various fields. The largest and most used organisation is the Red Cross, which have a rather broad field of expertise. Other important organisations include the Norwegian People's Aid (general), the Rescue Dogs (search by dogs) or the Air Services (search by aircraft). One of the smaller organisations in FORF is the Norwegian Radio Relay League, NRRL (radio amateurs). They offer technical and communication support, for (1) SAR operations or (2) for larger emergencies where critical communication infrastructure is hit. Especially in the latter case, long-distance communication can be provided. Radio amateurs are enthusiasts that have access to a wide range of radio frequencies and technologies and can improvise to get messages through worldwide.

A more recent and successful contribution of radio amateurs to SAR is mobile phone localisation where a special task group can be assigned to interpret traffic data from cellphone networks in order to estimate the likely position of missing person. The last 10 years we have provided position tracking and geographical information systems. This is further described in the rest of this chapter.

It varies significantly which voluntary organisations are active in different police districts around the country. Volunteers may organise differently locally and have different focus in different areas. In addition different police districts may have different practice and focus. It is somewhat obvious the type SAR operations can be rather different in different parts of the country. Things are different in the largest cities than in small villages. In most police districts radio amateurs are seldom used, but in some they are used in a significant part of the SAR operations.

3. Position tracking and APRS

In this section concepts of tracking and tracking infrastructure are described. Based on these concepts we have implemented a portable tracker and a web application for displaying tracking

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information on electronic maps. It is based on Automatic Packet Reporting System (APRS) [22] which is an open standard used by radio amateurs worldwide. The adoption of APRS by voluntary rescue services in Norway does not exclude other technologies.

3.1. Tracking concepts

A *tracker* is a portable device that contains a GPS receiver and a transmitter (or transceiver) that can send its position through some infrastructure to an information system that can process and present the position on a map shown in command centres, etc. During operations a tracker is typically associated with a rescue team or vehicle carrying it. Trackers may be integrated into communication radios and use different technologies and infrastructures (e.g. APRS, AIS, Tetra, cellphone, etc.). Even a smartphone may be used as a tracker using the GPS and a proper app, though there may be issues like battery capacity or coverage. A *position report* from a tracker is associated with a time instant. The information system may present the tracker's position at a particular time or a series of such reports from the same tracker within a certain time-span as a *trail* (or *trajectory*).

3.2. APRS concepts

In the APRS protocol, *location items* can be either *stations* or *objects*. Stations have globally unique *identifiers* which typically are *radio callsigns*. Stations transmit *position reports* in order to update their positions or other associated information. A station typically corresponds to a physical tracker. In addition stations can report the position of *objects*. Since objects are *"owned"* by stations that report them, they do not need to have globally unique identifiers. Conceptually, this would imply existence dependency, but in the APRS protocol a station can in some cases take over the ownership of objects from other stations. This can be useful, e.g., when the station that generated it in the first place stops operating and we still need to keep track of the object.

A location item has a (possibly moving) position and is associated with a *symbol* that is sent with position reports. A symbol can be used to indicate what type of item it is or what mission it is assigned, e.g., car, aircraft, boat, rescue-team, etc. A symbol is typically used to select an *icon* when plotting the item on the map.

A position report is associated with time either by *timestamping* it at the source or timestamping it when received. A *trail* for a given location item is an ordered list (by time) of reports within a given timespan before the last reported position. In a real-time view this means showing the movements of stations (as lines and points on the map) some minutes back in time.

3.3. Tracking infrastructure

A tracking system needs an infrastructure to convey and process the stream of information between trackers and the applications where the information is presented. This is also the case for APRS which use AXE.25 [23] data packets to send reports over a radio. It uses a single VHF channel and a rather narrow band form of modulation (1200 baud audio frequency shift keying). The *APRS protocol* [24] defines formats for position reports as well as short text messages, telemetry, weather reports, etc. Though it is criticised for being aged and not optimal, it is free

to use, an open standard, well tested, widely deployed in the radio amateur community and used on a daily basis. APRS devices are affordable, or not too hard to construct.

The infrastructure consists of several components (see **Figure 1**). Trackers broadcast their information. This is collected by internet gateways (or directly by client apps), possibly after being retransmitted by digital repeaters (digipeaters) to extend the coverage area. The APRS Internet Service (APRS-IS) is a worldwide network of servers that can interconnect the gateways and provide data to applications. The range of repeaters or gateways depends on the topography, antenna height, etc. A range of 50 km is not unusual. The fixed infrastructure can be extended by deploying mobile repeaters or gateways. Data in transit are not encrypted.

3.4. Implementing tracking

Traditionally, radio-amateurs contribute to voluntary search and rescue services by providing communication services. Tracking is an extension of this service. In a more technical sense the implementation of tracking can be said to be twofold given that much of the fixed infrastructure already existed: (1) Developing a tracker and (2) developing a web-based application for presenting information on electronic maps.

Though some APRS trackers were available commercially, they were often not complete units designed for SAR operations. In 2008, the radio amateur group in Tromsø therefore decided to design and produce an affordable, compact, waterproof, handheld-size tracker that was easy to operate and had battery capacity for at least 24 hours operation. It was a complete, self-contained unit. The tracker was named "*Polaric Tracker*" and prototyping took place in 2008 and 2009. Already in this prototyping process trackers were used in real SAR missions (see Section 4) which gave us valuable experience and ideas. Later, some other, handheld trackers have become commercially available, somewhat smaller in size, but with less transmitter power and somewhat shorter range. **Figure 2** shows a Polaric Tracker and a SainSonic AP 510 (commercial) tracker.

The other enabling technology development is the "*map server*" application named "*Polaric Server*". It was based on well-known Open Source software and designed to run on small portable servers to be brought to the command post as well as running as a online service on

Figure 1. APRS infrastructure.

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Figure 2. A Polaric Tracker (right side) and a more recent commercial tracker (left side).

the internet. It is essentially a GIS application which can be used to display position of objects on digital maps (based on received APRS reports) and update them in real time. End users only need a standard web-browser. The application supports manually annotating position objects on the server (with proper icons and labels), it supports tagging and filtering to deal with information overload, it can combine various data sources and it supports storing and querying past data in a spatiotemporal database.

In December 2009 the Norwegian Mapping Authority (Kartverket) started to offer geographical data and web services (WMS) to the general public, to enable the use of maps in various applications. This enabled us to immediately offer an open online service with quality maps. Keeping our service (mostly) open to the public was also believed to encourage testing and development as well as recruitment of interested people to the radio-amateur and voluntary rescue communities.

The application has been deployed in several instances. *Aprs.no* is the official online tracking service by the Norwegian Radio Relay League. The Norwegian Red Cross has been offering a similar service for their APRS tracking system and is now developing a new system[1] which builds on some of the ideas and experiences from the project described here.

4. Use of tracking in SAR

During almost 10 years of operation, the tracking system described in this chapter has been employed in a variety of SAR operations, exercises, sports events, etc. It started in 2009 in the Tromsø-area when the *Polaric Tracker* prototypes were made. The concept was tested in an exercise with the Red Cross and soon after, in February 2009 there was a large search for a person missing from a fishing boat near Vannøya in Karlsøy in Tromsø. Several voluntary

[1]This has been named *SARSys*. As this chapter is being written, it is work-in-progress and little published information is available. It will be designed to use tracking data from the Tetra network used by most emergency services in Norway.

organisations were called out to help. The first day there was an aircraft search at sea and trackers were placed in aircrafts to follow their location.

The next day it was decided to perform a search along shores. A base was established at Kristoffervalen near the search area. A total of 11 trackers were deployed on search teams from the Red Cross, Norwegian People's Aid, Civil Defence as well as boats from the sea scout group. A portable APRS repeater, internet gateway and map server was deployed near the base. A video projector was used to display the operational picture (see **Figure 3**).

After this incident, tracking has been used for a number of operations around the country. As also pointed out by others (see e.g. [13]) we observe that tracking work best for long search operations which can last for several days and cover larger areas. Here, multiple SAR teams operate at the same time with some coordination from a command centre and there is some time to organise. This is in some cases searches for presumed dead persons which are difficult to find. There are also examples of persons that have been lost in the mountains, search for missing people with dementia as well as search for suicidal persons. Though many searches have been in the wilderness, some searches have actually been performed in or near a city.

Voluntary organisations are sometimes invited to contribute in larger national and international crisis exercises, in some cases with tracking. An example is Barents Rescue 2013 [25] where tracking was used on Norwegian, Swedish, Finnish and Russian rescue units, boats and helicopters. In addition, tracking is popular in large sports events, like, e.g., marathon, ski or bicycle races which can be seen as relevant training, especially when the event is spanning large distances. It is useful to keep track of where the lead is, as well as where ambulances and other mobile support functions are moving.

In 2009 and the following, most of the tracking activities were in the Tromsø area in the Northern Norway. In 2010, there were about 10 SAR operations, most of them in Tromsø, but if we also count exercises and sports events the number is closer to 25. In 2017 NRRL was involved in about 25 SAR operations, most of them in the Oslo area.

Figure 3. Operational picture of shore search and aircraft search Vannøya, February 2009.

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4.1. Tasks and roles during operations

There are some tasks and roles that are typical for land-based SAR operations where trackers are used. When a person is reported missing, the police collect intelligence and at some stage it is decided to call out SAR personnel. A command post is established, often close to the incident and search teams are assigned areas to search. If possible, each search team will be assigned a tracker when going out. Also, vehicles used for transport or search like cars, ATVs, snowmobiles, helicopters, etc. may have trackers.

Operating the tracking information system can be a specific task or role in the command and control centre. The operator should keep a record of each tracker's callsign and what mission it is assigned to. This information is used to give trackers meaningful labels and icons when they appear on the map. Unnecessary items may also be hidden. The operator may present a relevant operation picture to operation commanders using a large screen or video-projector or the operation commanders may be given access to the application on their own tablets or PCs. Also the JRCC or the Local Emergency Management Authority may use the web-application to follow the operation or get reports with screenshots. The operator (or team of operators) may also take care of other communication tasks or technical support.

In addition to tracker's positions findings or other points of interest can be marked on the map. These can be put in manually by the operator or tracker can send such points as APRS objects (see Section 3.2). The annotation and editing task as well as post-operation documentation is often delegated to volunteers located at home. Having an online server-based mapping application that can be operated over the internet or radio makes such delegation easy. Operation commanders, other personnel in the command centre or even teams working in the field may also see the online map using their personal computers or tablets.

4.2. Documentation and historical data

After the operation is ended or ended for the day, an important task is to document what has happened. This includes information on what areas has been searched, when and by whom. The ability to query and visualise past search activity addresses this need and is useful in the planning of the next day. The police may want to show to close relatives of the missing person what has been done and what areas have been searched. It is also not unusual to invite close relatives to the command post during the operation where they can see the real-time map as well. In addition to online tracking, data could be downloaded from portable GPS devices to provide more detailed information. Having an application where data are collected and stored in a spatiotemporal database in real-time, we can do a historical search at any time during the operation. This can be an additional tool when monitoring the progress of the operation.

In an early phase this was improvised by using external APRS services that store data over some time. In 2012, after requests from the police, a module for Polaric Server for storage and retrieval using a spatiotemporal database was made. **Figure 4** shows an example of a full day search (10 search teams) on the left side and 1 day search by a single aircraft at the right side. This may look a bit chaotic, but keep in mind that we may narrow the search to specific missions or timespans and we may export the result in a open format (GPX) to be further analysed in other tools.

Figure 4. Historical records of a day of mountain-search near Tromsø in 2012.

One of the lessons learned from using this is that we should always take note of the missions of the individual search teams, the callsign of their trackers and the starting time and ending time of the missions. This information is collected when the team is assigned a mission and a tracker. Having this information we can in principle look any mission up in the database at any time later. For privacy reasons we may however want to limit the scope of the database.

4.3. Case materials

Since GIS and tracking is much about visualisation, it is useful to illustrate by showing some selected snapshots from real SAR operations. It is beyond the scope of this chapter to describe all incidents. Some details are also left out.

Figure 5 shows a real-time view (with trails) of a search in Lavangsdalen near Tromsø in 2012. At this particular moment there were 10 active teams and two observations (points of interest) marked as objects by the *"RK lag 1"* (Red Cross Team 1) tracker. The car of the missing person was found near the road (the cluster of trackers on the map) and this was the last observed position and the location of the command post. In addition, some belongings of the person were found in the stream up in the hillside. The search was therefore focused around the stream up to the mountaintops as well as near the road itself. The operation went on for several days and there were search teams from the police, Red Cross, Norwegian People's aid and Rescue Dogs. In addition a voluntary aircraft and a helicopter were employed. The person was not found and this has later become an unsolved murder case.

Figure 6 shows two pictures from a search for a missing person hiking in the mountains near Tromsø in 2012. The left image is a real-time view (with trails) shortly after the search was started showing eight active teams. The right image shows a historical search (for documentation)

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Figure 5. Search in Lavangsdalen near Tromsø in 2012.

Figure 6. Mountain search near Tromsø in 2012.

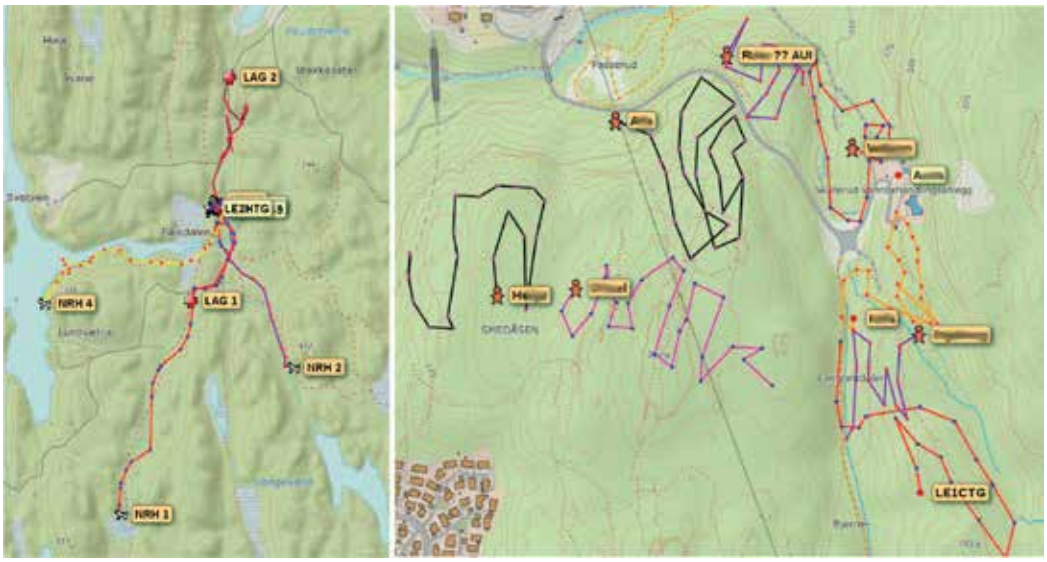

Figure 7. Search operations in Larvik 2012 and Oslo 2018.

with a selection of the effort of two of the teams through 1 day work. There were large uncertainties wrt the location of the missing person and the search went on for several days over a large area. Aircraft searches were performed and many voluntary people searched large areas without success. Due to the complexity of this operation it became clear that we needed to implement historical search (see Section 4.5).

The left image of **Figure 7** is rather self-explanatory. It shows a search operation near Larvik in 2012. It is a real-time view (with trails) of 5 active teams with trails. It clearly shows how the teams start from an initial planning point (IPP) and search along paths where the missing person most likely could have walked.

The SAR group of NRRL (radio amateurs) in Oslo is currently the most active group with 20 active persons. They cover two police districts including central Oslo and provide tracking, common operation picture, and other technical support like power and internet to the mobile command post. The right picture of **Figure 7** shows a typical operation in Oslo in January 2018 with a real-time view (with trails). Names of search team leaders are blurred. The search assignments and the actual search patterns can be clearly seen on the map. The missing person was last seen in the residential areas and a possible observation the night before search started, the person was walking toward the forest. A search close to this IPP was performed with nine teams from the Norwegian Rescue Dogs and the person was found and the position marked on the map.

NRRL provided trackers to search teams, two persons were helping at the command post and one person operating the map at home. A PC was placed at the command post to see the progress of the search. After the operation, historical trails were generated in an open (GPX) format and sent to the local police central along with logs from GPS units.

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5. Lessons learned

In this section we look into some lessons learned and issues for further research and development encountered in this project. This includes combining and refining data. First, the development process described here has mostly been voluntary work and innovation is typically a result of participation in voluntary rescue services where radio-amateurs have traditionally contributed with communication support. Advanced information system support is a more recent contribution.

A command centre of a large operation typically uses experts in various fields. Communication and information management and GIS in particular may be regarded as a field of expertise, so a role that could be useful in a command centre is the role of *information manager*.

5.1. The benefits of position tracking

We have observed some immediate effects of using tracking in SAR operations. This is also clearly formulated in statements from police officers leading SAR operations. According to one of these statements[2] the usefulness of such a tracking system is due to three factors:

1. The safety of personnel participating in search and rescue operations in the field.
2. Effective and efficient monitoring of the operations and coordination of resources.
3. Documentation of the operation after it has finished for the day. Planning for next day of operations.

The first two aspects are about *real-time* information, i.e., the focus is the *current* situation or recent events. To elaborate on the second aspect; being able to visualise the situation and its development has proven to reduce the need for other (verbal) communication and reduces the level of stress in the command and control centre. For instance, a quick look at the map can reveal that a search team is about to complete its mission and would soon need transport (from a location). Queries can be made if progress unexpectedly seems to have stopped. Warnings can be given if personnel accidentally move into dangerous areas. Some decisions can be made in advance, increasing the efficiency of the operation. Hence it can make sense to use the term *tactical picture*, in particular if the advance planning of operation can be visualised. Informants also emphasise the need for coordination in the rescue phase, and the usefulness of quickly locating the person to be rescued and resources nearby:

> *"When the finding was reported by one of the search teams, we could immediately locate its position, we marked it on a map on an ipad and gave to the police officer in charge".*

The third aspect is further described in Section 4.5. It is about past events and is useful in tactical and strategic decisions (planning), in post-operation reporting and de-briefing. It allows us to see what areas have been searched during the day. In contrast to the two first aspects, data need to be stored and properly indexed in a *spatiotemporal database* to facilitate queries on what happened in a particular area in a particular time frame.

[2]A note by Anne Sjøli in Troms Police District to the Tromsø radio amateur group, dated February 23, 2009.

5.2. Refining data: annotating spatial information

An essential feature of the system described here is the ability to *annotate* position items by the use of *descriptive labels* (in APRS applications such labels are often termed aliases or *tactical callsigns)*. In the AIS system a vessel always has an MMSI identifier, but can also have a callsign and a name. Usually the name is used for labels since it usually is easiest to recognise by humans. A callsign identifies a *tracker*, not the mission and is by itself not very informative. Therefore, some meaning needs to be added to help seeing what a tracker represents. A single tracker is assigned to different people, teams and vehicles over time, which again are assigned to different *missions* over time. If the *label* and the *icon* on the map instead of just showing the identity of the tracker, tell something about *who* carries it, its *mission* and possibly what type of vehicle it is, it is obviously more informative. However, some care should be taken not to overflow the map with information. The descriptive labels should be short. It is possible to add longer texts that are shown when the user clicks on the icon on the map.

A good choice of icons may also make the picture clearer and we may benefit from standardisation of icons. In the APRS protocol (see Section 3), each position report carries a *symbol tag* which is meant to indicate a *type* of vehicle or mission. The application will select a proper icon based on this tag. However, it may be impractical to update the symbol setting in each tracker each time it is assigned to a new mission. Therefore we allow the server operator to change the icon as well, for example, to use a red cross icon when a tracker is assigned to a red cross team. It may also be more convenient to enter this extra information into the server than letting each tracker send it. Trackers don't have alphanumeric keyboards and it is more efficient to assign the task to one person keeping a record of all trackers involved.

In addition to icons and aliases, newer versions of the software allow the operator to annotate position items with *tags* that are essentially freely chosen keywords. For example, items associated with SAR operations may be tagged *"SAR"*. Tags can be used when searching the database of items. Tags are also used to determine how items are to be displayed on the map, for example, if the label is visible, if the trail is visible, how long it is (time-span), what icon to use, and what colours and label styles to use. It can also be used to hide items and determine who are authorised to see them. This is configured as a *filter-specifications* created by the system administrator as *rule-bases*. The user can select from a menu of predefined set of filters to choose what items to display and how. This is an effective tool to address the problem of information overload. Tags can also be added automatically to position items by rules based on more technical information like callsign, symbol from tracker, channel or even other tags.

These observations indicate that a possible topic for further research is *semantic annotation*, which may be especially relevant when data from different sources are to be combined and linked. We could benefit from relating tracking information to conceptual models like [9] and look closer into ontologies and semantic technology [26, 27]. Future research may also explore more advanced spatial or spatiotemporal data analysis and even machine learning techniques to help analysing data and determine what moving items represent.

5.3. Combining data from multiple sources

The system described here is extensible and could potentially *combine* data from a range of different sources. Some types of data sources are: (1) *Static geographical data from authoritative public sources* (typically maps and GIS application data), (2), *other public open data* (mostly static), for example, about weather conditions, road disruptions, web-cameras along the roads, information about hospitals, shelters, etc., (3) *static geographical data produced by crowdsourcing, e*.g., OpenStreetMap [28], (4) *data from different position tracking systems* like AIS, smartphone apps, or various commercial systems and (5) *data entered by the users of the system* as the information is discovered, either directly to a web-application, via smartphone apps. Our current online service uses several of these, including AIS data from the Norwegian Marine Authority.

5.4. Summary and discussion

It is known that Geographical Information systems can improve situational awareness in crisis management. Tracking positions of search and rescue personnel, vehicles and other points of interest is no exception. Visualising the situation on a map what is going on is more concise and clear than telling the story just with words. Having such a map reduces the stress at the command post and reduces the need for other radio communications. Important benefits are (1) the safety of SAR personnel, (2) more effective and efficient coordination of resources and (3) available information for post-operation analysis and documentation. We have seen this in a number of real SAR operations.

This chapter describes the implementation and use of a tracking system based on APRS, mostly provided by radio amateurs. This has strengths and weaknesses and some challenges clearly exist:

5.4.1. Strengths

A main strength of the tracking system described is that it is an open system. It is based on open source software, open public data and open protocols. With an open protocol like APRS, a number of alternative client applications are available, you are not tied to a particular vendor or product. This also makes it rather flexible. If we operate from a command post without broadband internet, it can be run on a local portable computer with the Polaric Server software or another APRS compatible program connected to appropriate radio equipment.

In contrast, many fleetmap or tracking systems exist though most of them are rather proprietary and limited to particular products, or they require platform-specific programs to be installed on a PC. Such systems are often limited to particular sectors and historically interoperability between systems has been limited. Our system is easily accessible through the web for anyone who are interested. Normally it is open for all to see, but during sensitive SAR operations information can be hidden for other than logged-in users. This was implemented after a specific incident where journalists published links to the system during a operation [2].

It is low cost and based on voluntary work. And since it is used and tested by enthusiasts on a daily basis, there is a high probability that serious problems are discovered and fixed quickly.

Involving radio-amateurs with expertise on radio-propagation and powerful transmitters, let us cover areas not covered by cellphone networks or other fixed public networks. Radio coverage can also easily be extended to remote areas using mobile equipment and the system can be operated remotely.

5.4.2. Weaknesses

Some of the main strengths are also the main weaknesses. The system is vulnerable since it depends on the time, enthusiasm and advanced technical knowledge of very few volunteers to develop and run it. This is the main weakness, challenge and barrier of implementation.

The access to public or private funding is very limited. We got funding for developing the Polaric Tracker, but we have failed to get funding for further developing the software. It is also difficult to recruit software developers with the proper skills. Therefore, the project moves slowly and essential functionality is not implemented or bugs are not fixed due to lack of resources.

NRRL is a small organisation with ageing members. A fraction of the members are interested in SAR, so the service is offered in parts of the country. Currently the activity is mostly in the capital, Oslo. Even if the system is easy to operate, it is technically complex. The system main operators should have some technical knowledge and understanding how it works. Therefore some organisation and education is necessary.

Technically, APRS is rather old and not optimal and eventually more efficient technologies will take over.

5.4.3. Other issues

To reach its full potential our system needs access to open public data, most importantly to map data through web services. Not all countries allow such access to map data to the general public and Norway started opening up Web Map Services (WMS) in 2009. Free or commercial alternatives like OpenStreetMap or Google Maps do not provide sufficient detail in remote areas though valuable in more populated areas.

The *precision* of tracking points from cheap GPS units seems to be acceptable in the spatial dimensions. It is usually within a few meters. The challenge is however with the *temporal* dimension. An APRS channel is very narrow band and is shared among many devices. Therefore it has a very limited capacity. Furthermore, transmissions may be lost due to weak signals, collisions, etc. APRS trackers implement an adaptive algorithm to decide how often to send, that takes speed and direction changes into consideration.

Coverage in remote areas can be better than with tracking systems using the cellular networks at the cost of a lower bandwidth. We have experimented with using a smartphone app as a tracker. This could be an alternative in urban areas, but we need to be aware of the drain on the battery. Using a satellite-based tracking system offers an almost total coverage in remote areas, but is expensive to use and may offer less bandwidth.

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6. Conclusions

Geographical information systems (GIS) play an important role in crisis management in that it contributes to situational awareness by visualising spatial information on maps. A particular application of this is real-time GPS tracking of search and rescue (SAR) personnel, vehicles, observed points of interest, etc. This chapter tells the story how volunteers in SAR operations in Norway, in particular radio amateurs, contribute to situational awareness by providing services for position tracking based on open standards, open hardware and open source software. This took off in Tromsø 2009 with open public map data, a portable tracker and a web-based GIS application to visualise moving objects on maps.

The benefits of tracking is threefold: first, a main motivation is safety for the search and rescue personnel which is better if operation commanders can monitor where they are, second it has proved to be useful in monitoring and coordinating operation, especially in operations in larger areas where many different resources need to be coordinated, like search teams, boats, aircrafts, cars, snowmobiles, etc., or when initiating the rescue phase after locating the missing person. Third, we have after requests from operation leaders implemented a database of historical data to facilitate documentation and analysis after operations are ended; typically for reporting and de-briefing. Especially in the real-time views we observe how important it can be to annotate and filter the information properly, for example, by using informative labels and icons.

An open system has some advantages w.r.t. flexibility and interoperability. The main weakness, challenge and barrier of implementation seem to be that system is that it depends on the time, enthusiasm and advanced technical knowledge of very few volunteers to develop and run it. That it is voluntary work is both a strength and a possible weakness.

There are many cases for further research and development. In general tracking is part of the information system used to support operational and tactical decisions. We envisage the integration of a larger set of different data sources, crowdsourcing, and interoperability between different systems. To support this we can look closer into data models for SAR use, semantic annotation, etc. Further research on information systems for emergency management could look into several problems, for example, how they could adapt to varying connectivity, or varying quality of data (e.g. reliability), for example, by assessing the quality of combined data presented and informing the user what he/she can expect.

Conflicts of interest

The author is a radio amateur and have been involved part in voluntary rescue services in Norway. I have participated in developing Polaric Tracker which is described in this text and is the main author of Polaric Server which is described in this text. I am also responsible for the mentioned online service aprs.no.

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Chapter 3

Information Support of Crisis Management

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Additional information is available at the end of the chapter

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Abstract

The increasing importance of information has begun the process of interrelated changes of the whole society in today's world. The rapid development of information and communication technologies occurs also in the problematic of crisis management. Since we live in a dynamic world, it is important to be ready to the changes that life brings, responding and adopting new technologies. One of them is crisis management information system. Information system is a tool for information support. Information systems in general are very important and indispensable part of planning, organizing, managing and controlling. This definitely applies to crisis management information system. They are therefore used in the planning of emergency measures as well as in crisis situations. Crisis management is an activity, which can help us to save life, health and property in the whole world.

Keywords: crisis management, information support, information system, rescue operation, heuristic analysis of usability, natural disaster

1. Introduction

During life, one encounters a lot of emergencies or crisis situations. The whole world is threatened by a number of emergencies, which only differs in the location of the country, its geography, the number and size of industrial enterprises, etc. The big difference is also between countries in the Mediterranean (such as the Czech Republic) and countries located by the sea (e.g. the Philippines). The countries that are located by the sea must prepare for crisis situations such as typhoons, tsunamis, etc., which are not threatening the Mediterranean countries.

As mentioned above, each country is threatened by a different emergencies and the objective of each country is to protect its population. The development of new technologies has also brought new opportunities to crisis management. To manage all emergencies or crisis

situations, information support for crisis management is used today. Lukáš defines the information support for crisis management as a process of information support, management, decision making and cognitive processes. The objective of information support is to satisfy the information needs through the information activities necessary to carry out the process. Basic information activities include information retrieval, its processing, presentation, archiving and more [1]. The law defines information activities as "the acquisition and provision of information, the representation of data information, the collection, evaluation and storage of data on mass media and the storage, retrieval, editing or modification of data, their transmission, access, exchange, sorting or combining, blocking and liquidation of data deposited on mass media" [2]. Lowe defines emergency management information system as a computer database system, which is designed to support responders during emergencies by giving them detailed, real-time information, allowing them to graphically integrate it and then transmit their decisions through the chain of incident command [3]. Lindsey defines emergency management information system which connecting all the emergency operational centers and other stakeholders for streamline information sharing and decision support for both daily routine and emergency situations response operations, supporting all phases of emergency management: mitigation, preparedness, response, and recovery. The aim is to improve the communications and information sharing among institutions involved in emergency management in order to facilitate quick and correct decisions during emergencies [4].

This support is being used in all areas of crisis management. It is used by Integrated Rescue Service (IRS) to manage the crisis more effectively and quickly. At the same time, information support for crisis management is also used in public administration, for example on regional level. Public administration institutions also need effective decision-making and assistance in crisis situations.

2. Basic concepts

The following section provides an overview of the basic concepts that are related to the area of information support for crisis management. This terminology is based on legislation, literature, and the cyber security dictionary.

2.1. Crisis management

It is a comprehensive set of management activities and procedures, approaches, views, experiences, methods and measures aimed on analyzing and evaluating security risks, planning, organizing, implementing and controlling the activities used by crisis management authorities to manage specific situations. Crisis management is an integral part of the management of the state, organization or other institution that is interested in its development. Its objective is to prevent the emergence of possible critical situations, to prepare for the managing of possible critical situations, to manage the possible critical situations within the competence of the crisis management and to fulfill the measures and tasks imposed by the higher crisis management authorities, to start the reconstruction and further development. Crisis management is

also referred to as a tool to ensure sustainable development of society, organization, territory and country [5].

2.2. Crisis management system

They are used by governments to manage emergency situations by IRS. Each country has basically the same components as the Fire Brigade, the Medical Rescue Service and the Police. In the Czech Republic, these basic components have been given the name of an IRS, which according to the law means an effective system of links, rules of cooperation and coordination of rescue and security forces, state administration and self-government, natural and legal persons in the joint execution of rescue and liquidation operations, and emergency preparedness [6].

2.3. Information

During the time of managing of an emergency or crisis situation, information has a very important role. Information is a prerequisite for effective emergency response. According to Tvrdíková, the information should have these requirements, which are also referred to as attributes of information:

- timeliness, availability, reliability of information,
- content (actuality, relevance, truthfulness, objectivity, appropriateness),
- format,
- the price and utility value of the information,
- legality [7].

According to the Cyber Security Dictionary, information is defined as "any sign expression which makes sense for the communicator and receiver ."

Lukáš included the following most important information.

- Relevance—the nature of the information should reflect the nature of its use.
- Correctness—the information should be true and reliable. They should have priority.
- Timeliness—information needs to be provided at the right time, i.e. at the time of need and use. Important decisions cannot be made without necessary information if they are not available; however, there is no point in insisting on over-rapid provisioning information that cannot be used safely.
- Timeliness—the information should reflect the actual reality.
- Completeness—all required information, not just some, should be available. Insufficient knowledge due to incomplete information is very dangerous for decision-making.
- Adequacy—the information should be reasonably detailed. Excessive detail makes review difficult and often makes it difficult to get the really needed information.

- Cost adequacy—if it takes the necessary information to obtain an unreasonable amount of time or excessive effort for the benefit it provides, it cannot be considered cost-effective [1].

2.4. Information system

Tvrdíková defines the information system as a functional unit that provides collection, processing, preservation and accessibility of information and data. It includes information sources, media, hardware and software, and equipment, technologies and procedures, standards and employees [7].

According to the Cyber Security Dictionary, information system is defined as "a functional aggregate enabling goal-oriented and systematic acquisition, processing, storage and access to information and data. It includes data and information sources, mediums, hardware, software and utilities, technologies and procedures, related standards and employees" [8].

2.5. Communication system

According to the Cyber Security Dictionary, communication system is defined as "system which provides for the transfer of information among end users. It includes end communication devices, transfer environment, system administration, handling by personnel and operational conditions and procedures. It may also include means of cryptographic protection" [8].

2.6. Information and communication technology

According to the Cyber Security Dictionary, information and communication technology are defined as "all technology dealing with processing and transfer of information, in particular computing and communication technology and software" [8].

3. Legal scope

The following chapter focuses on the legal scope for information support for crisis management, which is usually included in the law on crisis management in the selected country. This term is understood in the legal order according to the requirements of the selected country.

Crisis management in the Czech Republic experienced a great boom at the turn of the twenty-first century, in the aftermath of the catastrophic floods in 1997 in Moravia. On the basis of these floods, a lack of coordination of rescue services in managing with the crisis situation was identified.

In 2000, a package of crisis laws was issued, including Act No. 240/2000 Coll., on crisis management (Crisis Act), Act No. 239/2000 Coll., on integrated rescue system and Act No. 241/2000 Coll., on economic measures for crisis situations. At the same time, there was also Act No. 238/2000 Coll., on the Fire Rescue Service, which was amended in 2015—number 320.

The Crisis Act defines the basic concepts of crisis management, crisis situations, crisis management authorities, rights and obligations of persons in times of crisis situation. The issue of information support for crisis management is also dealt with in this Act, namely in § 26 Securing Information Systems of Crisis Management, which states:

Crisis management authorities use information systems to plan emergency measures and manage crisis situations. Introduction and usage of crisis management information systems must meet the following rules:

a. the transmission of information to superiors, subordinates and collaborating authorities of crisis management,

b. technical and program adaptation to function under difficult conditions,

c. the security of retained information with the highest degree of secrecy contained in the processed dossier.

During the planning of crisis measures, crisis management authorities are responsible to comply with the principle of equivalence of written and electronic data contained in the crisis plan [9].

In Slovakia, the issue is addressed by the Act No. 387/2002 Coll., on state governance in crisis situations in time out of war and military conditions. Information support for crisis management is the same as in the Czech Republic in this law and states.

Crisis management authorities are involved in the crisis management process and use the state crisis management information system. Everyone has the right to inevitable information about upcoming measures and procedures for the protection of life, health and property in a crisis situation [10].

As can be seen in this chapter, information support for crisis management is also included in the country's legal order. Each country defines this concept in its own laws according to their requirements.

4. Information support for crisis management in selected countries

Information support for crisis management is very different in each country. This disparity is given within the country by emergencies typical for the country, by the attitude of the country to addressing emergencies and by different information policies.

The previous chapter describes the current situation of information support for crisis management in the Czech Republic. The aim of this chapter is to familiarize readers with information support for crisis management in other countries. Due to this comparison, the reader will gain broader insight into the possibilities of information support for crisis management.

4.1. United States of America

The US security and safety system has been built since the end of the Second World War. This system is considered as the most sophisticated and the most efficient in the world.

Information support for crisis management is used in the USA. This includes, in particular, the EIS/GEM InfoBook information system, which is used by the Federal Emergency Management Agency (FEMA).

4.1.1. EIS/GEM InfoBook

It is an information system for managing of crisis situations of various kinds. It is an information technology that is designed to support the prevention and solution of various crisis and emergency situations. Due to this system, users can respond appropriately to any crisis situation. It allows receiving, sending, and recording event management data with automated logging and automated reporting of the situation. It also allows recording of the necessary resources for managing the emergencies.

InfoBook provides current information in a combination with map data, data from databases, modeling and communication technologies.

The EIS/InfoBook modularity enables users to keep an immediate overview of the situation and its progress, the sources of risk in the territory or the facility, the forces and resources, their operations, and tasks, description of the territory, areas, buildings in terms of risks, equipment and other aspects. It allows processing of specific actions plans, hiding and evacuation. This system includes nine modules.

- Daily records—allow users to collect, manage and process records of emergencies and solutions.
- Plans and activities—create conditions for managing of the crisis situations—tactics and methodological solutions, emergency plans.
- Sources and resources—allow users to collect and manage data about forces and resources.
- Dangerous substances—provide data on hazardous substances, their adverse effects and the principles and procedures for reacting to their performance.
- Threat—creates tools to perform risk analysis of objects.
- Local planning—allows users to process detailed emergency plans for objects–deploy both risk and rescue resources.
- Persons—personal data management—links, qualifications, usability, training, experience.
- Response—creates the conditions for managing the response to the crisis, including the coordination of forces and resources during the intervention.

- Aftermath—allows users to keep track of damage and losses, as well as the infrastructure, transport and supply of the aftermath process [11].

This system is used by NATO, FEMA, NASA, IMB, British Petrol, and Shell Oil.

4.2. Australia

Emergency Management Australia is an Australian federal government agency tasked with solving and coordinating operations during emergencies. Emergency management includes plans, structures, and arrangements that are set up to coordinate government, voluntary and private agencies in Australia.

The Agency has four departments—the Security Coordination Unit, the Crisis Coordination Unit, the Crisis Support Unit and the Natural Disaster Recovery Unit.

Across Australia, there are a number of statutory authorities and government authorities responsible for managing and controlling emergencies such as natural disasters, technological and industrial events, or civil-political unrest.

4.2.1. Australian Inter-Service Incident Management System (AIIMS)

This system was developed in Australia in the mid-eighties. It is a robust system for managing emergencies and crisis situations. It enables smooth integration of multi-agency activities and resources to address any emergency. The system is therefore customizable and can be effectively used to manage emergencies either by one organization or by more organizations. These organizations are able to cooperate with each other and provide data.

The system operates effectively for any type of incident—natural, industrial, civilian, and many other incidents involving emergency response from organizations. In addition, the system can also be used for other events that are not considered as critical—sports and cultural events, exhibitions and conferences.

AIIMS provides a management system that facilitates the coordination of the activities of all involved agencies in addressing of any emergency. The system provides an entire framework for incident management that begins with the first response and grows with the severity of an emergency. Since the first emergency notification, many emergency management procedures have been implemented, which are predefined. The system contains a list of resources (forces and equipment) along with operational planning (**Figure 1**).

The system is based on an incident management team, which controls operations during emergencies. This team has delegated functions—a logistics office, an operating office, and a planning office. This team meets as a result of an emergency and addresses the situations and ensures the management and control of the emergency.

The advantage of this system is the possible cooperation of several organizations, due to the use of the same terminology that ensures their correct communication at all levels of emergency response. This creates a common chain of command within the incident management structure.

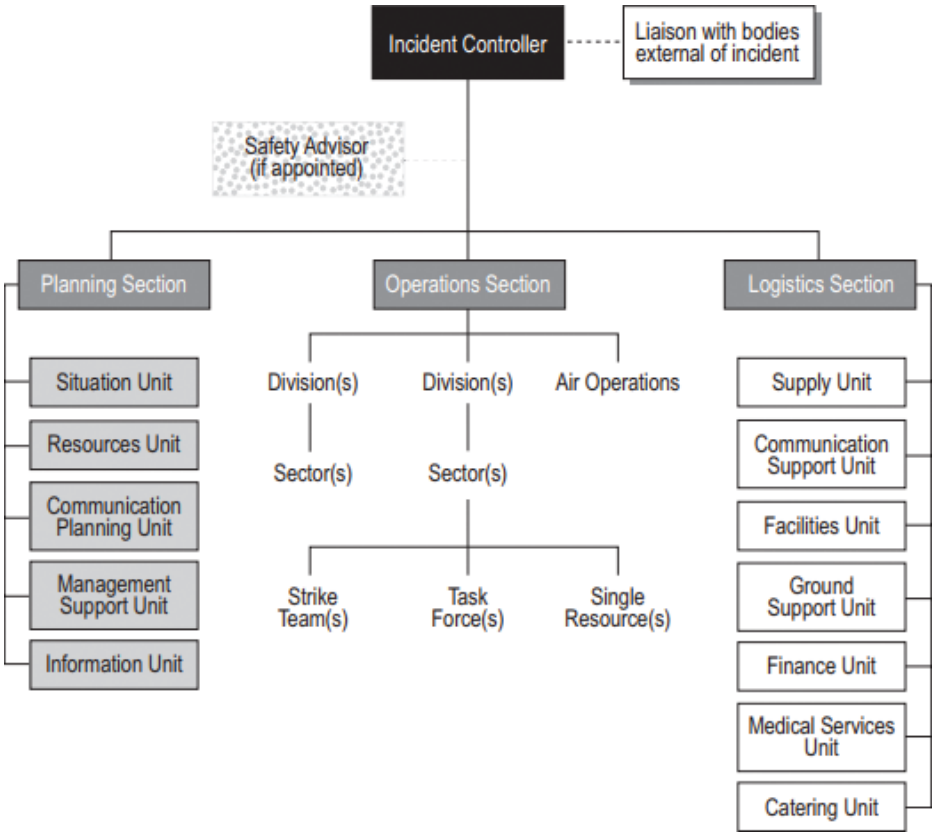

Figure 1. The structure of AIIMS [12].

Basic system incident management features include:

- defining features,
- uniform terminology,
- adaptable and scalable approach,
- defining an incident management structure,
- clearly defined roles and responsibilities,
- efficient resource management system,
- access to risk management,
- clearly defined communication flows,
- a comprehensive planning process,
- management and control system,
- a system that suits all emergencies and everyday situations.

Successful resolution and management of crisis situations, emergencies or other events are dependent on the above-mentioned features of the entire system [12].

4.3. Philippines

In the Philippines, The Crisis management system is governed by the National Disaster Risk Reduction and Management Council. This council creates crisis plans, measures and procedures in the case of a disaster and warning of residents in crisis situations.

Information support for crisis management has the highest priority due to frequent natural disasters—typhoons, floods, landslides. For crisis management, a web platform has been created, which also includes a mobile application making it possible to display actual weather, imminent crisis situations (floods, storms, landslides, volcanic activity), and basic elements of critical infrastructure (schools, health facilities, stations, fire stations, …) [13]. In the Philippines, they are using warning system NOAH. We can therefore assume that information support for crisis management has the highest priority on the given threats.

4.4. Czech Republic

The Czech Republic addresses the information support of crisis management on several levels —state, public administration and IRS. The subsections are focused on given levels of information support.

4.4.1. Unified crisis management information system

The crisis management information system should be built as a modular system with the following characteristics of each module.

The methodology module supports planning and decision-making processes, processing crisis and type plans at a given level of public administration, including planning and choosing the optimal solution to the given situation; module should include tools supporting modeling and simulation processes, risk analysis, vulnerability analysis, processes related to education, training, etc.

GIS module including GPS and navigation system using vector, raster, altimeter data and interest spatial databases—databases of key objects, addresses, etc.—in given scales and formats compatible with spatial information standards within the public administration information system. A typical GIS application to visualize an emergency or crisis situation is to "create a record" into the map background.

Common picture module of the situation about the area of emergency or crisis situation. The module was to get a uniform overview of the emergency or crisis situation and the ongoing activities in this area. The basis of communication should be a uniform interpretation of the given situation. A common picture of the emergency or crisis situation and its ongoing activities should allow cooperative planning and solutions including targeted logistical support.

The module for supportive application should include, in particular, the alert application; evacuation; evidence of a temporary change of residence; humanitarian aid; supplies of individual protection and supplies of collective protection; transport planning; time calculations of engineer works; logistics calculations, assessment of the situation at the point of disperse of the dangerous substance; radiation, chemical and biological protection, etc.

The formalized documentation module should include tools and functions such as DMS (Document Management System) and EDI (Electronic Data Interchange). For international communication purposes (within the EU, NATO, etc.), it should have formatted documents that complies with the relevant international standards.

Key requirements of the crisis management information system. The crisis management information system should be built as a system:

- respecting international and national standards,
- respecting the requirements of efficiency and economy (using appropriate parts of existing systems, application software, databases, etc.) and complying with the principles of system integration,
- operating on a platform with different communication environments using existing communications systems or parts (e.g., the Matra system),
- respecting the required information security according to the standards,
- internally (with selected relevant problem area of systems) and externally (with other IS) interoperable; interoperability is addressed in the form of a central repository connecting all components of the system in one harmoniously operating information unit.

The reason for the failure of the project crisis management information system was mainly:

- technological demands of the entire system,
- inappropriate legislative determination,
- limited amount of data and the impossibility of its continuous update.

The above reasons led to the failure of the objectives of crisis management information system in the Czech Republic.

4.4.2. Information support of crisis management at the regional level

Based on the failure of the single crisis management information system, each municipality in the Czech Republic decided to provide its own information support for crisis management.

The Czech Republic is divided into 14 municipalities in which each municipal office has established a department of crisis management. This department is the organizational structure of the municipal office of the municipality, which ensures preparedness for management of emergencies and crisis situations (**Figure 2**).

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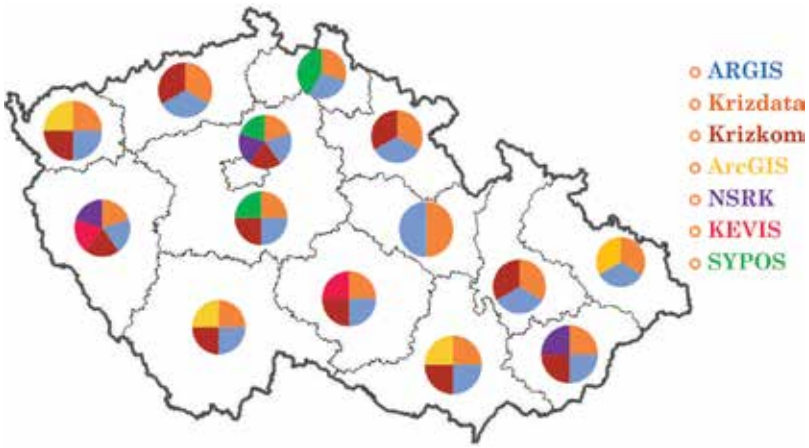

Figure 2. The map of crisis management information systems in the municipalities of the Czech Republic [own].

In the Czech Republic, many information systems to support crisis management are used. Among the most used information system belongs ARGIS, which is used by 13 municipal offices. Another major information system used by 11 municipal offices is the information system KRIZDATA.

Some municipalities have developed their own information systems to support crisis management. This small group includes the South Moravian municipality with its own portal Krizport. Another Zlín municipality that also developed its own information system called Information, Communication and Warning system (ICWS). Next is capital city Prague with its own information system Prague Crisis Management Information System. Last is Olomouc municipality, which has web application Community Cards.

Information systems do not need to be based only on computers and computer networks. Crisis management information systems therefore do not necessarily use tablets, computers, etc.; however, it may be worth using a physical recording media, namely paper. Non-computerized information systems are partly involved in providing information to support the crisis management in many municipalities. The advantage of non-computerized systems is particularly easy implementation of changes in the processing, but also in terms of reading, updating records and archiving.

Basic characteristics of own information systems:
Krizport

The main objective of this system is to transmit relevant and updated information on emergencies to the public and stuff who work in the area. The portal is divided to a public section where each user have access and private section where access is permitted only for selected users. This system is operated and provided by the Fire Rescue Service of the South Moravian municipality [14]. Private section mainly contains the current information of emergency and crisis plans.

ICWS

The purpose of this system is the integration of technology and communication systems used within individual municipalities with extended competence (MEC) to the host system with a unified user interface ICWS. It provides monitoring, unified view, mutual communication and control. The system is private and only to provide the information support of crisis management in the municipality [15].

ICWS is unique in the connection of clients using optical fibers to each crisis staff in the Zlín municipality. The advantage is that the system can also be used in case of power failure and can communicate with other crisis staffs or flood commissions. ICWS is also part of the meteoradar that monitors weather and precipitation in the municipality. The system can also monitor river levels through the profiles of the watchers, and warn the population.

4.4.2.1. Prague crisis management information system

Prague Crisis Management Information System was developed for the purpose of the information support of crisis management in the capital city and it is also used by the Central Bohemian municipality. The objective of this system is to support the management of crisis and emergency. It cannot be clearly remark that the system is used only in emergency situations (such as floods), but it is also used for less serious events (such as potable water supply).

4.4.2.2. Community Cards

The Community Cards is a web application that is used in the Olomouc municipality. In general, municipal cards are used throughout the Czech Republic. The Olomouc municipality is specific because these cards have been transferred to a web application that provides information to both the Regional Office for Emergency Response and the Fire Rescue Service of the Olomouc municipality. In the event of a power failure, it is also possible to use this application in offline form. This app contains information about cities in the Olomouc municipality—contacts, forces and resources, significant objects, location risks, fire protection units, crisis management authorities, and population warnings.

4.4.3. Information support for crisis management for rescue services

As mentioned in the previous chapters, information support of crisis management is used not only at the national or the regional level. Information support is also used to support the IRS. Each IRS unit uses different information support for their own needs. This can sometimes lead to issues in cooperative dealing with emergencies or crisis situations.

4.4.3.1. Fire Rescue Service of the Czech Republic

The Fire Rescue Service of the Czech Republic uses more information systems to support decision making and effective intervention. It can be information systems of crisis management within individual region, crisis management information systems set up by the state material reserves administration, systems that can model the releases of dangerous substances (RozexAlarm, TerEx …), ArcGIS information system, which serves in particular as a map background.

4.4.3.2. Case study on using ArcGIS by Fire Rescue Services in the Czech Republic

Fire Rescue Service of the Czech Republic operates on the map server that is configured bespoke to firefighters, joint rescue system and crisis staffs. The users have a variety of features and also a wide range of topical layers useful during the development of emergency and crisis plans or solutions to any emergency and crisis situation.

All sorts of technologies and techniques are still developing to ensure the fastest possible assistance. The geographic information system enables accurate and fast decisions aiming to save life, health, property and the environment.

Geographic information system is used by Fire Rescue Service of the Czech Republic PSAPs during the dispatch of units and equipment to the event location and also to support crisis management [16].

The main positive aspect of this system is the ability to create various data analyzes which have wide application in the area of crisis management. On the contrary, the negative aspect can be considerable financial costs of the license to use the information system (**Figure 3**).

Information system ArcGIS assists Fire Rescue Service in different areas. The system displays nearby Fire Rescue Service units (e.g. 1—professional units 5—local volunteer units) and also there were implemented details from the unified traffic information—road closures, bridges, underpasses, railway crossings and so on.

In ArcGIS, Operations and Information Centre of regional Fire Rescue Service recorded incident. Operations and Information Centre enrolled the type of incident (e.g. fire) into the system and chose the equipment that should go to the site (e.g. a fire tank truck, ladder), and Fire Rescue Service units (professional or volunteer firefighters).

After entering all above-mentioned data into the system, it will alarm Fire Rescue Service (professional and volunteer) using sirens, sending information via SMS. This will trigger alarm procedure (lights are switched, opening the door, all relevant information to the point of intervention appear on the garage monitor).

The trucks of Fire Rescue Service professional firefighters are equipped with portable technology—tablets on which the dispatch unit can find planned route and navigate to the location of the incident. The planned route takes into account the height of the truck to avoid underpasses and road closures, etc.

Once the Fire Rescue Service unit arrives at the site, commander of the intervention marks in the tablet the operational site, which was reflected on the operational center of the Fire Rescue Service, the Czech police, and Emergency Medical Services. This helps to accurately navigate IRS vehicles to the place of the event and also to inform other units about the tasks in progress. The commander designates specific areas (danger zones) that are not allowed to be crossed or zone where should IRS units intervene. For the civilian cars, the system shows detours.

Based on this case study, we can conclude that the system greatly simplifies information exchange between operating and information center and dispatch Fire Rescue Service vehicles.

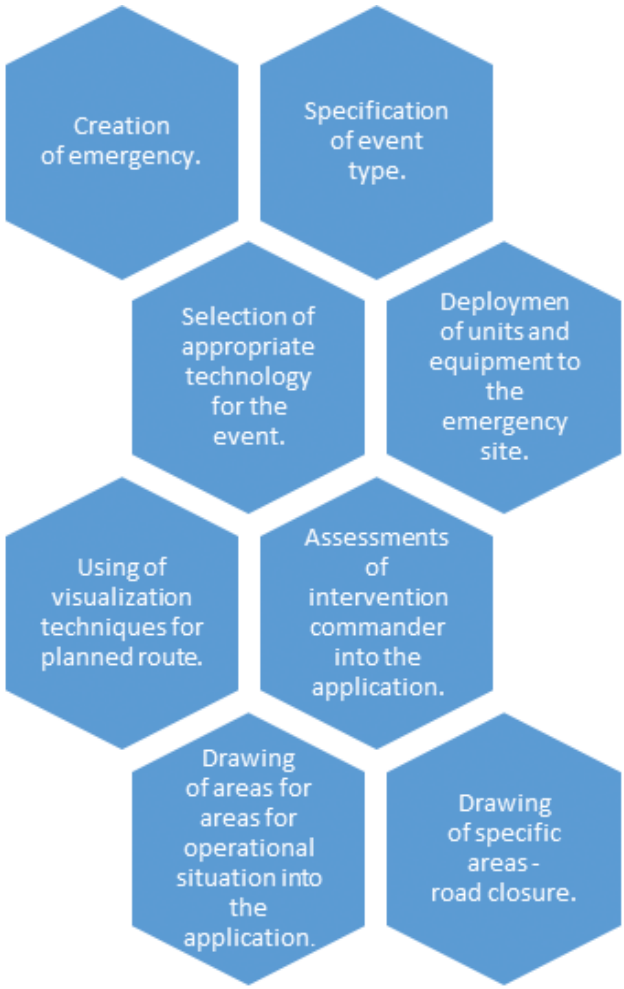

Figure 3. Visualization of operation station [own].

With this system, the Fire Rescue Service vehicles can get to the site faster and more efficiently without necessary complications that can occur on the route to the incident.

4.4.3.3. Medical Rescue Service of the Czech Republic

Medical Rescue Service of the Czech Republic uses an information system that serves as a modern tool for information support to the activities of the Medical Emergency Service. Provides support for dispatching activity, deployment of units, insurance reporting, etc. Also enables efficient collaboration and sharing of relevant information with other units of the integrated rescue system.

This system performs receiving and processing of emergency calls, deployment and controlling of units, communication with a vehicle computer, mapping and vehicle positioning, deployment logs, keeping driving books, insurance bills, warehouse management, statistics and deployment planning [17].

4.4.4. Police of the Czech Republic

The Police of the Czech Republic, as well as the previous forces of the IRS, use information support. This information support is rather used as a support for managing of events that are dealt with in police investigations. These include automated vehicle inspection systems, population, visas records, a system for detection of forged documents and the Interpol information system. These systems can also be used in managing of emergencies; however, the role of the Czech Police in a crisis situation is rather in managing traffic situations.

The information support of the forces of the IRS is adjusted to the needs of the selected rescue forces. It is clear that the Fire Rescue Service, which is usually the case for all emergencies or crisis situations, the most commonly uses information systems to manage these situations.

4.5. Comparison of crisis management information systems in the whole world

The crisis management information system may provide the following processes and capabilities:

- monitoring process—obtaining information from the environment, from production processes and from technological equipment, energy, networks (connecting, energy), social means, from public life, from legislation,
- the ability to alert and inform the population—about the imminent threat or origin crisis situations and its solutions, forms of warning (radio, television, Teletext, public information billboard, internet, news service, etc.),
- the ability to notify responsible staff—to arrive at a designated place or in areas of crisis,
- the ability to store and maintain information—about the territories and the risks that exist on it and may be a source of crisis situations,
- a system to support decision-making with the necessary information—providing information about the crisis, their characteristics, solutions, support processes, security rescue and liquidation work, logistic support,
- support for training and training programs—background for modeling, planning, teaching, research, development, exercise,
- source of optimization of institutions' activities and executive elements integrated into crisis management.

Table 1 shows the comparison of crisis management information systems in selected countries. As can be seen in **Table 1**, there are many crisis management information systems in the whole

State	Crisis management information system
Australia	Australian Inter-Service Incident Management System
Bolivia	SINAGER—SAT warning system
Colombia	SIPLAG—Integrated Planning and Control System
Czech Republic	Many systems at regional level and IRS
Ecuador	ECU 911—Application of Integrated Security Service
Indonesia	InAWARE—Indonesia All Warning and Risk Evaluation
Italy	Heat health warning systems and PRESTo warning system
Morocco	CRTS—Royal Centre for Remote Sensing
Philippines	NOAH—Nationwide Operational Assessment of Hazards
USA	EIS/GEM Infobook

Table 1. Comparison of crisis management information systems [own].

world (Europe, Asia, America, Africa). Some of them are warning systems, the next systems for integrated rescue service and unified system for government. We can the best evaluate the unified crisis management information system in USA and Australia. These systems are global and usable for the whole state. Other systems are only the part of the crisis management—warning systems (e.g. NOAH, InAWARE…).

5. Method

The crisis management information systems have a lot of the advantages and disadvantages, and therefore the heuristic analysis of usability was performed on these systems. This assessment is used for the qualitative evaluation of the systems that give us the accurate results in the connection of the strengths and weaknesses of the established system. Based on the analytical studies, we determined the staff of the Fire Rescue Services and municipal Authority of the municipalities for the analysis of the information systems. Based on the mentioned analysis, we conducted an evaluation using the following Eq. (1):

$$UIS = (R + H/2 \times H) \times 100 \tag{1}$$

where UIS = usability of the information system, R = sum of the results (acquired points), and H = amount of evaluated heuristics.

A set of the evaluation questions (70 problems) was used in the evaluation of the system, and these questions were divided according to the several indicators. These indicators can be described by the next questions.

The general—essential information from a general perspective, where it was investigated whether the system works; if the system contains only the relevant elements and information on the problem; the system can be used without help.

The usability—the usability of the system in the proper sense; the intuitiveness of the application; the ability to control in the particular conditions and adequate display on the mobile devices.

The security—a map content, which was determined by its actuality, credibility and the possibility of the system breach.

The content—the content where it was investigated whether the system includes the advertisements, the misleading elements and also regarding conciseness of the headings.

The search—the search regarding the evaluation of the results; whether the results match the searched query; whether it is viable to search by the coordinates; whether the autocomplete is accessible.

The graphics—the composition layout, typography, font color, and the suitability is evaluated as well as the esthetic impression of the unified system.

The evaluation methodology consisted of the answering of each of the assign question from the predefined plurality of the evaluation values (−1 = does not satisfy; 0 = partially satisfies; 1 = satisfies; the field is empty if the question is not relevant) [18].

6. Results

The aim of this chapter is to present the results of an analysis of the information support for crisis management in the Czech Republic. As mentioned in the previous chapter describing information support for crisis management in selected countries, the Czech Republic divides information systems to support multi-level crisis management.

Based on the above-mentioned use of heuristic usability analysis, we performed analyzes on selected crisis management information systems.

6.1. Analysis of unified crisis management information system of the Czech Republic

This chapter describes the usability of information support for crisis management in the single crisis management information system, which was only launched as pilot version between years 2008 and 2011, when it failed in a crisis situation—floods.

Table 2 shows heuristic analysis of usability of unified crisis management information system of the Czech Republic. This evaluation provides the statistics data from each of group of the indicators. As can be seen in **Table 2**, the best-evaluated indicator was "Graphic."

Based on the analysis, it can be estimated that the system was partially usable, and if a mobile application were implemented by the system administrator, the system could still operate. The Directorate-General of the Fire Rescue Service of the Czech Republic, which has been under the auspices of this system, does not expect that the system would be reintroduced and developed in the future.

6.2. Analysis of information support for crisis management at the regional level

Information support for crisis management in public administration at the regional level is entirely diverse. Some municipalities do not use any crisis management information systems. Only the four selected municipalities have set their path to the issue of crisis management and built their crisis management information systems. For these chosen information systems a heuristic usability analysis was performed.

Table 3 presents the results of the usability the heuristic analysis of the crisis management information systems in the Czech Republic. This evaluation provides the statistics data from each of group of the indicators. As can be seen in **Table 3**, Information, communication and warning system (ICWS, Zlín) had been evaluated as the system with the highest percentage in the total score of the evaluation (92.06%). This system had been defined the search and graphic indicators as the first-rate results of the evaluation. On the other hand, the results of the heuristic analysis information system. The Community Cards had not been integrated the tool for the searching. The graphic indicator of the all systems used in **Table 3** is evaluated as the best from all indicators. The graphic indicator is important for the quick and effective orientation in the system and therefore these systems need to develop this indicator in detail. We can constate that these systems are usable and suitable for the further development.

6.3. Analysis of information support for crisis management for rescue services

As mentioned in the previous chapters, information support of crisis management is also used to support the IRS. The ArcGIS information system, which is used to support crisis management, has been selected by the primary component—Fire Rescue Service (**Table 4**).

Table 4 shows analysis of information system ArcGIS. As can be seen in **Table 4**, the best evaluated indicator is graphic. This indicator took 100%.

Based on heuristic analyzes of information systems, it has been found that the systems are focused on managing the emergencies and crisis situations, thus significantly helps decision makers.

Indicators	Number of points	Number of questions	Number of answered	Rating
General	2	12	10	60.00%
Search	3	9	7	71.43%
Graphic	8	9	9	94.44%
Content	6	9	8	87.50%
Security	4	12	12	66.67%
Usability	−1	22	20	47.50%
Total	22	73	66	71.26%

Table 2. Heuristic analysis of usability of unified crisis management information system of the Czech Republic [own].

Indicators/CMIS	ICWS, Zlín	Krizport, Brno	CMIS Prague	Community Cards, Olomouc	Total
General	91.66%	95.83%	62.50%	86.36%	84.09%
Search	100%	83.33%	92.85%	0%	69.05%
Graphic	100%	100%	83.34%	100%	95.84%
Content	87.50%	100%	81.25%	77.78%	86.63%
Security	87.50%	72.73%	85.00%	50.00%	73.81%
Usability	85.71%	91.17%	63.34%	67.50%	76.93%
Total	92.06%	90.51%	78.05%	63.61%	81.06%

Table 3. Heuristic analysis of usability of crisis management information system of municipalities [own].

Indicators	Number of points	Number of questions	Number of answered	Rating
General	1	8	8	56.25%
Search	6	8	8	87.5%
Graphic	5	7	5	100%
Content	3	8	6	75.00%
Security	2	7	6	66.67%
Usability	6	10	8	88.00%
Total	23	48	41	78.90%

Table 4. Analysis of information system ArcGIS [own].

7. Discussion

In general, information systems are very important and essential part of planning, organizing, managing or controlling. This is undoubtedly applies to crisis management information systems. They are therefore used both in planning of crisis measures and managing the crisis situations. The basis of all information systems is not only algorithms, but also data. In order for the information system to function properly, it is important that the system contains the actual data.

This chapter deals with information support for crisis management in selected countries where different types of information support are available. The US has its own information system, which is used to address the most diverse types of crisis and emergency situations. The Philippines owns a web app that is specifically designed to manage the nature disasters that are most common in this country. On the contrary, the Czech Republic is very divided in this area and the information support is divided according to individual levels, state system, public administration systems and integrated rescue system systems.

A heuristic analysis of usability was selected for the evaluation of crisis management information systems. The aim of this analysis is to evaluate any information system using six indicators. For

crisis management information systems, the analysis was modified and a quantitative assessment of the predefined 70 questions was performed.

Heuristic analysis of usability was used on 6 information systems that are used to support crisis management in the Czech Republic. There has been an evaluation of the unified information system for crisis management, which is currently not used. Furthermore, four information systems that are used in public administration at the regional level and one information system used by the Fire Rescue Service. Public administration and Fire Rescue Services have been assessed as usable and suitable for further development. Information support for crisis management in the Czech Republic should be reintroduced as a unified crisis management information system that would tackle crisis situations globally, as is the case in the US or Australia.

The main weakness of information system is that the system does not establish responsibilities and competencies for tasks in crisis management. The crisis management system should be unified and customized, so to unify and adapt to the users' needs (from population protection staff to end-users—emergency responders) who work regularly on the system and need to customize the system The system should therefore be more user-friendly and have an intuitive interface.

8. Conclusion

The purpose of this chapter was to provide an overview of information support for crisis management that is being used in the world. The key chapter is a description of the information support for crisis management in selected countries. Four countries were selected in which information support for crisis management was described. One of the selected countries was also the Czech Republic, where the information support is further analyzed according to individual levels—state system, public administration systems and IRS systems. The heuristic analysis of usability was selected to serve as a tool for assessing crisis management information systems. In total, six information systems were evaluated.

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Conflict of interest

We have no conflict of interest.

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Chapter 4

Emerging Trends in Crisis Management: Usability, Earth Observation and Disaster Management

Sweta Leonard

Additional information is available at the end of the chapter

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Abstract

Availability of Earth observation (EO) data and dissemination has been revolutionized with technological advancement in computation and use of mobile tools such as phones, tablets and laptops. This is further expanded with availability of affordable data/internet connections which no longer require Ethernet cables to get internet connection. The result is explosion of spatial data on various blogs and personal profiles such as Tweeter, Facebook, Instagram and other internet feeds. This has created explosion of information with a lot of integrity issues on data quality, lack of data source and lack of responsibility and authenticity. The problem is further compounded with advancement in search engines and data harvesting applications which collects similar archived information and makes them available to the user on the internet search engines. There should be a clear link detailing the nature of EO and the kind of relevant information that can be derived from them.

Keywords: earth observation, usability, disaster management, mobile technology

1. Introduction: emerging trends in Earth observation and crisis management

Capturing EO data has been improved with increased spatial resolution where spatial features are now more vivid in captured images. The images are now freely accessible over connected computers and phone gadgets through various plug-ins and software's such as Google Earth, Bing maps, Arc Earth, Google Maps and other online web based platforms. The end result is explosion of diversified, semi organized and sometimes disorganized information available for use whenever a disaster or crisis is reported.

Population response to crisis varies with personality and perceptions especially in situation that require quick emergency response capabilities such as natural disasters or human hostilities such as terrorism and wars. Fear, despair and uncertainty normally brings [1]confusion among the population which creates a complex platform for managing surging population towards or away from disaster scene [2]. In any crisis, the populace always seeks reliable and authentic information which sometimes is hard to find; in that case a debate arises and experience are sought from past similar events and the nature responses that were administered. Disaster management trends has evolved from immediate response in the 1970s to risk reduction in the continuous years from the year 2000 to present where emphasis is on preparedness, response and mitigation through simulation. The economic losses have increased significantly to fourfold in most developed economies; a situation would probably be much greater in developing economies [3].

The role of EO is critical is traversing space within a short span of time and proving reliable information which can be interpreted by space experts to extract useful insights for meaningful decisions whenever the crisis is put into context [4].

EO especially use of commercial drones and satellite is useful for targeted monitoring of crisis in hostile and inaccessible areas since information collected provide useful insight for pre and post crisis period including human movements with new advancements like night satellite imagery monitor through Visible Infrared Imaging Radiometer Suite sensor (VIIRS) [5]. The main focus should be on minimizing redundancy of information and proposing models which supports building of resilience for risk and disaster monitoring [6] which will eventually reduce occurrence of crisis.

Accessing EO data for countries without capability to operate their own satellite systems rapidly within a short time largely depends on international cooperation and bilateral agreements among space agencies which can request (disaster) charters to be activated whenever a crisis is reported. The nature of ownership of systems have now shifted from previously military intelligence to privately licensed space and defense companies [7].Creating a balance between crisis disruption and real time demand for reliable information is current emerging trend in development of allied information communication technologies (ICT) which is critical is disseminating information through the web based crisis alert and warning systems [8]. Moreover, reliance on initially mapping and survey organizations as the sole custodian of spatial data and maps has been revolutionized with volunteered citizen participation through geotagging and development of mobile compatible web based applications which can display those maps with little data or through mobile data hotspots which can be set up whenever there is need even in vey adverse disasters through VSAT [9].

Processing of EO data and has been revolutionized with improved number of people with capacity of interpreting digital spatial imagery and wide range of application areas such as climate change, yield estimation, crop failure, land degradation and use of various sensors in early warning [10] where trends in surface solar radiation are estimated with reliable precision [11].

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Post crisis management receives less attention since immediate loss and damage normally receives a lot airing in both print and electronic media. This lowers confidence in recovery phase of crisis management projects which require external funding which largely depends on quality proposals and international cooperation which requires proper justification of the crisis aftermath [12]. Use of EO in post crisis management is sole responsibility of the affected country and her interested development partners who have to purchase such products where necessary. Public participation in post crisis especially through mapping is minimal more so through voluntary basis.

The policy systems in disaster management laws in many countries is a reserve of the senate or upper house [13]. Biased shifts to administrative systems with state control other than administrative policies create a scenario of overlaps and confusion in cases where administrative systems do not guarantee seamless integration of roles and resources at play [1].

The center of crisis management is subject to a number of internal and external dynamics. The economic growth, levels of development, social status and the nature of spatial planning plays a major role in the internal dynamics of any crisis and influences approaches laid down towards its management. Since crisis at times gets political in nature, influences from external dynamics are unavoidable which at times are influenced by geolocation of the country in crisis and interest of neighboring countries or interested international organization or unions [14].

Planning for post crisis requires budgets which are either funded by the government affected or through bilateral agreements. The post crisis phase receives a negative perception since the urgency is never seen; hence treated as low priority concern which does not require urgent approval of budgets from governments since some emerging issues might override until another disaster reoccur.

Extensive crisis with overlap of people displacement and inter border migration possess a new trend of threat to national security. Non affected countries/states perceive those migrating as taking advantage of the crisis situation to run away from their economic stagnation. The trend then changes from helping the survivors of such crisis to confining them to a controlled area which might pose a new threat of cascading effects such as disease outbreak, competition of resources and denial or restricted access to necessary rights and opportunities which are normally constrained by the crisis such as access to quality healthcare, education, socialization and at times lack of free movement [15].

Crisis perception by bilateral partners have a huge effect on access to international goods and trade systems especially where alliances of aggression are suspected by an international union. This leads economic sanctions and embargos with key allies and partners which eventually affect local currency stability and degrades local economy growth [16].

Creating a suitable crisis management plan is crucial successful management. This can be realized through establishment of committee for crisis deployment, developing a clear response policy in place for each category of crisis and design a suitable toolbox for crisis response [17]. Fundamental attention should be paid to addressing emerging issues such as

public demonstration and chaos through a vivid risk management mechanism [18, 19]. The process should outline clear procedures before, during and after crisis management which should be shared with local established teams in various established location for quick mobilization. Necessary drills should be carried out to facilitate establishment of any existing gaps to improve lessons learnt. It is paramount to have extensive inoculate for public negativity by creating structures that support strong ethical theme with capability of managing population mistrust [20].

2. Research methodology

Review of existing technologies in EO and their use in crisis management is done with emphasis in the role they play in crisis management. Since crisis management does not have a direct approach; but involves amalgamation of a myriad of approaches; this study focuses on the usability and challenges that arises from such developments. This study also places a lot of emphasis on the timing of the phase of crisis at which EO data is freely made available and dissemination of such information to wider targeted audience.

The initial phase is data organization and authenticity which also affects the data integrity and data quality. Since usability is independent but quality is dependent on accessibility and medium of dissemination, EO data has to be subjected to a usability filtering model on which basic quality parameters can be ranked to facilitate rapid decision making for novice users who might not be GIS specialists as shown in **Figure 1**.

Once the information is organized in an agreed model, dissemination of such information needs to be channeled through acceptable political leadership. Access to EO technologies and dissemination channels are controlled by state agencies, hence their collaboration is paramount for success in gathering local information from the survivors in any crisis management. This is important despite the fact that some data can be collected using UAV through eye in the sky mechanism.

The process of reducing uncertainties among survivors is a vital process and analysis of addressing the bottlenecks associated with bureaucracies in relaying critical information and setting up priorities in evacuation and installation of critical equipment. The role of local administration is taken into consideration for seamless operation and effective people management. Presence or absence of reliable statistical information and people whereabouts is crucial in estimating the possible fatalities and survivors. This creates demand for accurate model for people identification that has the ability to reduce uncertainties.

Since every technology comes with associated challenges, focus is on the best practices that are able to improve the use of EO data and mobile technology in crisis management. Technology alone without proper protocol has proven to be another source of problem which slows down uptake of information and eventually the whole process of crisis management. This study therefore, proposes a technological inventory audit model which maps out the possible areas

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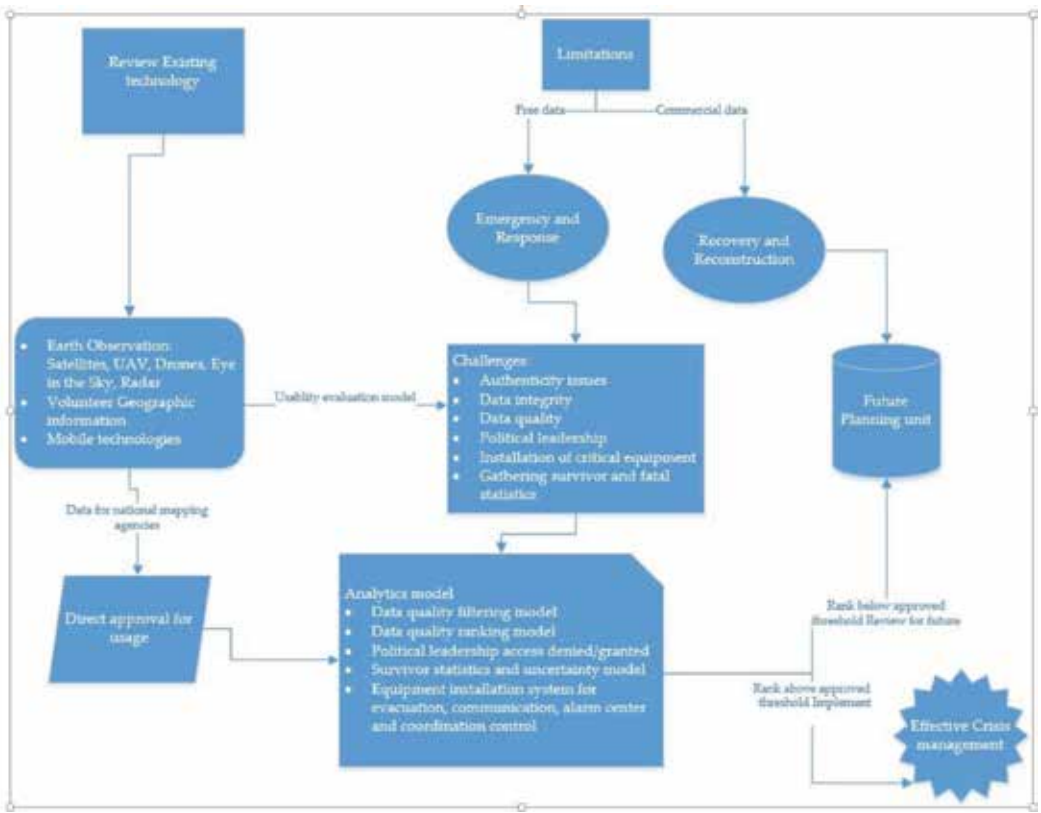

Figure 1. Crisis management data model.

that have the capability to relay mobile information to both survivors and response coordinators. This has to take into account the cascading effects, especially in floods, fire and nuclear disasters which worsen over time whenever a quick rebuttal approach is not taken.

Adoption of analytics with capability of assessing the level applicability of EO data based on certain pairwise comparative parameters with defined scores is vital in ensuring that non expert users have a chance in selecting the right product. It has also vividly emerged that data mining challenge from enormous volunteer sources shall be easily managed through such analytics since the usability shall be determined through a defined score index table which is recommended in this study.

Effective data management requires effective coordination during the initial phases and relevant measures designed for future mitigation. Lessons learnt from usability and analytical models are integrated to be used for review, future planning and establishment of effective mitigation mechanisms. The datasets meeting the criteria are eventually used for effective crisis management.

3. Usability of EO crisis data and role of mobile technology

Explosion of information during the initial phase of crisis creates an explosion of information which in most is highly disorganized and enormous. Most countries have national disaster and crisis management established bodies responsible for managing information related a given crisis in their respective countries [21]. Such bodies face the challenge of controlling proliferation of information in the social medial which could be trending faster than their official communication channels [22]. The situation is exacerbated with current use of mobile technologies which has made log on hotspots for sharing information readily available [23].

Evaluating the reliability and usability of such volunteered information requires a reliable framework with detailed quality check parameters with quantifiable rating [9]. Creating a balance between immediate needs of response and long term needs for coordination with all partners involved presents additional challenge especially managing proliferation of volunteers which might create a disaster within a disaster [24].

Data is generated to be used for decision making when it has been processed to useful information. The mobile technology revolution has made sharing information almost seamless and real time. This situation makes it easy to redistribute non authentic information to unsuspecting users. Crisis provides no time for argument but quick decision geared towards response. The speed of response is useful for saving life and rescue of property within the crisis area. However, new mechanisms have been developed with algorithms with capability of addressing needs of immediate responders using eye of the sky through UAVs.

Automated alerts can be synchronized for predictable disasters such as those with slow onset such as flooding and wildfires. Use of technology makes easier to disseminates such information through temperature monitoring and use of sensors of accomplish success through coordinated data mining algorithms which can easily relay information to contacts within the database and for action to be taken.

With improvement is web 2.0 technology, it is now possible to develop crisis dashboard monitoring system where one stop shop for crisis is established for a given crisis/disaster [25]. The data flow frequency provides insight to need for authenticating the information being passed. With new aspect of geo coding and geotagging, spatial components can easily be incorporated through simple data collection apps which can be installed into the gadgets given to individuals participating in crisis/ disaster management. The information be improved further through of geo-visualization and use analytics skills to improve data mining [26].

Usability model proposed in **Figure 2** examines suitability of such datasets against reference materials for both expert and general users of EO based data and products. The process of evaluating user categories varies from those with requirements well known to those unaware of EO requirements. This creates the need of reference data materials with capability of assisting in interacting with the datasets already ranked and not meeting the criteria for further check before being subjected to analytics model.

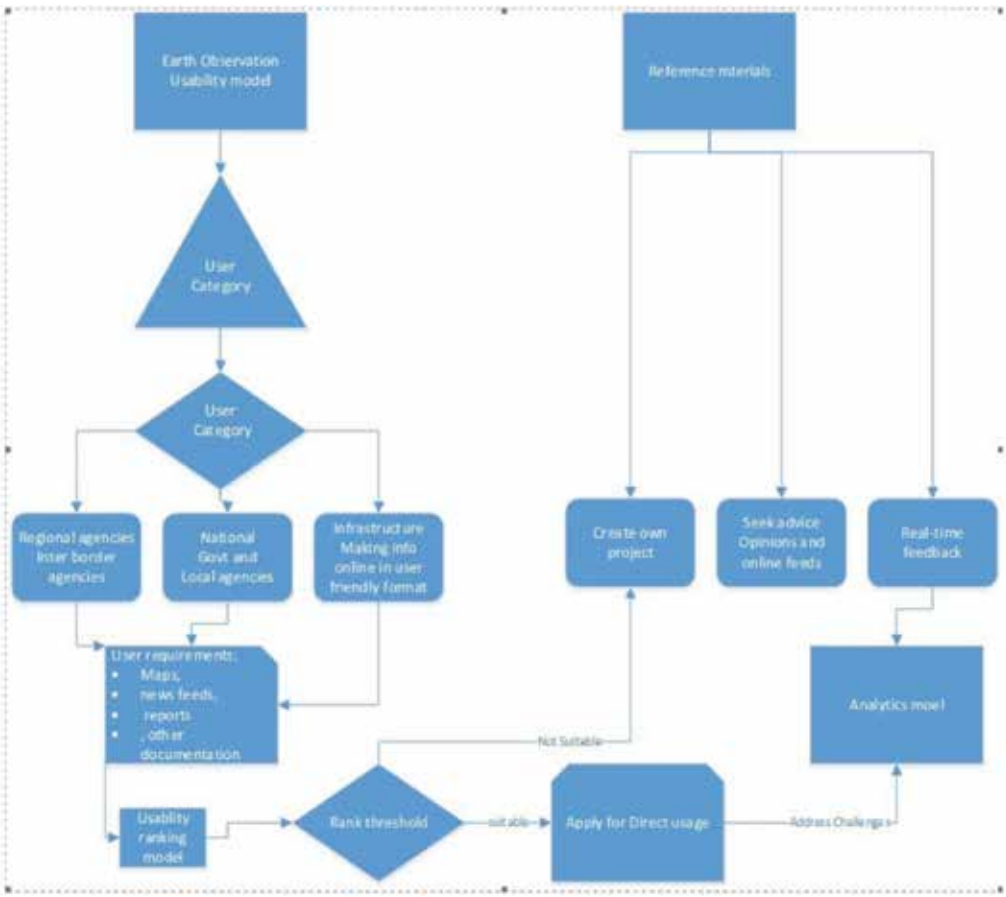

Figure 2. Usability evaluation model.

The widening of user category is useful in catering for accommodating various important organizations such as Global Earth Observation System of Systems (GEOSS), Disaster charter, DLR, among others who promote good community practice with emphasis on system and information quality which enhances user and use satisfaction to realize individual and organization impact on crisis management.

4. Challenges of using technology in crisis and disaster management

Response to crisis is dynamic and complex process which makes it difficult to determine the actual source of signal received over the internet [27, 28]. Responders have difficult task of

examining the ever growing traffic of information to filter useful information which would realistic for immediate and long term response especially scheduling of units efficiently [29]. In some instances, ICT is deployed with heavy investment but underutilized due lack of effective coordination [30].

Filtering data from various sources can realized by setting priority identification of datasets through a semantics filter. The filter can be optimized to ensure that datasets with user feedback feeds shows up as the higher rank in that order and subsequently to those of low ranks. The information can be improved with enabling of geocodes customized for any feedback received and anti-robotics codes captcha to ensure only human results are collected.

The recent development in use of eye in the sky (UAV) is also affected by spectrum scarcity since new devices have been developed which operate within these bands with development focus on cognitive radio technology to address the problem using intrinsic characteristics [31]. Use of EO based data and associated products still faces challenges of data access, availability of high spatial resolution and technological limitations which are further compounded with proliferation of crowdsourced data [32].

Extraction of useful information from EO based products might require heavy investment in terms of technology software and personnel. Hence, collaboration of already existing agencies within the crisis country who are familiar with use of such technologies should be identified prior to crisis occurrence. Understanding of communication and technology spectrum and the distribution of useful investment should be mapped well in advance to improve coordination whenever a crisis occurs. This allows the foreign interested partners to easily engage since the language of operation can easily be harmonized.

Technological developments are perceived to be the mode of communication in most urban regions, however, the reality is that rural areas are normally ill equipped with latest wireless technology like 3G or sometimes such regions lack strong GPRS signal network for GSM communication [33]. Therefore, reliance on technology alone for disaster management can itself be another crisis whenever there are power failures; or inconsistency in network upgrades.

The bureaucracy and legal bottlenecks associated with licensing and authorization at the time of crisis may slow down the process of getting reliable information or access of critical infrastructure such excavators, firefighting equipment, setting up emergency rescue centers and establishment of reliable communication channels which can be used by families of those affected. The problem is exacerbated when the equipment necessary for scanning possible survivors is either lacking or have to be borrowed from other countries abroad with strict protocol from government of the day.

Crisis and certain types of disasters normally occur and creates a myriad of uncertainties especially communicating to the public and adoption of open up approach where certain failures have to be admitted as precursor to increase in casualties and damage to property [34]. The situation further becomes complex when issues of adherence to stipulated regulations have been ignored or corruption has prevailed over the stipulated policy.

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5. Results and discussion

From this study, it has emerged that there are already certain approaches which have been developed to assist in usability evaluation such ranking of individual products through online portal as discussed by Sweta and Bijker [9] and Ferguson et al. [35]. However, in these approaches, none of them proposed the use of analytics model. In this study, the analytics model improves the extent to which the information can be filtered and used with less difficulty by both novice and expert users.

This study also proposes a solution of a more robust ranking system which takes into account more variables which previous studies examined individually. The collective approach allows more detailed comparison to be carried out by first allowing comparison of usability model results with limitation and challenges arising from emergency and response phase of crisis management.

This study has also found out that there is a weak link between EO data based product information to targeted users since less emphasis is placed on value of citizen observatory with direct information which is usable immediately. It has also emerged that parameters lumped together provides more robust information that individual modeling since several variables are weighed in the pre-processed products. Creating a platform for registering user requirements supported by proper search enabled semantic system is useful in implementing one stop shop for usability evaluation and access of such information to various category of users on several search engines.

Situation analysis coupled assessment and awareness are vital components crisis management and response planning. This study has found out that planning for movements especially provision of detailed routes, critical examination of documents for information validation, deployment of critical equipment for optical resource allocation and creating a well mirrored and secure network system are necessary items to be analyzed for effective crisis management.

The interagency bureaucracies, similarities and differences have been observed as part of challenges contributing to difficulties in effective crisis management. The working culture, public differences, availability of information is different formats are some of the challenges that needs to be harmonized. For example, data sharing in the usability format, tries to address the question of product rating by examining who needs what type of data and preferably in what format. The incorporation of organization psychology analysis is vital.

With multibillion dollar invest in satellite EO and related mechanism, emphasis should be placed in strengthening public–private collaborations to promote free open data access through establishment of relevant policies with little bottlenecks in the use of products from such collaboration. Although initiatives such as European Union (EU), European Space Agency (ESA) and USGS have established mechanisms to ensure free access to certain types of data through open data systems and open software's for processing such datasets, lack of in-situ measurements in some cases limits the full utilization of such products for intended purpose of crisis management.

6. Recommendation

This study recommends adoption of bottom up approach in communicating with public on disasters with high level of uncertainties. Strict adherence to stipulated regulations should be emphasized and made public so that any identified failures in the product or process can be corrected for effective crisis management. Minimizing anxiety is the best approach of containing crowds especially in the immediate aftermath with approaches like streaming electronic lists, use of public address and grouping of people by region. Each of the regions can be assigned an opinion leader and an assigned protocol officer to keep track of inventory. This helps to calm the crowd since they shall feel part of the process being undertaken and with proper approach of population segregation by age and disability, the process of handling dependents becomes efficient and seamless. The communication hub can then synthesize and disseminate feedback through bidirectional model.

This study also recommends availing of relevant documents and resources such as telephone numbers and gadgets with specific numbers for incoming and outgoing calls. Secure electronic system for managing information from social media, access to local area network, mechanisms for documentation of events and subjects, plans and maps to assist in security, fleet, rescue, deployment and location of potential safety location for temporary settlement of displaced persons.

For improvement of usability of EO datasets, that require calibration, this study recommends possibility of utilizing the power of citizen observatory to provide needed additional information to enrich EO products and assist in gathering feedback from use of disseminated products. The feedback data shall provide relevant information to be used in the ranking model gathering user feedbacks.

Mechanisms should be put in place to tackle conflicting and competing interests during crisis management. Focus should be placed in minimizing time taken to make decision to facilitate speedy actions for saving lives. The information being used for decision making could be improved with paradigm shift of incorporating 3D products for realistic contexts targeting geophysical environment using maps with good symbols and complete information for simulation.

The planning for future mitigation through effective approach with vivid incidents cycle of management for crisis detailing description on how future potential crisis can be mapped, disseminated and utilized. Incorporating crisis knowledge from previous lessons learnt through reachback approach. Mapping representations is useful reachback which should be adopted in any crisis management to link the customer service help desk, personnel in the field and crisis victims. The focus should be on delineating the reachback field of various crisis to facilitate information tailoring during communications among the partners involved.

7. Conclusion

This chapter has provided a review of technology development; with meticulous attention to those relevant for use in crisis and disaster management. Further insights are provided on the

role mobile and wireless technology with highlights on usability of such technology. Challenges to crisis management is addressed in terms of limitation of technology application, rigidness of policies and narrowness of bandwidth in use during crisis communication and adoption of technology. The study recommendations are drawn from lessons learnt from previous studies and documented observations from various seminars and conference proceedings.

The role of usability model is highlighted with solution based approach which links the needs of various groups of users to reference data to enable subjection of the result to analytical model. This study proposes a dual method of analyzing crisis data for effective management by addressing the complex scenarios and proposes possible solution to the identified challenges. The methodology further discusses the extensive dynamics associated crisis management and provides a detailed solution based model schema suitable for potential utilization.

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Section 2

Crisis Management in Organizations and Economics

Chapter 5

Trust and Organization: Integrating Responses to Freshwater Contamination within the Everyday Work of a Care Organization

Jörgen Sparf

Additional information is available at the end of the chapter

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Abstract

In order to cut the word count I rewrote the entire abstract. Please replace with: Crisis management literature regularly focuses on large-scale incidents, crisis management organizations, and a managerial top-down approach. In reality, many crisis situations are small scale and local, involve non-emergency organizations, and often affect the entire organization. This chapter addresses this lacuna by fleshing out the empirical case of the outbreak of a waterborne parasite in a small municipality in Northern Sweden. The analysis showed that the outbreak affected the whole organization and was managed by the active agency of operative personnel and central experts. Additionally, findings suggest that spheres of action and different time-spatial framings were decisive elements in managing the crisis. The study concludes that issues of trust and the organizational setting influenced the framing and handling of the outbreak. In particular, the level of vertically directed trust established before the outbreak, along with the relatively high independence of the different units at operational level, played a decisive role in the integration of the outbreak in the everyday work of the organization. The paper calls for the development of organization theory addressing non-emergency organizations, small-scale events, and the integration of adverse events in the formal and social structures of everyday work.

Keywords: crisis management literature, organization theory, open systems, social structures, active agency

1. Introduction

Studies in crisis management usually analyze how single cases occur in specific organizations and how they are sealed off ('siloed') from ordinary production by top-level management or

technical experts [1]. Much less attention has focused on how incidents are addressed through organizations, how ordinary personnel at different levels deal with the incident, and how they relate the incidents to their ordinary work. In addition, most research seems to primarily examine incidents within production or directly stemming from production. Apart from disasters and dramatic incidents, studies of external events are rare. This paper takes a different approach in examining precisely this kind of organizational addressing in a non-emergency organization, during an external and small kind of incident.

In reviewing the literature on crisis management for this paper, three major problems were identified. Firstly, Smith [2] states that existing studies mainly focus on large-scale hazards such as natural or technical disasters, big accidents and major emergencies. The theoretical development of crisis management "has been based upon the processes that surround severe cases or extreme events rather than more 'normal' forms of adverse events that can result in crises for organizations" ([2], p. 101). The preponderance of large-scale hazards has not only limited the theoretical development but has also led to a lack of practical knowledge applicable to local incidents and small-scale emergencies.

Secondly, there is a conspicuous lack of common organizations as objects of study. The object of study in existing studies is either clear-cut or 'manifest' [3], crisis organizations such as emergency organizations and rescue services, or High Reliability Organizations [4–7] and more recently, integrated operations [8]. The staffs in these organizations regularly deal with a range of uncertainties and disturbances. Almost all of their work consists of monitoring and avoiding risks, and dealing with emergencies. They therefore have the professional knowledge, equipment, training and skills to resolve incidents [9]. However, what is missing are studies on latent crisis organizations [3, 10], i.e. organizations in which emergency or rescue responses are not part of the work, and where the staff are not explicitly trained to deal with uncertainties and disruptions-in other words, any other common organization.

Thirdly, the literature does not describe how crises are handled concretely at different organizational levels. The majority of crisis management studies focus on managerial aspects of crises, rather than on theoretical exploration [11]. However, the managerial aspects are presented in an abstract way, most often from a top-down perspective and with no actual actions of the staff described. Also, they are often limited to focusing response and recovery activities [12]. The number of managerial and strategic tools is huge [11, 13–15] but they fail to provide knowledge on how crises materialize and are dealt with from an organizational perspective, i.e. how changes and adaptations are actually carried out by the staff as active agents, and how the changes are integrated within the formal and social structures of the organization.

The aim of this paper is to examine how the interplay between trust and the organizational setting might influence the framing and management of an uncertain, adverse event at different organizational levels. The case study for this is a local outbreak of the water-borne parasite Cryptosporidium in Östersund, Sweden. Empirically the study investigates how the personnel at the local healthcare administration normalized the outbreak by assessing, managing, and integrating the disturbance within the formal and social structures of everyday

work. Knowledge from the study could help building knowledge on how different levels in non-emergency organizations can react and respond to adverse events. This knowledge could then be applied for developing methods and procedures in professional work.

2. Case and context

On Friday, November 26, 2010, the local authorities in the municipality of Östersund, Sweden, sent out a message via the emergency alert system urging all people within the city's freshwater system to boil the tap-water before drinking or when washing dishes by hand. For a couple of weeks several people became ill with upset stomachs supposedly caused by a parasite in the fresh water. Three days later, the Swedish Institute for Communicable Disease Control verified that the samples of fresh water contained the parasite *Cryptosporidium Hominis*.

The emergency alert was communicated locally via television and radio, and published on the municipality's web page as well as the national website for emergency information (www.krisinformation.se). For the following weeks, local news media (radio, television and two newspapers) followed the case closely.

Fresh water in Sweden is normally of a very high quality. Good natural resources and strong regulation provide a secure delivery of water, drinkable straight from the tap. Östersund is no exception, and the local freshwater system, run by the local council, delivers water to approximately 50,000 users. Cleaning equipment with ultraviolet light was installed a few days before Christmas and all water pipes were flushed. As from February 18, 2011, the fresh water was free from Cryptosporidium. The case lasted for 85 days.

Including an estimate of visitors, the parasite caused about 27,000 cases of illness, of which 51 individuals were hospitalized [16]. This means that almost 50% of the people living or working within the water supply system became ill. No casualties were reported. The highest rate of contagion occurred at the beginning of the period. From mid-December onwards, only a few new cases were reported. In addition to the health issues, the outbreak had some adverse economic effects; people lost income, organizations suffered from interruptions in production, and hotels and the tourist industry had a severe drop in visitors, etc. The total estimate of cost to society was around €190 million [16]. Thus, the outbreak was apparently the biggest in Europe in modern times.

Two people work regularly at the municipal administration with risk and crisis management duties. This work entails compliance assessments, risk and vulnerability analyses, emergency planning, exercises, etc. However, these experts are not responsible for managing occurring crises. The different department and a top-level crisis management team should instead do that. The top-level team is only activated for large-scale emergencies and severe crises. As the outbreak was not formally defined a crisis the team in Östersund was not activated.

The healthcare administration is responsible for providing care, support and help to the elderly, disabled people and other members of the community who are in need of various forms of

support. The administration employs approximately 1400 people. In addition, 25% of care services are outsourced to private enterprises. In total, the administration serves about 2500 caretakers.

The healthcare administration is organized in three levels: an institutional level entailing the head of department and a deputy head (strategic issues); a managerial level where the division executives are located (executive and administrative issues); and an operative level where the care services are concretely delivered (operative issues). The department has five geographical divisions, each comprising several units such as housing and residential centers, as well as a variety of services. A number of experts, e.g. on information, epidemiology, and crisis management work in the central administration supporting all departments.

The main problems that the cryptosporidium outbreak caused for the healthcare administration was a high amount of sick leave among staff, placing a heightened work burden on the staff left and with a lot of temporary staff-partly untrained-called in. A range of practical problems concerning water handling was added to the regular work.

3. Theory

To raise the theoretical understanding of this study the analytical framework is developed from two bodies of theories. As the healthcare department is organized as an open system with loosely coupled units, firstly organization theory on open systems is applied. Secondly, the study concerns relational aspects and decision-making within the loosely coupled organization during the outbreak, hence issues of trust become important. To this end concepts from theories of trust are applied in the analysis. The theories are presented in the same order as above.

The perspective of open system views organizations as dynamic, adaptive, open systems that need to match the complexity of their environments [17]. Organizational adaption to the environment means preparing for and dealing with uncertainties and contingencies, something which Lawrence and Lorsch stressed back in 1967 when launching their contingency theory [18]. Their model assumes that there is no best way for corporations to organize, lead, or make decisions. Instead, organizations have to strike a balance between internal needs and external circumstances [19]. This is achieved by structural and cultural differentiation and integration [18]: "the more dynamic the environment, the more differentiated the organization needs to be; the more differentiated the organization, the more integrative mechanisms there need to be" ([20], p. 495).

One way of adapting to the environment is by 'uncertainty absorption' [21]. Whenever an organization cannot avoid or transfer an uncertainty, for example through insurance, decision-making needs to be made with bounded rationality. This means that full knowledge of the future is either impossible or that the cost permitted of acquiring information in the present is limited. When the level of knowledge is believed to be satisfactory (acceptable, though not optimal), or when resources are tightened, the uncertainty is considered to be absorbed.

According to March and Simon, uncertainty absorption is frequently used, consciously or unconsciously, as a technique for acquiring and exercising power [21]. Thus, not sharing information

can be a means of remaining in power. In crisis management, information is often tremendously important. Absorbing uncertainty in a crisis in the way that March and Simon describe, is probably more often the rule than the exception. Quick decisions have to be made under great uncertainty by constantly judging what is a satisfactory level of knowledge and what is not.

Other systemic theorists have challenged the idea that organizations behave as rationally as the contingency theory and bounded rationality approach assumes. Pfeffer and Salancik [22] for instance, point to the 'active agency' of individual organizations and their leaders where they stress the importance of the initiatives of agents. The idea is that in the dependency on the exchange of resources between the organization and the environment, the organization is not a victim of complex contextual forces, but models its course of action through an active agency. In crisis management, the capacity for open, quick exchanges of resources is crucial.

Just like Pfeffer and Salanick, Thompson [23] also addresses 'active agency' but also the 'sphere of action' as key elements in dealing with uncertainties. Thompson applies a rather cynical view of pure self-interest over discretion. He claims that "individuals exercise discretion whenever they believe it is to their advantage to do so and seek to evade discretion on other occasions" ([23], p. 118). To only stress one-sided, egotistical motives for discretion seems rather tendentious. Even though decision making in the midst of a crisis exceeds the realm of a manager's or other staff member's usual sphere of action [1], it is hard to believe that egoism is the most significant or the only guiding compass.

In order to examine the relational aspects within the healthcare organization as an open system, some concepts from theories of trust are added. The rationale for choosing trust concepts is that the different units within the organization are targeted with expectations. These expectations may come from the caretakers and their akin, the administrative management, the public, the news media, and the other units within the organization. The idea is that the health care is expected to run regardless of circumstances and that people in Sweden generally put a very high trust in the healthcare system.

In particular, two aspects of trust are relevant to apply here: *routine* (and disrupt from routine) and *directions.* The first one concerns, in this case, the expectation that regular routines will apply and that work will continue as usual, in terms of service delivery and decision making, even under stressful circumstances. Möllering [24] describes how taken-for-grantedness is a basis for action 'until further notice' and that faced with uncertainty, routines can enable action [25]. In a study particularly relevant for this paper Child and Möllering [26] found that managers with higher contextual confidence had stronger trust in local staff and that, trust was higher when managers had successfully transferred routine practices to the local operations. We can thus see that trust and agency have clear connections to routines [27], which we will come back to in the results section. The possibility of agency is dependent on the stability, familiarity and continuity carried by routines in the sense of regular action patterns and rules [28].

As the study concerns an open system with units at different organizational levels it is important to distinguish between different directions of trust. We can distinguish two directions of trust: One *vertical*, which is about power relations and communication between organizational levels, and one *horizontal*, which is about peer collaboration and solidarity [29]. The upwards-directed vertical trust has been vastly studied, i.e. the kind of trust employees put in employers or citizens'

trust in institutions [30–33]. Much less research has been conducted on the downwards-directed vertical trust, for instance on employers' trust in employees [34], and companies' trust in suppliers and customers [35]. Yang [36] though, claims that the downwards directed trust is equally important as the upward directed in explaining administrative behavior.

Horizontal trust concerns all kinds of relational networks between people and/or organizations where there is no formal power involved [29]. At an interpersonal level, there might be informal power relations involved emerging from previous interaction between the trustor and the trustee. However, these kinds of relations are not examined here, as it would be too complex to fit with the empirical study.

Regarding decision making Simmel [37] described how trust involves faith as a basic element. Guido Möllering [38] makes a more scientific distinction of this in describing trust as a mental process consisting of *expectation, interpretation*, and *bracketing*. The expectation concerns the expected results from the choice made, which is the narrow perspective on trust held by the rational-choice school. However, the expectation is succeeded by an interpretation of the possible results from the different options to choose among. This interpretation is based on the normative perspective of the decision maker and based on the values that he/she holds. This aspect of trust has lately opened up the former rational explanations of trust to include emotions and moral as parameters in trust-related decision-making. Since the interpretation is always ontologically based, trust has also a suspending function. This means that the inherent uncertainty in any decision-making is bracketed; "*suspension*: the bracketing of the unknowable" ([38], p. 417). By this explanation we can see how the combination of interpretation based on rationality, emotions, and moral, in combination with the bracketing function, explains Simmel's notion of faith as an element of trust.

4. Method

Data collecting consisted of interviews with staff members on different levels of the healthcare administration, and with experts in the Cryptosporidium case. To keep the study consistent, the only two divisions that were completely within the geographical area of the freshwater system were chosen for the study. It was thus possible to focus solely on the disturbances from the outbreak without having to consider any internal variations with regard to water supply. Three aspects were considered in selecting the care units: *The type of accommodation*; *The kind of care takers and their conditions*; and *The different kinds of care services provided*.

Individual interviews were carried out with: the Deputy head of department (IL)[1], the Division executives (ML1 and ML2), the Head Nurse (CE1), the Municipal security coordinator (CE2), and the Healthcare administration information officer (CE3). Group interviews with care staff were done as follows: Home care service, 2 interviewees (OL1), Special housing, 4 interviewees (OL2), Special housing, 6 interviewees (OL3), Elderly centre, 7 interviewees, of which one was head of department (OL4), and Home care service, 3 interviewees (OL5).

[1]The bracketed abbreviations refer to the quotations in the results section.

The interviewees were asked questions about the regular processes of risk and crisis management at work (e.g. planning, training, communication), and about personal and professional experience of other crises and straining situations. Above this they were asked to describe how the cryptosporidium case played out for them professionally and personally. The author carried out all interviews face-to-face at each workplace. All conversations were recorded. Procedures for the interview, data processing, anonymity, and the publication of the results were communicated in writing in advance and orally before starting the interviews. All interviewees consented with no objections. The option to opt out before, during, or after the interview was communicated in advance and at the interviews.

4.1. Analysis

Systemic organization theory asserts that an organization is a compound of both formal and social elements/structures. The construction of the analytical framework, presented in **Table 1**, is based upon this idea, adding a reflexive trust-dimension of active agency.

Organizational structures precondition how incidents are dealt with in organizations. Three elements were identified as being of special significance for handling the Cryptosporidium outbreak: *crisis management plans*, *formal roles and responsibilities*, and *crisis management processes*. Municipalities in Sweden are obliged to be prepared for crisis management; however, the rules of how to do this are open to local application. The organizational structures form a baseline for managing adverse events: the formal organizational preparedness.

The formal preparedness of the organization is socially embedded in the everyday work of the staff. A range of **social structures** thus influences how an incident is managed. Four social elements that were assumed to be significant in this case were included: *individual and collective experiences of crises*, *social work-relations*, *work-related knowledge*, and *informal roles and responsibilities*. A smooth and effective distribution of crisis management demands a certain

Organizational structures	Plans (documents, prepared crisis management team)
	Roles (assigned roles in crises)
	Processes (training and exercise, education, involvement)
Social Structures	Individual and collective experiences from crises
	Work-related knowledge (relevant old and emerging new)
	Informal roles and responsibilities
	Social work-relations
Active Agency	Actions and measures taken
	Shifting horizons of action
	Creativity/improvisation/innovation
	Critical distance and reflection

Table 1. Analytical framework.

amount of reliance and confidence between colleagues and between organizational levels. As such, social structures complement formal preparedness with trust.

This combination is the setting for an **active agency**. The agency refers both to the concrete actions, what the staff do to alleviate the problems arising from the outbreak, and the critical distancing of a reflexive subject. 'Active' refers to the ability and motivation of individuals and small groups for taking action in a given situation. In addition to the concrete *actions and measures taken,* three elements are included: s*hifting horizons of action, creativity/improvisation/ innovation,* and *critical distancing and reflection*.

The analysis of the transcribed interviews (ca 50,500 words) was carried out through several readings in order to identify issues and statements fitting the analytical framework. The content was then analyzed by using the analytical frame both from a vertical perspective (consequences, actions taken, communication, etc. on the same organizational level) and horizontally (consequences, actions taken, communication, etc. between different organizational levels).

5. Results

First a short introduction presents how the message regarding the outbreak was received and defined by the interviewees, and how internal communication was handled during the outbreak. In addition, some reflections on learning and when the interviewees believed the incident was over. The results from the analysis are then presented in a condensed form in **Tables 2–4**. The tables include the observations and issues raised in the interviews, and by the findings from the analysis.

Only one of the interviewees found out about the outbreak internally, all the others learned through the news media or through friends and relatives. Several of the interviewees even got to know from people living outside of Östersund or even abroad. No formal information was sent out internally. All available information seems to have been disseminated by word of mouth.

One interview question was "Who defined the incident?" For both the managerial and operative levels, the answer was quite obvious: the definition came from the top. However, for the institutional level, the definition was not at all clear-at least not at the start. At first the process of learning about the incident was slow. It basically concerned acknowledging an increase in the reported number of sick people. "We got the signals before the peak of the outbreak. I think we became aware of this when the figure of reportedly sick people was 500-600" (IL). Later on the institutional level took the standpoint that this was not a crisis: "it hasn't caused any crisis or anything" (IL). Despite the slowly emerging character of the event, the large numbers of affected people and organizations, and the rather long duration, the outbreak was not formally defined as a crisis by top management or experts. Managerial and operative levels however had the impression that the institutional level had made such a definition.

Regular meetings were held between heads of departments and experts. No information was initially communicated from the central administration to the departments or directly to the care staff. Nor was any information communicated from the department to the divisions. Eventually,

daily e-newsletters were sent out to all members of the health department. However, by the time the information was sent out, the operative staff had already taken initiatives to deal with emerging troubles.

> *"No, I don't think that we got any information at all really about what we should do. Maybe the district nurse told us to boil the water."*
>
> *"Yes, but at that time we had already started doing that. It was sort of natural thing to do."* (OL5).

The operative personnel were generally disappointed about the lack of internal information. A general observation was that operative personnel share information and solve problems informally. For example, they called the hospital for medical advice and other units to ask for assisting personnel.

The division executives seemed satisfied with the information. They mainly talked about information regarding the parasite, not about organizational issues.

> *"Since it is a new kind of parasite, that we are not familiar with, there is a risk of rumors emerging […] information is very important"* (ML1).
>
> *"This time it was good information. They sent out updated newsletters regularly from the department"* (ML2).

Practically all interviewees said they were going to drink the water as soon as the boil notice was officially lifted, though some planned to wait longer. At work, there was no intention of extending the water restriction longer than necessary. One division executive though, claimed that the incident would not be over until an assessment had been made. Some interviewees believed that the outbreak was a sign of a permanently changed environment "New parasites will surely show up eventually" (OL3), "When is the incident over? Never, it will always be present" (OL2).

The security manager planned for an overall assessment and some seminars. None of the other interviewees had any intention of collecting experiences from the outbreak.

5.1. Organizational structures

Since the central crisis management team was not activated, the responsibility for handling the crisis remained with ordinary management. Managers at both institutional and managerial levels stressed the importance of line management. Even though the division executives were responsible for regular fire-protection checks and had emergency plans ready, they did not have the knowhow to actually deal with incidents. There should be one person on the institutional level working 20% with risk and crisis management specifically for the department. However, a recently retired person who was not replaced at the time of the outbreak held this position. All managers and experts mentioned this with regret.

Several units had a crisis management plan-stating the minimum staff and duties to be prioritized-but in only one interview were the interviewees aware of the plan. Generally, the personnel expressed uncertainty regarding the plans and procedures for crisis management. All employees at an operational level took a mandatory half-day course in fire safety every 3 years

but none of them had ever been involved in crisis management planning, training, or exercises. Several said that they wanted to be more involved in that kind of work in a practical sense. From the experiences of a number of previous deaths among colleagues, due to cancer and accidents, a general need for local crisis teams was addressed in two interviews.

Apart from the security manager, the other two experts had not been involved in any preparation training at all. The head of the central information office had been involved in exercises and was responsible for the municipal crisis communication plan, but no one else from the healthcare department had been involved.

Institutional level	Managerial level	Central expert functions	Operative level
A parasite outbreak was not a scenario that had been planned for.	The department's crisis team = regular top management (division executives and managers at an institutional level). This group normally meets every second week for regular work planning.	*The security manager*	Feelings of uncertainty.
A central crisis team is assigned for large emergencies.	The ML has a list of people to call in emergencies.	Responsible for coordinating the planning, analyses, training, assessments, etc. in crisis management.	Have no emergency/crisis instructions.
The responsibility for security is shared between the department's security manager, the central security manager, and division executives.	More reactive than proactive crisis work.	Was not very involved in managing the outbreak.	Regular security (guarding) and health workers are outsourced.
Line management is very important.	Responsible for risk and vulnerability analyses at the department.	Plans on conducting an evaluation and seminars.	All units have regular collaborative meetings with managers, members of staff, union representatives, etc.
The department lacks a security manager The managers and experts receive training.	A file for systematic fire-protection.	*The other two experts*	The local crisis management plans were not applied in the outbreak.
	Courses in fire safety.	Not involved in plans or groups regarding risks and crises.	The unit manager was identified as responsible for giving information in the outbreak.
	A regular 24-hour emergency duty for nurses.	Not involved in exercises, security assessments or crisis plans.	All staff members are also responsible but it is difficult to define exactly what for.
	Regular assessments and audits of the working environment.	In the information office, only the head takes part in exercises.	Have never had any crisis training.
		They have lists of people to call in emergencies.	All staff members take a half-day course in fire safety every 3 years.
		Feel confident about their expert roles, but generally unsure about crisis management.	Several members of staff would like to be more involved.
		The department lacks a security manager.	There is a regular system for reporting ill patients.

Table 2. The outbreak related to organizational structures. Observations and issues brought up in the interviews and from the analysis.

5.2. Social structures

Many employees had worked in the department for a very long time. No interviewee at any level though had had any experience of work-related crises. The crisis was similar to the annual outbreak of 'winter vomiting disease', both in terms of individual symptoms and organizational effects. However, the experiences and systems for dealing with the returning disease were not applied in the Cryptosporidium case.

All contacts between units at the operative level and between different organizational levels seemed to be characterized by informality. The information officer described how new roles for the people at the information office were modeled ad-hoc as the outbreak evolved. These roles were allocated on a daily basis, and changed from person to person.

The care personnel were in many cases used to dealing with risks in their normal duties. There was no point in taking on other informal roles in this case. Practically everyone took on the individual responsibility for boiling and distributing water.

I think we are working with that [risks] all the time. I mean, training in using stairs with someone who is 80 years old is one hell of a risk. … It's like a habit so we do not think of it as dangerous anymore. (OL5).

From the managerial perspective, a large portion of trust in the staff was expressed. At the institutional level, not much was found regarding social structures, maybe because very little changed on this level.

Institutional level	Managerial level	Central expert functions	Operative level
The informal nature of internal relations meant that the outbreak was handled smoothly.	Need for a role which bridges safety and the department's work. What needed to be done was done in an informal way. A high level of trust in the staff. Many people at the department have worked here for many years. Despite the long experience of staff, the outbreak came as an unpleasant surprise. Problems may arise differently for private enterprises outsourced to. No extra meetings were necessary.	Their expertise was acknowledged. The need for the right skills became obvious. The experts had key roles in solving the case. Modeled ad-hoc roles at the information office, informally given or allocated every morning.	Almost no experience of crises. But experienced in dealing with risks in everyday work, such as supporting the elderly in physical training. At two units, colleagues had died of cancer and accidents. Are very used to dealing with problems in their daily work in an informal way, either independently or in collaboration.

Table 3. The outbreak related to social structures. Observations and issues brought up in the interviews and from the analysis.

5.3. Active agency

Only at the institutional level were regular meetings about the outbreak held, at first daily but then more sparsely. At a managerial level, almost no action was taken. At an operational level, many small adjustments were made such as boiling water, distributing water in small bottles, putting up warning signs by the water taps, and talking to patients about the outbreak. All of these measures were improvised by the personnel. Some examples of creativity were found such as using strong metaphors or images to really drum into dementia patients that the water was contaminated. However, there was no collaboration or sharing of knowledge/experiences about the outbreak between units.

Institutional level	Managerial level	Central expert functions (not the security manager)	Operative level
The affected municipal departments initially had meetings every morning, then more sparsely later on. Frequent contact between levels during the outbreak. Did not activate the central crisis team. This team is governed by special laws and requires special organizing. The effects of the outbreak were similar to regular stomach diseases. Maintaining the line organization was important. No plans for how the outbreak might have developed (e.g. spreading to other water systems).	Almost characterized by a passive agency. No meetings or communication out of the ordinary. Put great confidence in the staff.	Showed great individual initiatives. Did not have any instructions to follow but had to improvise. The case was prioritized before other duties. Within the case, they made their own individual prioritizations.	Everyone boiled water. No unit received special deliveries of water. Boiling the water was soon incorporated in daily routines. The water was turned off for several patients. In most accommodation, warning signs were put up next to the water taps. Some dementia patients had to be warned by using strong images ("there is shit in the water"). The extra tasks took time away from other duties, for instance boiling water, distributing individual bottles to every patient, and turning on and off the water. Most solutions were improvised since no instructions were given. At a couple of units, the outbreak was discussed at morning meetings. The outbreak was quite straightforward. Common sense was enough to deal with it. Many reflections relating to regions with drought or bad water, but also their own, local vulnerability. Several interviewees addressed the environmental issues related to the increased sales of bottled water.

Table 4. The outbreak related to active agency. Observations and issues brought up in the interviews and from the analysis.

Two horizons of action seem to have guided the active agency at an operative level: the safety and well-being of the patients, and keeping the working environment as unaffected by the outbreak as possible.

The experts clearly acted autonomously. The head nurse did not wait for orders or definitions but instantly acted upon the warning alert. She called all nurses at the divisions who were working that night, ensuring that all of them got the information. The information officer showed some innovative initiatives in setting up a notification system and various ways of channeling internal information. However, she stated that the information office in general focused much more on the external information to the public, than on internal information to the staff.

One significant observation was that the variations in reflections on the outbreak were larger and more non-work oriented at the operational levels than at all the other levels (including the experts).

6. Discussion

The aim of this paper is to examine how the interplay between trust and the organizational setting might influence the framing and management of an uncertain, adverse event at different organizational levels. From an organizational perspective, the outbreak represents an almost ideal contingency; it was characterized by a genuine uncertainty regarding causes and how to manage and solve the concurrent problems, most inhabitants had never heard of the parasite before or knew anything about the effects, the outbreak was a combination of a creeping crisis with a slow onset and fast solution and a long shadow crisis with a fast onset and lingering consequences [11]. All in all, the outbreak came as a total surprise to everyone, and put a lot of strain on both the central municipality administration and on the different technical administrations.

As the outbreak had direct effect on the day-to-day operation for each unit, the contamination was not possible to avoid or transfer. The units had to deal with it in their everyday work. Further, sealing off the water supply was not an option either since the water grid is the same for the whole community. Nor was an organizational "siloing" possible because all units were affected and the outbreak affected the core work. Therefore, the outbreak and the uncertainty had to be integrated with the regular tasks at each unit. Absorption was the only feasible alternative of managing the situation.

Throughout the outbreak all operational decisions were made at each unit. Related to Möllering's [40] conceptualization of interpretative trust, this could have led to distinctly differing decisions between the units. This however, turned out to not be the case. And even if some small decisions differed, the general outcome of the decision-making seems to be fairly similar. The explanation for this can be that the units are used to operate solitarily in everyday work. Therefore, the staffs are used to work toward specific goals regarding the wellbeing of the caretakers. In the outbreak, this goal attainment seems to have contributed to a positive outcome by guiding the decisions taken by the staffs.

Thanks to informal relations and an active agency, especially by the care staff at an operative level and also by the experts, the crisis was quickly adjusted for, and measures for dealing with the outbreak were integrated into everyday work above all through improvisation and creativity. Improvisation and creativity are two long-standing terms in crisis research. However as with crisis management studies, general existing studies of improvisation tend to focus on disasters and large-scale emergencies and on manifest crisis management organizations, especially with regard to emerging organizations and leadership [39–42]. Much less is written on the improvisation of ordinary staff in ordinary organizations facing minor emergencies.

Pfeffer and Salancik's [22] notion of active agency chiefly concerns how *organizations* can act independently in relation to external forces. A general criticism of this notion is that organizations cannot act, only *individuals* can. The active agency demonstrated in the outbreak is a good example of individual initiatives. A high level of internal trust and a wide individual sphere of action seemed to be a decisive precondition for this active agency. This is in line with Thompson's [23] identification of the sphere of action as a key element in dealing with uncertainties. If the personnel is expected and encouraged to take initiatives in everyday work, it is plausible that they will also do so in a crisis. However, having well-defined limits of the sphere of action is a crucial prerequisite. Participation in planning is another way of enhancing the capacity of the street-level workers [43].

Although no empirical information was found indicating pure egotistical motives, as proposed by Thompson, it should be mentioned that the operative level had low trust in the institutional level. One reason for this could be the reluctance at the institutional and managerial levels to produce and internally disseminate information and instructions. This could be interpreted as an example of March and Simon's description of avoiding information-sharing as a power technique [21]. Power was not explicitly mentioned in the interviews, but March and Simon do stress that this strategy can be unconscious as well as conscious.

A particularly interesting finding is that the framing of the outbreak differed between the organizational levels with regard to time and space (see **Figure 1**). The institutional level talked about previous incidents and exercises within the administration (*historical-internal focus*). The division executives at a managerial level mainly addressed internal issues, but were much more future-oriented (*future-internal focus*). The experts asserted that regaining confidence among the clients' relatives, by the local citizens in general, and by tourists and

Figure 1. Time-spatial framing of the Cryptosporidium outbreak at different organizational levels.

visitors (*future-external focus*) guided their prioritizations during the outbreak. At the operational level, the reflections and connotations did not concern the work or the local context. The issues brought up concerned experiences from around the world such as historic hazards and the struggle with water that many people around the globe deal with every day. They also mentioned the environmental consequences of bottled water (*historical-external focus*).

This variation in framings might not be possible to ascribed trust or organizational setting. However, the logic behind the framing is assumedly related to the different roles of the respondents, and to the immanent perspectives at the different levels. Consequently, there are clear organizational influences to this framing. Interestingly, the framings partly contradict Thompson's [23] assertion on the nature of different organizational levels. The operational level was not the most closed rational in this case, the institutional level was. On the contrary, the operational level took an open adaptive approach, which Thompson reserved for the institutional level. In Thompson's theory, management plays a very active role in mediating between levels. In the Cryptosporidium case, such a role was not at all visible.

The self-sufficient units and their solitary decision-making, combined with the variations in the framing of the outbreak, highlight the issue of how trust in different directions is characterized. The vertical, power-oriented trust is particularly interesting as it stayed the same as under normal circumstances but was charged with new meanings and interpretations during the outbreak. A high level of downwards directed trust on the one hand provides the units with a large sphere of independency, but is also a way of exercising power by avoiding being questioned. The downwards-directed trust did not change during the outbreak but increased, or strengthened, i.e. the management continued to trust the staffs just as much or even more as in normal circumstances. This was also communicated to the staffs. However, from a critical point of view, this acting could be a sign of exercising power and fleeing from responsibility. Further, it may put the units under a lot of stress and make them more vulnerable.

The upwards-directed trust in the healthcare administration is normally high. The units claim that it is liberating under normal circumstances to be free to make their own decisions. However, the outbreak was something so out of the normal that it was difficult for the staff to know what to do. In the interviews, they stated that they were completely ignorant about the parasite, they did not get any instructions or have sufficient training for crises, and the crisis plans were not adopted. Caught by surprise, yet acting with creativity and improvisation, the staffs seem to have been expecting something more from the management – unclear what though. Presumably, the expectations fall back on two main issues: the lack of clear responsibilities and the lack of sufficient training (see **Table 3**). From a trust perspective, it is therefore a bit peculiar that the upwards-directed trust remained. One speculation though is that the staff might not want to lose the well-grounded trust once the outbreak was over. By bracketing the uncertainties with small decisions to overcome emerging problems, and by avoiding to questioning the management, the staffs secured not to jeopardize their independence. If this is true, then the interplay between the upwards-directed and the downwards-directed trust seems to facilitate the exercising of power discussed above.

7. Conclusions

The general conclusions from this case study are that trust and organizational setting influenced the framing and handling of the cryptosporidium outbreak. Especially, the level of vertically directed trust established before the outbreak, along with the relatively high independence of the different units at operational level was crucial.

Returning to the observations from the introduction on the character of studies in crisis management, it seems clear that there is a need for developing organizational theory of non-emergency organizations, small-scale events, and the integration of adverse events in the formal and social structures of everyday regular work. Existing organization theory and theories from crisis management studies can only partly describe the relational aspects of this integration.

The classical organization theories seem to treat only *known uncertainties* ('known unknowns') directly related to ordinary work and production. They do not treat *genuine uncertainties* ('alien externalities' or 'unknown unknowns') or explicitly the management of crises in organizations. Thus, these theories are not directly applicable to crisis management studies. However, since the theories include aspects of contingency and the absorption of uncertainties, they are relevant for developing a more specific crisis management theory. Such a theory would positively complement existing studies on disaster management and other large-scale events.

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Chapter 6

Applying the Organizational Centaur Theory on Boundary Spanners in Demanding Situations

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Additional information is available at the end of the chapter

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Abstract

The aim of the present study was to compare the existing conceptualization of the dual nature of organizational centaurs to discover what could be found in an investigation of organizational contexts characterized by risky and life-threatening situations. The study design involved a two-step procedure. The first step was inductive in character and followed the guidelines of grounded theory regarding selection of the participants in the study (*further called informants, N = 71*), data collection and initial analysis. The second step consisted of an attempt to compare this conceptual model to the existing ideal-typical descriptions of the organizational centaur concept. Managing crisis, disasters and other uncertainties as a boundary spanner can be understood in terms of a typology differentiated at the organizational and individual levels. The organizational part defines the prevailing conditions in uniformed, greedy organizations for boundary spanners who contribute to the organization's foundation of competence and behavior, and also outlines the limitations this may entail. The individual part focuses on the human such as no room for mistakes and the management of asymmetrical collaborations. It was concluded that the special case of severely demanding conditions added new insights into the organizational centaur framework.

Keywords: boundary spanners, organizational centaur, organizational adaption, crisis management, military operations

1. Introduction

In modern organizations operating in a globalized environment, there is an increasing demand for cross-sectorial collaboration and for organizational members to work at the perimeter of the organizations. When it comes to crisis management it has long been recognized that disasters and crisis characterize circumstances in which the boundaries between organizations,

roles, responsibilities and individual roles are blurred [1, 2]. Collaboration and collaborative roles such as boundary spanners in crisis management are therefore crucial. Previous research in a variety of organizational contexts has shown that boundary spanners in context of crisis management issue are characterized by the intrinsic competencies and authorization to step outside organizational boundaries and collaborate with different external organizational actors [3–7]. Boundary spanners have an ability to stretch the boundaries of an organization, thereby facilitating the influx and outflux of information, negotiations, knowledge and innovations [2, 3]. They facilitate managerial decision-making and build confidence and long-term relationships [8]. Further, boundary spanners contribute in many ways to the creation of social capital in an organization and between organizations [9]. However, according to [10], this can cause information asymmetry in organizations, as boundary spanners can act on their own agendas and may break rules [11]. Boundary spanners have many additional descriptions of the role such as networker, broker, collaborator, cupid, civic entrepreneur, boundroid, spark plug and collabronaut [12]. "Grassroots bureaucrat" [13], "spontaneous volunteer" [14] and "spider in the web" [15] are other monikers.

1.1. Organizational centaur

Boundary spanners can also be seen as organizational members who have a great ability to put a personal stamp on work tasks and other organizational actions. They become, in [16] terms, 'organizational centaurs' – half human, half organization. He writes:

> *When organizations do something, it is always the individuals who act. However, they do not primarily act on the basis of their own impulse but on behalf of the organization. Their actions are not their own but those of the organization. However, since people are still acting with their own experiences and thoughts there is always tension between the actions of the organization and the human actor. Organizational action is a social hybrid. The actor is a human individual but the action is organizational. One can talk of organizational centaurs: partly human – partly organization* [16 page 63].

The idea of the organizational centaur conveys the fact that organizations are not homogenous actors and indeed cannot act at all, as only individuals have that ability [16]. Organizational members not only act as organizational representatives but also as separate individuals with their own feelings and characteristics [16]. Ahrne [16] further maintains that when an individual acts on behalf of an organization, it is still the person who brings something of himself or herself in each act. The main difference between the concepts boundary spanner and organizational centaur is that the theories focusing on boundary spanning usually describe individual actions and interactions [17]. Organizational centaur conceptualizations, on the other hand, describe a duality and a holistic view of the organization and the individual as a form of social hybrid [16]. There is a lack of research on the organizational centaur concept in highly demanding and stressful environments. Typical examples of the latter are military and disaster response organizations. The character of intra- and extra-organizational boundary spanning needs to be explored in these environments and be compared to what has been found in more ordinary organizational settings. In particular, in extreme conditions where life and death may

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be at stake, issues such as responsibility, risks and consequences of mistakes call for more research. In addition to the need for further conceptual development, these issues may have long-term effects for afflicted individuals as well as professional actors, their organizations and their nations.

In a previous series of studies, we have explored boundary spanners in demanding situations. Although many aspects have been empirically identified, a unified theoretical framework of the obtained results is lacking. Therefore, we decided to attempt the organizational centaur concept as a unifying theoretical umbrella in order to understand boundary spanners in context of crisis management and other uncertainties. This required two steps:

- To synthesize our own previous results on boundary spanners in demanding situations as they derive from several separate studies.
- To qualitatively evaluate a comparison between this empirically generated synthesis of boundary spanners on the one hand and the general concept of organizational centaur on the other.

In addition to the challenge of comparing two theoretical models, the present one had an additional theoretical challenge in that the organizational centaur model represents the critical theory tradition and the empirically generated boundary spanners model has a functionalistic base. Against this background, the aim of the present study was to compare the existing conceptualization of the dual nature of organizational centaurs to what could be found in an investigation of organizational contexts characterized by risky and life-threatening situations.

2. Method

The study design involves a two-step procedure. The first step was inductive in character and followed the guidelines of grounded theory regarding selection of informants, data collection and initial analysis [18]. Using the constant comparative method of analysis, a hierarchical conceptual model was developed. The second step consisted of an attempt to compare this conceptual model to the existing ideal-typical descriptions of the organizational centaur concept.

2.1. Demanding situations as the context of the research

Demanding situations include crises, wars and armed conflicts, as well as extraordinary events, and society may respond to these kinds of challenges on a national and international level. This article focuses on Swedish situations and the Swedish authorities which have had to cope with demanding circumstances in both domestic and international contexts. Specifically, the examples from civil and military contexts are described in the next section.

2.1.1. Civil contexts

The tsunami catastrophe struck on December 26, 2004. As a result of an earthquake, the waters of the Bay of Bengal formed 10-metre high waves that flooded the coastal areas of several

countries. Approximately 200,000 people died and around 50,000 people are still missing from the area. The number of Swedish deaths (people on vacation in Thailand) in the catastrophe amounted to 543, of which 120 were children under the age of 15.

In 2004, the Swedish prison service was affected by a series of incidents. This article focuses on a hostage drama that took place at an institution in Mariefred on September 23, 2004. Despite preparedness and incident exercises among the prison officer staff, two inmates with knives fled the prison after taking a middle-aged warden hostage. Fears for the hostage's life quickly spread among his colleagues and also among the police and general public. The prisoners moved across several counties but were finally arrested outside a small city far from the prison.

On February 4, 2005, a large sulfuric acid tank suddenly collapsed in the harbor area of Helsingborg, a medium-sized Swedish town. As a result, approximately 16,000 tons of sulfuric acid were discharged into the harbor basin. A number of authorities and 35 municipalities took part in the clean-up, which lasted for 3 days. Although the accident did not cause any serious harm to humans, it is the largest chemical accident to have affected Sweden to date, with significant material and environmental damage.

2.1.2. Military contexts

Where a military context is discussed, it concerns staff from the Swedish Armed Forces serving on international missions for military observation, peace-keeping and peace-enforcement purposes. Typical military collaborative tasks highlighted in this study focus on liaison, negotiation and intelligence gathering, observations and situation outlook reporting. All of these activities are conducted under imminent danger to life and limb, and the military contexts are often also characterized by challenging geographical and social aspects such as squalor, decimation and extreme climatic conditions and a variety of socio-cultural traditions and customs. Actors encountered in the host country include the local people, the armed forces from different countries and local actors such as clan warlords, local police, politicians and a range of non-governmental organizations (NGOs) [2].

2.2. Informants and organizations involved

In order to gain as wide a variety of experiences as possible, the selection of participants or informants for this study was made in accordance with the guidelines for Grounded Theory developed by Glaser and Strauss [18]. A total of 71 people were interviewed, of which 50 informants were involved in disaster management and 21 were participants in military operations. Of the 71 informants, 10 were women (**Tables 1** and **2**).

For the sake of clarity, military organizations and civilian crisis management organizations will from now on be referred to as uniformed organizations, a term inspired by Soeters [19].

2.3. Data collection

Data were collected from interviews, following a prepared interview guide. The interviews consisted of open-ended questions and individually adapted follow-up questions covering

Organization	Involvement in rescue operation	Number of informants	Female/ male	Their position (during the rescue operation)
1. The Swedish Rescue Services Agency	Tsunami	5	1/4	• Director-general • Head of Operational Management • An emergency service function called focal point • Two crisis managers
2. A local rescue service organization	Sulfur spill Hostage-taking	11	2/9	• Incident commander • Chief fire officer (CFO) • Chief fire officer (CFO) on duty • Overall incident commander • Incident site officer • Chief of staff • Full suit firefighter • Information officer
3. An emergency treatments unit	Sulfur spill	4	1/3	• Chief of emergency treatment • Officer on duty • Incident site medical officer • Emergency medical officer
4. Swedish Armed Forces	Tsunami	6	0/6	• Logistics coordinator • Medical doctor on duty • Liaison officer sent from operative unit (OPU) and located at the Swedish Rescue Services Agency • Two managers for the operational section on duty • The head of the logistics department
5. National Board of Health and Welfare	Tsunami	6	2/4	• Director-general • General Manager of Administration • Head of Social Services Department • Head of Crisis Management Department • Two Operative Managers
6. A regional public prosecution office	Hostage-taking	2	1/1	• Two chief prosecutors
7. Regional Police Department	Sulfur spill Hostage-taking	11	1/10	• Head of the police department in charge of law and order • Three chiefs of staff • Two negotiators • Two police incident officers • An adviser to strategic commander • An information officer • A liaison officer
8. A prison establishment	Hostage-taking	5	1/4	• Director-general, • Three detective inspectors • Chief of security
(N) informants		**50**	**9/41**	

Table 1. Overview of informants from civil disaster management.

the following themes: (1) background, (2) individual role and task during a specific rescue/military operation, (3) experience of individual actions during the rescue/military operation, (4) experience of organizational actions during the rescue/military operation, (5) experience

Organization	Number of informants	Female/ male	Their position (during the international military operation)
1. Swedish Armed Forces	20	0/20	• Military observers (3 persons) • Liaison officers (11 persons) • Contingent commanders (4 persons) and • Military attachés (1 person). • Police officer
2. The Ministry of Foreign Affairs	1	1/0	• First secretary to the Swedish embassy
(N) informants	**21**	**1/21**	

Tables are published in Alvinius [2] which is the doctoral dissertation.

Table 2. Overview of informants from international military operation.

of collaboration between the authorities and the organization during the rescue/military operation and (6) stress and demanding conditions during the rescue operation.

The interviews were conducted between January 2005 and July 2008 at the informants' workplaces, in the premises of the Swedish Defense University and in two informants' residences; two were conducted over telephone. The interviews were recorded and generally lasted about 60–210 minutes. All interviews were conducted and analyzed by the authors. The data may be outdated but it makes a contribution to further theoretical elaboration on boundary spanners and organizational centaurs in context of crisis management.

2.4. Data analysis step 1: inductive generation of a conceptual model

The interviews were transcribed verbatim and analyzed according to the constant comparative method of Glaser and Strauss [18], and clustering, a process of moving to higher levels of abstraction [18]. The first step was so-called "open coding." Data were examined line by line in order to identify the informants' descriptions of thought patterns, feelings and actions related to the interview themes.

The codes derived were formulated in words resembling those used by the informants. For example, the following statement was coded as 'Church minister helping':

> *I picked someone from the support group and our prison pastor /…/ but we were so lucky because another minister from Mariefred lived on the top floor [in the building where the hostage lived]. He was their neighbor /…/ so those three travelled together – our support person, our prison pastor and the other minister went and met his [the hostage's] wife and family to inform them.*

Codes were then compared to verify their descriptive content and to confirm that they were based on the data. The second step involved sorting the codes into different categories. The above example, 'Church minister helping', was sorted into the category 'Spontaneous links'. Similar codes sorted under the category 'Spontaneous links' had similar characteristics, that is, they had no organizational belonging, predefined positions or tasks. They occurred when the

needs of the crisis became too great for the organization to manage by itself, thus contributing to assisting the organizational members resolve the crisis. The next step consisted of putting 'Spontaneous links' into the superior category "Partly human" after constantly comparing interview transcriptions, codes, categories and superior categories. The category 'Partly human' is characterized by human actions, qualities and behavior and how significant these are to the organizational adaption to crisis. There was consequently a clear connection between becoming a spontaneous link as a result of one's knowledge and competences and contributing to solving the organization's task. A similar line of thought guided the creation of the other categories. Data were also analyzed with respect to the selection criteria, meaning that comparisons were made between the different organizations and the different roles occupied by the informants according to Glaser and Strauss [18]. The final step consisted of fitting the superior categories together using the constant comparative method. This resulted in a clarification of organizational centaur theory using the existing typology of partly organization and partly human concepts.

2.5. Data analysis step 2: comparison of the generated conceptual model and the concept "organizational centaur"

The second analytical step was in itself a two-step procedure. First, components of the organizational centaur concept were identified in the literature source [16]. Second, a qualitative evaluation was performed where these components were compared to the generated conceptual model. This evaluation was based on our understanding of the meaning of the components. The process resulted in the following categories: (1) categories that were evaluated as identical although sometimes labeled differently, (2) categories found in the existing organizational centaur concept only and (3) categories found in the inductively generated conceptual model only.

3. Results

3.1. Part 1: A conceptual model generated from data in highly demanding conditions

The analysis of the interviews shows that boundary spanners, seen through the lens of the organizational centaur, facilitate the adaption of the organization to demanding and uncertain conditions. Managing uncertainties as a boundary spanner can be understood in terms of a typology differentiated at the organizational and individual levels. For this reason, the analysis continues under two separate sections: (1) partly organization defines the prevailing conditions in uniformed organizations for boundary spanners who contribute to the organization's foundation of competence and behavior, and also outlines the limitations this may entail and (2) partly human focuses on the human factors that are particularly relevant in demanding situations.

Superior categories at the organizational level named partly organization that emerged in the analysis of the interviews were the following: (1) boundary spanners' organizational belonging

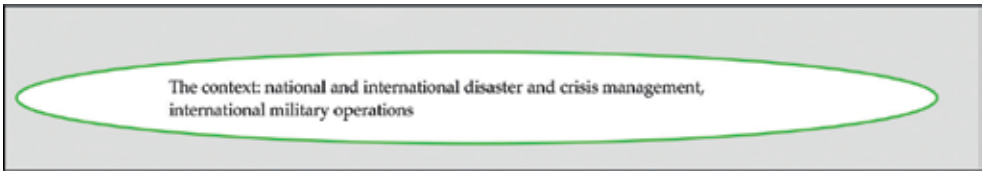
– being a part of greedy institutions, (2) acting at the boundary of the organization and (3) building neutral temporary organizations. The following aspects at the individual level named partly human have been crystallized in terms of the part human aspect of demanding situations: (1) no mistakes, (2) using contextual intelligence in boundary spanning, (3) managing asymmetrical collaborations, (4) improvisation vs. structure and (5) spontaneous links. Each aspect will be illustrated by relevant quotes to provide empirical clarification of the theoretical discussion. The purpose of this outline is to explain and define how the core variables are supported by quotes, codes and categories. Please see **Table 3** for an over-arching definition.

3.1.1. Partly organization

Boundary spanners who carry out actions on behalf of an organization are only operating as a part of the organization and will, to varying degrees, replace the organization in a certain context. This duality stems from double intentions that the boundary spanner is also partially carrying out a personal action that is controlled by personal qualities and emotions. The organization furnishes its members with resources, tasks, objectives, motives and knowledge, while the members furnish the organization with a body and a voice, with all that entails. The workers have only a limited say in what is to be done and how, because the organization curbs their capacity to change their minds, chiefly when it comes to major decisions. This makes acting on behalf of an organization somewhat trying, and is also the cause of tension between the demands and the actual execution of the task [20].

3.1.1.1. Boundary spanners' organizational belonging – being a part of greedy uniformed organizations

The analysis of the interviews shows that organizational adaption to demanding conditions occur through a number of organizational factors. In uniformed organizations, liaison is a



Partly organization Organizational factors contributing to boundary spanners' ability to adapt the organization to demanding conditions	**Partly human** Individual factors affecting organizational adaption
• Boundary Spanners' organizational belonging – being a part of greedy uniformed organizations • Being and acting at the boundary of the organization • Building neutral, temporary organizations	• No mistakes • Using contextual intelligence in boundary spanning • Managing asymmetrical collaborations • Improvisation vs. structure • Spontaneous links

Table 3. Boundary spanner as the organizational centaur in demanding conditions.

common type of task and organizational belonging defines and shapes the nature of this liaison, as tasked by organizations which have extremely high demands on performance, efficiency and results. One interview quote illustrates this:

> *The uniform represents legal violence, and behind that uniform, whether it's in UN or EU context, there is an organization that has the resources necessary to practice this legal violence. So the signals are clear – I'm here, I'm unarmed, I'm not dangerous to you but at the same time, my uniform represents those standing behind me.*

Quote above demonstrate boundary spanners who have a specific liaison task in a demanding situation. Many of these individuals liaise in very difficult conditions, for example, disaster management, and also in threatening environments, where life and limb are in the balance. For these boundary spanners, markers of belonging to a certain uniformed organization (emblems, military rank and uniform, etc.) can make them political targets for certain types of opinion, whether that be favorable or less so. It does not matter how friendly or skilled you are at liaising as an individual if you are wearing the 'wrong' emblem or rank on your uniform. There are advantages and disadvantages to belonging to a "greedy organization". Soeters [19] and Weibull [21] agree that military organizations are 'greedy institutions' that demand a great deal from their organizational members, who are trained, practiced, educated and specially selected to execute the activities of the organization. Hierarchical ranking is decided by grade and acquired level of expertise, and provides a clear indication of organizational position for each individual. Like-minded people are trained in creating a common sense of solidarity, which separates the group from others in the environment [22, 23]. On the other hand, boundary spanners experience increased internal conflict in that they are part of the strong solidarity of their own organization while they must also nurture contacts and their interests outside of the organization.

3.1.1.2. Being and acting at the boundary of the organization

Most of our interviews reveal boundary spanners acting in the field, having to manage serious accidents with many fatalities, looking after survivors or saving lives and fighting the enemy. The boundary spanners themselves had the remit and authority to collaborate with external actors belonging to their own organizations, other partner organizations or those who were volunteers and civilians. Being some distance from organizational boundaries had both advantages and disadvantages in regard to organizational adaption to demanding conditions:

> *[A commander] and I went along together to speak to the people in the field and he got a picture – one from the outside which was more precise than the one we could see. Things started to become clearer.*

In a civilian crisis management context, the work of boundary spanners cooperating with each other at the perimeter of the organization (far away from home) and in the field, where a demanding situation has occurred, can be very beneficial in forming an operational picture. In the quote above, the situation surrounded a leak of sulfuric acid at a harbor in Helsingborg, Sweden, and confirms how the operational picture becomes clearer the closer to the incident

you are. Even in uniformed organizations, it is common for organizational members to operate "at the boundary of the organization". In difficult situations, the opportunity to monitor the perimeters of the organization is reduced, and one way to manage this is through well-trained boundary spanners [2]. Their ability to quickly form an impression of the operational picture at the scene, convey information for better decision-making and communicate between uniformed organizations which speak 'different' organizational languages has led to a more favorable result according to Danielsson et al. [22, 23]. While those who act from a distance are naturally bound by predetermined organizational routines and regulations, as human actors they will always act as half organization and half individual. Creating relationships with external actors is a key task for boundary spanners. In more demanding contexts, informal contacts may have value but if they become an objective in themselves, the survival of the organization may be jeopardized. The quote below illustrates how too much trust between partners can lead to economic or emotional dependency, along with the risks associated with starting romantic relationships in the operation zone or accepting cash bribes when money is tight.

> *You might get hired and get paid…as an attaché or liaison officer in Afghanistan, you could find yourself in some sort of dependent position with the person you are collaborating with and it could be an emotional one – getting involved in various love affairs has happened.*

> *Because you can't… if you go out there and have disastrous finances when you come out. If a defense attaché leaves with completely wrecked finances or a string of different relationships, with lovers on the scene. Your collaborator can find that out pretty easily – it's the classic way of roping you in.*

Hidden agendas and informal relations can impact destructively on the reputation of the organization, on the individuals involved and on the working groups, both in the short and long term. The destructive forces of informal actions in an organizational setting have been studied by Hackman and Johnson [24], with particular focus on leaders using informal power to achieve personal or organizational goals. However, according to Hackman and Johnson [24], informal strategies are also constructive in terms of managing product development, coordinating with others and of help in removing incompetent leaders, which may be difficult to do using formal rules. While the above-mentioned studies state that informal actions influence the internal workings of organizational life, the present study shows that boundary spanners not only influence the organization, but also the environment.

3.1.1.3. Building neutral, temporary organizations

Boundary spanners who are geographically distanced from their organizations, at the scene of accidents, or in other regions or countries must still contribute to facilitating collaboration. In a number of cases, this means expanding the physical area and embodiment of the organization, as has occurred in civilian catastrophes where the rescue initiative has expanded across national boundaries and also involved military operations in the affected country.

> *Each nation has its intelligence outfits or sources in this area – informers or analyses or whatever, right? And then they have to be of service to the command center – in the national pipeline then. The problem is that these things are relatively sensitive and you're reluctant to*

> *release it between nations because it's a commodity… it's currency, isn't it? That's why nations make use of this buying and selling stuff – you buy and sell information between nations. So you have to have national intelligence services, so you literally build a village with containers arranged in a circle. Each container gets its information from home so you really have to make an assessment. So you meet in the middle to exchange information because they (the liaison officers) have a mandate from Swedish intelligence and security services as to what they can and cannot say. Then they exchange information with each other and then they can confirm things with the commander.*

A last aspect forming part organization is the opportunity for the organization, via individuals, to realize forms of neutral, temporary organizations or meeting places. The purpose of these is to handle sensitive information in an exchange and gather resources in one place, which takes place in designated localities, not only for security reasons but also ensure the exchange can be carried out on equal terms and in a more 'neutral' setting. Temporary organizations or meeting places can be provisionally set up in containers, as verified by the informant cited above.

As previous studies confirm, temporary organizations materialize in the field and boundaries are created between the 'real' organization and the environment. Johansson [13], discuss the concept of the semi-organized field, which is defined as an area delimited by prior arrangement, the purpose of which is to facilitate the exchange between organizations and individuals on the ground. As the quote shows in the semi-structured field, temporary organizations arise – a common occurrence in military contexts, offering an atmosphere of neutrality, a meeting place where exchanges take place on equal terms. Similar results have been shown in a study of how formal organizations act when something unexpected happens. Lanzara [25, 26] argues that formal organizations can be paralyzed in the event of an accident, and that is why temporary organizations arise, facilitating the clear-up operation. One explanation as to why temporary organizations emerge may be that individuals within them have local knowledge of the incident area, and have the ability to be creative, precisely because they have not had the time necessary to erect more formal structures. This is characteristic of crisis management, but in a military context it is about creating a neutral meeting point as a preventative measure, when life or death is at stake.

3.1.2. Partly human

Organizational adaption to demanding conditions is also dependent on the actions and behavior of the boundary spanners. This section presents the meaning of being partly human as a boundary spanner. Regardless of rank, grade and organizational belonging, the fact of being human may have positive or negative aspects, that is, it may be both an asset and a weakness for the organization. Here next we will focus on these particular human aspects of boundary spanning in demanding situations and their influence on organizational efficiency. The focus is mostly on boundary spanners' behavior.

3.1.2.1. No mistakes

How boundary spanners act in collaborative situations in various contexts depends on how well equipped they are in terms of competences and qualities that help them avoid faux pas.

Such faux pas may involve a lack of diplomacy or cultural awareness, incorrect expression, breach of regulations, provocative behavior, etc. The quote below focuses on how some have perceived such faux pas and felt their damaging short and long-term effects on the collaborative process:

> *I've learnt one thing, for example, that we should try to avoid the risk of stomach bugs, so I always have a bottle of alcohol for hand washing in the car so that each time you shake hands with someone you can clean your hands thoroughly. It can be very sensitive though. In Congo I happened to be seen by someone as I was cleaning my hands with alcohol and his comment was that we think they are sick – that white people have to wash after shaking hands with black people. So there's a cultural thing you have to be careful about too.*

Even so, boundary spanners can make mistakes if they are not watchful of their own behavior. The quote above from a liaison officer who has worked in Africa illustrates how a simple act of hygiene could be construed as an insult by the local population. There is very little tolerance for mistakes in uniformed organizations. Particularly in a military context, any mistakes made may be of a life-threatening nature and may destroy many different aspects of the organization. For example, trust in the individual can be negatively influenced in leadership [20], the organization, and ultimately, the credibility of the nation [17]. In short, tolerance of 'mistakes' in the military is less than it would be on the civilian employment market, due to its right to use weapons and violence. For boundary spanners that are even more vulnerable at the periphery of the organization, this is particularly important to manage.

3.1.2.2. Using contextual intelligence in boundary spanning

An important aspect of organizational adaption is how boundary spanners influence the situation through their emotional intelligence, herein described as contextual intelligence because it involves adaption of emotions to the dynamic and demanding conditions of the context. Having the ability to calm agitated individuals is one example of managing a situation, which relies on the individual making use of their personal resources on behalf of the organization.

> *So many of those situations, where I know how we, at a restaurant or a discothèque or someplace, he was upset because we closed the place because drugs and stuff were on the increase. But I often felt it worked – I had quite a calm effect on people I go in and talk to.*

> *I must have talked for two hours and that was mostly with the man who was in the apartment and not the suspect, but his mate, and he was the communicator, he was like a filter between us two – it worked really well because we do have a different way of talking sometimes, us police.*

In demanding contexts, the use of smart power and contextual intelligence means being able to sense threatening situations while having a de-fusing effect. One strategy of collaboration is to have a calming influence on other people who feel provoked and express anger or frustration. The second quote demonstrates that once the hostage takers had been located it was the negotiator's job to try to get them to give up and to ensure the arrest went calmly. Contact between the hostage taker and the negotiator was established and communication mainly took place via a friend of the suspect. Boundary spanners in uniformed organizations do not merely

employ weapons, they must have an ability to persuade without needing to use violence. One way of doing this is to employ smart power and contextual intelligence. In his book, The Powers to Lead, Nye analyses the conceptual pair of 'hard' and 'soft' power. Nye [27] defines the concept of power as something used in order to get others to do what you personally wish to achieve. To succeed in this, there are three different approaches: through force and threat, through various kinds of reward systems such as hard power techniques, but also through attraction and cooperation, such as soft power techniques. According to Nye [27], a combination of hard and soft power – so-called 'smart' power – is the best combination, employing different degrees of the different approaches depending on context and situation. Some situations require more hard power than soft, and vice versa. For a combination to be successful, Nye [27] considers contextual intelligence to be necessary. Contextual intelligence is the ability to understand different environments and thus choose those strategies which best suit the specific environment. This is particularly important for boundary spanners who will be operating in demanding situations.

3.1.2.3. Managing asymmetrical collaboration

The interview analysis highlighted one challenge faced by boundary spanners acting on behalf of the organization in demanding situations, namely collaborating with actors who do not always follow rules, belong to another hostile organization, are threatening or culturally different, or have too many or too little resources to meet on the 'same symmetrical terms'. As the task is always in focus, individual and organizational adaption is necessary:

> *We collaborate with individuals in the gray zone – sometimes you are forced to deal with certain people even if we know or have a good reason to believe that they might be criminal, but we still have to meet them because he might just be the mayor of the town.*

The quote above illustrates meetings with unofficial groups that, although having a criminal background, also have an important societal function, their role and position making them inevitable collaboration partners. The task of the uniformed organizations, (e.g. the Swedish Armed Forces) has increasingly come to be characterized by a need to cooperate with different actors, such as other military organizations in connection with multinational operations – which one can discuss in terms of symmetrical relationships. An increased need for collaboration with civilian individuals and NGO organizations is also apparent, presenting itself as asymmetrical relationships because civilian and NGOs do not have the same resources [2] or the same agenda for collaborative goals. Not uncommonly, local actors in the host country (e.g. chiefs of police), who are seen by Swedish officers as corrupt, are the very parties with whom they collaborate [2]. For boundary spanners, this is an enormous challenge, as collaboration does not take place on equal terms with partners of a similar background. For the collaboration to be successful, the boundary spanners must contribute in different ways in order to create a sense of symmetry between partners – an illusion that collaboration is being carried out on equal terms.

3.1.2.4. Improvisation vs. structure

Boundary spanners acting at the perimeter of the organization meet with a dynamic and often unpredictable course of events, putting great demands on competence and management. It is

not always possible to follow all the rules of the organization to succeed. Sometimes, improvisation is needed to save lives and accountability must often be dealt with later.

> *You can't forego the rescuing part in order to build up structure. That's something that can be done afterwards.*

The example above is a quote from the Southeast Asian tsunami, when a boundary spanner reported a strong need for freedom to act and to take personal initiative. The balancing act between improvisation and structure can be seen as one important aspect for boundary spanners to manage in demanding situations, as highlighted by a number of studies. Examples include when boundary spanners have succeeded in bridging the gap between structure and improvisation during the tsunami catastrophe [2], or in international military relationships [2, 28]. Jackall's [29] study points out that organizational members at both leadership and collegial levels depart from the prescribed regulations – no-one blindly follows all the rules. An organization would scarcely function if all the rules were adhered to. This is especially important to remember as the need for improvisation is considered essential in order for lives to be saved. Whether to stick rigidly to the rules and endanger life or break the rules to save it has been a relevant discussion but has become more topical in several specific contexts such as health and care services, but also crisis management in a military context [29]. The most important thing for boundary spanners is to find a balance between structure and improvisation. Overemphasizing authority and structure could easily lead to paralysis and delay, while overemphasizing freedom could lead to a lack of collaboration and to conflicts between actors who wanted to act in disparate ways. Similar results have been shown by Larsson et al. [28].

3.1.2.5. Spontaneous links

The focus of the analysis was organizational adaption and how this occurs through individuals, highlighting a particular type known as spontaneous links. A spontaneous link is a kind of improvised boundary spanner without clear organizational belonging, which becomes useful with its particular qualities and skills out in the field when something unforeseen occurs. Spontaneous links can also arise at different stages, as contacts or resources associated with other boundary spanners, thus creating a network. Although these individuals can make a substantial contribution, there is a risk that, like 'cooks', too many spontaneous links 'spoil the broth'. The most important aspect highlighted, however, is that no matter whether they belong to uniformed organizations or are volunteers, spontaneous links can help solve tasks and consequently help in the organization's adaption.

> *At the end of the day I got in touch with a guy XX who had contact with someone down there (Thailand); he suddenly appeared – this Swedish Air Force officer who was there celebrating his 50th birthday. So he turned up and asked if they needed help with anything.*

At the outset of the tsunami catastrophe, when uncertainty was great, boundary spanner roles named spontaneous links were operating out in the field, illustrating the fact that actors emerge when a need becomes visible, as was the case in the quote above. The analysis of the interviews shows that spontaneous links are shown to encompass volunteers as well as other boundary spanners from other organizations. Lovegren Bosworth and Kreps [30] found in

their study that role improvisation is more likely to occur in extending and emergent organized responses [30]. Further study of the roles that may arise during crisis management and in international military context is also advocated and there is emphasis of the fact that regardless of whether an initiative is planned or not, improvised roles will always arise, and to varying degrees. Johansson's concept of spontaneous volunteers as the individuals who assist at the scene of a disaster and his discussion of how they are viewed by involved organizations, for example, the rescue services and police [31], is an important contribution to the definition of roles which occur spontaneously.

3.2. Results part 2: comparing the inductively generated model to the existing organizational centaur concept

The results of the comparison between the qualitatively generated model on the one hand, and the existing organizational centaur concept on the other, are presented in **Table 4**.

Existing organizational centaur category	Generated model
Partly organization	*Partly organization*
• General organizational belonging – that members are bound to the organization through contracts, positions, etc. • General description of power and resources provided by the organization to its members. People's ability to act as partly organization is reinforced by the organization's resources • Regular monitoring of individuals. Grass roots bureaucrats and boundary spanners are nevertheless more difficult to manage as they operate at the organizational perimeter • Individuals can be replaced, although it is more difficult to replace those who possess special competencies or belong to a tightly knit group	• Specific description of a particular organizational member, that is, **Boundary Spanners.** Boundary Spanners' organizational belonging – being a part of *greedy uniformed* organizations. Military and response organizations that have extremely high demands on their members • Being and acting at the boundary of the organization, using organizational resources to save lives or enter armed conflict. The task is to manage difficult and stressful conditions • Building neutral, temporary organizations in threatening environments using resources provided by the organization • **Control dimension is little emphasized and trust, as well as being trained to act as a boundary spanner is more important. More empirical research required here, however** • **Missing. Empirical research required as to replaceability of individuals as skills, training and also gender, age and cultural background can impact on task solving**
Partly human	*Partly human*
• Loyalty to the organization • Human action makes the organization vulnerable in the long term • Informal processes are created as a result of emotions not being allowed to be released. **Empirical details on informal processes and informal roles are missing** • Breaking up from the organization	• Loyalty is embedded in "organizational greediness". A lack of tolerance for mistakes as these can put people's lives and health at risk. No mistakes. Any mistakes or human action affects the organization in the long term • Below follow a number of informal measures associated with task solving. Informal processes can be seen as both favorable and unfavorable aspects: Using contextual intelligence in boundary spanning. Managing asymmetrical collaborations. Improvisation vs. structure. Spontaneous links • **More empirical research required**

Table 4. Comparison between data and the organizational centaur concept.

According to our analysis, the existing organizational centaur model can be seen as being built up by four concepts forming the Partly organization part, and the concepts underpinning the Partly human part. The main finding is that most of these can also be found in the qualitatively generated model based on emergency-type organizations. Within the Partly organization domain, the control concept was less emphasized, while trust was more underlined. Moreover, the replaceability aspect was given no or limited attention in the emergency-type data. Turning to the partly human domain, the main difference is that there is a much richer amount of detail on informal processes and informal roles in the generated model. It was also found that the organizational centaur concept "breaking up from the organization" had no equivalent in the emergency-type model.

4. Discussion and conclusions

The aim of the present study was to compare the existing conceptualization of the dual nature of organizational centaurs (partly organization and partly human) to what could be found in an investigation of organizational contexts characterized by risky and life-threatening situations. In our opinion, the organizational centaur model proved to provide a meaningful framework for a more holistic understanding of the conceptual "bits and pieces" that were previously identified in empirical studies. At the same time, the presented grouping of these empirically generated concepts offers an illustrational of a special case of the organizational centaur model. The main difference between the two models has contextual roots. Boundary spanners in a greedy-type of organization need to manage demands where they jeopardize their own lives in order to solve organizational tasks [32]. This is not the case for organizational centaurs in civilian contexts [16]. Despite this difference, however, it was concluded that the most parts of the organizational centaur model had their equivalents in the empirically generated model. This further adds to our conclusion that the organizational centaur model provides a meaningful conceptual umbrella when looking at boundary spanners. The empirically generated model emphasized trust rather than control. This has been reported as an absolute necessity for boundary spanners in high-risk environments [2, 20]. This appears to be reasonable and different from less threatening situations. Top management needs to trust specially selected boundary spanners and the latter group needs to experience that they are trusted in order to perform their risky tasks well. The richness of data on informal processes for handling emotions, asymmetrical collaboration relationships, improvisation versus structure, spontaneous links, etc. constitutes a substantial addition to the centaur model. Similar kinds of details can probably be found in other kinds of organizational contexts as well. The components presented here illustrate this particular special case.

The fact that no data was found in the empirical model on replaceability can probably best be understood as a result of this question area not being covered in the interviews. An organization such as the military, for instance, has a long tradition of maintaining clearly defined procedures in the event of someone being killed or wounded in action. The organizational centaur model rests on a critical theory paradigm and the empirically generated model on a functionalistic one. Given this, the high correspondence may seem surprising. Our interpretation

is that life and death contexts foster a functionalistic approach. It is a win or die context and the interpreted similarity may not be relevant in other contexts.

This study has several limitations. In constructing the current conceptualization with one core variable and two superior categories, the researchers were limited to data obtained from a selected group of informants. The study's strengths include the abundance of qualitative data and the variety of contexts and informants and their experiences. In this globalized world, cross-sectorial and international collaboration is essential in order to manage the demanding conditions characterizing disasters, accidents, war and terrorism. The number of accidents, crises and wars has been increasing year on year [33] so the need is very real. Boundary spanning and spanners, seen as a form of organizational centaur (a social hybrid) can therefore play a key role in the context of crisis management. Practically, this book chapter can be used for educational purposes to increase awareness of the new demands made on boundary spanners in uniformed organizations and what they may need out in the field.

We conclude by presenting three suggestions of future research. Firstly, more research is needed to distinguish different types of boundary spanners (e.g. women and men) when it comes to dealing with stressful and difficult situations in disaster management and in a military context. Secondly, boundary spanners may experience inner conflicts due to the demands of the organization on the one hand, and the demands of acting outside of the organization on the other. For this reason it would be interesting to study the emotional stressors that boundary spanners might face, the feelings they have to deal with and how they might be given support.

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Chapter 7

The World Financial Crisis: Impacts on GDP and International Trade in Taiwan

Jean-Pierre Himpler

Additional information is available at the end of the chapter

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Abstract

Today's financial markets are—due to globalisation—more interlinked than ever before. The US-based subprime mortgage crisis 2007–2009 is therefore developed to a global crisis. This study aims to investigate the effects of that crisis on Taiwan, focusing specifically on GDP and Taiwan's international trade. Analysis results in GDP to have practically fully recovered to precrisis levels. Taiwan's international trade is stagnating in the post-crisis era. Investigations have further shown that Taiwan is becoming more dependent on China, a trend that was fuelled by the crisis.

Keywords: Taiwan, world financial crisis, PRC-ROC relationship

1. Introduction

Economies worldwide are affected by crises on a regular base [1]; however, the world economies have never been as interlinked as they are today [2]. The frequency of crises is raising already for many years [3, 4]. Any crisis in one country may affect other economies and therefore the world [5]. "In the last 50 years, worldwide about 40 events occurred that somehow showed traits of financial crisis (FC)" [6, p. viii]. In this study the term 'world financial crisis' (WFC) refers to the crisis that has been caused by the subprime mortgage crisis of 2007 in the USA. Every economy—even though or just because of globalisation—needs its own plan to face FC on a national and international level mainly depending on the extent of globalisation of its financial markets and economy [1]. Up to this point, only limited enquiries have been pursued specialising on the effects of the WFC on the Republic of China (ROC) focusing on the potential long-term consequences of the crisis for that country. Consequently, this research aims to fill this knowledge gap. To be able to be as thorough as possible in the

understanding of these long-term consequences, the focus of the research has been narrowed down to GDP and international trade.

Throughout the study, all investigations followed a strict plan developed out of the research gap and the resulting objectives and questions. First of all existing literature has been critically reviewed. After addressing FC and its origins in general, previous investigations about the WFC and the underlying forces in particular were revised. As for Taiwan, the focus was the country's reaction to the WFC. Secondary data about the Taiwanese economy focusing on the effects of the WFC was critically investigated. This analysis focussed on factors of major importance in economic change after crises. Next to these aspects of change relating to crisis in general, a specific criterion of the postcrisis relationship between the PRC and the ROC was investigated. The research of this factor also allowed investigating economic postcrisis trends on Taiwan including their potential consequences. The conclusion makes summarising statements about Taiwan's economy and explains the effects of the crisis including economic trends of the country.

2. Literature review: WFC and Taiwan

This chapter gives an overview of the existing literature referring to the WFC and its underlying causes. Furthermore, the background of the economy of the ROC—also referred to as Taiwan—including its historical development [7, 8] and the structure of its financial market are thoroughly evaluated as preparation of the genuine research. Particular emphasis has been put on the factors of analysis in unconventional FC models. The main focus has been put on the cross-strait relationship between the ROC and the PRC which was also affected by the crisis.

2.1. The WFC

The WFC is a US-caused crisis that had global effects. Never in history has so much economic wealth been destroyed in such a limited timeframe [9]. Literature agrees that this has been the worst financial crisis since the great depression [10–13]. Failing regulations [14] and bad management of a subprime residential mortgage market innovation [10, 15, 16] and a bursting bubble in the US housing market initiated the US credit crunch causing the US GDP to decline by 30%. Globally, within 2 months—namely, July and August 2007 [17]—an estimated loss of $10 trillion, representing 40% of the wealth in the global financial markets, has been generated [18]. In China 10 million of industry-employed workers had lost their jobs due to the crisis [19], so 'the poorest as always pay the most' [Dominique Strauss-Kahn (at that time, the Managing Director of the International Monetary Fund (IMF)) in [19] min. 73]. Andrew Sheng who is part of the China Banking Regulatory Commission stated after the crisis that 'they were having massive private games at public loss' [in [19] min. 8]—with 'they' most likely referring to Wall Street. However, China in the literature is not only seen as a loser of the crisis. Porsche-Ludwig who is working in science of law, science of politics and psychology and teaches political sciences and public law at the National Dong Hwa University in Taiwan [20] refers China as the biggest winner of the crisis [21]. Mitroff—a specialist on risk management and crises [22]—and Alpaslan—whose research focuses on large-scale crises [23]—explain the WFC to be a result of a 'culture of selfishness and narcissism' [24] and conclude that there is a

necessity to develop towards a 'culture of trust' [24]—which might be the only way to develop an economically sustainable future.

2.2. The republic of China-Taiwan

Politically, Taiwan is in a difficult situation, having been diplomatically isolated by the PRC resulting in no diplomatic relations with any Asian country [25], the USA [25–28] or any European country apart from Vatican city [29]. Historically and due to the background of the government [28], it is seen as a part of China (PRC) [27, 28, 30]—even though its history has only small connections to the history of the PRC [31]. However, PRC's potential invasion in the ROC is a threat to international security [27]. These political issues are of major importance to Taiwan, and any change—also in people's perception about the relationship with China—is significant for this macro-politically complicated relationship.

In the 1970s and 1980s, the economy was about as much an industrial economy as it was a service economy ([32]: 1973–1990: services 47.9%; industry 44.3%; agriculture 7.8% [33]). By 2000 Taiwan's economy entirely developed into a service economy ([34] (2011): services 68.8%; industry 29.5%; agriculture 1.8%]). The ROC is an export-driven nation, small- and medium-sized firms achieved stunning results due to their global industrial connections [26]. From less than 10% exports of GDP in 1960, the economy changed to achieve almost 65% exports in 2007 [35]. A majority of the Taiwanese exports are in the information and communications technology (ICT) sector [36, 37]. The right of war that had so far set out any democratic election on a national level ended in 1987 after 38 years and in 1996 the first independent election in Taiwan took place [28]. These elections proved that Taiwan successfully went through the transition from a dictatorship to a democratically governed country [28] going hand in hand with an economic liberalisation [38]. In the Global Competitiveness Ranking for 2012–2013, it was ranked to be the 13th most competitive economy amongst 144 participating nations [39]—a fact that might be a result of the economic miracle in combination with the political liberalisation of the country. The developments on Taiwan have severe consequences for the future of Mainland China. A reunification of Taiwan and China into one China—so the position of the ROC—is only possible when the PRC becomes a democracy [40]. Taiwan positions itself as an independent country; however, according to Chiu and Sun [8], the PRC will use military forces if Taiwan declares independence officially. It is unlikely that Taiwan's economy is to be isolated [41]; however, the extent of Taiwan's global political isolation is a result of its own policy choices and closure towards China, not only from Chinese blocking [41]. The difficult relationship between China and Taiwan [42] developed into an 'asymmetric interdependence' [7]. The question of 'how to manage the increasingly intertwined economic relationship between China and Taiwan' [27] developed into the main issue in the ROC politics. Since 'the opening up of China's economy to market forces in the 1980s [and 2009] Taiwanese businesses have invested around $100 billion in [Mainland] China' [27]. As in about 2009, the economic connections between Taiwan and Mainland China became closer, media worldwide even referred the two countries as one 'Chaiwan' [37, 43]. However, the USA and Japan on the National People's Congress 'renegotiated their security alliance for the first time since 1960' [27] as China's threat to Taiwan is a threat to their own and international security.

Taiwan's financial industry is growing steadily; even though it does not have 'world-ranked national champions among its [financial] institutions, some are large enough to cause systematic stress should they fail' [44]. Currently, Taiwan still has government-controlled banks, even though the number is declining as the country has privatised and intends to continue to privatising its banks [45]. Taiwan further intended to become 'a regional hub for fundraising and asset management' [44]. These intentions paid off with an increase of foreign stock ownership from 19.8% in 2001 to 32.9% in 2007. However, the sales behaviour in the Taiwanese banking industry is shortsighted, as shortsighted as the one that caused the US financial crisis. Sales agents paid their commission at the time of sale which results in them not knowing the product and selling in order to earn the commission no matter how this might affect the client [44].

2.3. ROC reactions to the WFC

At the beginning of the WFC, Taiwan's mid-sized economy was relatively healthy and particularly successful in international trade [44]. The NT$, as also explained by the literature, was less volatile before, during and after the FC than the currencies of other nations [44], which is due to its more internationally owned stocks. The country further went into the crisis with a number of government-owned banks. These served as an advantage during the crisis as they easily could be used to imply new government regulations; other banks were forced to follow [44].

In order to overcome the effects of the crisis and not to face as heavy consequences in the future, Taiwan developed a policy plan including short-term policies and middle−/long-term policies. According to Wang and Lin [5], Taiwan's Ministry of Economic Affairs (MOEA) published a presentation about a policy plan [46] explaining the steps of action in the different policies. In the short term, the country had four strategic goals to minimise the immediate effects of the WFC. First, the stimulation of consumer spending, second—in order to reduce the number of company closures—secured funding for SMEs, third the promotion of investment and fourth the increase of exports. Consumer spending was also supported via consumption coupons, which improved sales in the short term. For the medium term, a cross-strait trading agreement with China was planned. Detractors see that this so-called economic corporation framework agreement (ECFA), implemented in 2010, may result in a 'buyout' of Taiwan [47]. However, the agreement to reduce cross-border taxes was necessary, as China had already made free trade zone agreements with the Association of Southeast Asian Nations (ASEAN) region. According to Wang and Lin, the government is aware that intensifying trade with the PRC is an opportunity and danger at a time [5]. The currently employed policies also link to the long-term development of the country and have consequences for the national identity of the Taiwanese citizens. To find out more about the long-term strategy, please consult further readings [48, 49]. The structure of the long-term strategy shows that the government intends to diversify the Taiwanese economy. This might improve the country's situation—also when facing future crises.

2.4. Resulting strategy for primary research

In this study for the best understanding of Taiwan's postcrisis situation, it was decided to focus on the change of GDP [1, 50] and international trade [1, 51]. Analysing these factors rather than investigating in the frame of a FC model was perceived to be matching given the background of Taiwan, its connection to China and also the time limits of the study.

3. Discussion of the research methodology and methods

The study as such was a formal study answering the research question [52]—including a descriptive account of the current situation. An explorative element [52] also forms part of the research as it discovers a range of future research tasks (see Section 5.2). The study is supposed to reflect on the effects of the WFC (independent variable) on Taiwan (dependent variable)—including trends for its future. It was decided to conduct quantitative longitudinal investigations based on secondary data only.

3.1. Research philosophy and approach

The main purpose of this secondary study is to investigate and understand the WFC effects on the economy of Taiwan and developing economic trends for the country. Secondary data has been analysed graphically in order to investigate the research questions. Focus has been put on the criteria shown in **Table 1**. Further, the understanding of the connection between the PRC and ROC was significant. The aspects measured in that relationship are not primarily of economic nature but, however, are necessary in order to include all potential developments for the country and its economy. This is also important given that China's politics keep aiming for a reintegration of Taiwan into China [47]. This unique relationship of interdependence (PRC-ROC) can be seen as the moderating variable because the connection between the two countries is complex and because the influences of China on Taiwan's postcrisis situation are of paramount importance. The influence of China on the effects of the WFC on the ROC does not seem contributory at first; however, many of the effects on Taiwan come due to the strong dependence of the ROC on the PRC. The effects, discovered by using a realism approach were rationalised with regard to Taiwan's historical and economic background. This research is using an inductive approach: Conclusions are based on research results and explain the facts that investigations discovered [52]. Wherever possible the conclusions are based on the combination and linkage of multiple sets of data.

3.2. Relevance of the study

The study is highly relevant for academia and management alike. Academically, it is important for two reasons: First, there only is limited research investigating the effects of the WFC on Taiwan, and almost none is looking at it after 2011. Thus, there is a gap in research. Second,

Research criteria	Crisis or economic theory	Taiwan's historical background	Postcrisis actions of Taiwan
GDP	[1, 50]	Healthy economy [44]	Promotion of six flagship industries [5]
Int. trade	Crises effect global trade [1], and WFC has global impacts [51]	[26, 35]	Trade agreement with China [5], facilitation of national trade via iTaiwan 12 projects [48, 49]
Int. trade with China		Taiwan dependent on China [7]	

Table 1. Links to criteria of analysis.

the frequency of crises is rising [3, 4]; wherefore, economies change significantly. An understanding of how countries change after crises and face the next crises allows for an improved understanding of the changing economies of the twenty-first century. As stated, the study also is of managerial relevance. This is because the country was severely affected by the crisis. Only an understanding of what happened during and as a consequence of this crisis makes it possible to know, how management can react to a crisis, when it is just starting and did not fully develop yet. This study does not focus on the development of potential managerial aspects, but does create a foundation for future research on managerial decision-making in respect to crisis reaction strategies. The key strengths are an improved and more detailed understanding of the impacts of the WFC on Taiwan and the link of the WFC to the relationship between the ROC and the PRC.

3.3. Research data

Within this study only secondary data published by the Taiwanese government has been used, because of its availability and high quality [52]. In the case of Taiwan, a range of researchers used data published by the ROC government previously [33, 35, 53–55]; therefore, it was perceived as a reliable source of data. Most of the analysed data comes from the Directorate General of Budget, Accounting and Statistics, Executive Yuan, ROC [56]. Yearly and/or monthly figures from January 2003 (if available) up to the figures of 2013 wherever possible have been analysed. If different data sets for the same criteria—so with more or less detail or for different time periods (month (M), quarter (Q), year)—were available, the most significant data has been selected. In addition to these national statistics, some data is also taken from other institutions including the Election Study Centre at the National Chengchi University and the World Trade Organization [57].

3.4. Criteria and design of analysis

A limited range of criteria have been chosen for the carried out research. Next, to the criteria selected from a FC background, the PRC-ROC relationship was a focus in the investigations. **Table 1** has been developed, showing the links between the chosen research criteria, the underlying crisis or economic theory, the cause of selection considering the Taiwanese history and the actions Taiwan has been taken to confront the crisis.

4. Research findings and analysis

Results of secondary research were correlated to the research questions, Taiwan's background and also economic and financial theories—where appropriate. The analysis follows the structure of **Table 1**. The findings developed out of the discussed analysis, the effects and trends are synthesised in Section 5.1.

4.1. GDP size and industries

The GDP in **Figure 1** is visualised not only in NT$, Taiwan's currency, but also in US dollars (US$). This primarily allows for an improved understanding of the statistics, as most countries

are compared by their GDP in US$ [58] and as Taiwan—as an export-driven economy [26, 35]—is very dependent on the dollar ($) exchange rate. **Figure 1** shows that Taiwan's GDP is growing steadily. Before the crisis hit Taiwan, the GDP was only exposed to normal fluctuations. So, until the crisis affected Taiwan, the presented graph about GDP growth is in accordance with the literature [44] stating that Taiwan's economy has been healthy prior to the crisis. In the period between 2007Q4 and at least 2009Q2, the effects of the crisis are easily visible. In US$ the Taiwan GDP dropped between 2007Q4 and 2009Q1 by 17.4%. In NT$ the GDP dropped between 2007Q4 and 2009Q2 by 13.8%. This severe difference between the US$ and the NT$ drops stems from currency rate fluctuations. Due to the limited scope of this study and in order to not falsify internal effects of the crisis, most investigations focus on NT$. Since about Q2 of 2009, the Taiwanese economy is recovering from the crisis and is growing continuously. Precrisis levels in US$ and NT$ were both reached for the first time in 2010Q3. Between 2009Q2 and 2012Q3, the GDP in NT$ has grown remarkably by 19.8%. If only looking at the trend of growth, one may even see that the GDP size by now is only marginally deviating from the one that would have been expected without a crisis. Thus, if one only looks at the GDP, the country almost entirely recovered from the crisis.

As also stated by the Industrial Development Bureau, Ministry of Economic Affairs [34], in the literature [32, 34], Taiwan developed into a service-driven nation. **Figure 2** data analysis shows that by 2011 services grew to 72% of the overall GDP. The difference between the 68.8% in the literature [34] and the 72% that were found in research might be a deviation coming from the difference between the expected figures for 2011 and real figures for 2011. Executive Yuan was used for both studies as source of secondary data. The organisation published the expected figures at the end of the year and a few months later backed up figures after analysis of the real market. This deviation come from the difference between expected figures presented in the previous research and the real figures that were used in this more recent study. The literature indicating that Taiwan is a service economy is definitely right [32, 34].

As for the effects of the crisis, manufacturing decreased by 13.4% between 2007 and 2009 (see **Figure 2**). This is a consequence of the reduction in exports and trade with other countries

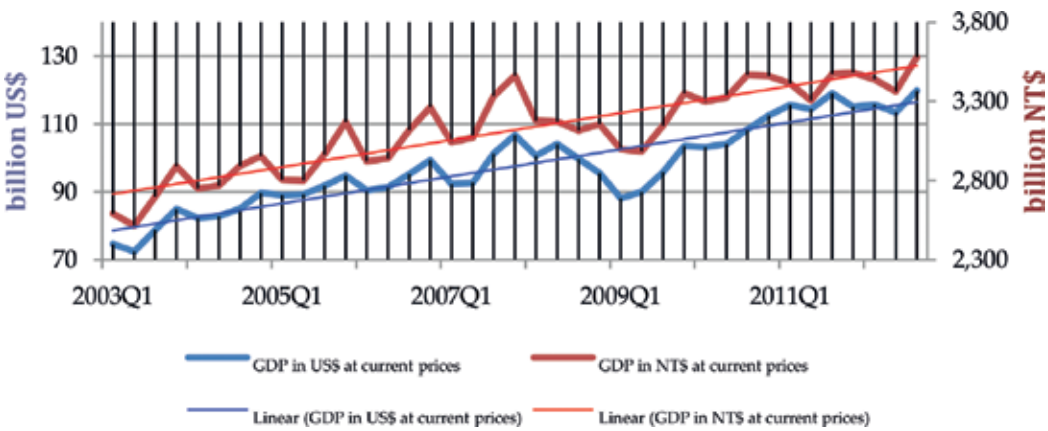

Figure 1. GDP at current prices quarterly [56].

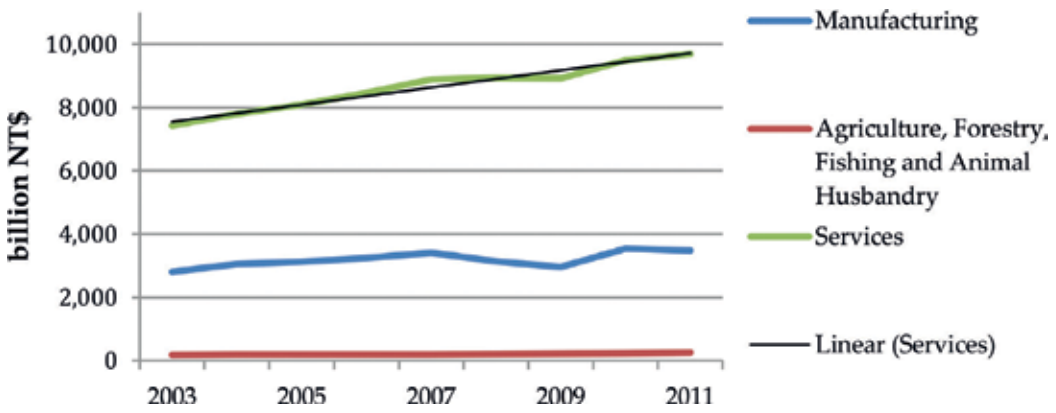

Figure 2. GDP at current prices by kind of activity [56].

which also had implications on the labour situation in the country. The downturn in manufacturing had a direct consequence on the provision of services amongst companies buying manufactured goods and also on private services that employees with reduced salaries, as a result of the crisis, could not afford anymore as a result of the crisis. The service sector, however—mainly provided nationally—has not been as heavily affected as the manufacturing sector, because services are provided mainly nationally and thus are usually not as heavily affected by changes in the international market. In 2008 and 2009, services stagnated; in 2010 and 2011, they restarted growing. Looking at the trend line, the service sector will definitely continue to grow and most likely will also increase its share of the GDP. This trend also seems likely as the Taiwanese government next to its support for exporting goods and also wants its service economy to grow [5, 34]. Nevertheless, the speed of growth has not reached precrisis levels.

The reader can hardly recognise a change in the agricultural sector in **Figure 2**. However, the agricultural sector—it was once the biggest source of income on Taiwan—grew by 30% since 2007 (**Figure 2**). This might be a consequence of the governmental support of high value-added agriculture in response to the crisis. Even though agriculture is growing, the number of people employed in agriculture is only changing insignificantly. High value-added agricultural products are traded at a higher price than plain agricultural goods; wherefore, at the same staffing level, a higher value might be produced. However, further research might be necessary to understand change of the agricultural industry on Taiwan including its changes due to subsidies for high value-added agriculture (see SubSection 2.3).

4.2. International trade

As trade between nations is a very competitive field [59] and often is used to compare countries with one another [39], US$ are investigated here. International trade has been growing steadily until the breakout of the crisis. It massively changed in the period of crisis and also has a different growth trend than before. Imports declined from 2.5 trillion US$ in August 2008 to 0.9 trillion US$ in January 2009 representing a reduction of imports of 65.4% within 5 months. The exports also declined heavily. Between August 2008 and January 2009, they declined by 50.9%

as international buying declined massively due to the severe lack of liquidity in the financial systems. Imports reached precrisis levels for the first time in March 2011. Exports recovered faster reaching precrisis numbers in May 2010 for the first time. The steady growth that was common before the crisis is not present anymore. This might not be directly linked to the crisis, but a consequence of a range of factors. Over time, circumstances might have changed causing a reduced growth of international trade. Nevertheless, it is not likely that international trade would be stagnating now, if there was no crisis. This, however, was not supposed to happen given the governmental actions conducted after the crisis (Section 2.3), and given, that according to the WTO international trade in total recovered since the crisis [57] (**Figure 3**).

4.2.1. Exports

Prior to the crisis, Taiwan's economy developed into an export-driven economy [26, 35]. This section analyses whether and how the exports of the ROC changed during the crisis days and thereafter. Particular emphasis has been put on the country/continent of destination. As literature states that the main focus of Taiwanese exports is technology-intensive goods [36, 37], the tech-intensity of traded goods was investigated. An in-depth analysis of the type of products traded including the effects of Taiwanese politics on these after the crisis would go beyond the scope of this study. Additional research on the effects of postcrisis politics on trade including a focus on the types of product traded is necessary. Further, this section aims for the identification of a trend development of how the exports of Taiwan could develop given what happened after the crisis so far including the postcrisis political actions (see SubSection 2.3).

Figure 4 visualises that prior to the crisis exports have been growing at a steady rate, mainly with Asia. The fact that they were growing and that—apart from seasonal fluctuations—they were not very volatile proves again that the economy of Taiwan was healthy before the breakout of the crisis. Taiwan in fact is trading with Europe and the USA, but its biggest trading

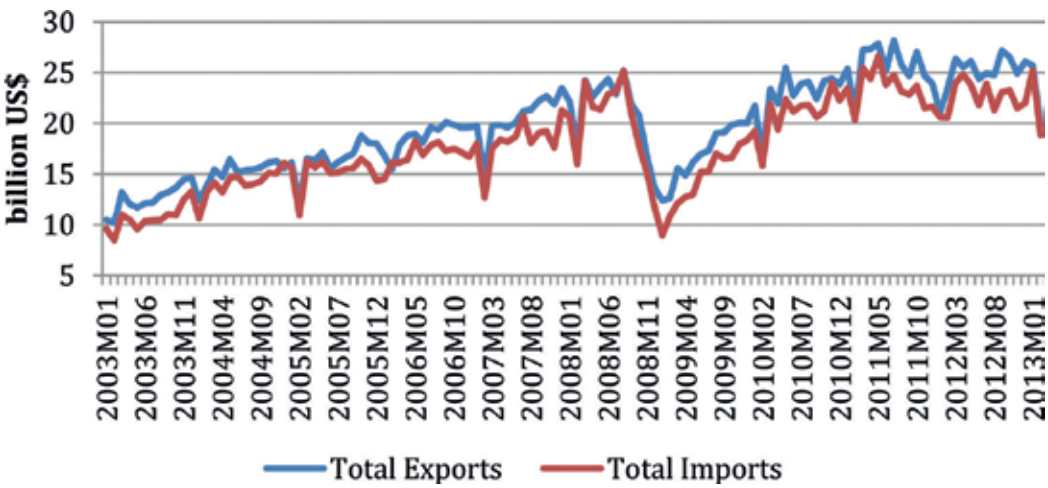

Figure 3. International trade in US$ [56].

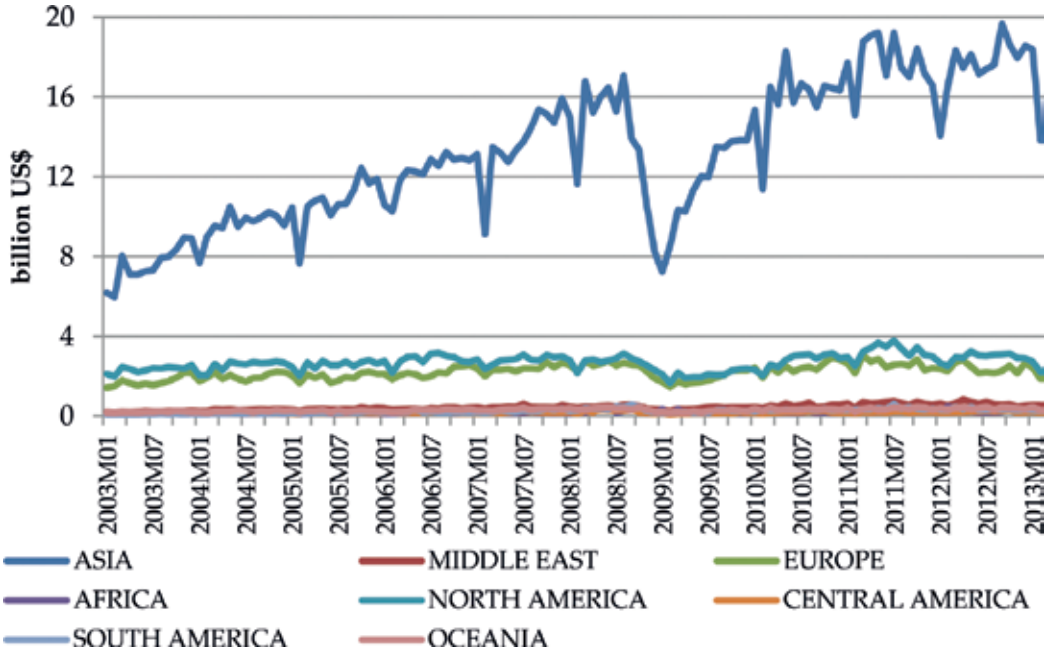

Figure 4. Exports by continent [56].

partners are located in Asia. This seems astonishing, given that the crisis happened in the USA and that literature elaborates on the effect of the US and European trade reduction [42]. Nevertheless, these references—explaining that Taiwan's downturn was caused by its strong connection to the European and American market—are not wrong. Europe and the USA were severely hit by the effects of the crisis. These economies are trading with Asia, and as their trading declined tremendously due to the downturn, many of their trading partners were also affected. However, it was not only these two groups of economies which caused the downturn in trade, as a lot of money worldwide were lost in the rating crisis.

In fact Taiwan's exports to Asia declined by 57.54% between August 2008 and January 2009 (**Figure 4**). This tremendous drop had effects on the country as a whole including its labour market and in the long term also the structure of its financial industry. Exports to North America and Europe also declined massively. In the very same time span (August 2008 till January 2009), exports to the USA declined by 33.3%, and to Europe they declined by 38.4%. Nevertheless—as already mentioned—they heavily impacted the trade within Asia, and their drop is only marginal to what the inner Asian trade reduction was and has caused. Europe and North America together only caused a reduction that is 21.1% of the one caused by Asia.

When further analysing the trade of Taiwan with Asian countries, it is obvious that most of Taiwan's exports go to Mainland China and to Hong Kong. This is due to the close location on the one hand and due to China's economic position on the other. China is a large trading point for the connection of the Asian with the European and US markets. China consequently had to suffer from the WFC as explained earlier [19], even though some literature sees China also as the winner of the crisis [21, 60]. This is, because the Chinese government

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did not suffer so many problems as other markets—especially due to the comparably high savings [60]. Government-owned banks could not go bankrupt, and that is only a part of the advantage of the PRC in the crisis [21]. China's economic meltdown had strong impacts on Taiwan as the number of exports from Taiwan to China also declined massively. Direct trade with Europe and the USA kept volatile since the crisis. Exports to the USA reached the precrisis level for the first time in November 2010, however, but are very volatile. Exports to Europe only recovered in October 2010. These are also volatile, however, but not fluctuating more than before the crisis (**Figure 5**).

It is significant to mention that exports to Asian countries are the highest and that China is the biggest Asian trading partner of Taiwan, followed by Hong Kong. After these, Japan and Singapore are to be mentioned. However, the crisis—apart from a trade drop as with most countries—did not influence the trading relationship with these nations.

As mentioned, a further aspect of investigation for exports was the tech-intensity of goods, because Taiwan—according to the literature [36]—is mainly exporting technology. In fact most of the goods traded are highly tech-intensive. The chart illustrates that the tech-intensity of traded goods has been growing for many years prior to the crisis. The number of exported low-tech-intensive goods declined from 47% in 1985 to less than 8% in 2010. High-tech-intensive goods in the same time period grew from about 19% to about 52%. The exports of mid-tech-intensive goods keep between 38 and 43% since about 1988. As for the effects of the crisis, high-tech-intensive trade declined by about 2% in 2008, whereas mid-tech-intensive goods grew by about 2.5%. The trade percentage of low-tech-intensive goods did not significantly change apart from its continuous decline even after the crisis. Since the crisis, the trade of high-tech-intensive goods is growing, and the ones of mid- and low-tech-intensive goods are declining. This happens even though the government intended a development away from high-tech trade as high tech turned out to be more crisis-sensitive.

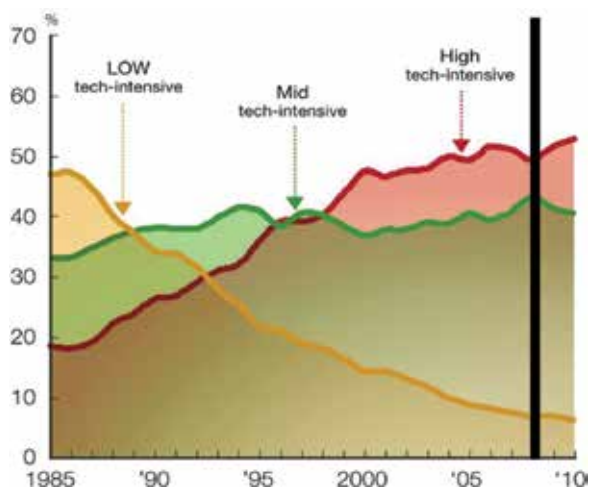

Figure 5. Composition of export products [61].

4.2.2. Imports

Not only the exports but also the imports were heavily affected by the crisis. As the country could not export its produced goods, the imports of material declined. In hand with the reduction of exports, income also declined resulting in a reduced use of consumer goods. The changes in the labour market affected the spending patterns of the whole country and also caused a reduction of consumer goods imports. Again, most of the imports of Taiwan come from the Asian continent. However, when analysing figures per country, it becomes clear that the largest import trading partner is not Mainland China (see **Figure 6**). Taiwan's largest imports come from Japan, followed by China and Korea. As for the effects of the crisis, imports have dropped significantly. Only the ones from Asia have dropped by 59.4% between August 2008 and January 2009. The largest decline is the one from Japan which went down by more than 2 billion US$ representing a reduction of 52% (see **Figure 6**). The figure further visualises that there was a massive drop of imports to Taiwan also from many other Asian countries.

4.2.3. China (including Hong Kong) as a trading partner

As previously indicated Mainland China (including Hong Kong) is one of the biggest trading partners of Taiwan. Mainland China and Hong Kong have been merged in this part because Hong Kong at least geographically is part of China [62] and because Hong Kong is very much used as an intermediator between Taiwan and China [8]. It is vital to mention that exports to the Mainland China are much higher than the imports that are coming from the Mainland (see **Figure 7**). This means that Taiwan is much more dependent on China than China is dependent on Taiwan. And, there is another fact indicating that whereas most of the Taiwanese exports go to the PRC, the majority of its imports comes from Japan, strengthening the dependence of Taiwan on

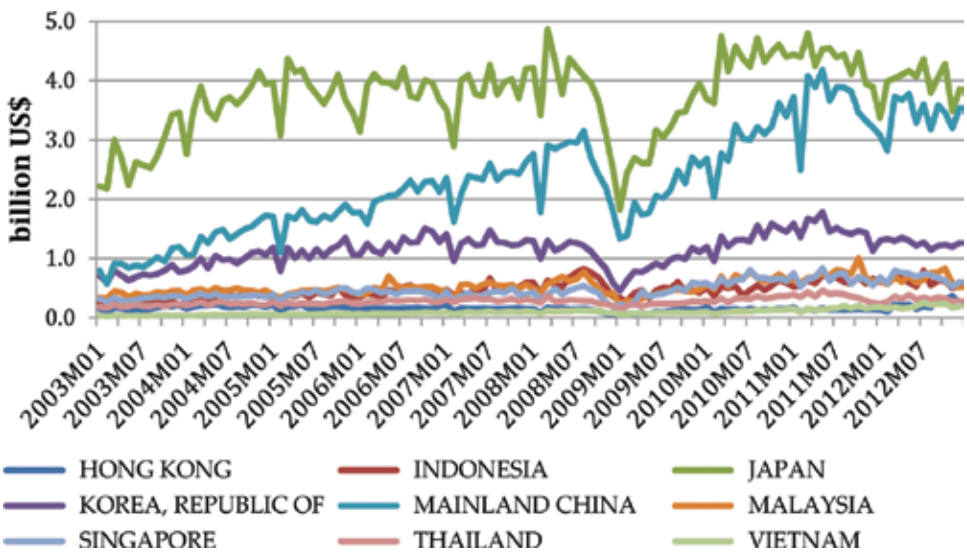

Figure 6. Imports by Asian country [56].

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Figure 7. Trade with mainland China (PRC and Hong Kong) [56].

China. Obviously, this dependency already arises from the large size of China in comparison to Taiwan. However, if Taiwan would be importing more from China and exporting less to China, the relationship would be very different, at least for Taiwan: China would due to its size certainly not become dependent on Taiwan; however, Taiwan would not rely that much on China resulting in a more equal discussion of the two parties on a political level—the current developments are rather making this relationship more difficult, given that ROC's dependence on the PRC is raising continuously. Finding new customers willing to buy the goods produced on Taiwan is more difficult than finding new locations to source material and pre-produced goods. This explains the dependence of Taiwan on China on an economic level. The dependence itself is not to be seen as a result of the crisis. This dependence is a result of the historic background of the two parties.

As for the effects of the crisis, exports and imports from and to Mainland China decreased significantly. Between August 2008 and January 2009, the exports from Taiwan to China dropped massively by 63%. Imports from Mainland China, however, declined massively. Between July 2008 and January 2009—so even a month more—the imports from China declined by 55.1%. The two numbers appear close; if, however, one compares the effective number, it becomes clear very fast that Taiwan is more depending on China and in this relationship more affected than China. Whereas exports to China declined by about 6.3 billion US$, imports from China declined by only 1.9 billion US$. By now both imports and exports are above precrisis levels. Exports were at precrisis levels by April 2010, which was 15 months after the bottom of the downturn. Imports were at the precrisis level in May 2010, which is 16 months later. Now, both values are as mentioned above the precrisis level. Imports however are growing faster than exports. This might be a result of the trade agreements between PRC and ROC as a reaction to the crisis (see Section 2.3 for further explanation). In the long term, that could mean—as happened with the exports (see Section 0)—that also for imports China becomes the largest trading partner and replaces Japan which would increase the level of dependence of Taiwan on China even more. This growing dependence, however, is not a result of the crisis—as it was existing and relevant before, but the crisis definitely accelerated its process.

5. Conclusion(s)

5.1. Consequences of the WFC for Taiwan

The range of consequences Taiwan is facing as a result of the crisis is broad, and one of the major results of this study is that it still will take the country many years to recover from this crisis—if it ever will. The major consequences of the crisis on Taiwan were:

5.1.1. Massive GDP drop that fully recovered

In the period of crisis, the GDP, one of the major measures for the wealth of a nation [1], dropped massively in the period of crisis. By now, the GDP recovered entirely, and it seems to be developing now as if there was no crisis. In the period of crisis, agriculture was almost unaffected, services stagnated and manufacturing suffered a massive drop.

5.1.2. International trade

The trade of Taiwan—imports and exports alike—suffered massively as a result of the crisis. Ever since, the total amounts of exports and imports are stagnating. The only trade that still keeps growing slowly but steadily is the exports to Asia—which are in fact the exports to China. Given that trade worldwide fully recovered, and is growing fast—as Taiwan's trade was prior to the crisis—Taiwan has to suffer long-term consequences of the crisis.

5.1.3. Relationship with PRC

Taiwan as a result of the crisis became more dependent on China. It seems that this dependency would have evolved no matter if there was a crisis. However, the WFC speeded up the process of becoming dependent as, for example, much of the money for the iTaiwan 12 projects was money stemming from foreign investment.

All the mentioned makes the economy much more vulnerable to future crisis as it incentivises spending rather than saving. It almost seems as if the WFC consequences would have caused the country to develop to a stage that is preceding an internal crisis: low interest rates, declining savings, limited export growth, internal growth at savings expense and so on. If there will be an internal crisis on Taiwan, the ROC will become even more economically dependent on the PRC, because the country will barely be able to help its economy to recover from an additional crisis given its currently weakened state.

5.2. Limitations and future research recommendations

This research has been limited in terms of time and funding and in particular by access to data. This type of study is—as explained in the methodology—only possible with the use of secondary data. Secondary data by nature, however, is limited as it is not initially collected for the purpose of the research in question and often is not detailed enough [52]. So, only very limited material has been available which imposed limitations on the study. Investigations might have more meaningful results when assessing product-specific imports and exports

by the country and investigating the political dependence of Taiwan on China even more thoroughly. The use of statistical methods, not used in this study due to its limited scope, might allow for an improved understanding of the country's future. Testing the structural model that has been developed but would be useful. The four most important areas that were affected by the WFC and where further research is necessary are as follows:

5.2.1. The cross-strait relationship between Taiwan (ROC) and China (PRC)

The political actions of Taiwan regarding the trade with China were meant to create a win-win situation for both countries. However, it could also be that China is pushing Taiwan into a dependence in order to abuse this dependence on a political level. Whether and how this was influenced by PRC politics and to what extent the degree of dependence has increased due to the crisis needs more investigations, as it is clear that the level of dependence increased due to the crisis—as, however, it cannot be explained at this point, to what extent this dependence increased due to the crisis and what levels of dependence would have been reached no matter if there was a crisis.

5.2.2. The postcrisis trade

This research, due to its scope, only investigated whom Taiwan is trading with, not including what in fact has been traded. Future research has to investigate the type of products traded and also how this changed after the crisis in more detail. It could be that the currently reduced growth of exports comes from changes in the exporting industries, but this needs further research.

5.2.3. The savings and spending patterns in Taiwan

Further investigation is necessary on the savings behaviour of the Taiwanese. There is a potential that the savings rate would have remained steady or would have grown if the crisis had not happened. Only in-depth investigations about the savings behaviour and the savings perception of the people can improve this understanding. Further, it was shown that the spending pattern of people is changing. It seems that the crisis had low impacts; however, if linking the spending pattern to the savings rate, this might allow for an enhanced understanding of the issue, as how people save closely links to how people spend.

5.2.4. Interest rates, consumption behaviour and employment

As a consequence of the crisis interest rates for loans, deposits and interbank call loans as much as unemployment rates were severely affected. Areas of research that would have gone beyond the scope of this study.

Next to these four recommendations, one further aspect important to research is the implications of crisis and macroeconomic change on management decision-making within the specific cultural framework of Taiwan. As also explained in the methodology, this study lays the ground for an understanding of the economic change as such; however, due to its scope, it only gives an understanding about the change as such, not about how this knowledge should affect managerial decision-making.

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Chapter 8

Managing International Financial Crises: Responses, Lessons and Prevention

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Additional information is available at the end of the chapter

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Abstract

A decade has passed since the onset of the turmoil in 2007 that escalated into the global financial crisis. The crisis has posed new challenges to fiscal and monetary policies in all the countries, including the euro area. Managing financial crises includes measures that reduce their economic damage and costs. Numerous and creative monetary and fiscal policy or financial interventions have been deployed either in the European Union or in the US, China and Japan to mitigate the impacts of the crisis. This chapter gives an overview, assessment and a short comparison of the responses. It also deals with the lessons that may prevent such an intense shock in the future. The prevention implies financial regulations, the reform of the global financial system to become more resilient and the changes that have reshaped the role of central banks.

Keywords: financial crises, crisis management, prevention, monetary policy, global financial system

1. Introduction

When confronted with emergencies never experienced before, strategic crisis managers hasten to mobilize expertise to come up with crisis decision-making. They should be able to make sense of the crisis and identify the core values that are threatened.

When we talk about crises in relation to businesses, it is the owners' responsibility to develop crisis management capacities to cope with the impacts of a disaster on stakeholders and on their companies' value. Regardless of its size, every company can follow the necessary steps in crisis management. Advanced planning is regarded as the key to survival. A written plan

including specific actions is important to make when things are running smoothly. A badly managed crisis can ruin decades of hard work and company value within hours. A crisis can strike any company anytime, anywhere.

As far as natural disasters are concerned, prevention and mitigation policies against them require massive investment but help to reduce the exposure and to increase the adaptation of affected countries.

Disruptive events still continue to occur. We can say their characteristics change over time. They can stem from unprecedented, poorly understood or ignored threats and hazards.

The 2008 financial and fiscal crisis, although it demonstrates features that are similar to those in the past, has been much greater in its severeness and intensity. In terms of falling output and rising unemployment, it has proved to be the most serious recession since the war. The crisis has posed new challenges to fiscal and monetary policies in all the countries, including the euro area. Without the creative monetary and fiscal policy tools applied in the European Union or in the US, China and Japan, the meltdown of the global financial system could hardly have been avoided. Global leaders have recognized that further systemic shocks could severely challenge even political stability.

The recent global financial crisis demonstrated some new factors in terms of its roots: widespread implementation of complex and nontransparent financial instruments, the high level of national and cross-border interconnectedness of financial markets, banks and institutions, the high degree of leverage of financial institutions and the role of the household sector.

Owing to the interconnected nature of the global economy, crises can spread beyond national borders. Globalization has also resulted in an increased interdependence of production and delivery systems as well as a globalized financial system. It is a key responsibility for governments to manage new crises while building resilience to shocks at all levels.

This chapter discusses the different practices in dealing with the recent financial crisis of 2008 highlighting the way monetary policies can adapt to its changed nature and complexity. The new risk management, however, should focus on strategies that take place before an event occurs.

The methodology of the author's research is primarily based on analyzing the qualitative data. The author used the literature review and analysis; therefore, the author collected data from diverse sources, including books, journals, newspapers, conference papers, reports from international organizations, government policy records and websites. It is not a simple presentation of such materials, rather the author integrated different arguments systematically and developed critical assessments of their meanings and value. The author's study comprises logical, explanatory, exploratory and evaluative methods of analysis.

2. Learning from the past and revealing new strategies of managing crises

Today's crises demonstrate a diversity and complexity that challenge crisis management in many ways. Hazards including industrial accidents, natural disasters, terrorist attacks,

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infection, refugee crises and financial threats have a cardinal feature in common: their socioeconomic impacts spread fast across borders, making modern societies vulnerable to a wide range of large-scale shocks. Innovative crisis management responses became vital, which was the case in coping with the consequences of the global financial crisis of 2008. European, the US, Chinese and Japanese policy makers initiated fiscal expansions to boost growth, while their central banks introduced unconventional monetary policies including quantitative easing, forward guidance and negative interest rates on banks' deposits with the central bank.

The complexity of managing today's crises calls for the efficient coordination of emergency responses to defend citizens and businesses and mitigate the harsh impacts. Similarly to emergencies that threaten businesses, response plans are fundamental tools for governments to manage "conventional" crises. To design such plans, it is necessary to study past events and draw the conclusions and the lessons, which could function well for routine events.

Banks, financial institutions and trading firms are vulnerable to hazardous "black swan" events like the global financial crisis of 2008, and are exposed to huge losses beyond the realm of normal expectations due to their flawed financial models. The term is based on an ancient saying which presumed black swans did not exist, though the observation of a single black swan was enough to disprove that belief in the seventeenth century.

Finance professor, writer, and former Wall Street trader Nassim Nicholas Taleb's "black swan theory" describes an event that comes as a big surprise and has a major impact. His book "The Black Swan: The Impact of the Highly Improbable" was published in 2007 and focuses on the extremely strong impacts of rare, unexpected and impossible-to-predict events referred to as "outliers," which is a point in a statistic that does not "fit" in the overall trend. The metaphor also sheds light on the fragility of any system. The idea in Taleb's book is not to attempt to predict "black swan" events, but to create robustness and build resilience. Humans tend to find oversimplified explanations and later convince themselves that these events are explainable in hindsight. Analyzing black swan events, however, helps us to gain a better understanding why certain events are recurring in history and what consequences they have.

The concept of resilience applied to societies, businesses, infrastructure, services and financial systems requires strong governmental or central bank commitment under fast-changing economic and social conditions which create higher probability for unexpected and uncommon crises.

3. When bubbles burst

The Great Recession was triggered by a bubble in housing and derivatives, which became entangled in the financial markets. The term "Great Recession" applies to both the US economic downturn, officially lasting from December 2007 when the US housing market went from boom to bust to June 2009, as well as the ensuing global recession in 2009.

Derivatives built on mortgages spread quickly and became the new, attractive thing that everybody wanted. Based on mortgages, there were so many of them available that when

the prices were bid upward with supply lagging, a bubble was formed. When the real estate market collapsed in 2007, large amounts of mortgage-backed securities and derivatives declined sharply in value, jeopardizing the solvency of over-leveraged banks and financial institutions.

The classic example for a bursting bubble is the Great Tulip Mania of 1637 in the Netherlands. Tulip bulbs became extremely valuable as the rich bid up their prices in the belief that there would always be a market for the exotic tulips, no matter how high their prices soared.

A bubble is usually fueled by speculation or The Greater Fool Theory.

A speculative bubble is usually triggered by the prospect of a greater profit and exaggerated expectations of future growth, rise in prices or other events that could result in an increase in asset values. This pushes up trading volumes, while supply remains at about the same level but demand increases. Price inevitably exceeds the asset's intrinsic value, an objective analysis would indicate that.

Value is what someone is willing to pay for. The Greater Fool Theory of investment suggests that someone is sure to seek your appreciated item, no matter how high its price is at the moment, and willing to pay an even greater price for it later on.

When the Greater Fool stops being the Greater Fool and prices are too high for the market to be sustainable, the bubble bursts. A crash is inevitable as the bubble must go down.

Burst of financial bubbles that brought underlying economic problems to the surface developed into a financial and economic crisis at global level in 2008. The financial crisis turned into a debt crisis and a euro crisis. There were three main factors existing in the precrisis period that resulted in the escalation of the economic and financial crisis in the Eurozone. (1) As argued by Obstfeld [1] and DeGrauwe [2], the financial dimension of macroeconomic stability was largely overlooked: the deepening of the financial integration and the expansion of the financial sector at the same time undermined financial and macroeconomic stability, (2) the banking system was highly interconnected and lightly regulated and (3) Economic and Monetary Union (EMU) member states made imprudent fiscal policy steps.

The economic situation within the euro area in 2007–2009 stemmed from its vulnerability and fragility owing to its architecture. The phenomenon that bank portfolios from the Northern part of the euro area were diverted toward the periphery of economies in Southern-Europe strengthened risk. Low nominal interest rates and easy access to credit-fostered demand and inflation reducing real interest rates, which had destabilizing effects such as housing booms accompanied with an increase in investment of nontradable construction or high government borrowing. This process ended up in cumulating current account deficits and external liabilities.

At the union level, the crisis has highlighted that institutional reforms are necessary to implement for two main reasons. One is that the euro area should develop effective mechanisms of fiscal supervision and policy coordination to prevent a crisis as severe as the recent one from occurring in the future. The other is: should a recession occur in any EMU country, it is important to stop its escalation in the particular country and its contagion to other countries.

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4. Theories on business cycles

Minsky [3] maintained that "To understand the short-term dynamics of the business cycle and the longer term evolution of economies it is necessary to understand the financing relations that rule, and how the profit-seeking activities of businessmen, bankers and portfolio managers lead to the evolution of financial structures."

According to Schumpeter's theory on business cycles "cycles are the essence of the organism that displays them" [4]. The starting point of his analysis is stable equilibrium with the aim of identifying the economic factors arising from the economy itself that destroy the equilibrium and lead to evolution. These real economic processes are referred to as the "circular flow" and "develop," which creates the economic evolution: changes in the economy that arise from itself. Contrary to Keynes, Schumpeter presumed that in the circular flow, there is a constant tendency toward an equilibrium which, under competitive capitalism, tends to maintain the optimal allocation of available capital and labor. In the "circular flow," the role of money is to facilitate the circulation of commodities. It is basically entrepreneurial demand that determines the credit supplied by the banks; consequently, the money supply is an endogenous variable. Schumpeter argued that in a developing economy, where an innovation prompts a new business to replace the old called by him "creative destruction," booms and recessions are inevitable.

Minsky adopted Schumpeter's idea of the innovating entrepreneur. Minsky regarded, however, financial innovations produced by financial institutions as the source of financial fragility, which lead to financial crisis and instability. Schumpeter contrarily stated that innovation was the main source of stability. Minsky concluded that Schumpeterian entrepreneurship, evolution and change are the most evident in banking and finance, where the drive for profits is the clearest factor to make a change [3]. Financial institutions were essential to Schumpeter's theory and in the development of Minsky's thought. The advanced market economies' institutional arrangements are the setting within which innovation is financed by entrepreneurs.

Whalen [5] argued that financial innovations including "exotic" securitizations, nonbank financial intermediation, trading in derivatives, unconventional mortgages, hedge funds and the globalization of finance markets are behind the recent global economic crisis.

Monetary policy rules on the central bank's systematic adjustment of its interest rate to respond to developments in inflation and macroeconomic performance are referred to as Taylor rules. Taylor [6] offered a framework for the analysis of historical policy and for the econometric evaluation of specific alternative strategies that a central bank can make. The framework links interest rate decisions directly to inflation and economic performance abstracting from a detailed analysis of the demand and supply of money. These reactive rules facilitate the discussion of systematic monetary policy.

5. Where does credit expansion lead to?

The question arises if the recent business cycles in the US and Japan can be explained on the basis of the Austrian business cycle theory (ABCT) since they display some of its signs. ABCT

suggests that an economic boom is sustainable if it is the result of an increase in investment funded by an increase in saving, while an economic boom which stems merely from credit expansion is not sustainable.

Excessive growth in bank credit is owing to the artificially low interest rates set by a central bank or through expansionary monetary policy. These interest rates are below the rate of the market for loanable funds that supply and demand clear. As a result, the information embedded in market prices or interest rates is distorted. Entrepreneurial decisions are affected, which causes a misallocation of capital across the economy and the credit-sourced boom results in a widespread malinvestment.

Consequently, a sustained period of low interest rates and excessive credit creation leads to an unstable imbalance between saving and investment. The boom fed by the credit expansion turns to recession when the money supply contracts and eventually resources are reallocated back toward their former uses [7].

Mainstream economists have concluded that the housing boom, subsequent to the 2001 recession, was mainly due to the Fed's accommodative monetary policy, which means expanding the overall money supply to boost the economy when growth is slowing—as measured by GDP—to encourage more spending from consumers and businesses.

Taylor [8] argued that between 2002 and 2005, the US monetary policy was far more accommodate than an approach based on an interpretation of inflation and output data would have called for.

White and other Austrians predicted that a burst of an asset bubble, specifically, the real estate bubble would trigger a crisis while forecasts of some non-Austrian economists, such as Nouriel Roubini and Stephen Roach focused more on macroeconomic imbalances such as the current account deficit or the federal government debt [9].

6. Public expectation from central banks

Monetary policy is supposed to support the objectives of general economic policy for the purpose of achieving sustainable growth and a high level of employment. Inflation-targeting framework (ITF) sets two goals. One is the central bank's commitment to keep inflation low, and the other is to keep the variance of inflation right. While the ITF can greatly promote attaining the first goal, attaining the second provides more room to debates. At the same time, a strategy for monetary management, namely inflation-targeting policies, conducted mainly in a discretionary form have been considered to be capable of keeping inflation low while supporting the central bank's flexibility to manage monetary policy with their independence being emphasized.

It is widely agreed that central bank transparency can make the policy more effective. According to inflation-targeting framework, it is possible to create a "nominal anchor" to the price level by the communication to the public [10]. The target would result in certain "psychological" market conditions which are favorable to reaching the very same inflation goal. The only way

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for central banks to earn credibility is to demonstrate that they have the tools and the willingness to curb inflation and to keep it low for a period of time [11]. In addition, the element of discretion provides the central bank with the capacity to pursue other political objectives thought necessary in a certain case without compromising the attainment of the stated goal.

Public expectation from the central bank should be met, by suggesting that the bank has the power to expand or contract the money supply, to raise or to sink interest rates, to impose exchange controls, to alter the level of obligatory reserves, to alter the classes of assets and the conditions of granting access to discount facilities and to impose new bank regulations. Both critics and supporters of the ITF, including Kohn [12], Friedman [13] and Svensson [14] claimed, however, that the ITF does not constitute best-practice in resolving the question of other goals such as real and financial stability. Nevertheless, stabilizing inflation is the best way to achieve that goal. The view of the ITF is supported by Bernanke, Laubach, Mishkin and Posen commonly referred to as "BLMP," who conclude that should a great supply shock of some unexpected origin in particular arise, missing or changing a previously communicated inflation target may even be justified.

7. Why do financial crises occur?

The conduct of economic and financial policies is strongly affected by the substantial implications of financial crises. A thorough analysis of the consequences of and best responses to crises has become an integral part of the policy debates. Crises manifest the linkages between the financial sector and the real economy. Theories focusing on the sources of financial crises have recognized the importance of sharp movements in asset and credit markets.

A financial crisis often occurs together with one or some of the following phenomena: a remarkable change in credit volume and asset prices, disruptive financial intermediation, immense balance sheet problems of firms, households, financial intermediaries and sovereigns or significant government support in the form of liquidity support and recapitalization.

The question may arise why neither financial market players nor policy makers anticipated the risks and tried to slow down the expansion of credit and increase in asset prices. Such phenomena have been around for centuries. Asset prices sometimes deviate from what fundamentals would suggest and move differently from the patterns of standard models. Asset prices can also be affected by investors' behavior or information asymmetries, changes in international financial and economic conditions. Information asymmetries exist among intermediaries and in financial markets. Safety deserves a premium, and perverse spirals can be created. When the demand for quality assets increases, some of the lower quality may experience a sharp decline in their prices. The crises in the past exhibit the signs of those of recent recessions when the collapse of banking systems was preceded by a sharp increase in credit in real estate investment.

The East Asian financial crisis, for instance, in the late 1990s is similar to the ones in the Northern countries. The experience of the United States in the Great Depression shows some similarity to the way leading to the recent global financial crisis in terms of an increase in household leverage or asset prices.

Credit booms can be triggered by a wide range of factors, for example, shocks such as positive productivity shocks, economic policies and capital flows. Lagged GDP growth is positively associated with the probability of a credit boom. Increases in international financial flows can strengthen the credit booms. Global conditions also affect the national financial markets resulting in asset bubbles easily spill across borders.

Capital inflows can extend the availability of funds for banks leading to relaxing credit constraints for corporations and households. Accommodative monetary policies have been connected to credit booms and excessive risk taking. Asset prices and borrower's value are affected by interest rates so are the conditions of lending. Risk-taking is usually higher when interest rates are lower and a shift to quality, when interest rates rise. The rapid increases in real estate prices and household leverage are explained by the relatively low interest rates in the US during the period 2001–2004.

Structural factors such as financial liberalization and innovation facilitate more risk-taking and can also trigger credit booms. Empirical studies found that crises were often preceded by financial liberalization. Shocks or liberalization keeps innovation in move. Regulation, supervision and market discipline are not quick enough to catch up with greater competition and innovation. Vulnerabilities in credit markets can emerge. A decline in lending standards owing to stronger competition in financial services may contribute to financial fragility in the short run in particular.

During financial crises, asset prices and credit booms and busts differ from the movements of a normal business cycle: booms are shorter and more intense than other upturns, and crunches and busts are longer, deeper and more violent than regular downturns. The violent episodes last longer [15].

Reinhart and Rogoff [16] distinguished two groups of crises, both including two types. The first group is classified on the basis of quantitative definitions, and the other depends mainly on qualitative and judgmental analysis. Currency crisis and sudden stop belong to the first group since these are measurable variables and allow the use of quantitative methodologies. Other crises are connected to adverse debt dynamics or banking system turmoil. Since these variables are not easy to measure, the use of qualitative methodologies is more appropriate.

When a country cannot service its foreign debt, the financial crisis takes the form of a sovereign or private (or both) debt crisis. In a systemic banking crisis, bank runs and failures can make the banks suspend the convertibility of their liabilities or force the government to intervene to prevent that by extending liquidity and capital assistance on a large scale.

Research that has been conducted on the causes of the recent crisis revealed some factors similar to previous crises. Although these factors may differ on the exact weights in different results features concluded in common are as follows: unsustainable asset price increases, credit booms leading to excessive debt burdens, build-up of marginal loans and systemic risk, and that regulation, supervision, and market discipline is too slow to catch up with greater competition and innovation.

Nonetheless, the recent global financial crisis demonstrated some new factors in terms of its roots: widespread implementation of complex and nontransparent financial instruments, the high level of national and cross-border interconnectedness of financial markets, banks and

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institutions, the high degree of leverage of financial institutions and the role of the household sector. These new and common factors in the framework of the "new financial architecture" led to the severest financial crisis since the Great Depression.

Restoring confidence in the financial system, if possible at all, required immense government participation, outlays and guarantees. As for real and financial implications, they are hard and show common features with other episodes. They include large output losses and declines in consumption, investment and industrial production. Financial crises have large economic costs. Crises impact economic activity and can trigger recessions worse than a "normal" business cycle recession. The average duration is longer, and output losses are larger than those of a recession not triggered by a financial crisis. So is the cumulative loss, the output loss relative to the peak before recession.

Various approaches are used for measuring the real impact of a crisis on output. The traditional business cycles' methodology implies that recessions associated with credit crunches and housing busts are costlier compared to those associated with equity price busts. Adding up differences between trend growth and actual growth for some years after the crisis can show overall losses, which vary in different countries. On this basis, according to Laeven and Valencia [17], emerging markets tend to suffer larger losses due to the recent crisis than advanced economies, which can also differ significantly. An indication of the significant costs that crises incur is consumption and overall welfare. In recessions associated with financial crises, a fall in consumption is 7–10 times larger than in those without such crises in emerging markets and consumption still keeps growing, though at a slower pace [18].

Financial variables show with large downward corrections. In advanced countries, credit falls by about 7.0%, house prices drop by about 12.0% while equity prices decline by more than 15.0% during credit crunches, house and equity price [19]. The most remarkable hit on the real economy from a financial crisis is the lack of credit. After banking crises, sectors grow more slowly, so they naturally need more external financing owing to banks' limited lending capacity. Recoveries in aggregate output after credit crunches tend to take place before the revival of credit growth and turnaround in house prices. Sectors more dependent on external finance grow relatively less. "Creditless recoveries" are more common after banking crises and credit booms.

Financial crises are associated with reductions in investment, R&D and employment and firms' giving up on growth opportunities. The timing of crises is more difficult or even impossible to predict than identifying vulnerabilities. The phrase "Minsky moment" refers to the situation when a market fails or falls into crisis after a long period of speculation or unsustainable growth. What we have seen in the recent case of the financial crisis was a slow movement of the global financial system toward" money manager capitalism," as Minsky put it, that collapsed in 2007. Wray [20] named it the "Minsky half-century."

8. Financial innovation and the "new financial architecture"

In the late 1970s, a radical financial deregulation process began that accelerated the evolution of financial markets. Financial innovation took various forms and stimulated strong financial

booms that ended up in crises. The "new financial architecture" (NFA) refers to the integration of financial markets with light government regulation of the era characterized earlier. NFA created a framework for flawed practices and institutions which can be regarded as the deep financial roots of the recent crisis.

As a result of financial innovation, complex and opaque financial products became available in financial markets. They lacked transparency, which made it impossible to be priced correctly and therefore, lost liquidity when the boom ended. The explosion of these securities flowing through banks at a high rate created large profits, while destroyed the transparency which is necessary to ensure market efficiency. Large investment banks like Lehman and Merrill Lynch were given high ratings by international rating agencies enabling them to borrow at a low price. Instead of exposing risk, the agencies systematically disguised it.

The recent economic crisis was remarkable not only because of its severity and size but of its nature. The true nature of the underlying situation seems to be difficult to reveal since trading of over-the-counter (OTC) derivatives, especially the ones which take the form of collateralized debt obligations (CDOs), accounts for confusing those who attempt to paint a clear picture. Collateralized debt obligations are structured financial products that pool together assets such as mortgages, bonds and loans which serve as collateral for the CDO. The creation of asset-backed securities enabled the banks to increase their leverage significantly. These structured financial products were particularly attractive assets for banks to keep because they could be held off-balance-sheet with no capital adequacy requirements.

Derivatives are financial contracts that derive their value from the performance of the underlying asset, the most common of which contain commodities, stocks, bonds, interest rates, currencies or other. The risk of derivatives stems from using leverage, which means that investors can earn large returns from minor changes in the underlying asset's price. On the other hand, however, they can suffer massive losses in case of opposite moves in price.

The Third Basel Accord is a global regulatory standard on bank capital reserves. According to the Basel III rule, the banks are required to hold 4.5% of common equity and 6.0% Tier I capital of risk-weighed assets (RWA) besides introducing additional capital buffers during periods of high credit. There was no need for a percentage of the value of these assets to be held as a capital reserve. CDOs, which comprised loans of different quality, and other derivatives were distributed widely between the dominant institutions in the financial system. They were regarded as relatively safe, since they were given a high rating by rating agencies, while in fact, their credit worthiness and cash flow possibilities were doubtful. This was an unsustainable situation. In late 2007, the whole financial network came under strain questioning the viability of many financial instruments leading to the withdrawal of these funds from Wall Street investment banks and associated institutes.

The collateralized debt obligation "market" was impossible to sustain. Wall Street investment banks were able to evade regulatory constraints. A "shadow banking" was constructed alongside the regulated sector. These banks do not take deposits and have no access to central bank funding or debt guarantees. They deal with short-term funding on asset-backed commercial papers and provide cash loans against collateral as security or long-term loans like mortgages. Shadow banks with less-risk aversion did not mind having clients not eligible to

applying for loans. Due to high interconnectedness, they can contribute to increasing systemic risk indirectly as well. Without the support of their central bank as lender of last resort, they are unable to refinance their short-term liabilities. The shadow banking system is blamed for significantly contributing to the global financial crisis of 2007–2012 [21].

Since OTC derivatives are not traded in an exchange, there are no central counterparties (CCPs). As a part of the financial sector reform, noncleared OTC transactions are to be shifted to central counterparties, which would result in a better risk management and resiliency in accordance with giving more transparency to the OTC market.

The conduct of economic and financial policies is strongly affected by the substantial implications of financial crises. A thorough analysis of the consequences and best responses to crises has become an integral part of the policy debates. Crises manifest the linkages between the financial sector and the real economy.

9. The euro area crisis and its lessons

The euro area crisis that began in 2009 stems from the financial/fiscal trilemma. Obstfeld [1] suggested a new policy trilemma for currency unions: (1) cross border financial integration, (2) financial stability and (3) national fiscal independence cannot be simultaneously maintained within the union after a certain level of the financial integration has been reached. Conclusively, financial integration and independent national fiscal policy do not create financial stability.

Consequently, if countries sacrifice the options of financial restraint and capital controls, they cannot credibly backstop their financial systems without external fiscal support. A country reliant mainly on its own fiscal resources will likely give up on financial integration as well as stability because financial risks will be assessed nationally by the markets. As an alternative, if a country with limited fiscal space withdraws from the integrated financial market, it may control and insulate its financial sector in order to reduce fragility to the minimum level. Any diagnosis that overemphasizes the lack of enforcement of existing fiscal rules is partial.

The author's argument is that the turmoil in euro area in the period after the outburst of the crisis finds its roots in financial vulnerabilities of the incomplete design of Economic and Monetary Union (EMU). Initially, architects were concerned with monetary policy, fiscal policy and structural reform in nonfinancial markets, for example, labor markets, leaving the financial dimension out of scope. The process of financial integration, ruling optimism concerning risk and growth, as well as global liquidity, created credit conditions at the time when monetary union began to work resulted in excessive borrowing. Asset price bubbles occurred in housing and in the sovereign debts increasing banks' exposure to the risk of collapse creating the "too-big-to-fail" (TBTF) issue. It means that when a systemically important financial institution (SIFI) fails, losses or disruptions could be severe enough to lead to failure of third parties. The problem is rather the fact that financial institutions are too interconnected to fail. It is necessary to prevent TBTF banks from failing in order to maintain the stability of the financial system in the short run. Nonetheless, bailing out TBTFs will result in a less stable financial system and raises the issue of moral hazard [21].

The theoretical basis of the creation of the monetary union is optimal currency area theory that considers exogenous shocks rather than the endogenous dynamics of capitalism. Diagnostic failure prevailing in the North blames government profligacy for the euro crisis. Both allow disguising the design flaws of the euro area. The author's argument is that endogenous dynamics of booms and busts work also on the level of national economies, which remained so within EMU. The central bank as the lender of last resort is supposed to counterbalance the instability of capitalism, which stems from its nature. It implies two responsibilities: injecting liquidity in the banking sector and to the government bond markets. When problems in the government arise, sovereign bond prices drop, extending the problem to the banks and causing insolvency, thus developing a vicious circle. The European Central Bank (ECB) as a lender of last resort in the government bond markets has an infinite capacity of buying government bonds. The European Stability Mechanism (ESM) that became operational in October 2012 cannot commit to such an outcome due to its limited resources. It is only the infinite resources that enable the central bank to stabilize bond rates. This is the only way to gain credibility in the market [22].

The structure of the balance sheets of both the banks and the sovereign is unbalanced in terms of maturity. It refers to the liquidity difference of their liabilities and assets, thus a collective move of distrust can trigger a liquidity crisis that can cause sovereign default. This also underpins the necessity of the central bank's extended core responsibility. Stabilizators can be built in the government budget. The private sector's postcrash deleverage may carry the threat of a deflationary spiral. Increased savings together with reduced consumption output and national income will decline leading to the savings paradox. It can be offset by the government's saving less and borrowing more. The private sector's asset sales can trigger a downward spiral by causing insolvency for those holding these assets. The harmful effect can be stopped by the government's taking over them. These processes moved by the stabilizing elements are not organized on the level of EMU. Monetary integration does not obviously include economic integration.

According to the theory of optimum currency areas (OCA) [23], sufficient real wage flexibility and labor mobility can compensate for real divergences. The lack of those in Europe makes it less likely for the requirements of a sound monetary union to meet. In addition, market efficiency with prices fully reflecting available information has not been constituted by the European Union, which also suggests that monetary integration does not imply economic integration. Maastricht has brought the loss of two economic policy levers, monetary and exchange rate policies, and has left two other, the national fiscal policies and the EU budget itself. It means national governments are restrained in reacting to asymmetric shocks, the outcome of which depends to a great extent on the relative phasing of business cycles between each member state and on the ability that cycles can be responded through the EU budget. Since monetary sovereignty and exchange rate tool are no longer accessible, fiscal latitude is needed for the members to treat shocks, particularly in an environment where labor migration has failed to function as a valve for dealing with asymmetric shocks.

In summary, emphasizing the lack of enforcement of existing fiscal rules provides a partial diagnosis to the euro crisis. The euro area's inherent weaknesses revealed by the crisis have made euro area vulnerable. At the core of its vulnerability stands the impossible trinity of strict no-monetary financing, bank-sovereign interdependence and no co-responsibility for public debt [24].

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Secondly, the euro area has deprived itself of the shock absorbers most economies can lean on to reduce the negative effects of demand shocks and fully expect a central bank to respond an economic downturn.

The author's argument is that euro area crisis was not a sovereign debt crisis. The fact that Belgium and Italy, which entered the crisis with extraordinarily high debts did not land in serious trouble, while Ireland and Spain, which entered the crisis with low levels of sovereign debt needed bail-outs, underpins this statement. The problem was massive capital flows across borders, which encouraged high levels of private borrowing in the economies which at last got into trouble. A reversal in those flows generated by the financial crisis made private borrowers and banks get into big trouble, which turned into serious economic downturns and bank failures and led to explosive growth in sovereign debt burdens. Massive sovereign debt was the symptom rather than the cause of the crisis.

Countries without a single currency have the option of turning to the tool of money creation to support their financial systems in hard times. Financing public debt in such a way leads to destabilized price level ending up in a quadrilemma: at least one of (1) strong capital market integration, (2) financial stability, (3) national fiscal independence and (4) price level stability must be given up.

As it comes to discussing, the fragility of EMU by examining the role of the central bank as a lender of last resort and the automatic stabilizers in the government budgets, it is significant to see the existence of a "deadly embrace" between the sovereign and the banks [2]. It refers to the case when falling government bond prices threaten the banks, or sovereigns are threatened with insolvency. As a result, when one is endangered the other follows. This creates a good starting point to analyzing the operation of the ECB.

Accumulation of private debt resulted in developing bubbles. Deleverage as a consequence of bursts got the deflation dynamics going thus, pushing the economy into a deflationary spiral.

The idea of the financial instability hypothesis (FIH) was pioneered by Hyman Minsky. He argued that financial crises are endemic in capitalism; the model does not based on exogenous shocks to arouse business cycles of various massiveness, instead, it suggests that business cycles are generated from the internal dynamics of capitalist economies, the fragility of financial markets and the system of interventions and regulations necessary to keep the operation within bounds. Capitalism is prone to move from periods of financial stability to instability, which is a type of market failure and needs government regulation.

10. Effective crisis management measures to avoid the worst

The global financial crisis and associated recessions have shown the ability of macroeconomic and financial sector policies to mitigate the costs of such episodes.

The measures implemented aimed specifically at enhancing credit support. They are defined as "nonstandard, unconventional measures" and are considered as part of the central bank's toolkit, but "by definition exceptional and temporary in nature" [25]. In the wake of the

Lehman collapse and exploding sovereign debt crisis in the Eurozone, the unconventional measures taken by the central banks were mainly aimed at stabilizing specific segments of financial systems. They are referred to as "credit easing."

Central banks like the ECB, the Federal Reserve System (Fed), the Bank of England (BoE), the Bank of Japan (BoJ) or the People's Bank of China (PBC) differ in terms of their tasks or legal statuses while they show more similarities in their institutional structures, monetary frameworks and in the use of instruments. Central banking practices in the world have evolved toward greater independence, transparency and the adoption of monetary policy committees. This trend has contributed to reducing the differences among these five institutions and can also be seen among other central banks.

The differences include communication strategies; nevertheless, the responsiveness of the financial market seems to be high for both the Eurosystem and the Fed in terms of monetary policy inclinations and views on the economic outlook. The ECB and the BoJ quantify their definitions of price stability, while the Fed does not. All these central banks mentioned earlier had to face a series of diverse challenges, which were rather country-specific in Japan or more global in the other economies.

The Fed made clear its objective of preventing a meltdown and gained credibility in spite of the fact that it temporarily suspended its commitment to price stability. Euro area's output had fallen behind that of the US in 2009 and had not been able to catch up.

The author concludes that it was due to the delay in economic stimulus. In addition, the credibility of the ECB was not strengthened by its deeds. With the core inflation rate in below 1% a year, the euro area slipped into a low inflation trap, well below its stated target of 2% a year.

The epicenter of the crisis was located in the US during the period between 2007 and 2009. It moved to the euro area at the end of 2009 and at the beginning of 2010. It was the reason why monetary policy responses to the crises of Fed, BoE and ECB were done at different times. A decline in financial asset prices escalated in a financial crisis, but while in the US and in the UK, it was centered around subprime assets; in the euro area, it was centered around government debt. Subprime assets did not actually have the value they were supposed to and sovereign debt was considered risk-free, which is used by banks as collateral [26].

As for monetary transmission mechanism, in the US 25.0% of corporate external financing is done by banks, while 75.0% through financial markets. In comparison, in the euro area 75.0% of corporate external financing is conducted by banks and 25.0% through financial markets. This proportion in the UK is approximately 50–50%.

In addition, the US and the UK have a single sovereign Treasury bond and Treasury bill market. It is easier for the Fed and the BoE to perform monetary policy than for the ECB, which has to deal with 19 different Treasury bond and bill markets.

The ECB has one primary objective, price stability and the other goals are subordinated to the first. The Fed and the BoE have more than one objectives, monetary stability and financial stability. The financial stability goal consists of a sound and stable financial system. The BoE has explicitly stated that financial stability is regarded as a major goal.

The three main objectives set by the Fed besides monetary stability are: permanent economic growth, maximum employment and low long-term interest rates. Its target for price stability is measured by the consumer price index, which is 2%. Its present estimated long run unemployment rate will increase from around 5.2 to 6.0% [27].

The BoE has expressed the "lender of last resort" operations as a mean to ensure financial stability. Compared to the ECB, this function is stronger for the BoE.

The ESCB[1] is allowed to buy debt instruments from euro area member states in the secondary markets,[2] as the ECB has done so during the crisis, on the condition, it is necessary to meet the ESCB objectives.

In the euro area, monetary easing has been low compared to the US or the UK. Several major advanced economies got close to a liquidity trap. At that point, standard monetary policy becomes ineffective because nominal interest rates hit zero, both money and bills have a close to zero interest rate so they become close to perfect substitutes, short-term interest rates cannot drop further. Given these circumstances and the economy needs more monetary stimulus, demand is still insufficient to reach full capacity in the medium and long term, the central bank deploys unconventional or nonstandard monetary policies. Negative interest rates are employed to avoid a recession after reaching a liquidity trap. There are theoretical options that can be considered to escape.

Owing to the higher debt levels in the US and the UK compared to the euro area, the political constraints are high. The central bank can buy government debt or private debt in primary or secondary markets. In these circumstances, the Fed purchases Treasury bonds and bills and mortgage-backed securities (MBS). To buy private debt, Congress approval is needed. The BoE bought only UK Treasury bonds and did not purchase private debt. The ECB bought some government debt from peripheral member states in the secondary markets, but sterilized its purchases. Raising inflation expectations to lower real interest rates may be a radical but effective solution by allowing inflation to be above the central bank normal target at least for some time [26].

Having assessed the effects of unconventional or nonstandard monetary policies, the author concludes that without a swift deployment of innovative policy tools, the meltdown of the financial sector could not have been avoided. These measures mitigated the harsh impacts of the global financial crisis on the real economy in terms of output, unemployment and inflation.

Taking into account the effects of the asset purchases deployed as unconventional stimulus, the purchases were targeted toward long-term assets held by nonbank financial institutions, like insurance companies and pension funds, which may be encouraged to use the funds to buy other, riskier assets like corporate bonds and equities. Asset purchase announcements

[1]European System of Central Banks, The ESCB comprises the ECB and the national central banks (NCBs) of all EU Member States whether they have adopted the euro or not.
[2]Article 123 of the Treaty on the Functioning of the European Union prohibits directly monetary financing of the Euro area member states through overdrafts and credit facilities and direct purchasing from debt instruments.

had an impact on long-term asset yields, interest rate futures and measures of financial market uncertainty, which supports the importance of the signaling transmission channel. In the US, asset purchase shocks had an effect on long-term yields and the real exchange rate, underlining the role of the portfolio rebalancing channel.

Unlike the Fed and the BoE, the ECB responded to the crisis in terms of asset purchasing too late and in a limited scale. The Eurosystem had to face a continuous decline of inflation to a level below its definition of price stability of close but below 2.0%. To bring inflation back to 2.0% in the medium term, the ECB announced a broad package of measures in June 2014 to deal with the deflationary risks, which was present in the Eurozone since late 2013.

The current global financial crisis has had a significant negative impact on the Chinese economy affecting exports, foreign exchange reserves and structural adjustments. Since China is over-dependent on exports to stimulate its economic growth, weakening external demand means an adverse impact on the Chinese economy. In November 2008, China's continued GDP growth was disturbed by both losses in export-led manufacturing and reduced foreign direct investments from the international capital market. When external demand collapses, overheating caused by strong investment demand and strong export demand will turn into overcapacity, and inflation into deflation, immediately. It was the case in September–October 2008 since in the second half of 2008, export demand collapsed due to the global financial crisis causing the overcapacity come to the surface.

The author concludes that the global economic crisis exposed the vulnerability of China's growth pattern. The overcapacity of its economy would have surfaced and called for correction without the global financial crisis as well. The investment-driven and export-led growth pattern is not sustainable as the investment rate cannot increase forever and the growth rate of China's exports cannot stay persistently higher than that of the global economy.

At the end of 2008, the Chinese central bank held foreign exchange reserves worth US$1.95 trillion,[3] the majority of which were denominated in US dollars comprising mainly the US treasury bonds and agency bonds. The deepening of the subprime crisis meant a potential threat of devaluation and downgrade of its US bonds, thus eroding the international purchasing power of China's foreign exchange reserves. In addition, to prevent a slowdown of economic growth, the Chinese government had to consider postponing or even canceling some structural adjustment policies necessary to ensure the sustainability of the growth of the economy such as bursting the price bubble in the real estate sector and increasing the flexibility of the RMB's exchange rate mechanism. From the second half of 2009, the largest developing country managed to regain its previous GDP growth levels while most advanced economies were still struggling to recover. The global crisis affected China only for a limited period, from late 2008 until late 2009. The Chinese Government's reaction had proved effective in boosting short-term economic growth, but was insufficient to ensure sustainable

[3]Although the People's Bank of China does not disclose the proportion of currency and assets of its foreign exchange reserves, the author made a rough estimate based on external data according to the IMF's COFER statistics. The asset composition of China's foreign exchange reserves can also be estimated through the statistics disclosed by the US treasury on the overseas holdings of the US securities.

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long-term development and to avoid new risks from arising. The structural problems of the economy were exposed further by the crisis.

China's exposure to the global financial crisis is moderated by its lack of direct exposure to the subprime mortgage issue. The economy applies numerous restrictions on capital flows, particularly on outflows of capital. Limiting the ability of the Chinese citizens and private firms to invest abroad, the policies compel them to invest domestically. Even if these restrictions could be evaded by some who invested abroad in subprime mortgages, the extent of this investment is unclear and is probably relatively small.

Although the People's Republic of China's (PRC) government made a bulk of foreign investment overseas owing to China's massive foreign currency reserves, most of these investments went to safe, low-yielding instruments, such as the US Treasury securities. PRC officials are cautious and conservative by nature in their investment strategies; they are unlikely to invest in mortgage-backed securities and other innovative financial instruments, which they do not know or may be viewed as speculative.

While China's direct exposure to subprime mortgages seems to have been limited, the impact of the subprime mortgage problem did affect China via its harsh impact on the economies of China's two largest trading partners: the US and the EU. Economic downturn in the economies throughout the world made the Chinese economy slow down significantly due to their lower purchases of Chinese exports, which began to decline. So did the FDI inflows.

The Chinese government's economic policy reaction to mitigate the impact of the global financial crisis includes stimulating household consumption effectively, reducing the pressure of unemployment and diversifying China's foreign exchange portfolio. China was one of the first major economies to recover from the spillover effects of the crisis. Thus, its economic policy responses, particularly those of the PBC are assumed to have been effective.

Before the global financial crisis, the PBC was a central bank in a transition economy. Financial liberalization was incomplete, and the Bank applied both direct and indirect tools. During the crisis direct controls dominated as risk management solutions, and further market-oriented principles were replaced by administered interest rates and exchange policy [28].

Due to the crisis, direct government intervention intensified, which continued to limit the PBC and even threatened China's market-oriented reforms. Nonetheless, in the frame of the fiscal stimulus package, the Chinese property market quickly returned to its previous growth after the decline in 2007 and 2008 attracting a great volume of commercial loans. With low deposit interests and in the lack of diversified investment products, household savings were continuously invested in the property and stock markets, which made government intervention only rarely successful [28].

Nonetheless, the global financial crisis challenged the Chinese central bank to such a degree that explicit government intervention seemed to threaten China's continuing market-oriented reforms. While demonstrating proactive risk management, the bank remained constrained by political domination. The Chinese government has intensified direct controls over both the central bank and wider financial markets.

The global crisis called for cross border cooperation, and the internationalization progress continued toward further Asian regionalization. To offer liquidity support, different institutions were established including a Credit Guarantee and Investment Fund (CGIF), an Asian Development Bank (ADB), the Associations of Southeast Asian Nations "ASEAN+3" and Macroeconomic Research Office (AMRO). The Chiang Mai Initiative (CMI) has evolved from a bilateral US dollar-denominated exchange arrangement to a multilateral facility [28]. The establishment of the Asian Infrastructure Investment Bank (AIIB), which has attracted economies outside Asia as well, indicates that China has reached a new stage of financial integration.

Owing to China's crisis management, the economy was able to achieve its GDP growth targets for 2008 and 2009. In January 2010, the GDP growth rate of over 10% exceeded that of previous years on average. The Shanghai Stock Exchange Composite Index rose by 45.0% and retail sales rose by 14.8% on a year-on-year basis. Industrial output increased by 7.3% and investment in real estate by 6.4% [29]. With regard to these figures, Chinese policy responses to the global financial crisis seem to be effective.

Compared with the US and the UK, severe housing collapses or banking failures did not hit Japan during the global crisis. Japanese banks were less innovative and continuous recapitalization rather than profitability created a sound financial environment. The Japanese stock market indicated the external instability by gradual sustained decline. Fiscal stimulus and monetary expansion were employed to deal with the global crisis. Owing to its over-dependence on exports, thus being vulnerable to external shocks Japan and its underperformed peers and emerging countries in Asia in 2008 and 2009. As foreign banks largely reduced their investment in the interbank market and their holdings of Japanese stocks negative outward portfolio investments increased from 2007 while inward portfolio investment turned negative in 2008 and 2009 leading to a credit crunch on Japan. Japan's economy turned into a serious economic recession from late 2008.

As Japan still suffered huge losses, the BoJ was required to pursue unconventional measures. Regarding these points, the selected crisis management solutions were similar, including interest rate cuts, clarified commitment and asset purchase programs, but monetary easing was more aggressive during the global financial crisis.

As for the timing, the BoJ was late to deal with the bubble economy and its impacts, although it acted proactively mainly in cross border cooperation. Regarding the independence of the central bank, it can be stated that in a financial crisis, a central bank is likely to have to sacrifice at least part of its independence. This was the case with the BoJ while it increased its direct control over financial markets [28]. As the bankers' bank, by taking over credit risks from the private sector, the BoJ directly affected resource distribution. By providing commercial loans to contracted institutions, the Bank ensured liquidity while intensified its on-site examination and off-site monitoring in order to assist to improve liquidity risk management at the firm level. The key crisis management solutions can be summarized as ample liquidity provisions, support for credit market functioning, macroeconomic stimulus and injections of public capital and elimination of balance sheet uncertainties [30]. Under the crisis challenge, the Bank's

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role as a government-driven monetary authority further strengthened and so did its function to promote the government's strategy.

11. Results and conclusions

During the global crisis, most banks did not limit themselves to the orthodox policies for crisis management, but explored new unconventional monetary policies.

The ECB does not have a strong financial stability mandate that could justify intervention. Whereas the euro area is integrated monetarily, banking systems are still national. It implies that the member states are vulnerable to the cost of banking crises.

It is likely that the wrong diagnosis of the reason for the crisis led to austerity measures and later to the austerity spiral. In the author's opinion, austerity might be a tool as long as it counterbalances profligacy. Generalized austerity only serves to deteriorate the sovereign and private debt crisis. If the main goal was to reassure the financial markets so that they would trust in the Eurozone again, the new European economic governance and budgetary rigor was effective.

With more frequent cross border financial crises, central banks have had to increase regional and international financial cooperation.

Having studied a wide range of relevant literature, the author states that there is still a little consensus regarding the definition of financial stability. It is agreed that systemic risk means a strong threat to financial stability, which was proved by the global financial crisis. Risks with extended negative effects beyond any institution or economy are regarded as contagion. The nature of the risk is determined by the degree of probability on which a certain risk will exert a systemic aftermath [28]. Such a hypothesis refers to a risk allocation as risk with domino effects. Systemic risks have contagion effects at the core with different forms of externalities. Transmission mechanisms are important factors in understanding systemic risk. In interdependent banking networks, the strong interconnectedness will increase the chance of a systemic risk, while the weak linkage will reduce its occurrence.

To deal with systemic risk, both private and public solutions can be viewed as inevitable. Preventive solutions focus on reducing risks before they undermine banks by monitoring their management, capital, solvency, liquidity standards are public resolution techniques [28].

Central banks operate different policy instruments during financial crises and at other times, but their tasks are similarly related to financial stability.

The recent crisis has forced changes that have reshaped the role of central banks, challenging the ways in which they continue to commit to their orientations.

Systemic consolidation and restructuring require the renewal of the regulatory framework. Due to the interconnectedness of banks and cross border activities, it is rather difficult to manage toxic assets and clean the banks' balance sheets. The establishment of the new EU

supervisory system will contribute to preventing future financial crises, which highlights the importance of multilateral surveillance of economic policies.

The global imbalances are inevitable to reduce including China's exchange rate policy and its huge surpluses in savings.

The crisis has confirmed the importance of transparency with regard to the financial markets; most central banks have been required to improve their communications and transparency, the optimal level of which is difficult to determine due to the discretion granted by law.

Governments are confronted with many types of crises with serious economic and social impacts. Managing crises is their responsibility as they play a vital role in building the resilience of their economies and societies.

Better understanding of hazards and threats enables better risk assessment to more efficient prevention policies and mitigation programs. As crises continue to evolve, managing techniques continue to adapt to dealing with the unprecedented.

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Chapter 9

Corporate Governance in Downturn Times: Detection and Alert – The New Italian Insolvency and Crisis Code

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Maurizio Comoli and Ambra Garelli

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Abstract

In its life cycle, an enterprise may experience periods of crisis. If the crisis is monitored promptly and appropriate measures are taken, not only may the enterprise continue to operate but it may also be able to seize opportunities for growth. The Italian legislator is introducing a procedure aimed at supporting companies to detect the very first warning signs of a crisis. The supervisory board of auditors, the audit firm, and certain qualified creditors will have the right and duty to start the early warning procedure ("allerta"). The board of statutory auditors (Collegio Sindacale) plays a fundamental role: its ex-ante supervisory and control activities over management allow it to effectively play an important role as main recipient of any crisis warning signs. The new regulatory framework lays down certain indicators and critical thresholds, which may trigger the alert process. Initially, the Delegated Legislation (Bill No.3671-bis) sets forth certain specific financial indicators. The new bill (Crisis and Insolvency Code) on the contrary refers to a more complex and sector-specific system of indicators. The findings of an empirical research conducted by analysing a sample of more than 600 enterprises and testing the discriminating capacity of the indicators initially considered are presented herein.

Keywords: crisis, insolvency, alert measures, board of statutory auditors (*Collegio Sindacale*), audit firm, *crisis settlement body for companies* (OCRI from its Italian initials), performance measurement, crisis indicators, Italian crisis and insolvency legislation, crisis thresholds, European directive on preventive restructuring frameworks and insolvency (COM (2016) 723), UNCITRAL

1. The business crisis as an opportunity for growth

The crisis is a stage in which the company can find itself during its life cycle. If well managed, but above all identified in time, it can also represent an opportunity for growth. In fact, the crisis (from the Greek κρίσις, decision) translates into change, the need for a turnaround and represents, at the same time, an event from which to derive a strengthening of the company with evolutionary perspectives that would not have occurred, without the manifestation of the state of difficulties [1].

The crisis-opportunity binomial [2] could appear to be a contradiction; it is normal to think that a company experiencing difficulties does not have the resources to grow, but it is instead fundamental that the crisis be faced also by investing in internal resources and skills, guiding them towards the achievement of new balances [3]. A crisis promptly diagnosed and managed with a view to growth will bring with it not only an improvement of the members' skills in the organisation and the introduction of management innovations, but including the increase of the cohesion level of the entrepreneurial group and the gaining of experience for preventing future crises.

The concept of crisis, for entrepreneurs, is complex to deal with, many of them take an attitude of rejection towards this event and have substantial difficulties in admitting the downfall, even when they are already involved, at least as long as it does not assume size such as to be diagnosed as a real overt crisis.[1] Crises, in fact, are preceded by stages of decline [4], which if promptly diagnosed and addressed, can stop the degenerative process, and even trigger a total reversal process [1]. Situations of decline or crisis may arise from inefficiency, overcapacity or structural rigidity [1] from decay of products, from shortcomings and marketing errors, from the inability to programme, from errors in strategy, from a lack of innovation or from others [4]. Crises often occur, therefore, not because they are unavoidable, but because companies are unable to perceive the warning signs; they are not able to limit the harmful effects and above all to monitor the threats to prevent them [5]. Often the degenerative process is due to the inadequacy of entrepreneurial and managerial resources with respect to the complexity of the issues to be managed [6].

2. Crisis stages and warnings: the role of actors involved in corporate governance and external parties

When a company goes into crisis, imbalances and inefficiencies start to appear, productivity and turnover are reduced, with the consequent creation—in the case of an industrial company—of stock surpluses and, more generally, of an inadequate coverage of financial needs.

[1]Please refer to the following paragraph for the classification of the various stages of crises, the benchmarking of possible interventions consistent with new legislation and the identification of the role of actors involved in corporate governance and external parties.

This provokes during a period of greater or lesser duration, a contraction of profits or even losses with the consequent gradual impoverishment of the available shareholders' equity. The persistence of this situation can lead, if timely measures are not taken, to more significant difficulties and to the inability to cope on a regular basis, with the obligations assumed. This can be followed by damages to the company's image and credibility and consequently, the loss of customers and a decline in confidence in the financial system which translates into, in the Italian context, primarily as the loss of bank credit facilities.

A number of authors studied the typical timetable of situations that usually occur when a company goes into crisis and, if it fails to carry out an effective and prompt *turnaround* action, it becomes insolvent [4, 7, 8]. During each stage, it is possible and relevant that persons in charge of the corporate governance—both with a management role as with the role of supervision and control—must carry out associate actions as the difficulties arise and therefore, the management of the crisis stages. In accordance with the European Directive (COM (2016) 723)—on preventive restructuring frameworks and insolvency—Italy has implemented the Directive by introducing the "enabling act" first and then the "crisis and insolvency code". In the following paragraphs, we try to provide a systemic reading that takes into account the indications of the new Italian "crisis and insolvency code" published as a draft in December 2017. The stated goal of the new regulatory framework is to achieve a better satisfaction of creditors safeguarding the rights of debtors, as well as encouraging the overcoming of the crisis by ensuring business continuity.[2]

2.1. First stage: incubation of the crisis and "informal" internal alert

At the beginning, an incubation stage develops which can be considered normal as can occur to any company on structural grounds. It manifests itself with the identification of management or production inefficiencies. Its severity and evolution must be assessed by the administrators also with the aid of forecasting tools such as the business plan to assess the progress of management and intervene with specific corrective actions. Corporate supervisory bodies will analyse the behaviour of administrative bodies ensuring that an adequate organisational system is implemented with particular reference to the presence, structure and functioning of an adequate system of internal control and having a reliable and effective dashboard of indicators that monitors all the parameters and thresholds identified in the new "insolvency crisis code". Reference is made to Section 4 in which more information is provided on the subject of "crisis indicators". The new Italian legislative framework provides that when "serious indications" of a crisis are detected, control bodies must immediately notify the board of directors of the appropriate measures.

The current critical situation is absolutely evident and requires the exercise of a high degree of professionalism and experience by all the players involved. It is only necessary to observe that

[2]It is worth highlighting that the new crisis and insolvency code provides a judicially relevant definition of the two concepts of "crisis" and "insolvency". More specifically, the "economic crisis" must be understood as the state of economic and financial difficulties that makes a debtor's insolvency probable and that for companies, it manifests as an inadequacy of prospective cash flows to *regularly* meet planned obligations. On the contrary, a debtor is defined as "insolvent", when it is no longer able to meet its obligations on a regular basis, and this manifests itself as defaults or other external factors.

at this stage, the intervention of the corporate supervisory bodies must be balanced and must take into account the fact that the company is facing difficulties, but that these are likely to prove reversible. Only an understanding of the features that characterise the situation being faced will therefore allow weighing lines of conduct appropriately. Measures that are too invasive and disproportionate, due, for example, to errors in classifying the situation that lead to anticipating behaviour, and therefore, reports, foreseen for the subsequent stages, could themselves constitute causes of a worsening and stiffening of the situation, which is clearly undesired, risking taking the form of self-fulfilling prophecies.

On the other hand, directors must learn to understand the importance of the role of the board of statutory auditors (*Collegio Sindacale*) and new duties, but, it is good to underline, including the new powers that the new code has objectively acknowledged, further legitimising their work. Especially in smaller companies, it will therefore be necessary for directors—to avoid unnecessary conflicts and therefore, risks of repeated reports—to develop, on the one hand, a better ability to listen to the indications of supervisory bodies, and on the other hand, a better capacity for reporting which must be systematic, formalised and timely on the measures undertaken and their impact.

2.2. Second stage: maturity of the crisis and "formal" internal alert

If a solution is not found, the company may slip into a second stage of maturity of the crisis. The inefficiencies that during incubation were not promptly dealt with produce more consistent effects and begin to affect company resources. The first financial difficulties are beginning to be encountered, which can result in worsening of the economic results achieved and also in terms of assets with a reduction of the available shareholders' equity, affected by the unsatisfactory results of the period. The reading of official financial statements can lead to the first, probably weak, reactions from stakeholders, which, while continuing to have confidence to the company, can however start to show concern. At this stage, it is even more essential for the intervention of administrative bodies to be decisive and focused as they must assess the severity of the most probable evolution of the situation and the effects of the latter on business continuity.

In order to make the alert more timely and, in consideration of the importance of banks, especially in the Italian context, as main lenders, or only lenders to smaller-sized companies, the new regulatory framework has introduced direct disclosure obligations between these parties and the corporate supervisory bodies. More specifically, banks, when they notify changes or revisions in credit lines to the customer, must also inform the corporate supervisory bodies, if any.

Supervisory bodies, in particular, as we will see better in next paragraphs, the board of statutory auditors, which constantly monitors a series of corporate performance indicators, are called at this stage to assess whether to implement an "internal alert" system. They must ensure that directors are aware of the existence of a more identified and relevant criticality than in the previous stage and of the need to undertake a well-identified path to avoid the consolidation of a crisis situation.

To this end, the board of statutory auditors and the other controllers may decide to take some further steps, this time more formal. Once the situation has been classified as significant

and, of course, in the event of inertia of the directors, that is, only in the case where adequate measures have not already been implemented by the directors as a result of less invasive interactions with the supervisory bodies themselves, they may decide to implement a specific "reporting procedure". The latter consists of sending, with reason for its own decision, an official written notice—therefore, with proof of receipt—to the directors with whom an appropriate, but short time limit not exceeding 1 month is set—within which the board of directors must report on the solutions identified and the initiatives undertaken.

The risk that, in the absence of timely intervention, the thresholds that may lead to automatic reporting by qualified public creditors, better described later, may be excessed must be duly taken into consideration by both the directors and the control bodies.

2.3. Third stage: reversible full crisis, internal alert "to external entities" and external alert

If the intervention described in the previous stage does not occur in a timely manner or if it does not produce a positive outcome, the company may however enter a full-blown crisis stage. The latter is characterised by the emergence of more significant financial imbalances that, once again, if not actively managed, can seriously compromise business continuity. We arrive at the "crisis" in a judicial sense, or in other words, as mentioned earlier, to the "inadequacy of future cash flows to meet regularly planned obligations". During this stage, the relationship with the lenders to the business activity becomes fundamental. In respect to the latter, they must be provided with the opportunity of having access to detailed and prospective information in order to allow them to assess the company's situation and a shared and rational strategy must be agreed upon with them. The risk of losing the trust of corporate stakeholders is, however, more general during this stage and not limited to this category. Even customers, suppliers and employees, to cite the main stakeholders, need to have access to the same information; otherwise, the company can lose fundamental resources for its own survival [9, 10]. The company and, therefore, the directors must demonstrate in a transparent and convincing manner the existence of strength elements—of an industrial or commercial type—and/or that extraordinary interventions have been planned—such as internal reorganisation, cost restructuring, strategic repositioning, partnership with new entities, recapitalisation by the shareholders themselves or by third parties—such as to make it possible to classify imbalances identified as temporary.

The corporate supervisory bodies monitor the correct setting up of a dialogue process with the parties that are strategically relevant for company's survival. They must also assess whether the company can still emerge from the crisis independently, under the guidance of solely the directors or if, in order to secure the company's business, it is necessary to trigger an "internal alert to external entities" process. With this regard, the new legislative framework provides that, in the event that planned interventions, including possibly following the first informal and then formal "internal alert" referred to in the previous stages, are considered inadequate or in the event of inertia, that is, failure to take sufficient measures, the corporate supervisory bodies must report the situation identified to a specific third party called OCRI (from its Italian initials, "*Organismo di composizione della crisi di impresa*") or crisis settlement body for companies. It is necessary to highlight that: (1) on the one hand, the timely reporting to the

body responsible for the settlement of the crisis constitutes a cause for exemption from joint and several liability for the corporate supervisory bodies due to the detrimental consequences of the omissions or actions subsequently implemented by the board of directors in contrast to the requirements received, which are not a direct consequence of decisions taken before the report; (2) on the other hand, and in the same way, reward measures are foreseen for entrepreneurs who provide a timely remedy to the crisis situation.

As already mentioned, the new code also identifies a specific category of parties considered to be particularly relevant for the timely emergence of the crisis which are defined as "qualified public creditors" and which are given very significant powers in the alert process. The parties are IRS (*Agenzia delle Entrate*), the national insurance institution and the tax collection agent. They are given the power to send an additional alert to the "crisis settlement body for companies" (OCRI). This alert is a "totally external alert" or, better, an "external alert to external entities" as it is brought forth by a third party with "opposing interests" with respect to the company and is addressed to another external entity. The envisaged procedure is totally objectified as it operates in accordance with specific automatisms, based on overcoming the identified thresholds of doubtful debts,[3] it is necessary to understand that it could therefore already be triggered even in previous stages. The above-mentioned is a modality of introducing the alert which is completely independent and concurrent with respect to that entrusted to the corporate supervisory bodies: an exchange of direct and preliminary information between the two parties does not seem in fact to be coordinated nor explicitly required. External alerting requested by institutions can be divided from a timing standpoint into two phases. First of all, they are required to give immediate notice to the debtor—and therefore, directly to the directors and not to the corporate supervisory bodies—of the fact that the debt exposure has exceeded the critical threshold identified by the legislation as relevant.[4] Then, they must wait the short term of 3 months to allow the debtor to resolve the situation subject to notification by one of the following actions: (1) the extinction per se of his/her/its debt; (2) or reaching an agreement with the reporting body; (3) or again, the company's submission of application for settlement assisted by the crisis or the application for access to an agreed procedure for resolving the crisis. In the event of the directors' inactivity, at the end of the 3 months, they are again required within the short term of 30 days to: on the one hand, send a specific report to the supervisory bodies of the company, and on the other hand, contextually, to send a specific report directly to the crisis settlement body for companies.

[3]The debt exposure is considered to be of a significant amount: (1) for the revenue agency, when the total amount of debt expired for value added tax is equal to at least half of the total value added tax due for the previous year and is in any case higher than 100,000 Euro; (2) for national insurance, when the debtor is overdue by more than 6 months in the payment of national insurance contributions of an amount greater than half of those due in the previous year, and in any case, higher than the threshold of 10,000 Euro; (3) for the tax collection agency, when the sum of the receivables assigned for collection by the debtor exceeds the amount of 5% of the volume of business resulting from the taxpayer's last tax return, provided it exceeds the threshold of 30,000 Euro, or in any case, when it exceeds the amount of 5000 Euro; in the case of exclusively value added tax debts, the reference threshold is that indicated in t and (4) If the debtor documents that it is the holder of tax credits or other receivables from public administrations for which 90 days have elapsed since the formal notice, for a total amount that, brought in correspondence with the debts, determines the failure to exceed the thresholds identified by the legislator. In this case, qualified public creditors shall refrain from reporting.

[4]The notice to the debtor must be made by certified electronic mail or, in the absence, by registered mail with acknowledgement of receipt which must be sent by the revenue agency together with the reporting of irregularities. The national insurance institution and the tax collection agent must notify the notice within 30 days of the threshold being exceeded.

The notice from "qualified public creditors" to "corporate supervisory bodies", envisaged only subsequently—after the terms granted—and not at the beginning of the process, seems to confirm that already noted, namely the fact that the two alerts are concurrent. It is quite clear indeed that when the first parties turn their attention to the latter to inform them, they are not carrying out an action aimed at finding a shared solution, but in fact, they notify one-sidedly what is now considered a concrete state of affairs that one can only note. It seems that this notice has more than anything else the function of providing a certain date at the time when the first of the alerts was also triggered for the purpose of applying exemptions and incentives to the corporate supervisory bodies on the one hand, and on the other hand, penalties from the institutions. It must be noted that while corporate supervisory bodies are expected to provide incentive mechanisms for emerging from a state of crisis, in the case of "qualified public creditors", the new legislative framework provides for penalties in the event of inertia of the institution and therefore, potential delays in reporting. In particular, for the IRS (*Agenzia delle Entrate*) and the national insurance institution, it is envisaged that the right of pre-emption will have no effect on the receivables held by them, while for the tax collection agent, the unenforceability of the receivable is envisaged for collection costs and charges.

The effects of the operation of the OCRI or of the crisis settlement body for companies are immediate. It is expected that the body appoints a board of three independent professionals (henceforth also known as the Triad), bound—among other things—by the obligation of confidentiality on all information acquired during the performance of their duties and who must keep secret facts and documents of which they may become aware in connection with their office.[5] The Triad promptly convenes the directors to identify with them the possible measures to be taken to remedy the crisis and sets a deadline by which the directors must report with regard to their implementation. If the company proves to have identified a specific route and to have undertaken initiatives deemed useful to follow it, a deadline of not more than 3 months is set, which can be extended up to a maximum of 6 months in the event of positive results of the negotiations, in order to search for an agreed solution to the crisis. In most cases, the route proposed by the company must be out of court based on substantial agreements undersigned with the creditors and filed with the body, and they cannot be shown to parties other than those who have signed them. These agreements assume significant legal value as they are not subject to the revocation action exactly as would happen in the event of implementing a recovery and resolution planning ("*piano attestato*" pursuant to art. 67 of the bankruptcy law—see below). The new code does not exclude the direct recourse to procedures for regulating the crisis—characterising the next stage—see below—without a prior attempt to settle out of court, also providing in these cases for the possibility of a more invasive intervention by the Triad.

[5]Once the report has been received, the contact person of the Body appoints without delay a panel of three experts from those registered in the register of crisis and insolvency managers, of which: (1) one is appointed by the chairman of the specialised section with regard to insolvency proceedings by the court in the place where the company's registered office is located or by a representative of the company; (2) one is appointed by the president of the chamber of commerce, industry, crafts and agriculture or by his/her representative, and must be different from that appointed by the contact person and (3) one is appointed by the local representatives of the business associations of each category, each of which forwards to the body, a list containing a number of experts registered in the aforementioned register, among which the contact person identifies the one appointed by the representative association of the sector to which the debtor belongs.

2.4. Fourth stage: reversible insolvency and use of crisis and insolvency procedures

In the event of the failure of out-of-court negotiations, assisted or not by the Triad appointed by the OCRI, the company structurally enters into a stage classified as reversible insolvency. The new code recognises "insolvency" as the status of a debtor who is no longer able to meet its obligations on a regular basis. During this stage, this situation is known and manifests itself in the company, both outside of third parties for the failures incurred and for attempts—which have been proved unsuccessful—to reach individual or collective free agreements with creditors. In the event that the external alert has already been triggered in the previous stage, and by the assigned or extended deadline, it has not been possible to reach an out-of-court agreement with the creditors involved, the Triad requests the debtor to apply for access to a procedure for regulating the crisis or insolvency within a very short time (maximum 30 days).

In the first instance, the directors must verify that the situation is still reversible, that there are specific possibilities for carrying out a turnaround in direct or indirect continuity or the implementation of a liquidation intervention plan beneficial to creditors. The tools provided for this from the new crisis and insolvency code[6] are, in substance, even if subject to some significant changes, those already introduced in 2005 in Italian legislation following less invasive reforms, but that undoubtedly have had a significant cultural and behavioural impact[7] [11–16].

To counter the difficulties of the crisis, the Italian government has indeed already introduced during the last decade some specific instruments: (1) recovery and resolution planning ("*piano attestato*" pursuant to art. 67 of the bankruptcy law); (2) restructuring agreement ("*accordo di ristrutturazione*" pursuant to art. 182 bis of the bankruptcy law) and (3) PAC-preventive arrangement with creditors ("*concordato preventivo*" pursuant to art. 160 of the bankruptcy law).

In the PACs, the proposal extends along one of the following alternatives [15, 16]: (1) restructuring of debts and satisfaction of credits through any form, including the sale of assets and the allocation of shares or other financial instruments ("*concordato liquidatorio*"); (2) ongoing business managed by the debtor ("*continuità diretta*"); (3) business or part of the ongoing business transferring the property thereof to one or more different companies ("*continuità indiretta*"). In the first case—liquidation agreement—the debtor must "ensure" payment of secured creditors and a minimum payment of at least 20% of the corresponding original unsecured debt. More than this, the debtor must provide new funds to be able to add at least a 10% to the sums allocated to unsecured creditors.

These techniques form a continuum based on the degree of judicial intervention and the degree of formality in general [21]. Ideas to shape them come from the US Chapter 11

[6]Procedures for settling the over-indebtedness crisis which essentially concerns consumers, professionals and minor entrepreneurs are here ignored.

[7]The reform of Italian Bankruptcy and Business Recovery Law was introduced in 2005 and then reviewed more than once [11, 17–19]. It has fundamentally changed the philosophy and the basics of the country's business recovery procedures. The new regulations has been introduced to the maintenance and recovery of the company by estimation of agreements between creditors and entrepreneur, with a greater involvement of the former in management of the crisis [12, 20].

tradition [22–25] and from United Nations Commission on International Trade Laws [26], Legislative Guide to the Insolvency Law. The focal point is that restructuring can help to preserve the business value of debtor enterprises, the interests of other stakeholders and the benefit of creditors as a whole [4]. According to the UNCITRAL Legislative Guide (2005)[1], all debtors that falter or experience serious financial difficulties in a competitive marketplace should not necessarily be liquidated; a debtor with a reasonable survival prospect (such as one with a potentially profitable business) should be given the opportunity to demonstrate that there is a greater value (and, by deduction, greater benefit for creditors in the long term) in maintaining the essential business and other component parts of the debtor. Restructuring and reorganisation proceedings are designed to give to the debtor some breathing space to recover from its temporary liquidity difficulties or more permanent over-indebtedness and, as necessary, provides the debtor with an opportunity to restructure its debt and its relations with creditors. If reorganisation is possible, generally, it will be preferred by creditors if the value derived from the continued operation of the debtor's business will enhance the value of its claims [11, 12].

The success of any restructuring technique is related to the quality of operations that the company has planned to implement. This is the reason why, no matter which of the three instruments the company chooses, the law requires that more than one independent expert should analyse the potentially prospective financial data produced by the recovery strategy. Different specific opinions are required about the feasibility of the project and the fairness of the expected figures. In recovery and resolution planning and in restructuring agreement, they are expressed by an independent expert indicated by the company, while in PACs, a second opinion is needed from the Trustee indicated by the Court.

In addition, the situation is continuously monitored by the Board of Statutory Auditors (*Collegio Sindacale*) [27]. In fact, at this stage, the corporate supervisory bodies—after contributing to the alert process that led to structuring the solution chosen by the company—continue to perform their supervisory and auditing activities. To this end, they monitor, in compliance with the documents issued by the Italian Board of Certified Public Accountants (Rules of Conduct of the Board of Statutory Auditors, December 2015), the conduct of the directors, the economic and financial performance and the company's financial statements, assessing, in carrying out their periodic checks, the sustainability of the choices made and the methods for actually implementing the latter. The results of this activity are noted in their minutes and reports.

2.5. Fifth stage: full insolvency and application for judicial liquidation

If directors do not consider the possibility of applying one of the procedures for regulating the crisis and insolvency or the latter have not had the desired outcome, the company finds itself in the final stage of the process called overt insolvency. The situation is now irreversible, financial reconstruction goals are no longer usefully pursued, nor are there sufficient fresh financial resources available to implement an agreed settlement. In fact, it is only necessary to remember that the new code provides for the possibility of setting up a settlement agreement only if there is an insufficient contribution to increase the satisfaction of unsecured creditors by at least 10%. The only viable way therefore, remains that which the new code calls "judicial

liquidation", with this expression meaning the procedure currently known as "bankruptcy".[8] It is important to highlight that among the persons entitled to file a petition for the opening of the proceedings, the code envisaged alongside the debtor himself, creditors, the public prosecutor and the corporate supervisory bodies and therefore, first of all, the board of statutory auditors.

2.6. Summary table

Table 1 provides a summary that highlights planned initiatives and who is actively involved in the various stages of the crisis, distinguishing between bodies that operate in the corporate *governance* sphere with management roles or supervisory roles and external entities.

2.7. A short comparison with the French "Alerte"

The Italian system to detect business crisis can be compared with the French "Alerte". The Italian law actually was inspired by this prior model.

Two roles are similar. As soon as the entrepreneur understands that sooner or later the company will get into a crisis, he can undertake a preventive and objective diagnostic process. This helps him to identify the causes of the situation and to be able to remove them as quickly as possible. The entrepreneur evaluates the severity degree of his difficulties so that the "Alerte" process helps him to properly manage the situation. If the entrepreneur is not able to do the job by himself, auditors are asked to notify the alert as soon as they identify facts that could compromise the continuity of the business. If the entrepreneur, once informed, does not give a satisfactory answer or even when the decisions taken by the "assemblée générale" do not guarantee the business continuity, auditors can ask to be heard by Court President.

Some other roles are different. On the one hand, as already pointed out, the Italian new code identifies a specific category of parties considered to be particularly relevant for the timely detection of the crisis which are defined as "qualified public creditors" and which are given very significant powers in the alert process. The parties are IRS (Agenzia delle Entrate), the national insurance institution and the tax collection agent as already explained. On the other hand, in France: (1) a specific power is given to employees through the "comité d'entreprise". When they get aware of the facts that may affect the company's economic situation, they can request explanation to the employer. If the answer confirms the situation detected, they may decide to send a report to the entrepreneur and to the auditors and (2) then, shareholders informed of events that may compromise the business continuity, can notify the facts to management through a written question. The answer must also be communicated to the auditors who can notify it to the Court President if they consider it useful and (3) at last, the

[8]The desire to impose a change of name is not only a lexical whim, but brings with it the desire to eliminate the very negative connotation unquestionably linked—in the Italian context—to the concept of "failure" and consequently of "loser" when addressed to individuals. This decision was probably also influenced by the detection during the years of crisis of an important increase in the number of suicides among Italian entrepreneurs. According to the Link Lab Social Research Laboratory of Link Campus University, "suicides due to financial reasons" were over 800 from 2012 to date. From the above-mentioned, about 43% are entrepreneurs, of which more than 30% are in the North-East alone. *http://linklab.unilink.it/suicidi-motivazioni-economiche-dati-1-semestre-2017*

Stage	Business situation	Planned initiative	Parties involved	
			Within Corporate Governance (with management or supervisory roles)	**External parties**
1	Incubation of the crisis	Informal internal alert	• Directors • Corporate supervisory bodies: Board of statutory auditors (*Collegio Sindacale*), Audit Firm	---
2	Maturity of the crisis	Formal internal alert	• Directors • Corporate supervisory bodies: Board of statutory auditors (*Collegio Sindacale*), Audit firm • Legal advisor, Financial advisor	• Credit institutions, Banks • Independent expert, I.E. (*Attestatore*) • Possibly: Court, Judicial Commissioner J.C. in the event of a PAC
3	Reversible overt crisis	Internal alert to external entities (corporate supervisory bodies). External alert to external entities (qualified public creditors)	• Directors • Corporate supervisory bodies: Board of statutory auditors (*Collegio Sindacale*), Audit firm • Legal advisor, Financial advisor	• Qualified public creditors • Crisis settlement body for companies (OCRI) • Triad of independent professionals appointed by the OCRI • Independent expert, I.E. (*Attestatore*) • Possibly: Court, Judicial Commissioner J.C. in the event of a PAC
4	Reversible insolvency	Crisis and insolvency regulation procedures	• Directors • Corporate supervisory bodies: Board of statutory auditors (*Collegio Sindacale*), Audit firm • Legal advisor and Financial advisor	• Crisis settlement body for companies (OCRI) • Triad of independent professionals appointed by the OCRI • Independent expert, I.E. (*Attestatore*) • Court • Judicial Commissioner J.C. in the event of a PAC
5	Full insolvency	Judicial liquidation	• Directors • Corporate supervisory bodies: Board of statutory auditors (*Collegio Sindacale*), Audit firm • Administrative authorities that exercise supervision and control over the company	• Creditors • Public prosecutor • Court • Trustee

Table 1. Parties involved in the crisis governance and actions needed during the various stages.

most remarkable role, in France context, is the one reserved directly for the Court President. When he has knowledge of the difficulties of a company, he shall convene the entrepreneur to an interview, so that this last is provided with measures to correct his situation. He may,

if necessary, obtain from the auditors, the administrations, the social organisations and the "Banque de France", information on the situation of the company.

3. A change from the revolutionary scope: the extension of the range of corporate bodies obliged to legal forms of control as a condition for the success of the alert procedure

The real revolutionary scope of the new code is, in the authors' opinion, the enhancement of the corporate supervisory function with the extension of the range of corporate bodies obliged to legal forms of control. The appointment of the corporate supervisory body—board of statutory auditors (*Collegio Sindacale*) or maybe single statutory auditor—becomes mandatory if the company has exceeded *for at least two consecutive years; one of the following*[9]: (1) total assets in the financial statements: 2 million Euro (equal to less than 50% of the previous limit of 4.4 million Euro); (2) revenues from sales and services: 2 million Euro (equal to less than 25% of the previous limit of 8.8 million Euro); (3) employees employed on average during the financial year: 10 employees (equal to 20% of the previous limit of 50 employees). The obligation to appoint the control body or auditor ceases when, for three consecutive financial years, none of the aforementioned limits have been exceeded. Size of the company becomes crucial for the appointment of the Board of statutory auditors. The lowering of the threshold beyond which is required to appoint the Board of statutory auditors is expected to carry positive effect.

The scale of this cultural change is indeed likely to be much greater and more invasive than the introduction of OCRI itself, as well as the identification of automatic crisis detection mechanisms for qualified public creditors.

The introduction of these new thresholds represents a very important recognition of the usefulness of corporate supervisory functions for the correct functioning of the system, when carried out according to the ethical and professional standards of reference [28]. The Board of statutory auditors (*Collegio Sindacale*) is the specific watchdog distinguishing the Italian corporate governance traditional system[10] [12]. The abovementioned change intends to modify the behaviour of directors of medium-sized companies, but especially of small- and micro-sized companies that are very numerous in Italy[11] and today have escaped the obligation to equip themselves with appropriate control systems, or even with appropriate accounting and management systems. Infrequently, in these small businesses, the administrative functions are still perceived as an obligation related only to tax obligations and are delegated in full by outsourcing, losing

[9]Furthermore, companies required to draft consolidated financial statements and who control a company obliged to audit the accounts are required to appoint the board of statutory auditors.

[10]With the enactment of the Commercial Code in 1882, it was introduced a supervisory organ for the compliance control to the law, to the Constitution and to the Statute of the company because after the abolition of Government Supervision, it was necessary to entrust the fate of a company not entirely to administrators, whose activity in reality should be controlled to protect the interests of the company, its shareholders and all the stakeholders.

[11]For a breakdown of the company situation and in particular, the composition of the type of businesses affected by the crisis in the last period, please refer to paragraph 5 where the empirical analysis is presented.

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sight of the scope and relevance of tools such as the drawing up of frequent periodic financial statements and of business units and dashboards of significant indicators for management control and specifically for corporate governance. One only needs, in fact, to recall the Rule of Conduct 1.1 issued by the Italian National Council of Chartered Accountants and Accounting Experts (*CNDCEC*) [29] for the Board of statutory auditors (*Collegio Sindacale*), which establishes that the latter, in carrying out the function recognised by the law, supervises that the control system and the organisational structures adopted by the company are adequate to promptly detect signals that raise significant doubts about the company's ability to continue operating as an operating entity. The Board can request clarifications from the board of directors and request the latter to take appropriate measures.

Size is relevant because the smaller it is: (1) the less structured usually appears to be the general accounting systems; (2) the less implemented typically result in management systems and consequently, the capabilities to produce both short-term and long-term projections and forecast; (3) the weaker are expected to turn out to be internal auditors' procedures. In this context, reducing the threshold beyond which it is required to appoint the Board of statutory auditors introduces some useful and healthy routines.

In fact, among the functions of the Board of statutory auditors (*Collegio Sindacale*), the protection of all the interests must be emphasised. The administration and control system called "Traditional", as an alternative to the one-tier and two-tier corporate governance model, is the prevalent one in the Italian context. According to article 2380 of the Civil Code, the "Traditional" model constitutes the natural system of corporate governance for the management of Italian firms, the application of the two alternative models must be indeed expressly provided in a special provision of the company's statute. The structure of this model provides an administrative board appointed by shareholders, which is responsible for the management of the company, the Board of statutory auditors (*Collegio Sindacale*) again appointed by shareholders that carries out the control over the administration and the external audit firm also appointed by shareholders, which is responsible for the auditing. This model allows a precise division of roles: the administrative function is clearly separated from the control function. The Board of statutory auditors (*Collegio Sindacale*) appointed by shareholders is made up of three or five effective members (and two temporary auditors). One effective member and one substitute should be enrolled in the register of auditors. Since the introduction of the Reform of Company (Legislative Decree N. 6, January 17, 2003), the Board of statutory auditors (*Collegio Sindacale*) is responsible to supervise[12]: (1) the observance of the law and the statute, it should verify the compliance of acts and resolutions to the provisions of both law and statute; (2) the conformity of the management decisions to criteria of rationality (efficiency and effectiveness of choices) and if management has considered all the information necessary for taking operational decisions and (3) the adequacies of the organisational structure that must be suitable to the size, to the nature of the operations and to the strategies planned to achieve corporate purposes.

[12]According to Art. 2403 Civil Code, "The Supervisory Board oversees compliance to the law, to the company's Statute to the principles of good management and the adequacy of the organisational, administrative and accounting procedures adopted by the company during its functioning".

There is no doubt that the Board of statutory auditors (*Collegio Sindacale*) represents an important element of the Italian experience that should be emphasised in international contexts. The great crisis that has hit the world economy since 2008 could have been avoided if more companies would have adopted an adequate internal control system to ensure the protection of the social interest performing their duties. Even Joseph Stiglitz—who won Nobel Prize for economics, 2001—highlighted the criticality and riskiness of governance models based only on external auditor (typical of Anglo-Saxon models) praising the Italian model based on the structural presence of a typical totally independent internal control body, that is, the Board of statutory auditors (*Collegio Sindacale*) [27]. The members of the latter attend the assembly of the Board of Directors assisting directly to the decision-making processes and stepping in meanwhile things happen. On the contrary, external auditors operate when everything has already been decided or even implemented. The peculiarity of the Italian System Controls is the joint existence of two levels of controls. A "downstream" control carried out by auditors in charge of the accounting control and an "upstream" control carried out by the Supervisory Board in charge for the surveillance of management's behaviour. In small companies, the Supervisory Board usually undertakes both roles. With the new code, this will become the most widespread instance.

4. Dashboard of indicators and thresholds that trigger alerts: "Deterministic" approach and business economic approach

The extent of the changes introduced has made it essential to identify parameters that allow to understand as objectively as possible if the company is entering the crisis and what is the severity already reached by it in order to classify the situation. Only in this way, it is indeed possible not to delay (although it is important to underline that they must not be anticipated), the interventions envisaged by the new regulatory framework by the various stakeholders involved. This is a crucial issue which, if not duly addressed in corporate economic terms, risks not only to render the new mechanism for emerging from the crisis ineffective but also makes it very risky to issue alerts in advance. In fact, there are many elements that must be considered in order to form an opinion on a company's situation. Many authors [26, 27] have long indicated that it is not correct to base its evaluations on the exclusive reading of some specific indices, but that it is essential to adopt a systemic approach, certainly more complex, less efficient and less objective, but more effective and with substantial and not only formal discriminative capacity.

We here describe the changes made in the legislative texts currently made available that bear witness to the current debate and the important and positive interventions occurring during the course of the work, to then propose empirical research aimed at highlighting the degree of effectiveness of the various solutions.

The issue was in fact addressed first of all in the Government Enabling Act approved on 11 October, 2017 which identified more than a systemic dashboard of economic-financial and equity indicators, literally "four" financial indicators that the corporate supervisory bodies

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must take into consideration and assess in order to classify the company situation and consequently, to decide on which actions to take. These are the following parameters: (1) debt ratio; (2) credit rotation index; (3) inventory turnover index and (4) liquidity index. It is worth pointing out that in companies without a warehouse, the parameters identified are reduced to three.

The draft of the crisis and insolvency code, which has been followed up by the Enabling Act in order to implement the latter, no single indicators are recalled, but, taking in substantial terms the indications provided in the Enabling Act, it is less deterministic. It refers to a dashboard of indexes which need to be designed taking into consideration the specific characteristics of the entrepreneurial activity carried out by the debtor. Focus is on the sustainability of debts in the following 6 months and prospects of business continuity, as well as the existence of significant and repeated delays in making payments. The code then makes an explicit and strong reference to *specific standards* on the matter that will be issued by the professional category of reference, in other words, the Italian National Council of Chartered Accountants and Accounting Experts (CNDCEC). The latter is in fact indicated as the only entity required to draw up, on a 3-year basis, those indices which, assessed as a complete dashboard, reasonably assume the existence of a state of crisis in the company. It is important to highlight that the Code specifies that the choice of the indicators must not be formulated in a general way for all companies, but that specific indicators must be considered for each type of economic activity according to the National Statistical Institute (Istat) classifications. In formulating the reference documents, the Board is invited to consider national and international best practices.

The draft Code, however, continues to identify, along with the indices developed by the CNDCEC, some parameters and some thresholds of the values assumed by the latter, which give rise in certain situations to unique elements to be considered for the automatic occurrence of some effects. These are the parameters that are deliberately measurable in an "objective" way and this of course implies that readings of the latter are not acceptable in the context of a more systemic view of the business situation.

The "deterministic" approach remains in two cases: firstly, to qualify the debtor's initiative as to promptly trigger the alert and, therefore, to assess the applicability of reward measures for the debtor company and of the liability for the Board of statutory auditors (*Collegio Sindacale*). In fact, requests for access to one of the insolvency procedures after the 6-month deadline, or the request to the OCRI following the end of 3 months, to be counted from the moment of verifying the occurrence of the following, are considered timely: (1) the existence of debts for wages and salaries expired for at least 60 days for an amount equal to more than half of the total salary; (2) the existence of payables to suppliers expired for at least 120 days for an amount higher than that of unexpired debts. Secondly, as already described above, determine the moment in which qualified public creditors must serve their own notifications first to the debtor and therefore, in the event that no solution is found, to the OCRI and at the same time as the Board of statutory auditors.

The method based on a dashboard of indicators is only one of the different approaches. Inductive approach is the simplest method—based on non-financial indicators—to detect business crisis. This last—that uses external indicators such as an extraordinary staff turnover or the loss in market share—normally used by small and unstructured companies— requires

not only the ability of the entrepreneur to detect the business crisis but also the courage of the entrepreneur to bring out his situation. More challenging is the use of multivariate approaches— such as the linear discriminant analysis—which constitutes the benchmark for our empirical research above described (see Section 5)—or the logistic models. The aim of these approaches is to detect business crisis through the use of statistical methods to encapsulate all different financial indicators.

5. Verification of the effectiveness of the financial statement indices required by the enabling act: an empirical analysis

It has been proposed to verify whether the four financial indicators indicated explicitly, as mentioned earlier, in the Enabling Act (Ddl 3671bis) can be considered alone sufficient to form a reasonably acceptable opinion on the existence and severity of the crisis. It must be noted that this refers to the debt ratio, the credit rotation index, the inventory turnover index and the liquidity index. The tested research assumption can therefore be summarised as follows: *the use of only the four indicators identified in the Enabling Act is sufficient to correctly and reasonably differentiate the situations in which it is necessary to trigger the alert procedure.*

The analysis was conducted on a sample of 677 companies that requested access to the PAC before the Court of Milan during the years 2008–2014 (out of a total population of 1299 companies, with a coverage of 52%). Financial statements for the three financial years preceding the application were analysed. The sample was almost entirely composed of 98% capital companies, of which 61% were limited liability companies and 22% public limited companies. The analysis of the distribution of the companies in the sample shows that 47% belong to the secondary sector and 51% to the tertiary sector. With reference to the size, adopting the definition of the European Commission (Recommendation No. 2003/361/EC), the sample was distributed in four macro-classes based on the number of employees of the year preceding the presentation of the application for a settlement with creditors. The companies are mostly micro and small, or in other words, with a number of employees less than 50 (**Figure 1**).

The analysis is carried out considering the values assumed by the indicators provided for by the Enabling Act (henceforth also "Indices of 3671bis") and setting a comparison between the results

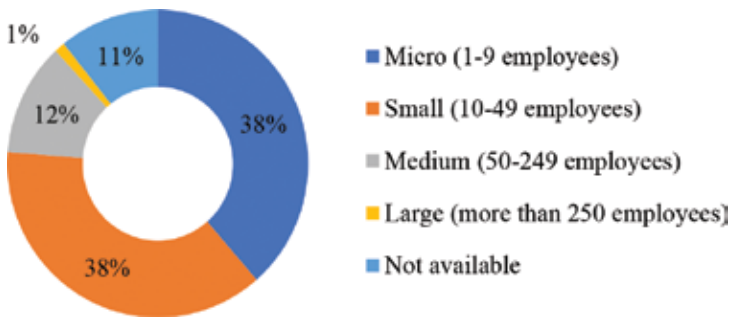

Figure 1. Size of companies.

achieved and those that would be obtained by applying the different model of the Altman Z′-score (Altman 1993) proposing a more systemic approach to the issue of corporate performance assessment. More specifically, Z′-score best suited to the Italian entrepreneurial network is used [28–30]. This expression of the well-known model is based on the use of a function that identifies the health status of each company (y), whose dependent variables (x) are represented by five financial statement indices. The indices in question are as follows: working capital/total assets (x_1); net profit/total assets (x_2); EBIT/total assets (x_3); book value of equity/book value of total debt (x_4); sales/total assets (x_5). The model is therefore composed as follows:

$$\boldsymbol{Z' \; score} = (\boldsymbol{x_1} \cdot 0.717) + (\boldsymbol{x_2} \cdot 0.847) + (\boldsymbol{x_3} \cdot 3.107) + (\boldsymbol{x_4} \cdot 0.420) + (\boldsymbol{x_5} \cdot 0.998) \quad (1)$$

Based on the value assumed by the dependent variable Z', three different "zones" are identified:

- safe zone: for results greater than 2.90; it includes those companies for which the probability of default is low;
- grey areas: for results between 1.23 and 2.90; it includes those companies for which the probability of insolvency is possible. It is a situation of uncertainty;
- distress zones: for results lower than 1.23; it includes companies for which the probability of default is high.

For each company in the sample, the "Indices Ddl3671bis" have been calculated on the financial statements for the 3 years preceding the application, verifying when they assumed values that are reasonably acceptable (positive) and when, on the contrary, they assumed significant values of the existence of a (negative) corporate crisis. Each of the four variables was therefore made measurable and classifiable in a dichotomous manner, identifying, in essence, reasonable thresholds of alert for each of the indices. To this end, significant values of high indebtedness, slow credit rotation, a slow turnover of the warehouse and a strong financial imbalance qualified as negative. This analysis allowed to identify a five-point measurement scale depending on the values assumed by the indices and the companies reclassified in the three typical index-zones of the analyses that can be obtained with the Z-score in order to make the results comparable:

- safe zone: companies in which there are no negative indices (zero negative) or that have only one (negative) index are included in this zone;
- grey zones: companies in this zone have recorded two negative indices;
- distress zone: companies which have recorded three or four negative indices are included in this zone.

The percentage of companies that fall into the grey area is very high, in fact these are percentages that vary from 60% of the year (x−1) to 49% of the year (x−3) which attest to the fact that in essence at least in half of the cases the indices are not able to provide unambiguous indications deemed useful to be able to differentiate between the various situations in an objective way.

The Z score was then calculated with reference to the same sample of companies and therefore on the financial statements themselves. The results seem to be much more significant. By analysing the zone in which the results can be found, it is noted that the percentage of companies that are included in the distress zone on getting closer to the year in which an application for a settlement with creditors has been submitted (65, 74, 87%); the opposite trend is assumed by the grey areas (31, 23, 11%) and the safe zone (4, 3, 3%) for which the percentage of companies included in them correctly decreases on approaching the year in which an application for a settlement with creditors was submitted.

Table 2 summarises the results obtained.

For purposes of the early emergence from the crisis, the positioning in the grey zone is the most critical since it does not allow to classify the situation with reasonable certainty. The percentage of companies located in the safe zone and in the grey zone is much lower if we consider the Z-score instead of Indices of Law Decree 3671bis, while the opposite trend is recorded with reference to the distress zone.

A weakness of the "Indices of Ddl 3671bis" is undoubtedly represented by the inclusion of the inventory rotation index. It is not always possible to apply the above indicator, in addition, different types of activities involve different warehouses and consequently turnaround days. The indicator can therefore be of complex interpretation if it is not inserted into part of a system with other data and other variables. Companies, for example, of the sample carry out, as mentioned earlier, very different activities from one another, from food to manufacturing, from metallurgy to building and services. The food sector needs a faster turnaround of the warehouse compared to the metallurgical sector due to the nature of processed products; it is not possible to generalise. To sum up, the main features of companies that can be considered to have an impact on the indicator significance are the specific sector and the size of the companies. Each sector has its own particular feature: size, maturity, number and size of competitors, level of technology and speed of innovation.

The non-systemic analysis of the four indicators proposed by the Enabling Act is therefore not sufficient to express a correct opinion on the existence of the business crisis. In more than half of the cases, in fact, it does not allow correctly and reasonably to differentiate the situations in which it is necessary to trigger the alert procedure.

Therefore, the choice of the new "Crisis and insolvency code" to broaden the spectrum of indicators to be considered referring to company economic practice and therefore to standards to

	Safe zone (%)			**Grey zone (%)**			**Distress zone (%)**		
	Ddl 3671bis	**Z′ score**	**Δ**	**Ddl 3671bis**	**Z′ score**	**Δ**	**Ddl 3671bis**	**Z′ score**	**Δ**
X-1	16	3	13	60	11	50	24	87	−63
X-2	28	3	25	53	23	29	19	74	−54
X-3	36	4	32	49	31	18	15	65	−50

Table 2. Comparison of the results of the Enabling Act and of the Z-score.

be issued by the Italian National Council of Chartered Accountants and Accounting Experts (CNDCEC) is noteworthy in order to identify dashboards of significant and differentiated indices by sector as well as the indication that the latter need to be reviewed and updated every 3 years to take into account the changes occurred during the period, with particular reference to evidence of technical and scientific evolution.

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Section 3

Crisis Management in Theory and Practice

Chapter 10

Public Awareness and Education for Flooding Disasters

Leon J. M. Rothkrantz and Siska Fitrianie

Additional information is available at the end of the chapter

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Abstract

In recent years, dramatic river flooding occurred in the city of Prague causing the raising of the river water level more than 8 m and the inundation of the lower parts of the city. The disaster resulted in numerous casualties and damages of buildings and infrastructures. Prior disaster analysis showed that the city was not well prepared for facing the disasters. A digital training could be a powerful tool for increasing knowledge and awareness of the citizens and providing training facilities about response to such disasters. A special Massive Open Online Course (MOOC), therefore, has been developed focused on flooding in Prague offering educational material in crisis flooding. Dedicated technologies have been developed such as a flooding alert and a nonverbal communication language based on icons. The MOOC enables participants to train the new technologies. Participants can also play roles in the crisis management team to increase the sensitivity of the complexity of a flooding crisis and its measurements. The first prototype of the MOOC was tested on a group of students of the Technical Universities of Prague and Delft. The test results will be reported.

Keywords: crisis awareness, MOOCs, dynamic routing, flooding disasters, serious gaming

1. Introduction

In the summer of 2002, there was a heavy rainfall in the central part of Europe [33]. Typical rain rivers, Danube, Elbe, Labe and Vltava had to transport an amount of water far beyond their capacity. Many dikes along the rivers were breached and large areas were inundated. There were hundreds of victims and great damages to buildings, properties and infrastructures. Old cities as Dresden and Prague were heavily affected and large parts of the cities were inundated.

As reported in [6, 32], the analysis showed that the crisis management teams on central and local level of the city were not well prepared for flooding disasters. Moreover, citizens were not aware of the complexity of a flooding disaster. For the city of Prague, the shortcomings can be summarized as follows:

- *Incomplete crisis plan*. A crisis plan was designed and many plans proposed, such as to improve the infrastructure of the city, to strength the dikes along the river, to broaden and deep the riverbed and to create buffers for raising water. Some of these plans were realized but many of them are still waiting for execution. However, some years after a disaster, there was a reduced fear of flooding and costly plans were postponed.
- *Complexity of a flooding disaster*. Many citizens underestimated the power and speed of the raising water. Instead they responded not until it was too late. However, series of events during a flooding disaster could be related to each other. For example, closing the possible inundated metro lines in time could impact evacuation possibilities of citizens.
- *Opposing interest*. To reduce the amount of water in the Vltava, confluent streams could be blocked by dams. This would cause flooding along the confluent streams. To protect the old town, other areas could be inundated on purpose. Such a decision was not always appreciated by people living in inundated areas.
- *Individual versus group decision*. During a disaster, the management team has to take group decisions conflicting individual interest, perception and behavior. In the case of mass evacuation, for example, the analysis showed that some individuals stayed behind until the very last moment and caused problems later on.
- *Communication problems*. Prague is an international city housing many citizens and visitors from abroad who do not master the Czech language. On the other hand, social media has showed their important role during a crisis. It is a great challenge of the management team to get involved in communication via social media.
- *Lack of training*. First responders have organized exercises and trainings at regular times. However, big disasters as flooding can only be simulated. A difficult aspect is how to involve citizens in such disaster trainings.
- *Flow of events*. As mentioned above, events during a flooding disaster could result in and impact other series of events. Therefore, measurements of the management team should be taken in time and not all at once. On the other hand, time and resources are usually limited.

Immediately after the flooding disaster the focus was on repatriation of people and repair of damage to buildings and infrastructures. New plans were developed to control the raise of the water. One of the plans was to build dams in the river Vltava and to create lakes in front of the dam. These lakes can be used to buffer raising water during a flooding disaster. Much effort was spent to improvement of the disaster plans. Lessons learnt for the previous flooding disaster were implemented in the new plan. However, the crisis management realized that

the execution of a disaster plan would require much training of all involved people. On the other hand, to increase crisis awareness of citizens and to organize training for new developed technology is far from trivial.

One of the new developed technologies is a crisis app [7, 9, 10, 29, 30]. Every citizen in Prague can download such an app on his smart phone. The app supports communication between citizens and crisis management team. To train the use of the app special training events have to be organized. Serious gaming, simulation and MOOCs enable the training of such tools. In this chapter, we discuss the development and use of a dedicated MOOC focusing on the flooding disaster of the river Vltava in Prague. The goal of this chapter is to solve the following research questions:

Q1: *Is it possible to use the digital learning material to learn people about crisis management?*

Q2*: Is it possible to increase crisis awareness and commitment by playing different roles in the crisis management team during a simulated flooding disaster?*

Q3: *Is it possible to improve the understanding of the complexity of a flooding disaster and improve the mastering of abilities by training of citizens by following the course?*

The outline of the chapter is as follows. In the next chapter related work will be presented. In recent years, many papers have been published considering the option of serious gaming and digital learning in crisis education. We continue this chapter by describing the general outline of the MOOC and its contents, namely: the developed crisis app, flooding icon-based communication, and crisis management game. Further, we present experiments, survey research and their results. Finally, we end this paper with conclusions and future work.

2. Related work

In recent years we published some papers on the flooding MOOC on learning conferences [24–28], which were focusing on presenting MOOCs as a new didactical learning tool. The content of the course and especially the crisis aspects were hardly discussed. On the other hand, the International Federation of Red Cross and Red Crescent Societies have used MOOCs to enable participatory, collaborative learning by engaging participants in discovery and problem solving for disaster risk reduction [17]. This form of distant learning was one of the implementation of key approaches that were formulated in the guide on public awareness and public education for disaster risk reduction published by this organization [16]. The key approaches were campaigns, participatory learning, informal education and formal school-based interventions. The guide provided an overview of all performed experiments. It has promoted National Societies to make specific choices in developing educational tools and set up their own experiments. The focus of the development was on approaches and tools for public awareness in disaster risk reduction.

Other attempts have been done on developing MOOCs in the field of crisis management. Bacon et al. [2], for example, presented a paper on the design of an immersive online crisis preparation learning environment and promoted MOOCs as a training tool. The chapter was based on three European-funded research projects, namely Pandora [21], dCCDFLITE [8] and POP-ALERT [22], which focused on the preparation of societies and populations to cope with crises in rapid, effective and efficient way. A MOOC platform had been developed to support crisis training of the public on a large scale on an earthquake disaster and a fire disaster. The MOOC was developed based on a survey study that highlighted the cognitive processes of people during the onset of a crisis and factors having an impact of decisions and behavior of people during a crisis. It should be available for general public from 2016, but unfortunately the project had some delay.

The MOOC developed by Beach [4] from the University of Pittsburgh on the Coursera platform provided at least five courses related to crisis management. The courses were intended for individual students who want to develop core competencies of disaster readiness and survival planning various natural disasters, such as flooding, tornado, hurricane, tsunamis and earthquake. The developer took an assumption that many people living in areas threaded by disasters looking for possibilities to increase their knowledge and abilities for crisis survival. Another example of a MOOC in this field was developed by Hostettler [16] from Ecole Polytechnique Federale de Lausanne. The MOOC taught science and techniques for reducing disaster risk and increase resilience during chemical hazards, floods, landslides and earthquakes. The goal of this MOOC was teaching relevant technologies in a relevant context. Students were tested on their increase of knowledge and less on acquired abilities. On the other hand, a MOOC developed by Leaning and VanRooyen [19] from Harvard University prepares participants to recognize and analyze emerging challenges in the humanitarian work during crisis response.

MOOCs could also be used for training existing software tools for crisis management. At the ISCRAM conferences many authors presented tools which could be used for communication during a crisis or to support evacuation. Some of these tools have been tested in real-life experiments but most of them were tested in simulation studies. Some of our previous works presented in these conferences were in the field of dynamic routing and nonverbal icon-based communication [9–13, 23]. Another project that focused on developing services and tools for emergency and civil security organizations for training and crisis management was the Indigo project [1]. Within this project, research and testing of other existing software tools for crisis management were also reported. Two of the tools were CRIMSON and Hazmat. CRIMSON was a system that combined latest simulation and virtual reality technology [3]; Hazmat was a hot zone-networked multiplayer simulation [20], where responders could be trained in emergencies with chemical and hazardous material emergencies.

Furthermore, we consider applying serious gaming approaches on our MOOC design. Serious gaming is ideally suited to developing new insights into complex situations such as crisis situations, experimentation, and education and training of people working in these

complex environments. Based on this, in [5], we discussed the use of serious gaming in the training of first responders during a crisis event. The serious gaming was developed based on dynamic scripting to replace the static linear flow of events by a dynamic mixture of events.

The proposal of using scenario and serious gaming during a crisis simulation was initiated by Walker [34] from RAND/European-American Center for Policy Analysis. He stressed the fact that course of events would be difficult to predict during a crisis. As a crisis would be developed in the course of time, momentary decisions would have their impact on the rest of the course. A realist interactive game design would almost be impossible. The only option would be to provide scenarios and gaming with predefined decisions and consequences based on analysis of historic disasters.

The Hague Security Delta [31] has used a serious gaming technology to train professional and managers to protect critical infrastructures during disaster events. Based on the results of these trainings, the company showed that serious games could also be used for increasing crisis awareness and developing innovative theories [15, 35].

A game on Dutch flood risk management has been developed by Janssen [18, 34] to train actors in the assessment of measures which could reduce flood risk and limiting the impact. To visualize the consequences of human intervention and the effect of flood reducing measures, the author developed a simulation of the flooding and inundation of large areas using an area around the harbor of Amsterdam as a case study. The research showed that by playing the flooding game, the awareness of parameters influencing flooding disaster of players were increased. This game provided an environment to cooperate to realize common goals.

Another game for training decision makers in managing crisis was developed by researchers from Thales, T-Xchange and TNO in the framework of the research program Game Research for Training and Entertainment (GATE) [14]. It involved a role of a mayor of a city. Many mayors were willing to provide their knowledge, with which a mayor had to master in his daily management job facing important issues and dilemma's a mayor has to master in his daily management job in the city. To test the game, training facilities were developed by the T-Xchange company at the campus of the University of Twente in the Netherlands. One of the facilities offered was an augmented reality device using Google Glass. These facilities provided real time crisis simulation involving rescue workers and were used to perform and to test a number of serious games developed by the research program.

Instead of using training facilities, we aim at training first responders and civilians in managing crisis using a combination of the serious game approach and previous developed simulated tools using a MOOC. The goal of the MOOC is to increase crisis awareness and relevant abilities, which usually could only be done by time-consuming and costly training exercises. The dynamic scripting is applied on a role play game where participants of our MOOC will be confronted with outcomes of their management decisions from a list of possible options.

3. Model

In this section, we describe a selection of our developed learning modules that provide a main contribution to the crisis awareness, crisis knowledge, development of crisis abilities and offering training facilities. We will also present the implementation of the modules and the use of didactic approach.

3.1. Learning module development

Participants of the MOOC will be a member of a crisis management team. Solving problems and taking management decisions will confront participants with ongoing events during a flooding disaster. Furthermore, previous experimental results showed that the MOOC could generate high feeling of presence and involvement of participants in the flooding disaster [26]. A great difference with classical e-learning is that MOOC students are free to enroll (anonymously) in the MOOC course without enrolling as a student to the home University. Given the expected great numbers of participants, teachers are not present prominently.

The modules of the MOOC have been implemented using Moodle, a well-known open-source platform for developing and distributing digital learning material. Moodle is a tool to develop classical digital learning modules divided into learning material in categories and courses and equipped with quizzes or assignments. More advanced platforms and learning communities offer more advance training modules and support. In the past, we had some experience with *edX*. However, to be a member of the learning community requires a yearly significant contribution. The goal of the current course was to develop the course by low budget means. This course should inspire members of the Czech Technical University network and to develop MOOCs, which should be available for all partner universities. Furthermore, Moodle opens up possibilities to develop more advanced tools and to make these available for the Moodle community.

We found that one of the difficult problems in developing a MOOC was to organize cooperation between students. This was because of the following reasons: (1) Many students prefer to study individually rather than in a group; (2) The student population participating in the MOOC is rather heterogeneous with respect to age, education, background and abilities; (3) Cooperation via social media is difficult to organize in distant learning on a large scale; and (4) Compared to regular students most students involving in MOOCs have no direct relation to each other and there is usually a great group of left-overs not participated in cooperative groups [27]. Therefore, the integration of social media and group interaction is still under development.

Another problem with the use of MOOCs is the high dropout rate [25]. It is a great challenge to motivate students in such a way that they keep on board. We approach this problem using an interactive learning environment and a focus on application oriented learning using simulations. One of the ideas is by the use of inquiry-based learning [28]. The approach requires

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students to pose questions during learning instead of having answers to questions. A reminder to pose questions is sent at regular times to the students. A dedicated software has been designed to put these questions on a bulletin board as most frequently asked questions. Some of these questions will be answered or discussed by other students. But the main idea of generating questions is to improve the alertness of students during learning.

3.2. Social media

Social media play an important role during a flooding crisis. Citizens in Prague or people staying in Prague share their observations and emotions via social media (**Figure 1**). Management crisis team can use this information posted on social media to improve the context awareness, to detect signs of panic in the community or to assess ongoing topics and for supporting the decision-making process.

The crisis team has less control over the communication. To sort the tweets on Twitter, the management team could introduce the hashtag`#flooding` and post some tweets in the hope that people will post their tweets using the same hashtag. Information posted on social media can be very subjective, full of misperceptions or even faked news. Tweets #1 and #2 in **Figure 2(a)** contain probably contradictory information. However, this occurs due to the hilly landscape of the city of Prague. It could happen that valleys were full of water and the hills were still dry. Furthermore, below the surface of Prague there are many caves and sewage, transporting the water below the barriers.

Many Czech speaking people staying in the city of Prague. But also many foreign tourist staying in Prague, who are speaking many languages except Czech (**Figure 2(b)**). These tourists could send their messages with observation to the crisis center and vice versa. They

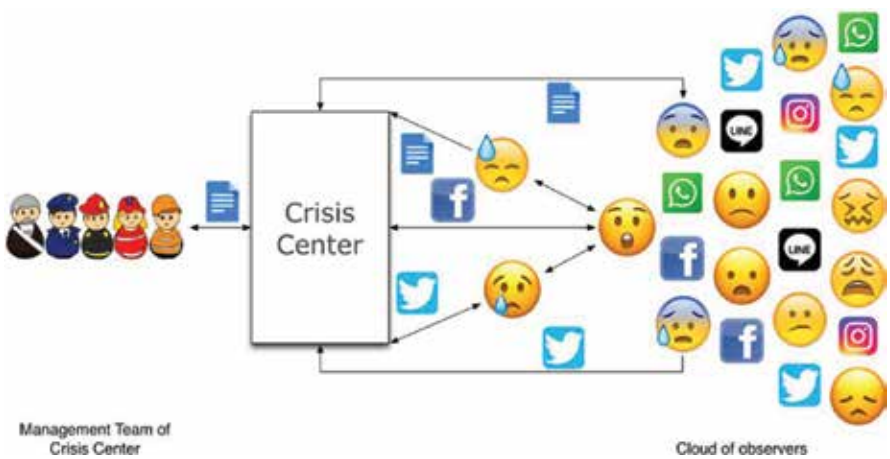

Figure 1. Cloud of observers communicating via social media.

Figure 2. People in the city are able to use an app to send their observations to the crisis center: (a) tweets and (b) multi-language messages.

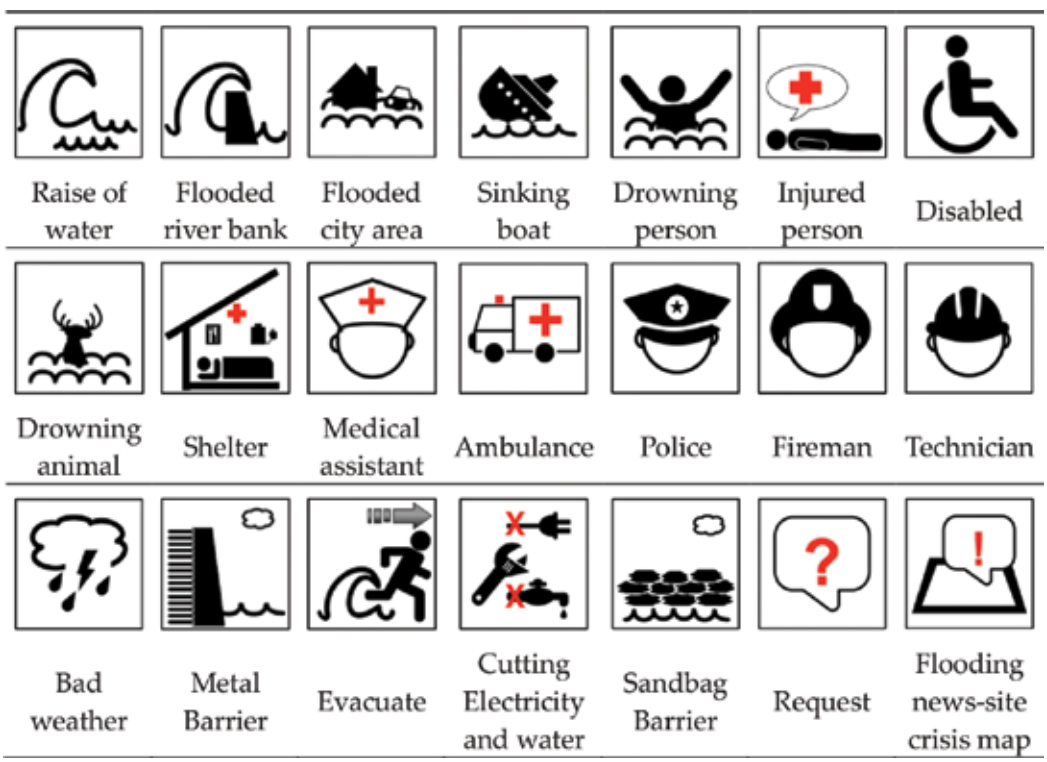

Table 1. List of icons in the flooding language.

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will receive emergency messages from the crisis center or from people in the shared disaster area. It is impossible to do this in all available languages, therefore, there is a need to use a dedicated nonverbal language. We developed in the past a crisis language with a dedicated syntax and grammar [11–13, 19]. The idea was to convert a sentence in natural language to a string of icons automatically. Many icons and grammar rules were needed. In the current approach, we applied the icon language to the flooding situation and we converted observations to a string of icons directly without natural langue as an intermediate step.

A flooding is a typical natural disaster with specific events, which can be symbolized by icons (**Table 1**). People in the city can send messages, composing a string of icons via the crisis app using the icons from the flooding language. A GPS coordinate and time stamp will automatically be added to the message. In the crisis center all the icon messages will be interpreted and converted to natural language sentence. An icon message is usually ambiguous or incomplete. However, we have to consider such a message in the crisis context (**Figure 3**).

3.3. Evacuation during a flooding disaster

One of the most difficult events is to organize an evacuation from the lower parts of Prague. It has involved about 500,000 citizens, who have to be evacuated in time before the area will be flooded. As presented in Section 3.2, a dedicated app with an icon-based flooding language has been designed to enable the citizens and the crisis center to communicate with each other and can be used during the evacuation process. However, citizens tend to postpone evacuation to the very last moment, because people do not want to leave their houses and properties behind without supervision. Another problem is that the situation is changing dynamically that requires a very flexible and adaptive evacuation plan. In the framework of the MOOC, we developed a dedicated adaptive routing device enabling pedestrians to route to shelters or safe areas [23]. This section describes this routing device in more details.

Figure 3. Mobile messages sent in the form of text, photograph and icon message that convey the same meaning in the context of flooding disaster.

Nowadays, people are familiar using route planner software on their smart phone to navigate them to a certain destination. The app receives the position of the user at regular times. Therefore, the system is able to track the user and computes the traveling time between way points. A navigation system usually uses a well-known shortest path algorithm for a static environment, such as Dijkstra's algorithm, to compute the shortest path from start destination. During a flooding disaster, people can use the navigation app to route them to safe areas. However, during such a disaster, streets could be inundated, tunnels could be closed and bridges could be collapsed. The pedestrian on their way to safe areas have to adapt their route or even have to return if the upcoming water blocks their route. Even, local citizens of Prague may not know how to go to safe areas in such conditions. In addition, if many pedestrians use the same route, congestions can occur and it takes more time to walk along the route.

We developed a dedicated flooding app that was equipped with a navigation system. The system displays flooding events on a map and an arrow showing the direction to a safe area/ shelter (**Figure 4**). The map is dynamically updated in case of upcoming water. Similar to the route planner in Google, the system uses a shortest path from current location to safe area. For this purpose, the street network of the City of Prague is visualized as a graph with crossings as points and streets as connecting edges. Given a starting point and a destination point, the system can compute the shortest path and route the user along this path based on the static

Figure 4. Navigation on the flooding app and the graph representing the street network of the city.

t	A-B-D-E	A-C-D-E	A-E
00.10	Blocked	Blocked	30
00.05	Blocked	25	30
00.00	23	25	30

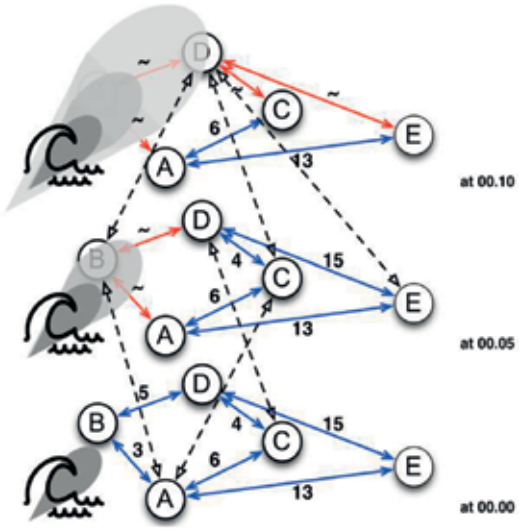

Figure 5. Visualization of the dynamic routing algorithm.

routing algorithm. However, during a flooding disaster, a dynamic routing algorithm is needed.

To apply the dynamic routing algorithm, the app receives observation reports that are sent by people in the area. Using this information, the app is able to update the availability of each route and the map dynamically. Let us consider five locations on the city map: A, B, C, D, E and assume the point E is the safe area. **Figure 5** displays the computation results of the walking distances from A to E (in minutes) along different path. At each cycle, the algorithm calculates multiple versions of a particular annotated graph. Each graph represents the situation at a particular time t with 5 minutes interval with blue edges representing available routes. In this example, A-B-D-E is the shortest path at t = 00.00. The illustration shows that upcoming water has threatened B at t = 00.00 and completely blocked this point at t = 00.05, which result in A-C-D-E is the shortest path at t = 00.05. However, since the upcoming water is then also threatening D and completely blocked this point at t = 00.10, the paths D-C and D-E become not available from A. At t = 00.10 the shortest route is A-E. This example shows that at regular time steps, that is, 5 minutes, the shortest routes are computed via the links and using the eventually updated links in the graph. The final output is the path A–E.

3.4. Simulation in the flooding MOOC

The developed MOOC uses movies and simulations to provide a high feeling of presence of a flooding disaster. The current version employs many YouTube movies to provide a realistic

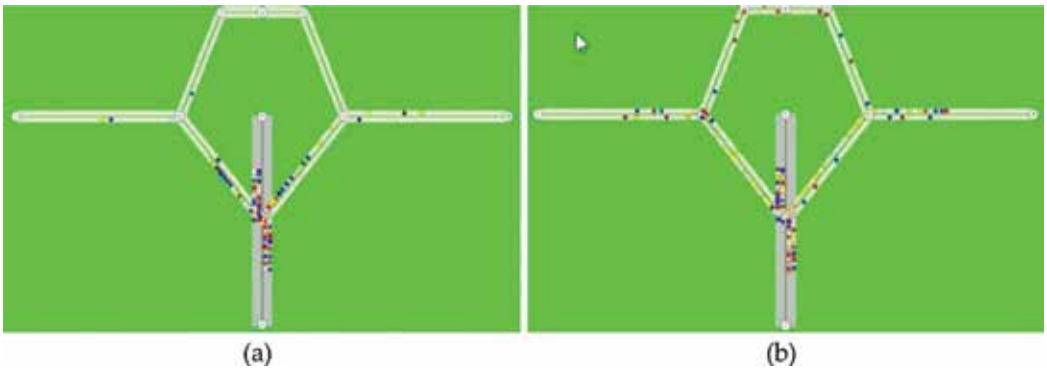

Figure 6. Routing simulation: (a) bottle neck in the south and (b) rerouting to the northern route.

visualization of the crisis. On the other hand, the simulations are used to allow a virtual participation in such a crisis. In the following, we illustrate the use of simulation using two examples. These examples show the kind of problems that the crisis management team has to solve. By being a member of the management team and participating in the simulations, we expect the participants become aware of the problematic situations.

Figure 6 shows an example of routing problems of people on their way to safe areas. The problem for the management team is that sometimes they have to take measurements which give optimal routing for the whole cohort of people on the cost of individuals. Many individual people use an egoistic approach instead of an altruistic approach. In this example (**Figure 6(a)**), car drivers prefer to use the southern route, because this is the shortest and preferred route. It appears that a congestion appears in very short time. Car drivers are unaware of the fact that they also can use the northern route in time. When some drivers use the northern route, this results in an optimal flow through of the whole cohort of drivers as shown in **Figure 6(b)**. The

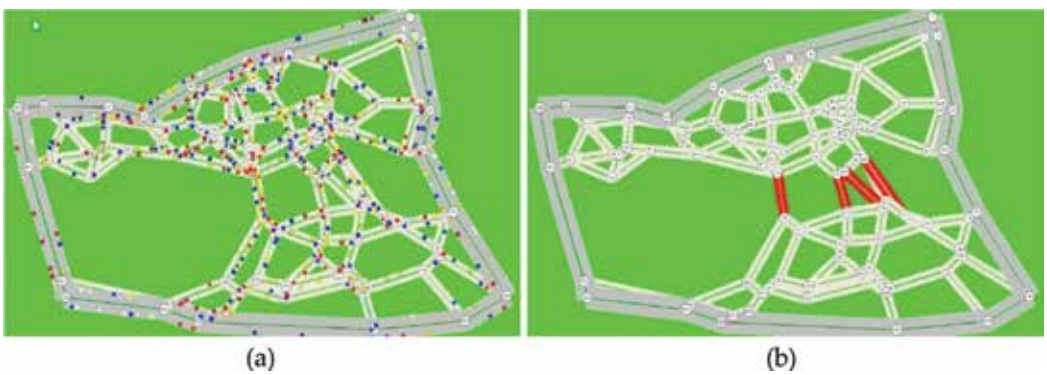

Figure 7. Routing simulation: (a) moving pedestrian and (b) blocked bridges.

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management team can take regulations to invite car drivers to take the northern route in time or even force them to do so.

Figure 7(a) displays a simulation of moving pedestrians in the city as moving pixels; whereas, **Figure 7(b)** shows a simulation when we disable the crossing of three bridges. In this situation, members of the management team have to predict the movement of pedestrians in the new situation and define regulations to route them in an optimal way.

3.5. Management flooding game

To increase knowledge and perception of a flooding crisis, to increase awareness of what is going on during such a crisis and to increase the knowledge and abilities, at regular times the crisis management of the city organizes training sessions for first responders. However, a flooding disaster is difficult to organize in real time. Therefore, the management could train the first responders in the execution of the crisis plan based on scripts. On the other hand, a

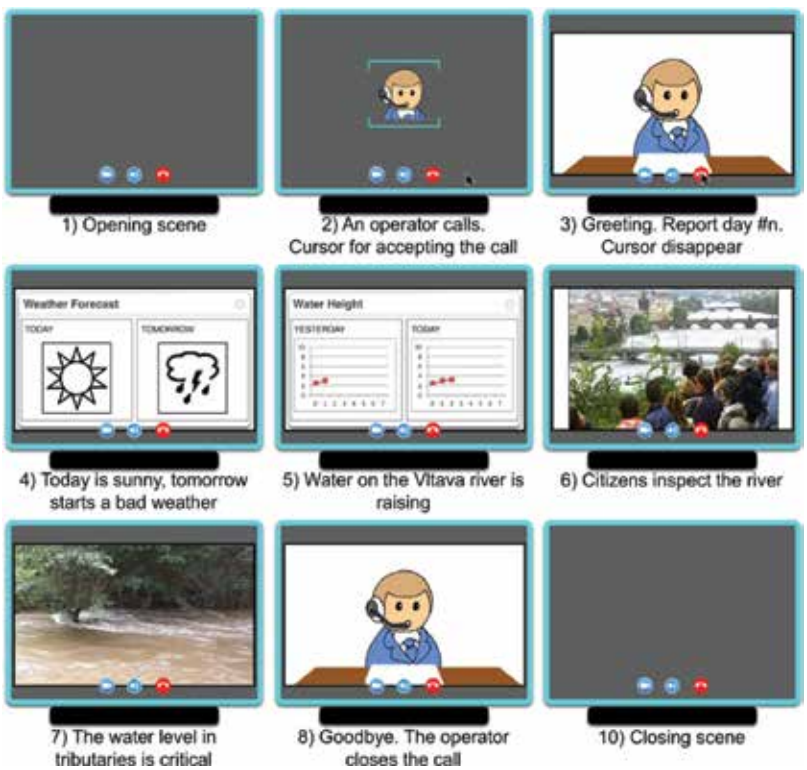

Figure 8. An example of the assignment video (as a sequence of scenes) reporting today's weather report, the river water level and the current situation in the area.

 1. Open Dam	 2. Evacuate	 3. Rescue
 4. Raise Metal Barriers	 5. Raise Sandbags Barriers	 6. Wait and See
 7. Close Tunnels/Bridges	 8. Cut off electricity & water	 9. Close metro lines

Table 2. Measurement decision.

problem is to generate the appropriate context awareness during the simulated fake crisis. An even bigger problem is to organize training sessions for citizens of Prague.

The developed MOOC offers digital training facilities for citizens of Prague and interested students. One of the provided options is to offer participants a role in the crisis management team and to play a simulated flooding crisis. This enables participants to experience the problems of crisis management and increases the sensitiveness for the crisis problems. The goal of this management team is to secure safety of citizens and to prevent/reduce damage of properties and infrastructures.

The flooding crisis game will be played as follows: every day the management team receives new information about the weather forecast, the water level and the current situation of the city. The information is coming in the form of an assignment video (**Figure 8**). After receiving the assignment video, the crisis management team has to select a measurement to be executed. Many measurements as displayed in **Table 2** interfere with each other. For example, after closing the transport facilities, it will be difficult to immigrate a great number of citizens. Whereas, before the dikes are breached and the water is increasing in the street, it is difficult to motivate people to immigrate. The participants have to imagine that there is an enormous time pressure while considering these actions. If the management team executes some measurements too late, it will be difficult to repair afterwards. On the other hand, if some areas are inundated on purpose to save other areas, this will not be appreciated by people living in inundated areas. One of the biggest problems is the probabilistic nature of a flooding disaster. After the management team makes a daily selection, the choice will be commented automatically. By playing the crisis game players, we expect that the participant will be confronted with

many problems to solve. Consequently, their awareness of the complexity of a flooding crisis will increase by their involvement in the decision-making process.

4. Presentation, experiment and survey

4.1. Conference presentation

In 2016 a Smart City Symposium was organized in Prague. One of the topics was the design of information systems and surveillance systems to protect the city and its environment for disasters as flooding, landslides, and fires. A first prototype of the MOOC [26] on flood control was presented for an audience of scientists, representatives of the city council and representatives of first responders. It was appreciated that the MOOC was based on the flooding disaster in 2002. Participants were interested in the results of a large scale user test.

From 2013 to 2016 a European project ETN FETCH was running on development of Future Education and Training in Computing: How to support learning at anytime and anywhere with a focus on long-life leaning. More than 80 European Universities were partner in the project. One of the authors was a work package leader responsible for the development of new didactic models of distant learning with focus on MOOCs. On the yearly work package meetings and e-learning conferences the progress of the development of the MOOC on flooding disaster response was reported and discussed by a forum of 120 researchers specialized in distant learning. The results were reported in the proceedings of the e-learning conference [24–28]. The focus of the e-learning conferences was on the development of new didactical models, and high dropout rates of MOOCs. In the current paper the focus is on the training, increased awareness and training of cognitive models and abilities of citizens during flooding disasters.

4.2. Preliminary experiment of management role play game

At the start of the academic years 2016 and 2017, 483 first year's students of mathematics and computer science took part in the flooding game during their introduction time at Delft University of Technology. The game started with an introductory lecture of one of the authors on the flooding disaster in Prague in 2002. After the lecture, the students were split up in groups of 15 students. They were supposed to play the role of the crisis team during flooding and had to rank 7 measurements displayed in **Table 3** on a priority scale (with 1 being the least important measure to 7 being the most important measure).

Table 4 presents the average group score of the 7 measurements that was resulted in this experiment. Only prediction of the river water level had a high ranking which was not a big surprise for students of mathematics and computer science. The lower scores of the other measurements could be related to less preferred measurements to be executed at the onset of

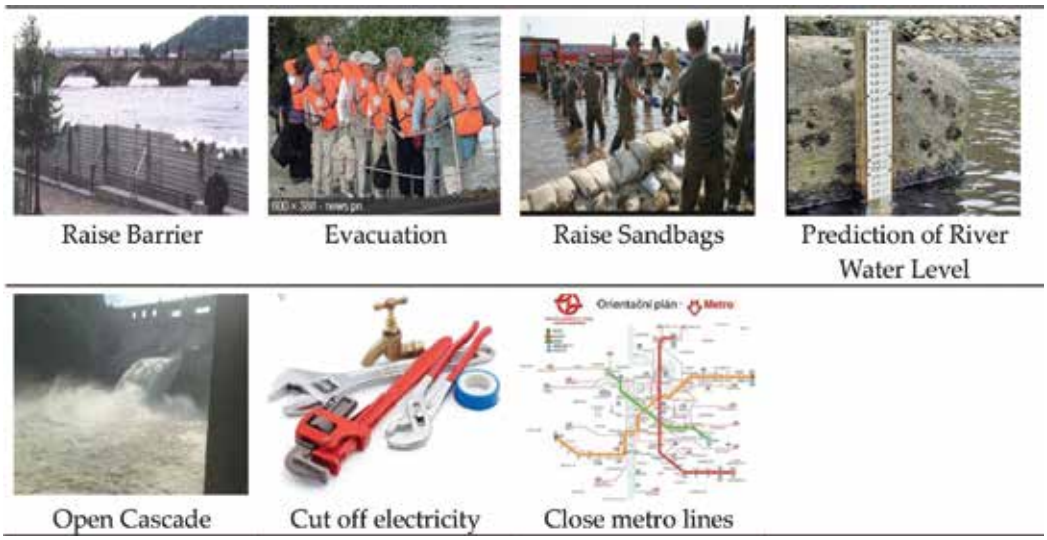

Table 3. Measurement decision in an experiment.

Barrier	Evacuation	Sandbags	Prediction	Cascade	Electricity	Metro
4.43	3.14	3.64	6.64	4.29	2.43	3.00

Table 4. Average score of priorities on a 10-point scale.

the flooding. Therefore, a lengthy discussion within the management team was needed to rank these measurements. The comment provided by the students showed that they were not aware of the heavy impact of mass evacuation and the speed and destructive power of the raising water.

4.3. Preliminary survey

To investigate the situation awareness of civilians of the different aspects of a flooding crisis, a survey was conducted involving 207 students of mathematics and computer science students at Delft University of Technology. In this survey, they were asked to fill in a questionnaire of 12 statements. The students could score on a 5-point scale if they agree or not with the statement with 1 being the completely disagree to 5 being completely agree. The results of the survey are presented in **Table 5**.

Based on the survey results, we found that most students were not aware of the complexity of a flooding disaster and the correlation between different components. However, these students had already made their own crisis plans and did not believe in the worst-case

Items/scale		Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
1.	I was not aware of the complexity of the flooding disaster	5	22	33	85	62
2.	I was not aware of the strong correlation between measurements	12	40	26	93	39
3.	The main unpredictable variable is the weather forecast	8	25	36	47	91
4.	In crisis situation, I follow my own plan	25	39	76	44	23
5.	In the past, it proves that crisis managers predict worse case scenarios	4	38	117	33	15
6.	It should be possible to rank the measurements on a priority scale	8	19	64	83	33
7.	Civilians wait for the very last moment before leaving the crisis area voluntary	6	21	38	87	55
8.	The behavior of the citizens is unpredictable	10	41	112	35	9
9.	It is difficult to implement the actions of the management team because of conflicting interests	24	30	37	97	29
10.	It was difficult to select measurements because of missing information and knowledge	6	31	33	103	32
11.	Every student has to take courses in crisis behavior at school	9	33	106	52	7
12.	It is a good idea to develop MOOCs for different types of crisis	14	51	87	44	11

Table 5. Average score list of priorities.

scenarios. Further, the analysis of the comments following the questionnaire showed that: Most students stress the fact of a planning and a disaster plan. There was also a request for computational model. Bayesian networks models could be used to predict the raising of the water. Mathematical models can also be used to describe the flooding of areas next to the river in case of breaching the dikes. The hilly terrain is full of peaks and valleys. Detailed maps are available and could be used how the water will be spread over the area using finite elements methods [18]. Students did not realize that most civilians use a subjective risk assessment instead of objective methods predicting the behavior of the whole cohort of people.

5. Conclusion

The goal of this paper was to improve awareness, cognition and abilities of civilians of flooding disasters by education delivered by MOOCs. Literature surveys and our preliminary

results showed that MOOCs could be used to educate civilians. One of the advantages of MOOCs is that the educational material is easily accessible via MOOCs for a mass audience. Furthermore, no entrance exams or preliminary education is required. Unfortunately, our MOOC on flooding disaster response would also be subject to the disadvantages brought by MOOCs in general such as high dropout rates. However, regular training of first responders is usually compulsory. In such cases, the obligation of the first responder to use the MOOC can be a boost point for the participation rate. Furthermore, we received a great interest from authorities, involved in risk reduction in the Czech Republic, in the use of MOOCs for various risks, such as fires, landslides, traffic accidents, accidents in chemical complexes, and pipeline explosions. As a proof of concept, some MOOCs on disaster management have been developed in 2016, and published on the platforms *Coursera* and *edX*. These MOOCs were focused on the development of abilities of civilians and first responders to be used in crisis situations. We hope and expect that current MOOC will play a role in disaster education next future. To improve the awareness of civilians, the MOOC should be a regular course in the curriculum of students at Universities and secondary schools specifically at the areas that prone to flooding disaster. However, at the moment this is wishful thinking.

We mentioned already that by gamification, a MOOC can be attractive for many players. Inspired by the last summer of 2016's big hype around the game Pokémon Go, we observed that many players from different ages and educational background took part in the game. Players used their smart phone to catch virtual characters (Pokémon). An attractive aspect of the game was that players could meet each other on specific locations as squares, parks, beaches to exchange information and to play tournaments. As MOOCs are designed for participant's remote in place and time, we can apply such a game design for developing a new MOOC. When there is a need of the MOOC participants to meet each other for some days on a specific public domain location, the MOOC can provide a media for meeting, appointments and announcements. For example, in our case, the designers of the game could plan an event on one of the islands in the river Vltava in Prague during the summer and use the event to stress the game aspect of the MOOC as a serious game.

From the roleplay game experiment and the survey involving the university students, we found that missing information and knowledge was a problem for the participants to take the right decision and offering their opinion. It can be questioned if a sample of students is a good representative of civilians in a city. However, we consider the results of the experiment and the survey as a first promising step. As the experiment and the survey was taken before the participants followed the MOOC, it will be interesting to see if the opinions will change the coming years after following the MOOC. Future work will include first responders and members of the city council in the survey. At this moment, the MOOC is tested on a large scale of audience and new results will come available in the coming year.

Learning on the preliminary results, therefore, in the roleplay game of the current MOOC, we designed that students would be confronted with the weather forecast and level of the raising

water on a daily basis and have to select a measurement. We expect that such information will provide more time pressure and raising actions in the game especially when the flooding conditions are changing dynamically. Furthermore, we also observe that a greater part of civilians takes apart in MOOC education, such as managers, which are also a target population of our research. From the massive character of MOOCs in general, we can expect that MOOCs will play an important role in the education of civilians on disasters. Finally, although we tested only one module of our MOOC, that is, the management game, however, other learning modules of the MOOC have covered the different aspects of flooding. We expect this will also increase the awareness of civilians of flooding.

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Chapter 11

Crisis Management: A Historical and Conceptual Approach for a Better Understanding of Today's Crises

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Additional information is available at the end of the chapter

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Abstract

We argue that the basic and contemporary concepts related to crisis management, especially in the communication field, share some similarities with what was practiced in ancient civilizations such as the importance of direct contact between the leadership and the public. Other similarities include the accurate diagnosis of the real causes of the crisis, the forbiddance of the dissemination of false news and the reassurance of the public opinion that there is a solution to the crisis, a sound management decision, and a good plan for its implementation. We link the past time crises to the contemporary era, providing a comparison framework. The history of crisis tends to show us that the study of crisis management cannot be linked to a specific civilization or era, especially when humanity had witnessed multiple and complex environmental, political, economic, and military crisis. Moreover, some of the problems and complex issues in the modern era are rooted in history. Thus, many geopolitical crises nowadays are the result of old causes. The study of crisis management from an academic point of view should be a multifaceted analysis, including a historical, a cultural, and an anthropological one, which determines the course of evolution and consequences of the crisis.

Keywords: history of crisis, crisis management leadership and crisis, ethics and crisis

1. Introduction

Humans today are witnessing multiple serious crises, whether economic, social, environmental, but the most devastating crises are those security crises that end up with endless wars, killing thousands each year, and displacing millions of others. In fact, most of those destroying conflicts could be avoidable if the parties involved embrace wisdom by putting common

interests ahead of their own desires, and choosing patience and dialog over stubbornness and extremism, particularly when conflicts and crises do not build nations and civilizations, but destroy everything instead. Today's crises bring new challenges to address and the theoretical frameworks that have been developed by various scholars may not be adequate to deal with them [1].

The term crisis carries many meanings in itself. These meanings guide the crisis managers and leaders in deciding what to do in a crisis situation. It is an interesting applied area as well since we talk about "managing" a crisis when actually each crisis situation is very unique by itself.

What constitutes a crisis is not easily agreed upon however, despite lack of clarity, there are specific conditions of crises in the crisis literature. For example, crisis situations share six characteristics which are rare, significant, high impact, ambiguous, urgent and involve high stakes [2]. Crisis involves a period of discontinuity, a situation where the core values of the organization/system are under threat, and this requires critical decision-making. There is a destabilizing effect to the organization and its stakeholders and an escalation of one or more issues, errors or procedures are expected in this period [3].

A crisis could start out by a simple piece of news being disseminated through media outlets or social networks, then find recipients at large, which leads to the state of agitation and uncertainty within the target of the crisis. In a narrow framework, crisis can be limited to avoid negative media coverage; however, this is only related to the communication side of a crisis. Crisis prevention, mitigation and communication response starts with a strategic business plan and "…the integrity and legitimacy of the organization are central to the theme of crisis" [4].

The solution against any crisis begins initially with fighting its causes, such as dealing efficiently with the sources of rumors and false news including via social media, which target official and non-official organizations and create a toxic environment, which turns into an explosive one in the real world, if not tackled early enough and efficiently. Crisis management is a proactive process which involves dealing with the crisis before it happens, during the crisis and aftermath [2]. Crisis management is a process designed to prevent or lessen the damage a crisis can inflict on an organization and its stakeholders. As a process, crisis management is not one thing [5]. The purpose of crisis management is to protect the organization, sector or the stakeholders from damage and prevent or diminish the negative outcomes of crisis [6].

As stated, crisis management is a process with many parts and one of the crisis management models is explained as a three-stage process by Coombs [7]. The pre-crisis stage consists of three sub stages: signal detection, prevention and crisis preparation. At this stage, if a crisis has been detected, this crisis should be prevented from taking place and prepare for crisis management. The goal is to reduce the risks that may create crisis and also be prepared strategically and tactically. In this respect, action wise, the organization at this stage is expected to have a crisis management plan that is updated regularly. The organization forms a team for managing the crisis, selects spokesperson/s and prepares draft crisis messages. The second stage is the crisis stage itself, and this stage is formed by two substages, which are crisis recognition and crisis containment. At this stage, the organization's response to the crisis situation, its communication with stakeholders and how the organization deals with crisis is important. This stage covers the response of the organization to what has actually happened: the crisis

management plan is put into action, and the literature suggests three points which are to be quick, to be accurate and to be consistent. Support from public relations is heavily observed at this stage since they develop the messages to be sent to all stakeholder groups, making sure that the public safety is the most important aspect. The damage that is inflicted on the organization is worked on to repair it. The post-crisis stage, as the name suggests, comes after the crisis is resolved. At this stage, the organization evaluates how they dealt with the crisis. Their focus is to be better prepared for potential crises. The crisis may not be as hot as before, but still the organization scans the media and the activities of stakeholder groups. Understanding the perceptions of their stakeholder groups is vital. In the crisis management literature, there are other crisis management process models suggested [8, 9, 10]. However, this three-phase model is a simpler one compared to them.

A crisis situation creates need for information and that need is fulfilled with communication. Neither the crisis management plan nor the crisis communication before, during and after a crisis should be ignored. Crisis communication addresses to both internal and external audiences affected by the crisis situations. It provides information and that information should be consistent throughout the crisis situation with the designation of one primary spokesperson [11]. Coombs differentiates between two types of crisis communication: "crisis knowledge management" and "stakeholder reaction management." "Crisis knowledge management" involves collecting information, analyzing the information gathered, sharing what is learned and decision-making. The "stakeholder reaction management," involves efforts to influence the organization's stakeholder groups through communication. This may be accomplished through words or what is done, the deed. It is important to understand the perception of the stakeholders' groups of the crisis situation, the organization under crisis and its response to the crisis to influence them [12].

We claim that although scholarship in crisis has augmented both in public relations and management fields recently, crisis situations of different types are common in all civilizations and always there had been an attempt to fight with it. This chapter discusses some areas of a crisis with a focus on the history of the crisis. The attempt to deal with crises in the past times may not be as strategic as today's way of managing crises, but all civilizations fought with it situationally based on the specifics of the society and/or its leaders. Moving from this point, the chapter also shares modern time academic work on crisis including crisis and its link with other fields, crisis management theories, factors affecting the crisis management, leadership in crisis situations, and ethics. Our understanding of crisis is broader than an organizational crisis with operational and/or reputational crisis situations, but encompasses all types of crisis situations. At the conclusion of the chapter, we also put forward some ideas on how to "approach" crises.

2. Literature review

2.1. "Crisis" from past times

The accumulation of knowledge associated with the evolution of the concept of crisis management is not only the emanation of the modern academic studies or the practices and

experiences of organizations and agencies, crisis management, rather it benefitted from the expertise and experiences of previous human civilizations. All civilizations had laid the methodological foundations in managing the various crises it faced, within the scope of the moment and its specific challenges, "Crisis and contention do not surface instantly in any society they are rooted in history" [13].

It is argued that as we look back, crises have been a part of the personal, domestic, and international landscape from time immemorial, from the ancient world to the twenty-first century [14]. Thucydides described a crisis between Athens and Sparta that resulted in the Peloponnesian War (431–404BC). The factors that are associated with the importance of direct communication, interaction, and dialog with the public opinion were important in crisis management in the Greek and Roman eras. These civilizations were largely focused on creating spaces for dialog, debates, and direct communication with the public. Those social activities took place in most public venues, such as theaters, stadiums, places of worship, and so on.

As for the Greek civilization, the foundations of its values were based on philosophy, raising theological and nontheological issues for never-ending dialog and discussion. Moreover, the Greek civilization was characterized by its proactive community participatory approach in resolving crises. The citizen had the right to discuss all issues of concern to public affairs. On the other hand, The Roma civilization tended to take care of material and entertainment needs of its citizens to ensure the stability of the empire. Romans also urged residents of Rome and its colonies to participate in the discussion of the problems of the empire, as they believed that the dialog contributed to absorb public anger and this was what had enabled the empire to overcome many crises.

As stated earlier, some of the problems and complex issues in the modern era are rooted in history. Thus, many of the geopolitical crises nowadays are the result of old causes. For example, some military and political conflicts, as well as the emergence of the protesting movement of ethnic and religious minorities in the Middle East and North Africa, have their causes linked mainly to military and political rearrangement plans that were consecrated in the Vienna Conference on 9 June 1815 and the Sykes-Picot Agreement of 1916. They constituted a secret agreement between France and the United Kingdom that was ratified by the Russian Empire, on the sharing of the Fertile Crescent land between France and Britain to determine the zones of influence in West Asia after the pummeling of the Ottoman Empire.

The social texture of a society and the nature of crisis which surface in it are a product of its historicity [13].

2.2. Defining crisis and its linked fields

Defining crisis is not an easy task because of the interdisciplinary nature of the crisis concept. There is disagreement on what constitutes a crisis [3]. Although there is no agreed definition of crisis, there is a general consensus that a crisis event is highly unexpected and uncertain in nature [15]. We suggest to remove this definition.

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Ithaar Abdul Hadi argues that the concept of crisis is an idiomatic concept used by Arabs as an indication for severity and drought [16]. In the English language, it means a change for the better or the worse [17]. The origins of the word, crisis, in the late Middle English (denoting the turning point of a disease): medical Latin, and from the Greek word krisis, 'decision,' and from krinein 'decide.' The general sense 'decisive point' dates from the early seventeenth century [18].

The Chinese Mandarin character for crisis includes "danger" and "opportunity." This idea is especially useful because it conveys the fact that we may create opportunities out of a situation that threatens us [14]. Some Western and Chinese crisis experts claim that it may mean danger and a "turning point," which indicates a sense of possible positive outcome [19].

Heath and Millar by tracking crisis discussions over the years state that some of these definitions studied feature a mistake or a turning point in the organization, some emphasize the need for management efforts beyond normal sequence and some other discussions focus on stress, inadequate control, uncertainty, violation of ethics weak preparation, preparations and the need for crisis communicating planning [4].

Definitions of crisis by various scholars are outlined in "Parameters for Crisis Communication" by Coombs [20] and Timothy Coombs defines crisis communication as "the perception of an unpredictable event that threatens important expectancies of stakeholders and can seriously impact an organization's performance and generate negative outcomes" [21]. This definition highlights the issue of the negative impact of a crisis on the effectiveness of the affected company or organization's performance, as any crisis hinders its development and leaves it in a state of confusion, anxiety and instability. "…Crises are largely perceptual. If stakeholders believe there is a crisis, the organization is in a crisis unless it can successfully persuade stakeholders it is not…." [12].

Gibson argues that true crisis is usually the result of a management failure to respond appropriately to an issue, emergency or accident that requires a timely response and communication [22]. Coombs, in his definition below, explains the types of damage a crisis can create:

> *crisis is defined as a significant threat of operations that can have negative consequences if not handled properly. In crisis management, the treat is the potential damage a crisis can inflict on an organization, its stakeholders, and an industry. A crisis can create three related threats: (1) public safety, (2) financial loss, and (3) reputation loss* [7].

The roots of crisis management are in emergency and disaster [20]. Mitroff & Anagnos argue that in contrast to the disciplines of emergency and risk management, which deal primarily with natural disasters, the field of crisis management deals mainly with man-made or human-caused crises [23]. Disaster and crisis do not mean the same thing. Crisis management may take place in disaster situations, but disasters are larger in scale and require coordination. Crises can be embedded in disaster and poor disaster management can result in crises for the agencies responsible for dealing with it [24]. Disasters require society's and society's network dealing with it, and the collaboration process is emphasized in disaster management.

Crisis communication is linked or connected with three areas which are issues management, risk communication and reputation management. Failure in any of these areas can create a

crisis situation and a need for crisis management. Also an ineffective crisis communication can create a need for risk communication, issues management and reputation management as well [24].

How are issues management and crisis management related? An issue can create crisis or vice versa. The issue generators are not only government entities, but also stakeholder groups. Stakeholder groups may raise issues about an organization and if they perceive that the organization is not fulfilling their expectations, then, this can turn into a crisis condition where the organization's reputation may be effected as well [24].

Reputation management is a broad area where we talk about measurement in reputation, different reputation dimensions, and a comprehensive reputation management plan. Building and maintaining relationships is a very important topic in reputation management. Crisis communication is a specific part of reputation management because a crisis may endanger the reputation of the entity. A key difference between operational and reputational crises is that operational crises typically create some threat to public safety and/or stakeholder welfare. Reputational crises are not likely to produce the same level concerns. An operational crisis can have an impact reputational image, but reputational crises do not have an impact on operations in a meaningful way [25].

The tactical approach to crisis management dictates what needs to be done or avoided when a crisis of any type hits. In this light, we come across lists of do and do not's, such as "say never no comment, "or be accessible to media." However, we have to benefit from research that has looked at specific dimensions of crisis and the theories that have been borrowed from other disciplines and then became a theory of crisis management. In this way, crisis management field does not turn into a mediated- crisis control using media relations online and offline because the ingredients and surroundings of any crisis situation is complex and should not be underestimated.

2.3. Crisis management theories

An analysis that has been done in crisis communication research articles in Journal of Public Relations Review and Public Relations Review from 1975 to 2006 reveals the theoretical frameworks of crisis management. The theories that are applied in crisis communication research are situational crisis communication theory, issue and crisis management theory, image restoration theory, apology theory, attribution theory, contingency theory, situational theory, organizational theory and the research also finds other theories such as the excellence theory, the diffusion and innovation theory, the self-disclosure theory, the chaos theory, the commodity theory, the stakeholder theory, postmodern theory, co-orientation theory, and Fink's stages of crisis [26].

The crisis management theories are from public relations, management and include some rhetorical theories such as image restoration and apology theory. The most mentioned theory in the study was the situational crisis communication theory (SCCT). In brief, below are the explanations of the widely mentioned theories in the research paper.

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The situational crisis communication theory proposed by Coombs and Holladay is an extension of the attribution theory [27]. The underlying idea behind SCCT is that corporations should strategically respond to a crisis situation based on an understanding of how the public attributes responsibility for the crisis. If the public perceives a crisis to be more intentional then, they attribute more responsibility to an organization and vice versa [28] SSCT is used to test different crisis response strategies. SCCT is audience-oriented theory and still developing [20].

Issue and crisis management theory: The term issues management is coined by Howard Chase in 1976. In his words:

> *Issues management is the capacity to understand mobilize, coordinate and direct all strategic and policy making functions, and all public affairs/public relations skills, toward achievement of one objective: meaningful participation in creation of public policy that affects personal and institutional destiny* [29].

As stated before, issue and crisis have reciprocal relationships. An issue can create a crisis and at the same time, a crisis can create an issue to deal with. If the issue is not handled effectively, it can turn into a crisis. In other words, if effective issue management is done, it is less likely to be faced with a crisis situation. Therefore, in the issues management process, there is a need for anticipation of emerging issues. This scanning can be considered as pre-crisis planning.

Image restoration (*repair theory*): Benoit argues that the image restoration strategies are reputation repair strategies that can be used after a crisis and that successful crisis resolution requires honest and ethical communication in times of crisis [30]. Image restoration theory offers several crisis response strategies. This can range from "denial" to "evading responsibility" and to "reducing offensiveness" and there are several options to select from these strategies. The theory developed by William Benoit evolved over the years. The core concept of the theory states that an attack can threaten the reputation (image). An offensive act or accusation of responsibility for the act is a threat for reputation, and the theory uses communication to defend its reputations [9, 20].

Apology, corporate apologia: Apology and apologia are not similar. Apologia, as another communication response strategy, is more than apology. By using apologia, the organization explains clearly and tries to convince the stakeholders that it is right [9]. Apologia is counter-description where the person/organization defends itself for creating a more favorable content for the allegations. Four strategies can be used when an organization is accused of wrong doing. These are denial (not involved in any wrong doing) bolstering (reminding of good things that has been done) differentiation (remove the action from its negative content) and transcendence (place the action in a new and favorable context [31].

Attribution theory: Attribution theory highlights and emphasizes communication and media dimension and the importance of the role of public relations in crisis management. It explains how people make sense of events. When an event happens and especially when this is negative event, people try to determine why the event occurred. People will make attributions of responsibility for events. When applied to crisis, stakeholders will make attributions of crisis responsibility internally (organization) or externally (environmental factors). Logically, if the stakeholders attribute responsibility to the organizations for the crisis situations, then they will have more negative images of the organization and vice versa.

This theory is audience-based and attempts to understand the factors in the crisis situation itself that shape the crisis attributions stakeholders make [20, 32].

Contingency theory of conflict management tries to explain an organization's communication with its public groups and specifies the various factors that have an effect on this communication. It has the concept of "stance" which implies how an organization responds to competition and conflicts with other parties. Stances are on a continuum and at one point of the continuum, there is advocacy and at the other end is accommodation. When an organization argues for its interest, it is advocacy and when the organization makes concessions to other parties, it is accommodation [33]. Contingency theory applied to crisis demonstrates similarity between the stances and the crisis response strategies of image repair and SCCT [20]. Contingency theory offers additional variables to consider such as threat type and threat duration.

2.4. Factors affecting the process of crisis management

Crisis management process requires many skills and expertise because as stated previously, we are talking here about the process of changing reality and convincing the public opinion of the organization's point of view that defends its vision and interests [34]. Moreover, the crisis management requires social, legal and communication crucial knowledge in the search for possible solutions.

Here are some of the factors affecting crisis management:

Firstly, psychological factors constitute an important element for the individual in charge of crisis management. Self-control, self-confidence, and coolness, are some of the mental attributes that are highly needed, as the crisis management process requires patience, wisdom, and sound thinking in the planning for the management of the crisis and providing appropriate solutions. In this context, Jin argues that the process of managing crises requires some basic knowledge in psychology, mainly because managing some crises needs to a great extent of controlling emotions and sentiments, self-control, patience, calmness and keeping away from anxiety and carelessness [35]. These attitudes and behaviors are essentials for managing a crisis efficiently, professionally, and with a lot of conciseness, preciseness, and without tempered reactions that can affect negatively rational and successful decisions.

Secondly, good knowledge of the environment surrounding the organization may include knowledge related to the cultural, social, and political system of the society. This is due to the complexity of the process of managing a crisis that needs quick and decisive decisions and emergency management planning, and execution [36].

Thirdly, those in charge of managing crises should have a good knowledge of the nature of local laws and regulations related to libel, defamation, disinformation, and copyrights. Also, legal and legislative components are associated tightly with moral and value aspects of the society, for those in charge of managing the crisis should be able to control its consequences. Moreover, they will manage to even improving the performance of the organization, its reputation and image, by committing themselves to openness and transparency, and showing genuine empathy for the victims.

For example, British Petroleum (BP) applied the mentioned principals during the oil spill crisis on April 20, 2010, in the Gulf of Mexico [37]. The Company opted for transparency and honesty with the American public opinion and the authorities, by making full disclosure of the crisis and its repercussions, and providing full apology. It also offered compensations that exceeded $20 billion, even though the company's losses from the incident had reached $70 billion.

Fourthly, setting up a communication and media plan aimed at connecting with the public, for it desperately needs a true narrative of the crisis. Thus, any delay, miscommunication, or silence would expose the organization to rumors and false news that aggravates and complicate the crisis even more. Communication strategy must be built on honesty with the public and opinion leaders because it is the right and proper way to restore the ravages of the crisis. The process of regaining the trust of the public during or after the crisis is the biggest challenge, and it is impossible to win it without embracing speech openness and full transparency in managing the crisis.

Fifthly, the necessity of involving the public in managing the crisis. This can take place in several ways. One of them is including nongovernmental organizations, opinion leaders, and members of local community. Involving them in the crisis communication strategy in order to reach the appropriate solutions leads eventually to the absorption of public anger and win back its confidence. In fact one of the approaches in regaining the trust of the public during or after the crisis is to respect the feelings of those affected by the crisis and recognizing their rights in order to rehabilitate them and involve them in making the appropriate decisions.

2.5. Decision-making in crisis and leadership in crisis

On a communicational level, it is primordial that managing a crisis in a positive manner requires a deep understanding of the local cultural environment and its characteristics, as well as the values and ethics of the society to which they belong. This brings us to a discussion of decision-making and ethical leadership.

In the light of what is considered as crisis, decision-making in crisis is very vital. The crisis management process requires making wise and sound decisions, as they contribute to a successful exit of the crisis and alleviate its effects [38]. This might explain why decision-making often requires considerable expertise and knowledge. In fact, key features of an outstanding leader is his ability to make the right decisions in times of crisis, hence the timing of making those decisions is crucial to their success and efficiency. Leaders should not rush to conclusions and make hasty decisions about them, especially when the nature of the crisis does not require a swift interference or decision-making process. This highlights a quality of leadership by not caving to pressure and making mistakes in the process, while it is necessary to take the time needed to look deeply into the problem and consult the people who are aware of it.

Leadership in crisis has become important especially after the 9/11 and the threat of terrorism. This new reality demands for leaders who have communication skills, caring and vision of the crisis situation. In addition to these qualities, empathy and expertise and providing experiences with an ability to lead are the requirements from leaders who have to deal with crisis situations [39]. Task-oriented leadership behaviors are found more helpful to the effectiveness

of crisis leadership. At the same time, people and organization-oriented leadership behaviors are not also low on the effectiveness. The authors conclude that although their research highlights task-oriented leadership, but focusing on this leadership alone will not increase the efficiency of the crisis management [40].

Leaders establish the foundations of the collective consultation that allows the opportunity to participate in decision-making and the research for solutions in time of crisis.

2.6. The ethical aspect of crisis management

The ethical aspect of crisis management is one of the most important components that recent studies emphasize upon, knowing that the ethical element is crucial to the mental image rebuilding process, and to regain the confidence of the public opinion as well [41, 42]. "Engaging in ethical communication in times of crisis seems to be the ongoing theme in today's stakeholders communication research and practice" [41].

Coldwell confirms that recent financial and business crises have indicated repeatedly the poverty of ethical and responsible leadership behavior in high places [42]. A most recent example of this phenomenon with global repercussions was the Volkswagen (VW) Crisis, which was largely brought about through the unethical Business Behavior of its leaders." On September 18, 2015, Volkswagen became embroiled in crisis after the US Environmental Protection Agency (EPA) confirmed Volkswagen's violation emissions scandal [43].

Ethics recommend that the physical and psychological needs of the stakeholders be the top priority in a crisis [44]. A crisis should be managed in an ethical manner and "decision-makers who understand the needs of a wide range of stakeholders as part of their strategic decision-making will make more ethical decisions during a time of crisis" [45, 46]. Thus, ethical rationality is a habit that must be ingrained in the culture and daily operations of the organization [47]. This ethical rationality involves the careful management of the organization's internal and external stakeholders throughout the duration of the crisis. Moreover, many recent studies emphasize on the correlation between the moral aspect and the practical elements such as credibility, objectivity, and the accurate knowledge in the field of public relations [42].

Credible messages about the potential cause or blame for crisis help the organization to create a connection to shareholders of the organization. An honest approach is essential during times of crisis. If communication during crisis events is not ethical, there could be detrimental reputation damage to the company if proper blame is not assigned for the causes of crisis [48].

Morality and integrity form a solid foundation for a real prevention and risk management plan, which can be adopted by modern crisis management strategies. This is the best method to solve crises, meaning by using amnesty and being flexible, as crisis resolution methods by pass the intra-conflicts that create a worse environment.

Crisis management requires openness and credibility, as lies and opacity lead to deprive a company of public trust, and make it even harder to regain any credibility in the public opinions. There are always long-term gains when telling the truth. The other aspect of practicing truthiness has to do with adopting a strict and clear approach in using traditional and digital

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media when relaying information, news, and opinions. Lots of crises start with a rumor, false information, an unverified piece of news, and so on. The responsibility of spreading misinformation lies on both the sources and the media, as freedom of speech is tied to a minimum of responsibility. In fact, the result of spreading rumors leads mostly to large crises, as we have seen what happened to some banks in the United States, Hong Kong, Taiwan, Greece and Cyprus, where major financial institutions were affected by the spread of rumors during the global economic crisis that hit the United States in 2008.

The only applicable measure against rumors is to educate people on its negative impact and its unattended consequences. This mandate works as a basis for public relations ethical principles/standards: be honest, be accurate, be loyal, and be just [49].

Management should start with establishing an effective communication strategy, which relays on building a clear, logical and convincing message, as the public is mostly influenced by the communication style and form, as well as its substance. Spokespeople are essential in the context of crisis management. The style of the spokespeople must be marked impacted by their unique and attractive personality. On the other hand, their eloquence, and their open and effective communication style, coupled with their unique way in delivering information and knowledge, enable them to influence their audience. The other specificity of spokespeople's approach is their abilities in using nonverbal communication, as their facial expressions, their mettle, and body language always reflecting the mood of the moment. Spokespeople must know how to adjust their voice during their speeches, mixing high and low pitches to suit their talking points.

3. Conclusion

Examples of different types of crises are identifiable throughout the human history even though they may not integrate wholly the professional and academic knowledge of crisis management as we know by of today. Public opinion has been an important force in the history and we see examples of leaders/organizations that have scanned the opinion of the public informally and thus showed respect to the opinion of the people. The history is also rich with examples where public opinion is not paid attention to and thus resulting in negative consequences. Public opinion, public safety, positive image, and less damage in the crisis situation to the inflected parties have been important pillars in a crisis situation. For example, Suleiman the Magnificent, the longest reigning Sultan of Ottoman Empire died during the Battle of Szigetvár, but his death has been kept as a secret to avoid further negative situations. In any type of interaction, we can see any of these happening-information, persuasion, compromise, cooperation, which reminds us of the function of crisis management stages. The accumulation of knowledge on crisis management forms the basis either for avoiding or managing crises effectively. For example, most of the past military and security crises, including the Second World War, have been linked to the spread of hatred and racism. Similarly, we are witnessing the same type of political rhetoric in the mainstream media. The persecution of the Rohingya minority in Myanmar for over 50 years of military rule is a vivid example of a culture of hatred that had become a systemic policy.

It is inevitable to live in a crisis-free zone as citizens of the world; therefore, we suggest "crisis literacy" awareness similar to media literacy in some ways. The main concepts of media literacy can be applied to crisis literacy as well and having crisis literacy expertise will create an ability to encode and decode crisis situations in a meaningful way. Today's information landscape is originating from myriad of sources. The judgment of the individuals may be distorted through these wisely crafted powerful illusions and sometimes the reality from the creatively constructed crisis communication media messages can be omitted purposefully. The mediated crisis management efforts may blur the stakeholders groups about the facts. At the same time, audiences attempt to shape the perceptions about the crisis just like the media and the organization may do.

In addition to crisis, literacy education embedded in media literacy and/or crisis management course, and we also suggest working and compiling on crisis management cases from previous civilizations in all realms of life such as political, religious, individual, international, and so on. An analysis might reveal not much has changed in what has been done in a crisis situation since then. However, we also need to add that crisis management has become more scientific today. Global crisis management can be analyzed from different approaches, and we suggest a historical, ethical and societal approach/framework which will be comprehensive for all aspects of crisis, including, leadership, ethics, and communication. The world needs it now.

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Chapter 12

Wargaming-Based Crisis Drills

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Additional information is available at the end of the chapter

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Abstract

Crisis drills should be held periodically in order to find problems of crisis plans, other than to run into problems during a real crisis. Wargaming is an efficient way for crisis drill with low cost and in a convenient manner. For government authorities, they can make deep research into the crisis management by designing a crisis drill wargame, and they can make proper crisis plans by playing the wargame. For the related duty departments or person, they can practice or adopt the examination of their workflow and professional ability by playing the wargame. The system features and elements of wargaming are introduced firstly, and then the form and process of wargaming-based crisis drill are explained. Also, the evaluation methods and decision models are proposed. At last, a wargame replay is analyzed to show the benefits of wargaming evaluation.

Keywords: wargaming, crisis drills, evaluation, decision, analysis

1. Introduction

With the rapid industrialization and urbanization of the modern society, more and more people and properties are gathering together, especially in China; hence many cities are overcrowded. The loss will be huge, and the daily life will be severely affected in the case of crisis. According to the statistical data compiled by National Bureau of Statistics of China 2016, the most loss is led by earthquake disasters, there are 14 times of earthquakes that are heavier than 5.0 Richter scale in 2015, the direct economic loss is 17,919.18 million RMB yuan, and 813,000 persons died or are wounded which is the most number in recent years. The following most loss is led by marine disasters; the direct economic loss is 7274 million RMB yuan; there are 79 stormy tides, red tides, huge waves, and sea ice disasters happened; and the casualties

and missing people is 30 in total. The geological disasters, such as landslide, collapse, mud-rock flow, and land subside, are the common disasters and happened 8355 times with 422 casualties; the direct economic loss is 2505.28 million RMB yuan which is the least loss in recent years, but the investment for prevention of geological disasters is 17,626.63 million RMB yuan which is the most in recent years. **Table 1** shows the statistical data of geological disasters in China in recent years [1].

So, through good crisis management, to take proper measures, such as investment for infrastructure construction, emergency resource schedule, crisis drills, etc., can make obvious effects on crisis prevention. Government authorities or organizations need to do deep research on crises, to grasp their features, and to make good schedules of human power and emergency resources in order to prevent or eliminate the developing of crisis.

A crisis generally has three main features, dynamics, complexity, and interaction [2]. A crisis is always evolving which makes it turn from minor phenomenon to complex event and even severe disaster. Nevertheless, a crisis has complex correlated facts and conflicts, it is very hard to aware of the original incentive at the beginning, and it is also a big challenge to take right measures to eliminate the crisis in time. A crisis is usually not an individual event, that is, it will trigger a series of linkage events, which makes the crisis more complex and severe.

According to the crisis features, crisis managers, such as governmental authorities or related organizations, are required to have abilities of crisis early awareness, dynamic decision-making, and emergency resource assignment. In general, governmental authorities need to make plans for all kinds of crisis, and related people who are in charge should study the plan and perform the plan in case of the real crisis. Crisis drill is a good method to examine the complementary of the crisis plan. It recommends that crisis drill should be held periodically by governmental authorities to optimize the crisis plans, other than to run into problems during a real crisis. At the same time, crisis drills can be held between related responsible people, to train or examine their crisis management skills.

As a matter of fact, organizations do held crisis drills as scheduled, and they need to make good preparations for the drill, including the materials purchasing, human organization, departments' coordination, etc. It is a hard work for the organizers; however, it may be a funny thing for the participators. This type of real drill has some limitations:

Year	Number of geological disasters	Casualties (person)	Direct economic losses (million RMB yuan)	Investment of prevention (million RMB yuan)
2011	15,804	413	4131.51	9280.85
2012	14,675	636	6252.53	10,241.83
2013	15,374	929	10,435.68	12,353.63
2014	10,937	637	5670.27	16,340.39
2015	8355	422	2505.28	17,626.63

Table 1. Statistical data of geological disasters in China.

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- **Patterned scripts:** The drill is strictly controlled by the prepared script. Participants must obey the rules and act as actors. So, the drills are lack of flexibility and are hard to reflect the dynamic property of real crisis.
- **Expensive costs:** The drill needs props, vehicles, labors, etc., and will consume a lot of water, gasoline, electricity, and related resources. And, sometimes the aftermath site needs to be cleaned. In summary, it is usually very expensive to hold a drill.
- **Complex works:** The drill may affect the local traffic and communication; it is also a need to coordinate with related departments before and during the whole drill process.
- **Poor aftereffects:** People are usually interested in the drill process, like some funny persons or events, but ignore to summarize the problems or experiences of the drill.

Wargames originated from ancient strategy games, and modern wargaming originated with the military need for military exercises which remain an important part of military training today. Sometime between 1803 and 1809, the Prussian General Staff developed wargames, with the basic features of moving metal pieces, game table, using dice rolls to indicate random chance, and with a referee scoring the results. Then, that was the so-called wargame [3]. Wargames are best used to investigate processes; either designers or players can learn a lot from the processes [4]. The computer simulation technologies have advantages of accurate calculating and can process huge amount of complex data; then computer technologies are introduced in the modern wargaming systems.

Just as the name of wargaming, the wargaming-based crisis drill will be held in a game form. The game is designed according to the crisis management plan. It provides the players an interaction virtual environment of crisis. The opponents will be the decision-maker vs. the crisis, that is, the decision-maker should battle with the crisis.

2. System features of wargaming

Wargaming is a kind of computer simulation technique with quantitative analysis ability, which can help to model and solve the complex system problem with the form of several components' competitions. Crisis drill is just like a battle fighting process between crisis managers and crisis. The challenges to model the process are the human factors and uncertainties among them. Comparing with traditional computer simulation methods, wargaming method has the following features:

2.1. Back-to-back competition

Wargaming-based crisis drill is not a pure computer simulation program; to be exact, it is a framework for human to take part in the simulation. In formal wargaming-based crisis drill, departments or forces in crisis management as examinees may be divided into several groups and let them in separate rooms. Each of them should play according to their duty to stop the crisis. Similar to a real crisis happens, they can only get partial information around their visual

field as the fog of war in computer games. To get more useful information, they must issue orders like search and investigation. Who can get more complement and precise information, and who can make good decision and win the game to pass the examination?

2.2. Round-based gaming process

The crisis drill process will be the wargame playing process following the drill scenario round by round. The round-based mechanism requires the simulation and evaluation of crisis drill to be represented in discrete round mode. This may lead to some conflicts between actions in a round, for example, who will be the offense/defense when two units meet in a round? For a synchronous mechanism, actions are issued simultaneously by all players, and they will be validated at the end of the round. For an asynchronous mechanism, we split one round into several stages and use a round list to control the gaming order. This is more convenient to control the gaming process and guarantee the reality of simulation.

Comparing with the real-time strategy (RTS) game, the simulation model is based on statistical data in round-based wargaming, other than a fixed math or physical model in RTS game. So, wargaming is closer to the real world, and above all, players have enough time for decision-making and analysis between the rounds.

2.3. Chess pieces operation

In wargaming system, chess pieces are the symbols of crisis or anti-crisis forces. Players can represent their strategy by operating the chess pieces in sequence. This is more convenient than the general computer simulation method which emphasizes on tedious parameter setting mode. Each piece has a set of action/command list. Players only need to select the chess piece and choose corresponding command from the list.

2.4. Dicing the uncertainty

One of the difficulties in crisis management is uncertainty. In an entity wargame, the uncertain factors are simulated by dicing, which can produce various probability numbers. For computer algorithm, it can produce random number instead of dicing. In wargaming system, it uses combat result tables to deal with the uncertainty of gaming results. Combat result table is a set of probability table; it calculates combat result based on the combat strength of units and random number, which can provide data close to the actual for crisis management. The parameters in the table are based on statistical analysis other than occasional observation.

2.5. Date analytics and machine learning

Wargaming system provides a knowledge representation and database manager platform for crisis drill. By the usage of database and knowledgebase technologies, the crisis drill process will be logged into database and even can be shared in cloud platform. We can do replay to find problems and do data mining or knowledge discovery to sum up the experiences. This can help people to improve crisis drill skills and to optimize crisis plans. Also, we can develop

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machine learning algorithms to teach computers play in the drill, so as to help people make decisions in a real crisis, just like the AlphaGo learn to play Go that beats the human professional Go players [5].

3. Elements of wargaming system

There are four basic elements in wargaming system: counters, gaming board, rules, and scenario. For a specific crisis drill, the wargaming system needs to be designed according to the special demand and characteristics.

3.1. Counters

Counters represent main entities, for example, action units, materials, facilities, etc., in crisis management. In order to get the information at a glance, they are designed as icons with symbols and numbers. There are two types of counters, units and marks, according to their function. Under a sequence of commands, along with their arrangement and movement, they can reflect the plan or drill process of crisis management.

3.1.1. Units

Units are the chess pieces in wargame. For the convenient of identification and operation, there are some elements in their icons, for example, use different colors to represent their owners, use figure or symbol to represent their function type, and use numbers to represent some attributes' values, such as the mobility, energy capacity, panic degree, etc. **Figure 1(a)** shows the fire brigade unit of red player with information of formation, mobility, and fire-fight ability at a glance.

For crisis drill, it involves many departments or organizations, and they have complex relationship among them such as command, coordination and cooperation, etc. Similar to military drill, players are divided into red, blue, or other teams, so we need to make classification according to the organizational and government forming system.

In wargaming design, we need to establish command and supply relationship among units according to their administrative or commercial association, so as to endow units with the power that the real object it represented can do. For the convenient of gaming process, we may combine several units into one counter to integrate their power and also can be dismissed.

Figure 1. Counters in wargaming system (a) Fire brigade unit, (b) Fire brigade unit with fire-control order mark.

3.1.2. Marks

Marks are used to describe some events or status, such as the damage of a bridge, the cutoff of the grid, and the depth of waterlogging. Marks can also represent the orders issued to units, such as the fire-control order sent to the fire brigade unit in **Figure 1(b)**. In each round, players issue an order or execute an action; an order mark will be produced.

3.1.3. Command

According to the functions and duties of unit, there will be a list of commands that players can assign tasks to the unit. Overall, a sequence of orders on series of units forms a decision plan of the commander. With the gaming process, the effectiveness of the decision plan will be evaluated. **Table 2** shows a sample command list in a hazardous chemical leakage accident wargaming system.

Unit	Unit code	Command list	Command code
All	U_{all}	Move	O01
The government headquarters	U1	Establish headquarters	O11
		Rescue command	O12
		Disaster-level assessment	O13
		Relief report	O14
The public security troop	U2	Crowd evacuation	O21
		Site security	O22
		Traffic control	O23
		Site investigation	O24
The medical aid troop	U5	Search and rescue	O51
		Site rescue	O52
		Wounded transfer	O53
The chemistry and epidemic prevention troop	U6	Environment monitoring	O61
		Isolate and decontaminate	O62
		Purify water quality	O63
The emergency and rush repair troop	U7	Equipment maintenance	O71
		Living guarantee	O72
		Site recovery	O73
The transportation troop	U8	Goods transfer	O81
		Waste disposal	O82

Table 2. A sample command list.

3.2. Map

For crisis management, a map can show the distributions of human forces, materials, and crisis spot with detailed geographic information, and this can help to get overall knowledge and make right decision. Counters are placed into the map to represent the distributions of crisis and anti-crisis forces. Players can issue orders to their counters to express their crisis management plan or crisis drill actions; meanwhile, one important thing is to study the map to get detailed information, and the map will be updated round by round. A map should have basic elements like scales, terrains, and position. For the simulation requirement, a map should be gridded into square or hexagon lattices with proper scales [6, 7]. Each grid has terrain information, for example, water, desert, swamp, forest, road, etc., which will affect the actions of units. The absolute or relative position of the elements can be located based on the grid coordinates.

3.3. Rules

Rules can be theoretical laws to players' actions, and they come from mathematical models and expert experiences. Following these rules, the units' actions can be executed and evaluated. There are some rule sets in wargaming system, action rule set, decision rule set, and evaluation rule set.

For action rule set, often used in the ordering phase, some orders are preprocessed to validate the operation. For example, when issue "Move" order in **Table 2** for a car unit, it cannot enter the terrain of water, but for a boat unit, it can only move following water terrain.

For decision rule set, the final result of an action will be calculated, and the result will be updated to all clients and be logged into database. Based on the round-based gaming mechanism, decision tables are often used to process the stochastic factors and produce reasonable results. For example, the decision table in **Table 3** shows the fire extinction results of a fire fighter unit.

In **Table 3**, the relative ability refers to the ratio that the fire fighter unit remained; the dice number is the random number from 1 to 6. Different combinations of a relative ability and a

Dice number	Relative ability				
	≤1/1	1/2	1/3	1/4	≥1/5
1	1	1	1	0.8	0.5
2	1	1	0.8	0.7	0.4
3	1	0.8	0.8	0.6	0.3
4	0.9	0.8	0.7	0.5	0.2
5	0.9	0.7	0.6	0.4	0.1
6	0.8	0.6	0.5	0.3	0

Table 3. Typical decision table in wargaming system.

dice number will produce a reasonable decision result considering the unit's current state with randomized affect.

For evaluation rule set, a more comprehensive evaluation of the action will be calculated and will be iterated like some back-propagation algorithms to get reasonable reward function values. This can help to produce justice drill score and help to make AI-based decision-making.

3.4. Scenario

Scenario is the scripts or story of a crisis drill. On one hand, scenario introduces the aim, task, and basic information of this drill; on the other hand, scenario initializes the condition of crisis, counters, and resources.

By reading the introduction of a scenario, players can learn the basic information of the drill. The examiner or specialist can also add or activate some special events to increase the drill difficulties or make the simulation closer to the real society, which is exactly the advantage of wargaming-based crisis drills.

4. Form and process of wargaming-based crisis drill

4.1. Setting of player seats

There are three main actors in wargaming-based drill system, judge, red players, and blue players. A crisis drill sometimes can be an examination for crisis management abilities. Judge, the judgment group as examiners, can get all information in the map. Generally, they are also the designer of the drill plan, and they can monitor and adjust the gaming process or even lead in new affairs to make adaptive test for specific drillers. Red players as examinee are the anti-crisis forces in crisis management. Their duties are to eliminate the crisis, protect people's life and properties, and so on. In back-to-back mode, players may be divided into groups and isolated in different rooms. Each group can only get partial information around them, just like they are located in a real crisis. They should issue orders like "search," "scout," and "communicate" to their units to get more detailed information. Blue players, the control group, play the role of crisis developing. Although most of the simulation works can be processed by computers, we still need the blue players to help to control the crisis expanding and subsidy affairs in a more comprehensive economic and social background. The system can also provide viewer's seat for visitors to watch the drill process and results, but has no authority to issue orders.

4.2. Wargaming framework

The wargaming provides the platform for modeling, simulation, and evaluation of crisis management; besides, it maintains the data produced in drilling which can provide potential support for crisis management study. **Figure 2** shows the framework of wargaming-based crisis drill.

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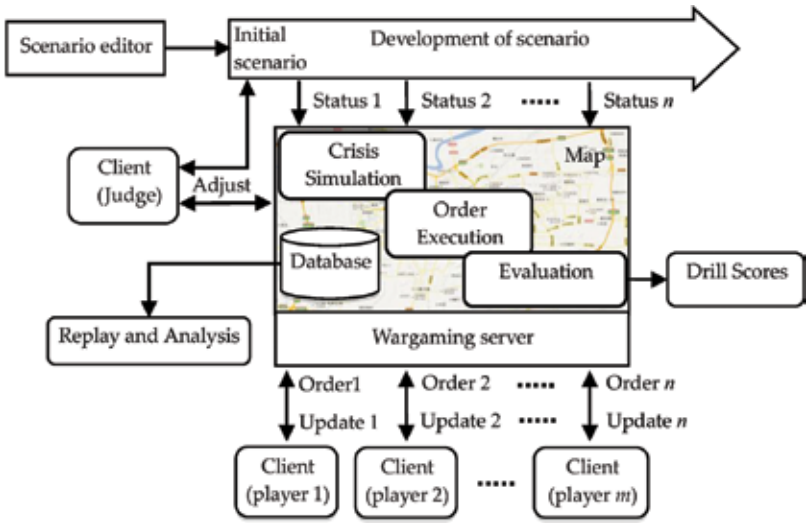

Figure 2. The wargaming framework of crisis drill.

Scenario editor can help to transform the crisis management plans into drill scenarios. For organizations, the scenario is the test paper they need to make, and then the gaming process will start from the initial scenario and develop following the scenario. Players select proper seat and login the system from clients while loading the scenario, and then the gaming process is performed round by round. In each round, players study the current situation and issue orders to their counters, so all orders are simultaneously uploaded into the wargaming server. The server will simulate the crisis, execute the orders, and evaluate their effects. Similar to the real world, some orders may be partially executed or canceled because of the interference of other players' actions or the influences of undetermined environment. The judge can examine the simulation results to find out the unbalanced data or wrong data and adjusts them to a reasonable value to keep the authenticity of the gaming process. Then the gaming process puts forward to the next round.

The end of the gaming can be evaluated by several conditions that meet the drill destination. For example, if the blue player's counters are all eliminated from the map which means the crisis has been controlled, so red players win the game. For a fire-control drill in a factory, if the factory is exploded, then red players fail the game. Since the process of the gaming is logged into the database, we can carry out more analysis works to find out the weak point, the bottleneck, or better schemes to help players to improve their decision ability for the drill, on the other side, to help the organizers to improve the crisis management plan.

4.3. Flow control of wargaming system

There are two main stages in wargaming flow: operations on clients and adjudications on server. During the operation stage, the order validity is checked on clients. Then players can know whether the orders can be issued or not, but they cannot know the execution results.

During the adjudication stage, the orders are executed with taking consideration of all the wargaming factors to guarantee the adjudication results reasonable. The flow control of wargaming system is shown in **Figure 3**.

5. Evaluation methods of wargaming

For wargaming system, evaluation is also processed following with gaming. Evaluation methods are based on some mathematical models, and utility theory is applied to estimate the dynamic sequential affects. During the gaming process, actions and orders issued by players will be evaluated till the end of wargame. The computer summarizes the utility of all decision orders by weighting, which are the scores of players' performance in the crisis drill.

5.1. Command evaluation

According to counters' order forms, evaluation of commands can be divided into four types, movement, position, effect, and impression. Each category has different specifications and needs different ways to score.

5.1.1. Evaluation of movement-type index

In wargaming system, many continuous variables, such as the speed and time, need to be discretized into some point values to characterize the ability of a unit. When a unit piece executes the "move" command in the map, a certain amount of maneuvering point values will be consumed. What is more, the properties of terrain, weather, and unit capacity will affect how much point value it will be consumed at the time of passing through a hexagonal grid. The unit will not be able to move anymore as the mobility point value of the unit is used up.

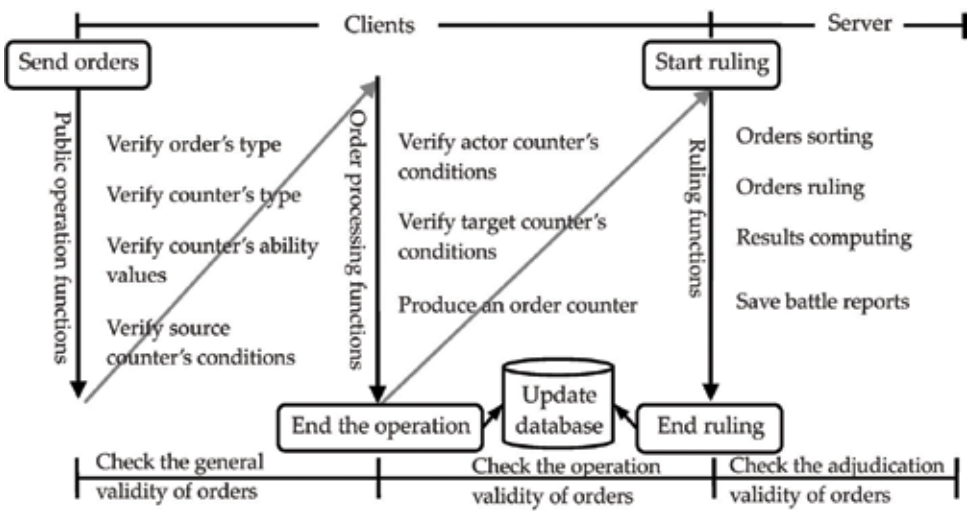

Figure 3. Flow control of operations and adjudication.

Here, we use the ratio of movement point value consumption to the initial movement point value to measure the effect of the command. The evaluation template of movement-type index is shown in **Table 4**.

In **Table 4**, the movement point value is the moving capability of units, and the movement points consumed are the efforts that units contribute to finish the task. In general, the faster the unit moves to the target, the better quality it finishes the job with less movement points consumed. So, we use a third order function to evaluate the effect of movement-type command:

$$f(x) = 1 - x^3, x \in [0,1] \tag{1}$$

where, $x = \frac{x_c}{x_0}, x_c > 0, x_c \leq x_0, x_c$ is the movement point value consumed to complete this operation; x_o is the initial movement point value of the unit.

5.1.2. Evaluation of position-type index

The position-type index mainly concerns the target location of the command. In wargaming system, the hexagonal grid with corresponding coordinates is used to indicate the position of the element in the map. When players issue orders, a reference position, desired interval, and maximum allowable interval should be set. Then the hexagonal grid number of intervals can be determined by calculating the distance from the target position to the referenced position of the unit's command. Considering that some referenced location cannot be entered directly, such as the fire site, we set x_o to represent the expected interval between actual position and referenced position, x_{min} represent the minimum allowable interval, and x_{max} represent the maximum allowable interval. The evaluation template of position-type index is shown in **Table 5**.

The scoring function of the position-type index is as the following formula:

$$f(x) = \begin{cases} 1 & x = x_o \\ \dfrac{x - x_{\min}}{x_o - x_{\min}} & x \in [x_{\min}, x_o) \\ \dfrac{x_{\max} - x}{x_{\max} - x_o} & x \in (x_o, x_{\max}] \\ 0 & x = \text{others} \end{cases} \tag{2}$$

where x = max(|c_{xd} - c_{xr}|,|c_{yd} - c_{yr}|) is the number of hexagonal grids between the actual location and the reference location. (c_{xd}, c_{yd}) represents the coordinates of target location of action, and (c_{xr}, c_{yr}) represents the coordinates of referenced position set by drill designer.

5.1.3. Evaluation of effect-type index

Effects of a command execution can be evaluated by the related gain or loss results. According to the command property, the result may be the number of casualties, the number of destroyed hexagonal grids, or the number of polluted hexagonal grids. The effect degree can be divided into three levels, for example, the degree of personnel casualty can be divided into death, heavy injury, and slight injury, and the destruction or pollution degree of hexagonal grids can be divided into heavy, medium, and light levels. The three levels from heavy to light are level I, level II, and level III. The evaluation template of effect-type index is shown in **Table 6**.

Properties	Variables	Command list			
		Movement	**Wounded transfer**	**Goods transfer**	**…**
Command code		O01	O53	O81	…
Action unit		U_{all}	U5	U8	…
Initial movement points	x_0				
Movement points consumed	x_c				
Score	$f(x)$				

Table 4. Scoring of movement-type index.

Properties	Variables	Command list		
		Establish headquarters	**Crowd evacuation**	**…**
Command code		O11	O21	
Action unit		U1	U2	
Target location	(c_{xd}, c_{yd})			
Referenced location	(c_{xr}, c_{yr})			
Expected interval	x_o			
Minimal interval	x_{min}			
Maximal interval	x_{max}			
Score	$f(x)$			

Table 5. Scoring of position-type index.

The scoring function can be represented by an exponential function:

$$f(x) = e^{-0.1\beta x}, \quad \beta > 0 \tag{3}$$

where $x = 5x_1 + 3x_2 + x_3$, (x_1, x_2, x_3>0) is an equivalent value that represents the gain or loss degree of the action; x_1, x_2, x_3 represents the gain or loss value in level I, level II, and level III; and β is a correction coefficient, mainly to compensate the error caused by different map scales or something else.

5.1.4. Evaluation of impression-type index

Some commands may have subjective features that need experts to make evaluation directly. Based on their experiences, experts make overall judgment by watching the gaming process. To avoid the subjectivity of these experts, there will be *m* number of experts that give their rating of the command. The scoring table of impression-type index is shown in **Table 7**. The final score is the average of these rating values, and sometimes the minimal and maximal values will be neglected.

Properties	Variables	Command list			
		Search and rescue	Prevent leakage	Purify water	…
Command code		O51	O31	O63	…
Action unit		U5	U3	U6	…
Level I	x_1				
Level II	x_2				
Level III	x_3				
Correction coefficient	β				
Score	$f(x)$				

Table 6. Scoring of effect-type index.

No.	Command code	Action unit	Experts rating					score
			1	2	3	…	*m*	
1			r_{11}	r_{12}	r_{13}	…	r_{1m}	f_1
2			r_{21}	r_{22}	r_{23}	…	r_{2m}	f_2
…	…	…	…	…	…	…	…	…

Table 7. Scoring of impression-type index.

Level I index (objective)	Level II index (plan)	Level III (action)
Crisis management ability (A)	Crisis responsibility (B_1)	The time that corresponding units reach the target site (C_{11})
	Command decision capacity (B_2)	Creation of headquarter (C_{21})
		Action coordination (C_{22})
		Judgment of crisis damage (C_{23})
	Emergency rescue capacity (B_3)	Search and rescue trapped people in time (C_{31})
		On-site rescue of the seriously wounded (C_{32})
		To send wounded people to designated medical institutions in time (C_{33})
	Crisis disposal capacity (B_4)	Containment of hazardous article leaks (C_{41})
		Extinguish fire source and deal with explosion accident (C_{42})
		Look for leaks, repair damaged equipment (C_{43})
		Decontamination of contaminated waters (C_{44})
	Monitoring and early warning capacity (B_5)	Continuous monitoring of the environment (C_{51})
		Contamination monitoring and decontamination of the wounded (C_{52})
		Alert the public timely (C_{53})

Level I index (objective)	Level II index (plan)	Level III (action)
		Inform the media about the crisis disposal (C_{54})
	Emergency support capacity(B_6)	Contact providers to provide emergency resources (C_{61})
		The requested resource arrives at the demand location in time (C_{62})
		Identify and classify the resources achieved (C_{63})
		Ensure the communication system is working properly (C_{64})
		Ensure the normal supply of water, electricity, and gas (C_{65})
	Social control capacity (B_7)	Organize the evacuation of the surrounding masses (C_{71})
		To warn of potentially dangerous areas (C_{72})
		Guide vehicles to avoid traffic congestion (C_{73})
	Restoring and rebuild abilities (B_8)	Decontamination of on-site equipment and all personnel involved in the rescue (C_{81})
		Clean-up of contamination and transport to waste disposal site (C_{82})
		Maintenance and restoration of basic living conditions (C_{83})
		Investigate the cause of the accident (C_{84})
		Summarizing experiences and lessons in crisis (C_{85})

Table 8. A sample index system for crisis drill.

5.2. The creation of index system

An index system needs to be created according to the practical condition in crisis management. The index system can be hierarchical structure; then organizations can score the drill process in a categorized way to represent the specific abilities of players. Level I index is the total score for the drill objective, level II index is the criterion for crisis disposal plan, and level III index is the score that specific action accomplished.

To create the index system, organizations need to analyze the crisis plan, crisis disposal process, department responsibilities, national standards, etc.; then, according to the drill objective and the wargaming process, sometimes need to consult with experts; and make the detailed index system. **Table 8** shows a sample index system of a hazardous article leakage crisis.

6. Decision models for wargaming drills

A behavior tree (BT) is a mathematical model which can create very complex tasks composed of simple tasks and widely used in computer games [8]. In wargaming-based drill system, the scenario and action rules can be represented easily and understandable in a graphical way by

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using BTs; meanwhile, some autonomous factors like fire expansion, typhoon moving, etc., can be created based on BTs. Also, the gaming process becomes efficient based on BT, and it makes preparation for the application of artificial intelligent for some algorithms which are based on decision trees, etc.

Hierarchical behavior trees can be created in wargaming-based drill system. Upper level behavior trees are composed of main policies according to level I or level II indexes. Lower level behavior trees are the standard BTs according to level III indexes. That is, the upper level illustrates the strategy for wargaming, but the lower level represents the tactical implementations of the drill actions.

Figure 4 illustrates a sample BT for an outbreak public security incident plan. For behavior trees, every node may have three states, succeeds, fails, or running. A sequence node has the

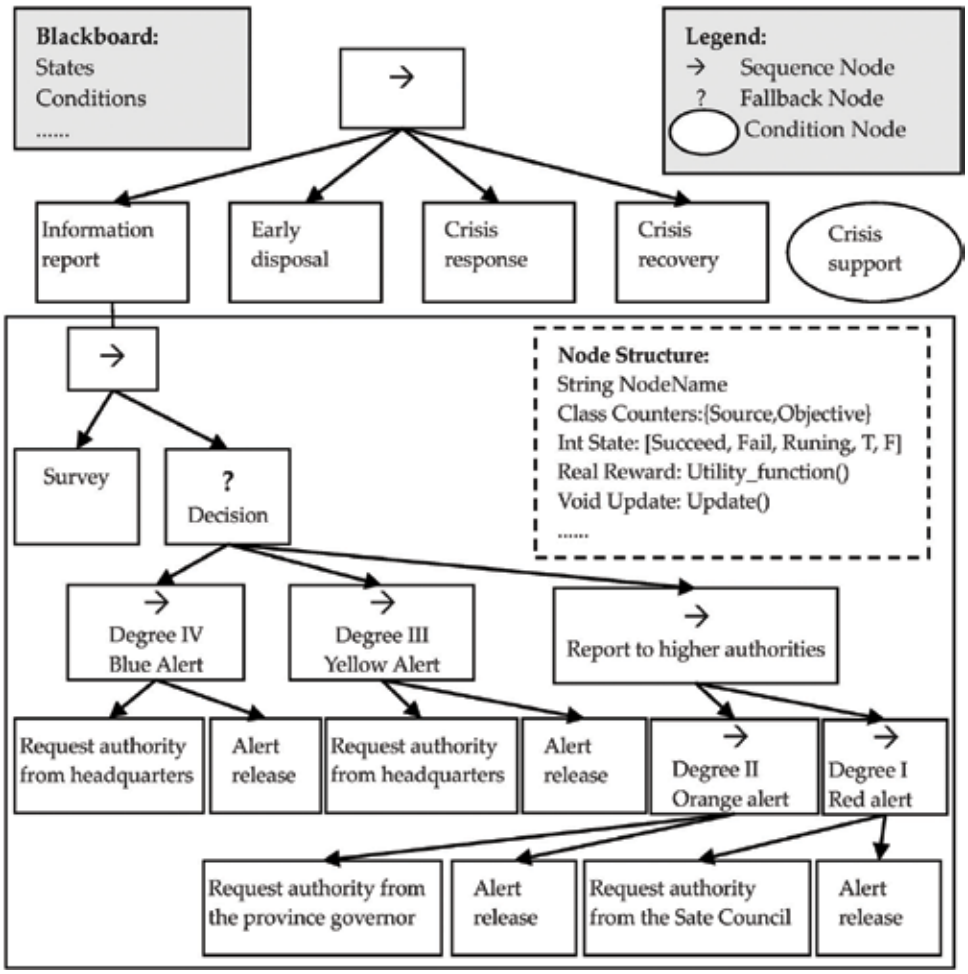

Figure 4. Sample behavior tree for a crisis plan.

process logic of "AND," that is, if all children succeed, the node succeeds; if one child fails, the node fails; if one child is running, the node is running. A fallback node has the process logic of "OR," that is, if one child succeeds, the node succeeds; if all children fail, the node fails; if one child is running, the node is running. A condition node can be a proposition or precondition for an action; it returns success or failure depending on the condition satisfaction. It gives a behavior tree more controllable functions. More decorator nodes may be needed to describe a complex behavior. User can define custom policy for the decorator node. For the convenience of data sharing in programming, a blackboard is used to share data between modules.

In practice, every node will be represented by a structure or class according to object-oriented programming languages, such as C/C++, Java, Python, etc. With the processing of tree node, states will be updated, and a reward will be evaluated at the same time. The reward value can be calculated according to the evaluation models described above. In fact, the reward can be evaluation scores when we focus on the examination function of the crisis wargaming; on the other hand, the reward can be utility values for optimal decision searching when we focus on the decision support function of the crisis wargaming. With the rapid progress in artificial intelligent (AI), especially the success of AlphaGo, we can believe the machine can sometimes give more reliable decision than average humans. The basic mechanism for AI algorithms, such as reinforce learning, is that they always pursue to maximize the rewards. So, the crisis wargaming has the nature form for the implementation of AIs.

7. A case study

Here, we give a replay of an oil pipeline leakage accident. Based on wargaming system, the disposal process is replayed and evaluated. Especially, the process is studied, and the gaming scores show the reason of crisis disposal failure.

7.1. Background

At around 2:30AM November 22, 2013, there was an oil pipeline leakage accident corresponded by Sinopec China at Qingdao City. Due to the improper disposal, an explosion occurred during the repairing process at around 10:30AM, and it caused 62 dead and 136 wounded people with 0.75 billion RMB yuan direct economic losses.

7.2. Gaming and evaluation

According to the record of the disposal process lateral published by the government, we replayed the process in the wargaming system as **Figure 5**. Then we can get the evaluating scores of the disposal process at that time, which are shown in **Tables 9–12**; for the command codes and unit codes, please refer to **Table 2**.

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Figure 5. A partial screen capture of wargaming.

Properties	Variables	Command list				
		Move	Move	Move	Move	Move
Command code		O01	O01	O01	O01	O01
Action unit		U2	U1	U3	U6	U7
Initial movement points	x_0	20	20	20	20	20
Movement points consumed	x_c	5	9	8	15	13
Score	$f(x)$	0.984	0.909	0.936	0.578	0.725

Table 9. Score of movement-type index.

	Variables	Command list	
		Establish headquarter	Crowd evacuation
Command code		O11	O21
Action unit		U1	U2
Target location	(c_{xd}, c_{yd})	(33,23)	-
Reference location	(c_{xr}, c_{yr})	(33,25)	-
Expected interval	x_o	3	-
Minimal interval	x_{min}	1	-
Maximal interval	x_{max}	6	-
Score	$f(x)$	0.5	0

"-" represents the command need to be done but the player failed to issue.

Table 10. Score of position-type index.

	Variable	Command list	
		Prevent leakage	Purify water quality
Command code		O31	O63
Action unit		U3	U6
Level I	x_1	1	1
Level II	x_2	1	2
Level III	x_3	3	6
Correction coefficient	β	0.8	0.8
Score	$f(x)$	0.41	0.26

Table 11. Score of effect-type index.

7.3. Results

Above all, we make individual evaluations of the action units and the accomplishment of their commands. In the form of three-level index system, based on the evaluation of individual action units, the overall evaluation results of crisis management ability can be obtained according to a linear weighted model, that is, the comprehensive score of higher level can be calculated by summarizing the production of the lower level index scores with their weights. The total index weighted scores by the linear weighted model is shown in **Table 13**.

Comparing with **Table 7**, the level II indexes of B3, B6, and B8 are ignored since our replay stopped till the explosion happened which means the game is over.

According to the aforementioned evaluation methods, the results are scored from 0 to 1; then, the three-level indexes are all from 0 to 1, and higher score means better capability. In this

Command code	Action unit	Experts' rating					Score
		1	2	3	4	5	
O12	U1	0.725	0.475	0.65	0.675	0.475	0.6
O13	U1	0.725	0.475	0.65	0.35	0.425	0.525
O71	U7	0.275	0.275	0.375	0.425	0.25	0.325
O61	-	0	0	0	0	0	0
O42	-	0	0	0	0	0	0
O43	-	0	0	0	0	0	0
O22	U2	0.85	0.55	0.725	0.625	0.875	0.725
O23	U2	0.875	0.675	0.75	0.85	0.85	0.8

"-" represents the command need to be done but the player failed to issue

Table 12. Score of impression-type index.

Level I index	Level II index	Level II index weights	Level III	Level III index weights	Level III index score	Level II index score	Level I index score
A	B1	0.146	C11	1	0.826	0.826	0.471
	B2	0.310	C21	0.114	0.5	0.558	
			C22	0.479	0.6		
			C23	0.407	0.525		
	B4	0.376	C41	0.285	0.41	0.326	
			C43	0.364	0.325		
			C44	0.351	0.26		
	B5	0.053	C51	0.381	0	0	
			C53	0.458	0		
			C54	0.161	0		
	B7	0.115	C71	0.368	0	0.478	
			C72	0.364	0.725		
			C73	0.268	0.8		

Table 13. Index weighted scores in the first round.

incident, the overall score is 0.471 which means the crisis management ability is poor. Referring to **Table 8**, the responsible authority failed to perform monitoring and early warning actions, since index B5 scores 0. In fact, the lack of monitoring environmental condition (C51) action lost the opportunity to avoid explosion, and the actions of alerting the civilian (C53) and reporting the disaster disposal information to the media (C54) ought to reduce the loss in incident. The crisis disposal capacity (B4) is poor since it scores 0.326, and the action of cleaning the polluted water (C44) scores 0.26 as the worst one, which is the direct reason of explosion while the oil in polluted water was on fire.

To sum up, by replaying the Sinopec oil pipeline leakage accident wargaming, we can make quantitative evaluation of the unit's action which can show their capacities in crisis disposal. Furthermore, by creating a three-level index system, we can evaluate the crisis management capacity of departments or decision-makers in level II indexes. In fact, level II indexes take into account the decision sequence and cooperation among units, so they are comprehensive evaluations. Overall, the level I index is the total score of the crisis drill.

8. Conclusion

We introduce a novel crisis drill mode—wargaming. It provides a platform for system modeling, drill evaluating, and decision-making. It makes the crisis drill just like playing computer games. During the drill process, most of the factors are quantized and saved into databases, which can help to carry out deep research and AI-based planning. For government authorities, they can make good crisis plans by gaming a crisis drill once and again, to find the best

assignment of emergency resources, the best human resource management, the best crisis disposal workflow, and so on. For the related duty departments or person, they can practice or adopt the examination of their workflow and professional ability in a crisis drill.

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Chapter 13

Landslide Risk Management and Crises Events

Valentina Svalova

Additional information is available at the end of the chapter

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Abstract

The problem of geological and landslide risk management is seen as a series of events leading to risk reduction, including risk analysis, risk assessment, risk mapping, vulnerability evaluation, concept of acceptable risk, monitoring organization, engineering-technical methods, insurance, and others. Some examples of crises events are presented and investigated.

Keywords: landslide, risk, risk management, risk assessment, risk reduction, monitoring

1. Introduction

Natural disasters always caused fear and horror in people. The greatest horror is caused by earthquakes, volcanic eruptions, and tsunamis that are unpredictable and catastrophic in its consequences. The most unpredictable are earthquakes. Active volcanoes are constantly monitored, giving the possibility of anticipating a possible eruption. Tsunamis also have a number of predictive features, which makes it possible to mitigate the consequences of their onset.

Often unexpected for a person are snow avalanches and giant landslides and debris flows. Giant landslides and debris flows are often caused by prolonged torrential rains or earthquakes. The task of preserving the cultural heritage can be considered theoretically solvable. A practical solution will require only correct and timely engineering decisions and material costs, and the role of science is very great here.

Landslide is a major geological hazard, which poses serious threat to human population and various infrastructures such as highways, rail routes, and civil structures such as dams, buildings, and others [1–21].

The idea that landslide could occur is frightening people in every area prone to such phenomena. This is because the effects of landslides can be devastating, leaving thousands of people without home and threatening their lives.

Mountainous and coastal areas are the most affected regions but that does not mean that the other areas are safe.

Landslides cause huge damage in the world and kill many people each year. Casualties are caused by rockslides, rockfalls, and debris falls. In order to know this phenomenon better, and eventually protect themselves from its destructive action, people should be aware of how landslides are formed and how they act.

The word "landslide" describes different processes that result in the movement of materials like soil, rock, earth, mud, debris, artificial fill, snow, ice, ash, combination of these materials, and others.

When these materials start moving, they may be falling, toppling, sliding, spreading, flowing, and others. According to the moving trajectory, landslides could be rotational or translational. There are some specific types of slides or mass movements as lahars, solifluction, avalanches, glaciers, and others.

Landslides are associated not only with mountainous areas, but also they affect low relief areas. In this case, the trigger factors could be failures determined by building or roadway excavations, collapse of mine piles, slope failures associated with quarries, lateral spreading landslides, river bluff failures, and others.

Depending on the location and type of human activity, the landslide effect could be lessened. People should know hazard zones and avoid activities like digging in such areas.

For systematic analysis of landslide hazard, it is fruitful to use the notion of risk.

Geological risk is a relatively new and not fully explored concept [22–31]. There are many definitions of geological risk. And often scientific study or scientific approach to the problem begins with a presentation of the author's position and the choice of the definition of geological risk for the problem under consideration. One of the most common approaches defines that risk is the expectation of damage, or risk is the product of the probability of possible hazardous events on the damage produced.

The problem of landslide risk management is considered as measures leading to landslides risk reduction. It includes landslides monitoring, mapping, landslide forecast, engineering works, slopes strengthen, insurance, and others. Strictly speaking, geological risk management includes:

1. Hazard identification;
2. Vulnerability evaluation;
3. Risk analysis;
4. Concept of acceptable risk;

5. Risk assessment;
6. Risk mapping;
7. Measures for risk reduction;
8. legislative;
9. organizational and administrative;
10. economic, including insurance;
11. engineering and technical;
12. modeling;
13. monitoring; and
14. information.

Vulnerability to landslides depends on location, frequency of landslide events, type of human activity in the area, and other factors.

2. Natural hazards and disasters: hazard identification

Natural hazards are potentially damaging physical events and phenomena, which may cause the loss of life; injury or human life disruption; property damage; social, economic, and political disruption; or environmental degradation.

Natural hazards can be divided into different groups: geological, hydro-meteorological, climatological, outer space, and biological hazards.

Natural hazards can be single, multiple, regional, and global in space. Each natural hazard is characterized by its location, intensity, and probability.

A disaster is a serious disruption of the normal functioning of a society causing widespread human, material, economic, or environmental losses.

For the last 35 years, the frequency of the disasters associated with natural hazard events has been steadily increasing. An average number of 405 events per year was registered by Munich Re in 1980–1989, 650 events in the 1990s, 780 events during the period 2000–2009, and more than 800 events in 2010 [32]. **Figure 1(a–f)** shows that total number of disasters increase, but the number of geological disasters has not changed much for the last 30 years when compared to the number of hydro-meteorological and climatological events. Victims and economic damage increase drastically.

Earthquakes, volcano eruptions, tsunamis, crust, suffusion, coast erosion, and landslides belong to geological hazards.

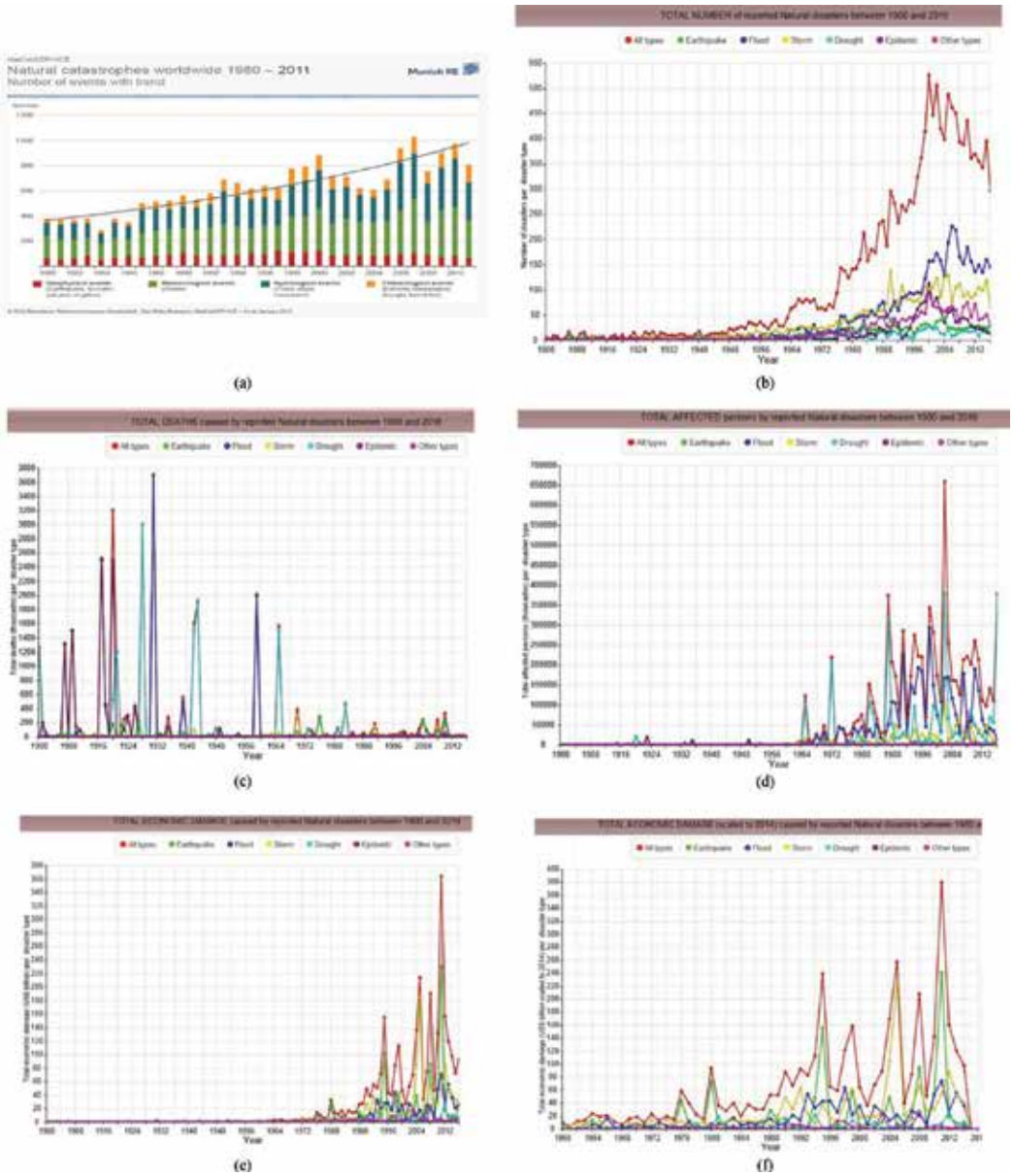


Figure 1. (a) Annual number of disasters associated with natural events from 1980 to 2013 1: red represents the geological events; 2: green represents the meteorological events; 3: blue represents the hydrological events; and 4: orange represents the climatological events (NatCatSERVICE, Munich re, 2014). (b) Total number of natural disasters, 1900–2016. http://emdat.be/. (c) Total deaths caused by natural disasters, 1900–2016. http://emdat.be/. (d) Total affected persons by natural disasters, 1900–2016. http://emdat.be/. (e) Total economic damage caused by natural disasters, 1900–2016. http://emdat.be/. (f). Total economic damage (scaled to 2014) by natural disasters, 1960–2016. http://emdat.be/.

Hydro-meteorological and climatological hazards are the most frequent causes of the disaster events among all natural hazards (**Figure 1**). The most common meteorological hazards are heavy rains, storms, hurricanes, droughts, tropical cyclones, rainstorm floods, heat waves,

and low temperature disasters. Moreover, meteorological hazards include lightning, tornadoes, dust storms, hail, frost, fog, and haze [32]. Adverse impacts from weather and climate extremes can be considered meteorological disasters when they produce widespread damage and cause severe alterations in the normal functioning of communities or societies.

3. Risk assessments

According to the most common definition, risk is the probability of the natural hazard event multiplied by the possible damage:

$$R = P \times D, \tag{1}$$

where R—risk, P—probability, and D—damage.

For multi-risk assessment, it is possible to use the sum of risks of different hazards:

$$R = \sum R_i. \tag{2}$$

For the risk map construction, it is necessary to use the natural hazards maps and maps of possible damage. These maps can be of local, regional, federal (sub global), and global levels.

Areas of such crises events must be places of the highest risk at the natural risk maps of the territories.

3.1. Landslides risk assessment and mapping

Geological risk mapping is an important step toward solving the problem of natural risk management. Due to the complexity and diversity of the problem, the combination of probabilistic and deterministic approaches and expert estimates arises.

The probability of landslide process depends on the stability of the landslide slope, trigger mechanisms (precipitation, earthquakes), and technological factors. The first step is studying the physical and mechanical sliding process at different conditions. Nevertheless, the landslide process mechanics are still not fully understood. Landslide prediction is not always possible. Even statistical frequency of landslides activation for a particular area varies very widely.

As an example to be considered is the approach to the construction of the landslide risk map in the territory of Moscow.

Landslide processes in Moscow are well investigated. Landslides cover about 3% of the city, where there are 15 deep and a lot of small landslides, and the landslide hazard is mapped. In the last few years in Moscow, there is a significant activation of landslide processes. To assess the landslide hazard, the height of the slope, the landslide body volume, mass velocity, rock properties, topography of the surrounding area, the range of possible promotion of landslide masses, hydrogeological conditions, and trigger mechanisms have to be taken into account. Selection of taxons' (special areas) varying degrees of landslide hazard in the city

is a completely solvable task. Gradation is possible as in the three degrees of danger (high, medium, and low) as in the five ones (very high, high, medium, low, and not dangerous), depending on the details of the task.

The most expensive land and buildings in Moscow are located in the city center, where the oldest historic buildings, buildings that are most vulnerable to natural hazards, and the most expensive new ground and underground constructions, subway lines, complex traffic, and technical communications of high density are present. There is an increased density of population. We can assume that the closer to the center of Moscow, the greater the potential damage from possible landslide process.

Hazardous industrial production brought to Moscow's periphery. But the protected zone of Moscow on the Vorobiovy Hills and in Kolomenskoye also has high cultural value, and the potential damage there is highly evaluated. Therefore, a first approximation map of landslide risk in Moscow may be an overlay of landslide hazard maps and population density, building density, land prices, density of roads, and infrastructure maps. Areas with the highest degree of landslide hazard and the highest damage are the areas with the highest landslide risk in the territory of Moscow [31].

For the automated analysis of the factual material and the risk map construction, it is necessary to find the intersection of the landslide hazard map and integrated map of possible damage, that is, for each i-th fragment Ri of risk map to find the product of probability Pi of landslide event to the amount of different j-th possible damages from landslides, that could result in the damage to land, to buildings, to transport, to communications, to people, and others:

$$R\,i = P\,i \sum j\, D\,ij. \tag{3}$$

It is necessary to calibrate maps of landslide hazard from 0 to 1 to reflect the probability of landslide events ($0 \le P \le 1$). Thus, gradation, for example, is possible on a scale of (0; 0.25; 0.5; 0.75; 1), where 0 corresponds to no danger of landslides, 0.25 corresponds to low, 0.5corresponds to average, 0.75corresponds to high, and 1corresponds to a very high probability of the landslide process. This assessment is an expert in nature. In principle, it is possible to construct the landslide hazard maps as the intersection of maps of factual material, such as map of relief contrast, rock strength, slope stability, speed of motion of the surface, the density of rainfall, seismicity, and so on. Of course, this will require additional research and evaluation.

For a comprehensive assessment of the damage in each region, it is suggested to calibrate the possible damage of each option on a three-point system (0, 1, 2), where 0 corresponds no damage, 1corresponds to middle, and 2 corresponds to high damage. The parameters here are: (1) cost of land, (2) cost of housing, (3) density of buildings, (4) population density, and (5) density of roads and communications. The higher the value (the value of land, housing, etc.), the greater the damage in case of a hazardous event.

Then, the possible damage to five parameters for each element varies from 0 to 10.

The risk also in each element ranges from 0 to 10. This is the risk in relative terms (high-low), on a 10-point scale.

$$D\,i = \sum j\,D\,ij, j = 1–5, D\,ij = (0, 1, 2), 0 \leq D\,i \leq 10, 0 \leq R\,i \leq 10. \quad (4)$$

After dividing the map of the area into squares and calculating the risk for each square, you can get a map of the area at risk on the 10-point scale.

On the basis of preliminary expert estimates, it will be the areas in the vicinity of Moscow River and Yauza River, as well as in the areas of contrasting relief along riverbeds of paleorivers in the city center.

The areas of highest landslide risk are Vorobiovy Mountains (Hills) and Kremlin Hill. (**Figure 2**).

They are shown as white circles in the map of geological danger in Moscow. (**Figure 3**).

These areas may be considered as "hot spots" on the risk map. Even though in some of these areas, the population density is not so high, the other components (cost of land, the historical importance of the object, the density of underground utilities, and others) have contributed greatly to the high-risk assessment [31].

Figure 2. (a) Vorobievy Mountains with Moscow State University, ski jumps, and metro bridge. (b) Vorobievy Mountains with building of Presidium Russian Academy of Sciences (RAS), Andreevsky monastery, and new living houses. (c) Kremlin embankment.

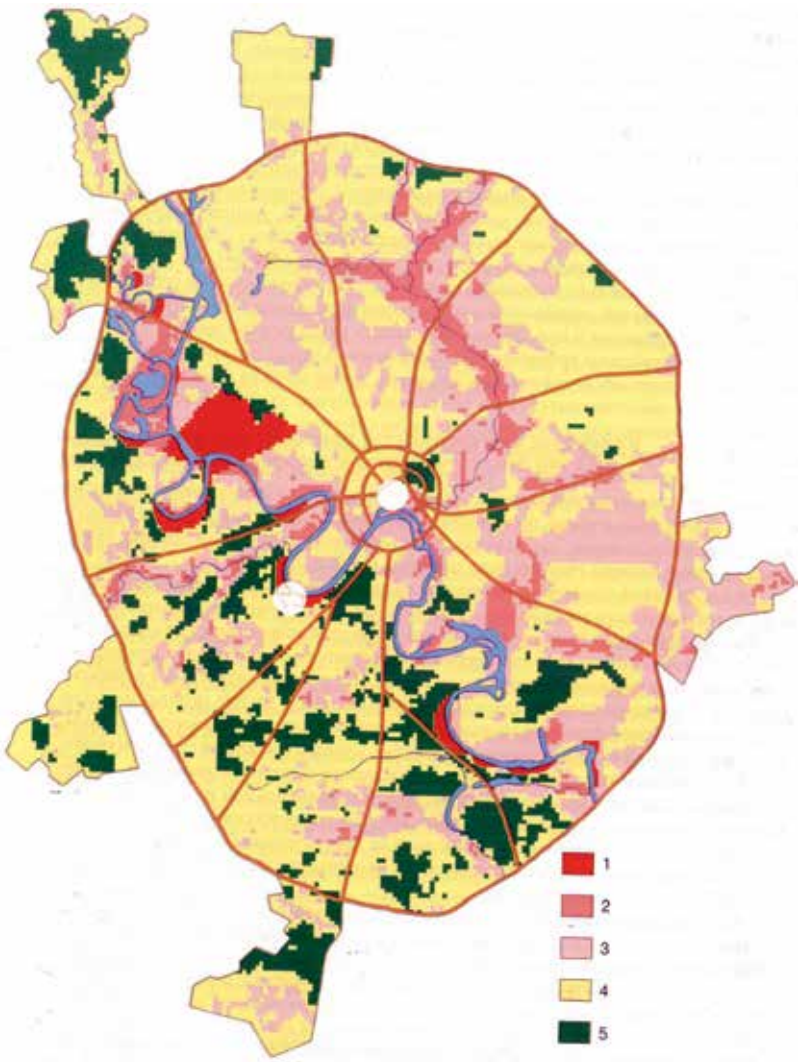


Figure 3. Map of geological danger in Moscow. Landslides, karst, and underflooding. (Osipov V.I., Kutepon V.M., Mironov O.K.) [1]. Landslides are near rivers in semi-dark (red and pink). 1: Very high danger, 2: High, 3: Middle, 4: Low, 5: No. white circles: Risk "hot spots." Kremlin hill (center) and Vorobiovy Mountains (south-west).

These areas must be measured for risk management and reduction at the first line. It means monitoring organization, slope strength, ban on extra buildings and activity.

4. Risk management and reduction: engineering and technical methods

When studying landslides, risk reduction is one of the most important aspects to be considered while discussing engineering and technical methods that are used to strengthen slopes

and rational land use. The most well-known method for slope stabilization is the changing of slope surface (reducing the height of the slope, correction of the slope profile) and reinforcing constructions and water discharge when undertaking building construction. Different protective methods are widely used (**Figures 4–6**).

4a)

4b)

Figure 4. (a and b) Technogenic landscapes in China.

5a)

5b)

Figure 5. (a and b) Strength of slopes and defense constructions along the roads in China.

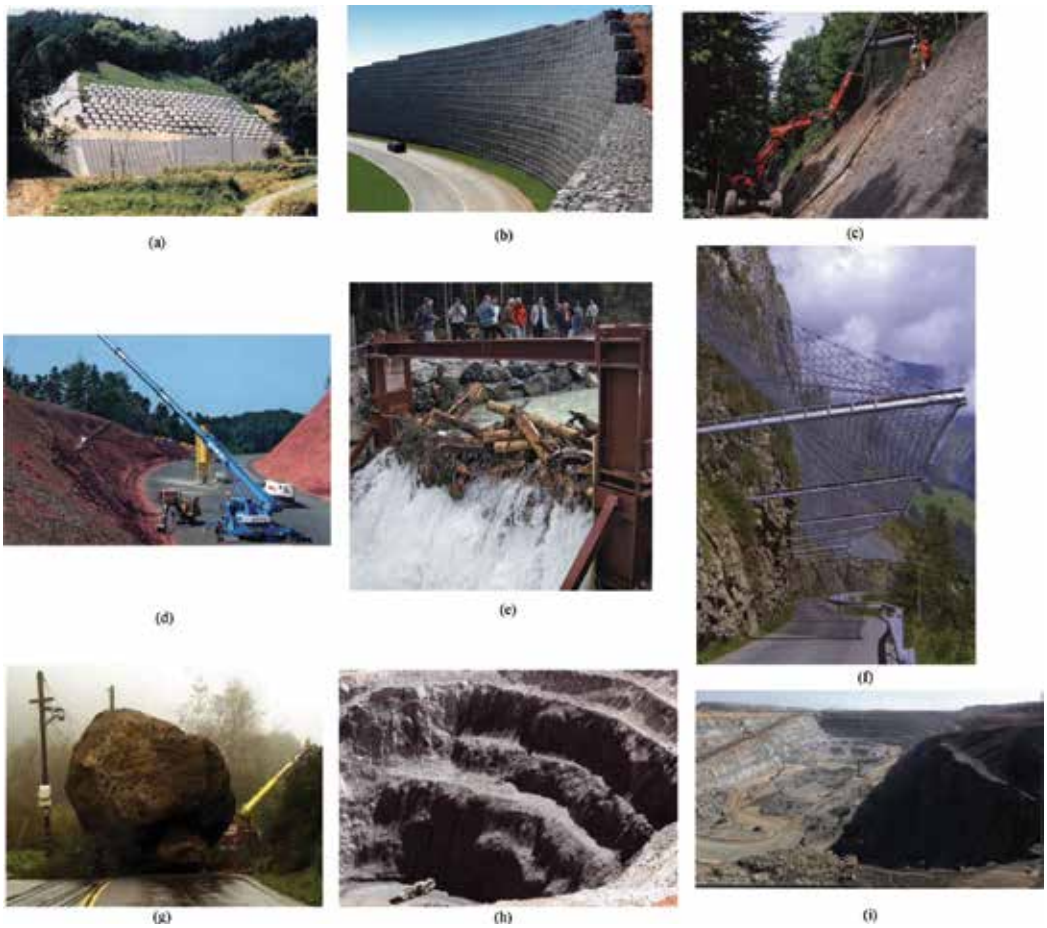


Figure 6. (a) Anchor construction—Japan. (b) Strengthen wall—Switzerland. (c) Slope defense by flexible metallic net—Switzerland. (d). Slope protection by flexible metallic net—Switzerland. (e). Barrier for retaining debris flow—Switzerland. (f) Ring metallic net protection above road against rockfall—Switzerland. (g) Big stone on the road. It is possible to make it fall down, to break, or to reinforce by cement on the slope of the road. (h) Rock slope surface stabilization and rockfall hazard mitigation using coated double-twist rockfall mesh. Australia. Mining company Barrick (Australia Pacific) Ltd., 2010. (i) Rockfall mitigation drapery using double-twist rockfall mesh—South Africa. Mining company Anglo-platinum, 2009.

5. Case studies for landslide-prone slopes protection

Sometimes destructions after landslides or earthquake are so huge that it is more acceptable to leave the place of fatal event than reconstruct buildings or strengthen slopes. There are examples in Bulgaria, Italy, and the USA where innovative decisions for slope strengthening and construction repair are suggested.

5.1. Landslide in Cavallerizzo town, Italy

In Italy, the town of Cavallerizzo was closed after a big landslide was reported on March 7, 2005. It was impossible to visit the town (**Figure 7**) even in 2008 and was visible only from a distance. All roads to the town were blocked.

Figure 7. (a) Big landslide in Cavallerizzo town, Italy, on March 7,2005. (b) Cavallerizzo town in 2008.

Scientists warned the authorities on the dangers of landslide, but they waited till the last moment before evacuating the people. They were fortunate as no one was killed during the landslides.

5.2. Ancona, Italy

On December 13, 1982, the city of Ancona in Italy experienced a huge landslide. The landslide in Ancona took place after a long period of precipitation. The 1982 event began without warning, lasted only a few hours, and affected the whole area simultaneously within a maximum width of 2 km near the coastline involving a volume of about 180 million cubic meters. Some buildings were damaged. A total of 3000 people were evacuated.

After the major landslide, the Ancona administration came out with the "Living with Landslide" policy. An Early Warning System and Emergency Plan was put into place in 2009. Stabilization was unacceptable because of the high cost and impact to the environment. This system offers the best safety measures for the people living in Ancona.

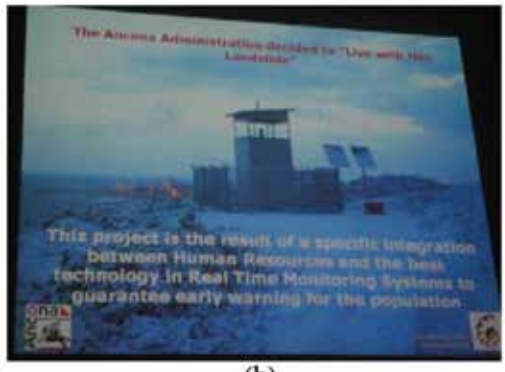
The Early Warning System consists of an integrated and continuous monitoring system aimed at controlling both superficial and deep displacements over the whole area. The surface monitoring is based on 34 geodetic GPS, 8 automatic robotic stations, 230 reflector point and later control with 8 high-precision inclinometric sensors for the stability control of the main station. The complex network of instruments installed makes the Ancona landslide one of the best monitored stations in the world (**Figure 8**).

Many amazing towns in Italy need well-organized monitoring and constant attention to landslide risk (**Figure 9**).

5.3. Road repair in Bulgaria

When there is no option left, it is necessary to repair the mountain roads after a landslide event. So, in Bulgaria, an engineering decision was suggested and fulfilled under the research, conduction, and control of Dr. Kiril Angelov, Bulgaria (**Figure 10**).

(a)



(b)

Figure 8. (a) Geological field trip to Ancona, Orvieto and Civita di Bagnoregio. (b) Presentation of monitoring system.

5.4. The collapse of the highway in California after the rain

On November 21, 2011, after a heavy rainfall, part of the coastal road to San Pedro, California, collapsed (**Figure 11**). During the incident, no one was injured. Monitoring of soil movement began in the spring, when cracks appeared near the White Point Nature Preserve. The highway was gradually lowered from June and the track was closed in September.

The coast of the Palos Verdes Peninsula has been subject to landslides due to unstable rocks that are prone to shifts toward the ocean.

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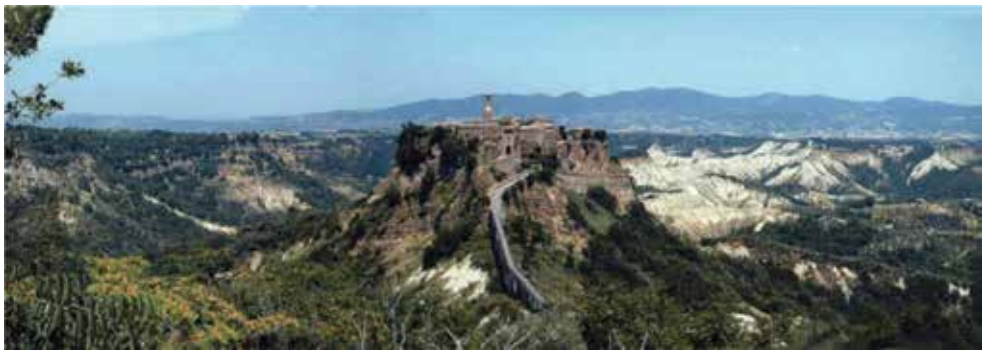

Figure 9. Civita di Bagnoregio.

Figure 10. (a) Road breakage; (b) stage of repair; (c) ready road.

Figure 11. (a) The collapse of the highway in California and (b) view from airplane.

There was no danger to surrounding houses as the landslide was far from the nearest buildings. The Paseo del Mar section of the road, 300 meters long, was closed and fenced.

The authorities in Los Angeles came out and said that the section of the road that collapsed could not be repaired and hence a new route of the scenic road would be built elsewhere.

5.5. USA: Bingham Canyon Open Pit Copper Mine

The largest nonvolcanic landslide in North America occurred in the world's largest mine.

At 9:30 pm, on April 10, 2013, a landslide occurred at the mine.

The largest man-made mining site in the world is the Bingham Canyon Mine, located in the State of Utah, USA. Here, ore is extracted for more than 110 years. In Bingham Canyon, a quarter of the country's copper is mined.

Such volumes for so much time have led to the formation of a giant crater about 970 m wide and about 4 km long. With the growth of the "pit," the operators-controllers ascertained the fact that the walls of the mine were becoming increasingly unstable. Then, seismic sensors were installed. In early 2013, there was a danger of a collapse of the northeastern "wall."

Fortunately, even before two destructive landslide waves, evacuation was carried out. The duration of each avalanche was approximately 1.5 min. The volume of the landslide was more than 65 million cubic meters.

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The power of the landslide was so great that seismologists recorded it, like an earthquake at 2.5 on the Richter scale.

Since 1966, mine is listed in the National Historic Monuments Register under the name of Bingham Canyon Open Pit Copper Mine (**Figure 12**).

Figure 12. Bingham Canyon Open Pit Copper Mine at landslide and before (last).

6. Cultural and natural heritage at landslide risk

There are many historical and beautiful natural objects and places under landslide risk in the world. It is possible to classify them into some types. But every object of natural and cultural heritage is unique. Suggested types could be, for example:

1. Temple on the top,
2. Churches on the high bank of the river,
3. Town in the mountains,
4. Waterfall in the mountains,
5. Volcanoes,
6. Islands,
7. Sculptures in the mountains,
8. Hot springs in the mountains,
9. Others.

Natural disasters always remain a grandiose natural force, which is impossible to combat directly, but it is only necessary to study and to adapt to it.

6.1. Crisis event, Malta

The **Azure Window** was a 28-m-tall limestone natural arch on the island of Gozo in Malta. It was one of Malta's major tourist attractions. The arch is featured in a number of international films and other media representations [33].

The formation was anchored on the east end by the seaside cliff, arching over open water, to be anchored to a freestanding pillar in the sea to the west of the cliff. It was created when two limestone sea caves collapsed.

Following years of natural erosion causing parts of the arch to fall into the sea, the arch and freestanding pillar collapsed completely during a storm on March 8, 2017 (**Figure 13**).

Everybody understood that one day the arch can be destroyed. Local authorities, government of Malta, and UNESCO knew about it. But nothing was done. Enough engineering measures were not provided. Only it was forbidden for people to go upstairs and to visit the top of the arch.

We thus lost an amazing object of cultural and natural heritage.

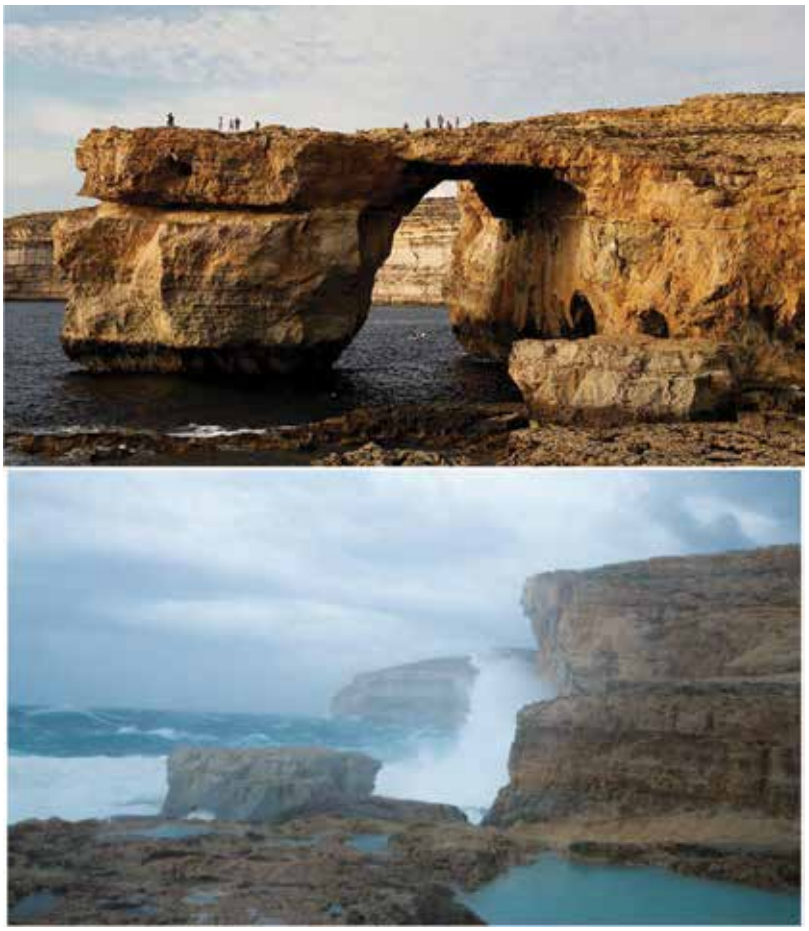

Figure 13. Azure Window before and after.

7. Discussion and conclusions

Systematic approach to the crises events research on the base of risk concept is a very fruitful and progressive method.

Local authorities must be ready for constant monitoring and technical-engineering works in such areas. Good examples of monitoring organization and engineering works are demonstrated and suggested in some different areas. But sometimes people do not pay enough attention to the problems. Sometimes, it is necessary to evaluate whether to undertake reconstruction of the object after crises event or to change the place for another similar construction or living as in the case of Cavallerizzo (**Figure 7**), Bulgaria (**Figure 10**), or USA (**Figure 11**). The best way is to forecast crises events and provide protective measures in advance. Bingham event (**Figure 12**) could be avoided and protected as in Australia (**Figure 6h**) and South Africa (**Figure 6i**).

Life and work in areas of high natural risk demands knowledge, resources, equipment, and willing to be ready for prognosis, forecast, people education, and information. In case of crises events, it is necessary to be ready for the consequences, liquidation of the territories, and object reparation. The most important thing is to provide help to people. Sometimes people have to live in such dangerous places. It is necessary for people leaving under natural risk to understand and estimate this risk and to know how to overcome such risks and how to act in case of crises events. It is necessary to elect and appoint responsible people with good knowledge and special education for managerial posts. The local governments are responsible to establish rules meant to reduce the effects of possible landslides. Land-use regulations are required in landslide-prone areas. The absence of such policies and dangerous human activities are the main factors that lead to landslides. No matter if landslide is caused by huge rainfall, seismic activity, or volcanic eruption. The damage from a landslide event can be disastrous. Thousands of people may lose their houses or could lose their lives. It is important for local authorities to know which areas are prone to landslides and take appropriate measures in order to reduce vulnerability to such hazards. The effects on people and buildings can be lessened if hazardous areas are avoided or if activities in such areas are restricted. Local governments are responsible for land-use regulations for landslide risk reduction. It is possible to reduce exposure to hazards on the basis of educating people using the past history of disaster events. Departments of local governments must assist with their advice and activity. People can also benefit from the professional services of engineering geologists, civil engineers, or geotechnical engineers. Due to the huge losses caused by landslides, their prevention is very important for all the people living in hazardous areas. Preventing a landslide from causing material damage and human losses should be the main goal of local authorities.

Risk management concept is a good instrument for systematic approach to the problems decision.

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Crisis management is an interdisciplinary subject field represented by theoretical problems, practical activity, people management and the art of crisis situation solving. Overall, the studies that this publication contains are to provide an overview of the state of the art mainly focused on crisis management cycle represented by certain phases and steps. Topics include also lessons learned from natural and man-made disasters, crisis communication, information systems in crisis management, civil protection and economics in crisis management. We hope that chapters of this book will provide useful information within crisis management issue for a wide audience.

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