

Intelligent computer support for crisis management

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Abstract. Computer support for crisis management is today mostly focused on immediate emergency and rescue operations, while there are few all-in-one systems capable of deploying support to decision making processes in state administration and at international level. The paper presents the concept of a Hybrid Decision Support System for Crisis Management (HDSSCM) which is an intelligent platform providing direct support for crisis decision makers. The idea has been developed with a view to, firstly, demonstrating the potential inherent in systems that would be able to address a wide range of emergency response operations, and secondly, to outlining a system architecture proposal. The discussion is placed in the context of Poland's crisis management system. Specific parameters of polish system represents both an inspiration and an underpinning for the proposed intelligent platform. The authors also describe some recent applications and current trends in the area of crisis/disaster management systems.

Keywords: Decision support system, artificial intelligence, crisis, disaster, emergency, management, public administration

1. Introduction

The dynamic and robust changes in economy, politics and culture, coupled with concurrent random fluctuations, will inevitably lead to a variety of crisis situations (e.g. the September 11 attacks; the Greece debt crisis; the 2010 Polish Air Force Tu-154 crash; the Chernobyl disaster; recurring floods, earthquakes and tsunamis, etc.). Threats may emerge anywhere in the world and may affect any aspect of human existence or activity; they arise among individuals, between large groups of people, between nations, or they may stem from an inability to control natural phenomena [1,2].

Reports on past crises indicate that some of them could have been prevented, or at least their adverse outcomes could have been substantially reduced, if more effective information systems had been in place [3]. Such observations have resulted in the emergence of such concepts as risk management, emergency plan-

ning, business continuity management, or corporate governance [4]. The innovation proposed in this paper will combine all these elements owing to a widely applicable approach founded on cloud computing – a very modern technology which accounts for superb flexibility and scalability. Hence, the approach will intrinsically address the “mantra” of all emergency response staff supported by computer systems: deliver the right information to the right person in the right format, at the right time and the right place [5].

This paper has been also inspired by the lack of integrative solutions capable of accommodating all required information and all decision support chains present at the crisis or pre-crisis stage. This conclusion seems to be sustainable in the light of prior studies and analyses of relevant information technology (IT) tools. Most existing systems only address rescue operations, in this way merely supporting the management of personnel and resources involved in remedying a crisis or in dealing with the consequences of incidents threatening to generate a crisis [6–8]. At the same time, whether in Poland or elsewhere in Europe, there is no all-in-one system that can handle all of the tasks which

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Table 1
A detailed description of non-military crisis management in Poland

Level	Components/responsibilities	
Gmina (commune/ municipality)	In municipalities, the competent authority is <i>mayor</i> (designated as <i>president</i> in some large cities), while in rural communes it is <i>vogt</i> . They are directly elected representatives of the population, chosen in general elections. The diversity of titles reflects historic tradition but also relates to the type of locality governed – commune (rural), municipality (township), or city (agglomeration). Mayor (or <i>vogt</i>) is in charge of monitoring, planning, responding to, and recovery from, hazard incidents in the municipality's (commune's) area, as well as of civil defense planning and critical infrastructure protection. Mayor's responsibilities also involve execution of tasks within operational plans and organization of training programs to enhance emergency response to potential threats and to help mitigate the effects of terrorist attacks. The executive body is a <i>specialized organizational unit</i> at the municipal hall (office). Auxiliary and support functions are carried out by <i>crisis management teams</i> . Additionally, <i>crisis management centers</i> may be established by competent authorities to provide a 24-hour duty service.	
Powiat (district)	The competent authority is <i>starost</i> , appointed by the <i>Powiat</i> Council whose members are elected by popular vote. The chief executive's responsibilities, as well as supporting structures at the level of <i>powiat</i> , are the same as at the level of <i>gmina</i> , except that some additional responsibilities relate to the supervision of subordinate <i>gmina</i> structures.	
Voivodship (region)	The competent official is <i>voivode</i> , who is a representative of the central government performing and overseeing the duties of government administration in a specific region. The responsibilities and the structures correspond to those of mayor/ <i>vogt</i> . The <i>voivode</i> 's powers and responsibilities with regard to crisis management include leading and coordinating the cooperation among all units of central and local government administration in the respective region. Furthermore, in cases of emergency, command of selected military units may be transferred to <i>voivode</i> by the Minister of National Defense. Regional government is composed of the <i>seymik</i> (legislature) and the <i>voivodeship</i> executive board. Under a separate legal act, <i>regional level governments</i> have been assigned a number of responsibilities relating to nuclear safety and land transport safety. Chair of the executive board – <i>voivodeship marshal</i> – usually appoints an officer to deal with matters of public safety and defense on his/her behalf.	
State	At the national level, crisis management is the responsibility of the <i>Council of Ministers</i> . In time of emergency, decisions are made by <i>the minister responsible for internal affairs</i> ; in any such event, however, the minister is bound to notify the <i>Chairman of the Council of Ministers (Prime Minister)</i> immediately, and the decisions are subject to review by the Council of Ministers at its next meeting. In the face of an imminent crisis, Prime Minister may announce one of four levels of alert. Conditions for the declaration of martial law, the state of emergency/exception and the state of natural disaster are laid down in the Constitution.	<p><i>The Government Crisis Management Team</i>, affiliated to the Council of Ministers and presided over by its Chairman (Prime Minister), is a consultative and advisory body responsible for initiating and coordinating crisis management and crisis containment operations. Its responsibilities include the preparation of resource deployment proposals, counseling on the coordination of operations, developing and reviewing plans and reports.</p> <p><i>The Government Center for Security</i>, reporting to the Chairman of the Council of Ministers (Prime Minister), monitors potential hazards, triggers crisis management procedures, and is responsible for civil (defense) planning. It liaises and collaborates with corresponding NATO and European Union structures. The Center supports the Council of Ministers, Prime Minister and Chairman of the Government Crisis Management Team. The Center's director is responsible for the development of the National Critical Infrastructure Protection Program.</p>

any state-of-the-art decision support system, a concept originating in times so remote as the 1970s, is commonly expected to perform within contemporary businesses [11]. An attempt to design an integrating platform that could revolutionize the use of information technology in crisis management was undertaken e.g. in Australia in 2008 (the CAIRNS project), even though that model has never progressed beyond the stage of prototype and has not been effectively implemented [9]. Other initiatives to build similar systems, as well as the present-day application areas of computer systems in crisis management contexts, will be mentioned later in this paper.

The first part of this paper highlights the major characteristics of Poland's crisis management system. A comparative overview of some other existing systems used to support rescue operations, recovery processes, and related decision making, is also offered; the discus-

sion is primarily focused on the European continent, but it also encompasses the United States of America. It aims to justify the authors' central hypothesis that any system capable of satisfying the requirements of crisis management would need to integrate all of the existing tools within a single intelligent platform in order to utilize these as information resources and knowledge repositories for decision making processes. The second part of this paper presents the concept of a Hybrid Decision Support System for Crisis Management (HDSSCM) and describes further research and development efforts targeted at implementing this idea.

2. Non-military crisis management in Poland

The Polish crisis management system was designed and built under a parliamentary act that took effect in

Table 2
Examples of decision support systems for emergency management used in European countries

Provider	Functionality
VIRVE (State security network Ltd.)	An integrated network connected to the telecommunications system operated by Motorola and enabling the management of the state security system of Finland. Besides a number of rescue operations, the network links fire departments throughout the country and certain components of the national crisis management system. The system aims at optimizing the employment cost of highly specialized workforce while at the same time maintaining the ability to penetrate the country's area, i.e. operate effectively with a smaller number of high performance rescue teams. http://www.erillisverkot.fi/state_security_networks/events/ .
deNIS (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe)	DeNIS and deNIS II systems have been developed for the defense of Germany and Switzerland. Their operation is limited to continued observation, via satellite centers, of areas prone to natural hazards and disasters. If necessary, the systems alerts relevant services and, using forecasting tools and predictive modeling, attempts to determine what impact the incident may have. It is not therefore a typical national security management system.
RIB	The system is used in Sweden and based on a knowledge base which, over the years, has accumulated vast resources of information on counter-crisis measures and activities undertaken in response to dangers threatening to kill or harm people. At the moment, the system is composed of modules containing such elements as a map environment, connectivity with mobile devices during rescue operations, or crisis modeling and risk managements tools. http://www.msb.se/en/Civil-contingencies/Support-systems/ .
Decision support for Mayfield	An extensive system providing comprehensive support to the management of fire fighting, medical emergency and police resources. It offers advanced analytical and forecasting modules that make it possible, for example, to use up-to-date maps to locate potential landing zones for a rescue helicopter. Its perhaps most unique feature is the capability of supporting life savers in action by supplying technical information and drawings of buildings. The systems runs throughout the state of New York, that is, at a government level corresponding to that of the Polish <i>poviat</i> . http://dssresources.com/cases/mayfield/index.html .
Astri Polska Sp. z o. o.	The company offers such services as: fast mapping, damage assessment in quasi-real time, tools for detecting and early warning against disasters, flood risk analysis, and reconstruction planning. Model-based applications make it possible to simulate the spread of fires and floods. The latest satellite telecommunication infrastructure alongside modern information and GIS technologies are used, integrating various data types, e.g. meteorological data. This combination of features helps emergency and rescue services to deliver an effective, professional response to crisis situations and to handle recovery from disasters. Satellite data are provided by an Astrium satellite constellation. Much of their rich experience is owed to the GMES (Global Monitoring for Environment and Security) project. http://www.astripolska.pl/0,1,68.html .

2007 [12] and whose provisions made it conform to the three-stage model adopted in Europe and the USA [4, 13]. This approach obviously originates in EU directives that apply to Poland like to any European Union member country. As a result, the crisis management process in Poland is organized as follows [12]:

- A) The planning, monitoring and reporting stage – this is how the system operates on a daily basis, performing basic administrative functions stipulated by applicable legislation (planning, preparedness/resource monitoring, emergency response plans). In compliance with the law, at each crisis management level staff training and development programs are run at this stage to further enhance their performance.
- B) The response stage – this is when procedures designed at stage one are triggered, initiating a response to an incident. Under emergency, command of personnel is taken over by authorities/bodies responsible for crisis management at particular government levels, i.e. at the level

of *gmina* (commune/municipality), *poviat* (district) or *voivodeship* (region), or at the national (state) level (cf. Table 1). Key principles of crisis management are followed, such as: “unity of command”, “priority of territorial division”, “general enforceability”, “functional approach”, “continuity of the state”, etc. Relevant legislation allows for suspension of powers and for appointing government representatives or commissioners in case an official is unable to perform his/her duties or undertake effective actions.

- C) The recovery stage – this stage does not occur until emergency management procedures are triggered. It is aimed at remedying and eliminating the consequences of the incident, and restoring resources expended at the response stage.

3. Existing applications

The following table, which delivers an overview of several systems of our choice supporting incident (i.e.

local threats in the case of Poland [13]) management processes and implemented as part of rescue systems in different European countries, is offered in an effort to illustrate the viability of a research and development project aimed at building a Hybrid Decision Support System for Disaster/Crisis Management. It has already been pointed out that systems of this kind have been growing the fastest in Europe. Although Table 2 features the German system called deNIS, which represents an exceptionally interesting variety of an expert system that enables broad consultation and allows building up a live decision support system in crisis situations, it should be emphasized that this solution has never been deployed outside Germany.

Combinations of satellite telecommunications technology with graphical imagery based e.g. on GIS raise a lot of interest that easily translates into practical implementations. In October 2004, Techmex¹ – a Polish exchange listed company – launched a Regional Satellite Operations Center (the only satellite operation center in Central-East Europe and one of 18 such centers in the world), being a licensed operator of the US-made Ikonos satellite capable of photographing the Earth's surface at a resolution of 82 centimeters. Techmex's Rescue Field Navigation System displays the rescue squad's current position against a satellite map with a vector layer. The map can be enriched with any kind of object that might be relevant to the user: roads (indicating the type of surface and its accessibility), paths, rivers, water access points, hospitals, police and fire stations, hostels, railways, train stations, airfields, power transmission lines, etc. Advanced information technologies incorporating satellite imagery for use by emergency response services are also researched and developed by Astri Polska Sp. z o.o., featured in Table 2.

In 2005 the European Commission decided to create an early warning system called the Secure General Rapid Alert System ARGUS. The wealth of its practical applications was showcased at a training drill held in the vicinity of Zegrze near Warsaw in 2006. The scenario was built around a hypothetical earthquake that had occurred in one of the EU member countries. It was also hypothesized that damage to the dam in the village of Debe might flood the populated areas adjoining the reservoir in Zegrze (known as the Zegrze Lake). Rescue teams from the State Fire Service were supported by the latest technologies such as satellite

telecommunications, satellite navigation, satellite photographs and field maps of the affected areas, alongside satellite-based monitoring.

The following overview will help identify areas where efficient information technology applications have already been introduced. Insufficient IT infrastructure has been reported in a number of emergency cases. For example, one might recall the conclusions compiled after the violent tornado, a natural disaster which is very rare in Poland, that struck areas adjacent to the town of Strzelce Opolskie on 15 August 2008 and was rated F3 on the Fujita Scale (locally up to F4, with winds blowing at more than 205 mph – one of the strongest that have ever occurred in Europe) [18]:

- 1) Lack of communication between services performing and commanding operations: the military, the firefighters, the police, and local and regional government officials.
- 2) Psychology assistance was non-existent at early stages of the crisis – only police psychologists were on duty.
- 3) An analytical and logistics group should be set up to support the Regional Crisis Management Center.
- 4) Severe bureaucratic barriers hinder the provision of most urgent aid.
- 5) The weather warning system is not accurate enough.
- 6) A “bird's eye” view would help estimate the damage but is not available.

Elements of the Integrated Rescue Command Point (ZSKR) have been implemented in the *poviat* of Wodzislaw Slaski (cf. [10]) using selected software modules supplied by Abakus Sp. z o.o. Given its natural conditions and population pattern, the district offers ample opportunities to combat dangers and emergencies: its high density of population (544 people per square kilometer, which is the second highest figure in Poland) is coupled with a combination of natural and industrial hazards (coal mines and a coke plant), frequent floods (the southern part of the district extends into is the Oder river floodplains), and a large number of intersecting transport routes (an A1 motorway junction, 6 regional class roads, 1 national road, and the Czech Republic border in the south). With its high hazard risk exposure, the *poviat* must have adequate forces and resources including 2 firefighting and rescue units of the State Fire Service, 33 Volunteer Fire Departments, and 2 flood control warehouses. Besides, the district has accumulated a lot of experience and expertise in crisis response operations (its emergency

¹Now, regretfully, in bankruptcy.

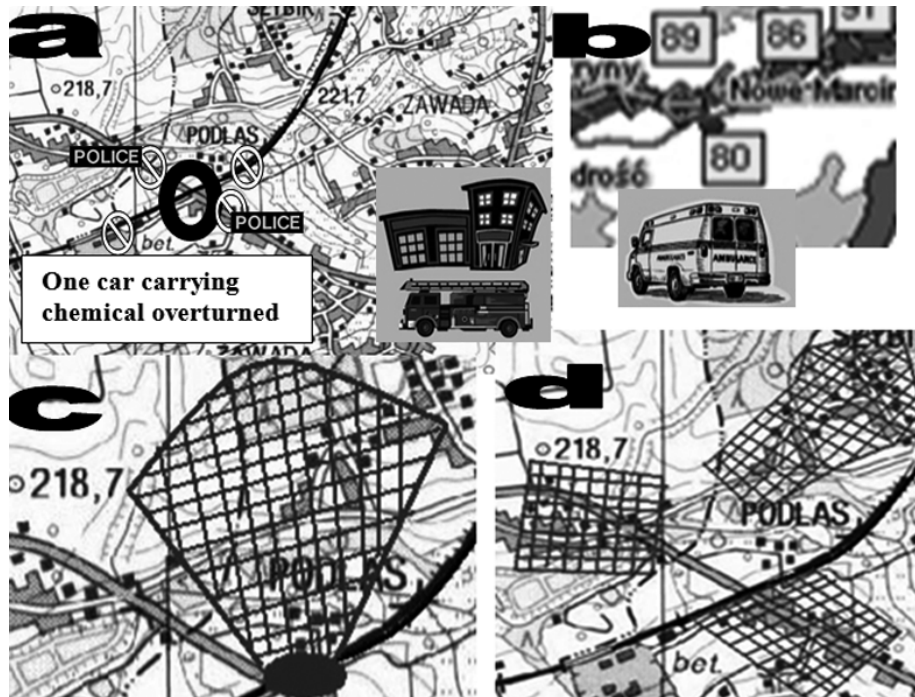


Fig. 1. An example of support for emergency response operations during an incident.

plans have been repeatedly acknowledged to have no match throughout the region).

To illustrate the functioning of the Integrated Rescue Command Point (ZSKR), let us consider an accident that occurred at a railway crossing and involved a tanker truck carrying hazardous substances. The incident is reported to an operator at the Emergency Information Center by an individual who used a mobile phone to call 112. The 112-ST module is triggered automatically to support the operator by e.g. instantly supplying the geographic coordinates of any address (given by the caller and) input by the operator, in this way facilitating the process of locating the incident in the Mapa-ST module (cf. Fig. 1). As soon as the incident report is verified and accepted, the hazard description details and must be confronted with the human and technical resources at hand to see whether the notification procedure should be initiated to involve a higher level of the emergency response system. In this instance, the Center decides to respond to the incident using its local resources only. At the same time, the lead role is assigned to the fire service, while the ambulance service and the police are to perform secondary operations – providing medical assistance to the driver, and controlling road traffic, respectively. In the meantime, the train dispatcher will be instructed to stop any railway traffic. The Operator then selects the Notify

option, indicates the required services and confirms the order by pressing the Submit button. The management of Fire Service and Medical Emergency Service resources is also aided by a computer system. The operations of all forces deployed to the incident is monitored (e.g. in Fig. 1(b) the operator is displaying a window that shows the route the ambulance is taking and the speed at which it is moving). When the emergency cars reach the scene, it turns out that a dangerous substance has been leaking. This is immediately communicated to the operator at the Crisis Management Center who can access the Kryzys-ST module to simulate the spread of the hazard (cf. Fig. 1(c)). Then, using the local population data, the system returns a list of addresses and an estimated number of people that should be evacuated, broken down into age groups. The likely evacuation area is displayed in a map (see Fig. 1(d)). In this case, however, evacuation points or additional hospital beds will not be necessary. The operating force successfully stops the hazardous leakage and evacuates the injured driver.

The system was also tested on another occasion, when in May alarm levels were exceeded on the *poviat's* major rivers. Within 72 hours, the Integrated Rescue Command Point effectively handled 300 flood-related incidents, integrating the operations of several different emergency, rescue and law enforcement ser-

Table 3
An overview of HDSSCM subsystems and technologies employed

Stage	Operations/ information	Platform (subsystem)	Responsibility	Technologies used
Plan	Preparatory/ secondary	Blue light	Ongoing planning and reporting, involving emergency response operations and critical infrastructure; advising and training of local communities; advising, training and support of personnel, including psychological support	E-video learning, virtual reality, multi-agent simulation system, data warehouse, web-services
Do	Preparatory/ primary	Green light	Monitoring and integrated early warning based on signals from local, national and international detection systems; fusing information from early warning systems	Expert system, early warning system, data warehouse, web-services
Check	Crisis response/ secondary	Yellow light	Analysis and assessment of hazards; selection and adjustment of emergency response plans; organization of and support for crisis command (headquarters) and task forces; estimating demand for external resources and their subsequent deployment and maintenance	Expert system/artificial intelligence, multi-agent simulation system, geographical information system, Unmanned Aerial Vehicles, data warehouse, web-services
Act	Crisis response/ primary	Red light	Providing assistance to task forces (technical support, triage, ² displacement of persons and property, public order and safety keeping), reconstruction of damaged infrastructure, distribution of funds and settlement of claims	Geographical information system, multi-agent modeling, data warehouse, web-services

vices. There are plans to further develop the crisis management system in the district of Wodzislaw Slaski, and an agreement to this effect has been signed between the *poviat's* head (*starost*) and the rector of the Military Academy of Land Forces in Wroclaw. The system will evolve toward what is described in the following chapters of this paper.

Each of the systems described above has brought a degree of innovation into the day-to-day running of rescue, life-saving, emergency or crisis management systems. They are perfectly fit to act as data sources and serve as a basis for (the development of) systems like the one outlined further in the paper.³ Indeed, the decision support platform concept presented in the following chapter largely draws on these implementations. Nevertheless, our basic objective in designing it has been to create a sort of “framework” for the integration of existing solutions as well as for appending new and innovative functionalities. What such an approach offers is the possibility to contribute a great deal of added value to the existing computer tools and to produce the effect of synergy in the collaboration of all public services and personnel deployed used within or on behalf of the national security system.

²START – Simple triage and rapid treatment.

³Such a strategy is illustrated e.g. by the call for tenders for the implementation of “A Warning, Alarm and Communication System for Dolnolaskie Voivodeship” announced on 7 March 2012, where the transfer of data from the existing systems ARCUS and RAMZES was specified among the terms and conditions of the tender.

4. HDSSCM platform architecture

This chapter is devoted to outlining the authors’ original idea for the architecture of a Hybrid Decision Support System for Crisis Management (HDSSCM). Given the domain (situations that often represent life or health hazards to humans) which the projected system is supposed to support, in designing and developing it the authors will aim at making it function automatically to the greatest extent possible, albeit initially it will not be fully automated. The system architecture is described from the perspective of Poland’s crisis management system portrayed in the first chapter. The authors concentrate on the level of *poviat*, because it is involved in most emergency operations, and is therefore critical to citizens’ safety [10].

A crisis management system is an extremely complex structure and has considerable dynamics. Due to the multitude of intricate internal linkages, it is not easy to isolate subsystems without losing sight of the synergy of the whole, e.g. its capability of preventing or mitigating crisis situations. The distinction proposed in Table 3 above⁴ adopts just two criteria: (1) the type of operations performed (e.g. preparatory or crisis response), and (2) the source of available information (primary, secondary).

⁴Inspirations can be sought e.g. in the iterative four-step PDCA model, also known as the Deming cycle, or in self-adaptive systems with a balancing (negative) feedback loop.

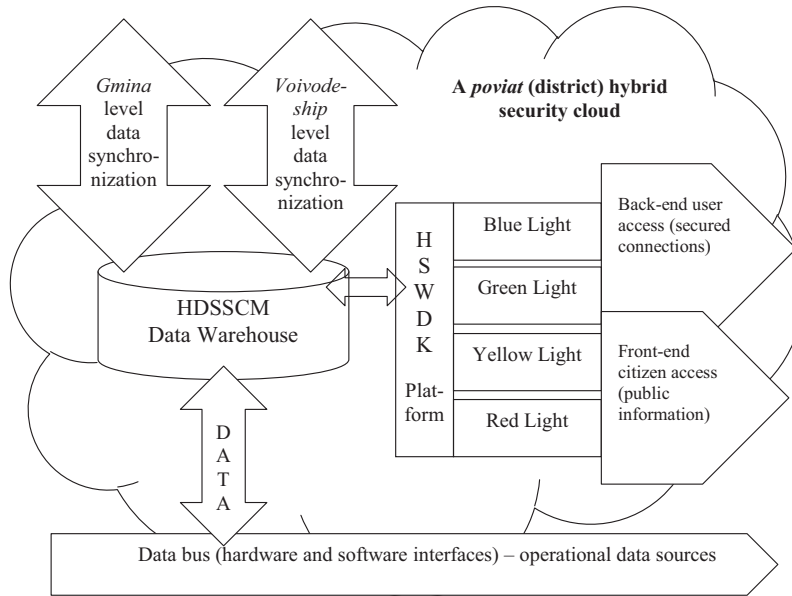


Fig. 2. The cloud-based architecture of the HDSSCM at the *poviát* level.

The system will be deployed within a cloud-based structure, which allows even such complex environments to operate in a very flexible manner. To maximize the benefits of this technology, a hybrid cloud model will be employed [16].

As a result, not only will the tool be highly scalable and capable of making the most of the hardware and software, but also, beginning at the level of *poviát*, an autonomous tool will unfold during a crisis and will be synchronized with higher management levels (cf. Fig. 2) to continue to deliver up-to-date information at all times. In case of a communication breakdown, each level will be able to proceed on its own while still providing specific individuals with access to relevant resources via a public cloud to enable further cooperation and issuing direct orders. The *poviát* structure, which this paper is focused upon, may serve as an example of how the construction of a cloud will make the full functionality of the system available to users in communes and municipalities, in this way making it possible to build a complete picture of the hazard or crisis. This can be accomplished through the use of the three currently most popular virtualization tools: *hardware as a service*, *software as a service*, and *data as a service* [16]. In effect, each unit of task force operating on-site will be able, using any computer device, to access the complete body of information on the latest developments as well as to follow up subsequent decisions made by those in charge [17].

Owing to innovative infrastructural technologies, the system will be able to accomplish the central objective of such platforms defined in the introductory chapter: to deliver the right information to the right person in the right format, at the right time and the right place [5].

This model is one of ideal-type and emerged from the identification of a partial approach to computer support for crisis management [10] in the context of research on the extended DDMCC (data – dialog – modeling – creativity – communication) paradigm [13]. Specific implications arising from the assumption that decisions are made during a crisis include the following:

- A) The rationale for having a planning, training and virtual education platform (“Blue Light”) embraces the need to continually develop the skill level of emergency response personnel and to improve cooperation among the different forces and services involved. Crisis management professionals approve of approaches that make use of simulators, video training, and simulation games. Individuals will be supported in their learning by a virtual trainer. In addition, the platform should monitor the current skill levels to support staffing decisions. The module will thus address an important responsibility delegated to the *poviát* under relevant regulations, which is to provide training and professional development opportunities for the personnel of all services



Fig. 3. Visualization of two HDSSCM elements during the exercise in Wodzislaw Slaski. (Colours are visible in the online version of the article; <http://dx.doi.org/10.3233/IDT-130177>)

forming part of the national crisis management system [12]. It is also necessary to strengthen dialog with citizenship and to elicit citizens' involvement via an internet portal as well as through the community approach (cf. e.g. [20]). Another issue and another dimension to be addressed by the platform is that of providing support for contingency planning. It is argued [19] that "[...] the diversity of crisis situations that may arise at the level of a single business establishment only – is almost infinite. However, an individual who is supposed to be able to assess hazards at municipal or regional level should have an exceptionally free mind in inventing and projecting scenarios that are highly unlikely today but may become all too real tomorrow", which links to prior research on computer support for creativity [21]. This research will be exploited in developing a book of good practices (a reference model), which is expected to increase the transferability and interoperability of the software.

B) The "Green Light" platform represents the early warning component that will support risk modeling to predict the likelihood of a crisis occurring. Risk monitoring is conducted under a model developed specifically for the purpose, and the pro-

cess is obviously contingent on effective collection, fusion and analysis of relevant data. The platform will comprise:

- B1. Executive Cockpit, which lets one find out instantly about recent developments and about what is going on at the moment (at the level of *poviat* as well as in its sub-units, i.e. communes and municipalities).
- B2. GIS elements required to view a specific site as well as illustrate the situation on the incident scene and the movements of personnel (units) involved [12].
- B3. To support the system's ability to build most realistic "what-if" scenarios. Also, hard data received via interfaces that have not been read by other operational systems (e.g. additional water level sensors, automated weather stations, or unmanned aerial vehicle control stations) will be stored here [10, 17,18].
- B4. To enable it to recycle and re-use decision scenarios, the "Green Light" platform will utilize solutions stored in a knowledge base and, consequently, should be able to suggest solutions to common problems at a very early stage of the problem solving process.

- C) The “Yellow Light” platform constitutes the information and integration component. It will trigger actions on receiving a warning of a likely hazard (weak and strong warning signals). Owing to videoconferencing technology⁵ and its integration with remote systems, crisis management systems can be quickly and efficiently activated, while at the same time ensuring effective communication across levels of public administration. With the incorporation of the “Green Light” and “Yellow Light” platforms, on initiating crisis management procedures decision makers will already be equipped with essential information, which means that latency, i.e. the time elapsed before the first decisions are made in response to the emergent hazard, can be minimized. Analyses of past incidents reveal the need to enhance support systems for persons remotely controlling operations. Reducing stress, weariness and effort, while at the same time increasing the efficiency of human actions, can be achieved by simplifying the human-machine dialog, improving the monitoring systems, and introducing autonomous systems capable of e.g. substituting for humans in performing algorithmizable activities, prompting them on what and when should be done, giving them advice via an expert system, as well as detecting and signaling relevant threats and discoveries, such as tentative identification of persons. It is also vital to ensure the stability and safety of technical devices, through e.g. triple power supply, automated recording of operations, or parallel communication channels.
- D) The “Red Light” platform is a computerized support component for the emergency decision making process relying on a data warehouse that bridges together, via a data interface bus, all the existing and operational IT tools. The platform will also support the process of self-parameterization in line with the extended DDMCC paradigm. Additionally, the “Red Light” platform will be furnished with advanced search mechanisms. Support for emergencies and hazard incidents involves mechanisms that have been sufficiently researched already, such as the process of habituation to risk in a master-and-disciples setting through joint training and observation of the tutor’s actions;

the “shield and sword” principle – the greater the hazard, the better protections and defenses and the greater the rescuers’ privileges (e.g. immediate evacuation omitting the trace procedure in case of injury); personality based personnel selection, or psychotherapy. It is necessary to keep improving socio-technical and praxeological procedures as well as rules of hierarchical order and control, and to continue developing better and better manuals guiding the behaviors of each team member and specifying their powers, requisite skills and competencies. In summation, a culture of high precision operation combined with acceptance and monitoring of high risk levels has to be built.

5. Case study of system element usage during the non-governmental organization crisis military training

The project called “ObronaNarodowa.pl – the National Guard Movement” was initiated in 2010 by a group of activists from Polish paramilitary non-governmental organizations. Within the project, nearly 200 people can train their skills at corporate level every year. National Guard units are responsible for crisis and disaster response, and the most recent training event was focused on the use of new technologies in decision making.

The event took place in Wodzislaw Slaski – a location that has already been mentioned in this paper. Since one of the authors was in charge of the training program, the organizers decide to use elements of HDSSCM to deploy intelligent support during the final exercise of this training.

In the picture below we presents all elements of the system. During the training organizers established Tactical Operation Center (TOC) where two components of the HDSSCM platform were run:

- A) The “Yellow Light” module – the information and integration component which triggers actions on receiving a warning of a likely hazard (weak and strong warning signals).
- B) The “Red Light” platform was used as a computerized support component for decision making process relying especially on GIS module supplied by ESRI Poland.⁶

⁵In cooperation with VidCom <http://www.vidcom.pl/?lang=en>.

⁶In cooperation with ESRI Poland <http://www.esri.com/>.

Although the solution was used locally only (in the city center area), the decision makers found it to bring a number of benefits. Besides providing an independent connection for the TOC, the company TTCOMM set up a direct satellite link via a mobile satellite station.

5.1. Insights from HDSSCM usage in described crisis/military training

Those two system elements were focused on bringing together information from the crisis area, internet and local people into one platform. In case of that this part of the platform such a real insights for different levels leaders:

- 1) Ability to access up to date information through the radio on demand.
- 2) Battalion commander have up to date information from crisis area presented on the city map so that the decisions could be faster and more accurate.
- 3) Evacuation of wounded was centralized so that response for such cases was much more faster than without HDSSCM (one of training participants was wounded with a thunder flash).
- 4) Access to the combat cameras image used by the people on the crisis area gave a great support for team and platoon leaders to make good decisions during the exercise.

This simulation shows authors how the system should work. It's a pity that during this event only two elements of it were running. It also shows that the integration can be treated as a base of good decision support for decision makers during the crisis/disaster situations. Support provided by the system was useful but on the other hand chosen elements should be improved to avoid redundancy of information provided by the system (it appears when TOC was trying to use "Yellow light platform" – information provided by the system were badly divided to different groups of importance priority in some specific cases what caused "information noise").

6. Conclusion

The ongoing advances of IT technology and the growth of its applications clearly affect all aspects of human activity and the lives of both individuals and communities. One of such aspects is dealing with situations that call for immediate action to save people's lives and protect their health. And these are obviously

the criteria that are applied in defining a crisis or hazard. Over just several years, this application area has seen a proliferation of tools designed to support humans in some specific efforts, e.g. in undertaking rescue operations [10]. Nevertheless, most countries – including Poland, regretfully – do not have integrative platforms that would bring together the existing solutions into a single, more manageable and effective system. Such a suite of customized, easily accessible and easy-to-operate tools available to the user on demand at any place and any time would make it possible to build a security system [16] supporting decisions that have to be made in order to ensure efficient performance of the state's responsibilities [13] under threats and crises mentioned at the outset of this paper.

This paper has attempted to, on the one hand, demonstrate the potential inherent in systems that would be able to address a wide range of emergency response operations, and, on the other, to describe an integrative architectural proposal: a hybrid computerized decision support platform called the HDSSCM, whose design, albeit underpinned by Poland's crisis management system, goes beyond its confines. Support for creativity, reference models (books of good practices that support organizational governance), improved communication across government levels (*gmina – powiat – voivodeship* – national/central level) owing to the "Yellow Light" infrastructure, and continuous development within the PDCA cycle – represent new elements built into the hybrid system in an effort to bring a new quality to emergency planning. A broad approach to the issue of crisis prevention and response is justified by the growing incidence of threats to organizational continuity.

More available sources of monitoring data (proprietary systems alongside national and international ones), including satellite technology based ones (the bird's eye view whose absence was criticized by the tornado case report) taking advantage of data fusion technologies (some were developed within the framework of research on the DDMCC paradigm [15], e.g. the Optima environment integrating artificial intelligence and business intelligence), are being incorporated in the HDSSCM to strengthen and extend support for risk identification, monitoring and management.

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