

Visual Public Protection Disaster Relief and Critical Infrastructure

(Visual PCI)

Aurel Machalek, Dominic Dunlop, Carlo Simon, Ralf Hoben
 University of Luxembourg
 Interdisciplinary Centre for Security, Reliability and Trust
 Luxembourg, Luxembourg
 email: firstname.lastname@uni.lu

Abstract— A 2013 Decision of the European Parliament and of the Council requires relevant national and appropriate sub-national level authorities to establish risk assessments covering the full spectrum of consequences. These may be expressed in terms of human, environmental, economic, and political/social impacts. Modern society is increasingly dependent on critical infrastructure and on the services that it provides. The loss of one of these services may hit the public immediately in manners which are not always predictable. Furthermore, the amount of time that a given service is unavailable will affect other services through numerous direct and indirect dependencies, which are seldom considered. Natural or man-made disasters, and combinations of both, will have effects that are difficult or impossible to foresee without the appropriate tools. Due to the rapid progress in electronic communications and information technology, one would expect today's crisis managers to have access to situational awareness and to the tools needed to inform their decisions. While much has been achieved for single-service operational headquarters like those of police, firefighting and ambulance services, there are no solutions that address the interactions and interdependencies of all critical functions and all critical infrastructure in a Public Protection and Disaster Response context. If a crisis develops when some aspect of critical infrastructure is partly or completely unavailable, crisis managers must make decisions using a very different framework compared to that used to handle limited incidents in normal times. Considering the difficulties resulting from the dependencies and interdependencies of critical infrastructure in normal times, making good decisions is becoming more and more difficult for crisis managers during a crisis. These challenges, combined with the enormous and possibly tragic consequences of suboptimal crisis management, provide good reasons to explore the subject.

Keywords-component; Visualisation; Augmented Reality; Augmented desktop; Data visualisation; 2D/3D Visualisation

I. INTRODUCTION

The main objective and ambition of the Visual Protection of Critical Infrastructure (Visual PCI) project is to create a coherent system for visualisation of all crisis management activities and assets able to handle full real-life complexity. There are many existing visualisation systems for specific aspects of crisis management, but all are strictly focused on their own narrow slice of the crisis management domain. Our goal is extremely ambitious: there is no known system capable of visualising all aspects of a crisis management situation simultaneously.

Visual PCI's ambition is to provide a novel and integrated tool for risk assessment, planning activities and crisis management at international, national, and appropriate sub-national levels.

The value of a system as a whole is generally much greater than the sum of the values of its parts considered in isolation: it is much better to have a car than just to have four wheels. The same is true for IT systems and simulation systems. A system capable of coherently simulating or visualising several aspects of a phenomena can also take into account interdependencies and feedback between those aspects, so raising the quality of simulation or visualisation to an entirely new level.

Consequently, the main value of Visual PCI is to create a coherent visualisation system capable of handling multiple aspects of crisis management at the same time, in accordance with selection criteria applied by the end user. Such a wider view will allow the end user to perceive interdependencies between various crisis-related phenomena and activities that could otherwise pass unnoticed. Thus the project will allow an appreciation of a crisis situation having a completeness far beyond the abilities of any existing system. The project's primary contribution is to allow interaction with – and visualisation of – the multiple layers that are relevant under disaster emergency conditions. The project will also build on the work done in the coMap project[1], which explored the specific roles which people should have when making decisions using table-top visualisation systems, and how such policies can be enforced.

If accepted by relevant end users, at national or even European level, Visual PCI has the potential to influence standardisation activities, as implied by [2], [3], and [4].

Because Visual PCI will rely on standards already used at a European level, data input from statistics and geospatial data will be facilitated, and previously-developed models may be used with no or little modification by all implementations. Thus, the use of Visual PCI in Member States is facilitated, while a federation of implementations may serve at European level.

Visual PCI will be designed to be used in different configurations comprising:

- A stand-alone solution,
- Multiple identical implementations in a distributed architecture to maximise Information Assurance by means of redundancy,
- Inside a federation to allow exchange between neighbouring implementations,

- In a hierarchical structure able to respond to organisational concepts and to provide scalability, and
- Any combination of these.

II. RELATED WORK

The Visual PCI project is aware of some recent projects in related areas of national risk assessment, public protection and disaster response as well as critical infrastructure. The following projects have been analysed for their relevance; Visual PCI differs from all of these in the novelty of its integrated tool for risk assessment, activity planning, and crisis management at international, national and appropriate sub-national level, accommodating human, environmental, economic and political/social impacts.

CRISADMIN: Critical Infrastructure Simulation of Advanced Models on Interconnected Networks resilience [5], was concerned with the evaluation of the impact of large catastrophic events, such as terrorist attacks on critical infrastructure, by deploying/developing a decision support system.

THREVI2: Threat-Vulnerability Path Identification for Critical Infrastructures [6] focussed on: identification of potential hazards and threats to CI systems; assessing the vulnerability of CI systems or components against these hazards; and defining accurate scenarios.

FACIES: Online Identification of Failure and Attack on Interdependent Critical Infrastructures [7] defined cooperation strategies for automatic detection of failures and attacks on CI, by promptly identifying a failure and/or attack on several interdependent types of critical infrastructure.

CISIM set out to improve an existing framework for simulating the resilience of critical information and communication technologies of (CT) infrastructure against threats, such as power failures, floods and terrorist attacks.

DISASTER 2.0: This project [8] investigated ways of strengthening public resilience to disasters by identifying: technologies, such as social media and semantic webs, that government organisations use to communicate with the public; innovative ways in which these technologies have been used; and how the public use these technologies during disasters.

CRISMA: Modelling crisis management for improved action and preparedness [9], this project focused on large scale crisis scenarios with often irreversible immediate and extended human, societal, structural and economic consequences and impacts. The project developed a simulation-based decision support system for modelling crisis management, aiding improved action and preparedness.

DRIVER: The Driving Innovation in Crisis Management for European Resilience) project [10] is developing an environment that will allow research and innovation to flourish in crisis management. The experiments that it enables may inform the building of scenarios for Visual PCI.

Finally, the use of a multi-touch table in disaster management is explored in [11]; this is just one aspect of the remit of Visual PCI.



Blue: Highways with interchanges
Red: Power supply network with transformers
Orange: Power distribution areas

Figure 1. Visual PCI 3D Model representing Luxembourg

III. VISUALISATION

The rapid development approach to a risk assessment support tool through visualisation with the early involvement of end users is the key to the success of Visual PCI. Visualisation of model building, data input, situational awareness and simulation is essential for user ergonomics. While the basic components for visualisation must be developed by IT professionals, it is also necessary that trained end users can add and modify elements in order to refine the models. Visualisation will provide confidence to end users about their ability to use Visual PCI and to improve the solution over time by fine-tuning the models. Visualisation will produce confidence in making risk assessments by allowing the navigation of risk chains through mouse clicks in order to check the origins of given risks and their impacts. Visualisation will also support situational awareness by producing maps with overlays providing relevant information about incidents, Public Protection and Disaster Relief (PPDR) resources and critical infrastructure services. Finally, Visual presentation of alternative courses of action will support crisis managers' decision process.

For example, the visualisation of Fig. 1 illustrates the dependency of the road network on electrical power. During blackouts, the lack of security services in tunnels, of illumination, and of control by traffic lights reduces the capacity of the road network.

The visualisations will also show time-driven effects like the build-up of traffic jams or changes in strategic fuel stocks. Slow and fast motion can be used as required by end users.

Visual PCI requires the following components:

- A robust visualisation component to facilitate the input and interpretation of information, the adaptation of models and the creation of scenarios to provide planning support for working groups and situational awareness and decision support for crisis managers. Fig. 2 shows a possible visualisation of an urban area.

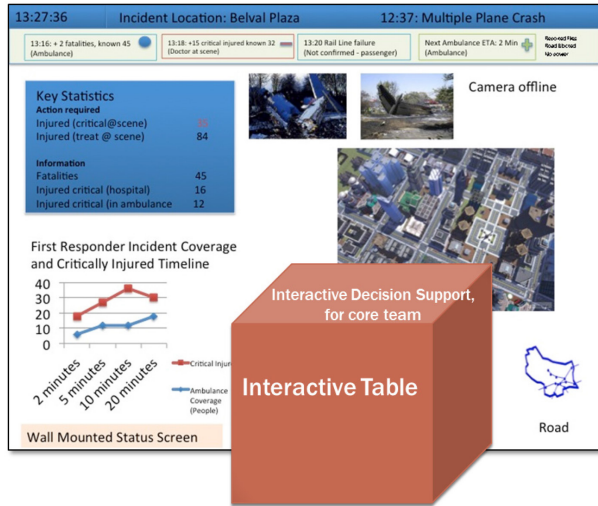


Figure 2. Visual PCI scenario

- A database holding statics and discrete information regarding population, environment, economic and political/social aspects, as well critical infrastructure and PPDR elements. The data required will be driven by the area of responsibility of the implementing end user.
- A computation environment, allowing the models to compute risk assessments and to run simulations regarding the impact of threats and hazards.
- A lightweight and flexible interface infrastructure for heterogeneous data sources allowing the updating of relevant data from different stakeholders, including real-time data from sensors.
- A document-generation capacity to produce periodical and updated risk assessments as required by end users.

IV. VISUALISATION: POSSIBLE SCENARIO

The following section explains how a planning group would use the interface during an incident.

As seen in the background of the figure 2, the interface consists of a large display providing selected information about a plane crash for the entire planning group, while an interactive table is used by a reduced number of people from the core team to make the actual decisions. The types of screen provided by Visual PCI will be in line with identified user requirements.

The large, wall-mounted display provides key statistics, still and live pictures showing the incident, the evolution over time of the number of victims confirmed and remaining at the site, and the first responder coverage capacity at the site. In the lower right, the functional layer of the highway system shows possible access routes and the expected delays ambulances will encounter. Zooming into the incident area provides details of the chosen location.

The concept of Visual PCI will allow planning groups to input a minimum of data to set the scene for a scenario. Once the site and the date/time have been chosen, Visual PCI is able

to extract from its database the information required to display the vicinity of the scenario, to estimate the traffic situation and to provide the probable number of people around the site. (This is not an exhaustive list of possible data types.) The information will be presented immediately in a way which is designed to avoid information overload and to reduce the time needed to reach decisions.

The team will then input the data relating to the incident. In the case of a plane crash, it is necessary to provide the number and categories of victims. The presumed injuries of the survivors will dictate the urgent work load of the rescuers. It will also be possible to predict the time necessary to register the victims and thus provide this information with a delay (as in real world accidents). Weather conditions may be chosen as a function of the season.

Visual PCI will show the PPDR resources available to intervene on the site, such as police patrols, ambulance crews and firefighters active or on standby in the region. The data available on traffic density and the weather conditions will dictate the travelling times to the scene. The use of blue lights by the emergency services will be considered by the simulation.

In risk assessment mode, Visual PCI will use a model response to simulate the evacuation of wounded people to hospitals. This simulation may then be repeated by Visual PCI for varying crash sites, number of wounded people and date/timing considerations.

The same scenario may be used for training crisis managers. In this setting, the model will wait for trainee input before dispatching PPDR resources. Fig. 3 provides a possible screenshot of the interactive table during training. Visual PCI may be configured to provide to the trainee key with information about predicted outcomes of possible decisions. Those may include traffic information or reduced emergency service efficiency for non-optimal options. This function will speed up training and enhance the confidence of the trainee through the provision of visual feedback.

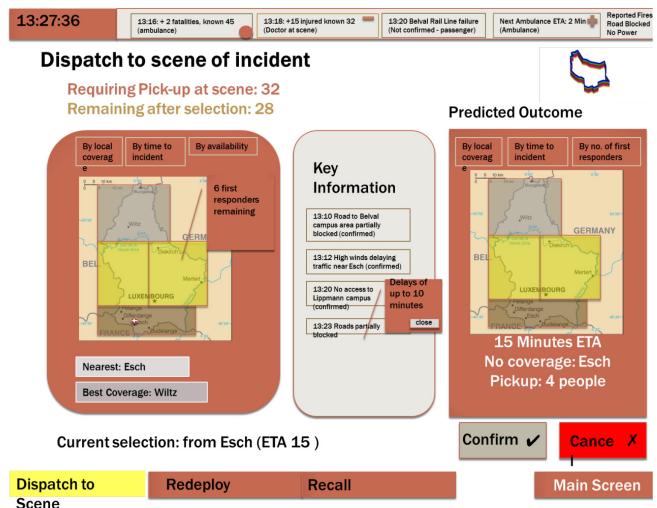


Figure 3. Visual PCI scenario interactive table display

In planning mode, selected scenarios developed by particular planning groups may be used by planning boards having differing vocations and expertise. This multi-disciplinary approach will enhance overall effectiveness.

The Visual PCI system will make use of a variety of technologies. For example, we expect to use Kivy¹ (an open source Python library) to allow for interaction on the multi-touch surface. Kivy is also cross-platform, ensuring that the outputs of the project are not tied to a particular vendor.

Additionally, an appropriate 3D modelling/game environment, such as Unity 3D² or perhaps open source alternatives such as Crystal Space³ will be considered. In order to allow for iterative and rapid development, high level programming languages such as Python or Ruby will be used.

V. CONCLUSION

Visual PCI will simplify and optimise risk management, planning and crisis management and therefore speed up recovery and costs and the number of victims. But Visual PCI will bring even more:

Visual PCI will know the local critical infrastructure and its dependencies and interdependencies. It has the capabilities being adaptable to local circumstances and of following the evolution of the infrastructure.

While Visual PCI is for crisis managers, the tool may also be used to detect infrastructure weaknesses and to predict future bottlenecks if fast-growing infrastructure outpaces the evolution of supporting structures. Therefore, Visual PCI has the potential to assist not only in risk assessments and PPDR planning, but also in national or regional development activities.

Visual PCI has the potential to influence the development of European Resilience Management Guidelines and demonstration through its pilot implementation.

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¹ <https://kivy.org>

² <https://unity3d.com>

³ <http://crystalspace3d.org>