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PREDICT project: PREparing for the Domino effect In Crisis siTuations

Keywords

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Abstract

The PREDICT project aims at delivering a comprehensive solution (PREDICT Suite) for dealing with cascading effects in multi-sectorial crisis situations covering aspects of critical infrastructures. The PREDICT solution based on the three following pillars: methodologies, models and software tools, will increase the awareness and understanding of cascading effects in crisis situations. Two types of tools that will be coupled together are being developed: a decision support system and a foresight and prediction tool. Three test cases are being elaborated in three different location across Europe to validate the PREDICT suite. The decision makers will benefit from the PREDICT Suite which will improve their capability to respond and enhancing their preparedness on domino effects.

1. Introduction

The PREDICT project is a new research project of the FP7 security call topic SEC-2013.4.1-2: "Better understanding of the cascading effect in crisis situations in order to improve future response and preparedness and contribute to lower damages and unfortunate consequences". The PREDICT project has started on April 1st 2014 and involves 11 partners. Three end-users are part of the project and are directly involved in the three test cases that will validate the PREDICT Suite.

PREDICT will provide a comprehensive solution for dealing with cascading effects in muti-sectorial crisis situations covering aspects of critical infrastructures (CIs). The PREDICT solution will be composed of the following three pillars: methodologies, models and software tools. A generic approach will be setup to prevent or mitigate cascading effects which will be applied in selected cases agreed with end-users. The software requires many tools working in the background and at least two tools interfacing with the crisis management (CM): a decision support system (DSS) and a foresight and prediction tool (FPT). Their integration will increase the awareness and understanding of cascading effects by crisis response organizations, enhances their preparedness and improves their response capability to respond in case of cascading failures.

2. PREDICT project objectives

The new methods and tools developed within the PREDICT project may reduce the negative impact of possible future cascading effects and may improve the planning of civil protection and crisis management operations. The PREDICT results will help lowering losses and damages in various fields, including economic or social safety and security. In order to bring this new quality into the cascading effects and crisis management domain, the proposed project will achieve the six following detailed operational and technical objectives.

2.1. Gather and analyse available domain knowledge

First a state of the art of the R&D activities in cascade effect & resilience and global modelling is performed in order to provide a better understanding of the cascade effects and resilience in complex systems. This is the first initial step to further develop appropriate CM tools and methodologies. Moreover, taking into consideration dependencies among various interconnected critical infrastructure sector elements and other not considered to be critical will help to determine probable cascade paths. The gathered knowledge will also help identifying and measuring the strongest relationships, assessing threats, risks and magnitude of possible impact associated with the cascading effects and taking into account cross-border effect in the CM.

2.2. Develop a common framework

A set of definitions, methodologies, scenarios, typologies, best practices needs to be put in place to build a common base for all PREDICT possible end-users. The common framework for understanding cascading effect will gather and structure all the factors affecting cascading effect and carried analysis results. This framework will also be used to define a set of quantitative and qualitative metrics and indicators for measuring the influence of cascading effect. A pertinent identification and characterization of threats is necessarily using the most appropriate security metrics. The starting point for the development of appropriate security metrics is a comprehensive state-of-art analysis of different existing metrics in different disciplines. This will improve the understanding of causes, consequences and sequences, in order to provide stakeholders with rationales necessary for making the right decision at the right time.

2.3. Create models of cascading effects and interdependencies

As modeling each phenomenon separately in a specific environment is not effective, the PREDICT project will propose cohesive and comprehensive models of dependencies, cascading effects and common mode failure which will include causal relations, multi-sectorial infrastructure elements and environment parameters, as well as the human factor aspects. Moreover, they will identify the key points in the incident evolution where decisions are needed, and the need for specific dependency and cascading risk information from stakeholders. These models also need to identify the type of decisions required, including preventive and preparation decisions.

2.4. Develop a suite of software tools

At an early stage the features of PREDICT DSS and FPT should be specified based on key end-users requirements. These tools will help the PREDICT solution end-users to introduce new scenarios, simulate them and assess the potential decision-makers procedures in terms of their efficiency and effectiveness during a crisis. Continuous evaluation of the PREDICT solution outputs will be ensured by a dedicated expert network. The developed suite of tools will be used in both preparedness and reaction phase of a crisis, allowing extensive virtual trainings and near real-time analysis of the situation. The developed tools will be suitable for assessing vulnerability of contingency plans, foreseeing consequences of complex crisis situations and determining the preconditions for failure of critical infrastructure.

2.5. Validate the solution through running simulations

Based on existing and developed cascading effects scenarios and using the developed models and tools, the PREDICT solution needs to be validated through running simulations. Such simulations will take into account CI elements, relationships between these elements, environmental conditions, possibly economic parameters, human behavior and many other factors directly or indirectly affecting the course of the crisis situation. All these information need to be available for the three test cases of the project, thus data mining will be a key background tool to manage this task.

The running simulations will be used to perform models behavior test, which aim at comparing the simulation-generated states of crisis situation with the observed reference behavior. This will ensure the validity of developed solutions and help to improve results of the project. Moreover, such simulation might be used to generate a set of different cascading effect scenarios. Due to a close cooperation with potential end-users, the PREDICT solution is considered to be deployed for them, for testing purposes and possible operational use.

2.6. Disseminate project results

The high-quality of the developed solutions is insured by a consortium consisting of a number of experienced partners joining research, industrial (incl. SME), and end-users approaches. End-users will be deeply involved in PREDICT at three levels: as partners of the consortium, members of the Advisory Board, and representatives from relevant organizations across Europe invited to regular workshops. Moreover, the project results will be presented on forums and conferences related to crisis management and critical infrastructure topics. Additionally, the consortium will build connections between the PREDICT project and other, related initiatives, projects and programs.

3. Status of the PREDICT Project

The PREDICT project started a year ago, the first Work-Package (WP) on domain analysis and requirements is finished all the other WP started. The results of this WP are the baseline for understanding cascading effects and resilience in complex systems. In this state-of-art research in major areas related to cascading effect and systems resilience, we focused on threats identification, threats specification, critical infrastructures' dependency and CM assessment.

On the metrics used to describe the "threats", in view of enhancing systems' resilience, we reviewed natural threats and man-made threats, excluding threats with adaptability-features. That is the case of: terrorist actions, sabotages and wars. The principal finding is that major threats are assessed considering four notions: magnitude of the threat, intensity of its impact (on a well-defined set of systems), its likelihood and its impact lasting time (mean time to heal).

On crisis management assessment, our research concluded that there are no international standards for CM, so best practices play a crucial role in CM. The private sector conducts short-term business continuity management and risk management. It appears that in many European countries, the public sector is better prepared for crisis situations than the private sector. Because of the interdependencies between CI sectors, CM at a national level requires collaboration in public-private partnerships. The governance structure of a country is a determining factor in public CM at all scales. Coordination and information exchange are crucial, and barriers need to be removed or weakened.

A deep analysis of lessons learned from crisis response operations and cascading effects, and the database of past cascading events, to identify the essential elements for identification and probability assessment of cascading effects and develop the main steps of the PREDICT methodology to assess cascading effects. The methodology consists of the following steps:

1. Identify the threats;
2. Identify the CI in the region;
3. Identify the key CI elements;
4. Characterize the vulnerability of the key CI elements to the threat;
5. Assess the first order impact of the threat on the CI elements;
6. Describe the dependencies between the CI elements in the region;
    - describe the required input and output of all key CI elements;
    - distinguish between the different modes of operation;
    - include the temporal and spatial factors;
7. Assess the CI cascading effects.

For this project, end-user workshops have been organized to help defining the features of PREDICT tools. For a DSS, we remind that the quality of the results depends directly on the quality of the inputs and their availability. Within a crisis context, the time is the second hard constrain. These two aspects will be optimized in the PREDICT DSS. The DSS will be built around the three test cases which are very different from each other's. A positive demonstration on these three test cases will prove that the concept can be generalized. For the FPT, the first essential requirement is to effectively process the available data. Thus effective and adequate data mining is considered to be the crucial feature of the FPT. Secondly, time-scale and geographical extension are two important factors. A task will be to optimize the time-scale and geographical extension. As a final point, end-users stressed that the tool should be user friendly, then input data and information should be familiar to the CMs, the models employed should also use similar taxonomies to be fully understood. Ideally, an optimum minimum size of data should be processed to provide quickly the highest level of pertinence and usefulness to decision-making process.

The backbone of the tools is now being developed. It is the design of the system architecture suitable for integration of the tools. The integration of the FPT and DSS with the necessary background tasks is not straight forward but a methodology is put in place. This approach follows the top-down Mission - Concepts – Realisation - Implementation (MCRI) scheme elaborated in the EU FP7 projects DIESIS [3], CIPRNet [1] and CRISMA [2].

4. PREDICT test cases

4.1. Maritime accident in Finland

This test case, where PREDICT comes as a partner, is a full scale exercise in the harbor if Vuosaari. This harbor is the seaport facility of Helsinki, Finland. It is located in the suburb of Vuosaari in East Helsinki. It handles goods traffic for the Helsinki region. Passenger services remain in Helsinki city center. The part of the Vuosaari fairway that is closest to the harbor is narrow, thus vessels are not allowed to meet in the last part of the fairway (*Figure 1*). In this scenario, a container vessel with 1000 containers arrives at Vuosaari harbour in Helsinki. The vessel contains, besides other goods, hazardous and noxious substances as cargo in several containers. This vessel has to wait in the waiting area because another vessel is leaving the Vousaari harbour. Due to a blackout, the stationed vessel loses its power and the south-east winds grounds the ship on small islets. Due to the grounding a crew member is injured, a fuel oil leak occurs, two containers are lost and one is damaged. In the scenario, it is unclear to CM which containers dropped into the sea. The damaged container contains phosphoric acid and leaks. The phosphoric acid reacts with Aluminum, which may result in a possible explosion with a hydrogen gas cloud. This cloud is irritating to the population. Few members of the crew have been affected by the hydrogen gas cloud and need to be evacuated as they require immediate medical care. The wind shifts from south-east towards east, transporting the cloud towards densely populated areas in eastern Helsinki. Due to traffic stopping and to the gas cloud this scenario has a high economical and human impact.

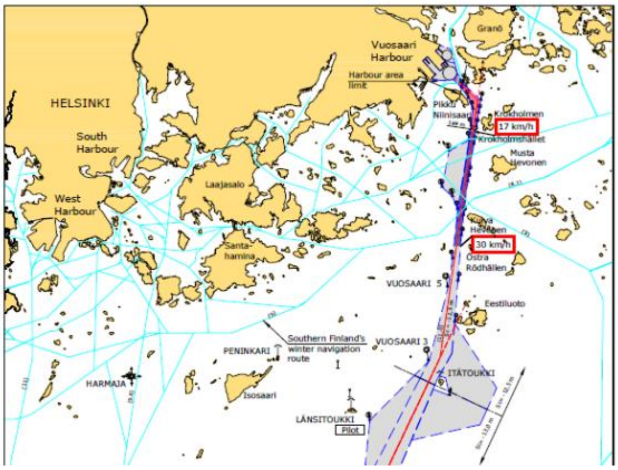

Figure 1. Location of Vuosaari harbor in Finland and the martime fairway in front of the city of Helsinki

4.2. Flooding in a densely populated area in the Netherlands

This test case is a command post exercise; the scenario is taking place in the centre of the Netherlands in the polder where the town of Gorinchem is. With about 35000 inhabitants, this city is lying at the river Waal bordering. The polder is on average about two meters below sea level. At the start of the scenario, a breach develops in the dike at Gorinchem, which leads to failure of the weirs lying directly behind it. Then the scenario runs with the rising of the water level in the polder and the different actions taken by the local CM.

First, the water reaches rapidly heights of 2.5 meter and more in the city of Gorinchem. After one hour the water flows into the polder and after 7 hours water heights rise up to 4 meters. The water front moves to the north along both sides of the A27 motorway, to reach Lopik 16 hours after the event, spreading gradually over the west side of the polder, flooding the cities of Papendrecht, Alblasserwaard, Nieuw-Lekkerland and Sliedrecht. A canal, running from Lopik to Gorinchem abates the spreading of the waterfront to the east for seven days, after which the eastern part of the polder also inundates. On day eight the A27 and A2 motorways, as well as the railways running along them are flooded.

This test case involves public authorities and critical infrastructure operators which will participate to the command post exercise. Many dependencies have been identified between the water flooding and others CI sectors such as gas transport, drinking water, telecommunication and the water board which is specific to the Netherlands.

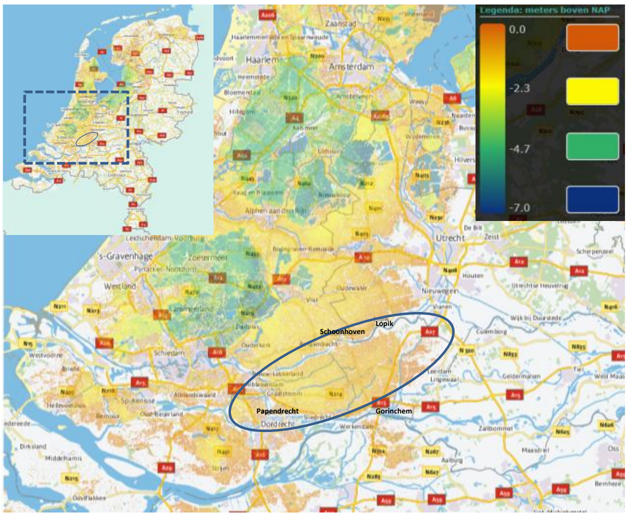

Figure 2. Location of Gorinchem and the polder on an elevation map of the Netherlands

4.3. International Railway Emergency near the Belgium-German border

This third test case is table top exercise. In the scenario, a freight train derails just before a tunnel between Germany and Belgium. The accident is due to track sabotage. The tunnel is the Rheinartzkehl tunnel, it is located near the three borders (DE, NL and BE). The train was loaded with chemicals and liquid gas. The coupling of the first derailed car breaks, the leading part of the train with 12 wagons derails and set fire. Two tank cars loaded with liquid gas explodes and sets fire to the other train wagons also containing dangerous chemicals. That day, the wind blows in the western direction pushing a chemical cloud towards Belgium and partially Netherlands. The explosions and heat fire extend to the surroundings getting into a small farm. People and animals need evacuation (2 fatalities and 6 severe injured).

The railways CM team in will directly interact with the local CM authorities whom will take the lead. The train driver, being part of the chain, he will be the first one to send the alert to the German authorities. In this scenario, the efficiency of the interactions between the railways, Germany and Belgium will be main focus.

The Partners

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