Snowball

Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools

D5.2: Agent Behavior Models

Tool to integrate the behavior of responders and of third party that are influencing the grids into the grid simulation

For the attention of the Research Executive Agency

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Snowball aims at lowering the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools.

The project runs from March 2014 to February 2017, it involves 11 partners and is coordinated by Gedicom.

More information on the project will soon be found at http://www.snowball-project.eu.

Abstract

Infrastructures and supply grids are highly interconnected and damages caused by natural hazardous events (heavy storm, volcano eruption, flood) can propagate across different systems. A damage propagation from a supply grid element to another, both within the same grid or across different grids, is called a cascading effect. These cascading effects are complex and could lead to damages in human, environmental, technical or economic systems, which were not originally caused by the natural hazard. In addition, damaged critical infrastructure in crises can lead to cascading effects aggravating the crisis impact for humans, the economy and the environment. This report describes the agent behavior models formalizing human behavior in crises as well as their purpose within the Coupled Grid Simulation Tool. In Snowball, the understanding of cascading effects will be increased by the use of a computer simulation, where different influences on supply grids are analyzed. The computer simulation focusses on the power grid, the water grid, the mobile phone grid as well as human behavior during crises. For instance, damages and outages in the power grid can propagate to the water and the mobile phone grid, i.e. lead to cascading effects. Human behavior can then either aggravate or mitigate these effects. With the help of a simulation, vulnerability and resilience measures for the considered grids having regard to human behavior are assessed. The human behavior is addressed in the computer simulation by using an agent modeling approach. The agents represent human behavior and could either act as aggravating factor or act as mitigating factor to cascading effects or damaged critical infrastructure; e.g., they could influence the supply grids by stressing already overloaded and damaged grids. The simulation aims at a better understanding of human behavior influence, decisions and reactions on cascading effects and of damages and damage propagation across different grid types in certain scenarios. The knowledge about possible human behavior and its outcome can support decision making to reduce the crisis impact, increase the preparation and the situational awareness in crises and identifying vulnerabilities of grids.

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Executive summary

Infrastructures and supply grids are highly interconnected and damages caused by natural hazardous events (heavy storm, volcano eruption, flood) can propagate across different grids. A damage propagation from a supply grid element to another, both within the same grid or a across different grids, is called a cascading effect. These cascading effects are complex and could lead to damages in human, environmental, technical or economic systems, which were not originally caused by the natural hazard. In addition, damaged critical infrastructure in crises can lead to cascading effects aggravating the crisis impact for humans, the economy and the environment. Snowball will increase the understanding of cascading effects by the use of a computer simulation, where different influences on supply grids are analyzed. The computer simulation focusses on the power grid, the water grid, the mobile phone grid as well as human behavior during crises. For instance, damages and outages in the power grid can propagate to the water and mobile phone grid and lead to cascading effects. Human behavior can then either aggravate or mitigate these effects. This report focusses on the human behavior model and describes the formalization of human behavior in crises as well as their purpose within the Coupled Grid Simulation Tool. With the help of a computer simulation, vulnerability and resilience measures for the considered grids having regard to human behavior are assessed. The human behavior is addressed in the computer simulation by using an agent modeling approach. The agents represent human behavior and could either act as aggravating factor or act as mitigating factor to cascading effects or damaged critical infrastructure; e.g., they could influence the supply grids by stressing overloaded and damaged grids. The Coupled Grid Simulation Tool aims at a better understanding of the influence of human behavior, decisions and reactions on cascading effects and of damages and damage propagation between different grid types in certain scenarios. The knowledge about human behavior can support decision making to reduce the crisis impact, increase the preparation and the situational awareness in crises and identifying vulnerabilities of grids.

The appearance and the impact of cascading effects in crises is influenced by human behavior with aggravating and mitigating factors. To achieve the aim of the computer simulation of understanding crisis damages and propagation, it must take into account human behavior models including mitigating and aggravating factors. The integration of the human behavior in the computer simulation tool requires a formalization of achieved results into an agent behavior model (ABM). The development of the ABM and its integration into the simulation tool is a first step towards the understanding of the role of human behavior in crises. Different decisions, reactions and behaviors can be simulated with the integrated ABM and their consequences can be estimated. The ABM provides a mapping of the most important aggravating and mitigating factors for human behavior of first responders, decision makers and population to the Coupled Grid Simulation Tool with respect to decisions under difficult conditions. In Snowball Deliverable 2.2 (Schönefeld und Hahm 2015), the aggravating and mitigating factors for crises were already identified. The ABM combines the information gathered in the previous Snowball Deliverable 2.2 (Schönefeld und Hahm 2015) and Snowball Deliverable 3.5 (Schönefeld et al. 2015) and provides a theoretical model which can be integrated by a computer simulation.

In the ABM, the mentioned studies are formalized including the environmental factors influencing the social vulnerabilities for population agents and the behavior of all agents, like the reactions of the close proximity, weather or the onset speed of the disaster. In the formalization, different agent types define

properties and states. Properties are similar to characteristics of humans, for example the experience of a specific first responder. A state is a set of actions an agent executes, for example panic buying in a crisis. The execution of actions and the probability of occurrence for each state is influenced by some properties and the environment of each agent. The ABM integrated in the simulation tool could evaluate and compare the influence of different human behavior, social vulnerabilities, communication in crises and decisions on cascading effects and the crisis impact. Beyond, the influence of trained personnel on cascading effects and the crisis impact could be evaluated by running the simulation with well-trained first responders/decision makers and with not trained agents.

The Coupled Grid Simulation Tool integrates the ABM in the damage simulation and damage propagation. Behavior of population can for example have influence on overloads on the mobile phone grid: if many people use their mobile phone, an overload can be caused in the mobile phone grid as well as an overload can be aggravated. The results of the ABM integrated in the Coupled Grid Simulation show the number of overloads in different grids and the reactions of humans to the crisis event, other humans and outages in grids.

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ABBREVIATIONS

ABM

Agent behavior model

CaESAR

***Ca**scading **E**ffect **S**imulation in urban **A**reas to assess and increase **R**esilience*

DEFINITIONS

Affected people/population

People affected by the crisis, could be injured, deaths or humans living in the impacted area.

Agent behavior model

Abstract mapping of human behavior to the simulation tool.

Crisis impact

Sum of all damages occurred during the crisis.

Cross-border cascading effect

Cascading effects across two different supply grids

Grid component

Part of a supply grid, for example a power pole or a power line.

Grid component type

Class of grid components, e.g. power poles or distributors.

Grid operator

Company who owns a supply grid.

Hidden Markov model

Stochastic model for system which can be observed directly.

Properties of agents

Each agent has different properties influencing the quality of actions or the behavior. If a similar crisis already happened in the concerned area, some population agents are already familiar with it and the probability for staying calm is high. In this case, experience is the property of the population agents.