

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

Organization FHG, EMAUG, LUPT

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

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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.



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 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 focuses 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 focuses 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.



Table of content

Abbreviations	10
Definitions	10
Introduction.....	11
1 Coupled grid simulation tool	12
1.1 Simulation World.....	13
1.1.1 Entities.....	14
1.1.1.1 Grids	14
1.1.1.2 Agents.....	19
1.1.1.3 Natural Events	19
1.1.2 Manipulators	20
1.1.2.1 Damage Estimator	20
1.1.2.2 Damage Propagator.....	22
1.1.2.3 Agent Manager.....	23
1.1.3 Clock Manager.....	23
1.2 Result Processing.....	23
1.3 Monte Carlo Simulation	23
2 Agent behavior models	24
2.1 Theoretical Model for Human behaviour in Crises	24
2.1.1 Population Agent.....	26
2.1.1.1 Evacuation behaviour.....	37
2.1.2 First Responder Agent	38
2.1.3 Decision Maker Agent	42
2.1.3.1 Communication and information in crisis	45
2.2 Agent behavior models in CaESAR	46
2.2.1 Agents in CaESAR.....	47
2.2.2 Agent Manager.....	48
2.2.2.1 Individual behaviour.....	48



2.2.2.2 Group reactions..... 50

2.2.3 Input for the ABM in CaESAR 51

3 Output ABM in the Coupled grid simulation tool 51

Conclusion 53

References..... 54

List of Figures and Tables

Figure 1: Structure of CaESAR modules. 13

Figure 2: Simulation model for interconnection mapping between different grids. The Grid module receives the geo position of components, the component types with their properties and the connections to other components from the interfaces processing shapefiles and grid models of external tools. A directed graph connecting different grids is built with these information. Each node in the graph contains a maximal load, an initial load and value for failure propagation..... 16

Figure 3: General architecture of the grid model. The supply grid level represents all general dependencies between the systems, e.g. water grid depends on power grid. On the dependency level, all cross-border dependencies are modelled, i.e. the physical connections between components of different grids. The component level represents the modelled supply grids with their structural components..... 17

Figure 4: Snippet of an example graph for power grids. The relevant components of the grid are generalized and represented by nodes. In this case, the distributor receives electricity from other parts of the grid. The distributor is connected with some houses with a power pole in-between. Power lines between these components are represented by edges. 19

Figure 5: Example input of natural crisis events for CaESAR. 20

Figure 6: Damage Estimator functionality. A grid node and a scenario hazard lead to an element hit on the corresponding grid node. This element hit is part of the function for damage estimation in the damage model. The damage model executed in each node leads to a vulnerability of a grid. 21

Figure 7: Damage propagation principle for broken links..... 23

Figure 8: Human groups with the possibility to influence the impact of the crisis by aggravating or mitigating behavior. 24

Figure 9: The environment and the properties of each agent influence the actions and state transitions. 25

Figure 10: Framework design for the simulation of damages on critical infrastructure during a crisis with a following simulation of human behavior. 46



Figure 11: Structure of CaESAR modules. 47

Figure 12: Mapping of above described properties to the Agentz Module. 48

Figure 13: Part of the Hidden Markov Model for state transitions in the agent behavior model 49

Figure 14: schematic representation of the group reactions. The leader agent starts a group reaction and other agents could follow according to their individual probabilities, the group size and agent type (follower, normal agent). 51

Figure 15: Agents and grids on the main map of the dashboard with geo-referenced positions. 52

Figure 16: Output of a run of the agent simulation. 53

Table 1: damage hit function for middle voltage power poles with the hazardous event flood (water level). 21

Table 2: Agent types of the model and description derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 25

Table 3: Properties for the population agent models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 29

Table 4: Observed aggravating behavior and derived states for the population agent models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 33

Table 5: Observed mitigating behavior and derived states for the population agent models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 36

Table 6: Environmental influences for the population agent models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 37

Table 7: Categories of injury and priority of supply according to this categories (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe 2015), (Crespin 2000). 37

Table 8: Properties for the first responder models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 39

Table 9: States and descriptions of the first responder agents derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 41

Table 10: Environmental influences for the first responder agent models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 42

Table 11: Properties for the decision maker models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 44



Table 12: States and descriptions of the decision maker agents derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015). 45

Table 13: Environmental influences for the decision maker agent models derived from Snowball Deliverable D2.2 and D3.5 (Schönefeld et al. 2015; Schönefeld und Hahm 2015)..... 45



ABBREVIATIONS

ABM

Agent behavior model

CaESAR

Cascading Effect Simulation in urban Areas to assess and increase Resilience

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.