This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 606742

Project final report

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Project acronym: **SNOWBALL**

Project title:

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

Funding Scheme: **Collaborative Project**

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PUBLISHABLE SUMMARY

Executive summary

The Snowball project was a 3-year European FP7 project coordinated by Gedicom. The topic of the call was "Better understanding of the cascading effect in crisis situation in order to improve future response and preparedness and contribute to lower damages and other unfortunate consequences" and 11 organisations from 8 different countries worked together to respond to it. The overall objective of Snowball was to increase preparedness and response capacities of decision-makers, emergency planners and first responders in respect to amplifying hazards in large disasters.

Snowball consists in a deep analysis of cascading effects and development of methods to anticipate them; and in a Decision Support System able to display current crisis monitoring and results of simulated decisions integrating cascading effects. SnowBall innovates in its modular approach to crises, its modelling techniques, its agent-supported coupled grid simulations, its generic Events Log Database and tools to follow public behaviour (Emergency Alert, Twitter sentiment analysis).

Snowball comprises 11 partners from 8 countries covering the full competence scope required: 2 industrials (Gedicom - Emergency Alert System; INEO Digital- Events log database), 2 Research Institutes and 3 Universities focussed on different segments of risks assessment: LUPT-PLINIVS (natural hazards); Fraunhofer EMI (critical infrastructure socio-technical simulation); EMAUG (human behaviour); UCL (public health) and ISMB (cloud, data process, mobile services), 3 end-users (Polish Fire School; Ministry of Interior of Finland represented by ESC; and Hungarian Red Cross) and 1 consultancy (EP).

The Snowball saw the creation of a general platform containing different tools to simulate or follow a crisis and allow better preparedness, through the visualisation of weak points, potential cascading effect and events and crisis propagation.

Context and objectives

The forces behind modernisation – social, economic, technological, administrative – have boosted the wealth of modern society to unprecedented levels, but at the same time they have made us more vulnerable to disruptions and threats. Increasingly complex and tightly coupled systems deliver efficiency and security, but also the potential for disaster if those systems fail. Public services, ranging from medical treatment to electricity and transport, operate under co-operative agreements and require coordination with multiple governments. Terrorist attacks may not only damage local targets, but also entire populations if critical infrastructures are targeted. Future crises will not respect man-made borders, but instead cascade across the social, economic and technological systems of densely populated countries.

The cascading effects are those which are at play in a "system of systems". They need to be better understood in order to predict at best the impact of a crisis and to take the appropriate measures. It is necessary not only to understand causes and consequences, but also why consequences may

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expand, in order to improve public safety.

Moreover, in the happening of a catastrophic event (e.g., earthquake, flooding, nuclear catastrophe, etc.) the dynamics of human behaviour play a central role. During these disasters and emergencies, irrational behaviours such as panic and confusion are likely to take control of human activities. In such a context, taking into account the effect of communication to the public as well as all other type of events gives a global view of the phenomenon. In such situations, the development of a decision support tool enabling to provide valuable insights into the mechanisms stemming from lack of coordination between people involved in catastrophic events could be worthwhile since the dynamics of social contagion may lead to bad overall results deriving from collective panic behaviour.

In this context of hyper-connected societies -where networks of all sorts are intertwined- and because of population densities being so high –and therefore undesirable behaviours having so much more effect- it is necessary to better understand the cascading effects that might occur and involve the infrastructures –natural and technological- together with the citizens.

Objectives

The overall objective of the project is to increase the preparedness of the European Union in respect to hazards that could amplify a large crisis. In the framework of Snowball project, a dedicated tool was developed in order to:

1. Apprehend and better predict and simulate the cascading effects that occur in a crisis;
2. Integrate population response and behaviour to the simulation tools;
3. Provide decision support to public authorities and decision makers in the light of cascading effects simulations;
4. Test the efficiency of the tool in the frame of various demonstrations.

In a nutshell, the project has developped a Decision Support System that presents on a dashboard the present crisis situation, the results of a simulation tool that will integrate cascading effects, and the tools to perform an action (to see the effects recursively). The forecast will be more realistic, thus providing the decision support system with more accurate data to work on in order to advise decision makers more efficiently.

A modular solution of elementary events forming a global crisis was adopted. Such structure allows an easy integration of cascading factors.

Demonstrations have allowed validating the tool and assessing the preparedness of Europe in the advent of a crisis integrating cascading effects.

A description of the main S&T results/foregrounds

Understanding and modelling of cascading effects

- ***Cascading effects: types, triggers and paths***

Within Snowball, 3 main sources of information have been investigated to understand recurring types, triggers and paths of cascading effects:

1. Past events disaster and losses databases (main reference: EM-DAT).

2. Literature review: (main references: Gill and Malamud, 2014; EU-FP6 EXPLORIS project; EU-FP6 NARAS project; EU-FP7 CRISMA project; Kröger, 2008; Reason, 1995; Provitolo et al., 2011; Schmidt & Galea, 2013; EU-FP7 BeSeCu)

3. In depth analysis of selected past crises (D7.1) (main references: Xynthia extra-tropical storm 2010; Hurricane Sandy 2012 and Eyjafjallajökull volcanic eruption 2010).

This allowed the detection of:

- recurrent triggering hazards and cascading effects paths

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- recurrent impacts on critical infrastructures and service networks (as source of technological hazards)

-impacts on selected categories of elements at risk (buildings/infrastructures, people, economy)

The analysis of past events also helps to better understand the significant and complex role of human behaviour, as aggravating or mitigating factor.

It impacts differently if we consider:

-population and their changing behaviour during crises (e.g. block of access routes, denial of instructions are aggravating; social, altruistic behaviour are mitigating), and the effects of cumulative individual behaviour as potential trigger of cascading effects (e.g. disaster tourism; rubbernecks/gawkers; bystanders; overload of CI networks due to increased use);

-decision makers and response bodies (especially in terms of quality of coordination and communication activities)

Media significantly affect behavioural aspects. Data from social networks (e.g. Twitter) can be an additional source of information, especially to detect emotion, sentiments and human behaviour.

Cascading effects triggers and paths can be visualised as tree structures, also called "event trees" or "time histories", emphasizing the relevance of time factor and the relation with organisational aspects in determining a specific cascading effects path.

Each chain of a time-history is constituted by consecutive events characterized by cause/effect relationships, which respect the compatibility between events and human behaviour/decision factors.

The representation of a time-history through a timeline offers a proper structuring and visualisation tool to highlight dependencies and support modelling/simulation.

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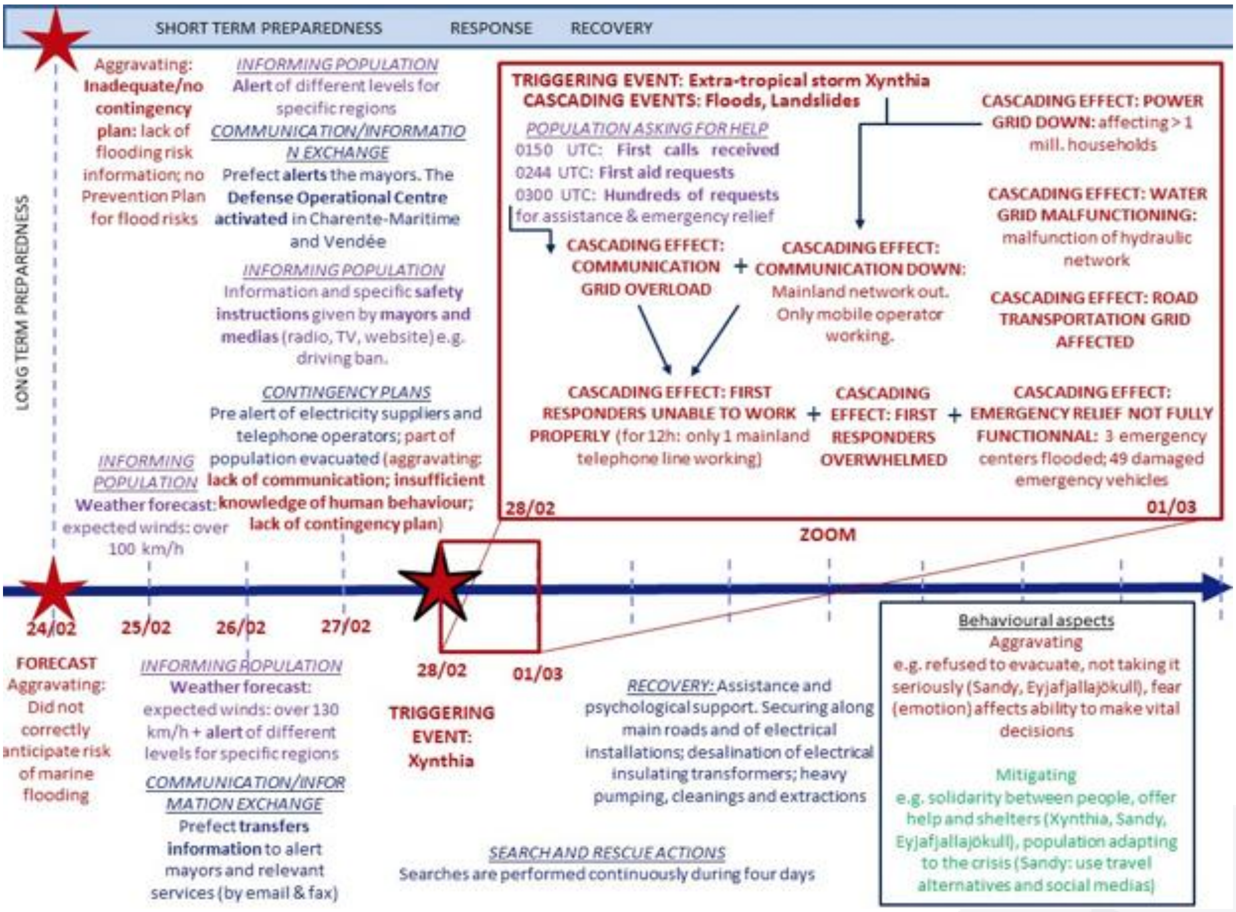

Excerpt of the use of a timeline for analysis of past events in Snowball. Xynthia 2010 case.

Cascading effects: theoretical concepts

Cascading effect theoretical concepts have been addressed within WP3, aimed at understanding and modelling cascading effects. In the deliverables 3.1 and 3.2, relevant cascading effects crisis scenarios have been identified from the analysis of past events and the main elementary bricks needed to perform cascading effects simulations have been defined (namely: time, space, hazard, exposure, vulnerability, impact), outlining the modelling methodology to simulate both the cumulative damage on elements at risk from a sequence of cascading hazards, and the propagation of damage across service grids and networks. D3.3 and D3.4, in continuity with the two previous deliverables, aims at identifying and quantifying from a theoretical point of view the dependencies and interactions between different hazards and the resulting damages on the elements at risk in a crisis scenario characterised by cascading effects.

Key definitions and terminology - cascading events and cascading effects:

1. Cascading events: "events that occur as a direct or indirect result of an initial event" (FEMA Independent Study Course, IS 230, Principles of Emergency Management, 2013). These are characterized by:

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- cause / effect relationship (i.e. an earthquake that induces a landslide that causes a building collapse that induces casualties),

- time interaction among different phenomena independently generated by the same triggering event (i.e. a flood can cause independently electric failure and interruption roads that can both influence the operation of the same hospital).

2. Cascading effects: "dynamics present in disasters, in which the impact of a physical event or the development of an initial technological or human failure generates a sequence of events in human subsystems that result in physical, social or economic disruption […] They are associated more with the magnitude of vulnerability than with that of hazards" (Pescaroli, G, and Alexander, D, A definition of cascading disasters and cascading effects: Going beyond the "toppling dominos" metaphor, Global Risk Forum, 2015)

The above definitions outline the key concepts to be taken into account in the definition of a theoretical model for cascading effects, aimed at providing a general framework to perform hazard/impact scenario simulations to be used as source of information by decision makers in the context of preparedness and emergency planning:

1. Cascading effects may produce cumulative damage on elements at risk, when a given element at risk is impacted by two or more hazards (e.g. a house impacted by an earthquake followed by a landslide). In this case, the main variables of interest concern the spatial extension of the hazards in the chain of cascading effects, the availability of hazard models for each of the events in the chain and the definition of dynamic vulnerability conditions for the elements at risk considered. The definition of transition probabilities between different damage states of the elements at risk considered is in fact strongly depending on the availability of specific dynamic vulnerability curves (see D3.2) in relation to the different hazards in the cascading effects chain.

2. The occurrence of a given hazard can trigger cascading effects that produce relevant impacts on elements at risk in distal areas from the location of the triggering hazard (e.g. Sumatra earthquake 2004, Ejafjallajökull eruption 2010). In this case, the main variables of interest are the magnitude of the triggering hazard, its characterization and the availability of single-hazard models able to give information on spatial and time dependencies of the potential cascades in distal areas.

3. The impact of a hazard on critical infrastructures and service networks, and the cascading propagation of damage due to the interdependence of infrastructural systems (e.g. power and communication grids) can strongly amplify the final expected impact. In this case, the main variables of interest are the multi-hazard vulnerability modelling of the infrastructural/grid components that once damaged are likely to trigger the failure of the entire system, the understanding of the influence of the time factor in case of service interruption and the consequences on social system, including the influence of the human behaviour as aggravating factor.

4. Human behaviour plays a key role in the evolution of a cascading effects path as potential trigger, aggravating or mitigating factor.

The study of types, triggers, paths and theoretical concepts has allowed to implement a theoretical model for cascading effect simulations taking into account the following key concepts:

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- Cause/effect relationships and chain of events

- Local and cross-border impacts, cumulative damages on elements at risk and damage propagation within dependant CIs and networks

- Specific vulnerability and exposure conditions

- Role of decision-makers and influence of their choices

- Time factor and human behaviour

The thorough analysis of past events highlighted the need of developing a set of tools and services aimed at improving preparedness to cascading effects in order to:

- Reduce vulnerability (long-term) and exposure (long/short-term)

- Increase effectiveness of decision-making and emergency planning / management choices

- Mitigate the risk of inadequate contingency plans

- Increase quality of communication / information exchange (between stakeholders and to the population)

- Strengthen cooperation / coordination actions

- Mitigate the negative effects due to behavioural aspects

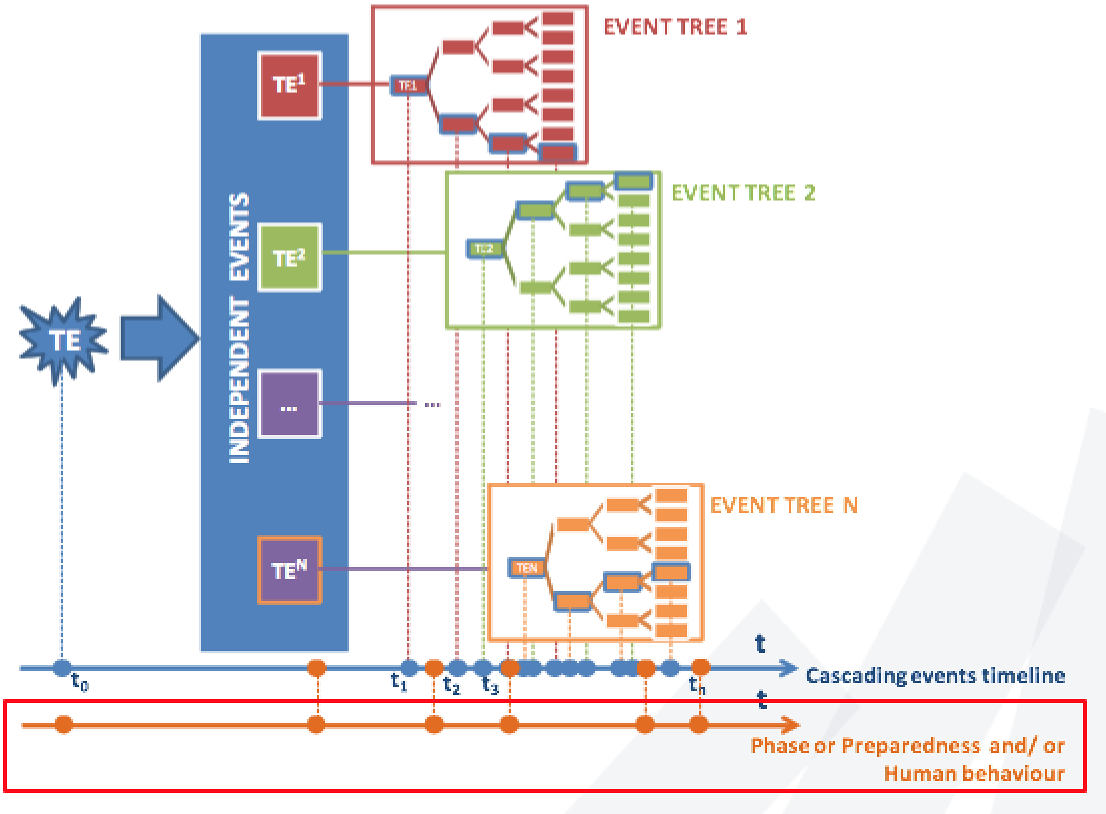
Theoretical model for cascading effects simulation

The Theoretical model for cascading effects simulation is presented in D3.4.

The model is based on the identification of triggering conditions of cascading effects for each hazard category and the development of a methodology to define the transition probabilities of the states for different elements at risk. Theoretical approaches for hazard/impact modelling and simulations, including the limitations to the application of a generic probabilistic approach are discussed, having in mind that the scope of the Snowball simulation tool is to provide actionable information to decision-maker to increase preparedness toward crises characterized by cascading effects.

The probability of occurrence of a given chain of events and the following impact on elements at risk does not depend only on the possibility of a hazard triggering another but also on their expected magnitude and the potential of occurrence in a given time and space window. The transition probabilities between different damage states of the elements at risk considered is also strongly depending on the availability of specific dynamic vulnerability functions for the elements at risk considered. Snowball methodology considers therefore as a necessary step the customization of the general theoretical model to specific use cases, in order to produce reliable hazard/impact scenarios, useful to support decision-making through simulations and scenario assessment methods. Snowball aims at developing a theoretical model where simulation of cascading effects scenarios can be carried out with different level of detail, depending on the availability of inventory/exposure data for the different categories of elements at risk and hazard/impact models for the various hazard sources. The architecture of the simulation model can be conceived as a flexible structure of different building blocks, and the compliance of the theoretical model approach with the technical architecture is briefly discussed in the report, highlighting the relevant links with the software modules in course of implementation. Therefore, the theoretical model here proposed has to be considered exhaustive in its methodological definition, while its application always require further data collection, analysis and modelling, customized on specific use cases and end-users needs.

The Snowball theoretical framework includes the methodological approach and the methods to perform probabilistic analyses and uncertainties assessment aimed at developing cascading effects hazard/impact scenarios. Hazard interdependencies within cascading effect scenarios are defined through the improvement of the conventional event tree approach, aimed at addressing the peculiarities of the cascading effects dynamics.



The general theoretical model is based on the "elementary bricks" approach, with a specific focus on the identification of variables to model the "time" and "human behaviour" factors within the cascading effects simulations as well as on the methods to include the impact of preparedness actions in the simulations.

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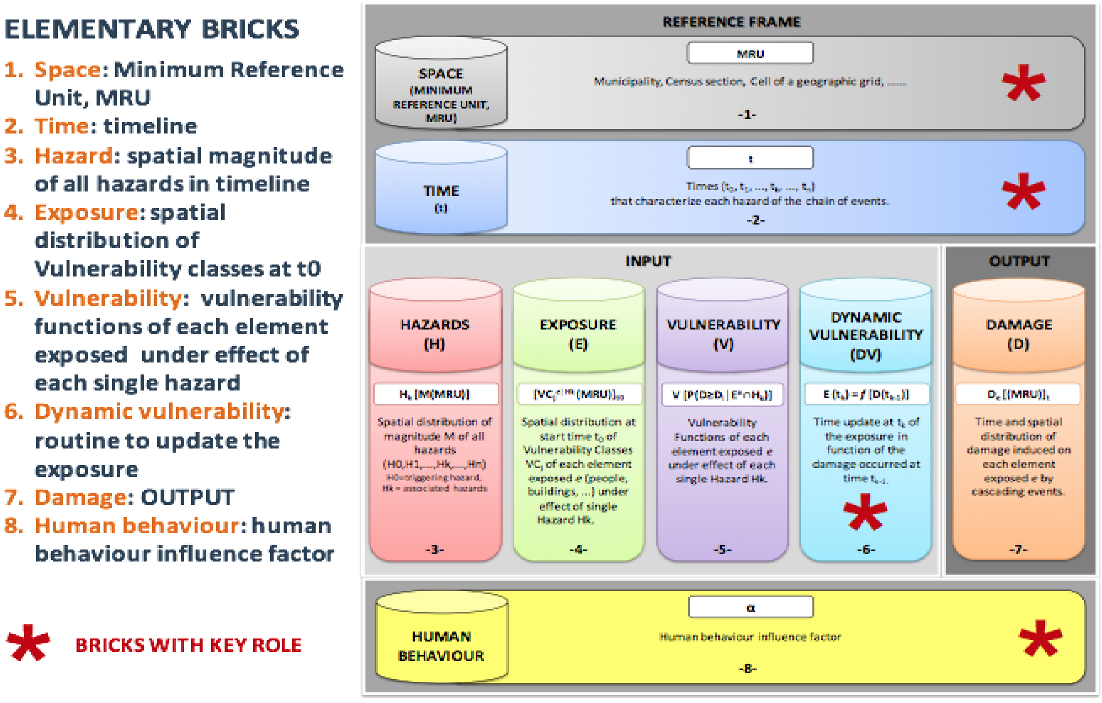

Since cascading effects, independently from the magnitude of the triggering hazard and the potential cross-border impacts, mostly depend on local (i.e. national to regional) hazard proneness and vulnerability conditions (e.g. Fukushima), so the only way to produce reliable and effective hazard/impact scenarios through probabilistic-based simulation tools is to perform at the local level the following steps:

- hazards characterisation according to the proneness of the area or the preferences of decision makers/end-users (including probabilistic assessment);
- exposure and vulnerability analysis, according to the elements at risk identified and to specific decision-makers/end-users requirements;
- identification of probabilities of transition among different hazards, supported by existing literature/studies complemented with Bayesian approach and/ or experts' elicitation procedures (Cooke, 1991; Aspinall and Cooke, 1998; Cooke et al. 2008), when such information is not available from previous studies.

Thus, the proposed approach for the SNOWBALL theoretical model is the following:

1. to provide a "generic" modelling framework based on the definition of a common logic to model the dependencies between the different hazards and the relevant parameters for the "elementary bricks" as defined in D3.2 (space, time, hazard, exposure, vulnerability, dynamic vulnerability, damage, human behaviour);

2. to apply specific models and simulations for the respective use cases, in line with end-users needs and compatible with eventually existing legacy simulation tools, understood as the best approach to provide a decision support tool useful in the context of preparedness to real crises involving cascading effects. This step will in fact provide the needed specialization and customisation of the theoretical

level in the context of the different use-cases through the support of Snowball experts, also involving local responsible for civil protection and modelling experts.

Human behaviour in the context of cascading effects

An important objective of the project was the study of the role of the human factor in the context of cascading effects to enable its integration into the models and simulations. D2.2, in addition to identifying the needs of the end-users with respect to the developed Snowball solution, served to examine the role of decision makers and first responders in the context of cascading effects as well as their views concerning the contribution of population behaviour to cascading effects. The insights gained from this work were systematically expanded and studied in the context of D3.5.

The results of the conducted studies (e.g. literature review, expert interviews, vignette study, virtual reality study) imply that it is difficult to classify behaviour as mitigating and aggravating as (1) the consequences of behaviour are dependent on specific conditions which have to be taken into account and (2) it is very complex and dynamic. Furthermore, emergent properties need to be considered that result from the interactions of the individual components of the human system (individual persons). Nonetheless, we were able to identify important factors associated with cascading effects, including the vulnerability of the population and of critical infrastructures, pre-crisis management, situational awareness, crisis communication, and decision making.

Cascading effects may result from factors that are present before a disaster, such as the vulnerability of the population to the effects of disasters ("social vulnerability"). It is defined by the level of awareness and preparedness of people or communities for hazards, their ability to cope with the impact, and their ability to recover from an event, and is influenced by individual factors (e.g. gender, age, socio-economic status) and societal factors (e.g. industrial development, infrastructures). The vignette study (D3.5) demonstrated that the population is only moderately prepared for disasters, with the extent of preparedness being related to sociodemographic characteristics. Decision-making and crisis management may play a significant role in increasing social vulnerability, e.g. by heightening the exposure of the population due to poor land-use planning, deficits in risk communication with the public leading to a lack of preparedness, mistakes concerning pre-crisis management (e.g. a lack of contingency plans and training) as well as insufficient awareness of and knowledge about cascading effects (e.g. failure of critical infrastructures).

Concerning population behaviour during disasters, insights regarding the frequency of specific behaviours, as well as their conditions and consequences were gained from the literature (D2.2, D3.5), focus group discussions with first responders (D2.2), and the vignette study with the population (D3.5). Contrary to the expectations of most disaster managers, the available literature showed that helping behaviours (e.g. rescue efforts, providing others with supplies), information search & distribution, affiliation, and evacuation were among the most frequent behaviours, whereas panic, irrational and antisocial behaviour are rarely observed. However, population behaviour may aggravate the situation by influencing critical infrastructures (e.g. blocking communication networks or overloading stressed power networks), depending on the vulnerability of the specific infrastructure to human impacts. For instance, the vast majority of the participants (> 90%) of the vignette study (D3.5) indicated the intention to confirm and disseminate information from warning messages, which may lead to an overload of communication infrastructures. The vignette study (D3.5) also indicated that intentions of people are often counterproductive: They indicated to follow a given advice (using the telephone sparely due to damaged communication infrastructures), but indicated a strong intention to take contrary actions (e.g. using the telephone) – This reflects the well-known need for information that has to be taken into account within the context of risk and crisis communication as well as the development of technical solutions. Not complying with orders (e.g. evacuation, sheltering) may also

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increase the disaster impact. However, it is often difficult to define a behaviour as mitigating or aggravating - Even (seemingly) mitigating behaviour such as helping may also aggravate the situation, e.g. when people put themselves at risk. Thus, the effects of specific behaviours greatly depend on circumstances of these actions (e.g. the type of disaster, knowledge and experience).

Adequate crisis communication of decision makers was found to be the one of the most important factors in preventing cascading effects due to inadequate population behaviour. The results of the vignette study (D3.5) highlighted the importance of crisis communication especially the influence of the source and content of the communicated information on perceived threat and behavioural intentions. The virtual reality study (D3.5) further underlined the significance of warning messages with respect to actual behaviour in crises: Participants who received a warning about an approaching severe thunderstorm were less often injured and needed less time to reach a safe zone.

Apart from failures concerning crisis communication, other factors related to crisis management during or after a disaster may constitute an aggravating factor, e.g. deficits in intra- / interorganisational communication, inadequate coordination and cooperation, a lack of situational awareness, deficits in decision making, and "blame-games" that damage interorganisational relationships, as well as failing to implement "lessons learned" from disasters.

The modules developed within the framework of Snowball take these different aspects into account and may therefore contribute to preventing or, at least, mitigating the aggravating effects of human behaviour in crises and disasters. To give an understanding to potential end-users of the Snowball solution with respect to the usefulness of the different modules and to put them into the context of cascading effects, especially with regard to the above-mentioned effects connected to the human factor, D8.3 was created.

Furthermore, the results of the vignette study (D3.5) served as an empirical basis for the development of an agent-based model and therefore allows for the integration of human behaviour into a simulation.

Snowball platform and services

- ***Snowball platform architecture***

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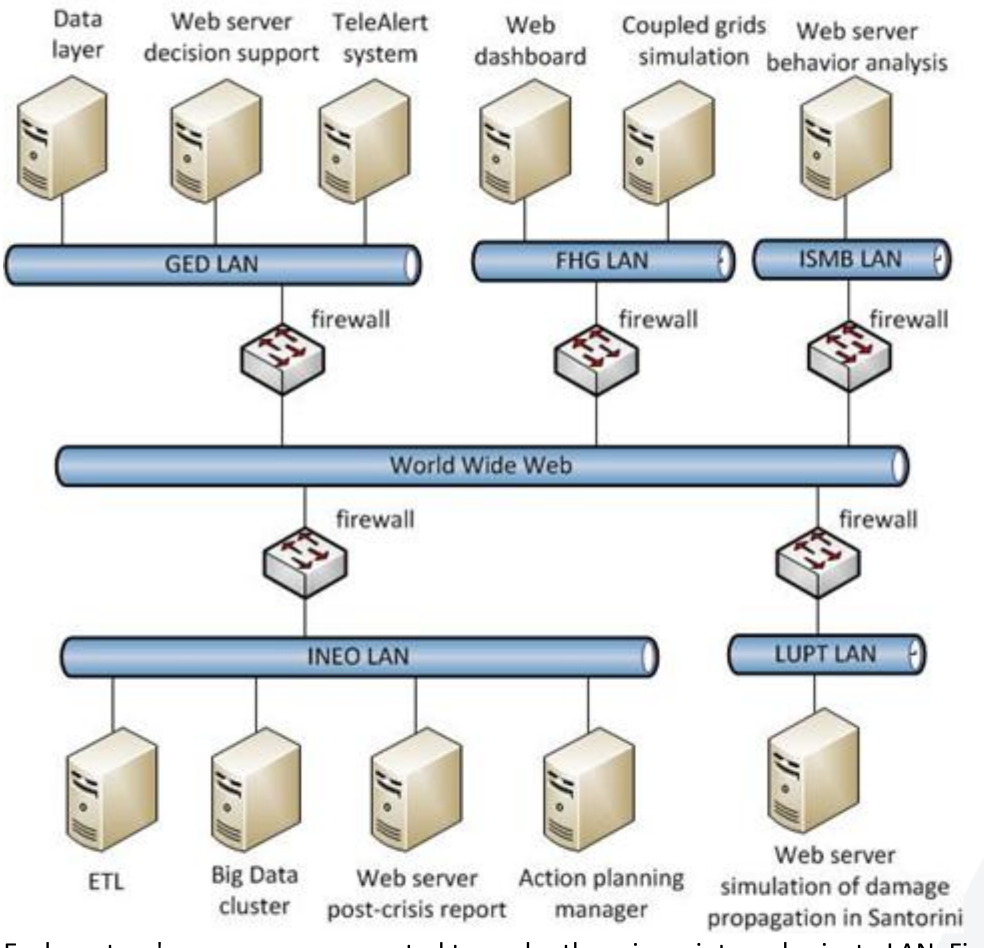

Each partner's servers are connected to each other via an internal private LAN. Firewalls allow partners to protect their IT resources from directly being exposed to the World Wide Web. The different snowball services are connected with each other within a secured private network.

- ***Cascading effect simulation tool and browser***

The "Cascading Effects Simulation Tool" and the "Snowball Simulation Browser" developed by LUPT represent the application of the theoretical model for cascading effects simulation as a decision support tool providing information about the potential impacts of different c.e. scenarios.

The application is based on the scenario analysis of different cascading effects time histories, triggered by one or more hazard. The test application has been developed on the Santorini case (see D7.2), analysing the cascading effects paths and cumulative impacts triggered by the following hazards:

- Volcanic unrest in Nea Kameni (Time History: 1, 2, 3).
- Tectonic earthquake in Amorgos fault (Time History 4).

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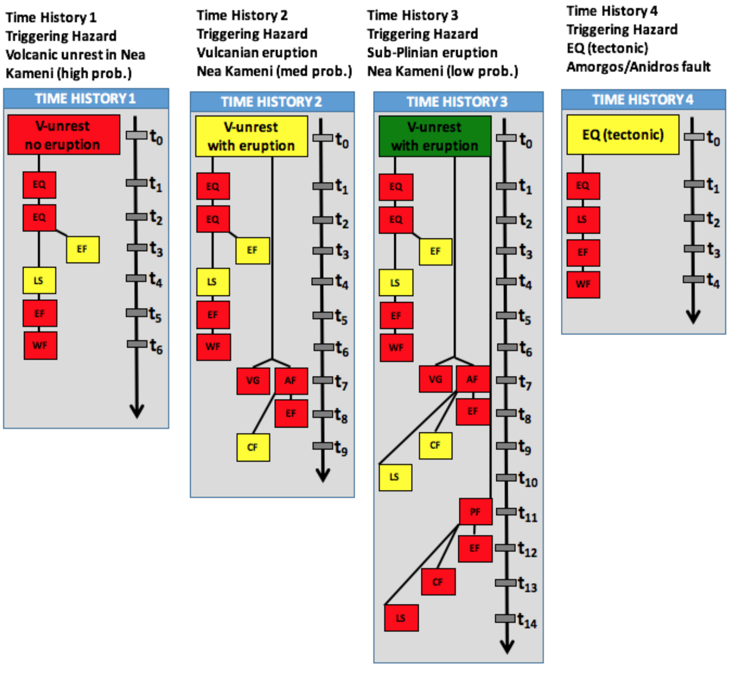

The Snowball Simulation Browser allows the end-user to easily navigate the impact scenarios provided by the Cascading Effects Simulation Tool.

Once selected the time histories to be analysed, the impact on multiple elements at risk (namely: people, buildings, critical infrastructures, service networks, economy) can be visualised as a geo-referenced map and table for each timestamp along the time history, taking into account the cumulative damage due to the sequence of events and the effect of decision making choices.

For each simulated impact scenario, a dedicated section allows to assess the effectiveness of alternative preparedness actions (e.g. population evacuation), by displaying a map and table comparison for each of the preparedness options, showing the damage reduction on selected elements at risk. The options can then be further compared with multi-criteria analyses through the Decision Algorithm developed by ISMB.

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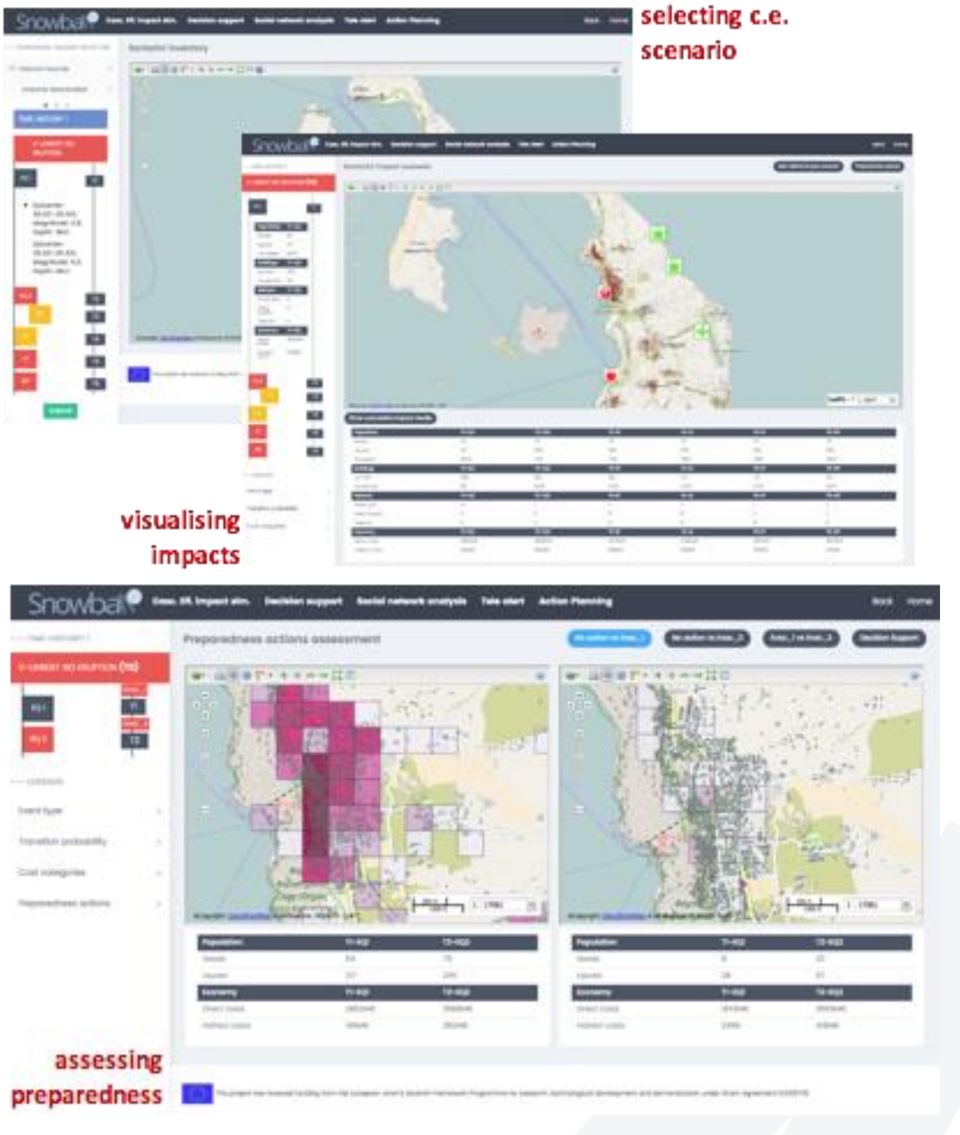

Screens of the Cascading effects simulation tools and browser. A public testing version of the web application is available at http://plinivs.it/projects/snowball/.

CaESAR – Coupled grid simulation tool

The Coupled Grid Simulation Tool is called CaESAR, which is the acronym for **Ca**scading **E**ffect **S**imulation in urban **A**reas to asses and increase **R**esilience. It simulates damages on critical infrastructure (power grid, water grid, mobile phone grid) in consequence of a crisis event and the propagation of these initial damages in a specified grid system and between different grid systems. The damage simulation and damage propagation are used to determine computationally the vulnerability of the entire system of grids and start a resilience assessment based on this information. The output of the vulnerability assessment can be used for identifying weak points in the supply grids according to structural damages, damage propagation and cascading effects to other grids. These weak points are defined as the most critical grid components because of their high failure probability and the drastic increase of vulnerability in case of their failure. For the weak points, mitigation strategies are proposed by the CaESAR tool. The mitigation strategies can be applied to the grids and a new loop of computation can be started to proof, if the resilience level is better than without the

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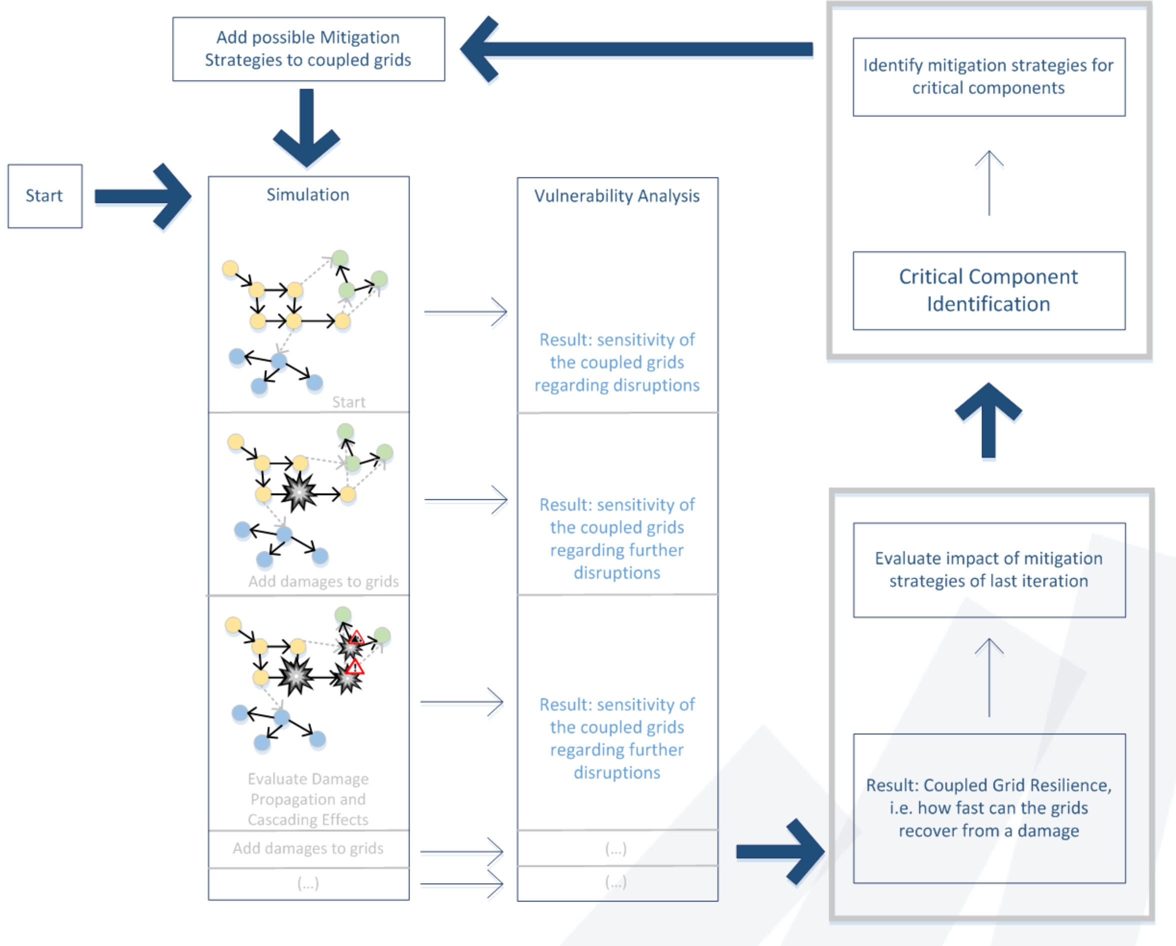
mitigation strategies. The overall target of CaESAR is to find good strategies for mitigation the crisis impact on grids.

Tool architecture:



On the base of a defined simulation model, the tool executes a computer simulation with the target of identifying possible reactions of the modelled systems to a predefined crisis. The simulation models are dynamic, which means that time is an important factor in the computer simulations. The dynamic simulation models define how the modelled systems behave in the appropriate situations including the time factor. In Snowball, the simulation models map the reactions of supply grids and specific human groups to the computer simulation. A repeated execution of the Coupled Grid Simulation Tool leads to an analysis of probable behavior for the modelled systems. It combines generally five components: grid models, agent models, damage models, damage propagation models, and assessment methods. These components are embedded in the simulation.

An event simulator (extern) or a user (web interface) delivers a crisis event as input with a geo referenced crisis area (polygon), an event type and an event intensity. The event input could consist of different events and/or different event intensities for representing cascading events. The grid model is a part of the coupled grid simulation tool and defines all data regarding the current simulation, like current weather situation (possible input definition by user or reading current weather situation request over an interface to the internet). The grid model holds also all modelled grid (water, mobile

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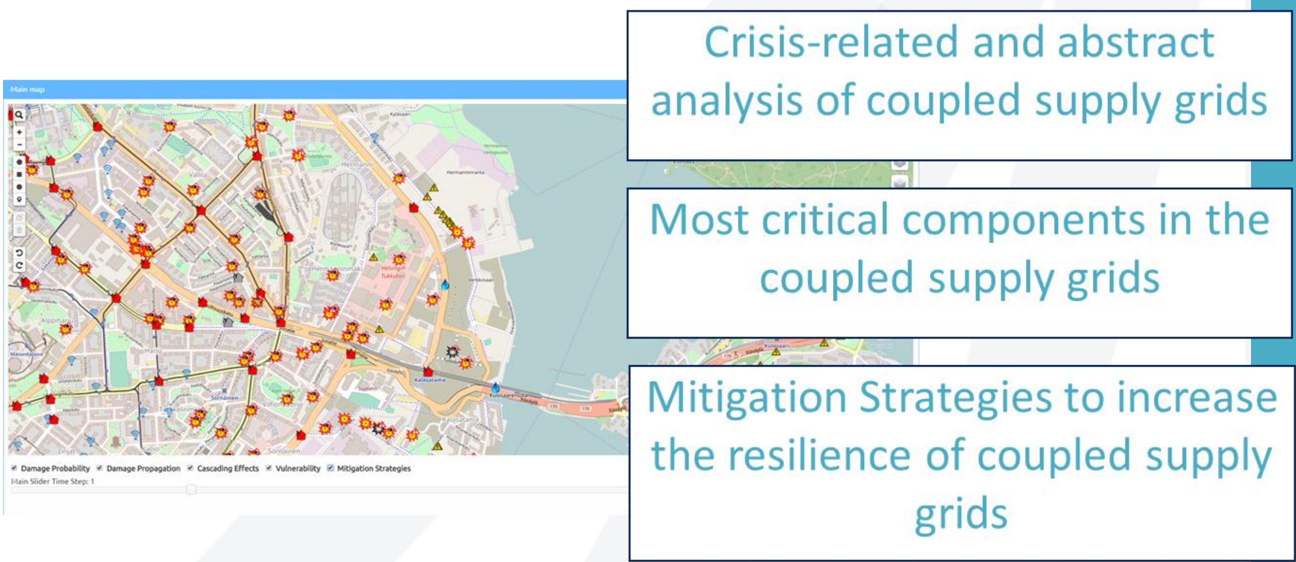
phone and power). A defined damage model computes a possible damage for each grid component. The grid model then starts a damage propagation simulation for each damaged component with the aid of the corresponding extern simulator. The simulator delivers a result of outages of components of the corresponding grid. This is the simulation within each single grid. The outage/damage propagation is delivered to the grid model by using the interfaces of the software. The grid model provides an evaluation of these damages. It also manages the possible propagation of an outage from grid A to grid B (e.g. power grid to water grid). The model implements this with geo references. If for example a water grid component is in the close proximity of a power grid component, a probability for the outage of the concerned water grid component is given. The developed model contains all components relevant for structural damage computation and failure propagation. Each component is mapped as node containing an initial load, a maximal load and is connected to neighbours. A damage could be propagated to each neighbour of the node, independent of the grid type from the neighbour node.

Based on the computation of the initial damage and the damage propagation, a vulnerability analysis is executed. The result of this analysis is the sensitivity of the coupled supply grids regarding disruptions. After this initial analysis, damages are introduced simulatively in the coupled grids. This means, during the computer simulation of CaESAR, different sets of grid component failures are considered. The impact of those damages and their damage propagations on the grids are computed. These computations serve then as input for the following analysis. During this analysis, a resilience value for the coupled grids is computed as well as a vulnerability value for each point on the simulation time line. With this value, components contributing decisive to an increase of the vulnerability value can be identified. These components are defined as critical components. In the next step, a set of predefined mitigation measures is test wise applied within the simulation to some critical components. The outcome of this step are different mitigation strategies with a resilience value of the coupled grids. The mitigation strategies increasing the resilience most are suggested to the user. This analysis can be done crisis-related or abstract without any crisis definition.

Results:



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- ***Social network analysis***

The Social Network Analyses module is mainly presented in D4.2, in terms of developed algorithms, in D4.6, in terms of the event log database, in D6.4 with respect to the post crisis report, the visualization component is presented in D8.3, while the related privacy topic is deepened in D2.6 (in the PIA annex).

The aim of this module is to collect and analyse on-the-ground data from social networks in order to improve preparedness to similar crisis or cascading effects, and support decision makers in having the relevant information to enhance situational awareness and let them make more informed decisions. During disasters, social networks receive an overwhelming amount of situation-sensitive information that people post in the form of textual messages, images, and videos. Despite the fact that social media streams contain a significant amount of noise, much research has shown that these same streams of information may also include relevant information. Although a wider study, analyzing the relationship among the outputs of different analyses on the same data, represents an improvement in the study of human behavior, little is known about interconnected studies as a mean to increase the preparedness phase. This module is designed to address this gap in the literature by conducting an empirical study on data coming from social network, collected during past crises.

In details, the main objective of the social network analyses is studying the sentiment analysis of the population in crisis situations. Moreover, some novel and investigative approaches have been studied and developed in order to try to extract additional and complementary information from the collected data. In details, information about the predominant emotion and human behaviour.

The sentiment analysis aims to evaluate the general mood of the population. It can be considered as the starting point of the social network analyses and allows to classify the social network data (the "tweets") in positive, negative or neutral sentiments. This is done using a supervised machine learning approach, through the following phases:

- Data collection
- Balancing the dataset
- Data pre-processing
- Labelling
- Feature design/extraction
- Feature selection

At the end of these phases, the process starts an iterative series of tasks that could be repeated in order to obtain the expected final classifier. These tasks can be briefly described as:

- Parameters optimization
- Validation

On top of the sentiment analysis, it has been developed the behaviour and emotion detections, with the aim of enhancing the general understanding of human behaviour in crisis situation. This happens by enhancing the information about the mood of the population with additional information related to the predominant emotion (classified as anger, disgust, fear, joy, sadness, surprise and neutral emotion) and behaviour (classified as mitigating, aggravating and neutral behaviour). These detections have been designed and developed using the lexicon based approach, through the following phases:

- Dictionaries setup (abbreviations, emotions and behaviours)
- Data collection
- Data pre-processing
- Labelling
- POS Tagging

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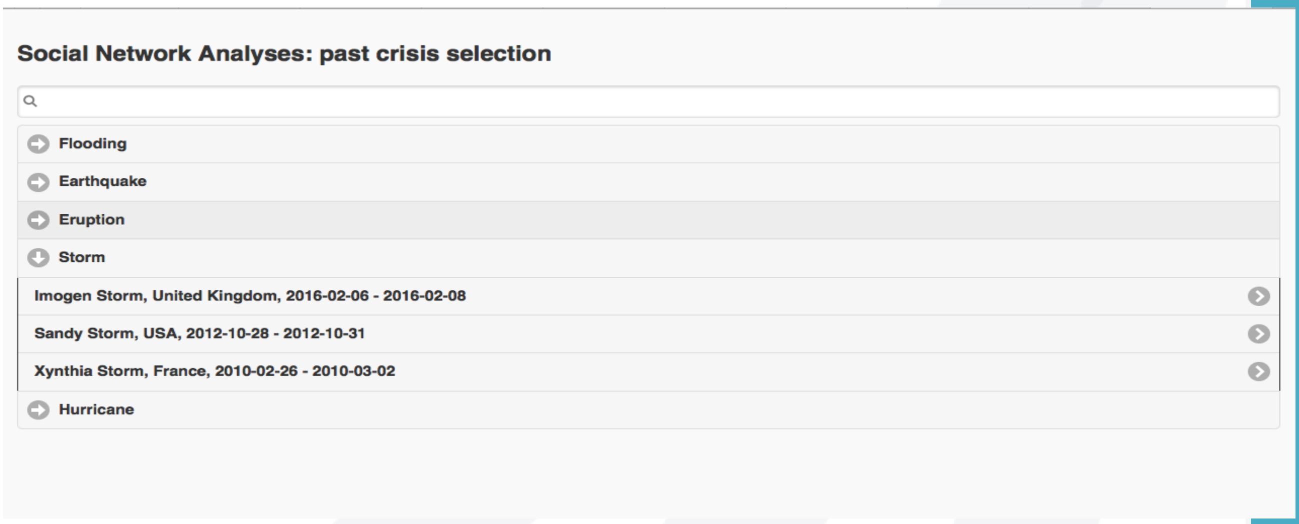
- Lemmatization
- Dictionary based matches
- Grammatical Rules applications
- Average and predominant outputs calculation

About the visualization, the output of the analyses are shown in a web-view, where line charts are used in order to show the distribution of tweets (in terms of moods, behaviour and emotion) emphasizing the time component. Moreover, in order to offer to the decision makers a magnifying view of the crisis in terms of human behavior, additional contextual information have been added in the visualization. In details:

- information about communication sent to the population (by newspaper, television and any other means/media)
- information about the specific phases of the crisis or the cascading events (e.g. the major outbreak of the seismic event, the presence of significant ash fall)
- information about decision makers actions (e.g. closure of airspace, trains cancellation, order to evacuate)

These contextual information have been added to have a snapshot of a past crisis and, from one side, to help to understand the impact of specific phases/events of the crisis on the population and, on the other side, to help to understand if specific actions done by decision makers have had the expected response by the population.

The following pictures show the developed web-view, where the decision makers can interact with the output of the social network analyses.



This picture shows the initial view, where all the crisis studied are shown:

- Alberta Floods, Canada, 2013-06-20 - 2013-07-12
- Bohol Earthquake , Philippines, 2013-10-14 - 2013-10-25
- Eyjafjallajokull Eruption, Iceland, 2010-03-21 - 2010-05-23
- Imogen Storm, United Kingdom, 2016-02-06 - 2016-02-08
- Sandy Storm, USA, 2012-10-28 - 2012-10-31
- Xynthia Storm, France, 2010-02-26 - 2010-03-02
- Typhoon Haiyan (Yolanda), Philippines, 2013-11-03 - 2013-12-30

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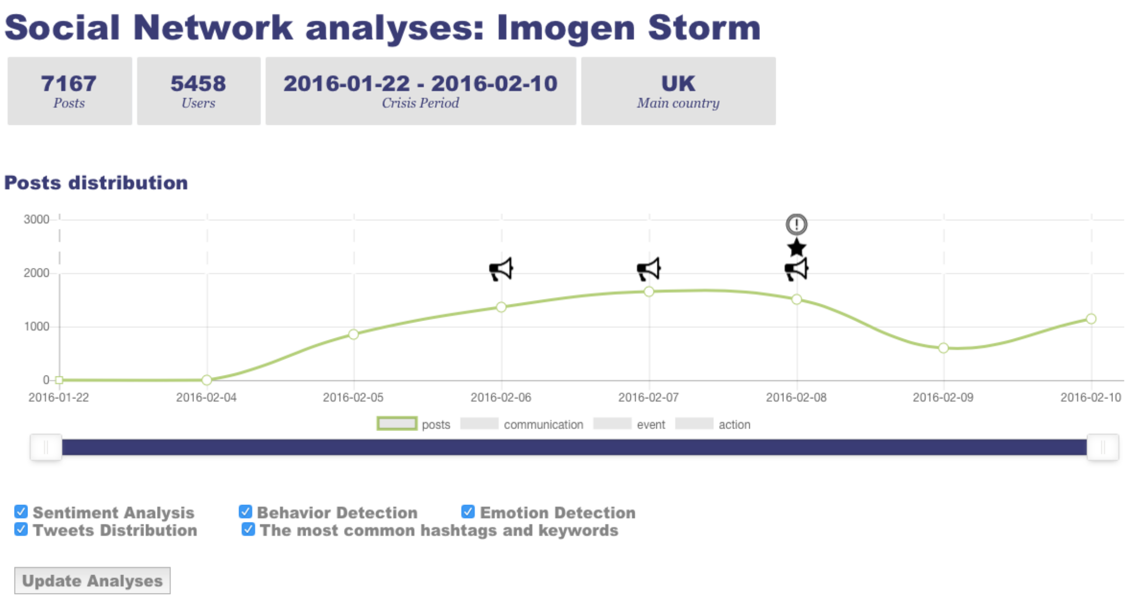
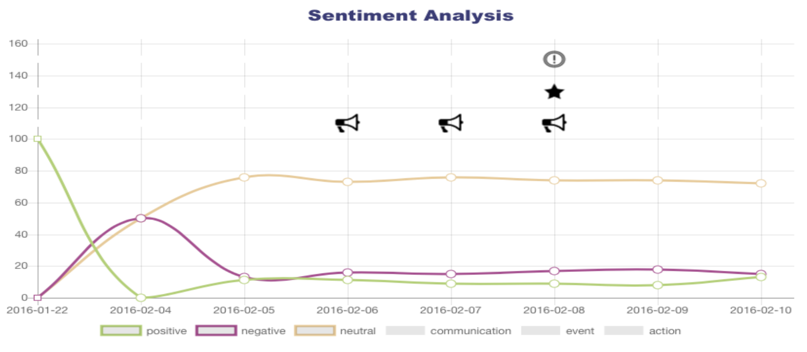
The selection of the crises can be done both through the list view and the search box. Chosen the crisis, the decision makers have a brief synopsis of the social data related to that crisis, as shown in the following picture.



The decision makers can now choose the analyses they are interested in and the relative period. Now, the view is updated with a line charts for each selected analyses, as shown in the following pictures.

Period: from 2016-01-22 to 2016-02-10

Tweets: 7167



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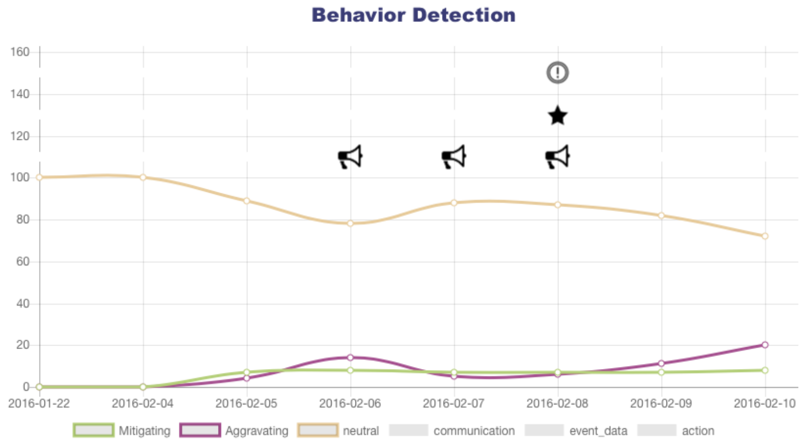

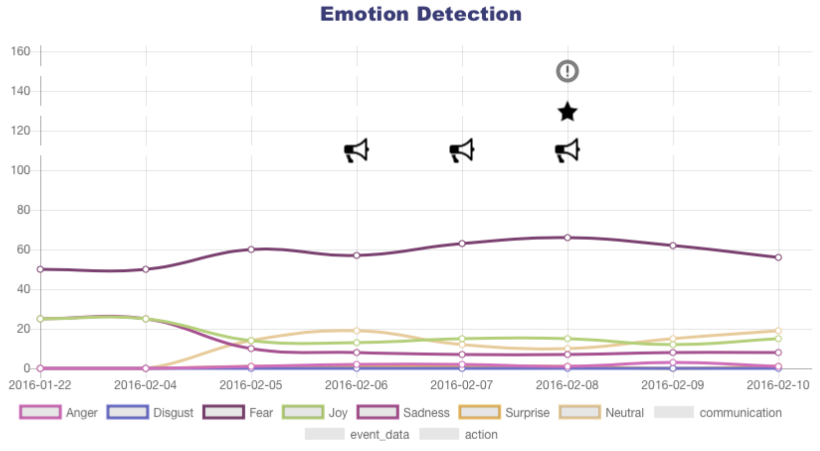

About the visualization, it is important to note that the visualization of the analyses, shown in the previous pictures, has been improved with additional contextual information (shown with icons: star, info and megaphone), accepting suggestions coming from end-users, in order to offer to the decision makers a magnifying view of the crisis in terms of human behavior. In details, such information are:

- about communication sent to the population (by newspaper, television and any other means/media);
- about the specific phases of the crisis or the cascading events (e.g. the major outbreak of the seismic event, the presence of significant ash fall);
- about decision makers actions (e.g. closure of airspace, trains cancellation, order to evacuate).

These contextual information have been added to build a snapshot of a past crisis and, from one side, to help to understand the impact of specific phases/events of the crisis on the population and, on the other side, to help to understand if specific actions done by decision makers have had the expected response by the population.

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In addition, the analysis of the data received from the social networks also facilitates:

- Detecting the crisis situation.
- Geo-mapping the crisis affected area.
- Detecting the type of the crisis situation.
- Identify the impacts, needs of people and population behavior during the crisis situation.

The combination of machine learning method, dictionary based method and natural language processing have been identified in order to perform the analysis and processing on the textual data coming from the social networks.

The machine learning method proposes using the statistical classification algorithms in order to identify in near real time the crisis situation. A novel hierarchical crisis events classification mechanism has been experimented and successfully integrated into the event monitoring framework. The machine learning models are trained with a valid, verified data labelled by the experts in the areas of the crisis management.

In principle, the models learn from the labelled dataset, this methodology is also known as supervised machine learning.

The implementation of the machine learning approach permits the automated near real time classification of the data into the categories with a high percentage of accuracy.

Within the hierarchical crisis events classification framework, three statistical classification models have been developed and tested, along with a time-series anomaly detection model that helps to identify unusual activities in the twitter data stream which indicates the unusual event occurrence to the user.

The models are built and trained with datasets curated by the experts in the domain. The datasets were pre-processed by using natural language processing methodologies in order to make them more effective and efficient to train the models.

- Event Identification Model (Classification: event_on or event_off)

Algorithm	Accuracy
Support Vector Machine	96.95 %
Naïve Bayes	95.42 %

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- Event Type Identification Model (Classification: Earthquake or Floods or Storm)

Algorithm	Accuracy
Support Vector Machine	97.87 %
Naïve Bayes	97.34 %

- Event Impact Classification Model (Classification: Caution & Advice or Evacuated People or Human Casualties or Infrastructure Damage or Needs, Supplies, Aid)

Algorithm	Accuracy
Support Vector Machine	82.5 %
Naïve Bayes	69.9 %

The dictionary based method proposes to build and curate the dictionaries containing a set of related words and phrases so as to semantically detect a crisis situation over the twitter data feed.

The dictionary based mechanism utilizes several dictionaries, each one linked to a particular lexicon identified to be related to the crisis situation. Several different dictionaries are used for each type of crisis where each dictionary is linked to a more generic relevant category.

12 different dictionaries are built which are Generic or Specific and are categorized into:

- Natural Hazards
- Human Impacts
- Human Needs
- Power Grid
- Water Grid
- Telecom Grid
- Impacts on Building

Indicators defined in order to detect and analyze the crisis situation:

- Global Indicator
- Crisis Manifestation (Type of crisis)
- Human Impacts
- Response and Needs
- Material Impacts

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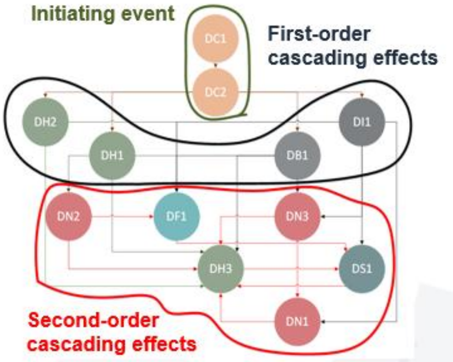
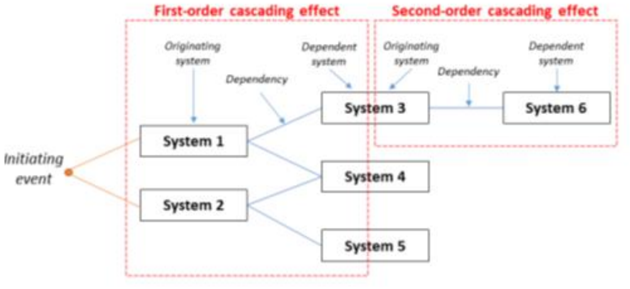
Dictionnaire	Description
DC1	Terms related to natural elements at the origin of the crisis
DC2	Terms describing the span of the natural hazard
DH1	Terms related with death and injuries
DH2	Terms related to missing people, trapped people and search for victims
DH3	Terms related to feelings during a crisis
DN1	Terms related to human needs: food and water
DN2	Terms related to human needs: health care
DN3	Terms related to human needs: home
DF1	Terms refering to first responders
DS1	Terms related to the security issues: violence, demonstration, riot
DI1	Terms related to impacts on grids (power grid, water grid, telecom grid
DB1	Terms related to impacts on buildings





Effect

Cause

	DC1	DC2	DH1	DH2	DH3	DN1	DN2	DN3	DF1	DS1	DI1	DB1	DE1
DC1	1	2	1	1	1	1	1	1	1	1	2	2	0
DC2	3	1	3	3	2	1	2	2	3	2	3	3	0
DH1	1	1	1	2	3	1	3	1	3	1	1	1	0
DH2	1	1	3	1	3	1	2	1	3	1	1	1	0
DH3	1	1	1	1	1	1	2	1	2	3	1	1	0
DN1	1	1	3	1	3	1	2	1	2	2	1	1	0
DN2	1	1	1	1	3	1	1	1	3	1	1	1	0
DN3	1	1	1	1	3	2	2	1	3	2	1	1	0
DF1	1	1	1	1	1	1	1	1	1	3	1	1	0
DS1	1	1	3	2	3	2	2	1	3	1	1	1	0
DI1	1	1	2	2	3	3	2	3	3	3	1	1	0
DB1	1	1	3	3	3	2	2	3	3	2	3	1	0
DE1	0	0	0	0	0	0	0	0	0	0	0	0	0

0	Exclusion
1	No link
2	Indirect link
3	Direct link

The event Geo-Mapping module is based on the Natural Language Processing mechanism.

This module does the processing in two stages:

1) The Tweet text is processed to identify if it refers to the name of a city or place where the event has occurred.

2) The identified name of the city or place is further processed in order to obtain its geo-location co-ordinates.

The obtained geolocation coordinates are further used to geo-map the event.

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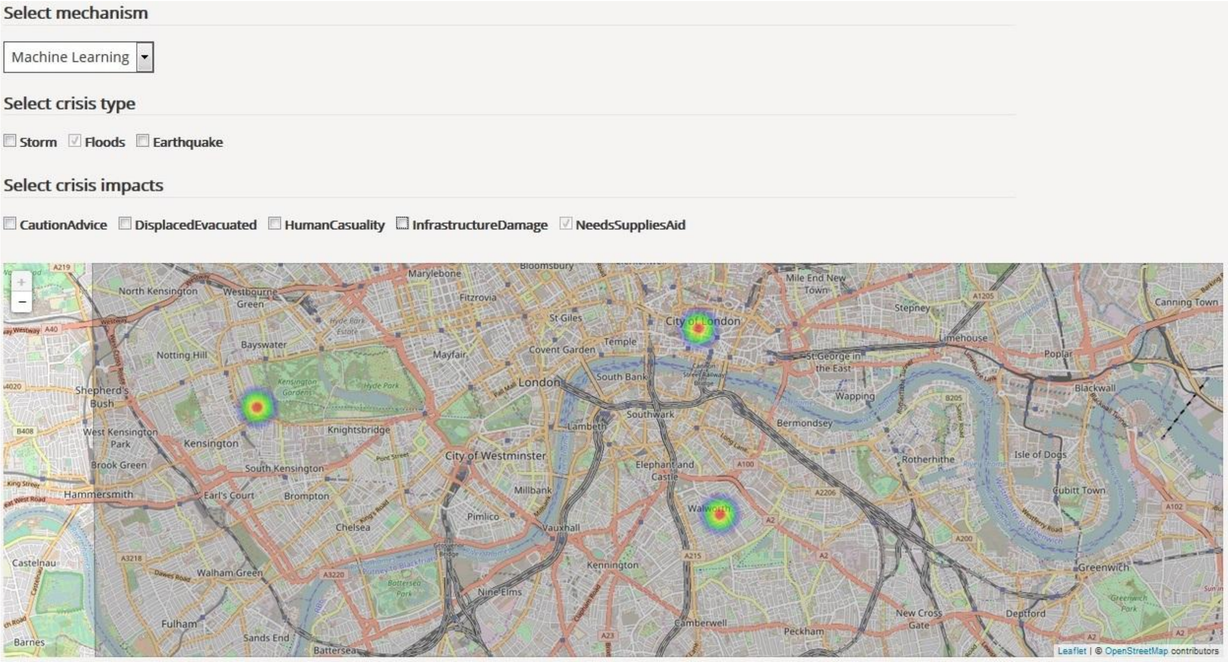
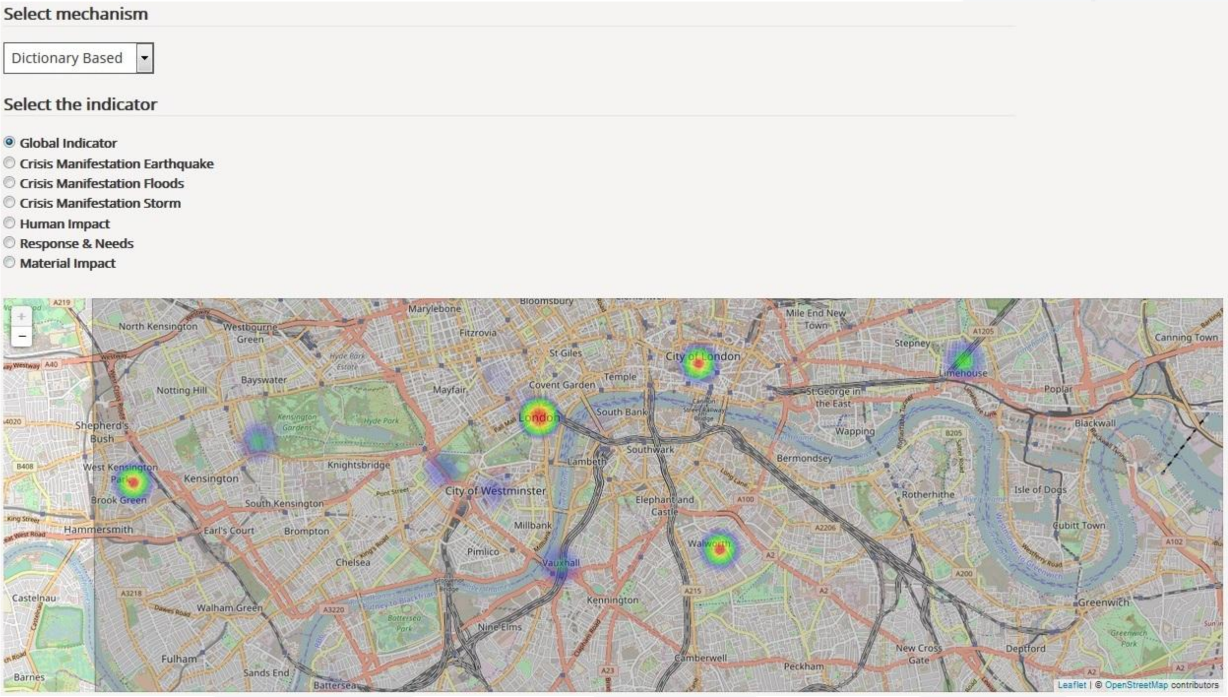
Results of the Machine Learning Approach :



Results of the Dictionary Based Approach:



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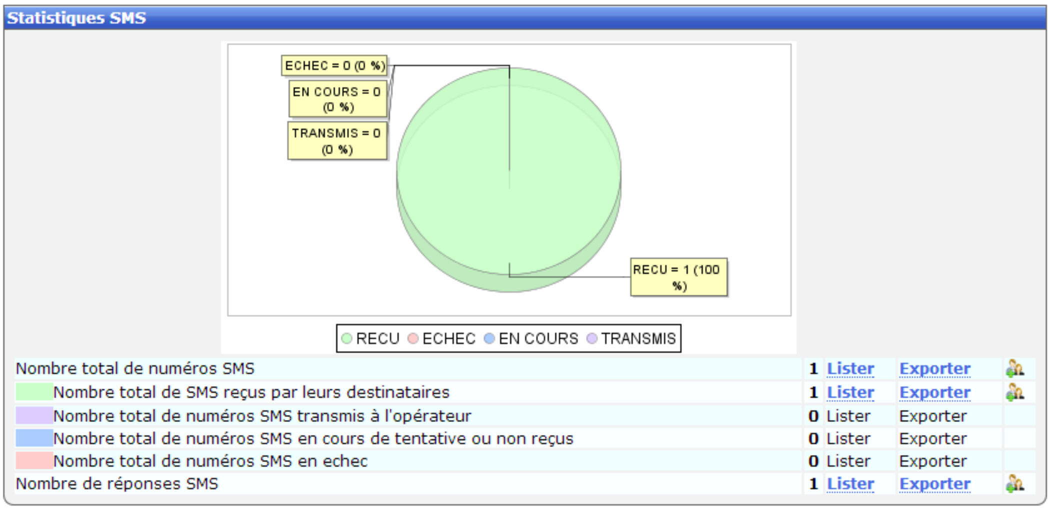
- ***TeleAlert - Pre-Crisis management system***

The TeleAlert System is presented in D6.5 and D6.6

Motivation: The Emergency Alert System is designed to call a large amount of population in a minimum of time. The friendly interface helps the end-user or the user in charge of the Alert Campaign to be able to launch the call campaigns. This tool shall collect a feedback information from the group being called and bring these data to the ELDB. This generated dataset is accessible for any simulation or decision system to be processed at a second stage in order to give accurate analysis.

Approach: This tool could be used for the preparedness phase as well as in the operational phase, only the target in terms of users and messages will be different.
In preparedness phase, depending on variable results from simulations of the cascading effect (provided by the snowball project), an operator should be able to organize and store dedicated phone scenarios. These scenarios are made by the flow diagram (See the D6.6) editor and should be changed at will.
The setup layer of the software is able to manage different rights in order to take into account a maximum of user rights constraints.

The campaign monitoring are available through a friendly interface which allow in a unique screen view to display the results for supervising the progress.



The following display shows the progress by call.

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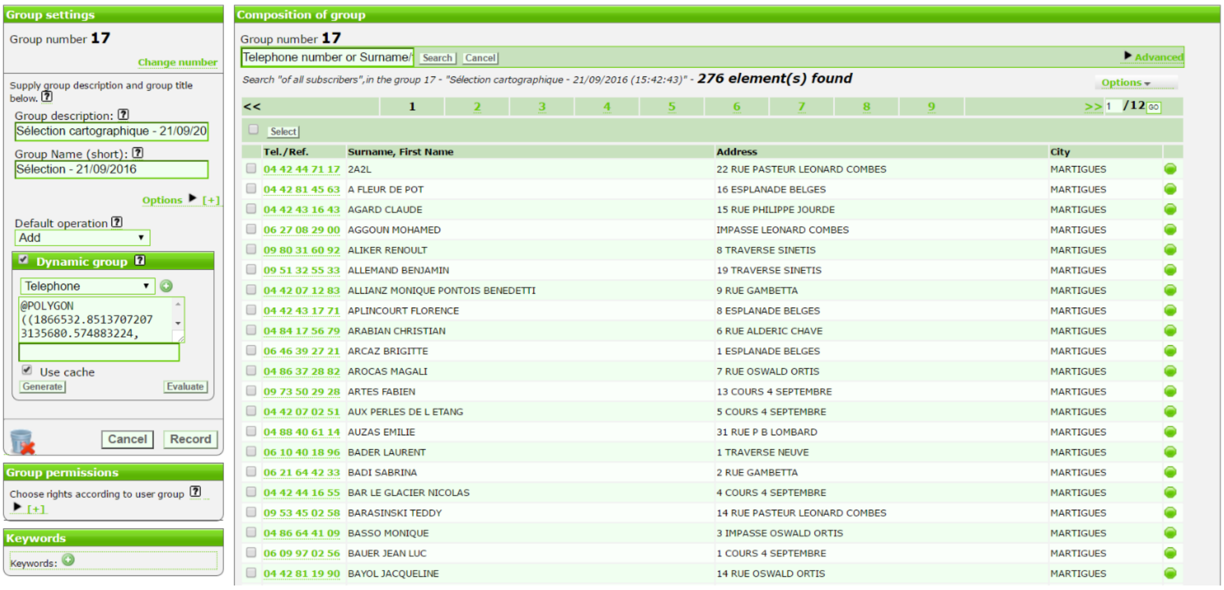

This tool is mandatory as well in the preparedness as the crisis management. Obviously, this software is used in the earlier stages in order to prepare the call campaigns according the scenarios. The target of the call campaign could be a group of persons (Firefighters, Policemen, civilian protection ...) in charge of the crisis management. But the same tool will be used to communicate with the population threatened by the cascading effects impacts in order to give advice or to order an evacuation.

- ***Decision Algorithm***

The Decision Algorithm is presented in D6.1 and D6.2.

Motivation: the choice of the most appropriate preparedness and mitigation strategies is rendered particularly challenging by the evaluation of cascading effects, which introduce an additional level of uncertainty as well as a stronger dependence of the impacts on the timing of the intervention.

Approach: the Decision Algorithm supports the decision maker in the choice of preparedness and mitigation strategies to better deal with cascading effects in disasters, in a pre-crisis phase. It is mainly addressed to emergency planners and crisis managers at a regional and at a national level, consistently with the general definition of end user of the Snowball platform. The Decision Algorithm is specifically designed to be used in a context where cascading effects are evaluated, by working on top of the event tree model developed in WP3. Starting from the concept of hazard chain, the Decision Algorithm allows to consider the timing of the intervention as a crucial variable for the decision, as cascading effects can dramatically change the scenario according to which preparedness measures are evaluated. The Decision Algorithm can also be used to compare mitigation strategies, namely structural interventions such as building or grid reinforcements that require time to be implemented, in a long-term perspective and considering cascading effects. The Decision Algorithm combines the ranking approach of ELECTRE III, which compares the intervention strategies with each other, and the sorting approach of ELECTRE TRI, which compares the intervention strategies with a set of predefined reference profiles. The algorithms require the inputs of the user in the choice of the weights, creating a sense of involvement and rendering formal and explicit the definition of the user's priorities. Moreover, the ensemble approach can be seen as a way of raising awareness into the decision maker,

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who is able to visualize the ranking and sorting distribution and to gain insights into the inherent complexity of the decision process. In fact, the distributions are able to show that decisions necessarily depend on facts that cannot be exactly predicted and convey a proxy of this uncertainty (Fig.1).

1) Simulation results

Run1	C1	C2	C3	C4
EVC A t0	10	11	20	18
EVC A t1	8	12	19	21
EVC A t2	10	11	19	18
EVC B t0	11	12	13	20
EVC B t1	12	13	17	19
EVC B t2	7	10	23	17

Run2	C1	C2	C3	C4
EVC A t0	11	10	20	18
EVC A t1	8	11	19	21
EVC A t2	10	11	19	18
EVC B t0	11	12	13	20
EVC B t1	12	12	18	19
EVC B t2	7	9	22	17

Run3	C1	C2	C3	C4
EVC A t0	9	10	20	18
EVC A t1	8	12	19	21
EVC A t2	10	11	19	18
EVC B t0	11	12	13	20
EVC B t1	12	13	17	19
EVC B t2	8	11	23	17

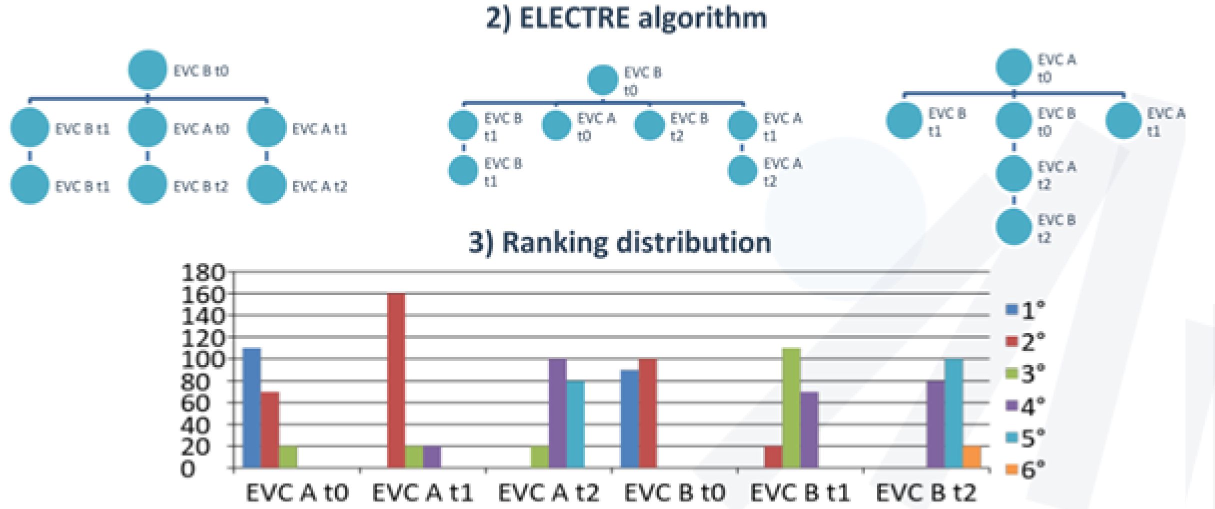

Fig.1: illustrating the approach of the Decision Algorithm. For a set of simulation results corresponding to small perturbations of a given cascading effect scenarios, ELECTRE algorithms are run to obtain a ranking/class assignment of mitigation strategies. From these results ranking/class assignment distributions are computed. The final ranking/class is the median of these distributions.

Implementation: from the technical point of view, the Decision Algorithm is made of a Command Line application that actually performs the computations and a simple web application that retrieves pre-computed scenarios and enables the interaction with the end user through the dashboard. The developed code, which includes a reimplementation of ELECTREIII and ELECTRE TRI, is openly released on github (http://www.github.com/enricopal/snowball_decision). It is compliant with the EDXL-DE standard and is able to use the Data Layer to exchange data or to compute results in real-time, it runs on the cloud infrastructure that has been developed appositely.

Results: in the pilot site of Santorini, the Decision Algorithm has been used to compare two evacuation strategies, in the scenario where a volcanic reactivation is followed by two earthquakes ('Time History 1 EQ1+EQ2'. The first evacuation strategy implicates evacuating all the population before the first earthquake ('EVC_anteEQ1'). The second evacuation strategy considers a scenario where tourists are evacuated before the first earthquake and the rest of the population before the second earthquake ('EVC_anteEQ1_anteEQ2'). In according to the principle of counterfactual evaluation, the scenario where no evacuation strategy is implemented has also been simulated ('No mitigation'). After a pre-processing of the data and a configuration phase of the algorithm, we leave to the user the possibility of enter weights (Fig.2).

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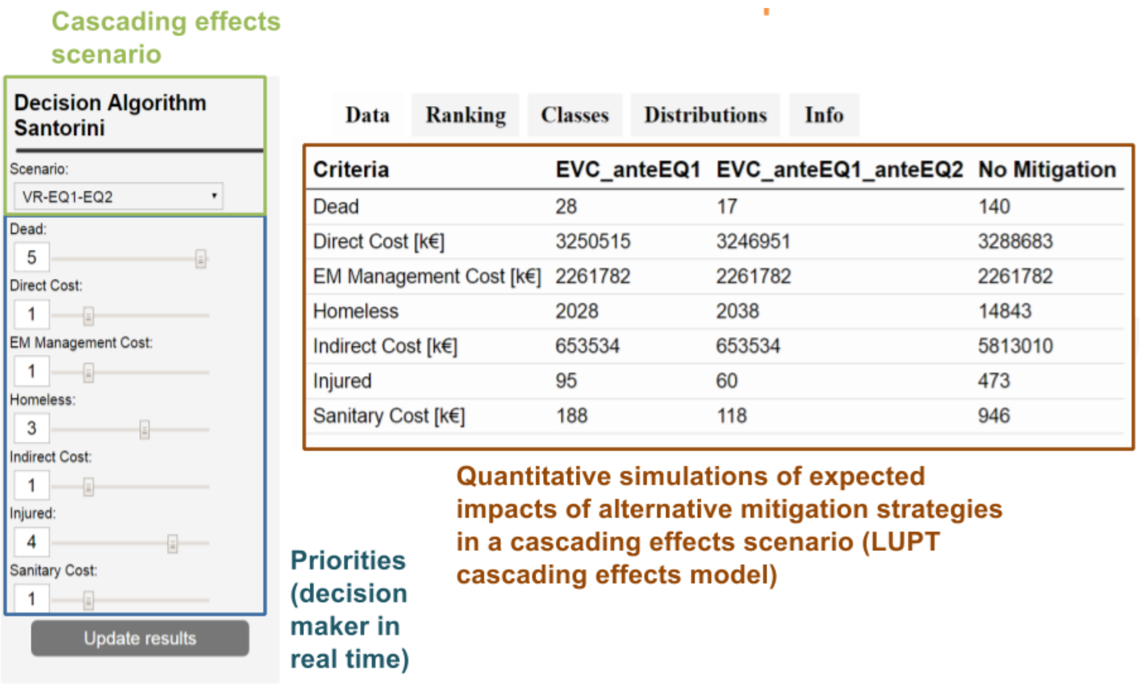

Criteria	EVC_anteEQ1	EVC_anteEQ1_anteEQ2	No Mitigation
Dead	28	17	140
Direct Cost [k€]	3250515	3246951	3288683
EM Management Cost [k€]	2261782	2261782	2261782
Homeless	2028	2038	14843
Indirect Cost [k€]	653534	653534	5813010
Injured	95	60	473
Sanitary Cost [k€]	188	118	946

Fig.2: the decision maker is able to visualize the quantitative simulations of mitigation strategies in a cascading effects scenario and to enter weights on a set of criteria as a proxy of his/her priorities

What we have observed in this case is that the results appear to be quite robust to different possible set of weights, except for extreme choices of the weights (e.g. most of the weight concentrated on 'Homeless' and/or 'Indirect Cost') and the strategy in which tourists are evacuated first appear to be preferable (Fig.3).

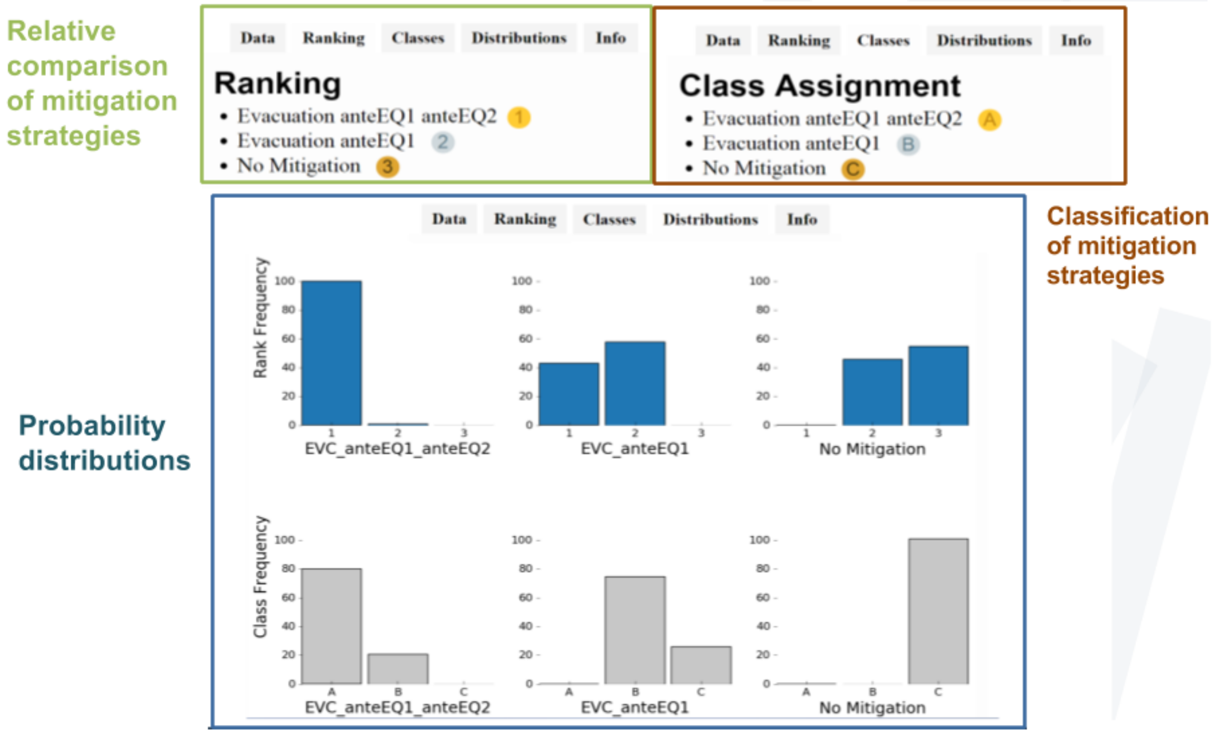

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Fig.3: the decision maker is able to visualize the results of the Decision Algorithm in terms of ranking (+distributions), class assignment (+distributions) of mitigation strategies.

The potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results

- ***Impact***

The technical impact of the project can be measured by the scientific outcomes and their use by the community to build on the next steps toward cascading effects analysis and preparedness actions. Publications and public deliverables will ensure that all outcomes are available and useable for future research and partners might continue actions on this field through other project (Eu funded or not).

The sociological impact might be greater in case of a project application. If the project is sold to potential users, both economical impact and sociological impact will be very high as the project tools will generate incomes as well as decreasing expenditures cost spent on crisis management.

- ***Main dissemination activities***

The dissemination activities of the Snowball project aimed to diffuse the knowledge acquired through the research work towards the scientific community, crisis manager, authorities and to communicate on the results of the project towards municipalities, end-users and general public. This wide audience targeted by the consortium implied to develop different levels of dissemination in order to reach effectively each target public.

The website

The first and biggest tool that reaches a wide public is the website (http://www. snowball-project.eu). It contains all information about the project : fact sheet, objectives, partners, work program and will soon contains all public deliverables to ensure a broad uptake of the scientific research as well as dissemination video made to present the project and the tools.

The "Petit-déjeuner"

INEO and GED organised two events in one day with the support of the leading French association in Civilian Defense. The High Committee of Civilian Defense (HCFDC) is an actor of the civil society, which participates in the reflection on the doctrine, the organization and the techniques of France with respect to the resilience of the organizations and societal security.

The HCFDC has a huge network of enterprises, authorities, policy makers in the field of crisis management, and the Snowball project benefited from their help and network in the events preparation.

The first event was held in the Senat in Paris, at the heart of the French parliament, and aimed at presenting the Snowball project and tools to a very targeted audience of Civilian Protection Manager, OCDE Manager, Ministry representatives, Researcher of French top centers, Bank & Insurance

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Manager, Grid operator, Defense company managers, etc. At the end of the presentation a video interview was made and released (http://hcfdc.org/uploads/video/pdj/2017/2017-02-07/PDj-07022017.mp4).

The second event was held at the HCFDC premises in the center of Paris, and aimed at demonstrating the Snowball tools.

Video presentation:

GED prepared a detailed script to have a video created to present the project, the tools and the scientific content behind. This video will be used in business context mainly, to sell the services to potential end-users.

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1 USE AND DISSEMINATION OF FOREGROUND

SECTION A

NO	Title	Main author	Title of the periodical or the series	Action	Link
1		ISMB	International Journal of Information Technology & Decision Making	Journal paper describing results of Snowball project, with focus on decision algorithm and cascading effects models	http://www.worldscientific.com/worldscinet/ijitdm
2		ISMB/LUPT	International Journal of Information Technology & Decision Making	Journal paper describing results of Snowball project, with focus on decision algorithm and cascading effects models	http://www.worldscientific.com/worldscinet/ijitdm
3	Cascading effects modelling and impact scenario analysis: a	LUPT	Journal of Civil Engineering and Management	Paper "Cascading effects modelling and impact scenario analysis: a simulation-based approach"	http://www.tandfonline.com/toc/tcem20/current

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	simulation-based approach"				
4	Impact of cascading effects in volcanic eruptions: the Santorini case study	LUPT		Paper "Impact of cascading effects in volcanic eruptions: the Santorini case study"	https://www.journals.elsevier.com/journal-of-volcanology-and-geothermal-research
5	Factors of Perceived Threat Regarding Severe Storm Events: Results of a Vignette Study in Four European Countries	EMAUG	Safety Science	Stefanie Hahm, Daniela Knuth, Sandra Lemanski, Diana Kietzmann, Silke Schmidt: "Factors of Perceived Threat Regarding Severe Storm Events: Results of a Vignette Study in Four European Countries"	https://www.journals.elsevier.com/safety-science/
6	Kaskadierende Effekte in Katastrophen: Die Rolle des menschlichen	EMAUG	Im Einsatz (In action / In the field)	Malte Schönefeld, Daniela Knuth, Sandra Lemanski, Stefanie Hahm, Silke Schmidt (2016). Kaskadierende Effekte in Katastrophen: Die Rolle des menschlichen Verhaltens. (Cascading effects in catastrophes: The role of human behaviour.)	http://www.skverlag.de/zeitschriften/im-einsatz.html

	Verhaltens				

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List of dissemination activities:

Partner	Event	Action	Period	Location	Type of audience	Country adressed
EMAUG	Workshop on floods in Central Europe ("TACTIC" project)	Malte Schönefeld: "Preliminary results of the Snowball project – Vignette study"	2016	Bogatynia, Poland	Representatives of organisations and science in Germany, Poland and the Czech Republic	Central Europe
EMAUG	Public Safety Communication Europe (PSCE) Forum Conference, Speaker Panel "Natural disasters: how to prepare for cascading effects	Malte Schönefeld: "Human behaviour and cascading effects - results of a vignette study"	2016	Athens, Greece	Organisations and actors in civil protection; researchers	EU
EMAUG	KatNet-Workshop "Die Flüchtlingsthematik als Herausforderung für Katastrophenschutz und -forschung" ("The refugee crisis as challenge for crisis management and research")	Malte Schönefeld: "Interkulturelle Kompetenz im Bevölkerungsschutz und kaskadierende Effekte" ("Intercultural competence in civil protection and cascading effects")	2016	Berlin, Germany	Organisations and actors in civil protection; researchers	Germany
ESC	BARENTS RESCUE 2015	Desription of Cascading events and Snowball project	2015	Kittilä, Finland	Researchers	Finland
FHG	Ministry of economy and energy	Project presentation	2014	Berlin, Germany	Government	Germany
FHG	Fraunhofer industrial partners	Project presentation	2014	Stuttgart, Germany	Industry	Germany

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GED	Belgian ministry	Project and tools presentation	2016	Brussels, Belgium	Government	Belgium
GED	Hungarian Red Cross	Inclusion of Snowball tool	2017	Hungary	Association, end user	Hungary
GED	HCFDC event	Inclusion of 2 Snowball tools in their project	2017	Paris, France	Government	France
GED	International official summits	Unformal discussions	2016	Mali	Ministries	Worldwide
HRC	Monthly Meeting of County Branch Directors	Project presentation	2017	Budapest, Hungary	HRC stakeholders	Hungary
HRC	Monthly Meeting of County Branch Directors	Project presentation	2017	Budapest, Hungary	HRC stakeholders	Hungary
INEO	Oracle Engie IT Meeting	Demonstration of Engie Ineo crisis management solutions and capablilites, including Snowball crisis event detection with social networks	2016	Nanterre, France	Sales manager, marketing leaders	France
INEO	Shield Africa 2017	Demonstration of Engie Ineo crisis management solutions and capablilites, including Snowball crisis event detection with social networks and general project	2017	Abidjan, Ivory Coast	Civil protection directors; official delegations	Ivory Coast, Mali, Burkina Fasso, Togo, Bénin, Congo
INEO	Customs and Engie IT Meeting	Presentation of Snowball results at Customs Adminstration DGDDI	2016	Paris, France	civil protection directors; official delegations	France
INEO	Domestics Affairs administration & Engie IT Meeting	Presentation of Snowball results at Domestic Affairs (Stsi2)	2016	Paris, France	civil protection directors; official delegations	France

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INEO	foreign Affairs administration & Engie IT Meeting	Presentation of Snowball results at Foreign affairs	2016	Paris, France	civil protection directors; official delegations	France
INEO	Ecology and Engie IT Meeting	Presentation of Snowball results at ministry of ecology (CMVOA)	2016	Paris, France	civil protection directors; official delegations	France
INEO	SEA Big Data	Présentation of Snowball results for a potential implementation of a Big Data platform for the LGV-SEA railway	2017	Poitiers, France	civil protection directors; official delegations	France
INEO	Marseille	Presentation of Snowball results of the city of Marseille	2016	Marseille, France	civil protection directors; official delegations	France
INEO	CREM Dijon	Presentation of Snowball to the city of Dijon	2016 & 2017	Dijon, France	civil protection directors; official delegations	France
INEO	Big Data Paris Event	Presentation of Snowball to the city of Paris	2017	Paris, France	datascience included civil protection directors; official delegation	France
ISMB	ICDSST2016	Paper presentation concerning the decision algorithm and the cascading effects simulation models	2016	Plymouth	Decision Support System researchers and practitioners	International audience
ISMB	EGOV2015	Paper presentation on evaluation of open data maintenance model with	2015	Thessaloniki, Greece	Data managers, researchers and practioners	International audience

		public administration and SMEs				
ISMB	ADBIS2015	Paper presentation on "Fast and effective decision support for crisis management by the analysis of people's reactions collected from Twitter"	2015	Futuroscope, France	Researchers in Databases and Information Systems	International audience
LUPT	GEORISK	Paper presentation on "Cascading effects modelling - Snowball project"	2014	Madrid, Spain	Researchers	International audience
LUPT	REGIONAL SEISMIC RISK	Paper presentation on "Seismic impact and cascading effects simulation"	2014	Arezzo, Italy	Researchers	International audience
LUPT	VOLAND CONFERENCE 2014	Presentation "Snowball project and Santorini case study"	2014	Santorini, Greece	Researchers	International audience
LUPT	Theoretical Model in Cascading Events	Presentation "Snowball project" Meeting to discuss the main aspects of "Decision making" included in SNOWBALL methodology.	2014	Rome, Italy	Stakeholders	International audience
LUPT	Cascading Effects on infrastructures in Santorini	Presentation "Cascading effects modelling - Snowball project" Dissemination to the Local Service Providers	2015	Santorini, Greece	Stakeholders	International audience
LUPT	Meeting "EU/FP7 SNOWBALL	Presentations "Theoretical model for cascading effects	2017	Santorini, Greece	Researchers, stakeholders	International audience

	project results and Demonstration of Santorini Pilot Case	and Santorini application" and "Santorini Use Case and Tools Demonstration" Dissemination to Providers and Local Authorities of Snowball results				
LUPT	(Forseen) EU-H2020 ESPREsSO Project meeting	Presentation "Cascading effects modelling - Snowball project" Snowball Dissemination to other EU Projects	December 2017	Copenhagen	Researchers	International Audience
LUPT	Joint meeting with DG-Home and DG-Echo	Presentation "Cascading effects modelling - Snowball project" Snowball Dissemination to EU level stakeholders	2017	Brussels, Belgium	Stakeholders	EU
SGSP	Open Seminary in Main School of Fire Service	Project Summary	2017	Warsaw, Poland	Academic teachers	Poland
UCL	Smart@Fire conference	Distribution of leaflets and conversation with participants to disseminate our project aim, methodology and main results	2016	Brussels, Belgium	All (Universities, research institutes, European Commission, private companies, associations, government, …)	EU
UCL	Meeting of the AIE 2016 "Epidemiology, surveillance and research in case of catastrophic	Mention of the project aim and potential results and conversations with participants	2016	L'aquila, Italy	Italian Association of Epidemiology, Univeristy of Milan, epidemiologist,	EU

	events"				Epidemiology & Prevention, City councilor L'Aquila, Epidemiologist Istituto Superiore di Sanità, Director Epidemiology & Prevention	
UCL	Symposium 'Extremes 2016'	Mention of the project aim and potential results and conversations with participants	2016	Hanover, Germany	Grantees funded under the call 'Extreme Events: Modeling, Analysis, and Prediction', mostly coming from universities and extramural research institutes in Germany	EU
UCL	RGS-IBG London	Project dissemination through powerpoint presentation and conversations with participants	2016	London, UK	Academics, decision makers, private companies, … (list of participants available on their website)	EU
UCL	Technical Advisory Group meeting for EM-DAT	Presentation of project aim, potential results and website	2016	Washington D.C, USA	members of FEMA, USAID/OCHA	USA

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SECTION B

Type of exploitable foreground	Description of exploitable foreground	Confidential Y/N	Forseen embargo date	Exploitable products and measures	Sector(s) of application	Timetable, commercial or any other use	Patents or other IPR exploitation (licences	Owner & other beneficiary involved
Commercial exploitation of R&D results	TeleAlert	N	Now	Software	Emergency Alert	On sale	Licence	Gedicom
Commercial exploitation of R&D results	Twitter crowler	N	Now	Software	Twitter analysis	On sale	License	ISMB
Commercial exploitation of R&D results	Decision Algoritm	N	Now	Software	Decision maker support	On sale	License	ISMB
Commercial exploitation of R&D results	Caesar	N	Now	Software	Grid impacts simulation	On sale	License	FHG
Commercial exploitation of R&D results	Damage simulation tool	N	Now	Software	Damage simulation	On sale	License	LUPT
Commercial exploitation of R&D	Pre-crisi management	N	Now	Software	Decision support	On sale	Licence	INEO

results								

Exploitable foreground (Target and Scope)

Snowball was designed according the decision makers' needs and constraints. The needs could be one of these tools and services supplied by the consortium or more. The complete set of tools and services could be the expected solution but we will often face to existing tools and the constraint consists to integrate all tools together.

All partners involved in the research domain or technical domain will be actors in the future, acting on the deployment projects and the evolvements of the components.

This is a great success for the project and a guarantee for the future customers to have access to all competences grouped in the initial project.

The target of the deployment of the Snowball system are mainly the areas threatened by probable cascading effects triggered by the natural or technological disasters.

We have, for each partner, an offer of services or tools or a mix of both. Obviously, the customization phase is mandatory and an agreement between the consortium and the customer must take in consideration the results of the pre-study included in the first phase.

The contribution in the deployment could be advice inside the sub-phases dedicated to the studies (risk, scenario, population behaviour, action plan definition). EMAUG and UCL are the partners involved on the deployment offering only advice without tool.

LUPT, ISMB and FHG include advice with the deployment of their tools.

INEO and GEDICOM are the industrial partners involved in the deployment with only tools.

On the light of the interviews with the decision makers, the conferences and the demonstrations, the Snowball market exists and we have opportunities to transform. But is not easy to assess this market because on each country the Civilian Protection have a specific organization covering regions inside the country or the entire country. On each case, the decision level for the investments or the improvement of the services are located at different level.

Our approach is, first to reuse our contacts trying to transform their needs in projects and, second to use the success of the first deployments for increasing our visibility in the market in order to increase our opportunities.

• How the foreground might be exploited, when and by whom

In order to understand the market of this System, it is better to refocus on the main objectives of the end-users of this system.

According to the results of the interviews, the decision-makers at the national level are our end-users. The main needs expressed by them are a set of tools able:

- To make simulation of the impacts caused by cascading effects associated with a natural disaster (Flood, Volcano, Earthquake …) or an industrial disaster, in a specific area,
- To propose simulations in order to apprehend what could happen on the field taking into account different alternative scenarios and the influence of the behavior of the population,
  To supply pre-crisis management tools to support decision-makers in mitigation or/and the improvement of the preparedness.

Obviously, existing tools are already used by these end-users and a new set of tools like Snowball must be able to run with these existing tools.

The first target of Snowball is the persons involved in the civilian protection, in the ministries, and in the regional organizations. We have named our end-users "Decision-makers" because it's not possible to use a common name for this role due to the large set of different organizations encountered in the countries.

The discussions we had with these decision-makers show us that they must face a large panel of risks, the natural and industrial disasters represent only a part of them.

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The reinsurance activities show an interest of the project concerning the simulation tools and the capacity to propose action plans dedicated to the mitigation and the improvement of the preparedness.

The potential reduction of the impacts, reducing the vulnerabilities and the improvement of the preparedness, are two main factors which allowed a better vision on the risk.

Market assessment

Naturally, the decision-makers at the regional and national levels constitute a large part of our market, but our market is not necessary limited at this profile of end-users.

The assessment of the market size is not easy to perform but on each demonstration and on each meeting, the Snowball's team has the opportunity to assess the expectations and the compliance of our solution coupled with the services approach.

During the decision-makers' interviews, we have identified:

- First, some persons looking for new tools but without ongoing project,
- Second, some persons more involved in an existing project looking for one or more tools provided by the Snowball project.

The first contact with these persons was dedicated to the needs knowledge but we have planned other meetings in the coming months for a demonstration.

• IPR exploitable measures taken or intended

No IPR in our context, the tools will used by the decision makers across a set of services in order to use efficiently the tools.

• Further research necessary, if any

Not necessary, but a next version of Snowball could be planned in order to integrate the best of among the developed tools inside the EC projects and to improve the tests thanks two pilots during 6-12 months.

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2 REPORT ON SOCIETAL IMPLICATIONS

A General Information (completed automatically when **Grant Agreement number** is entered)	
Grant Agreement Number:	606742
Title of Project:	Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools
Name and Title of Coordinator:	Jean-Pierre Bidau (Gédicom)
B Ethics	
1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***Yes*** ***Yes***
2. Please indicate whether your project involved any of the following issues (tick box) :	
RESEARCH ON HUMANS	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	

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• Did the project involve Human data collection?		X
RESEARCH ON HUMAN EMBRYO/FOETUS		
• Did the project involve Human Embryos?		
• Did the project involve Human Foetal Tissue / Cells?		
• Did the project involve Human Embryonic Stem Cells (hESCs)?		
• Did the project on human Embryonic Stem Cells involve cells in culture?		
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?		
PRIVACY		
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?		
• Did the project involve tracking the location or observation of people?		
RESEARCH ON ANIMALS		
• Did the project involve research on animals?		
• Were those animals transgenic small laboratory animals?		
• Were those animals transgenic farm animals?		
• Were those animals cloned farm animals?		
• Were those animals non-human primates?		
RESEARCH INVOLVING DEVELOPING COUNTRIES		
• Did the project involve the use of local resources (genetic, animal, plant etc)?		
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?		
DUAL USE		
• Research having direct military use		
• Research having the potential for terrorist abuse		X
C Workforce Statistics		
3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).		
Type of Position	**Number of Women**	**Number of Men**

Scientific Coordinator		1
Work package leaders	2	6
Experienced researchers (i.e. PhD holders)	18	27
PhD Students	3	4
Other	20	18
4. How many additional researchers (in companies and universities) were recruited specifically for this project?		
Of which, indicate the number of men:		13

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?	No

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective (0)				Very effective (5)	
1 Design and implement an equal opportunity policy	2,5/5					2
Set targets to achieve a gender balance in the workforce	2,75/5					
3 Organise conferences and workshops on gender	O	O	O	O	O	
4 Actions to improve work-life balance	3/5					

o Other:	

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

o No

E Synergies with Science Education

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8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)? o Yes- please specify: Bachelor - thesis and seminar of science	
9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)? o No	
F Interdisciplinarity	
10. Which disciplines (see list below) are involved in your project? { Main discipline21:	
o Main discipline21: o Associated discipline21:	
G Engaging with Civil society and policy makers	
11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	Yes
11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)? o No	

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizensa and organised civil society (e.g. professional mediator; communication company, science museums)?				No	
12. Did you engage with government / public bodies or policy makers (including international organisations)					
o o o	Yes - in implementing the research agenda				
o	Yes, in communicating /disseminating / using the results of the project				
13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers? **o** Yes – as a primary objective (emergency planning) o Yes – as a secondary objective (risk and crisis communication)					
13b If Yes, in which fields?					
Development Economic and Monetary, Foreign and Security Policy, Information Society, Research And Innovation Public Health Civil protection and disaster relief					

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13c If Yes, at which level?

o Local / regional levels

o National level

H Use and dissemination	
14. How many Articles were published/accepted for publication in peer-reviewed journals?	6
To how many of these is open access22 provided?	2
How many of these are published in open access journals?	4
How many of these are published in open repositories?	0
To how many of these is open access not provided?	2
Please check all applicable reasons for not providing open access:	
‰o no suitable repository available	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		0
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	0
	Registered design	0
	Other	0
17. How many spin-off companies were created / are planned as a direct result of the project?		0

Indicate the approximate number of additional jobs in these companies:		0
18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:		
‰o Increase in employment, or ‰o Safeguard employment, or	Xo ‰o ‰o	In small & medium-sized enterprises
19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year***)** jobs: Difficult to estimate / not possible to quantify		

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations? **No**
21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public? **No**
22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

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X Press Release X TV coverage / report X Brochures /posters / flyers X DVD /Film /Multimedia		x x x	Coverage in specialist press Website for the general public / internet Event targeting general public (festival, conference, exhibition, science café)
23 In which languages are the information products for the general public produced?			
o ‰ Language of the coordinator		o	English