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<tr>
<td>Authors</td>
<td>Kuldar Taveter (TTU), Martin Scholl (CIS), Sascha Schlobinski (CIS), Lixin Ma (TTU), Merik Meriste (TTU), Sergio Guarino (AMRA), Markus Jähi (VTT)</td>
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## Glossary of terms

The glossary of terms most relevant to this deliverable has been generated from [https://crisma-cat.ait.ac.at/glossary](https://crisma-cat.ait.ac.at/glossary) and reflects the status of definitions in December 2014.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Agent</td>
<td>A kind of &quot;autonomous&quot; and &quot;active&quot; OOI that does have control over its behaviour, can act in the environment, perceive, and reason.</td>
</tr>
<tr>
<td>Algorithm</td>
<td>Effective method (formula) expressed as a finite list of well-defined parameters for calculating a cost function (direct or indirect).</td>
</tr>
<tr>
<td>Application programming interface</td>
<td>An application programming interface (API) is a protocol intended to be used as an interface by software components to communicate with each other (<a href="http://en.wikipedia.org/wiki/API">http://en.wikipedia.org/wiki/API</a>).</td>
</tr>
<tr>
<td>Application</td>
<td>See CRISMA application</td>
</tr>
<tr>
<td>Attribute</td>
<td>A characteristic of an entity (e.g. of an object in a model or the model itself).</td>
</tr>
<tr>
<td>Building block</td>
<td>A Building Block (BB) is an abstract concept describing specific functionality as an element of the CRISMA Framework. Building Blocks are generic, composable, adaptable as well as domain- and location-independent and thus transferable to different crisis management domains. There are three different types of Building Blocks: Infrastructure, Integration and User Interaction Building Blocks.</td>
</tr>
<tr>
<td>Cascade effects</td>
<td>Cascade effects describe the effects (consequences) of cascade events and thus allow evaluating indirect effects caused by the originating incident.</td>
</tr>
<tr>
<td>Cascade events</td>
<td>Cascade events describe a sequence of adverse events generated by a single or different source. For example an earthquake that causes ground motion that triggers a landslide.</td>
</tr>
<tr>
<td>Cascading effects</td>
<td>See Cascade effects</td>
</tr>
<tr>
<td>Catalogue</td>
<td>CRISMA Catalogue is a wiki-like web application and can be accessed through <a href="https://crisma-cat.ait.ac.at/">https://crisma-cat.ait.ac.at/</a> (if access permission exists). Its main purpose is to simplify the task of finding documentation on CRISMA Applications, Building blocks, Models, etc., and furthermore to see how all this information is linked together. The CRISMA glossary is now an integral part of the Catalogue.</td>
</tr>
<tr>
<td>Control and Communication Information Model</td>
<td>The Control and Communication Information Model (CCIM) is defined in the ICMM in a lightweight, common, minimal and generic form, while each Federation can define its individual extension. It conceptualises the shared commonalities of all CRISMA reference scenarios.</td>
</tr>
<tr>
<td>Conceptual model</td>
<td>The CRISMA conceptual model (meta model) for crisis management describes conceptually how different types of world (environment) models, incident models, and response models are related and connected to each other for decision-making by crisis stakeholders.</td>
</tr>
<tr>
<td>Crisis</td>
<td>A crisis (from the Greek κρίσις - krisis; plural: &quot;crises&quot;; adjectival form: &quot;critical&quot;) is any event that is, or is expected to lead to, an unstable and dangerous situation affecting an individual, group, community, or whole society. Crises are deemed to be negative changes in the security, economic, political, societal, or environmental affairs, especially when they occur abruptly, with little or no warning. More</td>
</tr>
<tr>
<td><strong>Crisis management</strong></td>
<td>loosely, it is a term meaning 'a testing time' or an 'emergency event' (<a href="http://en.wikipedia.org/wiki/Crisis">http://en.wikipedia.org/wiki/Crisis</a>).</td>
</tr>
<tr>
<td><strong>Crisis management cycle</strong></td>
<td>Crisis management is a multiple-phase process, with the phases often paralleling, rather than merely running sequentially, as implied by common cycle illustration. A widely used 4-phases cycle defines the &quot;Preparedness&quot;, &quot;Response&quot;, &quot;Mitigation&quot; and &quot;Recovery&quot; phases. Within EU, the &quot;Mitigation&quot; phase is often replaced by &quot;Prevention&quot; (<a href="http://securipedia.eu/mediawiki/index.php/Crisis_management_cycle">http://securipedia.eu/mediawiki/index.php/Crisis_management_cycle</a>).</td>
</tr>
<tr>
<td><strong>Crisis management phases</strong></td>
<td>See Crisis management cycle</td>
</tr>
<tr>
<td><strong>Crisis management simulation system</strong></td>
<td>A system for simulating possible impacts on crisis management resulting from alternative actions and decisions.</td>
</tr>
<tr>
<td><strong>CRISMA application</strong></td>
<td>A CRISMA Application is an integrated crisis management simulation system that is build according to the concepts of the CRISMA Framework Architecture. It is composed of (customised) Building Blocks of the CRISMA Framework and integrated or federated legacy components (simulation models, applications, systems, etc.).</td>
</tr>
<tr>
<td><strong>CRISMA end-user</strong></td>
<td>A person that either uses a CRISMA application directly within a application functionality or is a stakeholder who gains insights from another person using a CRISMA application for simulation runs.</td>
</tr>
<tr>
<td><strong>CRISMA expert</strong></td>
<td>A person that uses either a configuration file or a CRISMA application to prepare a simulation case.</td>
</tr>
<tr>
<td><strong>CRISMA federate</strong></td>
<td>Any component that connects to the Middleware Infrastructure of the CRISMA Framework and is able to exchange Control and Communication Information with the Middleware Infrastructure. More specifically, a CRISMA Federate has to be aware of the API of the ICMM.</td>
</tr>
<tr>
<td><strong>CRISMA federation</strong></td>
<td>A number of CRISMA Federates that act together as a unit. A CRISMA Federation is a subset of a CRISMA Application.</td>
</tr>
<tr>
<td><strong>CRISMA framework</strong></td>
<td>A framework composed of ready-to-use Building Blocks and supporting tools that can be connected together to form a CRISMA Application.</td>
</tr>
<tr>
<td><strong>CRISMA impact</strong></td>
<td>CRISMA impact is the expected outcome and effect of CRISMA project. See also Impact.</td>
</tr>
<tr>
<td><strong>CRISMA system</strong></td>
<td>In the perception of the architecture, the CRISMA System is the overall project results consisting of all CRISMA Applications.</td>
</tr>
<tr>
<td><strong>Criteria</strong></td>
<td>Criteria relate indicators to a qualitative assessment of the respective crisis situation. Indicators and corresponding criteria are the basis for the CRISMA decision support concept.</td>
</tr>
<tr>
<td><strong>Criteria function</strong></td>
<td>A Criteria function maps an indicator to a criterion.</td>
</tr>
<tr>
<td><strong>Decision making</strong></td>
<td>Decision making can be regarded as the cognitive process resulting in the selection of a course of action among several alternative scenarios. Every decision making process produces a final choice. The output can be an action or an opinion of choice</td>
</tr>
</tbody>
</table>
**Decision support system**

Decision Support Systems (DSS) make up a specific class of computerized information systems that support business and organizational decision-making activities. A properly designed DSS is an interactive software-based system intended to help decision-makers to compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions.

**Emergency**

Any incident, whether natural, technological, or human-caused, that requires responsive action to protect life or property.

**End user**

See CRISMA end-user

**Entity**

Active (agent) or passive (object) OOI.

**Evacuation**

(1) Emergency evacuation: Removal of persons from a dangerous place due to a disaster (e.g. in the context of pilot D);

(2) Casualty movement: the procedure for moving a casualty from its initial location to an ambulance (e.g. in the context of pilot C) (http://en.wikipedia.org/wiki/Casualty_movement).

**Evaluation**

Evaluation is “systematic investigation of the worth or merit of an object” (Frechtling, 2010). Evaluation is a valuable source of information on how a project is being implemented, specifically, what works and what should be modified.

**Event**

Phase associated with the natural catastrophe occurrence, usually of short duration, and characterised by a severe modification of the scenario.

**Expert**

See CRISMA expert

**Exposure**

People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses (UNISDR, 2009).

**Feature**

A “feature” (ISO 19101, 2002) is "an abstraction of a real world phenomenon". A feature is considered "geographic feature" if it is associated with a location. According to (OGC 08-126, 2009), the geographic features are “fundamental unit of geospatial information”.

**Framework**

An information architecture that comprises, in terms of software design, a reusable software template, or skeleton, from which key enabling and supporting services can be selected, configured and integrated with application code. See also CRISMA framework

**Functional requirement**

Defines a function of a software system or its component. A function is described as a set of inputs, the behaviour, and outputs (https://en.wikipedia.org/wiki/Functional_requirement).

**Functional specification**

A functional specification is the implementation independent description of a software component's behaviour which means that operations are specified on an abstract level not defining specific data types or schemas. It is the basis for a formal specification.

**General Morphological Analysis**

General Morphological Analysis is a method developed by Zwicky (1969). It aims to view all the interest objects in a global view as a whole.

**Goal model**

A goal model is a container of three components: goals, quality goals, and roles. A (functional) goal is a representation of a functional requirement of the socio-technical system. A quality goal is a non-functional or quality requirement of the system. Goals and quality goals can be further decomposed into smaller related sub-goals and sub-
<table>
<thead>
<tr>
<th><strong>Graphical User Interface</strong></th>
<th>Graphical User Interface (GUI) allows users to interact with a computer through click and drag operations (e.g. with a mouse) instead of entering text at a command line.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazard</strong></td>
<td>A “dangerous phenomenon, substance, human activity or condition” (UNISDR, 2009) – characterized by its location, intensity, frequency and probability – that may cause adverse impacts on a social (e.g. loss of life, injury or other health impacts, property damage, social and economic services disruption) or environmental (e.g., ecological damages) system (Pelling et al., 2004; Birkmann et al., 2013; Dewan, 2013).</td>
</tr>
<tr>
<td><strong>Hazard model</strong></td>
<td>Hazard models are a piece of software and/or related data to simulate hazardous events.</td>
</tr>
<tr>
<td><strong>Impact</strong></td>
<td>Consequences of a hazardous event once it materializes, i.e. actually affects a societal system.</td>
</tr>
<tr>
<td><strong>Impact scenario</strong></td>
<td>Time-dependent scenario focusing on the effects of the event chain. Consequences of the several events, hazards and countermeasures of a scenario.</td>
</tr>
<tr>
<td><strong>Incident</strong></td>
<td>An occurrence, natural or human-caused, that requires a response to protect life or property. Incidents can, for example, include major disasters, emergencies, terrorist attacks, terrorist threats, civil unrest, wildland and urban fires, floods, hazardous materials spills, nuclear accidents, aircraft accidents, earthquakes, hurricanes, tornadoes, tropical storms, tsunamis, war-related disasters, public health and medical emergencies, and other occurrences requiring an emergency response.</td>
</tr>
<tr>
<td><strong>Indicator</strong></td>
<td>A thing that indicates the state or level of something. In CRISMA, an Indicator is an aggregation of elements of a world state produced by an indicator function and is one element of an indicator vector. Indicators are a concept that helps us to bring more structure in World States with the help of an indicator function (aggregating thus losing information) so we can do e.g. algebraic computations on this representation of world states for the benefit of being able to better evaluate complex World State data.</td>
</tr>
<tr>
<td><strong>Indicator function</strong></td>
<td>An Indicator function produces an aggregated image of a world state.</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td>Infrastructure in a crisis management context covers for instance dikes, hospitals, rescue bases and critical infrastructure (as water, power, telecommunication networks, etc.).</td>
</tr>
<tr>
<td><strong>Integrated Crisis Management Middleware</strong></td>
<td>The ICMM (Integrated Crisis Management Middleware) is a central Building Block in every CRISMA Application. It connects Crisis Management Simulations with the Analysis and Decision Support functionality of CRISMA by providing a central repository for harmonized world state and indicator information. The ICMM is fed by simulations providing the basic information to be used for world state analysis and decision support Building Blocks.</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>In the context of ICT, a named set of operations that characterise the behaviour of an entity. The aggregation of operations in an interface, and the definition of the interface, shall be for the purpose of software re-usability. The specification of an interface shall include a static portion that includes definition of the operations. The specification of</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>-------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Key performance indicator</td>
<td>A Key performance indicator (KPI) is a prominent performance indicator that is of particular importance e.g. because it relates to legal obligations. Key performance indicator help to characterise and compare alternative scenarios with respect to the crisis management measures that have been done.</td>
</tr>
<tr>
<td>Losses</td>
<td>The amount of realized damages as consequence of an occurred hazard. A typical subdivision of the type of losses is between direct losses (as consequences of the damage caused by adverse events) and indirect losses (business interruptions caused by an occurred hazard).</td>
</tr>
</tbody>
</table>
| Mitigation                                | (1) The lessening or limitation of the adverse impacts of hazards and related disasters.  
(2) One of the phases of the Crisis Management Cycle. Often replaced by "Prevention" within EU                                                                                                                                                                                                                                                                                                      |
<p>| Model                                     | A model is a hypothetical simplified description of a complex entity or process (Sterling &amp; Taveter, 2009). A model can be considered as “an abstract representation of a system or process” (Carson, 2005). A model is a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process that has been designed for a specific purpose (NATO, 2010). Stachowiak (1973) describes a model using three features: the mapping feature (reproduction of the original), the reduction feature (abstraction of the original) and the pragmatic feature (addressing a purpose for its user). |
| Non-functional requirement                | A requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours (<a href="https://en.wikipedia.org/wiki/Non-functional_requirement">https://en.wikipedia.org/wiki/Non-functional_requirement</a>).                                                                                                                                                                                                                                         |
| Object                                    | A kind of “passive” OOI that encapsulates some state, is able to perform actions or operations on this state, does not have control over its behaviour but exposes to its environment an interface of the methods to be invoked by external entities.                                                                                                                                                                                                                      |
| Object of interest                        | Object of Interest (OOI) is used in CRISMA to designate objects that are of interest to crisis management practitioners and therefore need to be represented and handled by a CRISMA Application. More precisely, the term is used for IT-representation of such objects within CRISMA. The term was initially introduced as disambiguation of the word &quot;resources&quot;. However, the OOI can also represent objects, which aren't considered resources by crisis managers, such as hospitals, dams or residential buildings. Since OOI instances always exist in a spatial and temporal context, OOI can be considered a specialization of the &quot;Feature&quot;. |
| Parameter                                 | Element included in the method of calculation of an algorithm. It can assume different values, depending on the kind of scenario simulated.                                                                                                                                                                                                                                                                                                  |
| Performance indicator                    | A Performance Indicator is an Indicator that can be used to assess the result of an Experiment. In that sense there must always be a corresponding criterion defining the level of satisfaction regarding a specific decision objective.                                                                                                                                                                                                                                                                       |
| Physical vulnerability                    | Physical Vulnerability expresses the propensity of an asset (or generically element at risk, or Object Of Interest OOI) to sustain a certain damage level in a suitably defined damage scale.                                                                                                                                                                                                                                                                                                           |</p>
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot</td>
<td>A pilot within CRISMA manages the definition and implementation of a CRISMA pilot application and provides the data for a specific crisis scenario and for specific application functionality. This results in a demonstrator that is used during a demonstration and for experimentation purposes in order to validate the CRISMA software. CRISMA pilots (pilot sites) provide generic experimentation frame and validations for testing, validate and promote CRISMA system and provide necessary return of experience in order to validate CRISMA in relevant wide range of crisis management situations including multi-risk and domino effects.</td>
</tr>
<tr>
<td>Preparedness</td>
<td>(1) The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions; (2) One of the phases of the Crisis Management Cycle.</td>
</tr>
<tr>
<td>Prevention</td>
<td>One of the phases of the Crisis Management Cycle (mainly used in EU, see &quot;Mitigation&quot;). Prevention (i.e. disaster prevention) encompasses activities designed to provide permanent protection against disasters. It includes engineering and other physical protective measures, and also legislative measures controlling land use and urban planning.</td>
</tr>
<tr>
<td>Recovery</td>
<td>(1) The restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors; (2) One of the phases of the Crisis Management Cycle.</td>
</tr>
<tr>
<td>Reference scenario</td>
<td>Reference scenarios are abstract crisis and response scenarios that help to understand the relevant aspects of a typical scenario.</td>
</tr>
<tr>
<td>Requirement</td>
<td>A singular documented physical and functional need that CRISMA system should perform. It is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system for it to have value and utility to a user (<a href="http://en.wikipedia.org/wiki/Requirement">http://en.wikipedia.org/wiki/Requirement</a>).</td>
</tr>
<tr>
<td>Resource</td>
<td>Crisis management context: Resources are deployed in the scope of crisis management activities. Resources may include material (e.g. sandbags, medical products, oxygen tank), personnel (e.g. medical officer, ambulance driver, crisis manager), vehicles (e.g. fire trucks), protection infrastructure and facilities (e.g. hospital, shelters), installations (e.g. weirs). ICT-context: Resource is every possible data object as part of the common CRISMA meta information model.</td>
</tr>
<tr>
<td>Resource management</td>
<td>Crisis management context: the interactions between actors in crisis management and how they affect each other including the steering and governance of crisis response actions and resources such as vehicles, personnel and equipment. ICT-context: Management in terms of storage, creation, update and delete of data objects in the context of IT implementation.</td>
</tr>
<tr>
<td>Response</td>
<td>Immediate actions to save and sustain lives, protect property and the environment, and meet basic human needs. Response also includes the execution of plans and actions to support short-term recovery.</td>
</tr>
<tr>
<td>Risk</td>
<td>The combination of the probability of an event and its negative consequences.</td>
</tr>
<tr>
<td><strong>Scenario</strong></td>
<td>A scenario describes the development of a situation over time. Crisis management scenarios are used to understand the impact of hazards and to evaluate the outcomes of alternative mitigation actions within changing conditions. In the CRISMA architecture, such scenarios are represented as consecutive world states.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Scenario evolution</strong></td>
<td>Sequential development of a scenario describing events as they could evolve based on alternative assumptions.</td>
</tr>
<tr>
<td><strong>Simulation</strong></td>
<td>A simulation is the manipulation of a model in such a way that it represents the expected behaviour of an individual actor or an entire system over time (NATO, 2010). In CRISMA a simulation is a computational process that uses World state data and Simulation control parameters as input and produces another World state containing the Simulation result.</td>
</tr>
<tr>
<td><strong>Simulation case</strong></td>
<td>A simulation case describes the user context, the objects of interests, the simulation models, simulation objectives and the user actions that are relevant for the modelling and simulation of a crisis management scenario with a CRISMA application.</td>
</tr>
<tr>
<td><strong>Simulation model</strong></td>
<td>A software that implements a model and allows simulation, no matter if it provides an own user interface or operates integrated in a larger software.</td>
</tr>
<tr>
<td><strong>Simulation results</strong></td>
<td>Simulation results are the output values of a specific simulation run. They provide the content of a specific scenario (series of world states).</td>
</tr>
<tr>
<td><strong>Situation</strong></td>
<td>State of the crisis at a certain moment. Represented as a status of the scenario in a CRISMA world state.</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td>System is a set of entities connected together to make a complex whole or perform a complex function (Sterling &amp; Taveter, 2009). System can also be defined as a complex of interacting components and relationships among them that permit the identification of a boundary-maintaining entity or process (Laszlo &amp; Krippner, 1998).</td>
</tr>
<tr>
<td><strong>T0</strong></td>
<td>Time of the original hazard event.</td>
</tr>
<tr>
<td><strong>Time of the original hazard event</strong></td>
<td>Time at which the original hazard occurred (T0). After this moment other hazard events may occur has a consequence of cascading effects.</td>
</tr>
<tr>
<td><strong>Time dependent vulnerability</strong></td>
<td>Referring to physical vulnerability, time-dependent vulnerability is defined as the vulnerability affected by deterioration of elements characteristics due to ageing and/or damage. In a broader sense, time dependent vulnerability generally indicates the variation of vulnerability characteristics over time (in the understanding of CRISMA, this e.g. also includes spatio-temporal patterns of exposure or varying situation patterns during the process of evacuation).</td>
</tr>
<tr>
<td><strong>Transition</strong></td>
<td>A transition is a relationship between two CRISMA world states. It can originate either from a CRISMA simulation model run or from a manual change by a CRISMA user.</td>
</tr>
<tr>
<td><strong>Tuning</strong></td>
<td>Act of changing the values or ranging of parameters of scenario with the aim of find the best performance in terms of impact.</td>
</tr>
<tr>
<td><strong>Uncertainty</strong></td>
<td>It comes out when we are not sure about the outcome of a process (like a measure of a physical quantity, or the occurrence of a destructive event). Several factors, acting simultaneously or separately, are responsible for the existence of uncertainty; we can group those factors in two groups: those due to the intrinsic...</td>
</tr>
</tbody>
</table>
stochasticity of the process (the so-called aleatory uncertainty), and those due to the lack of or imprecise knowledge of the process (epistemic uncertainty) (Marzocchi, Sandri & Selva, 2010)

<table>
<thead>
<tr>
<th>Use case</th>
<th>A list of steps, typically defining interactions between a user and a system, to achieve a certain goal (Cockburn, 2000). A use case is described as &quot;a generalized description of a set of interactions between the system and one or more actors, where an actor is either a user or another system&quot; (Cohn, 2010).</th>
</tr>
</thead>
<tbody>
<tr>
<td>User requirements</td>
<td>User requirements represent what goals in crisis management need to be achieved by means of the system and what roles of stakeholders are involved in that. In CRISMA user requirements are represented by crisis-specific goal models and behavioural scenarios and the consolidated crisis management goal model for the ICMS.</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009).</td>
</tr>
<tr>
<td>Warning</td>
<td>Dissemination of message signalling imminent hazard which may include advice on protective measures</td>
</tr>
<tr>
<td>Widget</td>
<td>Is an element of a GUI realised as an component providing a specialized user interface functionality. A complete GUI consists of a number of widgets.</td>
</tr>
<tr>
<td>World</td>
<td>Spatial and temporal context of an incident and the response</td>
</tr>
<tr>
<td>World State</td>
<td>A particular status of the world, defined in the space of parameters describing the situation in a crisis management simulation that represents a snapshot (situation) along the crisis evolvement. The change of world state, that may be triggered by simulation or manipulation activities by the CRISMA user, corresponds to a change of (part of) its data contents. A world state is the CRISMA architecture concept realising the CRISMA scenario ((situation (x,t)). A world state contains either some data(x,t) itself or contains a pointer to a previous world state that contains either the data or again a pointer.</td>
</tr>
</tbody>
</table>
### Acronyms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIT</td>
<td>Austrian Institute of Technology GmbH, CRISMA partner</td>
</tr>
<tr>
<td>BB</td>
<td>Building Block</td>
</tr>
<tr>
<td>CCIM</td>
<td>The Control and Communication Information Model</td>
</tr>
<tr>
<td>CM</td>
<td>Crisis Management</td>
</tr>
<tr>
<td>DoW</td>
<td>Description of Work</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>ICMM</td>
<td>Integrated Crisis Management Middleware</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>MCDA</td>
<td>Multiple Criteria Decision Analyses</td>
</tr>
<tr>
<td>MVC</td>
<td>Model – View - Controller</td>
</tr>
<tr>
<td>OOI</td>
<td>Object of Interest</td>
</tr>
<tr>
<td>OWA</td>
<td>Ordered Weighted Averages</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>WS</td>
<td>World State</td>
</tr>
</tbody>
</table>
Executive Summary

This document has been produced by the consortium of the European Project FP7-SECURITY – 284552 Modelling crisis management for improved action and preparedness (CRISMA).

This deliverable D44.3 describes how the decision support concept of CRISMA manifests itself in the simulation model and a virtual application implemented within CRISMA. D44.3 outlines the design of the simulation model and virtual application from the perspective of its user.

The main objective has been to implement a simulation model that allows for simulation and modelling of dynamic scenarios for building up crisis management scenarios and planning for rescue and contingency actions. The simulation model is based on the CRISMA decision support concept described in the public deliverable D44.2 (2014).

The nature of this deliverable is a software prototype ready for experts to experiment with decision making in the context of their particular crisis situation. This document reports on the capabilities of the CRISMA prototype software, which support simulation and modelling of dynamic scenarios for building up crisis management scenarios and planning for rescue and contingency actions.

The software described in this document is licensed under the Creative Commons Attribution-ShareAlike 3.0 Unported licence (http://creativecommons.org/licenses/by-sa/3.0/).
1. Introduction

1.1 Purpose of the document

D44.2 (2014) described the decision support concept of CRISMA, as well as the approach for economic impacts and multi-criteria assessment. This document D44.3 describes how the decision support concept of CRISMA manifests itself in the simulation model and virtual application implemented within CRISMA. This document outlines the design of the simulation model and virtual application from the perspective of its user.

The target readers of this document are on the one hand the public interested in the CRISMA project and on the other hand the participants of the CRISMA project.

1.2 Structure of the document

The structure of the document and the relationships between the different chapters and appendixes is as follows:

Chapter 1 (this chapter) introduces the document, offers a brief overview, and explains the overall purpose of this document and its intended audience.

Chapter 2 presents the general introduction to the concepts of world states and indicators in CRISMA, which form the main basis of the decision-making processes supported by the simulation model and virtual application.

Chapter 3 first outlines the decision support concept of the CRISMA system and then describes how this concept is supported by the features of the simulation model and virtual application for crisis management strategies and planned action.

Chapter 4 presents detailed information on the implemented application functionalities of the simulation model and virtual application.

Chapter 5 concludes the work that has been done so far and provides an outlook to follow-up activities.

The document ends with References and Appendix A.
2. General framework of CRISMA

2.1. World states

In this section, we summarize the main aspects of the conceptual model of the CRISMA system and relevant terms that are required for understanding the following section on indicators and the simulation model and virtual application described in Chapter 3.

The situation of the world at a given time during a crisis management scenario is called in the CRISMA system as a world state, which contains a set of data. The change from one world state to the next world state is called a transition; a crisis management scenario may be composed by one or many of triples of the form ‘world state – transition – world state’.

In Figure 1 the initial world state – depicted on the left side of the figure and occurring at the time T0 (initial time) – may be the collection of inventory data, meteorological data, as well as other input data that are provided to the system by the CRISMA user and/or retrieved through dedicated applications and web services that are interfaced with the CRISMA system. The time T0 is the time of defining the initial representation of the world state in the area of interest.

Starting from the initial world state the CRISMA user can simulate the evolvement of the generic crisis in its generic phase (e.g., preparedness, response, etc.) either by the use of simulation models driven by changes in model control parameters (which also form parts of the world state), or through direct manipulation of the world state. This concept is represented in the middle of Figure 1 under the “Simulation” tag. The transition is conducted by one or several simulation models that take selected world state data as input values and produce new world state data as output values. The world state can also be updated and changed by a CRISMA user to define alternative scenarios. This is symbolised by the Manipulation feature.

The knob drawn within the “Manipulation” tag represents the user’s interaction with the system. This can be done either by directly manipulating the world state data, e.g. by introducing a hazard, changing vulnerabilities of buildings, etc., or by tuning the model control parameters for simulation.

Therefore, the world state also includes a set of parameters to control simulation models operating in a transition on world state data. Moreover, indicators, criteria and costs can be calculated based on the world state data to give representative and quantitative information about one world state. This is additional data, which is associated with the world state to facilitate assessment of the results, but is not used by the models in world transitions.

The delta between world states can be used for a decision oriented assessment of the development between two world states or for a more extended scenario in the CRISMA application functionalities related to planning and training.
The set of data is defined in the simulation case and contains the relevant elements for the specific reference scenario and decision purpose.

The action of manipulation or simulation triggers a change of the world state (WS) to a new world state (WS'). Time is one of the WS parameters, which may, but does not have to change in world state transitions. In many cases, the WS data describes the state of the world at the time corresponding to the WS time stamp. However, it is also possible to store time series for the period between two world states. This can help to keep the number of world states small, while still keeping the possibility to analyse the time-developments on a higher level of granularity. This feature should be used with care, since most CRISMA software does not support analysis of the time-series in the WS data.

### 2.2. Indicators

In this section we explain how the indicators are handled in CRISMA. Indicators form the basis of the decision-making processes that are supported by the simulation model and virtual application (see Chapter 3).

Indicators in the CRISMA system characterize world states within particular simulation scenarios. They are calculated by applying the aggregation algorithms (indicator functions) to the world state data. An indicator can either be represented by a single existing value in the CRISMA world state or can be aggregated by a function of several values from the world state (e.g., average value or minimum or maximum values in a given region for a given time). An indicator may be represented numerically or graphically as a spatial...
indicator, such as a color-coded map indicating the numbers of casualties in different areas. Indicators may refer to hazard, vulnerability, impact or response aspects of crisis management. They can also describe the relationships between different values such as the number of first responders with regard to the number of affected people, or the percentage of injured people. Even though indicators are neutral and purely descriptive, the selection of indicators is nevertheless a statement referring to which aspects of crisis management are relevant to consider. Besides simple indicators there can also be compound indicators that are built by composing several indicators by some method (e.g., weighting).

To select indicators in CRISMA, we apply the same general principles of selecting and specifying indicators that can be used in the real world. According to these principles, the indicators should be expressed in measurable, replicable and reasonably easy to interpret units. We explain the meaning of these principles below.

Measurable means indicators should be represented in terms of either numbers (on which all or most mathematical operations are allowed) or scores (i.e., numbers resulting from some kind of rating system, on which only a limited set of mathematical operations is allowed).

Replicable means that the indicator should result from a well-defined unambiguous procedure, which can be expressed in a mathematical or algorithmic way; in turn that procedure uses only the data which is part of the world state. The phrase “reasonably easy to interpret” points to the fact that the users of the CRISMA system have very diverse backgrounds and may not be experts with respect to the scientific and empirical underpinning of the various indicators. Some extent of mental effort and learning may be expected from users. However, the indicators that can be only interpreted by a handful of people with very specific skills and background knowledge on the phenomenon at hand may turn out to be useless in practice regardless of their scientific sophistication.

In the context of CRISMA, an important concept related to indicators is that of criteria. A criterion is a special type of indicator that is constructed by defining the value-intervals for a primary indicator and assigning the “level of satisfaction” to these intervals. For example:

Indicator = “number of casualties”

A related criterion could be defined as:

- “Good” if Indicator <= 10
- “Average” if Indicator <= 20
- “Bad” if Indicator >20

In order to facilitate multi-criteria analysis, the criteria are defined as numbers in Integrated Crisis Management Middleware (ICMM) of CRISMA.
3. Simulation model and virtual application

The simulation model and virtual application (in the following referred to as "application" or "prototype") is a virtual tool that allows expert users to simulate dynamic scenarios, find and apply appropriate crisis mitigation options, investigate cascade effects triggered by a hazard event and analyse the simulation results. In doing so, users may build catalogues of crisis management scenarios containing planning for rescue and contingency actions in case of real hazards. Every alternative sub-plan of this catalogue can be further analysed by means of indicators as the main basis of the presented decision-making process.

3.1. Decision support concept overview

The overall idea of the decision support concept employed in the application and indeed in the whole CRISMA system is to: (a) Let the decision-maker produce and use scenarios in support of his/her decisions; (b) provide aggregated but representative information about the scenarios in the form of indicators; (c) support the decision-maker in defining an explicit decision-making strategy by relying on criteria, priorities, Andness, and Orness (see section 3.2); and (d) assist the decision-maker in comparing and ranking scenarios according to the decision-making strategy.

The overall decision support concept consists of the following seven elements – four data elements and three functional elements – to support the decision-maker: (1) an impact scenario (scenario is represented by a set of consecutive world states, see section 2.1) consisting of information required to take a decision, e.g. representing the possible consequences of a flood; (2) indicator functions that can be applied to these world states, e.g. to calculate the number of the homeless, building damage, or evacuation cost; (3) a set of representative scenario indicators (resulting from applying the indicator functions to scenario world states); (4) criteria functions that map all the elements of the indicator set to a (5) set of normalised indicators (criteria) in the form of the level of satisfaction on a normalised scale (0-1 or 0%-100%); (6) a ranking function which can map a vector of criteria to a single scalar “meta-criteria” value; and (7) the corresponding scalar values (scenario ranks/scores). The decision support concept described above is illustrated by Figure 2.

Figure 2: Decision support concept overview
The decision-maker can use the four data elements – impact scenarios, scenario indicators, normalised indicators, and scenario ranks – as a basis for his/her decisions and define an individual decision-making strategy by mapping indicators to criteria with the help of criteria functions. In addition, the decision-maker is supported by assigning priorities to indicators as well as defining the level of “Andness” and “Orness” of the ranking function (Dujmović, 2007) through the parameterization of the MCDA method proposed by Yager (1988). In summary, the decision-maker can:

- Use indicators derived from impact scenario data (usually aggregated) to quickly assess and compare impact scenarios
- Define a decision-making strategy by:
  - Mapping performance indicators to decision criteria (defining the level of satisfaction for each indicator)
  - Defining priorities by assigning weights to indicators
  - Defining the level of Andness and Orness to be considered when computing the rank of an impact scenario
- Deal with a multi-criteria decision problem by obtaining a ranking of scenarios with respect to the decision-making strategy defined.

3.2. Ordered Weighted Averages as a mean for decision support

Decision making problems considering more than one criterion on the basis of impact scenarios require appropriate methods to assess the performance of specific scenarios. For our decision support concept we have selected the Ordered Weighted Averages method (OWA) (Yager, 1988; Yager, 1996; Zuccaro & Filomena, 1988) that allows one to specify a particular decision-making strategy that defines the properties of a good solution. The OWA method allows us to:

- Implement several decision-makers’ perspectives (multiple points of view);
- Make the decision-making strategy explicit;
- Obtain a score/rank for each scenario;
- Let the decision-maker choose between different decision making strategies (e.g. optimistic, neutral, pessimistic);
- Compare results obtained under different strategies.

The OWA method is based on multi-criteria aggregation operators proposed by Yager (1988). OWA is characterized by a vector of ordered weights in addition to the importance weights assigned to each criterion. Using OWA, normalized indicator values are multiplied with the corresponding levels of importance. The vector of weighted levels of satisfaction for all indicators is re-ordered according to their values and weighted according to their position in the vector. The vector of ordered weights determines an instance of an OWA operator. For example, the vector of ordered weights \( (1, 0, \ldots, 0) \) gives full weight to the criterion with the highest level of satisfaction independent of all other criteria (maximum level of Orness). As a consequence, alternatives with a single outstanding property will be ranked as highest. This is called a risk-taking or optimistic decision-making strategy. In contrast, the vector of ordered weights \( (0, \ldots, 0, 1) \) will give full weight to the criterion with the lowest level of satisfaction. As a consequence, alternatives with the best “poor” criterion will be ranked as highest (maximum level of Andness). This is called a pessimistic decision-making strategy. Obviously, there are numerous intermediate strategies between these two extremes. Another easily interpreted strategy is the neutral strategy that does not emphasize any position in the vector of re-ordered criteria values (simple weighted
average). The vector of ordered weights can be calculated to match a specific decision-making strategy (Yager, 1996). In CRISMA these weights are defined manually by the decision-maker (see section 3.4).

3.3. Scenario analysis and comparison view

The scenario analysis and comparison view of the application consists of several widgets and visually represents the data on indicators and criteria for comparing different simulated scenarios side by side. The vector of indicators is mainly based on quantities (e.g., the number of casualties) calculated from a scenario. To be effectively used in a decision support context, indicators need to be qualified. Here qualification basically means assigning the level of satisfaction to the indicator data. The resulting “normalised” indicators can be better used as decision criteria. As indicators and criteria data have the same format (vector of scalar values), both can be displayed in the same fashion. In the following sub-sections we describe the widgets of the scenario analysis and comparison view of the application.

3.3.1. Indicator and criteria table widget

The indicator and criteria table widget visualises the data on indicators and/or criteria data in a table-like view. An example of the indicator/criteria table is presented in Figure 3. Please note that Figures 3-9 should be regarded as illustrative, as the screenshots depicted on them can be hard to read in detail.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>L’Aquila (M-7)</th>
<th>L’Aquila Cascade EQ-F7</th>
<th>L’Aquila (M-7 + 1BR)</th>
<th>L’Aquila (M-7 + 1BR - PE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casualties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of dead</td>
<td>189 People</td>
<td>1 People</td>
<td>15 People</td>
<td>1 People</td>
</tr>
<tr>
<td>Number of injured</td>
<td>2,449 People</td>
<td>54 People</td>
<td>8,414 People</td>
<td>8,414 People</td>
</tr>
<tr>
<td>Number of homeless</td>
<td>104,416 People</td>
<td>54 People</td>
<td>8,414 People</td>
<td>8,414 People</td>
</tr>
<tr>
<td>Damaged buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lost buildings</td>
<td>251 Buildings</td>
<td>178 Buildings</td>
<td>178 Buildings</td>
<td>178 Buildings</td>
</tr>
<tr>
<td>Damaged Infrastructure</td>
<td>1,416 Road segments</td>
<td>1,287 Road segments</td>
<td>1,287 Road segments</td>
<td>1,287 Road segments</td>
</tr>
<tr>
<td>Economic cost</td>
<td>32,547,532 Dollar</td>
<td>22,547,532 Dollar</td>
<td>22,547,532 Dollar</td>
<td>22,547,532 Dollar</td>
</tr>
<tr>
<td>Direct damage cost</td>
<td>76,416,689 Dollar</td>
<td>41,753,689 Dollar</td>
<td>41,753,689 Dollar</td>
<td>41,753,689 Dollar</td>
</tr>
<tr>
<td>Indirect damage cost</td>
<td>333,617,772 Dollar</td>
<td>85,657,772 Dollar</td>
<td>85,657,772 Dollar</td>
<td>85,657,772 Dollar</td>
</tr>
<tr>
<td>Evacuation cost</td>
<td>25,097,094 Dollar</td>
<td>25,097,094 Dollar</td>
<td>23,087,094 Dollar</td>
<td>23,087,094 Dollar</td>
</tr>
</tbody>
</table>

Figure 3: Indicator / criteria table

3.3.2. Indicator and criteria chart widgets

The indicator and criteria chart widget allows users to correlate individual indicator and criteria values. An example of the indicator/criteria relation chart is shown in Figure 4.
3.3.3. Criteria function definition widget

The criteria function definition widget allows the definition of functions to map indicator values to criteria. An example of a criteria function definition is presented in Figure 5.

![Figure 5: Criteria function definition](image)

3.3.4. Criteria spider chart widget

The criteria spider chart widget shows the data as a spider chart (a.k.a. radar chart) in order to support the quick assessment of the overall performance of the selected scenarios. In addition a "reference scenario" can be selected. Examples of criteria spider charts are represented in Figure 6.

![Figure 6: Criteria spider charts](image)

3.4. Multi criteria analysis and decision support view

While the scenario analysis and comparison view (see section 3.3) allows for the comparison of indicators and criteria for different scenarios, the multi criteria analysis and decision support view allows for the ranking of different scenarios with respect to a specific decision-making strategy. When doing so, it introduces complementary decision-support functionalities. The view is composed of two widgets: the decision strategy widget and the decision ranking widget. In the following sub-sections we will give an overview of these widgets.

3.4.1. Decision strategy definition widget

The decision strategy widget allows for defining weighting strategies for different criteria. This way, a weighting factor can be assigned to each indicator. This factor determines the
contribution of the particular criteria to the overall scenario rank. An additional weighting factor can be selected to weigh criteria in relation to the achieved level of satisfaction. This is done according to the OWA method (see section 3.2). An example of defining a decision strategy is illustrated by Figure 7.

![Decision Strategy](image)

**Figure 7: Decision strategy definition**

### 3.4.2. Decision ranking widget

The decision ranking widget is used to visualise the actual ranking on the basis of the currently selected criteria function and decision-making strategy. An example of decision ranking is shown in Figure 8. The figure represents four alternative world states characterized by four different scores, which have been calculated based on the same set of indicators using four different criteria functions.

![Decision Ranking](image)

**Figure 8: Decision ranking**
3.5. Application Building Blocks

The scenario analysis and comparison view described in section 3.3 and the Multi Criteria Analysis and Decision Support View overviewed in section 3.4 are only two of several building blocks that the application integrates. Table 1 provides a full overview of the CRISMA Building Blocks used. For more details on the specific Building Blocks follow the links provided in the table.

Table 1: Application Building Blocks

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Use</th>
<th>Permalink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Crisis Management</td>
<td>Infrastructure</td>
<td>This Building Block is mandatory for each CRISMA Federation</td>
<td><a href="https://crisma-cat.ait.ac.at/node/5">https://crisma-cat.ait.ac.at/node/5</a></td>
</tr>
<tr>
<td>Middleware</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Integration</td>
<td>Integration</td>
<td>This Building Block is required for accessing respective data slots of the world state of the application</td>
<td><a href="https://crisma-cat.ait.ac.at/node/32">https://crisma-cat.ait.ac.at/node/32</a></td>
</tr>
<tr>
<td>Indicators</td>
<td>Integration</td>
<td>The Indicators Building Block is required for calculating indicators.</td>
<td><a href="https://crisma-cat.ait.ac.at/node/28">https://crisma-cat.ait.ac.at/node/28</a></td>
</tr>
<tr>
<td>UI Integration Platform</td>
<td>Integration</td>
<td>Hosts Views</td>
<td><a href="https://crisma-cat.ait.ac.at/node/84">https://crisma-cat.ait.ac.at/node/84</a></td>
</tr>
<tr>
<td>World state View</td>
<td>User Interaction</td>
<td>Basic world state navigation and selection context</td>
<td><a href="https://crisma-cat.ait.ac.at/node/146">https://crisma-cat.ait.ac.at/node/146</a></td>
</tr>
<tr>
<td>GIS Widget</td>
<td>User Interaction</td>
<td>Visualisation of e.g. impact maps</td>
<td><a href="https://crisma-cat.ait.ac.at/node/90">https://crisma-cat.ait.ac.at/node/90</a></td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Use</td>
<td>Permalink</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----------------</td>
<td>-----------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>Cascade Events Configuration and Interaction View</td>
<td>User Interaction</td>
<td>Visualisation of cascade events’ probabilities and hazard model parameterisation</td>
<td><a href="https://crisma-cat.ait.ac.at/node/165">https://crisma-cat.ait.ac.at/node/165</a></td>
</tr>
<tr>
<td>Simulation Model Interaction View</td>
<td>User Interaction</td>
<td>Parameterisation of involved models and mitigation options</td>
<td><a href="https://crisma-cat.ait.ac.at/node/62">https://crisma-cat.ait.ac.at/node/62</a></td>
</tr>
<tr>
<td>Scenario Analysis and Comparison View</td>
<td>User Interaction</td>
<td>Level 2 and 3 world state analysis</td>
<td><a href="https://crisma-cat.ait.ac.at/node/159">https://crisma-cat.ait.ac.at/node/159</a></td>
</tr>
<tr>
<td>Multi Criteria Analysis and Decision Support View</td>
<td>User Interaction</td>
<td>Level 4 world state analysis</td>
<td><a href="https://crisma-cat.ait.ac.at/node/162">https://crisma-cat.ait.ac.at/node/162</a></td>
</tr>
<tr>
<td>Simulation Model Integration</td>
<td>Integration</td>
<td>Integration of several simulation models</td>
<td><a href="https://crisma-cat.ait.ac.at/node/34">https://crisma-cat.ait.ac.at/node/34</a></td>
</tr>
<tr>
<td>Cascade Effects Model</td>
<td>CRISMA Model</td>
<td>Cascade effects' probabilities</td>
<td><a href="https://crisma-cat.ait.ac.at/node/149">https://crisma-cat.ait.ac.at/node/149</a></td>
</tr>
<tr>
<td>Time Dependent Vulnerability model</td>
<td>CRISMA Model</td>
<td>Evolvement of vulnerability curves</td>
<td><a href="https://crisma-cat.ait.ac.at/node/135">https://crisma-cat.ait.ac.at/node/135</a></td>
</tr>
</tbody>
</table>

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4. Application Functionalities

Applications built by composing CRISMA Building Blocks listed in section 3.5 usually offer the following functionalities:

- View world states
- Execute simulations
- Apply mitigation options
- Investigate cascade effects
- Analyse and compare scenarios

Applications may choose which Building Blocks to include in their particular instances, so that every instance may not support all the application functionalities. In the following sub-sections we give an overview of the application functionalities listed above. Please note that all the examples and screenshots in this chapter exemplify the earthquake pilot of CRISMA from Italy – CRISMA Pilot D. Examples from other pilots will be included in the forthcoming CRISMA public deliverable D44.4.

4.1. View world states

The first and foremost application functionality enables the user to perform the most elementary actions – browsing and viewing of different scenarios that have been already created. The user may browse all the available world states that have been arranged by their inherent tree-like structure. Moreover, the user can find, view, and manipulate the most relevant sequences of world states – scenarios. As soon as the user selects a particular world state, its data items are visualised. The user may then examine individual data items and perform additional operations on them. Here, the user is first presented with a GIS view that allows for exploring the data using a map. The user can then zoom into a particular region of interest and click on the map and is ultimately presented with various detailed information. Ultimately, the user is presented with a path-like view of the steps of the simulation to be taken leading to a scenario. A snapshot of the “View world states” application functionality is represented in Figure 9.
The Building Blocks and their particular tasks in the “View world states” application functionality are represented in Table 2. Please note that all the examples and screenshots in this chapter exemplify the earthquake pilot of CRISMA from Italy – Pilot D.

**Table 2: Building Blocks of the “View world states” application functionality**

<table>
<thead>
<tr>
<th>Building block</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICMM</td>
<td>Provides the actual CCIM world state instances to the World State View and GIS View</td>
</tr>
<tr>
<td>Data Integration</td>
<td>Used for the actual access to the data linked in the world states</td>
</tr>
<tr>
<td>UI Integration Platform</td>
<td>Hosts the World State View and GIS View</td>
</tr>
<tr>
<td>World State View</td>
<td>Provides the World State Tree Widget, Scenario List Widget, Scenario Evolution Widget and the World State Widget. The user interacts by browsing the world states, setting the selection context, and viewing the actual linked data.</td>
</tr>
<tr>
<td>GIS View</td>
<td>Visualises data items of the currently selected world state that have a spatial context.</td>
</tr>
</tbody>
</table>

The schematic sequence of interactions between the Building Blocks shown in Table 2 is modelled in Figure 10.
Figure 10: Interactions between the “View world states” Building Blocks

The interactions between the Building Blocks depicted in Figure 10 involve the following user actions:

1. Browse the available world states in the tree: The user expands the relevant parts of the tree to see different crisis management scenarios that have already been created.
2. Choose a scenario: The user selects a particular scenario of interest in the scenario list (alternative: selection in the tree).
3. Choose a data item: The user selects a particular data item of interest.
4. Click on a point on the map: The user clicks on a particular point on the map to obtain the relevant detailed information.
5. Switch to the preceding world state: The user clicks on the predecessor world state in the scenario evolution widget to gain more insight into the situation. This may be required for adequate decision-making.
4.2. **Execute simulations**

The second application functionality describes how users can execute simulations in order to discover alternative recovery sub-plans. The prototype provides the user with an entry point to the so-called transition wizard from each alternative scenario he/she has already created. In other words, virtually every world state within any alternative scenario can be picked as the starting point of a simulation. The transition wizard of the prototype offers the user a list of transitions he/she is allowed to perform. For example, the user may be willing to conduct a study of how an already existing hazard affects people. Additionally, the wizard allows the user to choose if the particular simulation includes a time dependent vulnerability. Thereafter the wizard assembles the configuration needs (input parameters) of the simulation the user has chosen before and guides the user through the parameterisation process. For example, when the user chooses to create a new seismic hazard – an earthquake – the wizard asks about several parameters required to run the simulation, like the origin, depth, and magnitude of the earthquake, and the attenuation law pertaining to the earthquake. After the user has entered the required parameters, he/she is asked about some metadata like the name and description of the simulation, to be attached to the simulation representation. The user is then provided with a simulation progress indicator and eventually receives the results that he/she can then visualise as described in the "View world states" application functionality. A snapshot of the “Execute simulations” application functionality is represented in Figure 11.

![Figure 11: Snapshot of “Execute simulations” (example from CRISMA Pilot D application)](image)

The Building Blocks and their particular tasks in the “Execute simulations” application functionality are represented in Table 3.
Table 3: Building Blocks of the “Execute simulations” application functionality

<table>
<thead>
<tr>
<th>Building block</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICMM</td>
<td>Provides the actual CCiM world state instance to the transition wizard. It also receives the new world state that has been created by the simulation.</td>
</tr>
<tr>
<td>Data Integration</td>
<td>Used for the actual access to background data that may be used by the Simulation Model Interaction View. Also provides actual data to the Simulation Model Integration after the parameterisation is finished.</td>
</tr>
<tr>
<td>UI Integration Platform</td>
<td>Hosts the Simulation model interaction view</td>
</tr>
<tr>
<td>Simulation Model Interaction View</td>
<td>Provides the actual information what simulations are available and is as well able to produce a simulation parameterisation view. For doing so it may as well use other Building Blocks like the GIS View to produce an easy means to specify parameters with a spatial context. Ultimately, the view indicates the execution progress as it is interlinked with the Simulation model Integration.</td>
</tr>
<tr>
<td>GIS View</td>
<td>Used to let users easily provide the context of spatial parameters of a simulation</td>
</tr>
<tr>
<td>Simulation Model Integration</td>
<td>After the parameterisation this Building Block assembles the actual data as well as the current parameterisation to actually run the simulations the user has chosen. It also provides progress monitoring by watching the executed simulations so that the user eventually knows when the simulations are finished. Ultimately, it provides access to the actual simulation results.</td>
</tr>
<tr>
<td>Indicators</td>
<td>All relevant indicators are automatically calculated after the ICMM received the new world state.</td>
</tr>
</tbody>
</table>

The schematic sequence of interactions between the Building Blocks shown in Table 3 is modelled in Figure 12.
The interactions between the Building Blocks depicted in Figure 12 occur as a result of the following user actions:

1. Execute transition wizard: the user executes the transition wizard from the world state that he/she is willing to use as a basis for the simulation.
2. Choose simulations: the user selects simulations from the list of available transitions and defines the order in which they are to be executed. Additionally, he/she may choose to apply a time dependent vulnerability to the current transition.
3. Parameterise simulations: the user is presented with a parameterisation view specific for the particular simulation. For example, the user parameterises the model of hazard on buildings by doing the following:
   a. Select a point on the map: the user chooses the epicentre of the earthquake to be simulated by clicking on an arbitrary point on the map;
   b. Set the magnitude: the user sets the magnitude of the simulated earthquake by moving the magnitude slider to the desired value;
   c. Set the depth: the user sets the depth of the epicentre by entering a number;
   d. Choose attenuation law: the user chooses the attenuation law to be used for the simulation from the list of available attenuation laws.
4. Enter metadata: The user enters a name and an optional description of the simulation.
5. Wait for simulation to finish: The user is presented with the progress indicator of the simulation.
6. View results: The user views the results of the simulation as described in section 4.1.

4.3. **Apply mitigation options**

The third application functionality describes how users can include mitigation options in the simulations in order to produce alternative sub-plans for dynamic scenarios. This application functionality is very similar to the application functionality “Execute simulations” because of the identical transition concept. Similarly to the “Execute simulations” application functionality, here the user can enter the transition wizard from virtually any available world state. After entering, the user is presented with the list of available transitions. However, some of the available transitions are mitigation strategies rather than simulations. Similarly to the simulations, mitigation strategies also have to be configured and thus the wizard assembles the configuration needs of the mitigation strategies. For example, when the user chooses to increase building resistance, the wizard provides the corresponding view that lets the user to configure arbitrary areas with changed building resistance. After every mitigation option is parameterised, the wizard asks for some metadata to be attached to the mitigation strategy. Finally, the user is shown a progress indicator and can eventually view the simulation results as described in the "View world states" application functionality. Now the preparations are finished to simulate alternatives according to the application functionality “Execute simulations”. A snapshot of the “Apply mitigation options” application functionality is depicted in Figure 13.
Figure 13: Snapshot of “Apply mitigation options” (Example: increasing building resistance in CRISMA Pilot D application)

Please note that technically the mitigation strategies are considered simulations and thus use the same Building Blocks. The Building Blocks and their particular tasks in the “Apply mitigation measures” application functionality are represented in Table 4.

Table 4: Building Blocks of the “Apply mitigation options” application functionality

<table>
<thead>
<tr>
<th>Building block</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICMM</td>
<td>Provides the actual CCIM world state instance to the transition wizard. It also receives the new world state that has been created by the mitigation.</td>
</tr>
<tr>
<td>Data Integration</td>
<td>Used for the actual access to background data that may be used by the mitigation strategy. Also provides actual data to the Simulation Model Integration after the parameterisation is finished.</td>
</tr>
<tr>
<td>UI Integration Platform</td>
<td>Hosts the Simulation model interaction view</td>
</tr>
<tr>
<td>Simulation Model Interaction View</td>
<td>Provides the actual information what mitigations are available and is as well able to produce a mitigation strategy parameterisation view. For doing so it may as well use other Building Blocks like the GIS View to produce an easy means to specify parameters with a spatial context. Ultimately, the view indicates the execution progress, if necessary, as it is interlinked with the Simulation model Integration.</td>
</tr>
<tr>
<td>GIS View</td>
<td>Used to let users easily provide the context of spatial parameters of a simulation</td>
</tr>
<tr>
<td>Simulation Model Integration</td>
<td>After the parameterisation this Building Block assembles the actual data as well as the current parameterisation to actually apply the mitigation strategies the user has chosen. It also provides progress monitoring by watching the executed mitigation processes so that the user eventually knows when they are finished. Ultimately, it provides access to the actual mitigation results.</td>
</tr>
<tr>
<td>Indicators</td>
<td>All relevant indicators are automatically calculated after the ICMM</td>
</tr>
</tbody>
</table>
received the new world state. However, it is likely that mitigation strategies do not affect the indicators and thus the result is often the same as for the predecessor world state.

The schematic sequence of interactions between the Building Blocks shown in Table 4 is modelled in Figure 14.

Figure 14: Interactions between the “Apply mitigation options” Building Blocks

The interactions between the Building Blocks depicted in Figure 14 occur as a result of the following user actions:

1. Execute transition wizard: the user executes the transition wizard from the world state that he/she wants to use as a basis for his/her mitigation strategy.
2. Choose mitigations: the user selects mitigation strategies from the list of available transitions and defines the order in which the mitigation strategies should be applied.
3. Parameterise mitigation strategies: the user is presented with a parameterisation view specific for the particular mitigation strategy and performs the configuration. For example, the user parameterises the building resistance mitigation strategy by doing the following:
4. Zoom to desired area: the user selects the pan tool and navigates to the area of interest;

b. Create polygon: the user selects the polygon tool and draws a polygon on the map that encloses the area that will be affected by the building resistance change;

c. Edit mitigation area: the user double-clicks the newly created area object within the list of all mitigation areas and is thereafter presented with a parameterisation dialog;

d. Parameterise mitigation area: the user adds a name to the area and chooses the desired change in building resistance by entering an appropriate value.

4. Enter metadata: The user enters the name and an optional description of the mitigation strategy.

5. Wait until the mitigation process finishes: The user is presented with the progress indicator of the mitigation process and waits for this process to finish. This process is usually very short and the user may not even see the progress indicator as the process is finished within milliseconds.

6. View results: The user views the results of the mitigation strategies as described in section 4.1.

7. Create alternative sub-plan: The user creates a new alternative sub-plan using the new data as described in section 4.2.

4.4. Investigate Cascade Effects

The fourth application functionality describes how the user can investigate cascade effects in order to get insight into possible hazards that are initiated by the impact of the primary hazard — triggering event. It is implied that there is already a (simulated) hazard with certain intensity available. As a consequence, this application functionality is a natural follow-up of the application functionality “Execute simulations” in order to assess multi-sectoral consequences. The user chooses a world state containing the required data and the prototype then offers the option to investigate potential cascading effects. The cascading effects wizard now offers a list of possible cascading effects. For example, an earthquake may cause a forest fire. After the user has selected the cascading effect he/she is willing to investigate, the wizard assembles the appropriate views using the event transition probability data, which is calculated in the background. Now the user can inspect where a specific effect may occur and what its probability on a particular spot on the map. For example, when the user chooses to investigate the likelihood of a forest fire caused by an earthquake, he/she is presented with a map containing the probability of a forest fire in the form of multiple pole shapes, the height and colour of which indicate the likelihood of the cascading effect. The user may then parameterise the appropriate simulation, e.g. the forest fire model, in order to actually execute the cascading hazard model. The user is then asked to enter additional metadata that is eventually attached to the simulation, like the name and an optional description, and is then provided with a simulation progress indicator of the cascading effects’ simulation. Ultimately, the results are available and can be visualised as described in the ”View world states” application functionality. A snapshot of the “Investigate cascade effects” application functionality is represented in Figure 15.
Figure 15: Snapshot of “Investigate cascade effects” (example from CRISMA Pilot D application)

The Building Blocks and their particular tasks in the “Investigate cascade effects” application functionality are represented in Table 5.
Table 5: Building Blocks of the “Investigate cascade effects” application functionality

<table>
<thead>
<tr>
<th>Building block</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICMM</td>
<td>Provides the actual CCIM world state instance to the cascade effects wizard. It also receives the new world state that has been created by the Cascade Effects simulation.</td>
</tr>
<tr>
<td>Data Integration</td>
<td>Used for the actual access to background data that may be used by the Cascade Events Configuration and Interaction View. Also provides actual data to the Simulation Model Integration after the parameterisation is finished.</td>
</tr>
<tr>
<td>UI Integration Platform</td>
<td>Hosts the Cascade Events Configuration and Interaction View</td>
</tr>
<tr>
<td>Cascade Events Configuration and Interaction View</td>
<td>Provides the actual information what Cascade Events are available and is as well able to produce a Cascade Events parameterisation view. For doing so it may as well use other Building Blocks like the GIS View to produce an easy means to investigate the different spatially distributed probabilities and specify parameters with a spatial context. Ultimately, the view indicates the execution progress as it is interlinked with the Simulation Model Integration.</td>
</tr>
<tr>
<td>GIS View</td>
<td>Used to let users easily investigate the spatially distributed probabilities as well as to provide the context of spatial parameters of a Cascade Event simulation</td>
</tr>
<tr>
<td>Cascade Events Model</td>
<td>Provides the actual probability of the chosen Cascade Event using the current world state data.</td>
</tr>
<tr>
<td>Simulation Model Integration</td>
<td>After the parameterisation this Building Block assembles the actual data as well as the current parameterisation to actually run the simulations the user has chosen. It also provides progress monitoring by watching the executed simulations so that the user eventually knows when the simulations are finished. Ultimately, it provides access to the actual simulation results.</td>
</tr>
<tr>
<td>Indicators</td>
<td>All relevant indicators are automatically calculated after the ICMM received the new world state.</td>
</tr>
</tbody>
</table>

The schematic sequence of interactions between the Building Blocks shown in Table 5 is modelled in Figure 16.
Figure 16: Interactions between the “Investigate cascade effects” Building Blocks

The interactions between the Building Blocks depicted in Figure 16 occur as a result of the following user actions:

1. Execute cascade effects wizard: the user executes the cascade effects’ wizard from the world state that he/she is willing to use as a basis for his/her investigation.
2. Choose cascade effect: the user selects a cascade effect from the list of available cascade effects.
3. View probabilities: the user is presented with a map that shows the calculated probabilities for each relevant location using an appropriate visualisation paradigm. He/she navigates to the location of interest and clicks on the map to see the actual probability of the respective cascade effect in the given location.
4. Parameterise the given model of cascade effects: the user can parameterise the respective model with the parameterisation view that also provides the probabilities. For example, the user parameterises the Forest Fire Model by doing the following:
   a. Select ignition point: the user selects the point where the ignition will happen on the map;
   b. Set wind direction: the user sets the wind direction of the simulated forest fire by moving the magnitude slider to the desired number of degrees;
c. Set wind speed: the user sets the wind speed by entering a relevant numeric value;
d. Choose atmospheric stability: the user chooses the atmospheric stability to be used for the simulation from the list of available atmospheric stabilities.

5. Wait until the cascade effects’ simulation process finishes: The user is presented with the progress indicator of the cascade effects’ simulation process and waits for the process to finish.

6. View results: The user views the results of the cascade effects simulation as described in section 4.1.

4.5. Analyse and compare scenarios

The fifth application functionality addresses the analysis and comparison of multiple scenarios at different abstraction levels. The purpose of the scenario is finding the “best” solution for the current decision objectives. The abstraction levels of decision support in the CRISMA system are as follows:

**Level 1:** World state: The lowest abstraction level that provides a deep insight into the detailed data of the individual world states. However, because of the high level of detail it is very hard to obtain a comprehensive overview of the overall performance of a single scenario compared in comparison with another scenario.

**Level 2:** Indicator: The second abstraction level characterizes world states by important “bare” numbers – indicators. These numbers are calculated from the detailed data of world states by aggregation algorithms (indicator functions) specific for particular simulation cases.

**Level 3:** Criteria: The third abstraction level qualifies the values of the indicators by means of user-defined criteria functions. A criteria function maps the value of an indicator to the level of satisfaction that is inclusively between 0 and 100 per cent.

**Level 4:** Multi-Criteria: The highest abstraction level aggregates all individual levels of satisfaction to a single level of satisfaction, which is expressed as a score or rank, using the Ordered Weighted Averages’ Algorithm as introduced in section 3.2. This way, user-defined decision strategies can be specified.

This application functionalities address the Levels 2, 3, and 4. The lowest level – Level 1 – is currently not supported by the application. The only way to analyse and compare (sequences of) world states at Level 1 is by simple visual comparison of the world state data (e.g., damage distribution maps) side by side. However, proper analysis of world state evolvement is very important for certain types of crises, such as, for example, the case with a snowstorm and the resulting electricity blackouts in Pilot A of CRISMA. Therefore a specific tool for comparing sequences of world states as time series would be needed.

For the scenario analysis and comparison at Level 2, the user chooses the world states that he/she wants to compare, which are most likely the so-called scenario world states. The user interface of the application then assembles the indicator information and presents it along with the visual toolset for scenario analysis and comparison at Level 2. Within the toolset, the bare indicator values are shown in a table view and by means of bar charts. Additionally, a simple analysis tool is available for indicators, allowing for relating
single indicators to each other so that the user can see if their values correlate. For example, it could be interesting to see if the number of casualties correlates with the number of collapsed buildings. The user may choose any indicator as x-axis and any other indicator as y-axis and have a scatter plot generated on the fly with the actual indicator values shown for the selected world states.

In order to reach Level 3, the indicators have to be converted to criteria using criteria functions. For this purpose the user is presented with a criteria function definition view, where he has to provide a level of satisfaction for each indicator value (range). The level of satisfaction has to be at least one of 0% or 100%, meaning that the corresponding value (range) does not at all satisfy the user or satisfies the user in full. In addition to that, the user may also map value (ranges) of an indicator to specific percentages so that fine-grained mappings can be achieved. The indicator values within the value ranges are approximated linearly. The user may also create an arbitrary number of mappings so that multiple decision-making objectives can be accommodated. However, there can only be one active mapping at a time.

After defining the criteria functions, the user is presented with a table view showing the criteria values according to the currently selected mapping. The user can apply a simple analysis tool capable of relating single indicators to each other also for representing the relationships between the criteria. Additionally, the user can access a spider chart visualisation tool, where a single spider chart is created for each selected world state using the values of the criteria. Here, the user can also select a reference world state from the list containing all available world states, which is then rendered on top of each of the spider charts. This way, it is easy to compare a scenario against a reference scenario.

Ultimately, at Level 4 the user may produce a ranking for each selected world state. However, analogously to the requirement for defining criteria functions needed to reach Level 3, the user has to create at least one decision-making strategy. This means that the user has to assign a specific degree of importance to every single criterion. This results in the vector of relative weights of the criteria. However, currently there are only five different predefined weight vectors that the user can choose from because only problem domain experts are able to define adequate weights for the criteria. Eventually, at Level 4 the user will see the overall level of satisfaction for each individual world state and thus it’s ranking. The user may define an arbitrary number of decision-making strategies. However, analogously to the criteria functions, there can only be one active strategy at a time.

A snapshot of the “Analyse and compare scenarios” application functionality is represented in Figure 17.
The Building Blocks and their particular tasks in the “Analyse and compare world states” application functionality are represented in Table 6.

**Table 6: Building Blocks of the “Analyse and compare scenarios” application functionality**

<table>
<thead>
<tr>
<th>Building block</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICMM</td>
<td>Provides the actual CCIM world state instances to the Scenario Analysis and Comparison View as well as the Multi Criteria Analysis and Decision Support View. Moreover, it previously stored criteria function and decision-making strategy configurations are send to the aforementioned views.</td>
</tr>
<tr>
<td>World state View</td>
<td>Lets the user choose the selection context and thus the scenarios to analyse.</td>
</tr>
<tr>
<td>UI Integration Platform</td>
<td>Hosts the different views.</td>
</tr>
<tr>
<td>Scenario Analysis and Comparison View</td>
<td>Extracts the indicator data from the selected world states and initialises the criteria function comparison with previous configurations. Provides the user with the indicator and criteria table views, the relation analysis charts for indicator and criteria, the spider charts for criteria as well as the criteria function definition view to actually configure the mapping between indicators and criteria.</td>
</tr>
<tr>
<td>Multi Criteria Analysis and Decision Support View</td>
<td>Builds on top of the Scenario Analysis and Comparison View and provides the decision-making strategy definition view as well as the multi criteria ranking table.</td>
</tr>
</tbody>
</table>

The schematic sequence of interactions between the Building Blocks shown in Table 6 is modelled in Figure 18.
Figure 18: Interactions between the “Analyse and compare scenarios” Building Blocks

The interactions between the Building Blocks depicted in Figure 18 occur as a result of the following user actions:
1. Select multiple world states: The user selects multiple world states using the world states' widgets and the world state tree. As a consequence, visualizations of the table of indicators and indicators' bar chart are presented to the user.

2. Relate indicator: The user selects an indicator for the x-axis and another indicator for the y-axis. For example, the user selects the "Number of casualties" for the x-axis and the "Lost buildings" for the y-axis. As a result, the user is shown a scatter plot representing possible correlations between the two indicators.

3. Create criteria function: The user clicks on the “+” icon of the criteria function list in order to create a new criteria function and enters an appropriate name for the function.

4. Define mapping: For each indicator the user clicks on the visualisation of its lower boundary to define the indicator value for the satisfaction level of 0 per cent and on the visualisation of its upper boundary to define the indicator value for the satisfaction level of 100 per cent. The user may also define an arbitrary number of intermediate boundaries by clicking on the corresponding boundary visualisations, followed by entering a new range of indicator values and the corresponding level of satisfaction.

5. Relate criteria: The user selects a criterion for the x-axis and another criterion for the y-axis. For example, the user selects the "Number of casualties" for the x-axis and the "Lost buildings" for the y-axis. As a result, the user is shown a scatter plot depicting possible correlations between the two criteria.

6. Compare against reference scenario: The user selects a reference scenario from the list of available world states. As a result, the user is shown a spider chart visualisation for each of the selected world states with the additional reference world state chart rendered on top of the original ones.

7. Create decision-making strategy: The user clicks on the “+” icon of the list of decision-making strategies in order to create a new decision-making strategy and enters an appropriate name for the new strategy.

8. Define OWA vectors: For each criterion the user defines the level of importance by directly entering the numeric value or by using the slider. After that the user picks an appropriate weight vector from the list of available vectors. As a result, the ranking table is updated accordingly.
5. Conclusions

This deliverable summarized how decision-support concept of the CRISMA system was incarnated in the simulation model and virtual application for decision-support. We described the design of the simulation model and virtual application from the user perspective. As such, this deliverable accompanies the actual software implementing the simulation model and virtual application.

At the following stage of design and implementation, the simulation model and virtual application will be implemented and demonstrated by the CRISMA pilots, which represent five different crisis domains. As a result of an evaluation round by the pilots, the simulation model and virtual application will be tested, evaluated, and, when necessary, complemented. In the context of the CRISMA pilots, we will, for example, allow expert users to define and use individual weight vectors instead of the pre-defined ones when defining a decision-making strategy by OWA. Applications of the five CRISMA pilots may choose which Building Blocks to include in their particular instances. Consequently, each pilot will not necessarily include all of the application functionalities introduced in this deliverable.
6. References


http://www.crismaproject.eu


APPENDIX (A) Screenshots of Usage Scenarios

This appendix contains the complete set of screenshots related to the actions the user has to perform in a specific usage scenario. The concrete example data is based on Pilot D.

A.1. View world state

A.1.1. Browse available world states in the tree

The user expands the relevant parts of the tree to see the different crisis management scenarios that have already been created (v. Figure 19).

![Figure 19: Browse available world states in the tree](image)

A.1.2. Choose scenario

The user selects the particular scenario of interest in the scenario list (alternative: selection in the tree, v. Figure 20)
A.1.3. Choose data item

The user selects the particular data item of interest (v. Figure 21)
A.1.4. **Click point on map**

The user clicks on a particular point on the map to obtain the relevant detail information (v. Figure 22).

![Figure 22: Click point on map](http://www.crismaproject.eu)

A.1.5. **Switch to preceding world state**

The user clicks on the predecessor world state in the scenario evolution widget to gain insight in the situation before the current alternative (v. Figure 23).
A.2. Execute simulations

A.2.1. Execute transition wizard

The user executes the transition wizard from the world state that he wants to use as a basis for his simulation (v. Figure 24).
A.2.2. Choose simulations

The user selects simulations from a list of available transitions and defines the order in which they should be executed. Additionally, he may choose to apply time dependent vulnerability to the current transition (v. Figure 25).
A.2.3. Parameterise simulations

The user is presented with a parameterisation view specific for the particular simulation and does the configuration (v. Figure 26). For example, the user parameterises the building hazard model doing the following:

a. Select point on the map: the user chooses the epicentre of the earthquake that shall be simulated by clicking on an arbitrary point on the map

b. Set magnitude: the user sets the magnitude of the simulated earthquake by moving the magnitude slider to the desired value

c. Set depth: the user sets the depth of the epicentre by entering a number

d. Choose attenuation law: the user chooses the attenuation law to be used for the simulation from a list of available attenuation laws
A.2.4. Enter metadata

The user enters a name and an optional description of the simulation (v. Figure 27).
A.2.5. Await simulation finish

The user is presented with the progress of the simulation and waits for it to finish (v. Figure 28).

![Await simulation finish](image)

Figure 28: Await simulation finish

A.2.6. View results

The user views the results of the simulation as described in section 7.1 (v. Figure 29).
A.3. **Apply mitigation options**

A.3.1. **Execute transition wizard**

The user executes the transition wizard from the world state that he wants to use as a basis for his mitigation strategy (v. Figure 30).
A.3.2. Choose mitigations

The user selects mitigation strategies from a list of available transitions and defines the order in which they should be applied (v. Figure 31).
A.3.3. Parameterise mitigation strategies

The user is presented with a parameterisation view specific for the particular mitigation strategy and does the configuration (v. Figure 32). For example, the user parameterises the building resistance mitigation strategy doing the following:

a. Zoom to desired area: the user selects the pan tool and navigates to the area of interest
b. Create polygon: the user selects the create polygon tool and draws a polygon on the map that encloses the area that shall be affected by the building resistance change
c. Edit mitigation area: the user double-clicks the newly create area object in the list of all mitigation areas and is presented with a parameterisation dialog
d. Parameterise mitigation area: the user adds a name to the area and chooses the desired change in building resistance by entering an appropriate value directly

Figure 32: Parameterise mitigation strategies

A.3.4. Enter metadata

The user enters a name and an optional description of the mitigation strategies (v. Figure 33).
A.3.5. Await mitigation process finish

The user is presented with the progress of the mitigation process and waits for it to finish (v. Figure 34). This usually is very short and the user may not even see the progress as the process is finished within milliseconds.
A.3.6. View results

The user views the results of the mitigation strategies as described in section 7.1 (v. Figure 35).

Figure 35: View results

A.3.7. Create alternative sub-plan

The user creates a new alternative sub-plan using the new data as described in section 7.2 (v. Figure 36).
A.4. **Investigate cascade effects**

A.4.1. **Execute cascade effects wizard**

The user executes the cascade effects wizard from the world state that he wants to use as a basis for his investigation (v. Figure 37).
A.4.2. Choose cascade effect

The user selects a cascade effect from a list of available cascade effects (v. Figure 38).
A.4.3. View probabilities

The user is presented with a map that shows the calculated probabilities on every relevant location using an appropriate visualisation paradigm (v. Figure 39). He navigates to the location of interest and clicks on the map to see the actual probability of the respective cascade effect in this location.

![Figure 39: View probabilities](http://www.crismaproject.eu)

A.4.4. Parameterise cascade effects model

The user can parameterise the respective model with the parameterisation view that also provides the probabilities (v. Figure 40). For example, the user parameterises the Forest Fire Model doing the following:

a. Select ignition point: the user selects the point where the ignition shall happen on the map
b. Set wind direction: the user sets the wind direction of the simulated Forest Fire by moving the magnitude slider to the desired degrees
c. Set wind speed: the user sets the wind speed by entering a number
d. Choose atmospheric stability: the user chooses the atmospheric stability to be used for the simulation from a list of available atmospheric stabilities
Figure 40: Parameterise cascade effects model

A.4.5. Await cascade effects process finish

The user is presented with the progress of the cascade effects simulation process and waits for it to finish (v. Figure 41).

Figure 41: Await cascade effects process finish
A.4.6. View results

The user views the results of the cascade effects simulation as described in section 7.1 (v. Figure 42).

![Figure 42: View results](image)

A.5. Analyse and compare scenarios

A.5.1. Select multiple world states

The user selects multiple world states using the world states widgets, foremost the world state tree. As a consequence the user is shown the indicator table and indicator bar chart visualisation (v. Figure 43).
A.5.2. Relate indicator

The user selects an indicator for the x-axis and another indicator for the y-axis. For example: he selects "Number of dead" for the x-axis and "Lost buildings" for the y-axis. As a consequence the user is shown a scatter plot that shows possible correlations between the two indicators (v. Figure 44).
A.5.3. Create criteria function

The user clicks the plus icon of the criteria function list in order to create a new criteria function and enters an appropriate name (v. Figure 45).
A.5.4. Define mapping

For each indicator the user clicks the lower boundary visualisation to define the indicator value for the 0 percent level of satisfaction and the upper boundary visualisation to define the indicator value for the 100 percent level of satisfaction. Additionally, he defines an arbitrary number of intermediate boundaries by clicking the corresponding range visualisation. There, he enters a new level of satisfaction and an indicator value (v. Figure 46).

Figure 46: Define mapping

A.5.5. Relate criteria

The user selects a criteria for the x-axis and another criteria for the y-axis. For example: he selects "Number of dead" for the x-axis and "Lost buildings" for the y-axis. As a consequence the user is shown a scatter plot that shows possible correlations between the two indicators (v. Figure 47).
A.5.6. Compare against reference scenario

The user selects a reference scenario from the list of available world states. As a consequence the user is shown a spider chart visualisation for each of the selected world states with the additional reference world state chart rendered on top of the original ones (v. Figure 48).
A.5.7. Create decision-making strategy

The user clicks the plus icon of the decision-making strategy list in order to create a new decision-making strategy and enters an appropriate name (v. Figure 49).
A.5.8. Define OWA vectors

For each criteria the user defines the level of importance by entering the value directly or by using the slider. After that he chooses an appropriate weight vector from the list of available vectors. As a consequence the ranking table is updated accordingly (v. Figure 50).

![Figure 50: Define OWA vectors](image-url)