Models documentation V2

Christoph Aubrecht, Klaus Steinnocher, Denis Havlik (AIT)
Markus Jähi, Kalevi Piira, Jussi Yliaho (VTT)
Agnès Cabal, Christophe Coulet, Marianne Grisel (AEE)
Maria Polese, Giulio Zuccaro, Stefano Nardone, Alexander Garcia (AMRA) Miguel Almeida,
Luís Mário Rebeiro (ADAI)
Ari Kosonen (INSTA)
Kalev Rannat, Kuldar Taveter (TTU)
Frank Jonat (EADS)

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Contact

Anna-Mari.Heikkila@vtt.fi
Crisma.Coordinator@vtt.fi

Project

www.crismaproject.eu

Keywords

Deliverable leader

Name: Christoph Aubrecht, Klaus Steinnocher
Partner: AIT
Contact: christoph.aubrecht@ait.ac.at, klaus.steinnocher@ait.ac.at

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### Glossary of terms

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<td><strong>Application</strong></td>
<td><strong>architecture</strong> An Application Architecture provides a specification of application-specific Simulation Cases in accordance to the Integrated System Viewpoint of the Conceptual Business Logic of the CRISMA Framework Architecture.</td>
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<tr>
<td><strong>Architecture</strong></td>
<td>In computer science and engineering, computer architecture is the art that specifies the relations and parts of a computer system. See <a href="https://en.wikipedia.org/wiki/Computer_architecture">https://en.wikipedia.org/wiki/Computer_architecture</a></td>
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<tr>
<td><strong>Building Block</strong></td>
<td>A Building Block 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>
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<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, ...).</td>
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<td><strong>Model</strong></td>
<td>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. 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).</td>
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<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>
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As this deliverable is basically a structured technically-oriented compilation of the models that have been described in earlier stages of the project in scientific terms with the objective to support the users and specifically the pilot applications, no relevant new terms are listed here. However, the entire glossary of relevant terms and definitions is also accessible in the online CRISMA catalogue platform at [https://crisma-cat.ait.ac.at/glossary](https://crisma-cat.ait.ac.at/glossary).
Acronyms

API Application Programming Interface
CRISMA Modelling crisis management for improved action and preparedness
EMS European macro-seismic
LSM Life Safety Model
RNV Road network vulnerability
SOAP Simple Object Access protocol
TDV Time dependent vulnerability
WYSIWYG What you see is what you get
Executive Summary

This deliverable D45.2 describes the contents of CRISMA Stewards that aims at providing a hand-book of new developed models and tools, in order to support technical work at the CRISMA pilots. The content is based on the models for multi-sectoral consequences developed in CRISMA.

The handbook itself is part of the CRISMA catalogue, a customized web application that contains documentation on CRISMA Applications, Building blocks, Models, and on the software used to realise the CRISMA Models and the Building Blocks. This report gives a short introduction to the catalogue and lists the models that are included in the catalogue (i.e., newly developed models as well as additional ‘legacy’ models relevant for CRISMA pilot implementation). The listing includes a short description of the respective model, for a detailed documentation the reader is referred to the publicly accessible CRISMA catalogue.

This deliverable provides support to the pilot studies and further use of CRISMA results as it offers all necessary information on potentially relevant and available models in structured and compiled manner. The more architecture-related aspects are described in the parallel deliverable D36.2.
1. Introduction

The CRISMA project is supposed to “support the technical work at the pilots” by contributing to the setup of handbooks D45.2 and D36.2 (to be published in February 2015), covering relevant tools, models and software. Focus in this handbook D45.2 is on the model side, while D36.2 contributes from the architecture and software tool perspective. Proper documentation of the developed models (as well as of additional ‘legacy’ models relevant for CRISMA pilot implementation) and consistent compilation will ensure better understanding in the user community and facilitate integration in the pilot applications.

Main content of this deliverable is provided online in the CRISMA catalogue as specified later on. This document mainly serves the purpose of introducing the CRISMA documentation platform and structuring the model-specific content.

The CRISMA Catalogue has been continuously improved in a context-specific way, particularly following comprehensive discussions with all involved partners and representatives of the end-user advisory board. It was decided that each partner in charge of the development of a new model, i.e. all ‘model owners’, will be responsible to provide the pertinent documentation regarding the use of their respective models also referring to required input data and output types and formats. After an introduction session on the editing options of the CRISMA catalogue, the consortium agreed on the strategy that all model owners should include their models online themselves. That way it has been ensured that the model owners are also listed as appropriate contact points and receive relevant notifications.

The models documented in the CRISMA catalogue has been expanded along the project’s progress, and linkages and implementation aspects have been described in further detail. This deliverable is therefore well in line with the main objective of providing support to the pilot studies, as it offers all necessary information on potentially relevant and available models in structured and compiled manner. As outlined above, the more software and architecture-related aspects are described in the parallel deliverable D36.2.
2. CRISMA Catalogue

CRISMA Catalogue is a customized web application based on Drupal 7 (https://crisma-cat.ait.ac.at/). Its main purpose is to simplify the task of finding documentation on CRISMA Applications, Building blocks, Models and on the software used to realise the CRISMA Models and the Building Blocks. Secondary functions of the catalogue are to:

- Provide up to date overview tables on various topics. For instance, the https://crisma-cat.ait.ac.at/rerelations/bb page shows how Building Blocks are related to applications and to components, https://crisma-cat.ait.ac.at/relations/license2 provides an overview of the licenses used for various software components, and https://crisma-cat.ait.ac.at/organisations/ait lists the latest AIT-related contributions to the catalogue.
- Maintain the CRISMA glossary. See https://crisma-cat.ait.ac.at/site-news/glossary-work for more information.
- Simplify the communication within the CRISMA team. For this purpose, the "CRISMA team" is defined for each "Applications" and "Component", and comments can be added to all content. For convenience, the comments are relied to all interested parties per e-mail.

On the whole, the catalogue is meant to be used as a kind of a structured wiki. Therefore, all CRISMA team members are allowed to change (almost) all content. Drupal versioning system can be used to find out which team members have participated in document editing, compare the latest document version with previous revisions and if needed revert back to older versions of the document (https://crisma-cat.ait.ac.at/site-news/edits-and-revisions). On top of this, an editorial workflow can be enforced for some content types if needed (https://crisma-cat.ait.ac.at/site-news/revisions-workflow).

Unlike wiki:

- CRISMA catalogue accepts several types of text entry. The most important ones are the "plain text" which does not allow and fancy formatting and the "Filtered HTML". A basic WYSIWYG editor simplifies the formatting of the "Filtered HTML" text.
- the site enforces a content-type specific structure and relations between various pieces of content on the one hand, and on the other hand automatically converts the information entered in a single template in a multi-tab browser friendly form.
3. List of models

This chapter consists of a compiled list of the models (including the short descriptions) which were inserted into the online CRISMA catalogue by the respective model owners (in parentheses) until the end of November 2014. The model list aims to be complete with all relevant models implemented in the CRISMA framework described. In any case, the CRISMA catalogue is a live document, which means that adaptations and updates can still be done by model owners when deemed necessary and relevant. Figure 1 shows the CRISMA catalogue interface with the 'CRISMA Models’ section highlighted.

Figure 1. CRISMA catalogue – Models section

The CRISMA catalogue also provides the option in its structural setup to distinguish 'models' and 'components' which is related to the IT focus of the project. Taking the 'Population exposure model' as example, the difference in understanding can be explained as follows

- The 'model' is the specific spatio-temporal population disaggregation approach as developed for CRISMA.
- The 'component' is the software environment where this model is implemented; in that case this is 'emikat.at'.

Furthermore, the CRISMA catalogue links all the models not only to its implementation environment (components), but also to the applications where the respective model is integrated. Eventually those applications will refer to the individual pilot applications (e.g., Earthquake Casualty Model will be used for Pilot D Earthquake and forest fire application). Currently it mostly includes CRISMA technology demonstrators that were prototypically implemented for showcase purposes, but will be discontinued in their development once the focus will be fully set on the pilots.
3.1. **Building impact model (AMRA)**

Model for the assessment of expected damage on building classes due to earthquakes

The model allows the assessment of the probability of attaining established damage levels in a given damage scale for suitable defined building classes. The model is based on the SAVE methodology (Zuccaro et al., 2008). This vulnerability model is basically founded on the statistical elaboration of historical data on the damage occurred during past events in Italy in the last 30 years: Irpinia '80, Abruzzo '84, Sicilia '90, Parma '83, Umbria-Marche '97, Etna '02, Molise-Puglia '02. The procedure is based on "poor" data easily detectable and, far from giving detailed evaluation on building safety, allows to point out the most vulnerable structures and to draw up "lists" of buildings to be investigated.

3.2. **Cascading Effects model (ADAI)**

The cascading effect model for dynamic scenario assessment calculates the probability of attainment of cascading events scenarios, given an initial triggering event, or estimate consequence paths given the occurrence of selected scenarios. Within the model, a database of scenarios and a transition matrix are defined as the two fundamental pieces of information required to assess the effects of possible cascading effects.

A hazard crisis situation may be due to the occurrence of a single hazard event with large impacts or due to several hazard events that occur simultaneously. Hazard events occurring at the same time may have independent causes or may result from a sequence of triggering hazard events. The outcome of a situation for which an adverse event triggers one or more sequential events (synergetic event) is called “cascading effects” (Marzocchi et al., 2009, 2012).

The perception and understanding of the potential occurrence of cascading effects is of great relevance for planning and response activities since a surprising situation in a hazard crisis scenario may endanger people and goods, and may nullify a strategy that was developed accounting for a scenario in which the triggering event was a single occurrence.

Possible sequences of cascading events triggered by seismic activities (Figure 2), forest fires, floods, extreme weather conditions and chemical incidents can be modelled, with associated transition matrices. The model allows customizing the sequence of events and visualizing data of transition matrix for each node of the chain of event.
Figure 3 shows an example of a probability map of fire ignition triggered by electric cable failure due to a seismic event with the characteristics presented in Figure 4. To produce the map of Figure 3 other inputs such as the fuel map of the area, the voltage distribution across the power line, the electric pole fragility curve and the ignition probability function were used as well.
Figure 3. Map for probability of fire ignition by electric cable failure due to earthquake

Figure 4. Map of the triggering earthquake intensity distribution with location of the electric power network (distribution lines - smaller poles)

3.3. Coastal Submersion model (Artelia)

The Coastal Submersion Model is a 2D-hydrodynamic model based on the open source TELEMAC-MASCARET system. In TELEMAC-MASCARET system, we use mainly TELEMAC2D to calculate the time and space dependent hydrodynamic characteristics such as water levels, velocities, discharges.

The 2D model takes into account or computes the different phenomena:

- Hydrodynamics flow (maritime flow and land flow)
- Swell propagation
- Singularity treatment: weirs, bridge (including calculation of overflow on dikes and the dike failures)
- Meteorological influence: wind, Mean Sea Level variation due to pressure...
- Tides
3.4. **Decision model (Cassidian)**

The decision model is an essential part of the Reference Application for Resource Planning that is tested in Pilot E. It realizes a second layer above the Ambulance Model in order to being capable of running simulations with predefined strategy settings. These different strategy settings for resource planning allow users determining the best strategy in a specific scenario. Depending on the strategy, ambulances in an idle state is assigned to certain commands before rerunning the ambulance model simulation.

![Decision Model Diagram](image)

**Figure 5. States of the ambulance vehicles relevant for the decision model**

After and during running the ambulance model with specific commands assigned to specific vehicles, vehicles change their states as depicted in Figure 5. A soon as vehicles are in state "ready on site" or "ready" the decision model can assign new commands to them (write new world state enhanced with those commands) and restart the ambulance model.

3.5. **Dikes vulnerability model (Artelia)**

The dikes vulnerability model is a model programmed in python which allows calculating the potential statistical impact on dikes depending on their status. The model is based on the damage probability matrix.

In view of results of the dikes vulnerability model, the user could make an informed choice on break or failure of dikes for local simulation.
3.6. Earthquake casualty model (AMRA)

Model for the assessment of expected number of injured and deaths due to an earthquake

The probability of injury or death of the building occupants is generally evaluated as a function of the damage level of the building, and it can be assumed that ratio of injured and deaths are significant only for higher damage levels (D4 and D5 of the European macro-seismic EMS-98 scale).

The earthquake casualty model is logically inserted (as regarding the overall CRISMA model workflow) after the seismic building impact model that allows calculation of expected damage for building vulnerability classes, and also takes into account information on human exposure (as derived from the human exposure model), see Figure 7.
3.7. **Economic impacts model (VTT)**

Model for:
- presenting economic impacts arising from crises (ex post performance) and
- assessing different mitigation proposals and their costs/benefits (ex ante planning).

The economic impacts evaluation model is intended to be used in the preparedness phase of crisis management to support long-term strategic decision-making.

The model uses data on alternative scenarios (e.g. base line scenario and crisis scenario after implementing a mitigation measure) in order to make the economic assessment. The assessment is done by determining economic losses of a crisis and costs and benefits linked to different mitigation investments. The procedure follows a passage from a vulnerability analysis and potential damage estimation to a loss assessment, focusing on discovering how such “damage” may be converted into economic losses.

![Figure 8. Example view of CRISECON GUI component which provides a graphical user interface (GUI) for the model](image)

3.8. **Evacuation model (TTU)**

The Evacuation Model is a prototypical model that represents how the population can be evacuated from the hazard area(s) to the safety zone(s). The purpose of the evacuation model is to determine how fast and in which health condition(s) the population is able to leave the hazard area(s).

The Evacuation Model enables to represent units of the terrain and units of the population. Each unit of the population is different in terms of its location and population density and other parameters pertaining to the given social group - elderly, children, people at home, people in offices, etc. Each unit of the terrain is characterized by the roads within it and the type of the terrain - plain, mountains, etc. The roads can have "signs" pointing to the directions in which the units of the population should evacuate and which roads the population should take. In case there are no "signs" on roads, the units of the population in the simulation should have
some "knowledge" of what is the required direction of evacuation in case of a particular type of hazard in particular location(s). The speed of evacuating a given unit of the population from a particular location depends on the distance to the safety zone(s), the roads available, the kind of the social group in question, and the type of hazard under consideration. There can be one or more hazard areas and one or more safety zones on the terrain.

Please note that not all features described above have been implemented, as the Evacuation Model is a prototypical demonstration. However, should the need arise, the missing features can be relatively easily added to the existing Evacuation Model demonstration.

3.9. Evacuation model for Coastal Submersion (Artelia)

The evacuation model developed for coastal submersion in Charente-Maritime (France) used the software LSM2D. This model will cover the Ré Island as well as the area on the coast from La Rochelle to Yves. Different scenarios of evacuation could be simulated. The main results of this model are:

- the estimated time to evacuate the population
- the estimated closed roads
- the estimated casualties on population
- the estimated impacts on buildings due to the flood.

The model results are illustrated below in Figure 9. A demo video showing the development of the situation over time is included in the documentation section.
3.10. Evacuation resources simulation model (INSTA)

Evacuation Resources Simulation Model calculates the impact of resource allocations chosen by the user (from the proposals based on the preparedness plan) to mitigate the situation.

For example, if the situation requires evacuation of 200 persons and the user handles one bus (capacity 50 persons) to transport the people, the bus needs 4 round trips to evacuate them all. Depending on the duration of the round trip and the temporal interval between world states this may have an impact on several world states within a scenario. This model is used to calculate the progressing situation over the whole duration of the scenario.

3.11. Forest fire behaviour model (ADAI)

The Forest Fire Behaviour model is a deterministic integrated system, based on the Model of Rothermel (1972), for the spatial simulation of forest fire behaviour over complex topography and wind flows in areas with heterogeneous vegetation cover. Its main components are the fire behaviour predictions at local scale and wind field prediction at local and large scale taking into account different thermal and recirculation effects. Firestation also has the capability to simulate smoke dispersion and particles concentration over the area affected by the simulated fire.

There are three main factors that can affect the intensity of fire, creating peaks in the rate of fire spread: high wind velocities, topography and vegetation dryness. All these parameters are considered in the model through topographic and fuel cover maps and data of local meteorological stations. However, extreme fire behaviour phenomena such as spot fires, tornados or blow-up fires cannot be modelled.

Figure 10 below is a screenshot of the Firestation software during a fire simulation.

![Figure 10. Firestation software GUI](http://www.crismaproject.eu)
3.12. Population exposure model (AIT)

Model for distributing population in spatial and temporal dimensions

This model uses temporal and spatial proxies in order to disaggregate the population from administrative units to spatio-temporal grids. The outcome will be used in CRISMA as basis for time-dependent exposure assessment and in further steps for evacuation and casualty modelling (Aubrecht et al., 2014ab; Steinnocher et al., 2014).

Population data is usually available from census as totals per inhomogeneous spatial reference unit. For modelling population exposure, data is required that is independent from enumeration and administrative areas. Raster representations meet this demand but worldwide spatially and thematically consistent population rasters aren't available today.

3.13. Resource management model (TTU)

The Resource Management Models developed in the CRISMA project are built upon the OOI concept with different context dependent behavioural patterns for different crisis domains. Thus, there is no overall generic and all-purpose Resource (OOI) Management Model, but a set distinct models for different types of resources (e.g. ambulances, patients) and different situations. However, such domain and crisis specific Resource Management Models can be implemented on basis of the general Agent-Oriented Simulation Models Building Block, with its functionalities described in D31.2 (Taveter (Ed.), 2013).

3.14. Road network vulnerability (RNV) model (AMRA)

Model for the assessment of probability of road link interruption due to earthquakes.

The model was originally developed at Plinivs centre in order to assess the safety of possible escape routes in impacted areas. However, the model is here described in the logic of integration within the CRISMA framework.

According to the three levels of analysis for seismic vulnerability of road networks, described in D43.1 (Polese & Zuccaro (Eds.), 2013), here we are going to consider a "level I" model, aiming at assessing the connectivity capacity of a road network after a seismic event.

The model is based on the assumption that vulnerability of road networks is strictly connected with buildings collapses; therefore the model is usefully applied to roadways in urban areas. Indeed, it is reasonable to assume that the probability of interruption of a road is highly correlated to the seismic vulnerability of buildings along it.

3.15. Time Dependent Vulnerability (TDV) model (AMRA)

Model for the assessment of time-dependent damage on elements at risk.

Vulnerability of elements at risk may be considered to be affected by time-dependency for the following reasons: - continuous deterioration of material characteristics or ageing (in the long term) - cumulating damage because of repeated overloading due to adverse events - inherent dependency on time of the damaging phenomenon (as for the case of the cooling of houses...
with time from black-out in the extreme weather case). Given the initial vulnerability of an element (or class) at risk, in order to determine time dependent vulnerability the effects of time (or damage caused by an initial impact) have to be properly considered in order allowing consistent computation of time dependent damage and/or losses.

The TDV model allows performing consistent computation of time dependent damage by the use of suitably updated vulnerability functions. The updating can be done following two approaches:

- **1st option - variation of vulnerability functions**: this approach entails the explicit consideration of the variation of vulnerability functions describing the propensity of the exposed assets to suffer damage due to an hazardous event; the change of vulnerability functions may be directly determined as a function of the damage level that the generic element has suffered during the previous event (in case of vulnerability variation due to damage by previous impact) or as a function of time (in case of ageing or, as for the extreme weather example, when the phenomenon is inherently dependent on time), see Figure 11.

- **2nd option - update of inventory**: this approach, without changing the vulnerability functions, entails the re-classification of the exposed assets (in pre-fixed vulnerability classes) considering the worsening of their behaviour due to damage.

The TDV model is “domain-independent” in the sense that the logic scheme is the same for different hazard domains (e.g. earthquake, flood, extreme weather etc.), but for using the model in order to compute time dependent losses (in terms of damages in the established damage scale) there is the need to suitably feed the model for each hazard-domain.

**3.16. VTT House model (VTT)**

Model for estimating the extreme cold weather related vulnerability curves for buildings.

VTT House is a simulation model for calculating extreme cold weather based cooling curves of different types of buildings. The model is based on EN ISO 13790 and EN 15241 standards.
in addition to models for estimating solar radiation. The model includes methods for a
dynamic hourly-based calculation of building energy and thermal performance, including
heating and cooling and airflow related energy losses due to the ventilation system and
infiltration. In addition the model can be used to predict the speed of temperature recovery
when heating is restored.

For CRISMA integration, VTT House exposes a SOAP based web service API.

Figure 12. Example results: Inbound air flow, Outside temperature

Figure 13. Example results: Heating power, Inside temperature
4. Short conclusion

The CRISMA catalogue has been set up as a platform to compile all relevant information related to models, software and architecture components, as well as to highlight their intended use in the CRISMA pilot applications. The handbook on available and developed models serves as a pilot support on the implementation side.

During the progress of the CRISMA project, the catalogue have been updated and filled comprehensively, so that all relevant models implemented in the CRISMA framework are properly documented. All CRISMA partners actively contributed to these efforts which made this platform the main forum for topic-specific discussions. As a generic and open approach the CRISMA catalogue has constantly been evolving during the project's lifespan and eventually is also opened to the public.

The CRISMA catalogue structure with all the links and relations between the different models, components, and applications facilitates a better understanding for the end user. By describing individual components and model parts separately also the issue of transferability is addressed to some degree, as applicability of individual models can become clearer for additional application cases, at the end even outside of CRISMA.
5. References


APPENDIX (A)

Relevant content is compiled and regularly updated in the CRISMA catalogue at https://crisma-cat.ait.ac.at.

A glossary of relevant terms is compiled and regularly updated in the CRISMA catalogue at https://crisma-cat.ait.ac.at/glossary.