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Modelling crisis management for improved action and preparedness

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Preface

This publication presents an overview on solutions developed within the project "*Modelling crisis management for improved action and preparedness"* (CRISMA) that aims to support crisis managers and decision-makers dealing with complex crisis scenarios.

In recent years, the nature and magnitude of crises have changed globally, sometimes even drastically. Crisis managers often need to make ad-hoc decisions in situations where they are just partially aware of the common operational picture.

CRISMA aims to improve preparedness and resilience to crisis events by facilitating the manipulation and visualisation of complex crisis scenarios, which typically have multiple effects on society and require the integration of expertise from multiple sectors, and involve financial and ethical concerns.

Crisis managers and other stakeholders associated with large-scale crises benefit from CRISMA, as it helps them:

- To model realistic, multi-sectoral crisis scenarios and consequences
- To simulate and compare impacts from alternative actions
- To make strategic decisions
- To optimise deployment of, e.g. resources
- To make better action plans for the preparedness and response phases.

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1. Why CRISMA?

1.1 Is this book for you?

Do you need to prepare for the unexpected? Does a changing climate, technology or socio-economic environment make past crises look old and new ones more probable than ever? In more detail:

- Does your work involve long-term planning of land use, resources or critical infrastructures?
- Are you responsible for the management of first responders in crises?
- Would you like to improve your process for preparing operative crisis management or contingency plans?
- Do you need to agree on the "best" possible courses of action with a heterogeneous group of stakeholders?
- Are you implementing parts of a service chain or decision support applications related to any of the above?

If your answer to any of these questions is "Yes!", then perhaps you are keen to learn:

- Where current trends in technology and society are taking us;
- How these trends may help to lower the societal exposure to future crisis events; and
- How new trends, e.g. in software technologies can help to enhance preparedness towards crises never experienced before.

This is a book for you, if you are a stakeholder in the crisis management process and interested in concepts and software for improving preparedness.

1.2 Why would you need CRISMA?

In today's world, past experiences are often not a good approximation of the things to come. Following Heraclitus, *"The only thing that is constant is change"*:

- Hazards change, both for natural and man-made reasons – climate change being a well-known example
- Vulnerabilities change, for reasons such as the establishment of settlements in new areas, technical developments and societies' increased dependency on them, and societal evolution affecting people's ability to cope with crises
- The complexity of crisis events changes due to various factors, including the increased interconnectivity of technical systems (e.g. transport-electricity-telecommunications), concentration of population in new areas, changes in the socio-cultural domain, etc.

In recent years, the nature and magnitude of crises have changed globally, sometimes even drastically. At the same time, societies and their citizens have become more and more dependent on infrastructures that are both complex and interconnected.

This is not good news for crisis managers, who often need to make ad-hoc decisions in situations, where they are just partially aware of the common operational picture. Public and private stakeholders are also facing a serious question: If the past is not a good measure of things to come, how should we prioritise today's planning and training activities and investments?

Predictive models are a recommendable solution for supporting prioritisation and decision making. However, there is still a need to better understand what the predictions mean and how we could influence the results through interventions.

"It is hard to make predictions, especially about the future" (Danish proverb made famous by Niels Bohr). However, it may be even more difficult to understand what prediction really means for you and what to do about it.

It can be almost impossible to completely understand complex systems, but it is possible to get used to them and learn how they behave in certain conditions. In order to do so, it is important to train yourself by "playing" with the system:

- Introduce changes to the system
- Follow the spread of these changes in it
- Compare the results of the simulations
- Contemplate the possible reasons about why some of these changes significantly influence the outcomes and others do not.

CRISMA makes it possible for you to familiarise yourself with a variety of predictive models by simulating impact scenarios with them.

1.3 Preparing for the inevitable

CRISMA gives you the opportunity to improve preparedness and resilience to crisis events in a cost-effective way. This can be elaborated roughly into:

- Improving the preparedness and resilience of society by design; and
- Improving the operative crisis management capacity.

“Resilience by design” relates primarily to long-term planning. This requires a very precise understanding of current and future hazards for the elements at risk, and their vulnerabilities. The goal of planning is to minimise the negative effects of crisis events on society, within the limitation of socially acceptable actions and the available budget. The tools at the planners’ disposal are often expensive and the effects only visible in the long-term, such as in infrastructure investments, land-use planning, or re-settling the population.

Operative crisis management capacity is affected by infrastructure planning and investments, e.g. by the capacity of roads, location and number of hospital beds, ambulances and fire trucks. However, the capacity to react to crisis events relates even more to the way in which the available resources are deployed. It is therefore heavily dependent on the quality of operational guidelines for handling crises as well as the efficiency of training activities.

1.4 Using this book

This book consists of two mostly self-contained parts and you can start with the part with which you feel most comfortable:

1.4.1 The practitioners’ perspective

The first chapters of this book provide a brief summary of the basic approach, key results and general benefits of the CRISMA project. Reading these chapters will provide you with:

- A basic understanding of the overall CRISMA methodology including simulation and decision support concepts, and the architectural considerations of the CRISMA Framework
- Good reasons for adopting the CRISMA methodology
- Concrete examples of applications where CRISMA has been shown to make a difference
- Inspiration on important steps to improve your own future projects.

1.4.2 The technical perspective

The second part of this book discusses the approach and results of CRISMA in detail. It puts a strong emphasis on introducing new concepts such as World

States and world state transitions, Objects of Interest, indicator-based decision support, and so on.

This part of the book is a primer for technically-minded readers who are considering to use CRISMA. It provides:

- A crash-course in CRISMA concepts and framework
- A basic understanding of all the major services, software components and related standards used in CRISMA
- The information on how the CRISMA methodology, Building Blocks and Models can be used in order to build crisis management applications; and
- Hints on how to contact the CRISMA team on specific questions, and where to get additional information and download the software used and developed in CRISMA.

This first part of the CRISMA book provides an introduction for decision makers and technical managers. In order to understand how the framework elements can be used in your applications, we recommend that you continue reading the second part of this book, which is a technical CRISMA primer.

More detailed documentation, as well as the CRISMA software, is available for download from www.crismaproject.eu and catalogue.crismaproject.eu.

2. The CRISMA project

2.1 CRISMA objectives

The main goal of CRISMA is improved crisis management in large-scale and complex crisis scenarios. Typically, regular emergency and first responder organisations cannot manage these crisis scenarios alone. Extensive consequences and impacts can overwhelm crisis management organisations and citizens, which both could benefit from multi-organisational or even multi-national cooperation and external humanitarian aid, but the rules and means for cooperation might be lacking.

CRISMA aims to support crisis managers and other stakeholders in planning activities related to large-scale crises. They can benefit from applications that help them:

- To model and simulate realistic crisis scenarios
- To explore possible response actions, and the impacts of a crisis depending on both crisis evolvement and various actions
- To compare and evaluate the performance of possible actions.

CRISMA facilitates building up complex crisis scenarios that have multiple effects on society and require the integration of expertise from multiple sectors. Due to the problem complexity, no single “ultimate” model can achieve this. Therefore, the CRISMA Framework allows developers to easily combine data and simulation models to create crisis scenarios.

CRISMA also provides mechanisms for manipulating such complex crisis scenarios and visualising their evolution. Finally, CRISMA enables crisis stakeholders to discover and explore appropriate solutions that meet their specific interests, including financial and ethical concerns.

CRISMA provides you a conceptual and technological framework to simulate even the most complex crises and explore the potential effects of mitigation measures. It enables stakeholders to develop sound mitigation strategies.

2.2 Project approach

The diversity of threats is a major challenge in Europe and around it. Some countries are exposed to a full set of environmental crises, including floods, forest fires, avalanches, landslides, volcanos and even the occasional tsunamis, while others may be dependent on well-functioning crisis management due to their geopolitical position. Other states, may not encounter such crises as regularly, and thus their citizens are expecting the same good organisation in all sectors of the society even when facing new complex crises. Some examples can be seen in Chapter 3 of this book.

CRISMA offers the flexible architecture and methodology for crisis management, resulting from a collective work of experts in the field of crisis management and in the field of ICT support.

CRISMA reflects the real needs of the experienced crisis managers and end-user organisations, who participated in the project as partners and advisors to the consortium.

The technical foundation of the CRISMA Framework architecture builds on the evolutionary development of several previous EU-projects: ORCHESTRA (reference architecture for environmental crisis management systems), SANY (architecture for observation systems), and ENVIROFI (future internet enablement of geospatial and environmental applications). The CRISMA Framework architecture is kept as simple as possible, and as complex as necessary, in order to address the wide range of use cases, integrate legacy systems, adapt to various security constraints and integrate the diverse range of hazard, impact and risk models.

The CRISMA Framework architecture has been designed to remain relevant for years; future user requirements can also be incorporated into this flexible and adaptable framework.

In order to foster the acceptance and use of the project results, the consortium has opted for an open business model. Accordingly, reference implementations of the core framework components are based on open standards, and are available either as open source or in the dual licensing models. This presents many opportunities for the consortium members, as well as for third-party organisations, such as:

- Integrators and application builders can use the CRISMA Framework “as is”, to speed up the process of building specific end-user applications
- Software developers can offer the service of customising and improving existing CRISMA software, adding new or enhanced functionality to the framework or opening up third-party models for CRISMA applications. Selling the software licenses is also possible, since the CRISMA

Framework, by its design, enables interoperability between open source and proprietary components.

- Research institutes and consulting companies can provide consulting services and training for end-users, integrators and service builders
- Modellers can customise, parametrise and validate existing models for use in another context.

In support of the end-user community in crisis management, the CRISMA Framework includes no limitations on its further use. Integrators and software developers can re-use the CRISMA concepts and most of the software without any further help from the original developers.

2.3 Key results

For the **crisis management process**, the main achievement of the CRISMA project is a common methodology for decision support, which is applicable to all these applications and beyond.

For the **modellers and developers**, the most interesting CRISMA outcomes are the integration of various models, the specifications and reference implementations of the software framework, and the “development practices” (Chapter 5).

From the point of view of the **end users (public and private crisis managers and other stakeholders in the process)**, CRISMA provides a set of applications based on the CRISMA concepts. CRISMA applications can be used for multi-organisational:

- Short-term strategic planning and resource management; the application can easily be applied elsewhere because it is based on a relatively simple agent-oriented models structure. Models can be ported to any location, after some fine-tuning of parameters.
- Long-term infrastructure planning to support stakeholders by helping to visualise the impacts of their decisions and enabling the comparison of various options and, e.g. their cost-effectiveness.
- Training and cooperation of decision makers in a more flexible way.

3. CRISMA usage scenarios

Simulations of crisis scenarios and potential mitigation strategies can help us better understand the potential consequences of crisis management actions.

CRISMA allows for the interactive creation of crisis scenarios, the introduction of mitigation options, and the investigation of the effects of simulated decisions and actions. It allows for the analysis and comparison of different scenarios and the iterative identification of sound and efficient mitigation strategies, all of which can either be included in preparedness plans or used to train decision makers and other stakeholders.

CRISMA demonstrates the broad validity of this approach in five very different crisis management applications.

3.1 Nordic winter storm with cross-border blackout

Extreme winter storms with strong winds, heavy snowfall and icing are more and more likely in the Barents region. Combined with a rapid drop of the temperature below -35 °C, these extreme winter storms can cause major challenges for the energy supply, traffic infrastructure, and heating and communication network in the region. Houses without fireplaces start to become too cold to stay in, especially for children and the elderly. At the same time, snow-blocked roads make evacuations difficult, and the authorities must start prioritising their actions.

Today, stakeholders in this area struggle with longer distances, an ageing population in sparsely populated areas, and the scarcity of resources that have been planned for normal conditions. In addition, tourist centres such as ski resorts seasonally multiply the number of people in the area.

Stakeholders need means for better contingency planning to:

- Assess which areas require urgent actions
- Assess how the situation progresses within a given period and the impact of suggested mitigation actions
- Enhance multi-authority planning as well as stakeholder cooperation.

In this usage scenario, CRISMA supports the decision makers in identifying the impact and cost of a large-scale power outage during an extreme winter storm. The main goal is to enable them to find the most suitable contingency plans for

Nordic regions. This is achieved through a better understanding of the cooling of houses in cold weather during power blackouts and the effects on human beings; available evacuation resources and their allocation in the area; and economic impacts such as damage costs, operational costs and mitigation investments. The usage scenario of a Nordic winter storm with cross-border blackout is depicted in Figure 1.

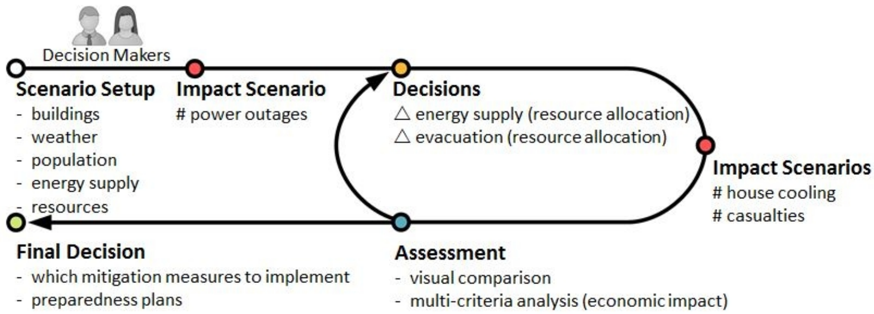


Figure 1. Nordic winter storm scenario workflow.

3.2 Coastal submersion

Submersions are an increasing concern in coastal regions; as a result of climate change, storm surges with strong winds are becoming more likely. Coastal submersions cover large areas, where buildings, dykes and other infrastructures are at risk of severe flooding and damage, and citizens are at risk of drowning or being badly injured.

Today, there are no vulnerability and impact assessments that evaluate both costs and losses on a general scale. Stakeholders need the means to:

- Assess multiple flooding scenarios by simulation of costal submersion events and evacuation behaviour
- Assess the vulnerability of dykes and buildings for identifying endangered regions
- Assess the impact of different mitigation options, such as the modification of the resilience of dykes, with the aim to reduce the impact of a possible flooding scenario.

In this use case, CRISMA supports the decision makers in identifying the impact and cost of coastal submersion and other flash floods. The main goal is to enable them to find the most suitable solution for a specific region. This is achieved through a better understanding of the coastal submersion effects, the preparedness for accident situations, and potential mitigation actions. The usage scenario of coastal submersion is depicted in Figure 2.

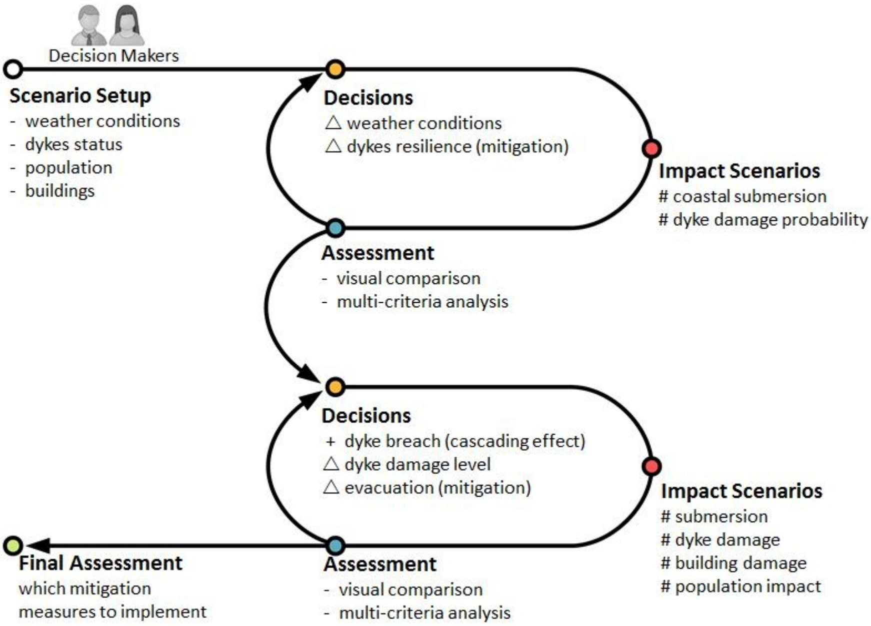


Figure 2. Coastal submersion scenario workflow.

3.3 Earthquake and forest fire

High seismic activity and earthquakes are a major issue in certain regions. In urbanised areas, they may result in a large number of victims and serious damage to buildings and other infrastructure. After a main-shock, there is a high risk of aftershocks resulting cumulative damage. Also, cascading events such as tsunamis or urban and forest fires may result in further loss in already damaged infrastructures.

Today, there are various models available, e.g. for seismic risk, vulnerability and physical damage assessment. However, one main difficulty lies in combining those multiple tools from different stakeholders. The issue is especially difficult when assessing cascading effects or estimating time-dependent vulnerability and economic impact. Thus, those combined effects are almost never examined, and experimentation with different mitigation options is hardly possible.

Stakeholders need the means to:

- Assess multiple earthquake scenarios by evaluating the vulnerability of people, buildings and infrastructure and simulating the impact on them
- Assess different mitigation options and show their impact for any given scenario
- Identify and assess possible cascading effects, such as follow-up earthquakes or forest fires, and simulate their additional possible impact.

In this use case, CRISMA supports the decision makers in identifying the impact and cost of earthquakes and cascading effects such as forest fires. The main goal is to enable them to find the most suitable short- and long-term mitigation solutions. This is achieved by supporting decision makers in enhancing preparedness through a better understanding of earthquakes' effects in a region and possible cascading effects; and through considering the impacts of enforcing evacuation or applying preventative mitigation actions on the vulnerable building stock. The usage scenario of earthquake and forest fire is depicted in Figure 3.

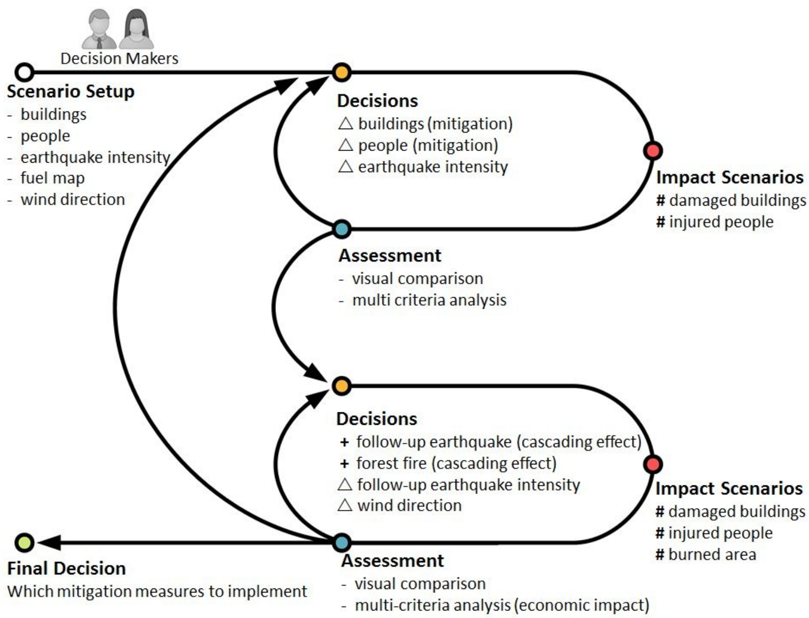


Figure 3. Earthquake and forest fire scenario workflow.

3.4 Accidental pollution in urban areas

Accidental pollution is a possibility wherever chemical substances are stored, transported or shipped. Especially in urban areas, a chemical plume quickly reaches a large number of people, causing toxication or even death.

Today, there is no flexible tool that would support the commanders of response organisations in training for decision-making, especially in this kind of situation with multiple casualties and limited resources.

Stakeholders need means to:

- Set up a training simulation for trainees to make decisions according to some simulated situation
- Simulate accidental pollution scenarios interactively taking into account decisions made by the trainee at any given time

- Observe the decisions as a trainer and rewind to certain decision points with the trainee to show other possible ways of resolving the situation at hand.

In this use case, CRISMA supports decision makers to improve their decision making during a crisis situation through decision training. The main goal is to evaluate decisions made in training sessions and identify their eventual impact on the simulated crisis. The usage scenario of accidental pollution is depicted in Figure 4.

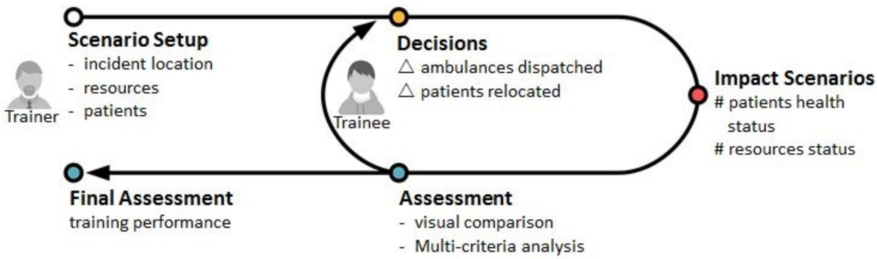


Figure 4. Accidental pollution scenario workflow.

3.5 Mass-casualty site

Mass-casualty incidents can be associated with traffic accidents, panic at mass events, collapse of buildings, etc. They are characterised by a large number of injured persons requiring urgent assistance that exceeds the capacity of the local first responders and medical facilities.

Today, the capacity to prepare response plans, as well as to organise and assess exercises for the mass casualty incidents is limited by the lack of appropriate ICT support tools.

Stakeholders need means to:

- Set up realistic situations that take into account injury statistics, response and transport times;
- Support the assessment of response plans and exercises with objective data;
- Compare the impact of alternative response plans in relation to the incident position, number and types of casualties, response strategy as well as the capacity and positions of the available resources.

In this usage scenario, CRISMA supports decision makers in their efforts to identify resource and capacity needs in multi-casualty events. The main goal is to improve and modify resource and capacity planning as well as exercises. This is achieved through simulating different response patterns for better resource management and evaluation of response plans.

4. Decision support in crisis management (CRISMA concept)

4.1 Simulation and decision support concept

The CRISMA decision support concept consists of the following three key elements: (1) simulated crisis management scenarios; (2) analysis and comparison of the scenarios based on indicators; and (3) scenario ranking based on decision criteria and multi-criteria analysis. (Figure 5)

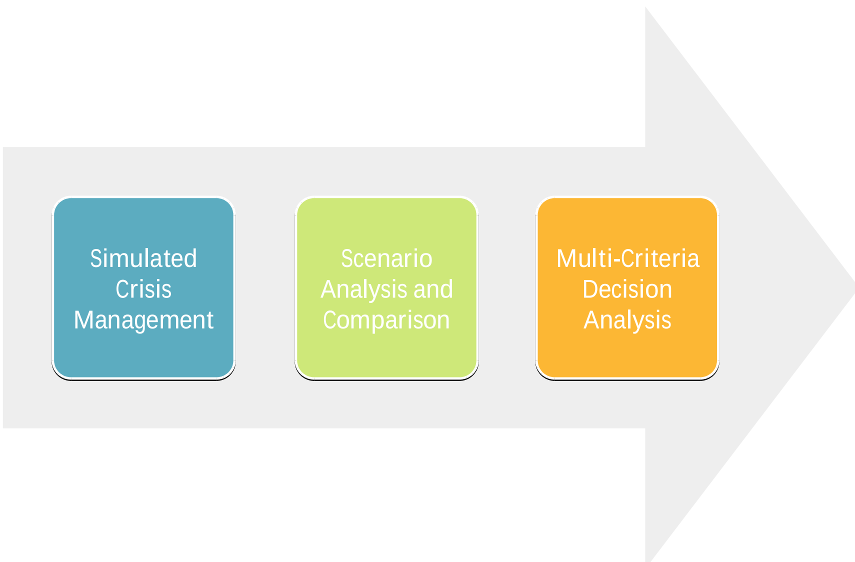


Figure 5. CRISMA concept overview.

The concept is realised in CRISMA applications (see Chapter 6), using the functionality of the building blocks and software components provided by the CRISMA Framework (see Chapter 5).

4.2 Simulated crisis management

The basic concept of simulated crisis management in CRISMA is to support the decision-makers in preparedness planning or training activities. CRISMA enables them to define the crisis management scenarios and simulate the effects of any changes in the crisis or response strategy on the crisis outcome.

This concept relies on the existence of a virtual world where all variables of interest are represented as parts of world states.

A 'world state' (WS) represents a snapshot of the world corresponding to a specific stage in a simulated crisis. The change of a WS corresponds to a change of (part of) its data content. The process of switching between individual WSs is called a world state transition. (Figure 6)

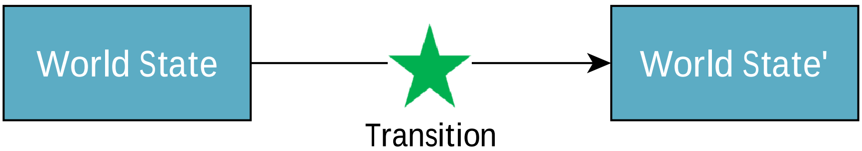


Figure 6. World state transition concept.

World state changes can be introduced either by the user (manipulation) or by executing simulation models. Conceptually, any change in a WS must result in another WS (WS' in Figure 6), which is derived from the original WS. A WS transition maintains the structure of the WS. It can change neither the granularity of the simulated world nor the type of elements (data slots) that constitute the WS.

A CRISMA *crisis management scenario consists of a sequence of world states that are generated by world transitions.*

The WS transition concept divides a crisis management simulation into discrete steps. At each step, the user is able to interact with the simulation, resulting in alternative scenarios (Figure 7).

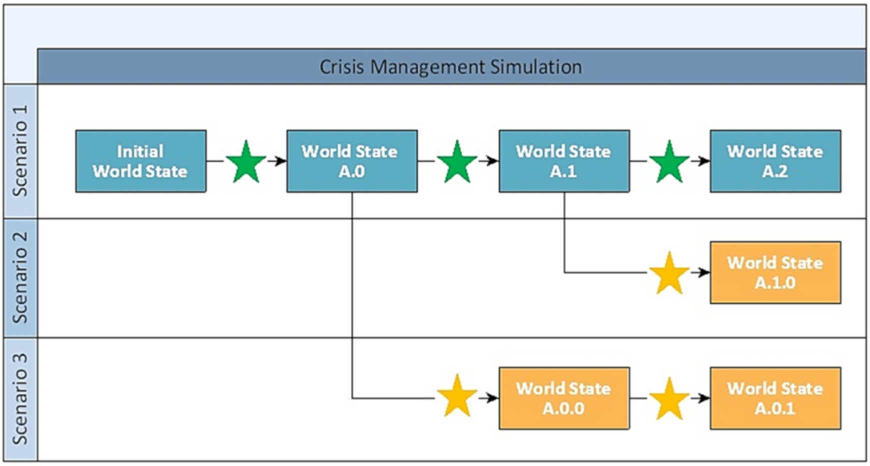


Figure 7. Alternative scenarios in a crisis management simulation.

The CRISMA simulated crisis management concept is applicable to (simulation of) all phases of the crisis management cycle (preparation, response, and recovery).

However, the concrete implementation of the data, models, and possible decisions is always tailored to a well-defined purpose for planning and decision-support activities. In this process, the complexity of a simulation can be reduced by modelling only the aspects of the crisis that are relevant to the respective analysis.

4.3 Scenario analysis and comparison

The scenario analysis and comparison concept in CRISMA considers the analysis of crisis management simulations on two levels:

- Exploration of world state data
- Comparison and assessment of aggregated data (indicators).

4.3.1 Exploration of world state data

The CRISMA simulated crisis management concept relies on the congruence of the WSs. That is, the world structure does not change during the simulation. In most cases, the WS structure is also preserved across different simulation exercises. This enables the analysis and comparison of the equivalent data elements from the alternative WSs. For example, it is possible to compare the data slots representing “victims”, “resources”, “housing” or “infrastructure” belonging to alternative WSs.

Alternative decisions made during a crisis management simulation result in different scenarios, and thus in different but comparable WSs (Figure 8).

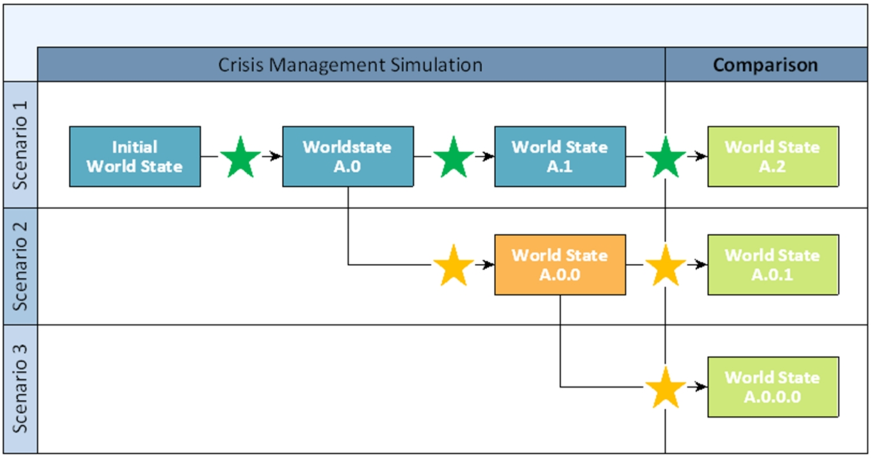


Figure 8. World state comparison.

A significant drawback of such an analysis based on WSs is the need to implement comparison algorithms that operate on the actual data of a WS (data slots). These data slots, such as risk maps, are often heterogeneous with respect to format, resolution, and semantics.

The variety and complexity of the data sets makes it virtually impossible to develop generic and transferable tools for algebraic scenario analysis and comparison. Common support for WS comparison offered by the CRISMA Framework (see Chapter 5) is therefore limited to the visual exploration and comparison of data.

4.3.2 Comparison and assessment of aggregated data (indicators)

The ability to visualise and compare scenarios using aggregated WS data (indicators) is a key design feature of CRISMA.

Key performance indicators, such as “number of homeless” and “operation cost” reflect the key properties of the underlying scenario. In CRISMA, the indicators map complex WSs to simpler representations. An indicator is a combination of elements of a WS produced by an indicator function.

In CRISMA, an indicator is calculated as a part of an extended WS, through the WS transition concept (Figure 9).

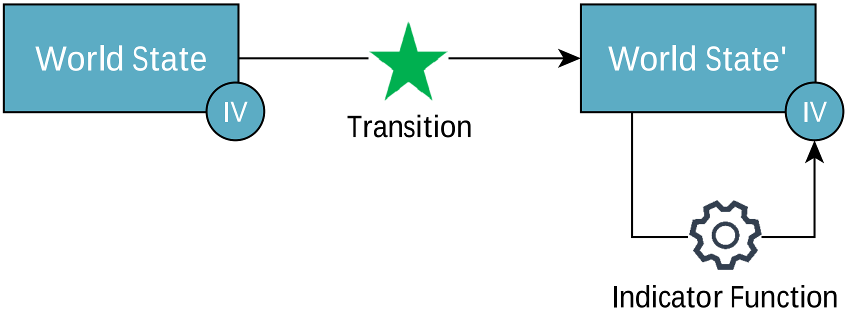


Figure 9. Indicator function (IV = indicator vector).

Key characteristics represent a WS as a set of simple indicators and provide the possibility for algebraic comparison of such indicators.

Consequently, it is possible to develop fully generic tools for indicator-based WS comparison and scenario analysis. With these tools crisis managers are able to explore the effects of changes, e.g. in hazard mitigation strategies, based on related WS information from different scenarios.

4.4 Criteria and multi-criteria decision analysis

The usability of indicators for decision-makers can be improved by normalising the indicators to some scale, such as 0–1 or 0–100%, and by assigning a level of satisfaction to the normalised indicator value. Qualified and normalised indicators are called decision criteria. Criteria are calculated by a criteria function (Figure 10) and organised in a criteria vector.

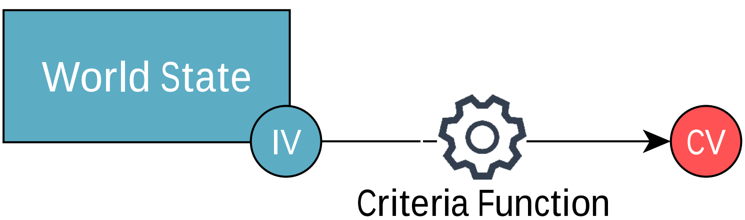


Figure 10. Applying a criteria function (IV = indicator vector, CV = criteria vector).

An example of a customised criteria function can be seen in Figure 11, where the absolute number of lost buildings in an impact scenario is mapped to a level of satisfaction ranging from 0–100%. In this example, the user has decided that losing more than 75 buildings is unacceptable, and has thus assigned 0% satisfaction to all “lost buildings” indicator values that are higher or equal to 75.

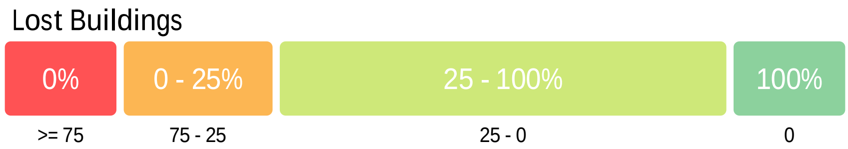


Figure 11. Example of a criteria function.

Unlike indicators, criteria are subjective. In the example above, another user might have decided to assign the 0% satisfaction level to 10, 20 or 50 lost houses. Criteria functions therefore have to be defined by end-users. Quite often, this will be done as a part of the scenario analysis, rather than as a part of scenario setup.

Even though criteria allow for the comparison by normalised indicator values, they do not automatically allow for the ranking of scenarios.

CRISMA addresses the challenge of multi-criteria decision-making through the generation of a score ("R" in Figure 12) that can be used for ranking scenarios. This concept is based on the ordered weighted averages (OWA) method[1].

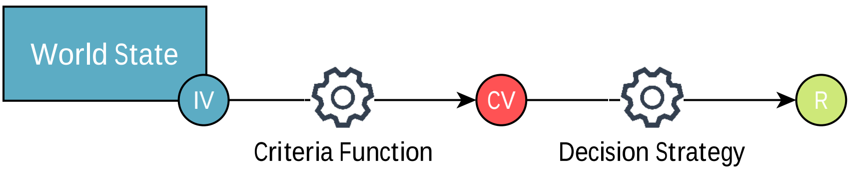


Figure 12. Applying a decision strategy (IV = indicator vector, CV = criteria vector, R = generated score).

Deciding on how to weight individual criteria and which decision strategy to use is up to you. CRISMA helps you to implement your strategy and rank the results accordingly.

Figure 13 summarises the concepts introduced in CRISMA that let crisis managers and decision-makers:

1. Produce and use scenarios (world states) in support of decisions
2. Derive aggregated but representative information (indicators) about scenarios
3. Perform qualifications of indicators by assigning to them levels of satisfaction (criteria), and
4. Define an explicit decision strategy and compare and rank scenarios according to that decision strategy.

[1] Yager, R.R. 1988. On ordered weighted averaging aggregation operators in multi-criteria decision making. IEEE Transactions on Systems, Man and Cybernetics, 18 (1), 183–190.

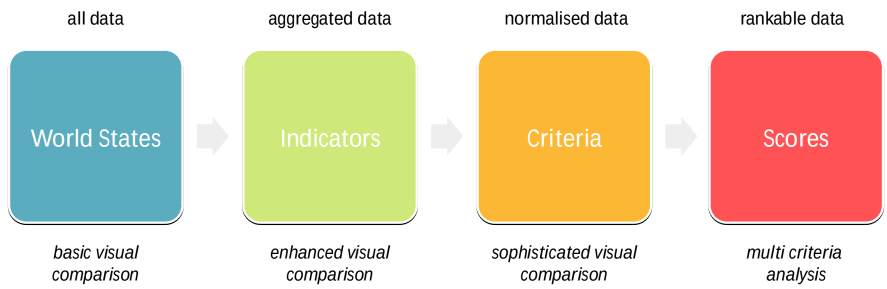


Figure 13. CRISMA concepts summary.

CRISMA provides software elements (building blocks and respective software components) that implement those concepts in the form of a software framework (see Chapter 6).

4.5 Other crisis management simulation concepts

4.5.1 Time-dependent vulnerability

Traditionally, physical vulnerability is considered stationary in time (latent vulnerability). However, in the course of a crisis, vulnerabilities might change depending on how the crisis evolves and the corresponding damage level to an element at risk. A classic example of a sequence of hazardous events is the repetition of medium–strong intensity earthquakes after a main seismic event. After the main shock, buildings might have sustained damage and thus their vulnerability towards additional shocks might have changed.

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)
- Cumulative damage because of repeated overloading due to adverse events
- Inherent dependency on the time of the damaging phenomenon (as in the case of the cooling of houses, with time from black-out in an extreme weather case).

Given the initial vulnerability of an element (or class) at risk, in order to determine the time-dependent vulnerability, the effects of time (or damage caused by an initial impact) have to be properly considered in order to allow for consistent computation of time-dependent damage and/or losses.

4.5.1.1 Simulation model for Time Dependent Vulnerability

The Time Dependent Vulnerability (TDV) model enables for the consistent computation of time dependent damage through suitable re-classification of the elements at risk to be performed. Without changing the vulnerability functions, the adopted approach entails the re-classification of the elements at risk (in pre-determined vulnerability classes), considering the worsening of their behaviour due to damage.

With the TDV model, series of standard Vulnerability Models (VM) and sequences of events can be logically modelled. The basic process of the TDV model (Figure 14) is as follows:

- Initial distribution of the buildings' vulnerability
- The TDV model receives the necessary input parameters about the sequence of hazard intensities to use in the simulation
- The TDV model runs the Impact Model for the first event
- Damage results, together with the inventory data of the element at risk, are used to update the element at risk classification
- The updated (re-classified) data is used as "new" input for consecutive impact model runs.

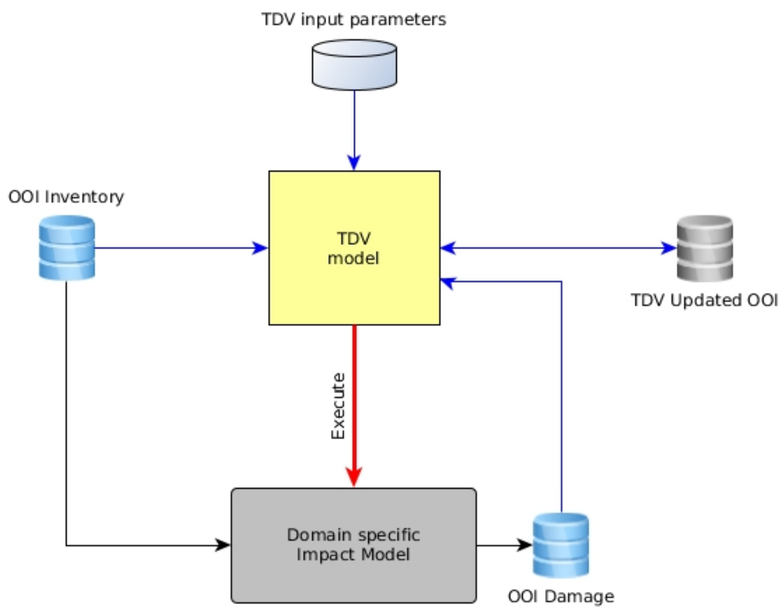


Figure 14. Input/output specification of the TDV model and link to other models.

4.5.2 Cascading events and effects

Natural or man-made disasters can trigger other disasters, leading to a tremendous increase in fatalities and damage. Indeed, the interactions generated by cause/effect relationships among different phenomena, often referred to as cascading effects, may give rise to significantly higher risk indices with respect to the ones resulting from the simple aggregation of single risk indices. For this reason, a multi-risk assessment should be carried out, taking into account all the possible interactions of risks due to cascading effects.

4.5.2.1 Cascading events model

The model for considering cascading effects in the dynamic scenario scheme of CRISMA has been designed to support scenario-based analyses.

Within the CRISMA Framework, cascading effects are integrated as sequences of triggered events, following an initial “triggering event” occurring at a given time and affecting the WS at that given time. In particular, there are three different concepts that have been introduced for the integration of the cascading effects into the CRISMA Framework: (1) the database of cascading events/effects scenarios (CES); (2) the transition matrix concept; and (3) the assessment and update of the expected impacts. Given a specific area of a study, a database of CES shall describe most exhaustively the possible scenarios of interaction between hazards and negative effects for the exposed assets. A possible representation of CES is with event trees. The Transition Matrix (TM) contains all the information on the conditional probabilities of having a given intensity of a triggered event, given the intensity of the triggering event; the availability of TMs for a CES enables the probabilistic quantification of occurrence and expected damage for the cascading effect scenario. Finally, for the impact assessment, the necessary vulnerability and impact model needs to be available.

Hence, the cascading events model enables the evaluation of selected paths of analysis along a CES, both probabilistically and in terms of expected losses in the established metric (e.g. economic losses), provided the TMs and vulnerability/impact models for the combinations of events along a path are available.

The model produces a sequence of WSs pertaining to the respective path of analysis.

4.5.3 Economic impact

In the context of crisis management, the primary reasons for conducting an economic evaluation is to present the economic impacts arising from crises, as well as to assess different mitigation options and costs/benefits of alternative strategies. Thus, with the economic evaluation, we aim to answer questions such as:

- What is the total cost of a crisis?

- What is the cost of a mitigation measure?
- What would be the difference in the total cost if an alternative mitigation strategy had been used?
- How sensitive are the results to changes in estimates and model features?

The evaluation is made by determining economic damage. The procedure suggested is the following:

1. Cost assessment of the direct impact (mainly: initial damage costs)
2. Cost assessment of mitigation measures (direct cost of the measure – reduction of the direct impact)
3. Evaluation of the overall macro-economic effects (direct and indirect effects; recovery pathway; costs, gains, transfers).

Conceptually, an economic evaluation model takes a WS as input and calculates the related cost according to the output of impact models. In addition to the calculation of the cost of the crisis, the conceptual model includes the evaluation of present and future costs (and benefits) linked to mitigation investments. As a result, the economic evaluation model produces a set of economic result indicators. The results of the economic evaluation can be used, together with other indicators produced by other models, to support decision-making.

5. CRISMA Framework

The CRISMA Framework, as a realisation of the CRISMA architecture, provides the software and tools that are necessary to develop concrete CRISMA applications. In particular, the CRISMA Framework delivers:

- Rules and guidelines for the development of CRISMA applications
- A middleware for the integration of CRISMA building blocks and legacy components
- A generic core control and communication information model (Core CCIM) that is usable by any CRISMA application
- Software realisations of all building blocks specified in the architecture ("software components"), and
- A set of reference applications which may act as a blueprint for the development of concrete CRISMA applications.

5.1 CRISMA architecture

The CRISMA Framework architecture (Figure 15) specifies generic, composable and reusable Building Blocks (BB) that can be assembled into concrete applications for simulating crisis management activities at a strategic level (crisis management simulation applications). The framework architecture is independent of a specific crisis management purpose and thus can be applied in many contexts. In contrast, a concrete CRISMA application architecture is always tied to a specific crisis management purpose.

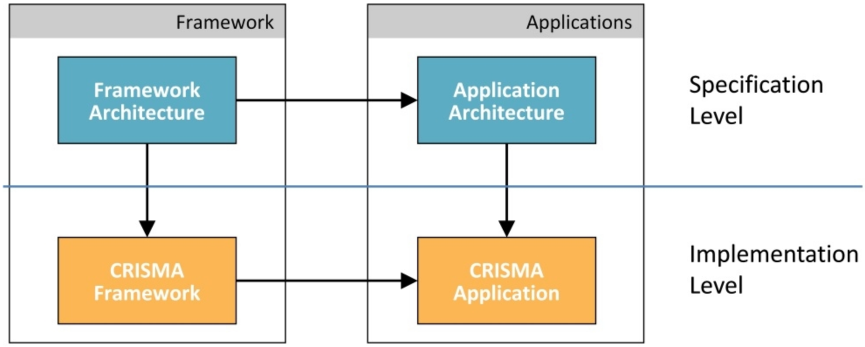


Figure 15. CRISMA Framework Architecture and Application Architecture.

The CRISMA Framework architecture is based on paradigms for distributed systems and designed as multi-tiered architecture.

5.2 Rules and guidelines

The CRISMA Framework provides rules, guidelines, and recommendations concerning the development of CRISMA applications. This includes, e.g. how APIs are specified and implemented, or what technologies are used for the development of specific components.

5.3 CRISMA Middleware

The Integrated Crisis Management Middleware (ICMM) is the core of every CRISMA application. It serves as the glue that enables interactions between components that were originally not designed to work together (e.g. components of a legacy system). The APIs provided by the middleware support information exchange about resources, control flows and notifications. However, actual data access, transfer and transformation are beyond the scope of the ICMM making the data flow more efficient. The problem of interoperability between CRISMA BBs and legacy components is addressed by standardised protocols and message formats, and supported by data integration BBs.

5.4 Core Control and Communication Information Model

In any CRISMA application, information about a crisis management scenario (reference to input and output data, start time, end time, etc.) is considered as control and communication information (CCI), whereas the actual inputs and results of the simulations (e.g. objects of interest, simulation model input and output data) are considered as "data". The CRISMA Framework defines the core Control and Communication Information Model (CCIM) as a common, modular and generic information model for CCI, structured according to predefined but generic entities (world state, transition, data items, etc.). Its main purpose is to allow the management of this kind of information in a uniform manner across all CRISMA applications. Thereby it enables the development of generic BBs (e.g. WS analysis BBs) that can be used in all CRISMA applications as they are built on the basis of the very same concepts.

5.5 Building Blocks and software components

A CRISMA application is built up from software components that are part of the CRISMA Framework. These components realise the BBs described on a conceptual level in the CRISMA architecture. The CRISMA architecture anticipates the possibility that there can be more than one implementation of a BB (Figure 16).

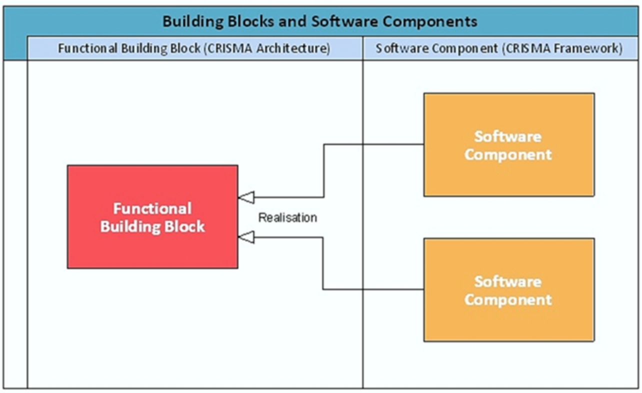


Figure 16. Building Blocks and Software Components.

The CRISMA Framework provides infrastructure BBs, integration BBs, user interaction BBs and crisis management models.

5.5.1 Infrastructure Building Blocks

Infrastructure BBs (Figure 17) work in the “background” and constitute the backbone of a CRISMA application.

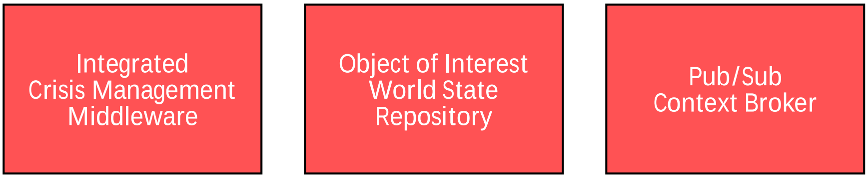


Figure 17. Infrastructure Building Blocks.

The infrastructure BBs are:

- Integrated Crisis Management Middleware
  provides a control and communication information hub that connects BBs in a uniform way
- Object of Interest World State Repository
  is a repository service for Object of Interest (OOI) data that can be consumed or manipulated by other BBs and simulation models
- Publish/Subscribe Context Broker
  is a crossover between an event broker which accepts events and dispatches them to subscribers and an access service providing information.

5.5.2 Integration Building Blocks

Integration BBs (Figure 18) support the integration of data and simulation models into a CRISMA application.

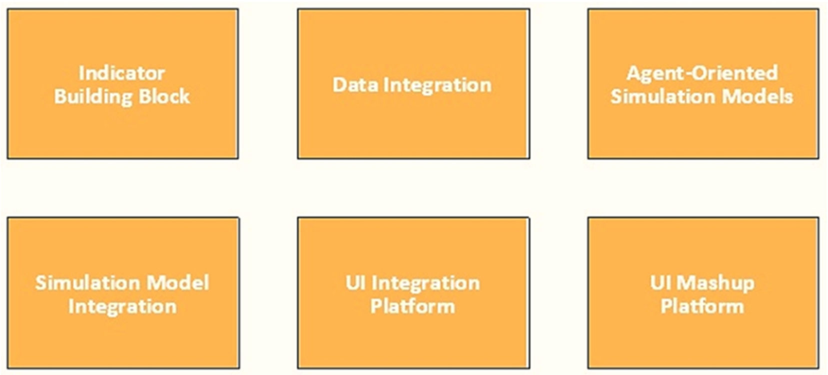


Figure 18. Integration Building Blocks.

The integration BBs are:

- Agent-Oriented Simulation Models
  enable the development of dynamic maps and specific (individual-based) simulation models composed of interacting software agents
- Data Integration
  provides components that can be used to easily serve data in a CRISMA-compliant way
- Indicator Building Block
  supports the creation of indicator data sets
- Simulation Model Integration
  is the runtime environment of composite User Interface (UI) modules that cannot be used as stand-alone applications.
- UI Mashup Platform
  is a runtime environment for mashable composite UI modules (widgets) and provides inter-widget communication, persistent per-widget configuration as well as proxy capabilities.

5.5.3 User Interaction Building Blocks

User interaction BBs (Figure 19) are graphical user-interface core elements of a CRISMA application.

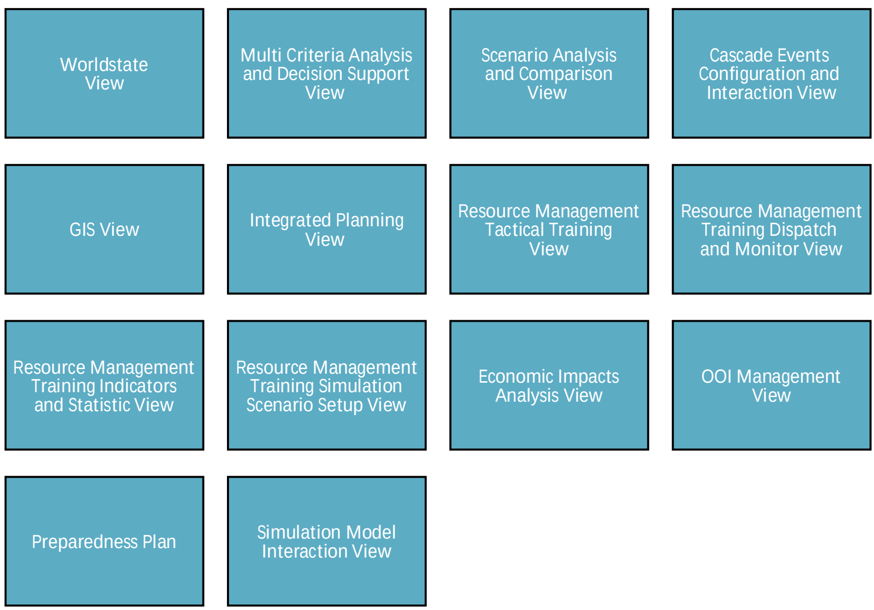


Figure 19. User Interaction Building Blocks.

The User Interaction BBs are:

- Cascade Events Configuration and Interaction View
  allows a user to configure and run a cascade effects scenario
- Economic Impacts Analysis View
  is an economic evaluation tool
- GIS View
  enables the visualisation and manipulation of geo-spatial data
- Integrated Planning View
  is a generic integrated view for the configuration and inspection of arbitrary crisis management scenarios in planning situations
- Multi-Criteria Analysis View and Decision Support View
  allows performing a ranking of different crisis management scenarios with respect to specific criteria
- OOI Management View
  enables the user to view and edit specific scenario or simulation data
- Preparedness Plan
  provides decision support functionalities in case of emergency according to plans based on the analysis of threats, vulnerabilities and possible emergency scenarios
- Resource Management Tactical Training View
  simplifies the task of designing the tactical training applications for control room operator and on-scene commanders
- Resource Management Training Dispatch and Monitor View
  provides a high-level overview of the simulation's WS and allows the user to dispatch simulated resources
- Resource Management Training Indicators and Statistics View
  focuses on the visual presentation of statistics and the key indicators of a given WS in order to provide an overview and to allow for comparison of WSs
- Resource Management Training Simulation Scenario Setup View
  allows modifying the creation of new resource management simulations
- Scenario Analysis and Comparison View
  allows visualising indicator and criteria data in a way that the users are able to analyse and compare different simulated crisis management scenarios
- Simulation Model Interaction View
  enables end users to interact with the various simulation models exposed by the simulation model integration BB
- World State View
  consists of a set of generic widgets to visualise WS data.

5.5.4 Crisis Management Models

Crisis Management Models (Figure 20) are simulation models that cover different aspects of crisis management.

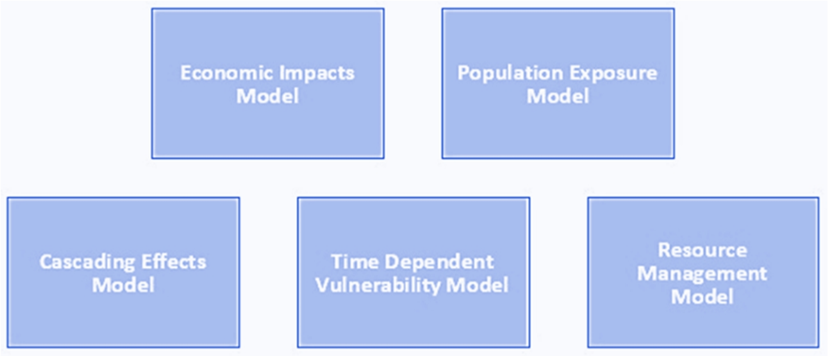


Figure 20. Crisis Management Models.

The Crisis Management Models are, for instance:

- Cascading Effects Model
  for dynamic scenario assessment, calculates the probability of attainment of cascading events scenarios to a given initial triggering event
- Economic Impacts Model
  calculates economic impacts arising from crises (ex-post-performance)
- Population Exposure Model
  is a model for dynamically distributing a population in spatial and temporal dimensions
- Resource Management Model
  built upon the OOI concept with different behavioural patterns for different crisis domains and the related resources (e.g. ambulances, patients)
- Time Dependent Vulnerability Model
  for the assessment of time-dependent damage on elements at risk.

6. CRISMA applications

This chapter illustrates how the CRISMA Framework and BBs can be used in real world applications.

In the CRISMA project, the applications integrate site-specific data and may interact with auxiliary site-specific tools that are not part of the CRISMA Framework, but add value for a particular user.

In the “Usability and transferability” sub-chapters, the re-configuration needs are discussed for those who wish to use CRISMA applications in different areas.

Detailed information on all CRISMA software specifications and reference implementations is available in the CRISMA catalogue[2]. The catalogue also provides information on ownership and IPR conditions for the CRISMA applications and their components.

6.1 Extreme winter weather crisis in the north of Europe

The Finnish “extreme winter weather crisis” application focuses on contingency planning to mitigate the impact of large-scale power outages occurring during wintertime. It implements the “Nordic winter storm with cross-border blackout” usage scenario (Chapter 3.1). The main objective of this scenario is to enable multi-organisational and cross-border cooperation and building up a common understanding for improved preparedness and defining the most suitable contingency plans for Nordic regions.

The concrete application scenario explored in the Finnish application is as follows: The area of South-West Lapland, in Finland is hit by an extreme winter storm, followed by very cold temperatures[3], which leads to an increased demand for electricity. At the same time, the production and supply of electrical energy is paralysed, leading to power outages. This 10 000 km^2 region has a total population of only 26 000 inhabitants, which is seasonally significantly increased

[2] This information can either be accessed from the interactive website at https://crisma-cat.ait.ac.at or downloaded as a printable “book” from https://crisma-cat.ait.ac.at/print/book/export/html/109.

[3] Cold weather (below -30 °C) occurs each year in Northern Finland. At the end of January 1999 the temperature was between -45 °C and -50 °C for approximately a week. Finland's coldest measurement of -51.5 °C was attained in Kittilä, Pokka 28.01.1999 (Finnish Meteorological Institute 2014, http://ilmatieteenlaitos.fi/saaennatyksia).

by tourist centres like ski resorts. The area is situated close to the Swedish border and a cross-border cooperation in all sectors of organisation is a necessity.

The majority of the households in this area have heating systems that are vulnerable to power blackouts. In order to avoid excessive cooling, the decision makers will try to ration the energy supply, thus assuring the majority of buildings are heated for at least a few hours per day. If the outage persists, the decision makers need to plan the evacuation of inhabitants before the internal temperatures fall below a critical level, causing hypothermia for the residents. The need for evacuation will depend on the available energy supply and duration of the blackout, as well as on the rationing strategy and the type of housing.

6.1.1 Application logic

The generic workflow of the Finnish “extreme winter weather crisis” application is defined in the “Nordic winter storm with cross-border blackout” usage scenario (Chapter 3.1). This application is for planning purposes, and supports the decision makers in identifying the impact and cost of large-scale power blackouts during extreme winter storms and the related evacuation planning.

Before a planning exercise, the application first has to be configured for a certain area and conditions. Part of the configuration, such as deciding which areas are cut off from the electricity grid, can be performed by end-users using the WS view. Administrators can use the OOI management view e.g. to fine-tune the different parameters describing the situation or mitigation resource availability.

For a given setup, the end-user starts the planning exercise by entering the WS view and executing the simulation without evacuation. The result of this step is a map showing the situation in different areas. The user can choose the parameters that are visualised on the map, the number of people in need of evacuation or an index describing the overall emergency level, for example. Other numeric values are available for each selected area (Figure 21). A time-shift function allows the user to visualise the map at different times and decide where and when the evacuation measures have to be performed.

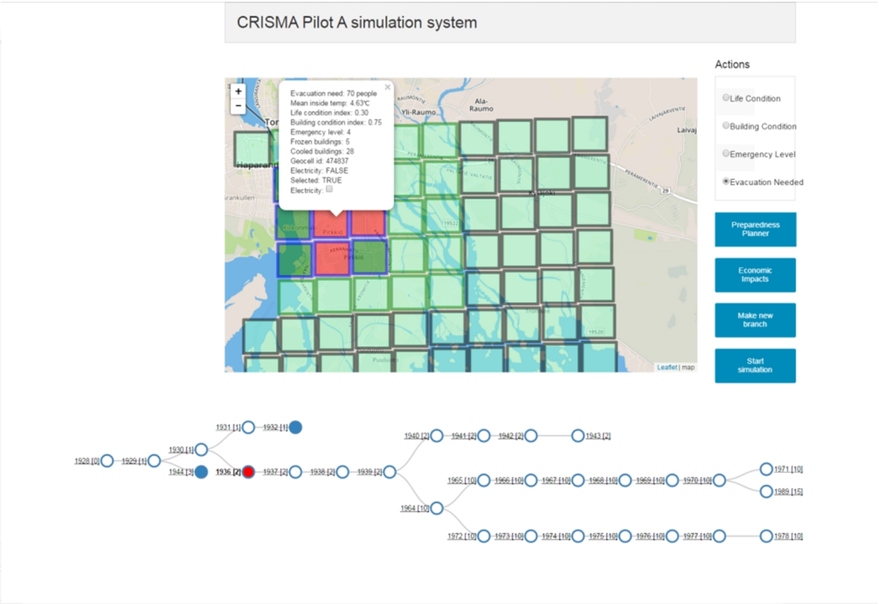


Figure 21. Visualisation of the evacuation needs in the "extreme winter weather crisis" application.

In the next step, the user can switch to the planning view, choose the evacuation parameters such as "which resources to use?", "when to order them?" and "where to send them?". The application supports the decision making process through provision of the "suitability" estimate for alternative evacuation strategies. In order to test the chosen evacuation plan, the user can also execute the evacuation model and examine the evacuation needs in the alternative world, where part of the population has been evacuated.

Finally, the economic impact evaluation model allows users to calculate the total cost of all plans that fulfil the basic "no human losses" requirement. This further simplifies the task of finding optimal crisis management solutions for each of the plan scenarios.

6.1.2 Implementation

The implementation architecture of the "extreme winter weather crisis" application is shown in Figure 22.

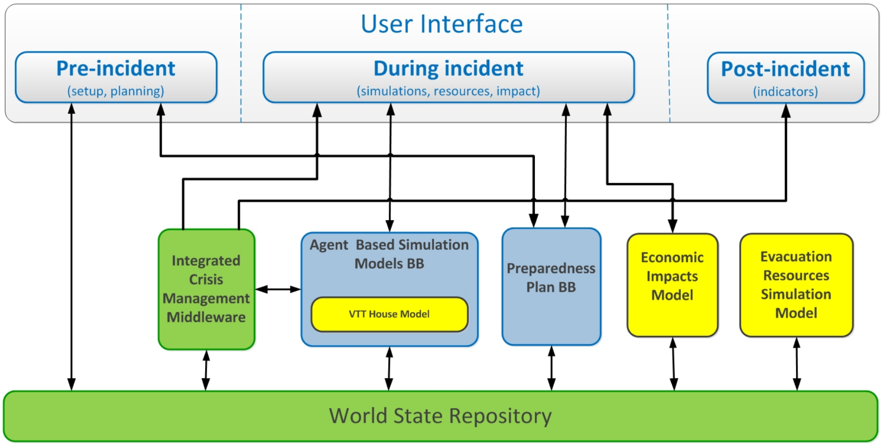


Figure 22. Application architecture of the "extreme winter weather crisis" application.

The functionality provided by each of the BBs and relations between the blocks are explained below. Most of the application functionality is realised by the following models and services:

- Integrated Crisis Management Middleware BB (ICMM)
  provides the platform for integration and management of the information from different sources, e.g. simulations, indicators and the WS model. ICMM is used in all CRISMA applications as a central catalogue that provides information on the whereabouts of the data and relations between the WSs.

- OOI-WSR
  is used to as a central storage for all information on OOI in this application (e.g. inhabitants, houses, resources, weather). In the course of the simulation, other BBs often read the information pertinent to one WS from the OOI-WSR, perform the WS transition and write the result to a new WS.

- VTT House Model
  calculates the cooling gradient of a residential building according to a given weather model (temperature, wind) and the building information (heating type, insulation, building type).

- Evacuation Resources Simulation Model
  is used to calculate the impact of the evacuation resources allocated to mitigate the situation. It calculates the progress of the evacuation and resource usage between WSs.

- Agent Oriented Simulation Models BB
  coordinates the simulation by executing the VTT House Model for all houses, relates the houses to population, and executes the evacuation model.

- Preparedness Plan BB
  enables the end-user to create preparedness plans based on the analysis of risks, threats and vulnerabilities. In the emergency situation the Preparedness Plan BB acts as a decision support tool, proposing actions to be taken to mitigate the situation as described by the end-user following the pre-defined narrative.

- Economic Impacts Evaluation Model
  is used to assess the economic impact of the crisis and the cost of the mitigation activities. This model allows the users to compare the economic efficiency of alternative crisis response plans and choose the ones that achieve the goals (no human losses) while minimising the material losses and cost of the operation.

The graphical user interface (GUI) of the application is realised through the following "views":

- Worldstate View
  is used to visualise and manipulate the information related to the WSs and WS transitions.

- Planning Views and Preparedness Plan Execution View
  are the web-based GUIs of the Preparedness Plan BB and are used to prepare and execute the evacuation plans.

- Economic Impact Calculation View
  is a graphical front end for the Economic Impacts Evaluation Model. It is used to configure the model, as well as to initiate the calculation process and to present the calculated results to the end user.

- Scenario Analysis and Comparison Support View
  supports decision making by visualising the key performance indicators (e.g. operation duration, number of evacuated citizens, number of deaths[4], value of lost property, value of lost productivity, price of mitigation actions, etc.)

- OOI Management View
  is used by administrators to define the types of OOIs that are used within the application.

[4] "No human losses" is a non-negotiable requirement in this application.

6.1.3 Usability and transferability

The “extreme winter weather crisis” application allows decision managers to experiment with various crisis management strategies and compare the results based on factors such as economic losses, human suffering and use of resources in the context of the winter storm with diminished electricity supply scenario.

The simulation models included in this application estimate the pace at which the buildings without electricity are cooling below a defined acceptable level. Combined with population data of the area, this information allows decision makers to focus evacuation actions to the areas with the most vulnerable people.

The preparedness planning functionality is a general purpose decision support tool, applicable to other kinds of crisis scenarios or to completely different domains, and helps the users to find the necessary and optimal set of resources for evacuation actions. By comparing different scenarios, users can discover the best possible course of actions fitting a certain sub-class of such events and promote the chosen set of actions in a preparedness plan. The same application can also be used in response phase, to evaluate the optimal response out of the pre-defined plans.

The application is fully transferable to other areas, with relatively modest efforts. For this purpose, the population, housing, electricity and road network, as well as the pertinent resource and shelter availability data, must be integrated and the evacuation templates adapted to the population and resource parameters.

6.2 Coastal submersion defence strategies for the Charente-Maritime county

When compared to other types of disasters, according to the International Disaster Database (EM-DAT) coastal submersions have increased at the fastest rate (IPCC 2007, 2013[5]). Most of these events, although commonly referred to as natural disasters, are not in fact the results of nature-related processes alone. They are to an ever-increasing extent directly attributable to various social, economic and political issues, with even historical and cultural aspects contributing to the overall vulnerability level.

Rapid urbanisation in coastal areas, combined with climate change and lack of maintenance of existing coastal protection infrastructure, can lead to a significant increase in the risk of local surface flooding coinciding with high water levels in rivers (fluvial) and high tide or storm surges from the sea (coastal) posing a greater risk of devastation in coastal communities. Furthermore, a spatial distribution of a mobile seasonal population of tourists increases the exposure factor and therefore their vulnerability. After a disaster, civil protection and disaster management authorities face the following questions:

- What are the reasons for this disaster?

[5] IPCC 2007 https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4_wg2_full_report.pdf; IPCC 2013 http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf.

- Could we have mitigated the outcome through improved response?
- How can we avoid such disasters in the future?

The CRISMA application for coastal submersion defence attempts to answer these questions and investigates the consequences, impacts and damages of different coastal submersion situations depending on the various mitigation activities.

6.2.1 Application logic

The generic workflow of the French application is defined in the “coastal submersion” usage scenario (Chapter 3.2). The concrete application scenario is based on the Xynthia storm that affected the Charente-Maritime region on the 27–28th of February 2010, leaving 47 people dead and causing more than 2.5 billion Euros of direct losses.

The main field of application is crisis preparedness planning and evaluation of mitigation solutions. Thereby, different storm surge events and their impacts are analysed under different circumstances (e.g. summer or winter, day or night) and under different intensities of events (e.g. stronger winds, in conjunction with high tidal level). Then, the effects of different mitigation solutions are evaluated, and eventually assess decisions made at different times. Concept and application logic of the coastal submersion defence CRISMA application is shown in Figure 23.

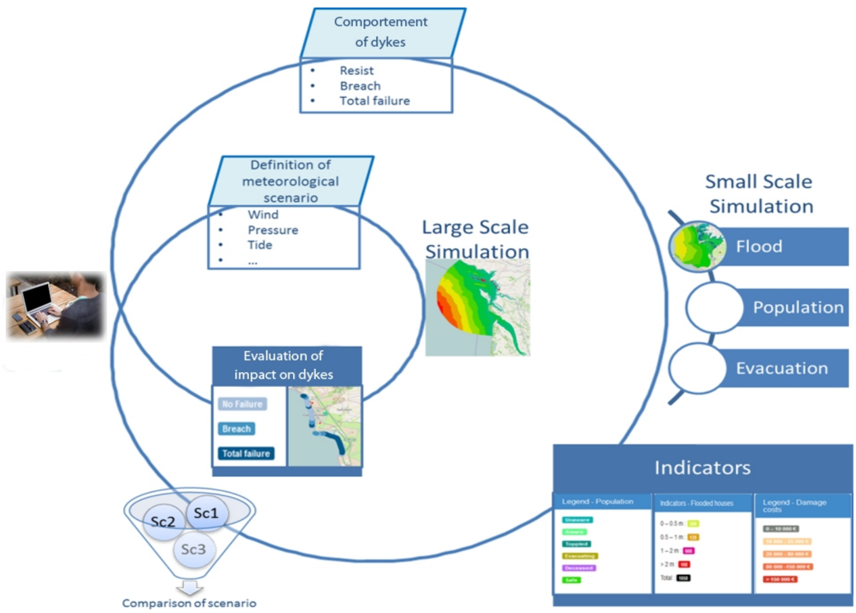


Figure 23. Concept and application logic of the coastal submersion defence CRISMA application.

Once the administrator has performed the initial setup and data preparation for a given area, the application can be used to:

- Define the event characteristics (e.g. maximal water height)
- Perform dyke and building vulnerability assessment
- Modify the dykes resilience
- Simulate coastal submersion at a range of temporal and spatial scales and for different states of the dykes
- Simulate the evacuation model for coastal submersion
- Simulate the effects of other mitigation activities (e.g. re-settling population, improving dykes)
- Calculate key performance indicators (including the population casualties, material and economic losses)
- Define criteria and multi-criteria ranking strategy.

These different stages allow the user to analyse the submersion effects (on a spatial and temporal scale, cost/benefit, etc.) and preparing the plans for mitigating the risks and effects of the coastal submersions.

6.2.2 Implementation

The implementation architecture and the main interactions between the framework elements used in this application are shown in Figure 24.

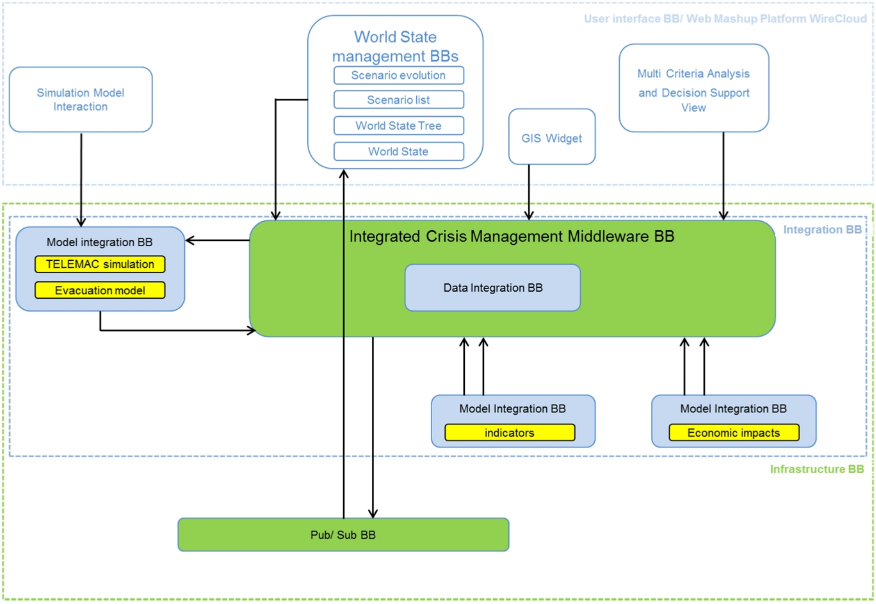


Figure 24. Application architecture of the "Coastal submersion defence" application.

In addition to ICMM that is used in all CRISMA applications, the coastal submersion defence application uses the following server components and models:

- Publish Subscribe Context Broker BB
  is a crossover between an event broker that accepts events and dispatches them to subscribers and an access service providing the information on the current state of the "world". It is used to inform users and other application components when specific events are recorded in other components and whenever a new WS is available.

- Data Integration BB
  is used to access the geospatial data of the various WSs, such as terrain elevation, buildings and population whereabouts. This BB is also used to publish the geospatial results of the coastal submersion model, population and the evacuation models.

- Simulation Model Integration BB
  simplifies the task of CRISMA-enabling simulation models so that they can participate in a CRISMA application. In this application, the simulation model BB has been used to connect the existing TELEMAC-MASCARET (inundation) and LSM2D (evacuation) models as well as to realise the CRISMA-aware dykes vulnerability model (written in Python) and

population exposure model (realised using the existing AIT EMIKAT platform).

- Costal Submersion Model
  is a 2D-hydrodynamic model. The realisation of this BB is based on the open source TELEMAC-MASCARET system. It provides the time and space dependent hydrodynamic characteristics (e.g. water levels, velocities, discharges) in this application.

- Population exposure model
  uses temporal and spatial proxies in order to disaggregate the population from administrative units to spatio-temporal grids. In this application, the generic population exposure model has been adapted to the situation in the coastal submersion domain.

- Dykes vulnerability model
  is used to calculate the potential statistical impact on dykes depending on their status. This allows application users to make an informed choice on dyke breach or failure for local simulation. The model is based on the damage probability matrix and realised in Python.

- Evacuation model for coastal submersion
  is based on the commercial Life Safety Model 2D (LSM2D) model. For demonstration purposes, this model was used to simulate the evacuation in the 'Les Boucholeurs' area of the Charente-Maritime. This was one of the most impacted zones during the Xynthia storm surge.

The GUI of the application consists of the following “views”:

- GIS View BB
  is a user interaction BB that enables the visualisation and manipulation of geospatial data. It is used to display the results of the simulation models and for manipulating WSs.

- Simulation Model Interaction View BB
  is a Composite UI Module that lets end users interact with the various simulation models connected with a Simulation Model Integration BB. In this application, the simulation model interaction view is used to list all available processes (model runs) as well as to configure, execute and monitor each Simulation Model.

- Worldstate View BB
  visualises Control and Communication Information Module (CCIM) related to WSs and WS transitions. This view allows the user to discover, visualise and manipulate the different WSs of the coastal submersion defence scenarios.

- Multi-Criteria Analysis and Decision Support View
  allows users to map indicators (e.g. flooded area, number of flooded houses, economic impact) into criteria, define decision strategies, and

finally rank the different scenarios with respect to specific criteria and strategy combinations.

6.2.3 Usability and transferability

The French coastal submersion defence application demonstrates the usage of the CRISMA Framework in long-term planning applications. The application incorporates realistic population, terrain and infrastructure (e.g. dykes, roads) data, and hydrologic and economic impact models. This allows the decision makers to:

- Identify the areas with a high risk of flooding
- Analyse the impact of various long-term measures (e.g. improving dykes, resettling population) on the flooding risk
- Estimate the feasibility of the evacuation and temporary sheltering of the endangered population
- Compare the human and economic impacts of different long-term planning and investment strategies.

Like all CRISMA applications, the coastal submersion defence application could, in principle, be used in any coastal area.

6.3 Earthquake and forest fire application

The Italian "earthquake and forest fire" CRISMA application simulates a natural disaster with irreversible damages. It implements the "earthquake and forest fire" usage scenario (Chapter 3.3). The L'Aquila region, which suffered severe seismic impact after the 2009 earthquake, is the basis for this scenario. The possibility to have a series of earthquakes in the same region is considered and also possible cascading events such as forest fires are simulated.

The possibility to quantify the impact and compare alternative scenarios corresponding to different decision-maker choices is not trivial, and the CRISMA solution for the earthquake and forest fire application facilitates it. Also, the consequences of "low probability/high impact" cascading events are difficult to evaluate, and usually not taken into account by the crisis managers. The Italian application illustrates how such events can be modelled and the resulting knowledge incorporated in the crisis management planning.

6.3.1 Application logic

This application presents the critical issues for decision making in preparing for earthquakes or for the actual management of a seismic crisis. It helps the decision-makers by simulating the possible consequences of their decisions in a number of intervention/no-intervention scenarios, also corresponding to different possible adverse event propagation (cascading effects) evaluated in a multi-risk framework.

Once the administrator has performed the initial setup and data preparation for a given area, and the user has chosen a scenario, the application can be used for:

- Preparedness and planning: allowing the best distribution of resources
- Training: simulating intervention scenarios after an earthquake or during a forest fire
- Response: supporting decision-makers by providing alternative management policies
- Quantitative assessment of impact scenarios (simulated for alternative strategies):
  - Cost/benefit analyses
  - Multi-criteria analyses
  - Assessment of choices (in planning and/or emergency) on the basis of scenarios and cost/benefit analyses.

6.3.2 Implementation

The implementation architecture of the earthquake and forest fire application is shown in Figure 25.

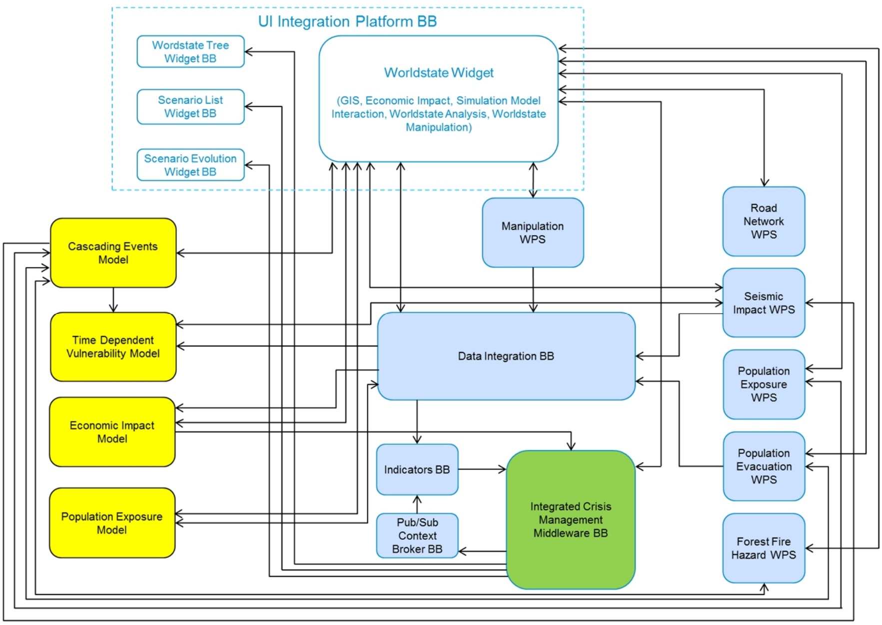


Figure 25. Application architecture of the “earthquake and forest fire” application.

In terms of the architecture, this application is quite similar to the coastal submersion defence application; they both use ICMM, publish/subscribe, data integration and model integration BBs, population exposure model, GIS view, WS view, simulation model interaction view, and the multi criteria analysis and decision support view, in a very similar way. Features specific to this application include:

- Indicators BB
  is used to calculate some simple economic indicators, in addition to human- and building- related indicators. For this reason, this application does not feature a dedicated economic impacts model.

- Building Impact Model
  provides assessment of expected damage on building classes due to earthquakes

- Earthquake Casualty Model
  provides assessment of expected number of injured and deaths due to an earthquake (casualty maps)

- Cascading Effects Model
  calculates the probability of attainment of cascading events scenarios, given an initial triggering event, or estimates consequence paths given the occurrence of selected scenarios

- Forest Fire Behaviour Model
  provides a 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 the local scale and wind field prediction at local and large scale taking into account different thermal and recirculation effects.

- Road Network Vulnerability Model (RNV)
  provides an assessment of probability of road link interruption due to earthquakes.

In this application, the reference implementation of the UI integration platform BB is used to host Composite UI Modules (User Interaction BBs) that are realised as HTML5 and JavaScript widgets. The UI integration platform BB supports the building of complex multi-view applications for the end-users. Specific for this application is also the independence from the UI Mashup Platform: views are realised by integrating the HTML5 widgets directly into the UI integration platform BB rather than first assembling them as a mashup.

Views that are specific to this application include:

- Scenario analysis and comparison view
  used to visualise indicators and criteria. This view helps the users analyse and compare different simulated scenarios.

- Cascade events configuration and interaction view allows the user to choose a path of analysis from a predefined cascading events scenario catalogue.

6.3.3 Usability and transferability

The “earthquake and forest fire” application demonstrates the usage of the CRISMA Framework for the simulation of natural disasters with irreversible damages. The aim is to provide a customisable, extensible and transferable example that allows the users to compare scenarios in a multi-risk framework including cascading events.

Compared to other CRISMA applications, the “earthquake and forest fire” application features a higher level of integration and more advanced tools for assessing the decision-making choices and possible consequences in each foreseen evolving scenario. In fact, the Multi-Criteria Analysis and Decision Support View (Figure 26), which has been specifically developed for this application, is re-used in almost all CRISMA applications today.

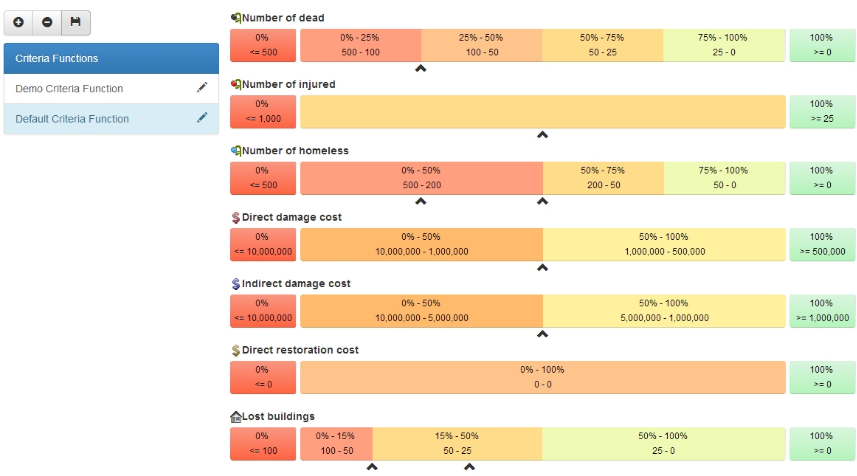


Figure 26. Multi-criteria analysis and decision support view – defining criteria function.

Similarly to the coastal submersion defence application, this application relies on accurate, tested and validated models of the earthquake, buildings, resources and population. The accuracy of the models is critical in long-term infrastructure planning and even more so when the application is used in the response phase.

Transfer to a new area is certainly possible, but the required effort is relatively high – especially compared to the next two applications.

6.4 Accidental spillage from a container at a large city port

The Israeli "accidental spillage" CRISMA application simulates a chemical incident in a densely populated area. It implements the "accidental pollution in urban area" usage scenario (Chapter 3.3). The main objective of this usage scenario is to teach the crisis managers how to react to these types of incidents.

The concrete application scenario is the one of accidental bromine leakage in the port of Ashdod. The scenario starts with a spillage from a container transporting bromine. In unfavourable meteorological conditions, the resulting plume could threaten up to 100,000 Ashdod inhabitants. Ashdod has a large cargo port and the probability of such an incident is non-negligible.

6.4.1 Application logic

This application deals with the management of casualties following a hazardous event in an urban setting. In our concrete training scenario, the incident affects one neighbourhood with a configurable number of victims that are suffering from bromine related intoxication in different degrees of severity.

The application features four distinct work steps. First, the administrator has to define the basic parameters of the training, such as the approximate area of the accident, types and quantity of the resources that are available in the nearby area and relevant nearby hospitals. This step is performed using the generic OOI management view (see Figure 27) and results in a site-specific, training template.

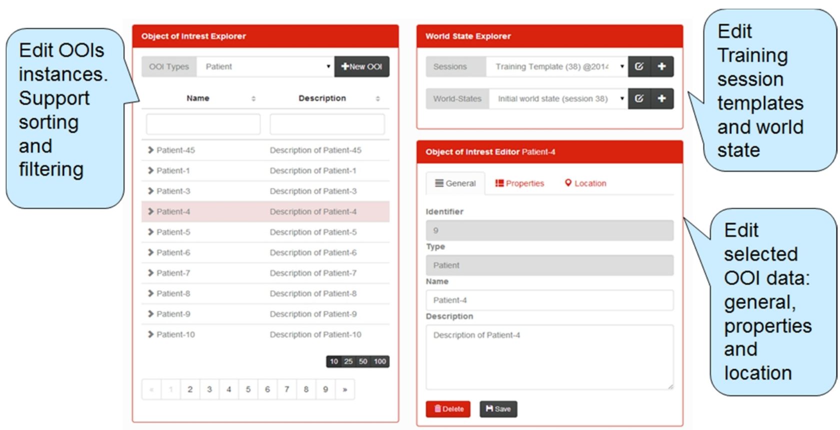
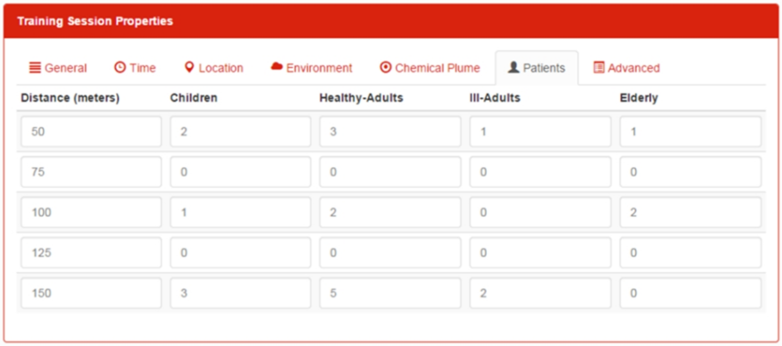


Figure 27. OOI management view – OOI instance and simulation management.

In the second step, the trainer uses the application-specific Scenario Setup View to name the training session and to set the concrete environmental parameters (day/night, rush-hour/empty streets, temperature, wind, etc.), plume-related parameters (plume centre, initial concentrations at various distances, dissipation rate, etc.), and parameters related to the postulated positions and types of the victims (see Figure 28).


Training Session Properties

General | Time | Location | Environment | Chemical Plume | Patients | Advanced

Distance (meters)	Children	Healthy-Adults	Ill-Adults	Elderly
50	2	3	1	1
75	0	0	0	0
100	1	2	0	2
125	0	0	0	0
150	3	5	2	0

Figure 28. “Accidental spillage” application – population setup view.

All functionalities used during the training are provided by the resource management training dispatch and monitor view (Figure 29).

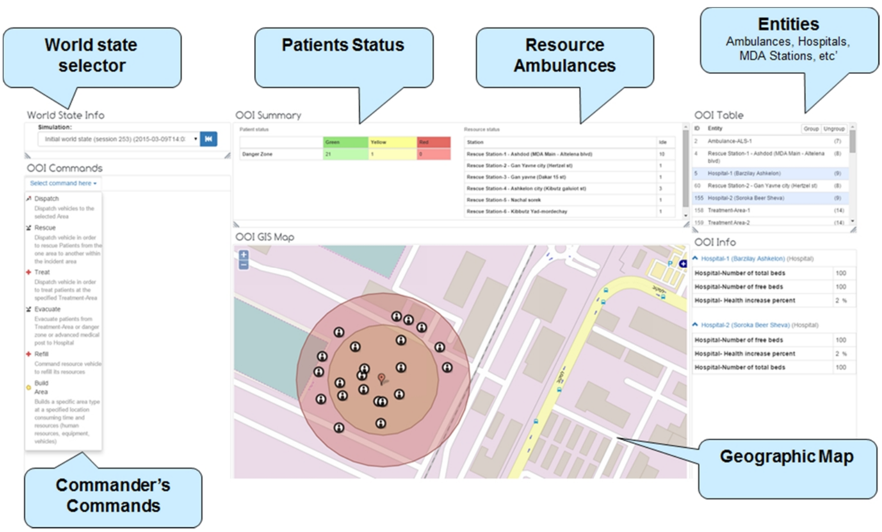


Figure 29. “Accidental spillage” application – training view.

The accident progress and final results can be analysed in several ways: firstly, by going back-and-forth in time using the WS selector in the training view (left-top corner in Figure 29); secondly by inspecting the indicators in the Resource Management Training Indicators and Statistics View (Figure 30), and finally by performing the multi-criteria analysis (see Chapter 4.4).

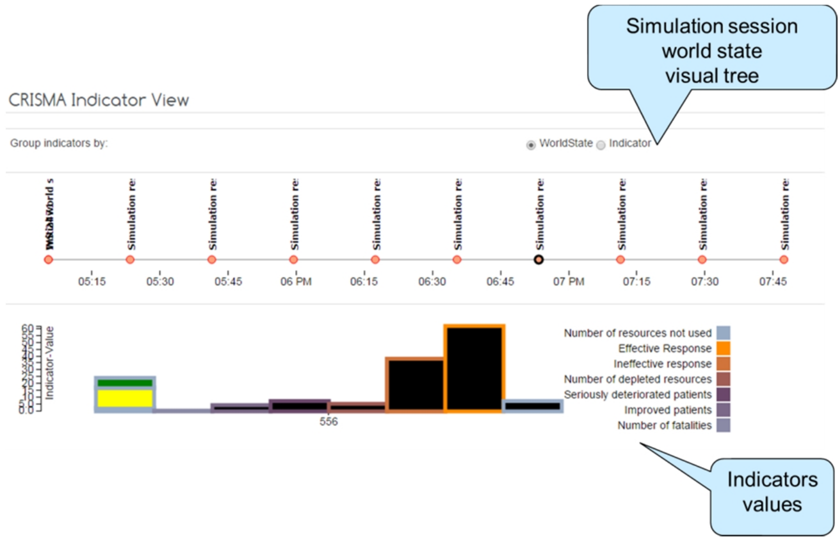


Figure 30. "Accidental pollution in the urban area" application – indicators view.

6.4.2 Implementation

The implementation architecture of the Israeli "accidental spillage" application is shown in Figure 31.

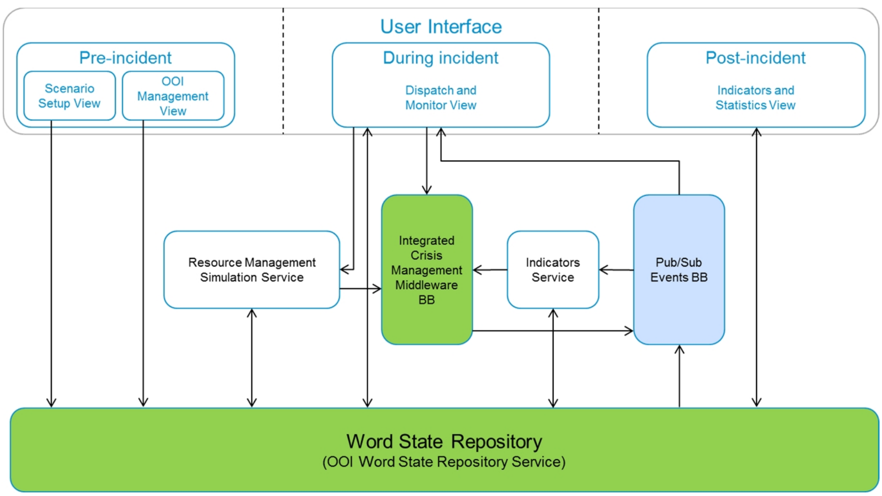


Figure 31. Implementation architecture of the "accidental spillage" application.

In terms of the architecture, this application is relatively simple. It consists of BBs like ICMM, publish/subscribe, OOI-WSR, indicators service, publish/subscribe context broker and the agent-oriented simulation models platform. They perform the same work as in other CRISMA applications, albeit with some differences:

- All simulation models used in this application (various resources, patients, plume) have been realised using the Agent-Oriented Simulation Models BB. Therefore, the model integration BB does not feature in the architecture diagram.
- Likewise, the data integration BB does not feature on the diagram because all the relevant data is stored in the OOI-WSR. The only exceptions are the background maps that are accessed through a standard web map service interface and used for illustration purposes only.
- In this application, the commands (simulation parameters) often remain active for several consecutive WS transitions. In order to assure that the simulation can be re-started from any of the previously generated WSs, the commands for individual agents are stored as a part of the WS.
- Models and indicator services are always triggered by “new WS available” events (issued through the pub/sub BB) and not by direct service calls. This simplifies the development since the model and GUI developer only need to agree on the form of the command.

Another interesting feature of this application is the use of the UI mashup platform BB as a main GUI for the application prototypes. All “views” defined in this application have been realised as web mashups. These mashup applications can be either used “as is” or embedded in existing web and desktop applications as HTML iframes.

6.4.3 Usability and transferability

The “accidental spillage” application demonstrates the usage of the CRISMA Framework for the decision support of the commanders. It provides an interactive model of the large-scale chemical accident and assures that the impact of the decisions taken by the trainees is realistic in a sense that the impact is guided by the natural laws and peculiarities of the training setup. The application can enhance the desktop trainings by assuring the dynamic aspects of the crisis management are correctly taken into account. For example:

- Only a limited number of resources are available in the neighbourhood
- The time required for all operations (including resource arrival to the scene) is realistic according to the training situation
- Rescuers and other resources have to rest or resupply after a while
- State of the simulated victims changes over time. The speed and direction of these changes depends on the victim’s history (contamination, decontamination, treatment).

- Particularly badly poisoned victims can only survive if given timely treatment.

This application presents the commanders with a "result" of their previous decisions by simulating the evolution of the situation (e.g. medical condition of the patients) based on the environmental conditions (concentration of the contaminant), the time elapsed, the resources acting on the scene, and baseline condition of the victims. The playback and analysis functionality of CRISMA allows the commanders to go back in time, take another course of action, and compare the results of the different decisions taken. The goal of the training is to improve the cooperation and coordination of all involved stakeholders and especially their decision-making capacity. Through this, the potential ability to respond to unexpected events is significantly improved.

Compared to other CRISMA applications, the “accidental spillage” application features a far more interactive usage scenario. The Israeli application, together with the Finnish and German applications, also place a higher emphasis on time as a critical factor in crisis management (Chapters 6.1 and 6.5, respectively).

The models of patients and resources that are used in this CRISMA application are very generic and configurable. Moreover, the application requires no complex area-specific models. However, some modifications may be needed to reproduce the peculiarities of the crisis management practices of the target area.

6.5 Mass-casualty incident

The German CRISMA application focuses on resource planning for mass accidents. It implements the “mass-casualty site” usage scenario (Chapter 3.4).

A Mass-Casualty Incident (MCI) is an emergency with a large number of injured or affected persons that cannot be managed with regular emergency medical services (DIN13050 2009[6]). These types of accidents overwhelm the local first responders. Two examples:

- A train/truck collision with 33 injured passengers occurred near Stuttgart on the 4th of July 2014
- A bus/bus/minibus collision with nine fatalities and 44 injured passengers occurred near Dresden on the 19th of July 2014.

Creating resource deployment plans for MCIs is challenging for local first responder organisations because these types of accidents demand the efficient deployment of large amounts of resources in a very short time, and the competent coordination between deployed resources. The resource planning must also typically be performed across existing administrative boundaries, and even in cooperation with neighbouring districts (German Red Cross 2012[7]).

[6] http://de.wikipedia.org/wiki/DIN_13050 last visited 8.5.2015.

[7] http://redcross.eu/en/upload/documents/pdf/2012/Annual_Reports/German%20RC_Annual_Report2012.pdf

6.5.1 Application logic

This application implements two distinct workflows – “exercise support” and “resource planning simulation”. Each of them is supported by a separate piece of CRISMA software.

The “exercise support” application simplifies the task of evaluating the results of field exercises. It provides information about (pre-)triage, care measures and evacuation. Additionally, information on spatial planning and dispatches of vehicles at the site is collected. By choosing this patient—addressed approach, this application is applicable under all circumstances and with various exercise scenarios.

The information captured during the exercise can be used in exercise debriefing and results assessments. More importantly, the related key performance indicators, such as the “pre-triage duration per patient” can also be used to calibrate the models used in the second (planning) application.

The “resource planning simulation” application is more complex. On the whole, this application is very similar to the resource management training support application, but the decisions about which resources to deploy (and how) are made by the Resource Allocation Tactic Model, according to user-defined tactics**.** Each specific tactic is configurable by the user in three steps: (1) set tactical areas (treatment, staging, loading and advanced medical post) on the map; (2) decide which resources to ask for and when; and (3) decide on the maximal resource allocation for each of the tasks, as well as on the relative priorities of the tasks. The simplest possible tactic is illustrated in Figure 32.

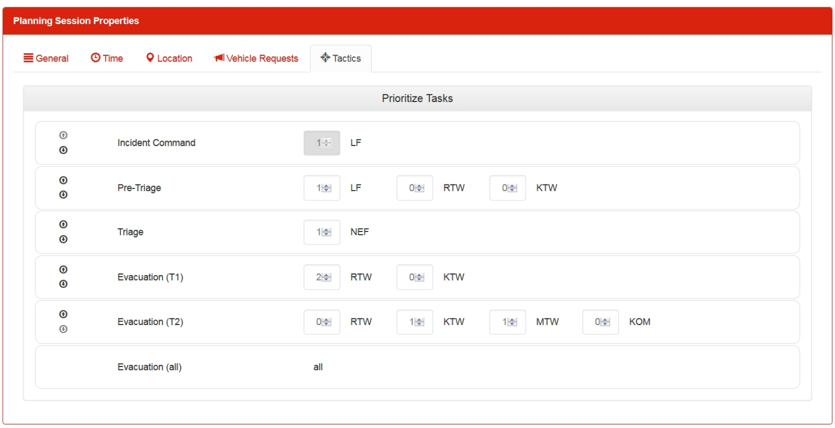


Figure 32. “Resource planning simulation” application – task prioritisation. LF, RTW, KTW, NEF, MTW and KOM represent standardised resource types used by the German Red Cross.

In this example, no treatment area has been defined and therefore no treatment-related options appear in the “tactics” tab. Pre-triage and triage are prerequisites for any further work and the tactics can thus only be adjusted by manipulating the following parameters:

- Number and type of vehicles assigned to each of the tasks
- Prioritising the evacuation of red patients (normal procedure) or yellow patients (e.g. in case the number of victims is large and hospitals are so far away that red patients can't be saved and yellow patients might perish).

The application is aware of the capabilities of the standardised resource types as well as of the standard tactics for their use. For example, the rapid response vehicle (NEF) is the only vehicle with an emergency physician on board and therefore the only resource that can be assigned to triage. Likewise, the emergency ambulance (RTW) is pre-assigned to patients with life-threatening injuries (T1) by the application, whereas the patient transport ambulance (KTW) is pre-assigned to the patients with less serious injuries (T2).

This application uses exactly the same patients and ambulance models as the "accidental spillage" application. Consequently, the WSs generated by the planning application have the same structure as the ones generated by the Israeli "accidental spillage" application (Chapter 6.4) and could be analysed in the same way: (1) by going back-and-forth in time using the WS selector in the training view, (2) by inspecting the indicators in the resource management training indicators and statistics view, and (3) by performing the multi-criteria analysis (see Chapter 4.4). Since this application emphasises the timings of various activities, the indicators and statistics view has been adjusted accordingly (Figure 33).

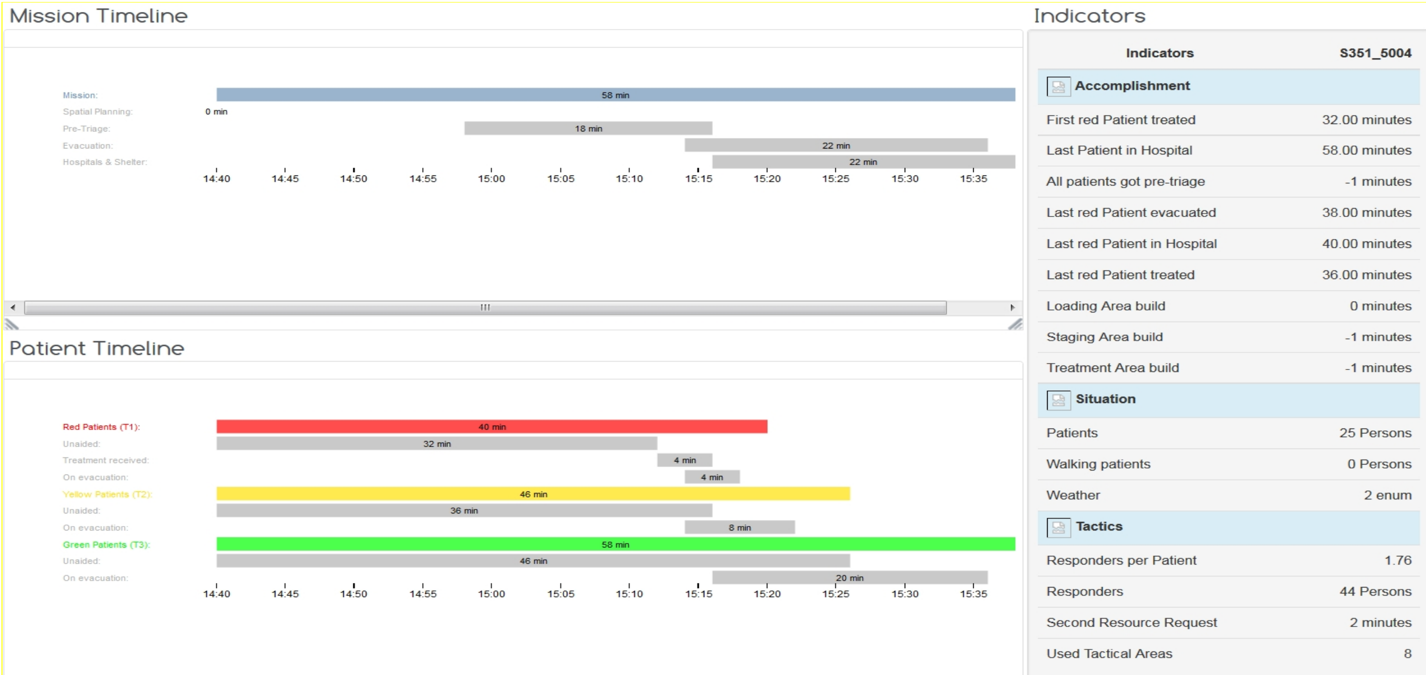


Figure 33. “Resource planning simulation” application – indicators and statistics view.

6.5.2 Implementation

As mentioned in the previous Chapter, this application is realised through the "exercise support" and "resource planning simulation" (sub-)applications. The application architecture of the "resource planning simulation" application is shown in Figure 34.

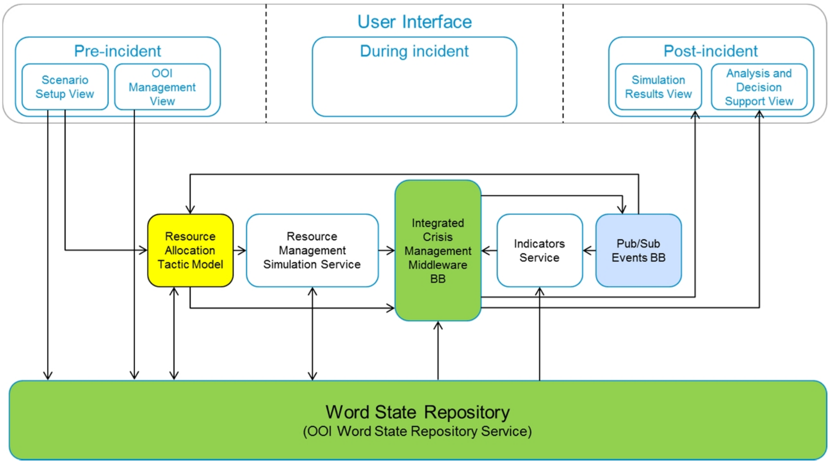


Figure 34. Application architecture for "resource planning simulation" application.

In terms of the architecture, the resource planning application is very similar to the "accidental spillage" application. The ICMM, publish/subscribe, OOI-WSR, indicators service, publish/subscribe context broker, and the agent-oriented simulation models platform BBs are used in the same way, and the two applications even share the same agent models for resources and patients.

A main difference between the two applications is their usage modus: while the Israeli application provides an interactive training mode, this one concentrates on planning and therefore does not feature the "dispatch and monitoring view". The role of the user, who decides which resources to allocate to what tasks (and when), is played by the Resource Allocation Tactic Model, and the scenario setup view of this application has been adjusted accordingly.

The architecture of the reference application for exercise support is even simpler. This application does not require any simulation models and it features only four server-type BBs: ICMM, OOI-WSR, indicators service and the publish/subscribe context broker. Likewise, the application only features two UI views: one for setting up the exercise and collecting the measured inputs from the field (capture view), and another for assessing the results (debriefing and multi-criteria analysis views).

The user interfaces of both applications have been realised as web mashups on top of the UI mashup platform BB. The user interface main views of the two applications were already introduced in the previous section.

6.5.3 Usability and transferability

The "mass casualty incident" application demonstrates the usage of the CRISMA Framework for resource planning. The accompanying exercise support application facilitates the planning, recording and assessment of first responders' activities during such accidents, mainly with respect to the time required for pre-triage, triage, on-site care and (start of) evacuation of the critically injured patients to hospital.

The application can enhance the planning process by calculating the probable outcome of the action with respect to the accident severity, geographic location and the tactics chosen by the user.

Similarly to the "accidental spillage" application (Chapter 6.4), this application is designed with transferability in mind: in resource management models, for example, patients and ambulances are designed to be very generic and the site- and experiment-specific features, such as ambulance capabilities, type and severity of the injuries are introduced in the application as model parameters. These parameters are determined at exercise-planning time and entered into the system by the end-users. In fact, the two applications were designed to showcase the transferability of the CRISMA applications: they share most of the code, resource models and the WS structure. Consequently, it would be relatively easy to add "mass-casualty incident" to the Israeli resource management training application and "accidental spillage" to the German resource management planning application.

However, the application relies on the availability of the correct information on hospitals, ambulance stations and resources, and some application features have been hard-coded to reflect the German Red Cross organisation.

7. Conclusions

Today, crisis managers and other decision-makers are more and more likely to face large-scale crisis situations that would exceed the capacity of any local crisis management. Natural and man-made disasters do not respect regional or national boundaries, nor are their consequences solely the responsibility of a single organisation. To prepare for these kinds of challenges, decision-makers need a better understanding of the crisis impacts, as well as the availability and benefits of multi-organisational and multi-national cooperation.

CRISMA has been developed to enable crisis managers and other stakeholders model and simulate complex crisis scenarios and alternative response and mitigation actions in a realistic way. Five very different test cases have been used to assess, and further develop, the CRISMA methodology and software. CRISMA can be used to address the large range of challenges encountered in the preparedness phase of the crisis management, like: regional, land-use and infrastructure planning on a long-term basis; contingency planning; optimisation of the operative crisis management plans; support for the preparation, execution and assessment of the results of the desktop and field exercises.

The CRISMA Framework has been built to provide an environment that enables building up one's own crisis scenarios and integrating both new and legacy models and tools into the one simulation system. The adaptability of the CRISMA Framework architecture and building blocks has been achieved by choosing an open approach. In CRISMA, much of the core framework functionality is served by open source software, which can however easily be replaced by alternative implementations of the same functionality if and when necessary. Also other CRISMA-specific core components, such as the Integrated Crisis Management Middleware and the Object Of Interest World State Repository, are based on existing open source products. The CRISMA Framework implementation has also been designed to anticipate future technological changes, e.g. by accommodating several types of web services (e.g. OGC-Style, REST). And the modular design allows future developers to add new building blocks when needed, either in open source or closed source, in line with one's own business model.

With the CRISMA Framework, crisis managers and other decision-makers are offered possibilities to combine models, data and expertise from many different sources, for creating a wider perception of crisis scenarios and alternative preparedness, response and mitigation actions. Impact comparison and visualisation improves multi-organisational cooperation and communication with other stakeholders and the public.

The CRISMA methodology and software support equally: (1) the crisis managers in adapting only a small part of the new crisis management tools and methods; (2) researchers and companies that are eager to prove that their results are best suited for a specific task; and (3) all public investments, which have to be transparently justified.

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Appendix A: CRISMA abbreviations

ADAI	Associacao para o Desenvolvimento da Aerodinamica Industrial, CRISMA partner
AEE	ARTELIA eau & environnement, CRISMA partner
Airbus	Airbus Defence and Space GmbH, CRISMA partner (former EADS)
AIT	Austrian Institute of Technology GmbH
AMRA	AMRA – Analisi e Monitoraggio del Rischio Ambientale S.c.a.r.l., CRISMA partner
API	Application Programming Interface
BB	Building Block
BPEL	Business Process Execution Language
CA	Consortium Agreement
CCI	Control and Communication Information
CCIM	Control and Communication Information Model
CIS	cismet GmbH, CRISMA partner
CM	Crisis Management
CRISMA	The FP7 project, “Modelling Crisis Management for Improved Action and Preparedness”
DRK	Deutsches Rotes Kreuz e.V., CRISMA partner
DS	Decision support
DSS	Decision Support System
EADS	see *Airbus*
ESB	Enterprise Service Bus
ESC	Pelastusopisto, Emergency Services College, CRISMA partner
FMI	Finnish Meteorological institute, CRISMA partner
FRA	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V., CRISMA partner
FTX	Field Training Exercise
GIS	Geographic Information System
GUI	Graphical User Interface
HLA	High-level architecture

HTTP	Hypertext Transfer Protocol
ICMM	Integrated Crisis Management Middleware
ICMS	Integrated Crisis Management Simulation System
INS	Insta DefSec Oy, CRISMA partner
KPI	Key Performance Indicator
LSM2D	Commercial Life Safety Model 2D
MCI	Mass Casualty Incident (MANV in German)
MDA	Magen David Adom, CRISMA partner
NICE	Nice Systems Ltd., CRISMA partner
OGC	Open Geospatial Consortium
OOI	Object of Interest
OOI-WSR	Object of Interest-World State Repository
Open-MI	Open Modelling Interface
OWA	Ordered Weighted Average
PSCE	Public Safety Communication Europe Forum AISBL, CRISMA partner
REST	Representational State Transfer
RM	Resource Management
RNV	Road Network Vulnerability
RPD	Recognition Primed Decision
SaaS	Software as a Service
SOA	Service Oriented Architecture
SOA-RM	Reference Model for Service Oriented Architecture
SOAP	Simple Object Access Protocol
SOS	Sensor Observation Service
SP	Sub-Project
SPB	Spacebel SA, CRISMA partner
SPS	Sensor Planning Service
SUMMIT	Standard Unified Modelling, Mapping & Integration Toolkit
SWE	Sensor Web Enablement
TDV	Time Dependent Vulnerability

TTU	Tallinna Tehnikaülikool, CRISMA partner
UI	User interface
VTT	Technical Research Centre of Finland Ltd, CRISMA coordinator
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service
WPS	Web Processing Service
WS	World State
WSR	World State Repository
XML	Extensible Markup Language

Appendix B: CRISMA glossary

Acceptable risk

Degree of human and material loss that is perceived by the community or relevant authorities as tolerable in actions to minimise disaster risk.

Access control

The ability to enforce a policy that identifies permissible actions on a particular resource by a particular subject. (SANY-SA. 2009. SANY Consortium, Specification of the Sensor Service Architecture V3, SANY public deliverable, http://www.sany-ip.eu, November 2009)

Accident

A sudden event in which harm is caused to people, property or the built or natural environment.

Accident rate

The number of reportable accidents related to the number of persons working, or the total number of hours worked, or to units, produced in an installation, company, etc. This enables, within limits, a comparison of the safety performance of various installations, companies, etc. provided exactly the same definitions for the accident rate are used.

Adaptation

The adjustment in natural or human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities. This can be specific for climate change (United Nations Framework Convention on Climate Change UNFCCC), but also apply for other challenges such as soil erosion, migration and structural economic changes. Adaptation can occur in autonomous fashion, for example through market changes, or as a result of intentional adaptation policies and plans.

Advanced visualisation

Tools and models that rely on relevant/new/extraordinary visualisation pat-terns or rely on user interaction concepts that seem to be relevant for CRISMA. This includes geographical displays (e.g. Geographical Information Systems, GIS).

Affected area

Area under the consequences of the impacts predicted by the scenario.

Aftershock

A smaller earthquake that follows the main shock and originates close to its focus. Aftershocks generally decrease in number and magnitude over time.

Agent

A kind of "autonomous" and “active” OOI that does have control over its behaviour, can act in the environment, perceive, and reason.

ALARA principle

A risk should be reduced to a level this is As Low As Reasonably Achievable. (Aven, T. & Renn, O. 2010. Risk Management and Governance: Concepts, Guidelines and Applications. Heidelberg / New York: Springer, cop.)

Alarm

Signal giving warning of danger.

Alert

Advisory that hazard is approaching but is less imminent than implied by warning message.

Algorithm

Effective method (formula) expressed as a finite list of well-defined parameters for calculating a cost function (direct or indirect).

ALOHA

ALOHA is an existing tool for plume dispersal. (www.chemicalspill.org/OffSite/aloha.html)

Ante-normalisation phase

Variable duration phase after the end of the event that can be considered finished when all the physical and chemical parameters are again normalised.

Application

See *CRISMA application*

Application architecture

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.

Application programming interface

An application programming interface (API) is a protocol intended to be used as an interface by software components to communicate with each other. (See: http://en.wikipedia.org/wiki/API last visited 8.5.2015).

Architectural approach for multi-sectoral application

Architectural approaches to building crisis information management systems that address several sectors within and beyond crisis management and emergency response. Especially broad user groups and application areas within the domain characterise multi-sectoral applications for emergency response.

Architecture

In computer science and engineering, computer architecture is the art that specifies the relations and parts of a computer system. (See: https://en.wikipedia.org/wiki/Computer_architecture last visited 8.5.2015).

Ash/rubble cleaning-up cost

Related to the activities provided for removal and disposal of ash/rubble from roads, buildings and other structures.

Attribute

A characteristic of an entity (e.g. of an object in a model or the model itself).

Authentication

Concerns the identity of the participants in an exchange. Authentication refers to the means by which one participant can be assured of the identity of other participants. (SOA-RM. 2006. OASIS Reference Model for Service Oriented Architecture 1.0. Committee Specification 1, 2 August 2006)

Authorisation

Concerns the legitimacy of the interaction. Authorisation refers to the means by which an owner of a resource may be assured that the information and actions that are exchanged are either explicitly or implicitly approved. (SOA-RM. 2006. OASIS Reference Model for Service Oriented Architecture 1.0. Committee Specification 1, 2 August 2006)

Back home cost

Related to the activities provided for the "back home" of the population evacuated from the emergency area.

Behavioral scenario

A kind of model that explains how the goals set for the socio-technical system (e.g., the ICMS) can be achieved by actors of the socio-technical system. Behavioral scenarios are used to elaborate goal models. They specify the order of achieving the sub-goals and the roles and resources required for that, as well as the output resulting from achieving the sub-goals. (Sterling, L. & Taveter, K. 2009. The Art of Agent-Oriented Modeling. Cambridge, MA: MIT Press.) In CRISMA, a behavioral scenario describes the sequence of activities required for accomplishing the goals, roles involved in that, as well as the resources used as input and knowledge produced as output for a specific activity.

Building block

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.

Business goal

A business goal captures the reasoning why the system is applied from an economical view. Business goals therefore decribe one aspect of a potential return-on-investment of the overall-system CRISMA. Business goals therefore stem from deciders on strategic levels and can be used as selling-points towards authorities later on. (V-Model XT, http://v-modell.iabg.de/v-modell-xt-html/)

Business interruption cost

The loss of profits and continuing expenses resulting from a break in activities due to a crisis.

Business logic

A technical approach to represent situations and transitions between situations in the upper meaning. No separation between world, incident, response situations. A situation (x, t) is called "world state" (including time series).

Business Process Execution Language

Business Process Execution Language (BPEL), short for Web Services Business Process Execution Language (WS-BPEL) is an OASIS standard executable language for specifying actions within business processes with web services. Processes in BPEL export and import information by using web service interfaces exclusively. (http://en.wikipedia.org/wiki/Business_Process_Execution_Language last visited 8.5.2015)

Capability

Capability can be viewed as the ability to perform actions.

Capacity

Capacity is the combination of all the strengths, attributes and resources available within a community, society or organisation that can be used to achieve agreed goals. Capacity may include capabilities such as infrastructure and physical means, institutions, societal coping abilities, as well as human knowledge, skills and collective attributes such as social relationships, leadership and management.

Cascade effects

Cascade effects describe the effects (consequences) of cascade events and thus allow to evaluate indirect effects caused by the originating incident.

Cascade events

Cascade events describe a sequence of adverse events generated by a single or different sources. For example an earthquake that causes ground motion that triggers a landslide.

Cascading effects

see *Cascade effects*

Catalogue

CRISMA Catalogue is a wiki-like web application and can be accessed through https://crisma-cat.ait.ac.at/ (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 a integral part of the Catalogue.

Chemical accident

Accidental release occurring during the production, transportation or handling of hazardous chemical substances.

Civil defence

The system of measures, usually run by a governmental agency, to protect the civilian population in wartime, to respond to disasters, and to prevent and mitigate the consequences of major emergencies in peacetime. The term "civil defence" is increasingly used.

Command Post Exercise

Command Post Exercise, training exercise that may be conducted in base or in the field, an exercise, in which the forces are simulated, involving the commander, the staff, and communications within and between headquarters.

Communications' facilitation

This concept is demonstrated by tools designed to facilitate communications between actors during incident management. For the purpose of rapid and precise exchange of information in crisis situations, communications' facilitation has to provide fault tolerant and reliable communications channels. These may include landline, internet, radio communication, etc. Communication tools must be able to automatically compile and send important information to collaborators.

Conceptual business logic

In CRISMA the role of the conceptual business logic is to describe the key concepts of crisis management simulation, the analysis of simulation results and decision support. The logic represents an analysis viewpoint meaning: rather than looking at the "real" evolvement of a crisis the logic focuses on the Path of

Analysis of a crisis management simulation that offers well defined possibilities to interfere and modify a simulation.

Conceptual model

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.

Conceptual model for economic evaluation

A framework which determines at the general level a structure and ideas of economic evaluation process in CRISMA before the prototype is defined.

Constituent

Element (Software Component) of a CRISMA Application

Context of use

In the human-computer interaction discipline, the context of use is the setting within an interaction takes place in terms of user characteristics, environmental conditions, and tasks.

Control and Communication Information Model

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.

Coping capacity

The ability of people, organisations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters. The capacity to cope requires continuing awareness, resources and good management, both in normal times as well as during crises or adverse conditions. Coping capacities contribute to the reduction of disaster risks. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 pp)

Cost breakdown structure

A hierarchical structure which includes all cost items relevant to the current case and divides larger cost items into smaller and more concrete cost parameters which are easier to give a monetary value.

Cost-benefit analysis

An evaluation method to determine the feasibility of a project/plan/investment (for example a mitigation measure) by quantifying its costs and benefits to help to make a decision.

Cost-effectiveness

Cost – effectiveness can be calculated by using a ratio by dividing costs of an investment (e.g. mitigation measure) by units of effectiveness. For a mitigation measure, the number of lives saved would be an obvious unit of effectiveness.

Cost-efficiency

The act of saving money by performing an activity in a better way. The cost efficiency of a mitigation measure is largely based on the avoidance or reduction of negative consequences of a crisis.

Crisis

A crisis (from the Greek κρίσις – krisis; plural: "crises"; adjectival form: "critical") 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 loosely, it is a term meaning an 'emergency event'. (http://en.wikipedia.org/wiki/Crisis last visited 8.5.2015)

Crisis management

The process by which an organisation deals with a major event that threatens to harm the organisation, its stakeholders, or the general public. (http://en.wikipedia.org/wiki/Crisis_management last visited 8.5.2015)

Crisis management cycle

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 "Preparedness", "Response", "Mitigation" and "Recovery" phases. Within EU, the "Mitigation" phase is often replaced by "Prevention".
(http://securipedia.eu/mediawiki/index.php/Crisis_management_cycle)

Crisis management phases

See *crisis management cycle*

Crisis management simulation analysis

Comparison and analysis of different World States, Alternatives and related Transitions enables crisis managers to explore the effects of changes in mitigation strategies affecting vulnerabilities based on related World State Data. In CRISMA this Crisis Management Simulation Analysis has three variants: The assessment of planning options, training i.e. the education of stakeholders, decision support for crisis management activities.

For each of the three variants CRISMA supports Crisis Management Simulation Analysis on three levels: (1) Exploration of World State Data, (2) Comparison and assessment of aggregated data. (3) Algebraic Comparison that enables e.g. ranking.

Crisis management simulation integration approach

An approach towards the integration of several simulations/models in order to support crisis management. Other tasks within crisis management (e.g., resource management) may also be fulfilled within this kind of approach (e.g., by an integrated database to administer resources).

Crisis management simulation system

A system for simulating possible impacts on crisis management resulting from alternative actions and decisions.

Crisis scenario

A scenario describing a crisis as it has happened or could happen in real life.

CRISMA application

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).

CRISMA developer

A person that realises a CRISMA application with support of the CRISMA framework.

CRISMA end-user

A person that either uses a CRISMA application directly within a use case or is a stakeholder who gains insights from another person using a CRISMA application for simulation runs.

CRISMA expert

A person that uses either a configuration file or a CRISMA application to prepare a simulation case.

CRISMA federate

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.

CRISMA federation

A number of CRISMA Federates that act together as a unit. A CRISMA Federation is a subset of a CRISMA Application.

CRISMA framework

A framework composed of ready-to-use Building Blocks and supporting tools that can be connected together to form a CRISMA Application.

CRISMA impact

CRISMA impact is the expected outcome and effect of CRISMA project. Also see *impact.*

CRISMA setup expert

A person that uses either a configuration file or a CRISMA application to prepare a simulation case.

CRISMA system

In the perception of the architecture, the CRISMA System is the overall project results consisting of all CRISMA Applications.

Criteria

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.

Criteria function

A Criteria function maps an indicator to a criterion.

Damage classification

Evaluation and recording of damage to structures, facilities, or objects according to three (or more) categories, such as: 1. "severe damage" which precludes further use of the structure, facility, or object for its intended purpose. 2. "moderate damage" or the degree of damage to principal members, which precludes effective use of the structure, facility, or object for its intended purpose, unless major repairs are made short of complete reconstruction. 3. "light damage" such as broken windows, slight damage to roofing and siding, interior partitions blown down, and cracked walls; the damage is not severe enough to preclude use of the installation for the purpose for which was intended.

Damage cost

Includes both costs of direct physical damages as well as indirect and secondary impacts arising from a crisis.

Data management

Data management encompasses the management of information about crisis management resources and other objects of interest. This concept is demonstrated by tools that provide access to a database relevant for crisis management.

Database of scenarios

A collection of plausible scenarios of cascading effects.

Decision making

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.

Decision node

Element of a decision tree which represents a decision (e.g., to assess different possible mitigation actions) to be taken in a particular segment of a decision tree.

Decision point

A point in time where the user wants to introduce a decision to compare what will be the outcome of different options. In CRISMA, visualisation is done on a time line to show where a decision has been met.

Decision support system

Decision Support Systems (DSS) make up a specific class of computerised information systems that support business and organisational 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.

Decision tree

A time line with branches showing options in each decision point. Not only useful as visualisation of decisions but also for navigation to compare different states at the same or different time stamps.

Decision-making process

The process of examining possibilities and options, comparing them, and choosing the way of action.

Demonstration

A demonstration presents relevant aspects of a CRISMA demonstrator at a specific place and date to a specific audience within a specific pilot.

Demonstrator

A demonstration presents relevant aspects of a CRISMA demonstrator at a specific place and date to a specific audience within a specific pilot.

Developer

see CRISMA developer

Development platform

Software development platforms are technologies that support application developers in developing simulation models and tools for crisis management.

Direct cost

The costs of consequences of the initial crisis situation that will be felt immediately.

Disaster

A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 pp)

Disaster risk management

The systematic process of using administrative directives, organisations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster. Disaster risk management aims to avoid, lessen or transfer the adverse effects of hazards through activities and measures for prevention, mitigation and preparedness. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 pp)

Economic evaluation

The comparative analysis of alternative courses of action in terms of both their costs and consequences (monetary values) in order to assist decisions. A monetary i.e. financial evaluation method. In CRISMA a method to estimate the costs (and benefits) of a crisis and to evaluate the costs and benefits of different mitigation measures over a time span.

Economic evaluation method

A monetary i.e. financial evaluation method. In CRISMA a method to estimate the costs (and benefits) of a crisis and to evaluate the costs and benefits of different mitigation measures over a time span.

Economic impact

Crisis impacts that are generally described in terms of direct and indirect costs (and benefits). Comprising both economic impacts of a baseline situation and a situation after implementing a mitigation measure or a set of measures.

Elements at risk

Population, buildings and engineering works, infrastructure, environmental features, cultural values and economic activities in an area potentially affected by an event (e.g. landslide).

Emergency

Any incident, whether natural, technological, or human-caused, that requires responsive action to protect life or property. (FEMA Glossary. 2013. http://emilms.fema.gov/IS700aNEW/glossary.htm#F)

Emergency and rescue operation cost

Any cost related to assistant or intervention during or immediately after a crisis to meet the life preservation and basic subsistence of those people affected.

Emergency management

The organisation and management of resources and responsibilities for addressing all aspects of emergencies, in particular preparedness, response and initial recovery steps. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 pp)

Emergency management cost

Related to the activities and to the units engaged in the emergency phase as operating structures, vehicles, equipment, and volunteers. For example, the cost related to the number of men committed in each operating structure to manage the emergency.

End user

see *CRISMA end-user*

Enterprise Service Bus

Enterprise Service Bus (ESB) is a software architecture model used for designing and implementing the interaction and communication between mutually interacting software applications in service-oriented architecture (SOA). (See: https://en.wikipedia.org/wiki/Enterprise_service_bus last visited 8.5.2015).

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).

Evacuation assistance cost

Related to the activities provided for giving continuous assistance to the population evacuated from the emergency area.

Evacuation operation cost

Related to the activities provided for the evacuation of the population from the affected area, according to the specific needs included in the individual municipal plans.

Event

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

Evolution scenario

A combination of several impact scenarios resulting from multiple hazards/incidents.

Ex-ante

Something taking place before the event in question.

Ex-post

Something taking place after the event in question.

Exercise

An exercise can be a field training exercise (real ambulances and responders in a training setting) or a simulation exercise (planning or training session using information system support).

Experimentation

Experimentation in CRISMA asks the audience for a specific interaction with a CRISMA demonstrator. It aims at testing if the target audience is able to interact with the CRISMA application and to interpret the result. It aims also at evaluating the quality of the added value of the application for the audience's specific needs.

Expert

see *CRISMA expert*

Exposure

People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 pp)

Extensible Markup Language

Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. (See: http://www.w3.org/TR/xml/).

External uncertainty

Extrinsic uncertainty means for the decision maker there are always gaps between the knowledge required to responding to the crisis and knowledge acquired.

Extrinsic uncertainty

See *External uncertainty*

Feature

A "Feature" (ISO 19101. 2002. Geographic information -- Reference model. International Organization for Standardization; OGC 08-126. 2009. Kottman, C. & Reed, C. (Eds.). The OpenGIS® Abstract Specification: Topic 5 Features. Open Geospatial Consortium Inc.) 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, the geographic features are "fundamental unit of geospatial information".

Federate

see *CRISMA federate*

Field training excercise

Field Training Exercise (FTX) – they are usually practice "mini-battles" which provide fairly realistic scenarios and situations based on actual situations a unit might face if deployed. (http://en.wikipedia.org/wiki/Field_training_exercise last visited 8.5.2015)

First aid

The immediate but temporary care given on site to the victims of an accident or sudden illness in order to avert complications, lessen suffering, and sustain life until competent services or a physician can be obtained.

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: http://www.opengeospatial.org/resources/?page=glossary).

More specific see *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.
(See: https://en.wikipedia.org/wiki/Functional_requirements last visited 8.5.2015).

Functional specification

A functional specification is the implementation independent description of a software components 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 Fritz Zwicky in 1967 (Zwicky, F. 1969. Discovery, invention, research through the morphological approach. Toronto: MacMillan) 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-quality goals (Sterling, L. & Taveter, K. 2009. The Art of Agent-Oriented Modeling. Cambridge, MA: MIT Press)

Graphical User Interface

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.

Hazard

A "dangerous phenomenon, substance, human activity or condition" (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 p.) characterised 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 (e.g. Pelling, M. 2004. Visions of Risk: A Review of International Indicators of Disaster Risk and its Management. UNDP – Bureau for Crisis Prevention and Recovery (BRCP), Geneva; Birkmann et al., 2013; Dewan, A. 2013. Floods in a megacity: geospatial techniques in assessing hazards, risk and vulnerability. Dordrecht: Springer; Birkmann, J., Cardona, O. D., Carreño, M. L., Barbat, A. H., Pelling, M., Schneiderbauer, S., Kienberger, S., Keiler, M., Alexander, D., Zeil, P. & Welle, T. 2013. Framing vulnerability, risk and societal responses: the MOVE framework. Natural hazards, 67(2), 193–211)

Hazard model

Hazard models are a piece of software and/or related data to simulate hazardous events.

Health intervention cost

Related to the health care management like the implementation of medical structures, the psychological and social assistance, the distribution of protective masks to protect from volcanic ash in times of relapse, chemical analysis, etc.

High-level architecture

A general purpose architecture for distributed computer simulation systems. High-level architecture (HLA) is an open international standard developed by the Simulation Interoperability Standards Organization (SISO) and published by IEEE. (See: https://en.wikipedia.org/wiki/High-level_architecture_%28simulation%29 last visited 8.5.2015).

Hypertext Transfer Protocol

Hypertext Transfer Protocol (HTTP) is standard protocol for data transport in the world wide web (WWW). (See: RFC_1945. 1996. Hypertext Transfer Protocol – HTTP/1.0. http://www.ietf.org/rfc/rfc1945.txt) and (RFC_2616. 1999. Hypertext Transfer Protocol – HTTP/1.1. http://www.ietf.org/rfc/rfc2616.txt).

ICC elements

Indicators, criteria and cost (ICC) elements are used to provide selected or aggregated information about world states or scenarios.

ICC function

Indicators, criteria and cost (ICC) functions are used to calculate ICC elements from world state data.

ICMS user handbook

The Integrated Crisis Management Simulation System (ICMS) user handbook is part of the CRISMA Catalogue and contains technical information about the software bricks being developed within CRISMA. It is to be used by the pilot application developers to develop their pilot applications.

Impact

Consequences of a hazardous event once it materialises, i.e. actually affects a societal system.

Impact assessment

In the context of crisis management: Assessment of the impact of events.

Impact model

Impact models represent the consequences of hazardous events.

Impact scenario

Time-dependent scenario focusing on the effects of the event chain. Consequences of the several events, hazards and countermeasures of a scenario.

In-situ

Something existing or taking place in its original place or position.

Incident

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. (FEMA Glossary. 2013. http://emilms.fema.gov/IS700aNEW/glossary.htm#F)

Indicator

A thing that indicates the state or level of something (Oxford dictionaries). 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.

Indicator function

An Indicator function produces an aggregated image of a world state.

Indicator vector

An Indicator vector is an instance in an indicator space and contains of a number of indicators as elements.

Indirect cost

Flows of costs (and benefits) that occur over a time after a crisis and inside or outside of the crisis area.

Information model

An information model is a representation of concepts, relationships, constraints, rules, and operations to specify data structure and semantics for a chosen domain of discourse. The advantage of using an information model is that it can provide shareable, stable, and organised structure of information requirements for the domain context. (Lee, Y. 1999. Information modelling from design to implementation. National Institute of Standards and Technology)

Infrastructure

Infrastructure in a crisis management context covers for instance dikes, hospitals, rescue bases and critical infrastructure (as water, power, telecommunication networks) etc.

Intangible cost

Intangible costs are typically those for which no market exists and there is no systematic or agreed method available to measure them. Comprising both direct and indirect intangible cost.

Integrated component

A component that takes part in an interaction of CRISMA Federates but is not itself a CRISMA Federate. It is not CRISMA-aware and thus does not interact with the CRISMA Middleware Infrastructure. An Integrated Component may be a member of a CRISMA Application but not of a CRISMA Federation.

Integrated Crisis Management Middleware

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 harmonised 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.

Interface

In the context of IT, 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 an interface shall include a dynamic portion that includes any restrictions on the order of invoking the operations. (ISO_19119. 2003. ISO 19119:2005 GEOGRAPHIC INFORMATION – SERVICES.
http://www.isotc211.org/Outreach/ISO_TC_211_Standards_Guide.pdf)

Internal uncertainty

Internal uncertainty means the decision makers as a team has always has his/her goals associated with responsibilities from its agency, respectively, facing making decisions.

Interoperability

Capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units. (ISO_19119. 2003. ISO 19119:2005 GEOGRAPHIC INFORMATION – SERVICES. http://www.isotc211.org/Outreach/ISO_TC_211_Standards_Guide.pdf)

Interoperability platform

A platform that enables interoperability between several information systems, simulation solutions, or organisational entities. Crisis management simulation integration approaches make up a special kind of interoperability platform.

Intrinsic uncertainty

See *Internal uncertainty*

Investment cost

All costs incurred prior to implementation of an investment (e.g. a mitigation measure). Investment cost describes the total amount of money necessary to put a measure into operation.

Key performance indicator

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 helps to characterise and compare alternative scenarios with respect to the crisis management measures that have been done.

Logistics management

Concepts and tools that help organisations to locate, request, track, and dispatch assets (people, equipment, and supplies) needed to manage an incident. The IT-support of logistics management is strongly connected to the terms data management, communications facilitation, and advanced visualisation.

Loose simulation integration

Integration of several simulation solutions at a higher level that does not imply communication between simulation engines/models at run time. In loose simulation integration, output data of one simulation run may serve as the input data for another. An example of loose coupling of simulation models is a simple GIS-based building-evacuation-model database.

Losses

The amount of realised 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).

Losses evaluation model

Losses evaluation models are calculation rules or functions to translate the result of impact models into valuable cost information.

Mashup platform

A component that allows to combine smaller components (widgets) providing specific functionality into a complete graphical user interface (GUI) to provide all the functionality needed.

Mental model

"A mental model is what the user believes about the system at hand." The mental model represents what users know (or think they know) about a system. "Users base their predictions about the system on their mental models and thus plan their future actions based on how that model predicts the appropriate course." (http://www.nngroup.com/articles/mental-models/) Usability engineering tries to reduce the gap between the user interface designers' and the users' mental models.

Meta-information

Descriptive information about resources in the universe of discourse. Its structure is given by a Meta-Information Model depending on a particular purpose. Note: A resource by itself does not necessarily need Meta-Information. The need for Meta-Information arises from additional tasks or a particular purpose (like catalogue organisation), where many different resources (services and data objects) must be handled by common methods and therefore have to have/get common attributes and descriptions (like a location or the classification of a book in a library). (RM-OA. 2007. Usländer, T. (Ed.). Reference Model for the ORCHESTRA Architecture Version 2 (Rev. 2.1). OGC Best Practices Document 07-097, 2007)

Meta-information model

Information-model for Meta-Information. See Meta-model and Meta-information.

Meta-model

A meta-model typically defines the language and processes from which to form a (description) model. Meta-modelling is the modelling methodology used in software engineering. (See: https://en.wikipedia.org/wiki/Meta_model last visited 8.5.2015). In this IT context "model" usually means "data model" or "information model" – a description of data structures.

Meta-modelling

Meta-modelling is the analysis, construction and development of the frames, rules, constraints, models and theories applicable and useful for the modelling in a predefined class of problems.
(See: https://en.wikipedia.org/wiki/Metadata_modeling last visited 8.5.2015).

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

Mitigation cost

Related to the activities provided for the risk mitigation. The risk can be mitigated by working on the consistency of the value exposed to the hazard and on its vulnerability.

Mock-up

Painted (by pencil or by computer drawing tool) representation of a human-computer-interaction dialogue. A special variant is a paper-mock-up (done by pencil and paper).

Model

A model is a hypothetical simplified description of a complex entity or process (Sterling, L. & Taveter, K. 2009. The Art of Agent-Oriented Modeling. Cambridge, MA: MIT Press). A model can be considered as “an abstract representation of a system or process” (Carson, J. 2005. Introduction to Modeling and Simulation. In Proceedings of the 2005 Winter Simulation Conference, 28/02/2012). 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. RTO TECHNICAL REPORT TR-MSG-062, Guide to Modelling & Simulation (M&S) for NATO Network-Enabled Capability, NMSG-062 Final Report). Stachowiak (Stachowiak, H. 1973. Allgemeine Modelltheorie. Wien-New York) 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).

Monitoring cost

Related to the activities necessary to enhance instrumental networks for the monitoring of risk-prone areas for example from a seismological, geochemical and geodetic perspective.

Monte Carlo simulation

Monte Carlo simulation is a method which uses random samples of parameters or inputs to explore the behaviour of a complex system or process.

Multi-hazard assessment

To determine the probability of occurrence of different hazards either occurring at the same time or shortly following each other, because they are dependent from one another or because they are caused by the same triggering event or hazard, or merely threatening the same elements at risk without chronological coincidence. (Commission staff working paper: “Risk assessment and mapping guidelines for disaster management”, European Commission, Brussels, December 2010)

Multi-risk assessment

To determine the whole risk from several hazards, taking into account possible hazards and vulnerability interactions (a multi-risk approach entails a multi-hazard and multi-vulnerability perspective).

This would include the events:

1) occurring at the same time or shortly following each other, because they are dependent on one another or because they are caused by the same triggering event or hazard; this is mainly the case of cascading events;
2) or threatening the same elements at risk (vulnerable/exposed elements) without chronological coincidence (EU Matrix)

Natural hazard

Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Non-functional requirement

A requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours. (See: https://en.wikipedia.org/wiki/Non-functional_requirement last visited 8.5.2015).

Normalisation phase

Phase characterised by the absence of change in the physical–chemical parameters; it can be considered as the phase in which everything is turned back as it was before the event occurrence. It comes before the rest phase, according to a circular logic.

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 "resources". 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 specialisation of the "Feature" as defined by ISO 19101 (ISO 19101. 2002. Geographic information -- Reference model. International Organization for Standardization) and OGC 08-126. (OGC 08-

126. 2009. Kottman, C. & Reed, C. (Eds.). The OpenGIS® Abstract Specification Topic 5: Features. Open Geospatial Consortium Inc.)

Open Geospatial Consortium

The Open Geospatial Consortium (OGC) is an international industry consortium of 480 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC® Standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications. (OGC. 2013. The Open Geospatial Consortium (OGC). http://www.opengeospatial.org/ogc)

Open Modelling Interface

Open Modelling Interface (Open-MI) is a standard defines a set of interfaces that allowing time-dependent models to exchange data at run-time. (See: https://en.wikipedia.org/wiki/OpenMI_Standard last visited 8.5.2015.)

OpenId

A standard for user identification. (See: http://openid.net/).

Operating cost

All costs incurred after implementation of an investment (e.g. a mitigation measure) and are related to the operation of a measure. Operating costs include both fixed costs and variable costs.

Operational level

Level of actions, management and decisions with short time span and narrow focus compared to strategic level. Typically running of day-to-day activities or in a crisis situation reactionary and proactive actions in relation to the immediate situation at hand.

Order of alarm and action

The Order of Alarm and Action (OAA) (German: Alarm- und Ausrückeordnung) defines by law which resources shall be deployed for which incident (number of injured, chemical incident, etc.)

Parameter

Element included in the method of calculation of an algorithm. It can assume different values, depending on the kind of scenario simulated.

Path of analysis

A Path of Analysis is a consecutive sequence of Transitions through a Simulation Case Graph. A Path of Analysis that starts at the root of a Simulation Case and ends at a leaf can be called a Simulated Crisis Management Scenario.

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

Pilot

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 a specific use case. 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, validating and promoting 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.

Pilot demo phase

The actual testing phase of a CRISMA application building, modelling and Simulation by a the pilot.

Point of interest

A specific point location that someone may find useful or interesting (http://en.wikipedia.org/wiki/Point_of_interest last visited 8.5.2015). In CRISMA context, the Point of Interest (POI) is a map object, usually visualised with a marker/icon on the map. POI is an object with properties, like geographic location, and/or some properties characterising this object. The POI can represent both passive (like buildings, bridges, etc.) and active objects (e.g. agents as representatives of some physical or virtual entities) on the map.

Preparedness

(1) The knowledge and capacities developed by governments, professional response and recovery organisations, 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

Prevention

One of the phases of the Crisis Management Cycle (mainly used in EU, see "Mitigation"). 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. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 pp)

Probabilistic hazard

The probability that a given adverse event of a given intensity will occur in a certain area within a defined time interval. For quantitative risk assessment purposes, the results of the hazard assessment are often summarised in the form of a 'hazard curve' that relates a given 'intensity measure' indicator with whether its occurrence probability (non-cumulative form) or an 'overcome a threshold' probability (cumulative form).

Public awareness

The process of informing the community as to the nature of the hazard and actions needed to save lives and property prior to and in the event of disaster.

Real scenario

Scenario developed for the modelling and simulation of a historic crisis.

Recognition Primed Decision

Recognition-Primed Decision (RPD) Model (Klein G. 1993. A Recognition Primed Decision (RPD) model of rapid decision making. In G. A. Klein, J. Orasanu, R. Calderwood & Zsambok, C. (Eds.). Decision-making inaction: Models and methods, 138–147) is one of the most influential in the literature of decision making by experts. This RPD models how people make quick, effective decisions when faced with complex situations. RPD obeys a recognition strategy, and it can be adaptive, to allow experienced decision makers to respond effectively. From then on, Klein's RPM model has been extended and even developed into a new research area Naturalistic Decision Making (NDM).

Reconstruction cost

Related to the activities provided for removing the physical damage to capital assets including buildings, infrastructure and industrial plants through "in place" or "delocalised" reconstruction.

Recovery

(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

Reduction of value Added for evacuation

The decrease of the value of the production, as it was before the event, due to the absence of activity in the area caused by evacuation of resident population and, consequently, on human labour.

Reduction of value added for psychological effect

The decrease of the value of the production, as it was before the event, due to the psychological effects caused by emergency on resident population and, consequently, on human labour.

Reference Application

A Reference Application is a completely integrated and functional demonstration of how CRISMA goals may be attained, in one or more particular domain(s). Hence, a reference application is the transferable "wiring together" of building blocks without any pilot-specific logic. Reference Applications are not necessarily industry-grade, production-mature software suites; rather, their purpose is to demonstrate how CRISMA concepts can be (not necessarily should be) implemented in their particular domain.

So, reference applications demonstrate how the CRISMA models and building blocks can be used to build various applications pertinent to crisis management. The presentation targets developers and integrators rather than end users.

Reference architecture

A reference architecture "is an architectural design pattern that indicates how an abstract set of mechanisms and relationships realises a predetermined set of requirements. One or more reference architectures may be derived from a common reference model, to address different purposes/usages to which the Reference Model may be targeted." (SOA-RM. 2006. OASIS Reference Model for Service Oriented Architecture 1.0. Committee Specification 1, 2 August 2006)

Reference model

An abstract framework for understanding significant relationships among the entities of some environment. It enables the development of specific reference or concrete architectures using consistent standards or specifications supporting that environment. A reference model consists of a minimal set of unifying concepts, axioms and relationships within a particular problem domain, and is independent of specific standards, technologies, implementations, or other concrete details. (SOA-RM. 2006. OASIS Reference Model for Service Oriented Architecture 1.0. Committee Specification 1, 2 August 2006)

Reference scenario

Reference scenarios are abstract crisis and response scenarios that help to understand the relevant aspects of a typical scenario.

Rehabilitation cost

Related to the activities provided for removing the physical damage to capital assets, including buildings, infrastructure and industrial plants by the rehabilitation of damaged.

Representational State Transfer

Representational State Transfer (REST) is a style of software architecture for distributed systems such as the World Wide Web. REST has emerged as a predominant web service design model. (See: REST. 2013. Representational state transfer.https://en.wikipedia.org/wiki/Representational_state_transfer.)

Requirement

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 (http://en.wikipedia.org/wiki/Requirement last visited 8.5.2015). A singular documented physical and functional need that CRISMA system should perform.

Residual risk

The risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery together with socio-economic policies such as safety nets and risk transfer mechanisms. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 p.)

Resilience

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. Resilience means the ability to “resile from” or “spring back from” a shock. The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organising itself both prior to and during times of need. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 p.)

Resource

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).

IT-context: Resource is every possible data object as part of the common CRISMA meta information model.

Resource management

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.

IT-context: Management in terms of storage, creation, update and delete of data objects in the context of IT implementation.

Response

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. (FEMA. 2010. Developing and Maintaining Emergency Operations Plans. http://www.fema.gov/media-library-data/20130726-1828-25045-0014/cpg_101_comprehensive_preparedness_guide_developing_and_maintaining_emergency_operations_plans_2010.pdf)

Rest phase

Medium–long duration phase and complete absence of phenomena that may precede a natural catastrophe.

Risk

The combination of the probability of an event and its negative consequences.

Risk analysis

A systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences.

Risk mitigation cost

Risk reduction costs. Refer to any costs attributed to research and design, the set-up, operation and maintenance of mitigation measures, to any costs occurring in economic activities/sectors that are not directly linked to measure investment and to any nonmarket impacts of risk mitigation measures.

Role

A prescribed or expected behaviour associated with a particular position or status in a group or organisation. In CRISMA this covers two dimensions: First, the role within a crisis management scenario. Second, the role related to the setup and use of a CRISMA application.

Run-Time Infrastructure

Run-Time Infrastructure (RTI) is service Bus providing HLA services. See High-level Architecture (HLA) and Enterprise Service Bus (ESB).

Sample scenario

Crisis and response scenario representing either real past events or imaginary events specified in detail.

Scenario

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.

Scenario description

In the context of CRISMA it includes text, timeline and tables that describe a crisis management scenario.

Scenario description for economic evaluation

Describes all quantitative data of crisis impacts (excluding economic data) of a given scenario produced by CRISMA models that can be used as an input for the economic evaluation model.

Scenario evolution

Sequential development of a scenario describing events as they could evolve based on alternative assumptions.

Screenshot

A screenshot is a real screen-capture of a dialogue window of an interactive system, while a mock-up is painted rough illustration of a such.

Sensor Observation Service

Sensor Observation Service (SOS) is one of the OGC standards. Specifies a service interface and data encoding methods for sensor data access. (See: SOS. 2012. Sensor Observation Service. Open Geospatial Consortium. http://www.opengeospatial.org/standards/sos)

Sensor Planning Service

Sensor Planning Service (SPS) is one of the OGC standards. Specifies service interface and data encodings to control sensors, where sensor is a very wide concept ranging from simple things like a thermometer to earth observation satellites and also, including simulation models. (See: SPS, 2011.)

Sensor Web Enablement

Sensor Web Enablement (SWE) is a suite of standards developed by Open Geospatial Consortium (OGC) describing basic data and service models used in other OGC standards. (See: SWEdata. 2011. SWE Common Data Model Encoding Standard. Open Geospatial Consortium http://www.opengeospatial.org/standards/swecommon; SWEservice. 2011. SWE Service Model Implementation Standard. Open Geospatial Consortium. http://www.opengeospatial.org/standards/swes.)

Service

In the context of IT, a service is a distinct part of the functionality that is provided by an entity through interfaces. (ISO 19119. 2005. Geographic information -- Services. International Organization for Standardization)

Service Oriented Architecture

Service Oriented Architecture (SOA) is a style of software architecture for designing and developing software in the form of interoperable services. (See https://en.wikipedia.org/wiki/Service-oriented_architecture last visited 8.5.2015.)

Simple Object Access Protocol

Simple Object Access Protocol (SOAP) is a protocol specification for exchanging structured information in the implementation of Web Services in computer networks. (See: https://en.wikipedia.org/wiki/SOAP last visited 8.5.2015.)

Simulated World

see *World state space*

Simulation

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. RTO TECHNICAL REPORT TR-MSG-062, Guide to Modelling & Simulation (M&S) for NATO Network-Enabled Capability. NMSG-062 Final Report). 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.

Simulation case

A simulation case describes the user context, the objects of interests, the simulation models, simulation objectives and the user interactions that are relevant for the modelling and simulation of a crisis management scenario with a CRISMA application.

Simulation control parameter

Simulation control parameters are parameters necessary to perform and influence a Simulation but are not part of the input World State. The range of values of Simulation control parameters defines how the end user can influence a simulation. E.g. alternatives share the same original World state and Simulation type using different Simulation control parameters and thus leading to a different result.

Simulation exercise

Decision making exercise and disaster drills within threatened communities in order to represent disaster situations to promote more effective coordination of response from relevant authorities and the population. In CRISMA context, a simulation exercise refers to instance of a simulation case in training or planning context.

Simulation model

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.

Simulation models loose integration

Describes a low level of integration between two or more simulation models, when a running simulation model is not aware of other running simulation models. The output of one simulation model can be used as the input for the next simulation model. This level of integration is required when two simulation models are running in-parallel with no need to share information during the run.

Simulation models tight integration

Describes a high level of integration between two or more simulation models at runtime. This level of integration is required when two simulation models are running in-parallel and need to interact with each other by sharing their intermediate output information during the run.

Simulation Objective

A Simulation Objective is a well-defined purpose of a Crisis Management Simulation supporting specific planning, training or decision support activities. The physical representation or the means to reach a simulation objective is the Simulation Case.

Simulation purpose

The simulation purpose is the intention of the initiator of a simulation case (what the core question is and what the format of usage of the simulation).

Simulation results

Simulation results are the output values of a specific simulation run. They provide the content of a specific scenario (series of world states).

Simulation run

Depreciated. See simulation.

Simulation tool

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.

Simulation view

A CRISMA user interface that allows a CRISMA user to interact with a simulation case in terms of changing simulation parameters, starting, stopping and saving simulation runs.

Single model simulation solution

Simulation tool that provides a particular model and allows the parameterisation of the model and associated simulation runs. No other model is used or referenced and the main scope of the application is that of a particular simulation for a dedicated purpose in crisis management (e.g., plume dispersion, building evacuation, etc.).

Situation

State of the crisis at a certain moment. Represented as a status of the scenario in a CRISMA world state.

Situation analysis

A systematic collection and evaluation of past and present economical, political, social, and technological data, aimed at (1) identification of internal and external forces that may influence the organisation's performance and choice of strategies, and (2) assessment of the organisation's current and future strengths, weaknesses, opportunities, and strengths.

Situational awareness

The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future. (Endsley, M. R. 1995. Toward a theory of situation awareness in dynamic systems. Human Factors, 37, 32–64)

Social Vulnerability

The inherent characteristics of a community or social system that make it susceptible to the potentially damaging effects of a hazard (adapted according to UNISDR, 2009). In the understanding of CRISMA this starts with the identification of actual social elements at risk (population), thus comprehends human exposure. In the context of WP43 that concept further integrates vulnerability aspects relevant for getting population out of the hazard zone (evacuation) as well as aspects geared towards potential impacts.

Socio-technical system

In the context of IT: A kind of system that includes hardware and software, has defined operational processes, and offers an interface, implemented in software, to human actors. (Sterling, L. & Taveter, K. 2009. The Art of Agent-Oriented Modeling. Cambridge, MA: MIT Press)

Software as a Service

Software as a Service (Saas) is a concept to provide software (e.g. typical desktop software functionality) through service interfaces usually offered by an external service provider (with a commercial interest)

Spatio-temporal information fusion

Spatiotemporal information fusion is the study of efficient methods for automatic or semi-automatic transformation of information from different sources and different points in time and space into a representation that provides effective support for human or automated decision making.

Standard

Denotes relevant technical standards on interoperability and federated simulation.

Standard Unified Modelling, Mapping & Integration Toolkit

Standard Unified Modelling, Mapping & Integration Toolkit (SUMMIT) is a modelling & simulation software environment that enables to seamlessly access integrated suites of modelling tools & data sources. (See: https://dhs-summit.us).

Storyboard

A storyboard is a step-by-step description of user interactions enhanced by mock-ups or screenshots as well as optionally by time information.

Strategic level

Level of actions, management and decisions with long time span and broad focus with a set of defined long-term goals.

SUMMIT

see *Standard Unified Modelling, Mapping & Integration Toolkit*

System

System is a set of entities connected together to make a complex whole or perform a complex function. (Sterling, L. & Taveter, K. 2009. The Art of Agent-Oriented Modeling. Cambridge, MA: MIT Press)

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, A. & Krippner, S. 1998. Systems Theories: Their Origins, Foundations, and Development. In Jordan, J. (Ed.), Systems Theories and A Priori Aspects of Perception, Chapter 3, 47-74. Amsterdam, the Netherlands: Elsevier Science)

Systemic Vulnerability

The concept of systemic vulnerability measures the tendency of a territorial element to suffer damage (generally functional) due to its interconnections with other elements of the same territorial system. (Pascale, S., Sdao, F. & Sole A. 2010. A model for assessing the systemic vulnerability in landslide prone areas, Nat. Hazards Earth Syst. Sci., Vol. 10, 1575–1590)

T0

see *Time of the original hazard event*

Table top exercise

Table top exercises use simulated scenarios designed to test and train the response capability of an organisation to a given event. The scenarios require coordinated response to a realistic situation that develops with participants gathered to formulate responses to each development.

Tactical level

Level situated one level above the operational level and carries out the orders given.

Tangible cost

Refers to damages to goods and services that can have market values. Can be either direct or indirect tangible cost.

Technical requirements

Technical requirements define the functions or constraints needed by the system to achieve a goal. They specify how a goal should be accomplished by the system. Technical requirements can be separated according to their characteristics into functional and non-functional technical requirements. In CRISMA, technical requirements are created based on user stories.

Technology demonstrator

Technology demonstrators consist of CRISMA technology showcase applications that are in principal crisis management independent.

Test

A procedure intended to establish the quality, performance, or reliability of something, especially before it is taken into widespread use.

Tight simulation integration

An approach towards coupling of several simulation models at a domain-specific, conceptual, and semantic levels. The standards DIS and HLA are designed for such integrated simulations. An example would be a system that integrates several vulnerability models of different infrastructures and takes into account interrelationships between them at any time of a simulation run.

Time dependent vulnerability

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).

Time of the original hazard event

Time at which the original hazard occurred (T0). After this moment other hazard events may occur has a consequence of cascading effects.

Transition matrix

A matrix-like representation of the conditional probabilities P(IM2|IM1), indicating the probability that a triggered event with intensity IM2 occurs given the occurrence of a triggering event with intensity IM1.

Transition Point

A Transition Point represents the type of the Transition that can be performed by the user at a certain defined point in a Simulation Case.

Tuning

Act of changing the values or ranging of parameters of scenario with the aim of find the best performance in terms of impact.

Uncertainty

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 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, W., Sandri, L., & Selva, J. 2010. BET_VH: a probabilistic tool for long-term volcanic hazard assessment. Bulletin of volcanology, 72(6), 705-716)

Unit cost

The cost allocated to a selected unit.

Unrest phase

Variable duration phase and change in the scenario parameters; it can be divided into four sub-phases: Attention (no evacuation), pre-alarm (no evacuation), alarm (no evacuation), and evacuation.

Usage context

see *context of use*

Use case

A list of steps, typically defining interactions between a user and a system, to achieve a certain goal (Cockburn, 1999). A use case is described as "a generalised description of a set of interactions between the system and one or more actors, where an actor is either a user or another system". (Cohn, M. 2010. User Stories Applied: For Agile Software Development. Reading, MA: Addison-Wesley)

User requirements

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.

User story

A user story is a short, simple description of a feature described from the perspective of the role who desires the new capability, representing a stakeholder of the system. General form of a user story is “As a player of (some role), I need to perform (some activity) to achieve (some goal)”. It describes a small implementable fragment of user requirement from the perspective of a user. (Cohn, M. 2010. User Stories Applied: For Agile Software Development. Reading, MA: Addison-Wesley)

Validation

A process to assure that project results are coherent and in line with the project goals and to demonstrate and validate the tools developed.

View Exercise view Incident view

A simulation view with the purpose of supporting exercise activities. A simulation view with focus on incident aspects.

Volunteer

A volunteer worker who engages in emergency activity at the request (whether directly or indirectly) or with the express or implied consent of the chief executive (however designated), or of a person acting with the authority of the chief executive, of an agency to which an emergency response or recovery plan applies.

Vulnerability

The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. (UNISDR. 2009. 2009 UNISDR Terminology on Disaster Risk Reduction, Geneva, Switzerland: Nations, 30 pp)

Vulnerability model

Vulnerability models mean models to represent and classify the elements at risk.

Warning

Dissemination of message signalling imminent hazard which may include advice on protective measures.

Web Coverage Service

Web Coverage Service (WCS) is one of the OGC standards. Can be compared to WMS, but delivers actual data instead of pictures of the data. So in contrast to WMS the data can be used for further processing. (See: WFS. 2010. Web Feature Service. Open Geospatial Consortium. http://www.opengeospatial.org/standards/wfs).

Web Feature Service

Web Feature Service (WFS) is one of the OGC standards. Defines requests and data encodings for a service storing geo-referenced data (the features). (See: WFS. 2010. Web Feature Service. Open Geospatial Consortium. http://www.opengeospatial.org/standards/wfs).

Web Map Service

Web Map Service (WMS) is one of the OGC standards. Defines request parameters and output formats for the delivery of Maps as pictures. (See: WMS. 2006. Web Map Service. Open Geospatial Consortium. http://www.opengeospatial.org/standards/wms).

Web Processing Service

Web Processing Service (WPS) is one of the OGC standards. Used to control processes, e.g. simulation model runs. Defines rules for parameters, input and output data requests. (See: WPS. 2007. Web Processing Service. Open Geospatial Consortium. http://www.opengeospatial.org/standards/wps).

Widget

An element of a GUI realised as an component providing a specialised user interface functionality. A complete GUI consists of a number of widgets.

World

Spatial and temporal context of an incident and the response

World State

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.

World state space

The world state space is an Information Space describing observations relevant for a specific class of crisis management simulations. Technically a Simulated world consists of a number of data slot descriptions as the elements of this information space. A Data slot references specific data required for a crisis management simulation e.g. a hazard map. A concrete and complete set of data referenced by the data slots of a simulated world is called a world state.

Xynthia

Xynthia was a violent European windstorm which crossed Western Europe between 27 February and 1 March 2010.
(See: https://en.wikipedia.org/wiki/Cyclone_Xynthia last visited 8.5.2015).

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Appendix D: The CRISMA consortium partners, their acronyms in the project and contact details for CRISMA

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Abstract	In recent years, the nature and magnitude of crises have changed globally, sometimes even drastically. Thus, crisis managers and other decision-makers are more and more likely to face large-scale crisis situations that would exceed the capacity of any local crisis management. CRISMA has been developed to enable crisis managers and other stakeholders model and simulate complex crisis scenarios and alternative response and mitigation actions in a realistic way. CRISMA aims to improve preparedness and resilience to crisis events by facilitating the manipulation and visualisation of complex crisis scenarios, which typically have multiple effects on society and require the integration of expertise from multiple sectors, and involve financial and ethical concerns. The CRISMA Framework has been built to provide an environment that enables building up one's own crisis scenarios and integrating both new and legacy models and tools into the one simulation system. With the CRISMA Framework, crisis managers and other decision-makers are offered possibilities to combine models, data and expertise from many different sources, for creating a wider perception of crisis scenarios and alternative preparedness, response and mitigation actions. Impact comparison and visualisation improves multi-organisational cooperation and communication with other stakeholders and the public. This publication presents an overview on CRISMA solutions and how they can be used in real-life examples. The research leading to these results has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 284552.
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VTT TECHNOLOGY 228 Modelling crisis management for...

Modelling crisis management for improved action and preparedness

In this publication you can find out what is CRISMA and how you can benefit of CRISMA when preparing for large-scale or complex crisis scenarios. CRISMA supports you in creating a better understanding of potential crisis impacts, as well as the availability and benefits of multi-organisational and multi-national cooperation.

The CRISMA Framework provides an environment that enables building up one's own crisis scenarios and integrating both new and legacy models and tools into the one simulation system. To ensure the adaptability of the CRISMA Framework, much of the core framework functionality is served by open source software. And the modular design allows future developers to add new building blocks when needed, either in open source or closed source, in line with one's own business model.

The CRISMA Consortium is at your service if you wish to know more.

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