What nuclear and radiological emergency management can learn from non-nuclear: a case study

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Abstract

Nuclear and radiological emergency management is often separated in terms of organisation and tools from conventional emergency management dealing with crisis situation resulting from natural or man-made events. However, in particular for a severe nuclear event or a large crisis situation, both have to deal in the early phase of the emergency with similar problems.

Within the German Security Research initiative, the integrated project SECURITY2People (Secure IT-Based Disaster Management System to Protect and Rescue People) aims at exploring the needs for and the structure of an integrated risk management system that is applicable for all types of emergencies and at all levels of emergency management from the local to the Federal Government. The following functionalities will be included:

- Role-based information management;
- Decision support at all levels of management;
- All types of simulation techniques;
- Applicability in training, exercises and operation.

One key aspect of the project is the development of tools that are applicable on the strategic and tactical/operational level serving the needs of rescue organisations but also administrative emergency management organisations. In this respect strategic decision making is supported by top level simulation models and knowledge data bases supported by a key performance indicator approach that allows a first estimation of the resources necessary to carry out the actions selected on a strategic level. Furthermore, a third-party application is linked to S2P providing simulations of first responder teams (fire brigade, rescue service) in real-time. Besides the usage in an emergency, this provides the unique possibility to perform exercises in a realistic manner.

The paper discusses the current status of the S2P project and highlights the potential for the use in the nuclear emergency management, in particular training and preparedness as the system allows the "real" simulation of recommendations provided by the decision making team or decision making software components.

Introduction

In many countries, research related to nuclear/radiological and non-nuclear emergencies is separated. This reflects often the national organisational structure in the emergency management with a clear separation of technical support organisations linked to nuclear or non-nuclear agencies and ministries. Even stronger is the separation on the European level where nuclear and radiological emergency management is funded within the EURATOM program whereas all other research is part of the European Research Agenda.

In this way, different methods and tools have been developed and are used in the nuclear and non-nuclear area. There are also differences that result from the application of the tools. In nuclear, the real applications of emergency management tools is very limited, thus most of the activity is devoted to training and exercising. In the non-nuclear field, large scale problems may happen each year (heavy flooding) or even some times more frequent (large scale traffic accidents), requiring the activation of stuff at all levels from the first responders up to national crisis centres.

In the non-nuclear area, however, the responsibilities are diverse as well are the organisations involved in the response. Typically, communities, provinces and countries have different structures and also

different tools. This results in the usage of different tools at the various organisations and at the various levels of responsibilities, at least this is the case in Germany (BBK 2010)

In the nuclear area, the situation is different as from the beginning of research in nuclear emergency management – starting after the Chernobyl accident – the European dimension of such accidents were acknowledged and therefore European wide methods and tools developed, resulting for example in the European decision support system RODOS (real-time on-line decision support) (see Raskob et al. 2010). RODOS has been designed for the usage at an emergency centre providing advice on countermeasures to protect the public in the best possible way.

Within exercises, recommended measures such as evacuation or sheltering of the potentially affected public are not carried out in real-time. In fact these actions were just "played" according to a script. In view of the authors, this is one component of the nuclear emergency management where improvements might be of benefit. In particular having instruments designed to simulate the evacuation of an area given the constraints in terms of resources and environmental conditions can replace scripts and make the exercise much more realistic. This has been recognised in the non-nuclear area with the integration of such tools into the national Academy for Crisis Management, Emergency Planning and Civil Protection (AKNZ) of the Federal Office of Civil Protection and Disaster Assistance (BBK) (BBK 2012).

The Project Security2People – Basic Ideas

The project SECURITY2People (Secure IT-Based Disaster Management System to Protect and Rescue People) that is part of the German Security Research initiative, aims at exploring the needs for and the structure of an integrated disaster management system. This system should be applicable for all types of emergencies and at all levels of disaster management from the local to the Federal Government. In addition operators of critical infrastructures and organisations dealing with security issues are also envisaged as future users of that system. The following functionalities are major components of the system:

- Role-based information management;
- Decision support at all levels of management;
- Different types of simulation techniques;
- Applicability in training, exercises, planning and operation.

An important feature of such a system is the appropriate information exchange between different stakeholders and public communications. For this purpose, social and psychological aspects of crisis communication have to be explored. Crisis communication is most effective if undertaken in a systematic way, and generally starts with the gathering of information. The system shall support the end users at an early stage in order to elicit interest and stakeholder input. Communication must then continue throughout the entire process.

Finally the system has to be designed in such a way that existing specialised management tools can be integrated into SECURITY2People.

The project started in June 2009 and is scheduled for a three years period. In the first stage, the project focused on the analysis of the current status in emergency management and the functional and technological requirements for such an integrated system. Based on the analysis, a concept has been developed describing the functionalities and the simulation models that should be part of the S2P system. As the project has 10 associated partners from police, fire brigade, rescue services, operators of critical infrastructures and public administrations, a cycle of analysis, realisation and validation was established allowing the associated partners to directly provide feedback within workshops scheduled roughly twice per year. In each of the workshops, a demonstrator was presented, reflecting the current state of development (see e.g. Raskob et al. 2010).

The Project Security2People – Modules

The S2P is under development in terms of demonstrators with increasing number of components. Figure 1 presents the status of the second demonstrator that has been realised by end of 2011. The system architecture uses state of the art data base engine (PostgreSQL) and a modern approach of building web applications (portlets). The user interacts with the system via a Web Portal. The web portal is based on open source software products. All portlets can be seen in figure 2. In figure 1, exemplarily portlets for the strategic level (Strategic Decision Support Component) and the operational/tactical level (Key Performance Indicators) are presented. All information for the models and from the models is stored in the knowledge data bases that also contain information from historic cases to provide a basis for the current one. Also external simulation systems, here the RODOS system, can be coupled to exchange information; in our example it is the result from a dispersion simulation. An important component is the GESI system that can simulate resources in real-time (see GESI-SIRA 2012).

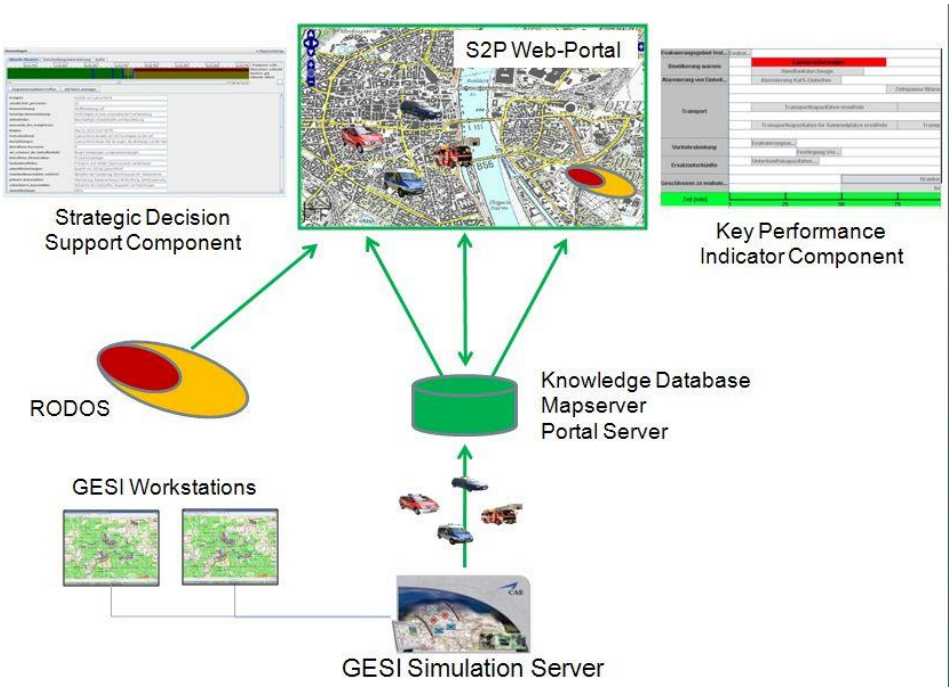

Figure 1: Demonstrator layout with the various components and the connection to simulations such as GESI and RODOS

In the following paragraphs, the main component of the S2P demonstrator will be described. As mentioned before, the basis is the second demonstrator which has been reviewed by the potential end users in 2011. The many different portlets are managed via the S2P portal. External components are connected via the interoperability platform. Important to note here is also the capability to manage data. This is an important aspect as the owner of an information decides if that information shall be made public to other organisations involved in the management of that disaster (important for police)

Situation awareness: This portlet displays information about the event and the resources that are allocated to deal with the consequences. The operator can put in location of resources or define areas that might be blocked for the public. Exchange of information between different organisations (e.g. police, fire brigade, rescue services) is foreseen. If the resource management system GESI is coupled to S2P, the movement of resources will be updated automatically based on calculations of GESI. This feature can be used for exercises or for “what-if” calculations.

Message management: This portlet provides a basic functionality of sending and receiving messages from all organisations using S2P. In particular important is the messaging for the tactical operation and for the allocation of resources to particular event. That system is comparable to the message management of Command and Control systems and can be coupled to them if available.

Knowledge data base: The knowledge data base contains historic events and measures that have been carried out to manage that event. Furthermore it may contain also scenarios that have been created during exercises. The knowledge data base is extended by a case based reasoning (CBR) algorithm that allows the adaptation of the existing scenarios to the current one. This feature is important as input to the strategic decision support.

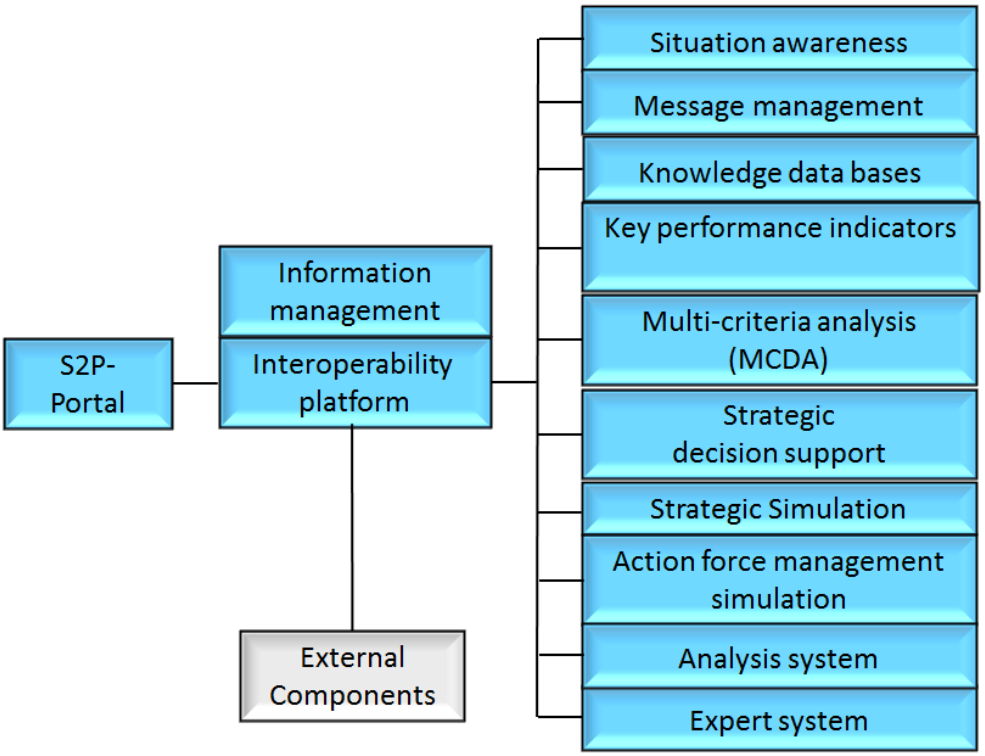

Figure 2: Individual components of the second S2P demonstrator

Key Performance Indicators: This portlet serves for the estimation of resources required for a particular action. An action is subdivided into individual processes (e.g. evacuation into alerting, movement of busses, movement of inhabitants, transportation out the area and others) for which resource and timing indicators can be defined. Based on simple formula, the timing and resources for that action can be calculated thus indicating if a proposed action can be carried out if desired.

Multi-criteria Analysis: This portlet allows the evaluation of different strategies based either on facts or on preferences of the decision making team. It supports also the structuring of the problem and provides transparent information how decisions have been taken. To analyse the stability of decision taken, it allows performing a sensitivity analysis of the selected preferences indicating where further discussion/clarification is needed. This portlet is applicable mainly in the later phase supporting strategic decision making.

Strategic decision support: This portlet displays the on-going emergency via a time-line. The time line shows specific events where management is necessary. This is indicated via traffic light colours. Based on the information from the event and the information in the knowledge data base, an assessment is made with the help of the CBR component whether the situation is still fine (green) actions recommended (yellow) or mandatory (red). Based on the ranking from the CBR component

(see figure 4), one strategy can be selected and the feasibility of that strategy can be estimated via the Key Performance Indicator portlet.

Strategic simulation: The objective here is to simulate the dependencies of potentially affected infrastructures. However, in the course of the project it was decided to postpone that development as more resources than anticipated would be required.

Action force management simulation: This portlet is based on the resource simulation system GESI. The portlet allows the operation of GESI as part of the S2P system with input of the operator and also retrieval of information on the performance of the resources. GESI simulates the movement of resources based on the environmental conditions (traffic, rain, snow etc.), capabilities of the resource (air based, vehicle, on foot) and available consumables. GESI can simulate several thousand of vehicles in real-time with time steps of several seconds. In this way a realistic simulation of the available resources can be carried out.

Analysis: This portlet allows the spatial and temporal display of measures/commands and events in a web browser. It provides a detailed analysis about decision taken, important for the evaluation of exercises.

Expert system: This portlets support the decision making team in selecting appropriate measures on an operational/tactical level. It is based on check lists and contains a logic that directs the user to those actions/tasks that are recommended for that particular event.

The Use Case

In the fifth workshop of the project in 2011, a specific scenario was presented that was managed by using several functionalities of the S2P system. As the system is still a demonstrator – and will be up to the end of the project November 2012 – the case was only exemplarily demonstrated.

The chosen disaster scenario was based on a release of toxic gases out of a chemical factory requiring decisions about evacuation, sheltering and further environmental or economic consequences.

The S2P system was applied in the following way. First the S2P system becomes aware of the problem – direct message from the responsible organisation. This message indicates that there was an accident in a chemical factory and a potential release of a toxic gas is expected within the next 4 hours. Only if the problem – a larger scale power blackout – could be resolved within that time, the release could be avoided. Following that message, the S2P operator accesses one or several chemical data bases to check if the chemical substance is as toxic as anticipated. Having this confirmed, he/she consults a chemical expert and initiates atmospheric dispersion calculations to define the area where actions might be necessary. The S2P system triggers calculations of an external system – here the RODOS system, and receives contamination pattern of the plume and areas where intervention criteria would be exceeded. The evacuation and shelter areas were also provided by RODOS. This information is transferred into the data base and interlinked with the number of affected people.

The next step is the start of the strategic simulation portlet analysing the potential measures that might be applicable for that event. The CBR component checks the available cases and evaluates them according to the attributes public health, the environmental impact and the economic impact. Out of the various options displayed in Figure 4, the decision making team can select those which might be further evaluated with the Key Performance Indicator component.

At the current stage of development, the CBR component can only propose a set of measures that have been applied in the past. In future, the research is directed towards the refinement of these countermeasure strategies related to specific aspects of the current event. However, this will be realised not as part of the current S2P demonstrator.

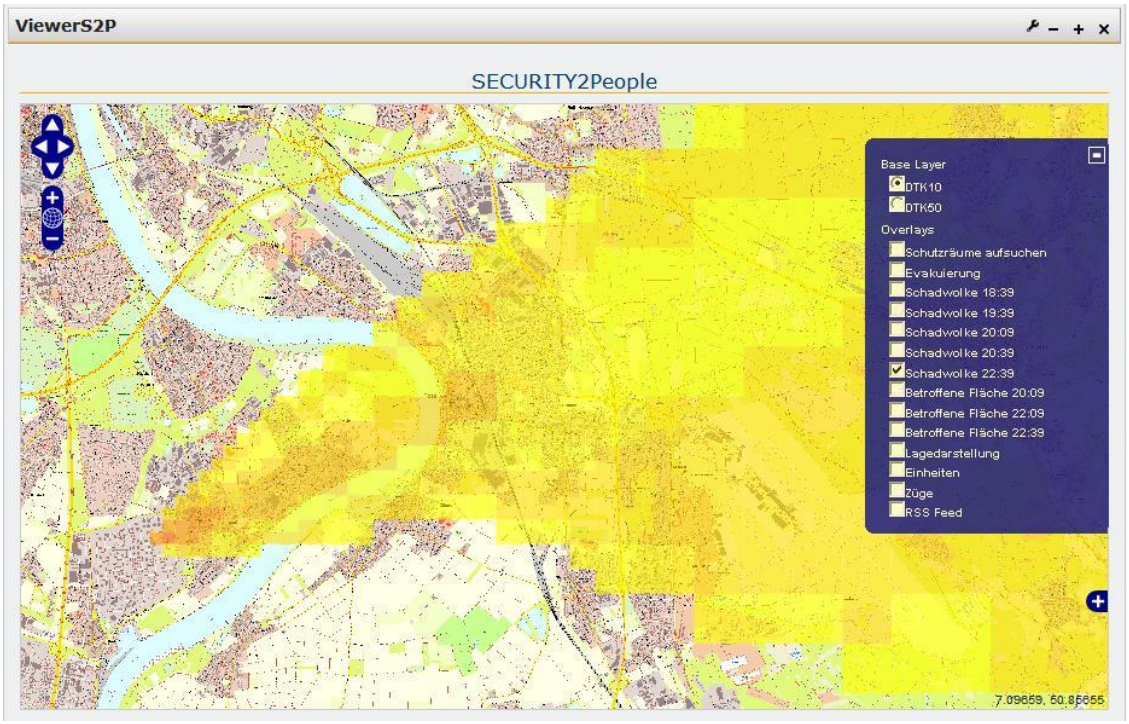

Figure 3: Results of the dispersion calculations performed with RODOS and displayed in the S2P portal

The next step in the chain is the check of the proposed strategies with Key Performance Indicator portlet. This indicates if the measure evacuation for example can be carried out for the given situation with an area of several square kilometres and a population number of roughly 20000 affected people. In case the portlet reports feasibility of the proposed measures, the GESI system can evaluate them in more detail. To this purpose a detailed simulation of the necessary resources from police, fire brigade and rescue services will be carried out and can be displayed again in the S2P portal (see figure 5)

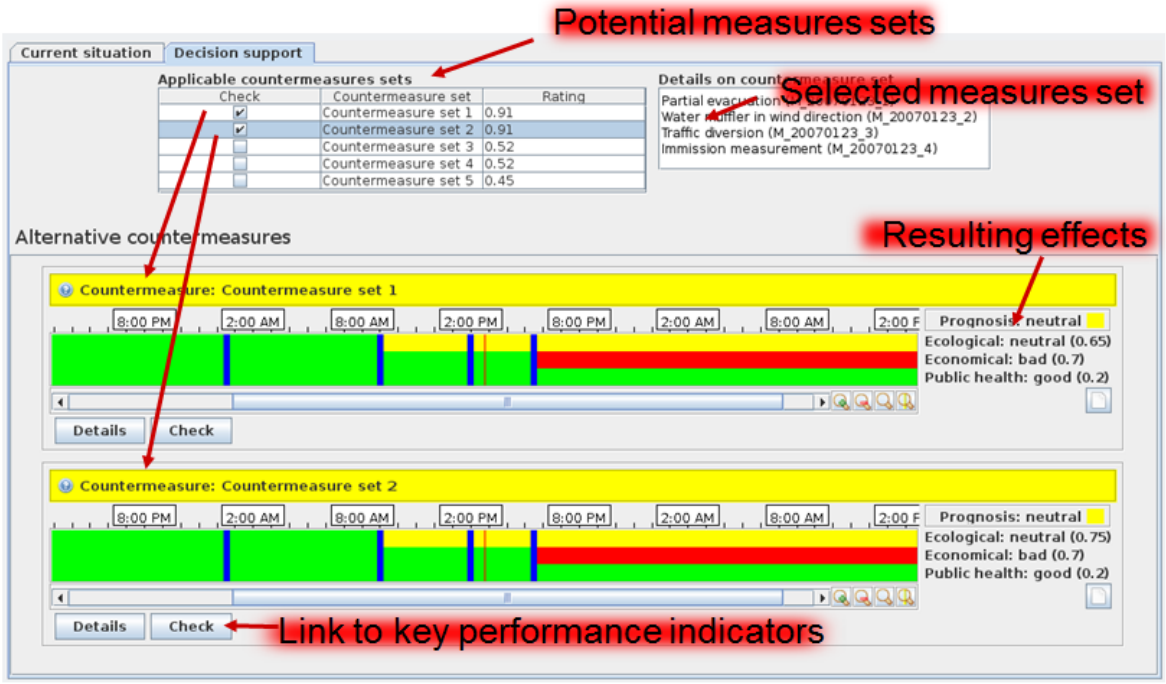

Figure 4: Result of the strategic simulation component

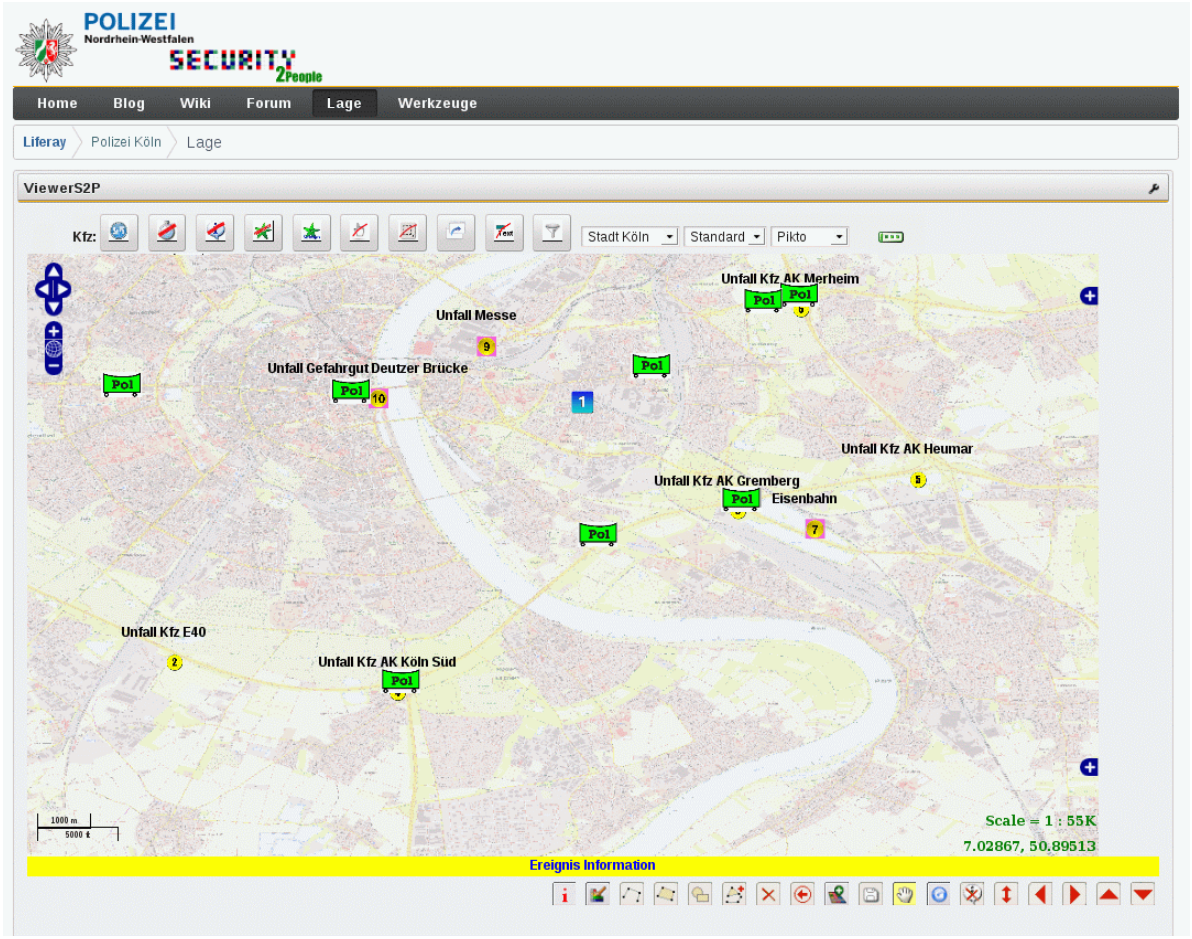

Figure 5: Visualisation of the resources of the police (additional accidents included)

The decisions taken will be put into the messaging system to inform the teams. The Commander-in-Chief will then direct the resources to carry out the actions decided. This again can be visualized via the situation awareness portlet, thus allowing to follow the ongoing actions.

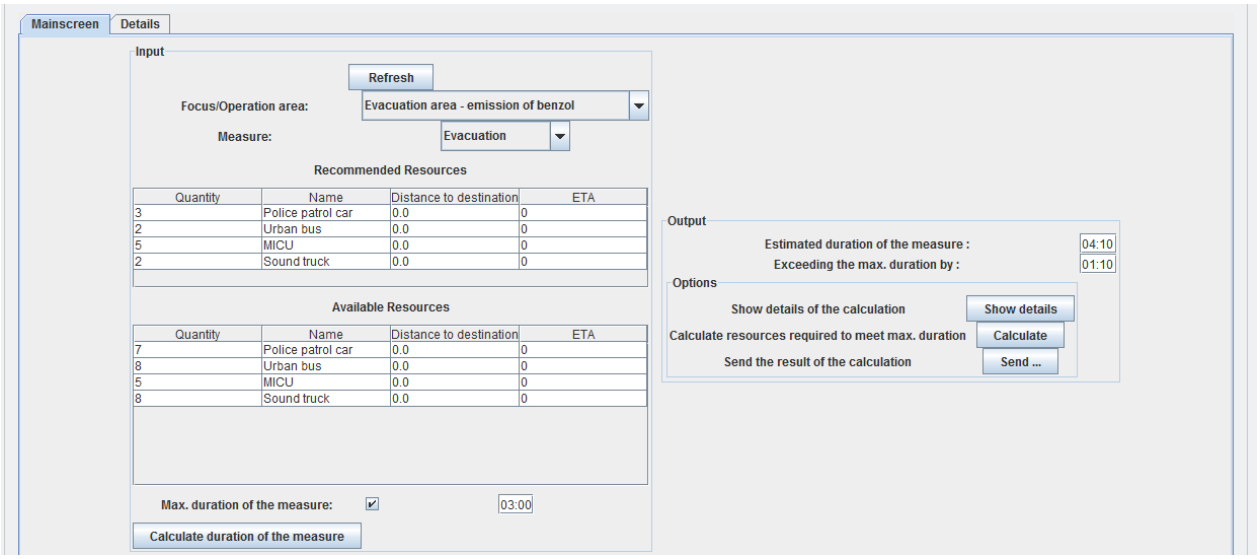

Figure 5: Key Performance Indicator mask for evacuation

Summary and Conclusions

Our use case demonstrated that the S2P system allows the support of decision making at all levels from the operational (where to allocate and place resources) up to the strategic one (decisions about the countermeasure strategy). Furthermore, with the capability of integrating external programs, operational components in the emergency management organisations can be further used, but now integrated into one operational picture.

The simulation of resources with the GESI system allows the planning and performing of realistic table top exercises as decisions taken within the exercise can be directly simulated and thus the decision evaluated in terms of performance. This closes a huge gap in existing approaches utilising predefined scripts that might be far from reality.

The knowledge data bases with the extension of the case based reasoning algorithms are extremely valuable for a first and fast evaluation of the situation. The check of the proposed countermeasure strategy via the Key Performance Indicators provides a first indication if the strategy is applicable. In most cases, in particular when time is short, this can replace the detailed simulation via GESI and might be very useful on the operational level.

The feedback from the potential end users of the S2P system following that demonstration was very positive (Tufte et al. 2011). All portlets have been appreciated and recommendations were provided about future developments of the system. The end users stated that the S2P is a clear step forward integrating tools for all levels of the decision making process.

At the end of the project the industry partners of the consortium plan to further develop the demonstrator to an operational system. The final product is envisaged for the usage in emergency centres at the country or federal state, both would fit into the emergency management procedures for nuclear accident cases.

Comparing approaches and tools applied in the nuclear and radiological management (e.g. the ARGOS and RODOS systems) used in many European Member States and beyond, one clearly can state that they miss decision aiding components that support the realisation of countermeasures developed at the strategic level. Distribution of iodine tablets, sheltering of the population and evacuation are recommended based on radiological indicators. However, there is no support in that way if the strategies proposed are feasible under the prevailing conditions. As external simulation programs such as RODOS can be integrated into S2P, such a system seems to be also valuable for radiological and nuclear emergency management and here in particular for designing exercises.

Acknowledgment

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