The International Emergency Management Society
2015 Annual Conference, 30th September - 2nd October 2015, Rome, Italy

EMERGENCY MANAGEMENT WITH INTERDEPENDENCY MODELING IN THE URANIUM PROJECT

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ABSTRACT
In the last ten years, the emergency response has been a key point for the welfare of citizens as well as for the economic losses. The widespread technology deployment improves the emergency response but the existing interdependencies among physical and cyber systems generate unpredictable consequences in the reconfiguration procedures. The European project URANIUM aims to provide a timely and an efficient tool for decision support that is simple to use also in complex emergency scenarios. This system gathers data from several SCADA (Supervisory Control and Data Acquisition) systems of Critical Infrastructures (CIs), such as power grid, gas and pipelines, telecommunication network, and transportation. The core of URANIUM project is two cascading modules: the first is CISIApro tool for evaluating risk of interdependent CIs and the second is an expert system for managing civil protection operations. CISIApro tool fuses data and information coming from SCADA systems in order to understand the consequences of negative events, such as faults, natural disasters and cyber-attacks. CISIApro models infrastructures and their interdependencies using an agent-based technique where each agent evaluates its own risk using information coming from its neighborhood. The expert system is based on structured decision support methodologies. It provides a suggestion for managing and optimizing the intervention procedures of civil protection. The output of this process is a cockpit, i.e., a synoptic view of predicted situations and a suggestion for emergency procedures.
This approach is experimented and under test on a realistic and quite complex case study of a smart area. The efficiency of emergency procedures is shown to be improved in terms of cost and time by means of a semi-automatic process where decision makers are needed.

KEYWORDS:
Interdependency modelling, civil protection, emergency management, decision making

1. INTRODUCTION

Modern societies are highly dependent on the continuous operations of their critical infrastructures that deliver critical goods and services. These include electricity, drinking water, information and communication technologies and waste disposal. Interruptions can have repercussions on the population and may affect other critical infrastructure through the domino effect: for example, a large power outage will affect immediately drinking water supply, telecommunications and rail. The European security as well as the quality of life of its citizenry depends on the continuous reliable operation of a collection of complicated interdependent infrastructures including transportation, electric power, oil, gas, telecommunications and emergency services. A disruption in one infrastructure can quickly and significantly impact another one, causing ripples across the nations. The importance of critical infrastructure is also clear from the fact that they can be defined as those industrial capabilities, services and facilities that in case of interruption of their normal operation can affect people's lives and, most important, can damage or destroy people's lives. During last decades, infrastructures are increasingly reliant on new information technologies, that allow for enormous gains in efficiency but they also create new vulnerabilities against natural disasters or terrorist attacks. Among international organizations critical infrastructure protection concerns, NATO was the first to be involved in this field. In 2009, NATO issued a series of definitions in the field, supported by all Member States and partner:

- critical infrastructure are those facilities, services and systems that are so vital to the nation, that their removal from service or destruction is potentially destabilizing national security, economy, health of the population and the effective functioning of government;
- CIP includes programs, activities and actions taken by governments, owners, operators and shareholders to protect these infrastructures.

Senior Civil Emergency Planning Committee within NATO has notified the eight subordinate committees to find solutions as an integrated approach to issues such as criteria for determining critical infrastructure, risk analysis methods and identifying vulnerabilities and their methods of protection. In particular, there are different forms of natural disasters, as typhoon, heavy rains, sea level rise, flooding, earthquake, etc. These natural disasters have caused significant economic, social, financial, property, environmental degradations, infrastructure damages and also tragic loss of human lives. When an emergency occurs, the relevant management personnel or decision-makers (DMs) need to decide what actions to take instantly to mitigate or minimize the negative effects. Such catastrophic incident reveals the need for efficient planning and the need for careful decision to be taken during the first few minutes following an incident. Decisions are critical to successful mitigation, damage management, death prevention, injury, structural loss, and the overall solution of the crisis. Project URANIUM consists of an intelligent decision making system that optimizes the allocation of resources following an infrastructure disruption and suggests how the resources could be utilized during disaster response. It provides a timely and an efficient tool for decision support that is simple to use also in complex emergency scenarios. This paper is organized as follow : First, a short overview of related research and work will be presented. Second, the decision-making problem in emergency response will be defined, and URANIUM solution will be introduced. Third, the discussion of the obtained results and the future work will be presented.

2. RELATED WORK

This section describes related work in the areas of disaster response, in particular critical infrastructure modeling and decision support making by Multi-Criteria Decision Method.

2.1. Critical Infrastructure Modelling

A survey of the modelling and simulation methods is presented by Satumtira and Duenas [17] , presenting an exhaustive and critic presentation of the most famous approaches. Their survey highlights that most of the existing strategies are not competing but rather complementary approaches, such as stochastic interdependence, cascading failures across systems and the establishment of risk mitigation principles. The modelling approaches include techniques based on game theory, graph theory, risk based model, Petri net or Bayesian networks. However, many of these interdependency models are used in a conceptual phase, or apply in simple and high-level scenarios. Rahman et al. in 2008 developed a simulator called Infrastructure Interdependency Simulator (I2Sim) based on the cell-channel model. The infrastructures and their interconnections are represented using cells and channels. A cell is an entity that performs a function: for example, a hospital is a cell that uses input tokens, such as electricity, water, medicines, and produces output tokens, such as beds served. A channel is a means through which tokens flow from a cell to another one. The interdependencies between different infrastructures are non-linear relationships summarized in Human Readable Tables (HRTs). I2Sim helps the decision maker optimizing the resources and the priorities in system restoration after critical events. I2Sim is also the core element of an advanced disaster management tool, called DR-NEP (Disaster Response Network Enabled Platform), based on a web services infrastructure where also domain simulator is included. The modelling technique has been validated in several case studies, such as Vancouver 2010 Winter Olympics. The case studies are mainly related to natural disasters and do not consider the impact of possible cyber attacks. In literature, the majority of the simulators are implemented as agent-based solutions (CAS - Complex Adaptive Systems), where a population of autonomous interacting agents coordinates their decisions to reach a higher-level global objective. The main feature of the CAS is usually the ability to create an overall infrastructure starting from the web of interconnections. The interdependencies are modelled as edges among agents allowing them to exchange information: each agent receives inputs from other agents and sends them back, see Nieuwenhuijs for further explanations. CISIApro (Critical Infrastructure Simulation by Interdependent Agents) is based on the CAS framework where each agent has a high-level description of the internal dynamic. This CAS simulation model has the main disadvantage to acquire detailed information about each single agent, but CISIApro aim is limited to the study of faults/threats propagation and performance degradation. Another recent trend is the co-simulation framework: several domain specific simulators are connected using a well-defined and generic interface (API) for simulation interoperability. The main goal of this framework is to re-use existing models in a commune context to simulate complex scenarios in order to evaluate control strategies. The MOSAIK ecosystem is validated in Smart Grid Scenario where telecommunication network and power grid simulators are integrated. The authors pose much attention on the integration of different simulators for the electric side to include models of electric vehicles in Python, photovoltaics in MATLAB/Simulink, residential loads as CSV timeseries, and two different distribution grids based, again, on Python. The main result is related to the ability to cope with different temporal resolutions (continuous, around each minute, every 15 minutes or no time at all), but the framework is at an early stage of development. In next paragraph, some approaches on how to assess impact of different cyber threats will be outlined.

2.2. Decision Support System

The existing studies have made significant contributions to decision analysis in emergency response. In several studies, various decision-making methods have been proposed according to the characteristics of different actual emergency events, such as flood disaster and fire hazards etc. For example, Hämäläinen et al. [6] proposed a multi-attribute risk analysis method to select a strategy for protecting the population in a simulated nuclear accident. Shim et al. [7] developed a decision support system (DSS) for controlling river basin flood. Fu [8] proposed a fuzzy optimization method for selecting the most desirable action to control the flood of reservoir. Geldermann et al. [9] proposed a MCDM-based evaluation method for nuclear remediation management. Lim and Lee [10] proposed a spatial multi-criteria decision analysis approach for evaluating flood damage reduction actions. Peng et al. [11] proposed an *incident information management framework* based on data integration, data mining and multi-criteria decision making. Ergu et al. [12] proposed a simple consistency test process to make ANP more suitable to solve decision-making problems in emergency cases. Qin et al. [13] developed an MCDM-based expert system to tackle the interrelationships between the climate change and the adaptation policies in terms of water resources management in the Georgia Basin, Canada. Tinguaro Rodrıguez et al. [14] applied a data-driven, two-level knowledge decision support system (DSS) prototype to support humanitarian NGOs in response to natural disaster. Technique for order preference by similarity to ideal solution (TOPSIS), known as one of the classical MCDM methods, originally proposed by Hwang and Yoon [15] for solving the MCDM problems Armaghan and Renaud et al [16] apply MCDA (ELECTRE) in the retrieval phase of Case-Based Reasoning.

3. INTEGRATED DECISION MAKING

Critical infrastructures have always been the most sensitive and vulnerable of any system and process. They are critical not only due to the attacks, but also due to other causes, both human and technical, some of them being difficult to identify and analyze. The threat of cascading failures due to dependency and interdependency aspects requires new concepts and tools for analyzing the behavior of these systems and their impact on infrastructure they serve. This section describes the URANIUM approach. It consists of is two cascading modules: the first is CISIApro tool for evaluating risk of interdependent Critical Infrastructures (CIs) and the second is an expert system for managing Civil Protection operations. CISIApro tool fuses data and information coming from SCADA systems in order to understand the consequences of negative events, and models infrastructures and their interdependencies using an agent-based technique where each agent evaluates its own risk using information coming from its neighborhood. The expert system is based on structured decision support methodologies. It provides a suggestion for managing and optimizing the intervention procedures of Civil Protection. Decision support is realized using a hybrid procedure based to MCDM (ELECTRE).

3.1. Features of CISIApro Simulator

3.1.1. Mixed Holistic Reductionist (MHR) Approach

The Mixed Holistic Reductionist (MHR) approach, proposed by [1], was created to exploit the advantages of holistic and reductionist methods. In holistic modelling, infrastructures are seen as singular entities with defined boundaries and functional properties. On the other hand, reductionist modelling emphasizes the need to fully understand the roles and the behaviour of individual components to truly understand the infrastructure as a whole. Different levels of analysis require one or both of the two point of view and their boundaries are lost in event of complex case studies. With the MHR model, relationships between infrastructures could be seen at different levels through either a top-down or bottom-up approach. A key element of operators is the quality of Services towards customers. This analysis strengthens the addition of another layer, called service, describing functional relationships between components and infrastructure at different levels of granularity. In

MHR, services to customers and to other interconnected infrastructures are explicitly considered as a middle layer between holistic and reductionist agents.

3.1.2. CISIApro Simulator

CISIA simulator is an agent-based simulator, where each agent has the same structure, see Fig. 1. Each agent receives resources and failures from the previous ones. A resource is a good, a service or a data produced and/or consumed by the agent, represented in CISIA as an entity. The ability to produce resources is summarized by the concept of operative level, depending on the availability of received resources, on the propagation of faults, and on the functionality of the entity itself. The entity receives also failures coming from the upstream interconnections and spreads it to the downstream ones. The considered classes of interdependencies are physical, logical, geographical and cyber. The complete analysis of the CISIA simulator is reported by De Porcellinis et al. in [2]. Usually, risk index is evaluated as impact, threat and vulnerability:

$$\boldsymbol{R}isk = \boldsymbol{I}mpact \times \boldsymbol{T}hreat \times \boldsymbol{V}ulnerability \qquad (1)$$

Typically, risk is a numeric value, from the impact severity, the likelihood of occurrence or threat, and the vulnerability analysis. In CISIA applications, the likelihood of occurrence is substitute with the trust of the information. For each entity, the user can add also a vulnerability variable, but in the following case study, we suppose that the vulnerability depends only on the distance from the source and on the persistence of the attack itself. The operative level of each agent is associated to a risk level: the risk is the amount of harm due to specific events, such as a failure, and can be evaluated as

$$\boldsymbol{R}isk = 1 - Operative\ Level \qquad (2)$$

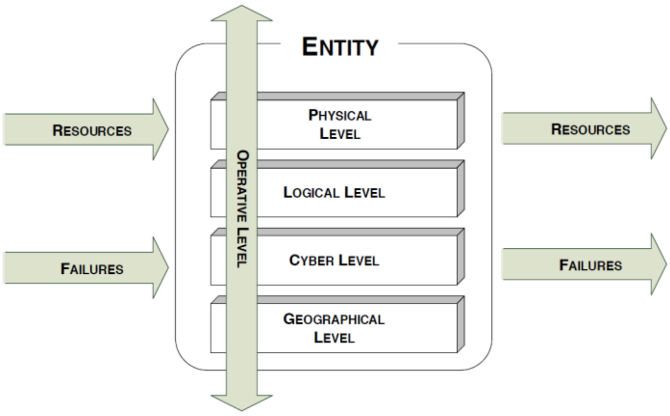

Figure 1. CISIA entity diagram

In 2014, CISIA has been re-design in order to overcome some implementation issue; the new simulator is called CISIApro. The main problem was related to the possibility of infinite logic loops when resources are instantly exchanged. CISIA main thread buffers all the information exchanged among entities in a time step. If the transfers are circled, then the simulation time step never ends. In CISIApro simulator, the information flow is well defined with a threshold of maximum executions in a time step in order to avoid logic loops, see also Fig. 4. Another disadvantage of CISIA was the long time needed to debug the software. In CISIApro, an efficient Graphical User Interface is provided for create entities and connect them in easy way, adding also the exchanged resources, as in Fig. 2. After the creation of the entities with their interconnections (i.e., interdependencies) and the exchanged resources, the users need to implement the behaviour of each entity, see Fig. 3.

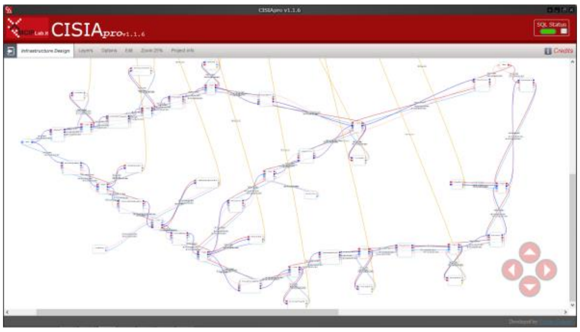

Figure 2. Example of CISIA Graphical User Interface

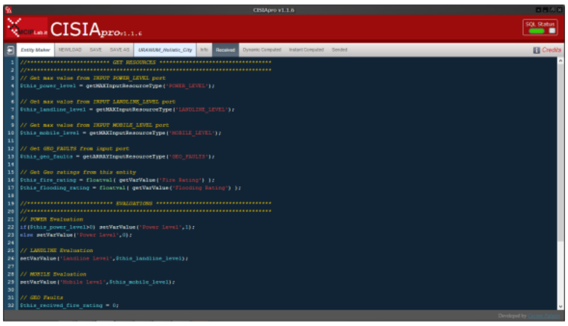

Figure 3. Snapshot of the entity maker inside CISIApro

Each entity is made of four modules that are executed at run-time, see Fig. 4: the evaluation of received resources and faults (RECEIVED), the implementation of dynamic and instant evolution (DYNAMIC COMPUTED, INSTANT COMPUTED, respectively), and finally, the evaluation of resources sent towards downstream entities (SENDED). CISIApro is designed over a database in order to distinct the construction design phase and the output storage with the proper graphical interfaces. CISIApro has a database structure, depicted in Fig. 5, memorizing all the information needed for the representation of several Critical Infrastructures and their interconnections. Each entity is an instance of an entity type and has a status made of variables. Each entity has ports for exchanging resources creating MHR layers. Each layer has proper interdependencies. Outputs of CISIApro is stored in a different database, see Fig. 6, with specific features, such as the record time-stamp in terms of date, time and milliseconds.

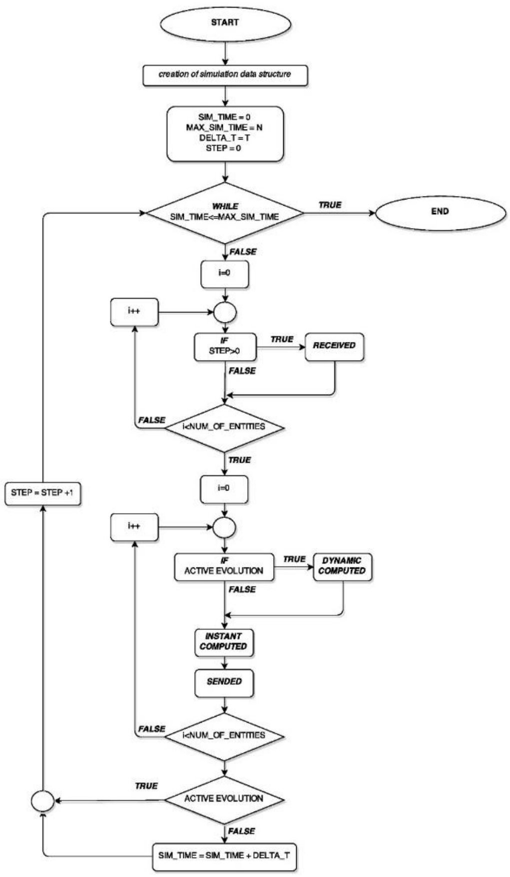

Figure 4. Flow diagram of the CISIApro simulation

Outputs of CISIApro is stored in a different database, see Fig. 6, with specific features, such as the record time-stamp in terms of date, time and milliseconds.

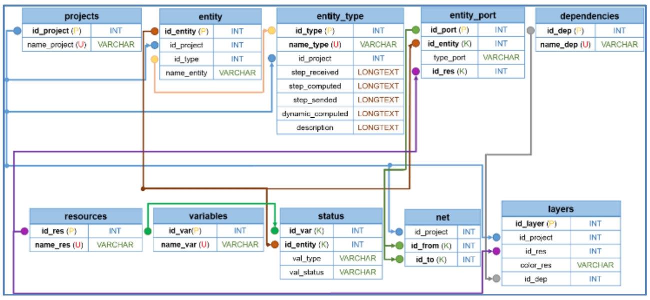

Figure 5. The representation of the CISIApro database

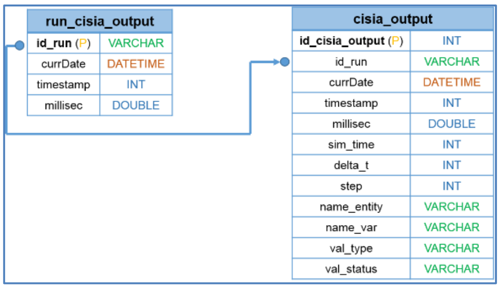

Figure 6. The representation of CISIApro output database

In CISIApro, the adjacency matrices, representing the interdependencies among entities, are generating during the design phase. During the simulation, the matrices are represented as queue data structures for fast computing. CISIApro has been validated in two European projects: FACIES [3] and CockpitCI [4]. In both scenarios, the aim is to help operator in decision-making process.

3.2. Decision Support System implementation

We distinguish four stages of decision making where the developed Decision Support System is crucial in processing the collected data and providing high-level information.

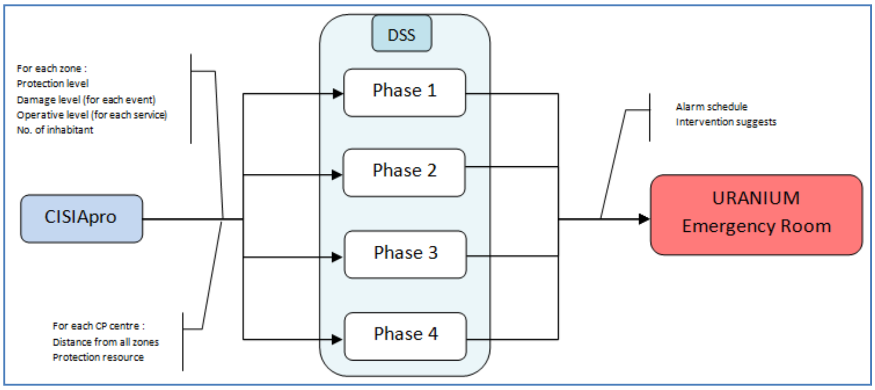

Figure 7. DSS information flow

We modeled the magnitudes in analysis as follows:
Protection level, represents the capacity of each zone to contrast the emergencies. It can assume values between 0 and 1.

- Value 1 : operational resources available
- Value 0,5 : operational resources not immediately available
- Value 0 : operational resources not available

Damage level, represents the damage value created by the particular event. It can assume values between 0 and 1.

- Value 1 : maximum damage, all infrastructures are damaged
- Value 0,5 : medium damage, some infrastructures are damaged
- Value 0 : no damage, all infrastructures work properly

Using CISIApro, the component of damage is spread to other cities in order to represent the scenario evolution in the short term. Propagation model regards the geographical interdependence. Damage decreases as one moves away from the catastrophe epicenter. This behavior is achieved by operational level degradation in the cities of epicenter neighborhood. Damage and operatives value correspond to the city damage state and city operatives state, in according with Civil Protection standards. These states are:

- Normality state
- Attention state
- Early warning state
- Warning state

- Emergency state

We introduced threshold values useful in the process of determining the status.
Threshold values (unique value for all city area, defined for each primary service or each event):
- *Attention threshold* divides the *normality state* from *attention state*
- *Early warning threshold* divides the *attention state* from *early warning state*
- *Warning threshold* divides the *early warning state* from *warning state*
- *Emergency threshold* divides the *warning state* from *emergency state*

3.2.1 First phase

The objective of DSS in this case is to determine the operative level scenario areas, comparing operative levels with predetermined threshold values, obtained according to CISIApro standard output. One-to-one correspondence is established between standard collateral information and each alarm. This provides important information on areas access, or communications malfunctions, to share with the Civil Defense. Additional information is sent to URANIUM Energy Management Room to report critical situations.

Input:
- Lop_{hj} = operative level of primary service *j* in city *h*
- Threshold value :
  - S_j^N = Attention threshold of primary service *j*
  - S_j^P = Early warning threshold of primary service *j*
  - S_j^A = Warning threshold of primary service *j*
  - S_j^E = Emergency threshold of primary service *j*
- Database of intervention suggests to Civil Protection

Output :
- Type and alarm level of primary services for each city
- Operative suggests to Civil Protection

3.2.2 Second phase

The DSS will proceed to identify the alert level in each area and for each type of event, by comparing the particular damage level with some preset values named values alarm threshold. For each alarm, there is one-to-one correspondence with an operating standard. This will provide important information to share with Civil Protection:
- Type of warnings for each area
- Units to alert and send to contrast current events

Input:
- d_{hj} = damage level of event *j* in city *h*
- Threshold value:
  - D_j^N = Attention threshold of primary service *j*
  - D_j^P = Early warning threshold of primary service *j*
  - D_j^A = Warning threshold of primary service *j*
  - D_j^E = Emergency threshold of primary service *j*
- Database of intervention operative standard

Output:
- Type and alarm level of primary services for each city
- List of Civil Protection vehicles suggested to be sent in each city to face the particular event
- List of city with an emergency in place

3.2.3 Third phase

The DSS has the objective of identifying one or more solutions, alternatives, that best conform to preset requirements, criteria using MCDM approach. These techniques can be used to identify desired measures among a variety of alternatives through analyzing multiple criteria, by which the strengths and weaknesses of various adaptation options are evaluated. Five recommended MCDM methods, including AHP, PROMETHEE II, and TOPSIS are used yet to process the disaster data. In URANIUM DSS, the optimal solution among all of the feasible alternatives are ranked and recommended by ELECTRE II method. Multi Criteria Decision Making methods defines criteria/alternatives matrix whose elements are the enhancement of damages, caused by the particular emergency. The Final level of damage is considered as a function objective to minimizing. The choice fell upon these methods of resolution because they take into account the leak of rationality and conforms best to reality, considering that the involved factors of disasters are normally intangible, and the judgments made by experts are usually imprecise and uncertain.

Input:

- d_{hj} = damage level of event *j* in city *h*
- a_h = No. Inhabitant of city *h*
- Lop_{hj} = operative level of primary service *j* in city *h*
- w_i = weight of criterion *I*
- Threshold value:
  - T_C^d = Threshold of weak concordance
  - T_D^d = Threshold of weak discordance
  - T_C^f = Threshold of strong concordance
  - T_D^f = Threshold of strong discordance

Output: Ordered alternative according with intervention priority

Each alternative corresponds to the intervention in the particular city that is in state of alarm. Criteria considered are the type of event, the operative state, and the number of inhabitant of each city. Exploiting the principle of dominance the DSS outputs the ranking of alternatives that correspond to timeline of alerts to be considered.

3.2.4 Fourth phase

Once having outlined the scenario and emergency alarm level for each area, the DSS will provide the optimal allocation of emergency operating centers based on hourly distance and on the level of protection that each presidio provides.
This will provide important information about the operator's emergency management responsibilities that each presidio has in combined operation of the joint group.

Input:

- p_k = protection level of Civil Protection presidio *k*
- d_{hj} = damage level of event *j* in city *h*
- Database of distances from each presidios to all cities

Output: List of operating presidios needed to face any emergency in place

DSS assigns the emergency to the closer operating presidio using the ranking obtained in the previous phase. If resources of the presidio are not sufficient to contrast the situation, DSS provide to define a joint action of other operating presidio in the scenario considered.

4. EXAMPLE SCENARIO

This paragraph uses a case study to demonstrate the application of the URANIUM process to a smart rural and urban area. The aim is the optimal allocation of emergencies to operating presidios of Civil Protection, in order to provide an adequate and timely response to the catastrophic events in place.

4.1. Scenario description

To particularize the interventions in considered scenario, a census of dangers that could occur in the area of Latina is useful.
Starting from the study of documentation issued by the Prefecture, is carried out an analysis of the risks that might occur in scenario's areas and leading to emergency situations that having to manage. The results obtained show events:

- Earthquakes
- Adverse climatic events
- Forest fires
- Hydro geological events
- Industrial hazards

A census of critical infrastructures considered in the province of Latina is as follow.

4.1.1. Power Distribution Infrastructure

To model this process we will consider the transmission system that includes 2 Primary Cabins (PCs) and, for the distribution system, the 18 Switches in the selected area. We consider each PC as a subsystem composed by two main transformers located in a small building inside a private area. Each transformer can be managed remotely and has also the usual electric protections that will automatically intervene when an electric fault occurs (e.g., short circuit, over load, over heating, etc.). The small building has sensors (and local subsystems) for smoke detection, temperature excess, flooding. Those sensors are connected to a central operational room and related local subsystems can be managed (reset, etc.) remotely. The small building is also protected against intrusion and this subsystem is connected to the central operational room. The private area that surrounds the small building is also protected against intrusion and remotely controlled. To access the PCs for maintenance or normal operations, the operators must follow an access procedure, which uses badges to open the gate of the area and the door of the building. This procedure is remotely controlled and must be executed in a defined time lapse.

4.1.2. Gas Distribution Infrastructure

We consider two Pumping Stations (PS) connected to the transmission and distribution pipelines. These PS are located in buildings inside the private area. The scenario includes also a storage that intervenes, for a limited time, in case of fault of a PS and consequent shortage of gas in the distribution network. We consider each PS as a subsystem composed by two compressors located in a building. Each compressor can be managed remotely and has also the usual protections that will automatically intervene when a fault occurs (e.g., compressor block, failure to open valve, loss of input pressure, etc.). Loss of electric power is also considered a fault. The building has sensors (and local subsystems) for smoke and fire detection, ventilation loss, gas leaks, temperature excess, flooding. These sensors are connected to a central operational room and related local subsystems can be managed (reset, etc.) remotely. The building is also protected against intrusion and such subsystem is connected to the central operational room. The private area is also protected against intrusion and remotely controlled. To access the PS for maintenance or normal operations the operators must follow an access procedure, which uses badges to open the gate of the area and the door of the building. This procedure is remotely controlled and must be executed in a defined time lapse. When a PS is unavailable (fault, maintenance, etc.) the scenario will include the storage that intervenes to compensate the loss of gas. The operation of the storage is modelled in two possible ways: one way considers a constant request of power and consequently is time-based; the other is based on the consumption request by the network and is flexible.

4.1.3. Telecommunication Services

Telco infrastructure has a certain level of mobility; its interdependent and interconnected structure presents both challenges and opportunities in coordinating the preparation of public and private crises, also regarding the Civil Protection activities.

4.1.4. Transport Infrastructure

Another relevant sector for URANIUM project is the Transportation one. With a view on rural areas, our main focus in that field is the ground transportation system. In an emergency case it is mandatory to provide for both resident and emergency responders the access at the evacuation routes. During emergencies, Civil Protection is in charge of the protection of the citizens. Several actors play crucial roles in the Civil Protection countermeasures:

- Police force;
- Fire-fighters;
- Coast guards;
- Hospital volunteers;

Each of these actors provides their means for the welfare of the people. Hence for the ground transportation system, our modelling choice has been the individuation of several principal and secondary routes to connect cities of the rural area.

4.2. Timeline and case study

The following frames summarize the timeline of the process, in Fig.8, that leads to the definition of operating tips for Civil Protection in a particular case study:

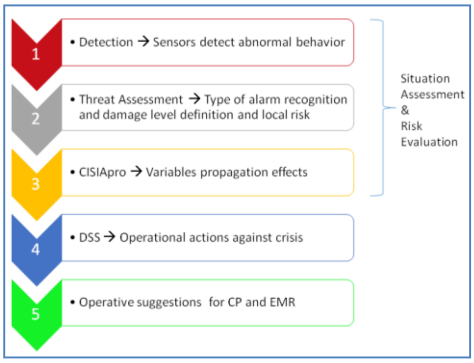

Figure 8. URANIUM process timeline

Step 1 – Detection (Fig.9)

Sensors indicate abnormal findings in Sezze, San Felice Circeo e Sperlonga.

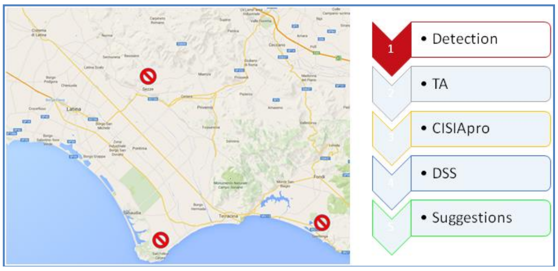

Figure 9. Case study detection

Step 2 – Threat Assessment (Fig.10)

In this step, type and size of events will be defined.

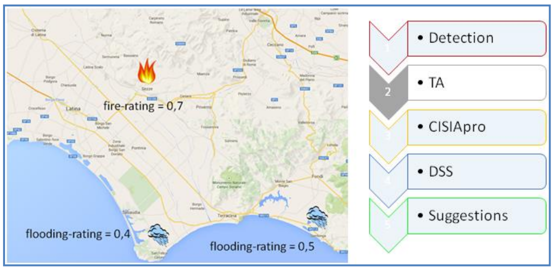

Figure 10. Case study threat assessment

Step 3 – CISIApro evaluation (Fig.11)

CISIApro makes the propagation of damage in the neighbouring cities. The operational level of urban centers decreases according to the modelling already introduced.

Figure 11. CISIApro risk prediction

Step 4 – DSS evaluation (Fig.12)
DSS defines the alarm level, the operative level for each city and suggests the time sequence of operations to be performed.

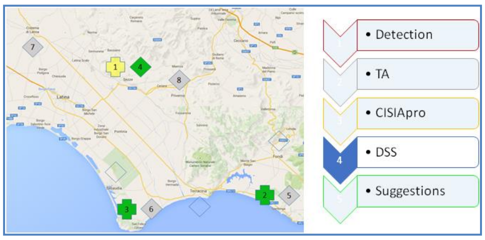

Figure 12. DSS output (crosses represent emergency intervention, rhombuses underline future risks)

DSS also defines the operational centers responsible for any emergency and the deployment of the vehicle suggested to return from the crisis, see Fig.13 .

Figure 13. DSS suggests deployment of Civil Protection vehicles

Step 5 – URANIUM suggestions (Fig.14)
Uranium provides tips and important information to Civil Protection for the management of the event.

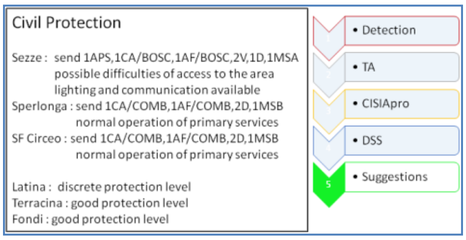

Figure 14. URANIUM suggestions snapshot

Final choice is left to the operator that has the possibility to check the scenario simulated evolution after the application of the countermeasures recommended by DSS.

5. CONCLUSIONS

Observing obtained results, we notice the optimum behaviour of risk predictor and DSS that are able to suggest a correct and weighted answer to face the particular emergence scenario, after few seconds of abnormal finding. CISIApro helps decision maker to evaluate the damage propagation and the CIs potential risks. DSS gives to operator the possibility to set emergence priority based on particular events in place, city population,

etc., using a different criterion weight. Concordance/discordance threshold values tuning is an important instrument gave to operator. He is able to set the degree of confidence about the collected data.
The project presented in this paper is an innovating approach for studying natural or human-made disasters on CIs, and for optimally allocating of Civil Protection resources during disaster response. This approach is experimentally tested on a realistic and quite complex case study of a smart area. The efficiency of emergency procedures is improved in terms of cost and time by means of a semi-automatic process where decision makers are needed. The complementary nature of these instruments and their strong tendency to optimization allow a great innovation, introducing the possibility of creating a SCADA component that allows, if properly synchronized, the automated management of crisis situations in every scenario.

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