# MODEL FOR ANALYSIS AND ASSESSMENT OF HAZARDOUS ENVIRONMENTS TO IMPROVE THE SECURITY OF THE POPULATION

МОДЕЛ ЗА АНАЛИЗ И ОЦЕНКА НА ОПАСНИ СРЕДИ ЗА ПОДОБРЯВАНЕ НА СИГУРНОСТТА НА НАСЕЛЕНИЕТО

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***Abstract:*** Prevention of industrial accidents in Europe and creation readiness of the authorities and the community for countering them are aimed not only at major catastrophes, but also at the small ones, which threaten the society, jobs and environment. Regardless of the internationally accepted framework for prevention and counteraction the industrial accidents involving hazardous substances (refers to the Seveso type site/area related accidents), there are fields that have not yet been developed, such as an assessment of the vulnerability of various sectors of economy, their interdependencies and the impact on social life. Considering these challenges, the main objective of the current article is to bring to the attention of stakeholders an integrated package of advanced developments, both in terms of Seveso type site/area related accidents, caused by reason of technological failures (technological mistakes) or are due to targeted man-made activities (terrorism).

*KEYWORDS: HAZARDOUS ENVIRONMENT; ANALYSIS; EVALUATION; POPULATION SECURITY*

## *1. Introduction*

In 1976, an explosion in a small chemical plant outside the town of Meda, in Italy’s Lombardy region, led to the adoption in 1982 of the European Union Directive 82/501/EC relating to major chemical accidents, which came to be known as the Seveso Directive. The document aims to prevent the occurrence of major accidents at sites that store, produce or make use of dangerous substances.

The latest version of the Seveso Directive adopted in 2012 (Directive 2012/18/EU, effective 1 June 2015). The changes include technical updates to take account of changes in EU chemicals classification, as well as better access for citizens to information about risks, how to behave in the event of an accident, more effective rules on participation in land-use planning projects related to Seveso plants, access to justice, and stricter standards for inspections **[1]**.

The Seveso Directive is also considered to be the European Union’s legal and technical instrument to fulfil the obligations, closely related with the UNECE Convention on the Transboundary Effects of Industrial Accidents **[2]**.

With a view to strengthen Chemical, Biological, Radiological, Nuclear and Explosives (CBRNE) security, as well as to ensure protection of citizens, institutions and infrastructure against CBRNE incidents, in May 2014 was adopted a new EU approach for detection and mitigation of CBRNE risks **[3]**. The objectives of this new approach are to better assess the risks, to develop countermeasures, to share knowledge and best practices, to test and validate new safeguards with the ultimate goal to adopt a new security standards.

Notwithstanding of the internationally accepted framework for prevention and counteracting accidents, involving hazardous substances, the related fields have not yet been developed are: assessment of the vulnerability of various sectors of economy; improvement of the sustainability of buildings against CBRNE substances of concern; implementation of state-of-the-art systems for contamination of air, water, food and working environment and standardization of related activities in the field.

Namely those fields serve as a basis for developing the concept of the proposed contemporary approach for complex analysis and evaluation of hazardous environments as an input signal for improvement of the sustainability of buildings against CBRNE.

## *2. Concept*

From the above mentioned it becomes clear that there are no systematic EU requirements in the field of construction, related to the buildings and facilities of critical infrastructure, central and local administration and society protection against the effects of CBRNE materials and explosive blast. All this imposes the need for modelling a comprehensive approach for assessment and analysis of hazardous environments, including buildings and associated infrastructure. It is important to underline that this contemporary approach in advance has been discussed with the colleagues from different scientific and business organizations from Austria; Bulgaria; Cyprus; Greece; Italy; Lithuania; Portugal; Romania; Slovenia; Spain and United Kingdom.

The main objective of this new approach is a model for assessment and analysis of hazardous environments to be developed, in order to enable the effective measures for infrastructure protection to be implemented, thereby increasing society’s level of protection.

Therefore, the main structural elements of the concept are:

- Risks Assessment Methodology for multi-sectoral interdependencies, concerning Seveso type site/area related accidents;
- Measures to enhance the protection and reliability of buildings against explosive blast;
- Preparation of the requirements for the development of procedures and equipment for chemical and radiation protection of Seveso type site/area;
- Stationary and portable sensory unit models proposal, with high sensitivity and fast detection of contamination by chemical agents and radioactive materials for early warning;
- Localization of personnel in restricted areas (inside and outside of the buildings) and remote monitoring of their physiological health parameters;
- Personnel training and education model.

## *3. Nature of the approach*

The contemporary approach is built upon a series of technological developments that have already been elaborated and successfully tested. At the same time, to achieve sustainable operation of the proposed innovation it is necessary to improve their technical characteristics, which will allow their smart combination. All this is enriched with the proposed models of methodologies and standardized requirements which lie at the heart of the approach.

### *3.1 Risks Assessment Model for multi-sectoral interdependencies*

There is a need to better understand how society as a whole might be affected by risks of accidents and terrorist attack on sensitive sites/areas (involving potentially hazardous substances), in order to enable effective protection measures to be developed.

In this respect, the breadth of impacts of major-accident hazards involving dangerous substances have to be investigated, considering multi-sectoral (inter-) dependencies (notably transport, energy, communications and water). This implies developing knowledge on multiple types of sectors and socio-economic conditions around Seveso type sites/areas that might be affected by accidents, taking into account the type of sites/areas, CBRNE substances of concern, the vulnerability of various sectors and their interactions with the population, risk evaluation based on advanced decision making techniques and scenarios mimicking different levels of severity of impacts.

In the light of adequate established policy goals, an effective assessment and decision-making model, related to the potential severity of a CBRNE accident, will identify ways to decrease the cost of this kind of crisis and develop adequate protection measures. Better risk assessment for evaluation of different sectors, regions or populations, for comparing them in terms of relative vulnerability can guide the proper allocation of funding on protecting measures. Thus, will be enhanced understanding by policy-makers and other stakeholders on how multiple sectors, community, region or nation could be affected in total by an accident from a Seveso site/area, and what the total impact might be (human, material and economic).

At the European level are known most relevant methodologies and approaches in the field of environmental risk assessment, which include the assessment of the human, socioeconomic and natural characteristics of the site’s surroundings or constitute set of criteria for the estimation of the severity of the environmental impacts caused by accidents involving dangerous substances, but no one offers a comprehensive approach for risk assessment directed towards multisectoral dependencies in case of Seveso type accidents.

### *3.2 Measures to enhance protection and reliability of premises and buildings*

The dynamic of the development of modern means of terrorist impact on buildings and people, and the accelerated development of the economy dictates necessity of adequate policies by the EU to be taken. In this connection, within the scope of EU policy in the field of construction, requirements **[4]** are developed, relating not only to safety of buildings and other construction works but also to health, durability, energy economy, protection of the environment, economic aspects, and other important aspects in the public interest. Provided that they are properly maintained, construction works must satisfy these basic requirements in order to meet the societal expectations for an economically reasonable working life while providing **[5]**:

- ***Mechanical resistance and stability***

The loadings that are liable to act on them during their constructions and use will not lead to any of the following problems: collapse of the whole or part of the work; major deformations to an inadmissible degree; damage to other parts of the construction works or to non-structural components such as fittings or installed equipment as a result of major deformation of the load-bearing construction and damage by an event to an extent disproportionate to the original cause.

- ***Safety in case of fire***

In the event of an outbreak of fire the load-bearing capacity of the construction can be assumed uncompromised for a specific period of time; the generation and spread of fire and smoke within the construction works are limited; the spread of fire to neighbouring construction works is contained; occupants can leave the construction works or be rescued by other means; the safety of rescue teams is taken into consideration.

- ***Hygiene, health and the environment***

The construction will, throughout it life cycle, not be a threat to the hygiene or health and safety of workers, occupants or neighbours, nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition.

- ***Safety and accessibility in use***

The buildings do not present unacceptable risks of accidents or damage in service or in operation such as slipping, falling, collision, burns, electrocution and injury from explosion and burglaries. In particular, construction works must be designed and built taking into consideration accessibility and use for disabled persons.

Below directions can be performed with the objective to improve the parameters of materials and systems.

- ***Materials and Systems* [5]**

Steel and reinforced concrete are the two materials often used in construction of the supporting structure of buildings.

o ***Steel***

Steel structural systems should be detailed to take advantage of inherent ductility, and connections should be designed to provide continuity between elements. Steel should be used in three basic frame systems: moment-resistant frames, in which lateral resistance is provided by specially detailed beam/column connections; braced frames, in which diagonal steel bracing members provide lateral resistance and simple steel frames, in which lateral bracing is provided.

o ***Reinforced Concrete Construction***

Blast-resilient design incorporating ductile reinforced concrete should exhibit the following attributes: walls should span from floor to floor rather than from column to column; splices should be staggered away from high-stress areas; reinforcing bars should be spaced no more than one wall thickness apart, and no less than one-half the wall thickness apart; special ductile seismic-type detailing should be used at connections; development lengths should be used to develop the ultimate flexural capacity of the section; ties should be closely spaced along the entire length of beams, spirally reinforced columns; design for preventing progressive collapse should consider a scenario in which an exterior wall measuring verticall one floor height and laterally one bay width is lost.

- ***Methods of enhancing the sustainability of buildings [5]***

There are a variety of methods to improve the sustainability of buildings against explosions. In the following lines these are outlined only with reinforce to the proposal’s context: Poured-in-place Concrete Frames and Walls; Reinforced Concrete Masonry Units; Structural Retrofit; Building Envelope and Structural Load-Bearing Exterior Wall Systems.

- ***Increasing sustainability of windows [5]***

o ***Window Systems***

Punched or punched-in windows consist of conventional windows set in an opaque structural or nonstructural wall or closely set conventional windows creating a continuous ribbon appearance.

Spandrel glazing consisting of continuous glazing, is typically inserted above a continuous structural or nonstructural spandrel.

o ***Glazing Materials***

- Annealed Glass also known as float, plate, or sheet glass, is the most common glass type used in commercial construction.
- Wire-reinforced Glass is a common glazing material, primarily used as a fire-resistant barrier.
- Heat-Strengthened Glass also called double-strength glass, is intermediate in respect to strength between annealed and fully tempered glass materials.
- Fully Thermally Tempered Glass also known as toughened glass, is typically four to five times stronger than annealed glass.
- Laminated Glass is composed of multiple glass layers with pliable interlayer materials.
- Polycarbonates are very strong and suitable for blast-load-resistant window design.
- Film also known as anti-shatter film, shatter-resistant window film or security film, is the most economical retrofit measure to strengthen the exterior glazed elements of the facade.

Proposed model for buildings' sustainability against chemical or radiological attack is a natural result of the complexity of achieving prevention against chemical, radioactive and explosive impact on the buildings in the conditions of Seveso type site/area related accidents.

### *3.3 Quick detection of contamination with chemical and radioactive substances*

During the impact (for example terrorist attack) on the Seveso type site/area, chemical agents or radiological materials can be used to overcome protection of the object and hence the realization of the main goal, interrupting its functionality with a number of other means used by terrorists.

That's why the Early Warning System is mandatory for security and protection of the respective object. The most reliable elements of these systems are sensors and sensor systems. The scenarios under which sensors will be needed and the protocols for their use may be as varied as each object's specific mission. Because chemical and nuclear weapons, each pose different threat scenarios, differences in sensors and their operational protocols will be considered.

Whatever type of attack the sensors are designed to prevent or respond to the roles, that sensor systems play can be described in terms of four specific categories:

- Threat warning covers point-of-entry monitoring for preattack detection, as well as area monitoring of presumed target areas;
- Incident response scenarios, by contrast, require handheld deployable sensors and minimal training for operators;
- For treatment, the sensors' greatest contribution will be made in the aftermath of a chemical or radiological attack. They will be able to provide quick and accurate diagnoses, without the hours or days of time lag associated with standard culture growth techniques;
- For recovery, the speed at which information is available is usually less important than the accuracy of the data. For recovery, sensors would be useful for monitoring the level of contamination at a site during and after cleanup activities.

Either way, to carry sensor-system performance to the level needed, the protection will require not only continued improvement in basic sensor performance but also a better definition and understanding of overall performance - when many sensors are networked together. Communications protocols **[6]** will be needed, and network architecture issues associated with connectivity, bandwidth allocation, signal processing, and data fusion must also be addressed.

The next important step is the system-design approach, which in our case includes:

- Establishment of standards - covering response time and field stability/ durability, for example - for detection of weapons of mass destruction;
- Use of two-level sensor systems in which a low-false-alarm-rate sensor - one with low specificity - triggers a second sensor with a higher false-alarm rate but with high specificity;
- Use of multiple sensors and reasoning algorithms to obtain lower overall false-alarm probability, predict contamination spread, and provide guidance for recovery actions;
- Use of networked sensors to provide wide-area protection of high-threat targets.

The quick detection of chemical and radioactive substances contamination is envisaged to be achieved by developing a stationary sensor system.

### *3.4 Real-time analysis of air, food and water for chemical and radioactive contamination*

Improvement "…the development and use of detection systems across the EU" **[7]** is one of the core measures in the field of new CBRN policy of the EU. Effective protection of Seveso type site/area requires increased innovation and development of advanced, intelligent detection and sensor systems for physical early warning of hazardous environments, which include a real-time analysis of air, food and water for chemical and / or radioactive contamination. The sensors, as the elements of sensor system, can also be used to monitor and report the condition of the various nodes (such as power plants and industrial complexes) and links (such as transportation systems and utilities) that form Seveso type site/area networks.

In addition to advanced sensing capabilities and increased reliability, sensors must communicate with each other and be deployed at many locations to form a robust network.

Massive amounts of data will need to be processed and analysed to selectively filter out background signals in order to detect anomalies or patterns. The data and analysis results will feed into many other sensors and sensor systems, and undergo further analysis to provide actionable information to intelligence, law enforcement, and decision makers about terrorist or other suspicious or potentially damaging activities. Advancement of pattern recognition analyses will require novel approaches, possibly based on human thinking processes and instincts.

Wireless technologies are increasingly crucial to automation, communication, and information technology systems pervasive throughout the Seveso type site/area sectors. Wireless networks, already vulnerable due to limited security, face increased risks from mobile wireless nodes that can enter, traverse, and leave the network.

The abovementioned requirements will be met by development of sensor systems that can monitor and report the condition of Seveso type site/area and environment, measure and report damage, quantify diminished service, and estimate downtime for refunctioning. Smart sensor systems can be programmed to suggest alternatives, which will require integration and communication with the advanced analysis and decision support systems.

As a final result, the real time analysis of air, food and water for chemical and / or radioactive contamination will be achieved by portable and portable sensor system development.

### *3.5 Localization of personnel and remote monitoring of physiological health parameters*

For prevention of the impact of hazardous environments, the physical and mental aspects of health of workers on duty at the Seveso type site/area must be ensured. For that purpose, it has to be developed and tested a system for real-time, remote location of personnel, performing responsible tasks and working in sites of Seveso type site/area and monitoring of physiological parameters of human health, such as heart rate, skin conductance, temperature and intensity of movements. System development will be conducted in compliance with European regulations in this area **[8].**

Localization of personnel can be achieved with active Radio Frequency Identification (RFID) tags and antennas located at a suitable points in the building and / or on the terrain.

The active RFID tags will monitor in real time the power of the signal supplied by the antenna, located in the vicinity, such as used the method of triangulation for determination the exact location of the person with the tag.

Parallel task, together with reporting the possibility of accurate localization of personnel is the physiological parameters of human health (heart rate, skin conductance, temperature and intensity of movements) for which sensory elements will be developed. Combined, the proposed four physiological parameters outlined picture of the current status of person and his working capacity, as well as indirect evidence of the environment in which it is located, thereby helping the business process and / or control.

All these sensory elements (sensor for heart rate, accelerometer, sensor for skin conductance, thermometer and active RFID tag) will transmit information, with once per minute frequency, to the nearest RFID antenna, respectively, to the command center.

The command center software will analyze in real time information on the physiological parameters and location of personnel and when these parameters go beyond the predefined rates will alert the operator on duty.

Along with, the software will back up data obtained for possible later inspection and / or for statistical analysis.

### *3.6 Training and education*

To achieve better preparedness of society against Seveso type accidents, unless improvement of prevention and protection measures, timely implementation of training and education activities is important step in the field.

It should include more work on sharing best practices and developing guidance in tune with EU policy, which provides:

- Support for training and education abilities of Member States to help the EU to build its capacity to be prepared for crises, create synergies and eliminate duplication in protecting EU citizens;
- Skilled operators behind the equipment, well trained and motivated to enhance the person's performance, while making full use of the technology on hand.

Thus is expected to be achieved **[3]**:

- Further develop training tools, encourage the sharing of best practices and develop guidance materials to support practitioners with state-of-the-art training;
- Address the human factor risks by promoting a programme to ensure that those who operate detection equipment are well trained and motivated, and improve communication between industry, security service providers and Member States through workshops and tools and improve the level of security.
- Ensure CBRNE risks are taken properly into account in the development of the European Emergency Response Capacity;
- Closer links with training and exercises provided in the framework of the EU Civil Protection Mechanism.

## *4. Conclusion*

Expected impact and benefits of the proposed model developments is a better preparedness of society and all levels of stakeholders towards the "Seveso type site/area related accidents". Also, in the light of adequate established policy goals, an effective assessment and decision-making model, related to the potential severity of a CBRNE accident, will point out ways to decrease the cost of this kind of crisis and develop adequate protection measures.

Thus, will be enhanced understanding of policymakers and other stakeholders on how the multiple sectors, community, regions may be affected by Seveso type accidents, and what the total impact might be.

## *5. Literature*

**[1]** DIRECTIVE 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC;

**[2]** Convention on the Transboundary Effects of Industrial Accidents, amended on 19 March 2008, United Nations Economic Commission for Europe;

**[3]** Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a new EU approach to the detection and mitigation of CBRN-E risks, Brussels, 5.5.2014; COM(2014) 247 final;

**[4]** Regulation (EU) № 305/2011 of the European Parliament and of the Council of 9 March 2011 lying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC;

**[5]** Buildings and Infrastructure Protection Series, Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings - FEMA-426/BIPS-06/October 2011, Edition 2;

**[6]** D 5.1 Software Sensor Communication Standards, 20 Aug, 2012, Frédéric Perlant, ASTRIUM Services;

**[7]** COM(2009) 273 final, Strengthening Chemical, Biological, Radiological and Nuclear Security in the European Union – an EU CRBN Action Plan, Brussels, 24.6.2009;

**[8]** DIRECTIVE 2007/47/EC of the European Parliament and of the Council of 5 September 2007, amending Council Directive 90/385/EEC on the approximation of the laws of the Member States, relating to active implantable medical devices, Council Directive 93/42/EEC concerning medical, devices and Directive 98/8/EC concerning the placing of biocidal products on the market.