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## MODERN TECHNOLOGIES IN ENHANCING SITUATIONAL AWARENESS AND PREPAREDNESS FOR CBRN EVENTS IN URBAN AREAS. PERSPECTIVE OF EUROPEAN COMMISSION CALL IN 2022

## ABSTRACT

*Objective:* The research objective is to indicate current priorities of the European Commission in funding modern technologies that enhance situational awareness and preparedness for CBRN events in urban areas. *Methods:* We analysed strategic documents of the European Union informing CBRN safety and security Horizon 2020 program priorities and the proposal which won the call HORIZON-CL3-2022-DRS-01-08. This process allowed us to indicate patterns reflecting European Union's priorities in funding development of modern technologies to enhance both the awareness and the preparedness. *Results:* Investigation of 7 fundamental documents gave strategic background for applying modern technologies that enhance situational awareness and preparedness for CBRN events in urban areas. Relevant directions were reflected in the call for proposals named Disaster-Resilient Society 2022. Only one proposal was selected for funding and it now forms the basis for CHIMERA project (the full project title is: Comprehensive Hazard Identification, and Monitoring system for uRban Areas). The project's mission is to provide a technological improvement in the CBRN domain complying with European legislation and boosting the capabilities of end-users with novel detection, identification, and monitoring functionalities at relatively high TRL. *Discussion:* As CHIMERA project describes directly many of issues addressed in the call for proposals, the current directions reflect strategic assumptions for ensuring safety and security in Europe. The project also uniquely concerns CBRN response capability gaps identified by International Forum to Advance First Responder Innovation. Success story of CHIMERA proposal may serve as a reference in developing new technologies in a project formula in the future.

**KEYWORDS:** *situational awareness; CBRN; project; Horizon Europe; CHIMERA*

## 1. INTRODUCTION

United Nations Office for Disaster Risk Reduction (UNDRR) moderates international efforts to elaborate an inventory of all kinds of hazards which are characterised by a potential sufficient to initiate a disaster. The efforts are documented in two UNDRR reports published in 2020-2021 (UNDRR, 2020; UNDRR, 2021). The reports indicate more than 300 factors conducting to situation when a local community cannot cope with severe situational

conditions nor meet their basic existential needs. It is worth to mention that a serious number of these hazards ascribe into CBRN ones (chemical, biological, radiological, and nuclear). General trends in number of disasters worldwide force one to think about them in a light of increasing disaster risk (GAR, 2022). Thus, the question is not ‘whether?’ but ‘when and where?’ CBRN hazards will materialise.

European Commission has been paying special attention to CBRN hazards for many years. This care about protection against chemical, biological, radiological, and nuclear agents is reflected in research and development programs and frameworks. One should enumerate at least the 7<sup>th</sup> Framework Programme for Research (2007-2013), the Horizon 2020 Framework Programme for Research and Innovation (f 2014-2020) and the Horizon Europe Framework Programme (2021-2027). These programs and frameworks were and still are (in the case of the Horizon Europe) main funding mechanisms for European-centred research and development activities related to modern technologies. *Horizon Europe is the most ambitious EU's Research and Innovation framework programme to date, with a budget of 95.5 billion euros in 2021-27* (SPINVERSE, 2023). The program is based on three pillars: 1) Excellent Science; 2) global challenges and European industrial competitiveness; 3) innovative Europe. Within pillar 2), the program is focused on the following relevant clusters: a) health, b) civil security for society, c) digital, industry, and space (Horizon Europe1, 2023). The program's scope proves that European Commission is continuously strongly interested in funding new technological solutions related to safety and security issues, including CBRN events.

As a response to a CBRN event generally requires involvement of different entities (public administration bodies, public services, etc.) to conduct multiple and harmonised actions (Gromek, 2017; Kozioł et al., 2021; Havarneanu et al., 2022), a significant aspect of the response is to frame a common operational picture (COP) to enhance situational awareness (SA) and to create foundations for effective preparedness even before the event occurs (Hwang, Yoon, 2020; Steen-Tveit, Munkvold, 2021). It seems to be notably important in urban areas where a large number of people live and may be affected by CBRN agents, and human existential conditions are shaped by complex infrastructure, road networks, services, access to public goods, etc. Significance

of COP and SA in such circumstances found its confirmation in several research and development projects supported by European Commission in the form of grants. For example, DESTRIERO project (the full title: A DEcision Support Tool for Reconstruction and recovery and for the IntEroperability of international Relief units in case Of complex crises situations, including CBRN contamination risks) connected multiple technologies to collect, analyse, and create COP for the purposes of reconstruction and recovery after a CBRN disaster (CORDIS, 2023). SECTOR project (full title: Secure European Common Information Space for the Interoperability of First Responders and Police Authorities) focused on shaping SA in a cloud formula to be less dependent on direct access to technologies (CORDIS, 2023). In turn, consortiums of EU-SENSE project (the full title: European Sensor System for CBRN Applications) (EU-SENSE, 2023) and EU-RADION project (the full title: European Sensor System for CBRN Applications) (EU-RADION, 2023) implemented artificial intelligence solutions to create heterogeneous sensors and connect them to a decision support system for first responders to make them aware what happened and how the situation develops.

The above-mentioned projects highlight general ways of development of modern technologies in enhancing SA and preparedness for CBRN events in urban areas. And every next European Commission – funded project mentioned above is a next step in the development. It also needs to be noted that COP and SA are core elements of entire project ideas. Consequently, a specific way to monitor development of modern technologies appears. The way is marked by ideas which got European Commission's reviewers and decision makers convinced to allocate public resources for their funding – in this case, the ideas with the greatest potential to enhance SA and preparedness for CBRN events in urban areas.

The research objective of this article is to indicate current priorities of the European Commission in funding modern technologies that enhance SA and preparedness for CBRN events in urban areas. Awareness about the priorities may be useful for academia, public administration, technology providers, and CBRN practitioners (fire services, HazMat entities, police troops, armed forces, etc.) in designing new technological solutions in a project formula, designing new and developing existing tools, optimising public funding for modern technologies

with most development potential and preparing to implement such technologies in CBRN response operations. From this viewpoint, it is also assumed crucial to know how modern technologies will develop in the nearest future.

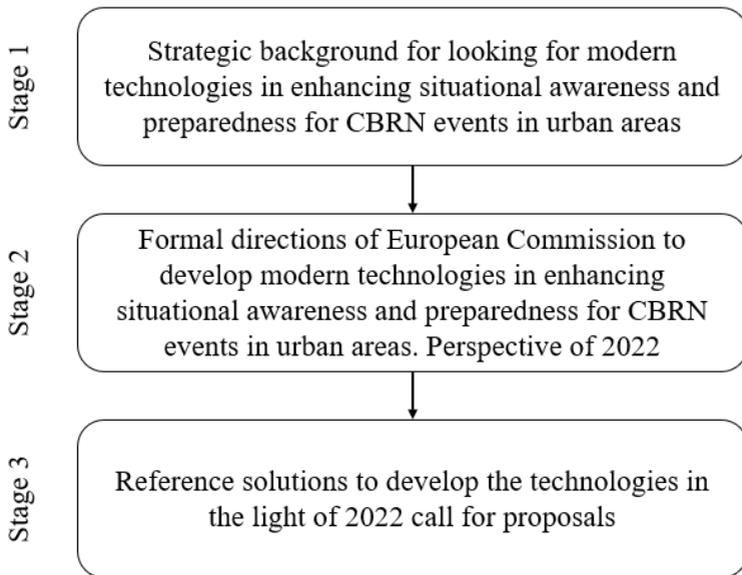
The structure of the article is as follows: Section 1 has provided the introduction to the research and presented general background information. Section 2 contains description of materials and methods used in the research. They regard literature review related to formal assumptions of the last call for proposals HORIZON-CL3-2022-DRS-01-08 on 'Enhanced situational awareness and preparedness of first responders and improved capacities to minimise time-to-react in urban areas in the case of CBRN-E-related events' and the winning proposal. Section 3 contains results of the research focusing on European Commission's formal priorities to develop modern technologies in enhancing situational awareness and preparedness for CBRN events in urban areas and relevant solutions. The solutions are described on the base of CHIMERA project – the only one project which has received funding after the call. Section 4 contains reflections about the CHIMERA idea and its practical realisation. Finally, Section 5 contains conclusions as well as suggestions for further scientific research.

## 2. MATERIALS AND METHODS

General view on the research method is presented on Fig. 1. The method comprises 3 stages. Stage 1 forms the analysis of strategic background for applying modern technologies in enhancing SA and preparedness for CBRN events in urban areas. It is assumed as essential to indicate reference points in international public policies, agendas and frameworks for processes of technology development. Stage 2 lists formal directions of European Commission to develop the technologies, within the last open financial perspective (that of 2022). It is identical with current view on the directions and a reference point to elaborate formal direction in the future (for example for 2023 calls for proposals). Finally, Stage 3 aims at reference technological solutions to develop in the light of 2022 call for proposals. It stems from the previous stages and gives the most detailed information about technologies and ideas for their integration, which

have commonly convinced the European Commission and reviewers to invest in them millions of EUR in the 2022 call for proposals.

**Fig. 1.** *General view on research method.*



**Source:** own study.

The method presents a logical way of thinking from general strategic assumptions to specific solutions.

Literature review was used to explore information sources related to the topic investigated (including the last call for proposals HORIZON-CL3-2022-DRS-01-08 on ‘Enhanced situational awareness and preparedness of first responders and improved capacities to minimise time-to-react in urban areas in the case of CBRN-E-related events’). Following information sources were considered:

- a. international policy frameworks stating formal background for the call,
- b. topic conditions and documents related to the call,
- c. the winning proposal.

All information sources are publicly accessible with one exception. The exception is the winning proposal which is formally restricted to European Commission and relevant consortium. The paper presents information from the proposal elaborated by the first author of the paper.

### 3. RESULTS

#### 3.1. STRATEGIC BACKGROUND FOR APPLYING MODERN TECHNOLOGIES IN ENHANCING SITUATIONAL AWARENESS AND PREPAREDNESS FOR CBRN EVENTS IN URBAN AREAS

Enhancing SA and preparedness for CBRN events in urban areas relates to several international policy frameworks. These frameworks reflect issues which currently shape safety and security in the European Union. CBRN aspects are worth to be mentioned as well. Based on background information concerning Horizon Europa funding related to CBRN events, the following international policy frameworks should be enumerated (ECEuropa, 2023a):

1. the Sendai Framework for Disaster Risk Reduction 2015-2030,
2. the Paris Agreement,
3. Transforming our world: the 2030 Agenda for Sustainable Development,
4. the European Green Deal (including the new EU Climate Adaptation Strategy),
5. the Security Union Strategy,
6. the Union Civil Protection Mechanism,
7. the Counter-Terrorism Agenda.

**The Sendai Framework for Disaster Risk Reduction 2015-2030** deals with disasters. This means *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). The disruption directly corresponds to severe conditions in which a local community is not able to satisfy basic existential needs and requires external support (for example

from other communities and, even, from another nations and international organisations). In addition, the framework indicates 5 general directions of the reduction. They are (Sendai, 2015; Gromek, 2023):

- a. limiting extent and severity of a disaster triggers,
- b. reducing vulnerability to a disaster,
- c. reducing exposure (the length of time) a disaster threat lasts,
- d. increasing the capacity to cope with a disaster consequences,
- e. increasing resilience to a disaster.

The Framework enumerates technological hazards and risks as factors which cause broadening of disaster risk reduction domain and highlights necessity to implement multi-hazard approach. In turn, limited availability of technology may generate vulnerabilities in a population in danger. Thus, technology transfer is said to be a significant factor in facilitating disaster risk reduction. From the perspective of COP and SA, a special attention should be paid to geospatial information technology, information and communications technology innovations, enhancing measurement tools and the collection, analysis and dissemination of data. In general, technology development is understood as one of basic solutions to enhance SA and preparedness for a disaster. In principle this may regard also CBRN events in urban areas (Sendai, 2015).

**The Paris Agreement** is one of basic European documents framing global efforts to be conducted against climate change (Paris Agreement, 2016). Even though it is not dedicated to CBRN hazards directly, climate change consequences may generate and/or intensify severe circumstances of CBRN events. As chemical, biological, radiological or nuclear hazards are elements of a complex crisis hazards' network<sup>[1]</sup> (UNDRR, 2021), they may initiate a cascading effect of hazards development. Consequently, every CBRN hazard is potential trigger impeding realisation of the Paris Agreement goals and adaptation to the climate change. Furthermore, climate change could make urban areas more vulnerable on multiple disaster triggers (Negev et al, 2022) which applies also to CBRN agents.

Even if the Paris Agreement aims mostly at strengthening the global response to the threat of climate change, its overall idea is open for the technology use and implementation to achieve the strengthening goals. Parties of the

Agreement see a need to support countries (especially the developing ones) by technology transfer and capacity-building. They understood technology as a set of tools facilitating global efforts focused on climate change (for example by reducing greenhouse gas emissions) as well as emphasise a strong need to develop worldwide technology cooperation. There are no direct mentions about the technology use in the context of enhancing situational awareness and preparedness for CBRN events in urban areas but the Agreement makes it possible to generate a synergy effect of technology funding, development and transferring simultaneously to ensuring its goals (Paris Agreement, 2016).

**Transforming the world in directions enumerated in the 2030 Agenda for Sustainable Development** calls for reduction of the negative impacts of urban activities and of chemicals which are hazardous for human health and the environment, safe use of chemicals as well as reduction of the number of deaths and illnesses caused by relevant substances. It mentions also about minimising release of hazardous chemicals and materials. In broader approach, practically all sustainable development goals relate to issues which may increase CBRN risks. It is especially noticeable when talking about Goal 1: End poverty in all its forms everywhere, Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture, Goal 6: Ensure access to water and sanitation for all, Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all, Goal 10: Reduce inequality within and among countries, Goal 11: Make cities inclusive, safe, resilient and sustainable, and Goal 16: Promote just, peaceful and inclusive societies (Agenda 2030). The goals mentioned focus on providing the right living conditions and on inequalities which may generate CBRN events (for example in case of riots, military conflicts, etc.).

This is why technology occupies an important place in the **2030 Agenda for Sustainable Development**. The Authors also highlight a role of technology funding, developing and distributing with no detailed references to CBRN issues. However, it may be assumed that COP and SA aspects are considered. It is reasonable because of close correspondence between technology development and new ways to collect, analyse and distribute information in general.

The European Green Deal (including the new EU Climate Adaptation Strategy) is a set of strategic initiatives aimed at climate change adaptation.

It reflects current view on the adaptation from the European Union perspective to ensure the Union is climate neutral in 2050. Some of relevant policy areas are related (mostly indirectly) to CBRN events and their conditions (for example clean energy, sustainable industry, eliminating pollution, sustainable mobility and biodiversity) (EU-ASEAN, 2022).

Technology issues are one of core elements in The European Green Deal concept. It is so important that some idea providers say even about the Green Deal digitalisation (Santarius et al., 2023). As the concept focuses on elimination of water, air and soil pollution (GOV, 2023), relevant technologies may be useful from the perspective of preventing from and responding to hazardous biological, chemical, radiological and nuclear agents. It may be reflected also in developing of new solutions to enhance situational awareness and preparedness for CBRN events in urban areas.

**The Security Union Strategy** gives specific directions to ensure the security in the light of XXI century challenges and threats. It presents them comprehensively, stating a background, indicating political and operational objectives and forecasting the nearest security-related future. A review of the Strategy objectives allows to emphasise building capabilities and capacities for early detection, prevention and rapid response to crises, focusing on results as well as linking all players in the public and private sectors in a common effort. The objectives are operationalised on specific areas of interest. Many of them concern CBRN events and threats in urban areas. They are (i.a.) critical infrastructure, cybersecurity, protecting public spaces, hybrid threats, terrorism and radicalisation (including access to CBRN agents), cooperation and information exchange, strengthening security research and innovation as well as skills and awareness raising (Strategy, 2020).

The Strategy highlights a significant need to develop SA in order to strengthen the EU crisis response system (for example by providing intelligence SA to EU institutions) and its beneficiaries. Modern technology is very welcome and required in this context. However, the document's authors see dualism in the technology development as well. Technological tools may be used for the security purposes (for example artificial intelligence, space capabilities, Big Data and High-Performance Computing) and against them (Strategy, 2020). Consequently, new technological solutions serving to enhance

SA and preparedness for CBRN events in urban areas should be relatively resilient to technologies used by adversaries.

**The Union Civil Protection Mechanism (UCPM)** aims to strengthen cooperation between participating countries to facilitate coordination in the field of civil protection. It is focused on protection of the most important utilitarian values, namely human life and health. Consequently, mechanisms operate in order to improve the effectiveness of prevention, preparedness and response to natural and man-triggered emergencies and disasters (Zwęgliński, 2015; Feltynowski, 2023). The Emergency Response Coordination Centre (ERCC) is the operational central point of such a mechanism. It is connected to EU's monitoring and early warning systems. It also uses the Common Emergency Communications and Information System (CECIS) which is a web-based application ensuring information exchange and communication with civil protection entities in the UCPM partners in the real-time formula.

Based on the UCMP specifics, enhancing SA and preparedness for CBRN events in urban areas seems to be one of crucial aspects of the mechanism development. It is especially important when UCMP modules operate in the field (for example urban search and rescue teams, CBRN teams) and effectiveness of their operation directly depends on the information available. Looking for new ideas and developing new technologies for the purposes of civil protection is so important that specific UCPM funds have been established to make financial support for perspective projects and other civil protection initiatives (ECEuropa, 2023b).

**The Counter-Terrorism Agenda** (the full title is: A Counter-Terrorism Agenda for the EU: Anticipate, Prevent, Protect, Respond) directly connects CBRN hazards and SA. It is said there that *The risk from chemical, biological, radiological and nuclear (CBRN) materials remains a concern* and *The potential damage of a CBRN attack is extremely high*. Even if European Commission preliminarily stated the highest priority to prepare for release of chemical agents, events in Europe and entire world proved that biological, radiological and nuclear agents cannot be forgotten. Also SA was situated very high at the overall spectrum of EU security interest but generally in the context of internal security (CTerrorism, 2020).

The Counter-Terrorism Agenda presents new technologies as both sources of terrorist-related threats and sources of solutions to avoid or stop terrorist operations. In the first scenario an attention is paid to common awareness about ways in which terrorists may use new technologies for their purposes. But the second context opens for a wide spectrum of solutions to support counter-terrorism activities. Focusing on the second one, the document authors emphasise necessity to develop and implement modern detection tools (including mobile detection equipment) and use them for, among the others, protection of public spaces. Very promising is the use of artificial intelligence in analysing CBRN event environment, just like technologies for/against the use of drones (CTerrorism, 2020). The Agenda presents relatively detail information concerning functional requirements for new technologies and a great amount of them ascribe into enhancing situational awareness and preparedness for CBRN events in urban areas.

International policy frameworks presented above allow to frame strategic background for applying modern technologies in enhancing SA and preparedness for CBRN events in urban areas. Some of them give only general views on functional contexts and requirements to be met by new solutions (for example Sendai Framework for Disaster Risk Reduction 2015-2030, Paris Agreement). And some of them precise the requirements in detail. In both cases, there is a wealth of inspiration for policy makers responsible for funding research and development programs to rationally allocate financial resources. Enhancing SA and preparedness for CBRN events in urban areas seems to be a common aspect of many inspirations presented.

### **3.2. FORMAL DIRECTIONS OF EUROPEAN COMMISSION TO DEVELOP MODERN TECHNOLOGIES IN ENHANCING SITUATIONAL AWARENESS AND PREPAREDNESS FOR CBRN EVENTS IN URBAN AREAS. PERSPECTIVE OF 2022**

A formal expression of needs highlighted in terms of strategic background described previously was European Commission's call for research-development projects in Horizon Europe Framework Programme. The call was named Disaster-Resilient Society 2022 (HORIZON-CL3-2022-DRS-01) and opened

between 30 June 2022 and 23 November 2022. It regarded HORIZON-IA HORIZON Innovation Actions (ECEuropa, 2023a). European Commission indicated specific outcomes expected from winning proposals and matching directions to develop modern technologies in enhancing SA and preparedness for CBRN events in urban areas. Following outcomes served as references in designing new project solutions (ECEuropa, 2023a):

- a. developing tools and technologies (including novel multiplatform CBRN-E systems) to enhance SA for the needs of preparation for and rapidly reaction to CBRN-E events both for direct (in CBRN action scene) and indirect (dispatcher, operators in crisis management centres) responders, especially in urban areas,
- b. supporting first responders' SA via high level processing solution,
- c. developing fast, reliable and portable devices dedicated for first responders to perform an in-situ provisional identification of CBRN-E suspicious samples (supporting in making decisions about personal protective equipment to be used by the responders and including smart wearable equipment),
- d. *integrating different commercial and experimental sensors/platforms, which should improve the state-of-the-art products in terms of communication (...), power consumption (...), interfacing capability (...).*

The call authors paid attention to a necessity to be in line of Horizon Europe Strategic Plan 2021-2024 and one of its expected impacts: *Losses from natural, accidental and man-made disasters are reduced through enhanced disaster risk reduction based on preventive actions, better societal preparedness and resilience and improved disaster risk management in a systemic way* (Strategic Horizon, 2021). This requirement was made more operationalised as proposals were dependent on contribution to the achievement of one or more of the following impacts (ECEuropa, 2023a):

- a. *Enhanced understanding and improved knowledge and situational awareness of disaster-related risks by citizens, empowered to act, thus raising the resilience of European society.*

- b. *More efficient cross-sectoral, cross-disciplines, cross-border coordination of the disaster risk management cycle (from prevention, preparedness to mitigation, response, and recovery) from international to local levels.*
- c. *Enhanced sharing of knowledge and coordination regarding standardisation in the area of crisis management and CBRN-E.*
- d. *Strengthened capacities of first responders in all operational phases related to any kind of (natural and man-made) disasters so that they can better prepare their operations, have access to enhanced situational awareness, have means to respond to events in a faster, safer and more efficient way, and may more effectively proceed with victim identification, triage and care.*

It was highlighted that European priorities in developing modern technologies to enhance SA and preparedness for CBRN events in urban areas should consider synergy-building and clustering to other projects previously funded by European Commission. Ideas executed in intensive international cooperation were very welcome. Relatively high technology readiness levels were expected (from TRL6 to TRL8). Furthermore, the funding institution required direct matching to first responders' needs, covering a wide range of top existing CBRN-E detection technologies and stating conditions to make effective decisions related to first responders' safety and security (ECEuropa, 2023a).

It is worth noting that European Commission opened for multiple entities participating in the call to increase chances to design and fund the best solutions in the scope expected. Thus, the call assumptions considered such entities eligible for funding as the Member States of the European Union and their outermost regions, the Overseas Countries and Territories linked to the Member States, countries associated to Horizon Europe, low – and middle-income countries, affiliated entities, European Union bodies and international organisations (Horizon Europe13, 2022). Such wide spectrum of potential beneficiaries was very promising to collect high quality proposals for research-development projects.

As formal directions of European Commission to develop modern technologies in enhancing SA and preparedness for CBRN events in urban areas require a project formula, the funding institution determined proposals to

meet a set of quality requirements. They were named as ‘award criteria’ and are listed below (Horizon Europe13, 2022):

1. excellence criteria:
  - a. *Clarity and pertinence of the project’s objectives, and the extent to which the proposed work is ambitious and goes beyond the state of the art,*
  - b. *Soundness of the proposed [for the first stage: overall] methodology,*
2. impact criteria:
  - a. *Credibility of the pathways to achieve the expected outcomes and impacts specified in the work programme, and the likely scale and significance of the contributions from the project,*
  - b. *Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities,*
3. quality and efficiency of the implementation criteria:
  - a. *Quality and effectiveness of the work plan, assessment of risks, and appropriateness of the effort assigned to work packages, and the resources overall,*
  - b. *Capacity and role of each participant, and the extent to which the consortium as a whole brings together the necessary expertise.*

Thus, European Commission clarified that every proposal should be clearly understandable for experts who played a role of the proposal reviewer, must address logically and rationally designed an idea which noticeably goes beyond the state of the art and needs to be characterised by effective exploitation and dissemination standards. These issues complement the formal directions and make foundations for effective investing in the best solutions only.

### **3.3. REFERENCE SOLUTIONS TO DEVELOP THE TECHNOLOGIES IN THE LIGHT OF 2022 CALL FOR PROPOSALS**

In the call HORIZON-CL3-2022-DRS-01-08 on ‘Enhanced situational awareness and preparedness of first responders and improved capacities to minimise time-to-react in urban areas in the case of CBRN-E-related

events' only one proposal won and is to receive EU funding. The proposal presents a comprehensive hazard identification and monitoring system for urban areas and describes the research-development project of the same title (Comprehensive Hazard Identification, and Monitoring system for Urban Areas; acronym CHIMERA). Stemming from the proposal, *CHIMERA system provides a technological improvement in the CBRN domain complying with European legislation and boosting the capabilities of end-users (i.e. first responders, dispatch centres, and crisis management centres) with novel detection, identification, and monitoring functionalities. The added value of the system is its proposed high TRL level making it possible to facilitate the system's route to market* (CHIMERA, 2022).

The project's mission is to prove technical feasibility to proceed with the project idea and to transform it into concrete products. From a practical point of view, the mission is translated into high-level objectives, project objectives and key performance indicators (KPIs). This allows to make it operational for the consortium and gives detailed reference values to monitor the project progress.

CHIMERA project has three high-level objectives (CHIMERA, 2022):

1. High-level objective 1 – To improve technological capabilities and situational awareness of the end-users operating under CBRN conditions,
2. High-level objective 2 – To minimize end-users time to react to CBRN threats in an urban environment,
3. High-level objective 3 – To improve European cities' resilience to CBRN hazards.

The high-level objectives cross and cover all project work designed, reference to strategic background for applying modern technologies in enhancing situational awareness and preparedness for CBRN events in urban areas as well as address formal priorities of European Commission in developing modern technologies to enhance situational awareness and preparedness for CBRN events in urban areas. To make the project efforts more operational, project objectives and KPIs should be enumerated. Table 1 presents catalogue of project objectives and relevant KPIs.

**Table 1.** CHIMERA project objectives and KPIs.

Objective Description	Key Performance Indicator
<b>Obj1</b> – to develop a multiplatform Command & Control (C2) CBRN system for responders, dispatch, and crisis centres allowing for the area of interest overview, management of assets, and real-time data visualization	System Usability Score System Usability Score comparison Designed in collaboration with cross-sectoral end users Verification document
<b>Obj 2</b> – to develop a multipurpose heterogeneous sensor node for CBRN detection allowing for the integration of commercially available detection instruments	Operational time on battery only Mean time between maintenance Data transmission rate Supported chemical detection instruments Supported radiological detection instruments Supported biological detection instrument Verification document
<b>Obj 3</b> – to implement a real-time dispersion modelling software for C&R agents to provide dispersion models and source estimations considering a 3D urban environment	Providing first forward dispersion estimation of air concentration and surface deposition, for areas < 1 km <sup>2</sup> and 15 minutes release period Continuous and enhanced updates of the concentration and deposition fields Data fusion and estimation of the CBRN hazard source release rate given collected sensor data Threat map calculation for R-given concentration fields Verification document
<b>Obj 4</b> – to integrate data fusion algorithms combining data from different sensors from chemical, radiological, or biological layers to enable agent identification and false alarm reduction	Detection Levels for different threat types (chemical, radiological) Identification Levels for different threat types (chemical, radiological) False Detection Rate False Identification Rate Processing time in comparison to single-sensor data processing
<b>Obj 5</b> – to develop a commercial-ready system database combining C, B, and RN substance/agent characteristics	Dose-response curves based on heterogeneous time-synchronized sensor response data Introduction of both relevant compounds as well as simulants for training Measurement campaigns with a detailed record of conditions performed in both laboratory and field conditions Iterative CBRN agent database software development Validation CBRN database

**Source:** own elaboration basing on (CHIMERA, 2022).

CHIMERA is planned to be a system designed to significantly improve end-users' capabilities in CBRN preparedness & prevention operations, to minimise their time to react, as well as improve European cities' resilience to a potential CBRN threat. To deliver this, CHIMERA proposes a multipurpose CBRN detection, identification, and monitoring system. The system will (CHIMERA, 2022):

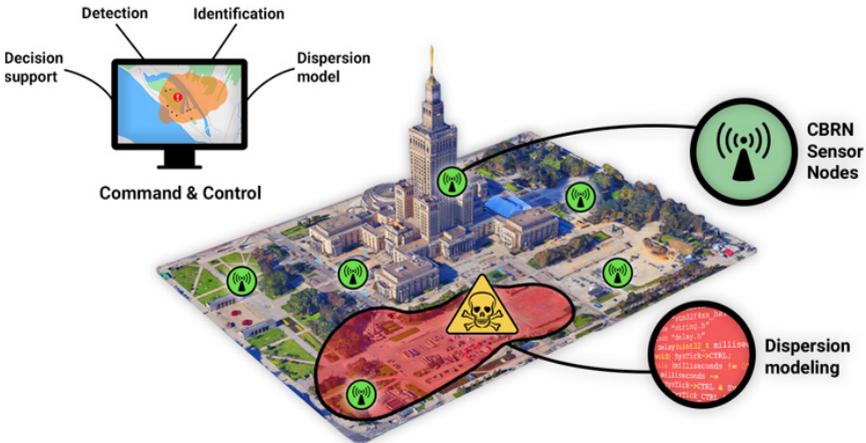
- integrate multiple detection technologies of CBRN agents,
- provide an advanced fusion of detection instruments signals,
- enable dispersion modelling and source location estimations,
- ensure optimised operational view and risk assessment through HMI, which supports cross-border collaboration,
- integrate a rich CBRN substance database with CBRN hazard response characteristics to allow quick detection and identification of the threat.

Figure 1 visualises the system concept and states a background for in-depth analysis of CHIMERA solutions.

Focusing on hazards' detection, CHIMERA detection layer will be composed of chemical, radiological, and biological point detection instruments, implemented in a form of heterogeneous nodes:

1. Heterogeneous **chemical** sensor node will integrate ion mobility spectroscopy (IMS) and flame photometric detection (FPD) as well as detect and process the data in real-time. The very important function is a possibility to perform the detection and identification in the field.
2. Heterogeneous **radiological** sensor node will be the unit combining a Geiger counter and a spectrometer. This presents the most mature technology and detection in comparison to other CBRN detectors. Also in this case, it will be possible to perform the detection and identification in the field in real-time.
3. Heterogeneous **biological** sensor node will be the unit combining laser-induced fluorescence and flame spectrometry. It characterises the lowest maturity level of all three domains. Thus, CHIMERA project will integrate commercial biosensors with the system to generate a complex CBRN operational view and make next steps in biological detection.

**Figure 1.** CHIMERA system concept image.



**Source:** (CHIMERA, 2022).

It should be highlighted, that the most of the instruments are available on the market, but some of them (for the radiological detection unit) will be completely new devices developed by the consortium. To ensure high operational potential, heterogeneous sensor nodes will be implemented. *The development of a heterogeneous sensor node is understood as a microcomputer-based device wirelessly paired together with various detection instruments. In the CHIMERA context, the node will combine different CBRN detection technologies, which aim to detect either chemical, radiological or biological threats. In principle, the implementation of technological heterogeneity is a measure to improve the overall spectrum of detectable substances as well as to allow for data postprocessing to decrease the false alarm ratio. For each integrated detection instrument, the CHIMERA project develops a dedicated adapter to enable wireless communication between the node and the detection instrument* (CHIMERA, 2022). The final product of the project will be fully modular and has an open interface to allow for extending the list of supported detection instruments applied in first response actions. Moreover, the sensor node will be available in mobile and stationary variants (for example to be used in unmanned ground vehicles or as personal equipment for rescuers).

The next significant area of CHIMERA solutions' operational use is hazards' identification. Besides classical view on the sensors implementation, the added value of the proposed system will be its functionality to perform data fusion of sensor signals. This functionality will be implemented directly on the sensor node thanks to improved computational capabilities of the new sensor node hardware (i.e. microcomputer instead of the microcontroller). Merged data frames with sensor signals will be post-processed with algorithms designed to enable substance (or nuclide) ID. This postprocessing will be performed for C and RN nodes. Due to the lower maturity of biological detection, the CHIMERA system will incorporate the existing readouts from the commercial biosensors necessary to determine the presence of bioagent. Improved detection and identification of CBRN hazards will be also supported by a dedicated database (to be developed within the CHIMERA project as well). The database will include characteristics of CBRN hazards recorded by the sensor nodes in laboratory conditions. Furthermore, the database will collect naturally occurring background noise. It is especially important in urban areas to minimise its impact on the sensor node readouts (CHIMERA, 2022).

From an operational point of view, significant impact of CHIMERA solutions should be noticeable when monitoring aspects are described. CHIMERA system will offer improved SA to all types of end-users involved in first-response actions (fire services, police troops, armed forces, HazMat teams, emergency management teams, etc.). To reflect their needs, The Command and Control Application (which is said to be the main access point to the system) will allow end-users to monitor the area of interest through access to information from sensor nodes, data fusion results, dispersion models and source estimates, and risk assessment based on the generated data and affected area and dealing with the uncertainty. The system will be embedded in a cross-border context to support detailed secured information exchange and be implementable in different operational contexts (for example in multiple countries and public services). In addition, the system will be able to predict and visualise the dispersion model (via a threat map). Dispersion modelling implemented within the CHIMERA system will use the ensemble forward modelling method to calculate the most probable dispersion model of the hazard detected. On top of this, the dispersion modelling component

will use the inverse-modelling method to estimate the most probable source of the hazard release. From the perspective of end-user, the system will give information on what kind of an agent has materialised, where it had been preliminarily released, what is the hazard zone and what the zone will be in the nearest future. This facilitates first operational decisions which match real hazard conditions and consider forecasting results.

To cover project objectives as well as to reflect specifics of heterogeneous CBRN detection and ascribe them to CBRN response practice, CHIMERA project is focused on delivery of following products (CHIMERA, 2022):

- a. Product 1: Heterogeneous sensor node (Hardware & Software),
- b. Product 2: Detection instrument adapters (Hardware & Software),
- c. Product 3: Heterogeneous radiological hazard detection instrument (Hardware),
- d. Product 4: Dispersion engine (Software),
- e. Product 5: Command and Control Application (Software),
- f. Product 6: CBRN database and false alarm-reducing algorithms (Software).

Such a complex project idea is not possible to be covered by a single executor. Thus, CHIMERA project is carried out by consortium comprising in high-quality research institutions and end-users. There are following consortium members (12 parties from 7 countries):

- a. ITTI Sp. z o.o. (ITTI; coordinator and industry/SME; Poland),
- b. Totalförsvarets forskningsinstitut (FOI; applied research centre; Sweden),
- c. Airsense Analytics (AIR; industry/SME; Germany),
- d. Central Laboratory for Radiological Protection (CLOR; applied research centre; Poland),
- e. the Main School of Fire Service (SGSP; academia and end-user; Poland),
- f. FORSVARETS FORSKNINGINSTITUTT (FFI; applied research centre; Norway),
- g. Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO; applied research centre; the Netherlands),
- h. Police Academy of the Czech Republic (PACR; academia; Czech Republic),

- i. THALES NEDERLAND B.V. (TNL; industry/SME; the Netherlands),
- j. Japan Atomic Energy Agency (JAEA; end-user; Japan),
- k. Gezamenlijke Brandweer (GB; end-user; the Netherlands),
- l. Berufsfeuerwehr Frankfurt (Oder; end-user; Germany).

The consortium's composition reflects EU point on development of new technologies related to COP and SA due to CBRN events in urban areas. The point reflects that complex hazards require complex solutions. Besides that, there is a great chance to deliver these solutions by developers who uniquely connect, as a whole, knowledge and experiences of academia, applied research centres, industry/SMEs and end-users.

## 4. DISCUSSION

According to the project proposal, CHIMERA solutions will be aligned with expected outcomes listed under the HORIZON-CL3-2022-DRS-01-08 topic, which were:

1. Development of tools and technologies, including novel multiplatform CBRN-E systems, to enhance situational awareness to prepare for and rapidly react to CBRN-E events both for responders on the ground as well as for dispatch and crisis centres, especially in urban areas.
2. Support of first responders' situational awareness via high-level processing solution, e.g. based on dispersion modelling or threat recognition/prediction solution using sensor data fusion and algorithms that combine heterogeneous sensor data to reduce the likelihood of false alarms and contribute to an improved decision-making process for the responders.
3. Development of fast, reliable, and portable devices for responders to perform an in-situ provisional identification of CBRN-E suspicious samples, enabling to decide which personal protective equipment (PPE) is required for first responders, including smart wearable equipment.
4. Solutions integrating different commercial and experimental sensors/platforms, which should improve the state-of-the-art products in terms

- of communication (e.g. by using novel and open communication protocols, pre-processing of data), power consumption (e.g. by offering supplemental power source to the existing sensors), interfacing capability (e.g. by proposing an open interface specification). The proposals should also cover the system transportability, online capability, and continuous operation issues.
5. Enhanced understanding and improved knowledge and situational awareness of disaster-related risks by citizens, empowered to act, thus raising the resilience of European Society.
  6. More efficient cross-sectoral, cross-disciplines, cross-border coordination of the disaster risk management cycle (from prevention, and preparedness to mitigation, response, and recovery) from international to local levels.
  7. Enhanced sharing of knowledge and coordination regarding standardization in the area of crisis management and CBRN-E.
  8. Strengthened capacities of first responders in all operational phases related to any kind of (natural and man-made) disasters so that they can better prepare their operations, have access to enhanced situational awareness, have means to respond to events in a faster, safer and more efficient way, and may more effectively proceed with victim identification, triage, and care.

The project does not cover all priorities indicated in documents stating strategic background for applying modern technologies in enhancing SA and preparedness for CBRN events in urban areas. It rather presents its own unique way to deliver new solutions addressing current security challenges and corresponding to the documents.

However, the proposal closely matches formal priorities of European Commission in development of modern technologies to enhance SA and preparedness for CBRN events in urban areas, within the relevant funding perspective of 2022. This gives foundations to ensure proper conditions for the project monitoring purposes and being in line with current European view on the topic discussed.

Furthermore, the project idea seems to answer operational end-users' needs identified by International Forum to Advance First Responder Innovation (IFAFRI) as 10 capability gaps. They are (IFAFRI, 2023):

1. Real-time tracking of responders (those equipped by tools developed in the project).
2. Real-time detection, monitoring and analysis of threats and hazards (thanks to direct use of the technologies provided).
3. Rapid identification (made possible by the use of heterogenous sensors and sensor nodes connected as a system).
4. Integration of information (available with the use of sensor nodes and different detection technologies in particular nodes).
5. Interoperable communications (possible thanks to market accessible tools from different technology providers and merit-related assumptions for the system operation).
6. Remote acquisition of information (as heterogenous sensors and sensor nodes will be remotely connected).
7. Remote operations (understood as bi-directional transfer of information between the field and a command centre).
8. Responder health (protected by rational decisions made on the basis of real-time information about the event's cause and consequences, as well as a situational forecast).
9. Actionable intelligence (built on access to data and information from multiple sources).
10. Protective equipment (characterized by potential for integration with sensors).

The project's strengths may also be potential sources of operational risks. Some of them are considered by the project assumptions. For example, focusing on end-users' needs requires close relations (especially desirable is direct involvement) with public services and other entities interested in practical use of the solutions designed. To make relevant cooperation efficient, end-users involved in the project should be research-oriented and familiar with a project formula. Secondly, implementation of new technologies is challenging for entities which do not have own capacities to make

laboratory experiments and use their own equipment. This is why building a consortium on trusted and reliable partners is so important for a successful project realisation. Thirdly, enhancing SA when CBRN event occurs is often requires composing a SA tool from hardware and software. Results of such a composition depend on the effectiveness of presenting information collected and analysed. In other words, SA tool should be clearly understandable for end-users who should be able to use it in the field. Summing up, project assumptions are able to reduce many operational risks. During the process of proposal's evaluation, this was reflected by high scores in the excellence criteria as well as by quality and efficiency of the implementation.

There is a need to remember that some of operational risks seem to be independent from the project assumptions. Heterogenous character of sensors requires special attention and is at technological risk (due to the integration requirements, information flows, *false positives*, specifics of machine learning, etc.). Some sensors are planned to be developed during the project realisation which is uncertain itself and requires additional resources (including financial resources and the time). Uncertainty addresses also practical implementation of technology pilots and demonstrations. It is especially noticeable in the case of field tests with end-users (for example when fire service entities use the technological tools during real or near-real chemical spill conditions).

Summing up, developing of modern technologies in enhancing SA and preparedness for CBRN events in urban areas is associated with a project specification. It must face operational risks characterised for a project formula of operation.

## 5. CONCLUSION

International policy documents, which form strategic background for applying modern technologies in enhancing SA and preparedness for CBRN events in urban areas, give also many opportunities to design, develop and implement new technologies. In general, the technologies should allow to get information about what has happened and how it may develop. It is crucial to design operational response in conditions of CBRN event, and especially

in urban area. Some of the documents present specific functional requirements (for example the Security Union Strategy, the Union Civil Protection Mechanism, the Counter-Terrorism Agenda) and some of them only general directions (the Sendai Framework for Disaster Risk Reduction 2015-2030, the Paris Agreement, Transforming our world: the 2030 Agenda for Sustainable Development, and the European Green Deal). It stems from their nature and essential content.

European Commission referred to strategic background for applying modern technologies in enhancing SA and preparedness for CBRN events in urban areas by specifying the priorities for project proposals in the topic disused. The call was named Disaster-Resilient Society 2022 (HORIZON-CL3-2022-DRS-01) and opened between 30 June 2022 and 23 November 2022. The call requirements specified outcomes, impacts and relations to strategic documentation for proposals in the competition. The requirements present what give chances for getting a funding on new solutions to enhance SA and preparedness for CBRN events in urban areas in current time perspective.

CHIMERA project won the competition and is selected for funding. It does not cover all strategic requirements for the technologies analysed but rather presents its own, unique way to achieve the call objectives. The consortium is characterised by composition of industry/SME entities, applied research centres, academia entities and end-users. The idea of the project matches directly to the call requirements.

The project presents a logical way for the use of modern technologies from CBRN agent detection, via identification, analysis and ending at efficient transfer of information collected. The project's mission, high-level objectives, operational objectives and KPIs ensure that designing solutions to enhance SA and preparedness for CBRN events in urban areas will be carried out rationally and follow a monitoring processes.

All these issues contributed to the success of CHIMERA proposal. Consequently, the project is actually the only one venture funded by European Commission that enhances SA and preparedness for CBRN events in urban areas. Its success story will probably determine other calls for proposals in this topic. In addition, it may inspire further development of modern technologies related to artificial

intelligence, IT tools creating COP and enhancing SA, and strong involvement of end-users in technology-determined research.

It is a need to highlight that the project ascribes into current trends in development of CBRN technologies and procedures (as the procedures are generally derivatives of the technology development) and may be reference from this viewpoint for other project initiatives, nationally and internationally. In accordance to the trends, there are noticed strong developments of detection automatization and reduction of false alarms. Technological tools are more able to learn on previous measurements and more resistant on environmental influence (for example on smog, humidity). Data transmission mechanisms allow to visualise measurement results up to date and progressively. End-users may collect crucial information necessary from CBRN response reconnaissance point of view relatively quickly. So technology providers implement machine learning, artificial intelligence and big data algorithms and this trend seems to shape modern technologies in CBRN response during the nearest years.

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## **ENDNOTES**

- [I] A crisis hazard means a hazard with a potential to initiate a crisis situation, a disaster or a crisis.