JRC Scientific and Technical Reports

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Jaime Sales
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The Institute for the Protection and Security of the Citizen provides research-based, systems-oriented support to EU policies so as to protect the citizen against economic and technological risk. The Institute maintains and develops its expertise and networks in information, communication, space and engineering technologies in support of its mission. The strong cross-fertilisation between its nuclear and non-nuclear activities strengthens the expertise it can bring to the benefit of customers in both domains.

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1. INTRODUCTION

1.1 Overview: Industrial Hazards and Risk Mapping

Hazardous installations represent a major source of risk for the human population and the environment. Hazardous installations are generally considered those that have on site a significant[1] quantity of one or more substances with properties hazardous to human health or the environment. Processes associated with such installations often involve chemical products and process conditions with hazardous properties such as toxicity, flammability or high temperatures and pressures. It is therefore of great importance to understand the potential hazards involved in such activities, and to keep information and maps that illustrate the possible consequences of any accident that could happen at an industrial installation. Typical activities covered in this category include the processing or storage of petroleum, petroleum products and other minerals; processing or storage of chemicals used in bulk to manufacture a wide variety of chemical-based products; manufacturing of the products themselves, e.g., cleaning agents, pharmaceuticals, cosmetics, textiles, paint and inks, plastics and resins, etc.; as well as energy production, and the manufacture and storage of food and beverages.

Mapping of industrial hazards and accident risks may be fairly simple, consisting of points on a map identifying the location of particular hazardous installations and the type and quantity of dangerous substances they use. The mapping of potential accident scenarios is a more sophisticated mapping technique for industrial hazards. These types of maps will indicate the extent and intensity of the physicochemical effects (toxic release, fire or explosion) predicted for a potential accident scenario. For example, such a map may show the concentration level of a toxic cloud at a predefined distance, the thermal radiation of a fire or the overpressure generated by an explosion. Moreover, this type of mapping requires very specific local data. In addition, it may require specific expertise and resources, such as modelling software, that increase the expense and effort of producing such maps. For these reasons, national maps of this nature are generally not available nor are they considered very relevant for risk management. Rather, maps are prepared for specific geographic areas on the basis of the type of industrial hazard or hazards located there and the expected extent of their consequences.

For the simplest types of industrial hazard maps, the name and location of establishments with hazardous substances may be considered sufficient. Additional dimensions such as types of activities, and types and quantities of substances present at these facilities might also be added (see Figure 1 example on the next page). Although this mapping technique may appear simple, it can actually be a useful basis for the most basic type of industrial risk map, that is, one which relates the descriptive properties with accident probabilities (see Figure 2 example on page 11).

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[1] The quantity that is significant varies from substance to substance and depends on the potency and type of hazardous property.

Figure 1: Tisza River Assessment (Source: E. Bournay, UNEP/GRID-Arendal, 2005)

In contrast, the mapping of accident scenarios requires substantially more data, particularly if modelling of the physicochemical effects across a particular geographic area is involved. It is necessary to know the inventory of dangerous substances in industrial installations in a particular region, as well as their hazardous properties, and the types of processes and equipment at the establishment that are relevant to the handling and storage of these substances. Furthermore, precise information is needed regarding substances and process conditions, such as volatility, flammability, temperature, rate of loss of containment and typical weather conditions. Also, studies to estimate the failure frequency of process equipment involved may also be performed and incorporated into the analysis of potential effects.

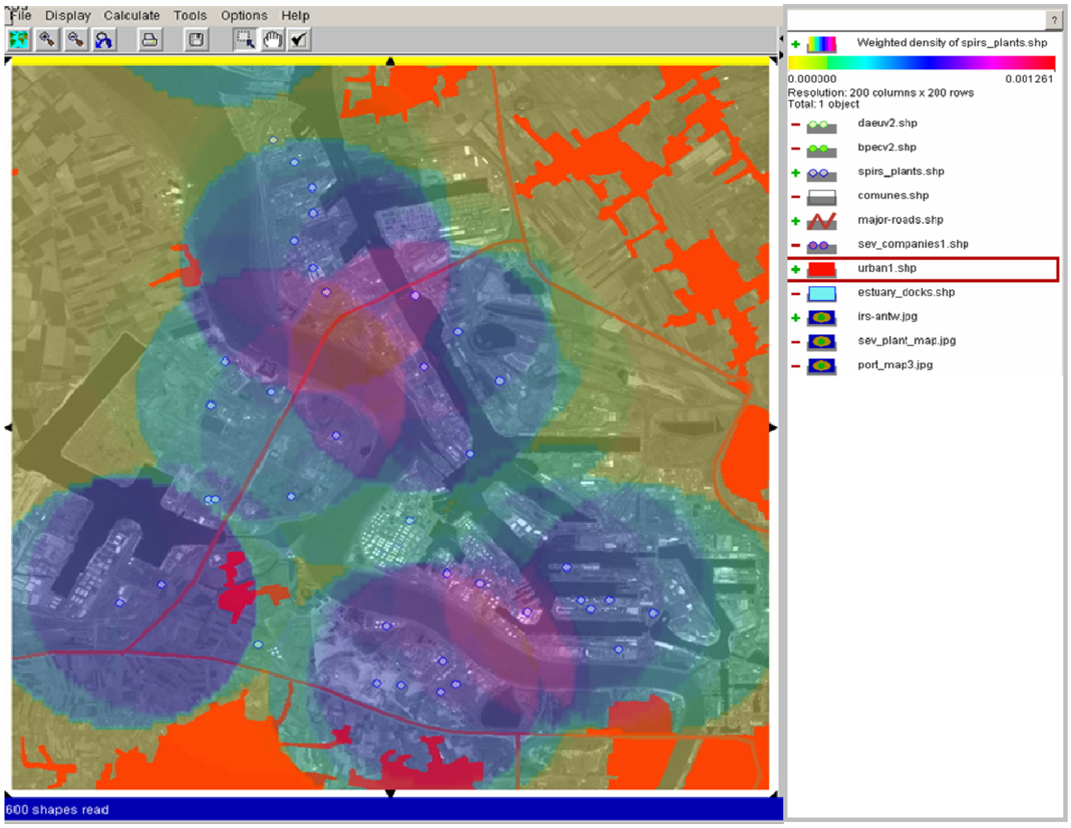
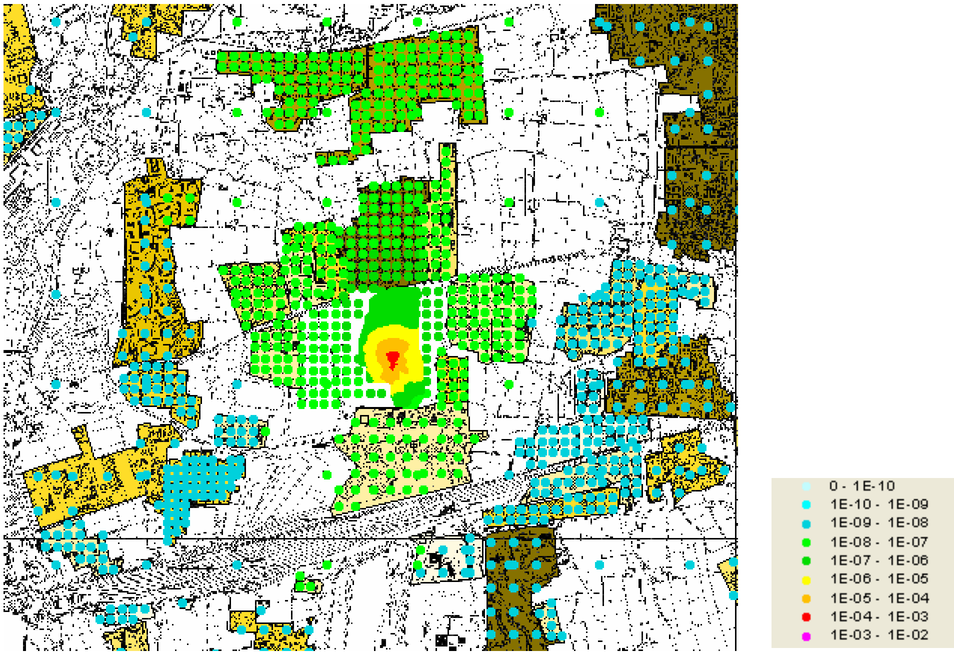


Figure 2: Risk Associated with Hazardous Installations Based on the SPIRS Hazard Index (Source: R. Peckham, EC-JRC-MAHB, 2005)

From these data, risk maps may be obtained by combining the effects of potential accident scenarios with their predicted frequencies (see Figure 3 examples on the next page). The result is translated into curves depicting different levels of risk around the installation, allowing estimation of specific consequences through the calculation of exposed populations and natural resources inside these curves. There are several well-known sources for frequency data. Moreover, information on the causes and consequences of past accidents at the establishment or similar establishments can be used to predict the likelihood of similar accidents in the future.

Clearly, the surveyed countries differ, sometimes considerably, in terms of the size and composition of their economies. Therefore, it is to be expected that industrial risk does not have the same relevance for each. In particular, countries with a greater industrial activity would be expected to be more at risk. However, each country normally will also consider the potential for transboundary effects from potential accident scenarios in neighbouring countries.



a) Local risk of the BEQUAR plant: contribution by all risk sources

b) **c)**

Contribution to risk by: b) Tank Wagon and c) Ethanol Tanks

Figure 3: Accident Scenario Maps from the Benchmark Exercise in Quantitative Area Risk Assessment in Central and Eastern European Countries (BEQUAR) (Fabbri et al., 2007)

National and European level risk mapping of industrial installations is somewhat facilitated by the requirements of the Seveso II Directive (96/82/EC). This Directive is aimed at the prevention of major accidents which involve dangerous substances, and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner. Articles 6 (notification of the presence of a major industrial hazard), 9 (Safety report of the establishment) and 14 (reporting of major accidents) require reporting of information about major industrial hazards at establishments to the competent authorities.

However, it must also be recognized that a number of the surveyed countries (including Bulgaria, Hungary, Lithuania and Poland) have had industrial risk data available for a number of years due to pre-existing legislation and practices (Wood et al. 2003).

Figure 4 shows the estimation of experts concerning the relevance of industrial risk to their countries (Wood & Jelínek, 2007).

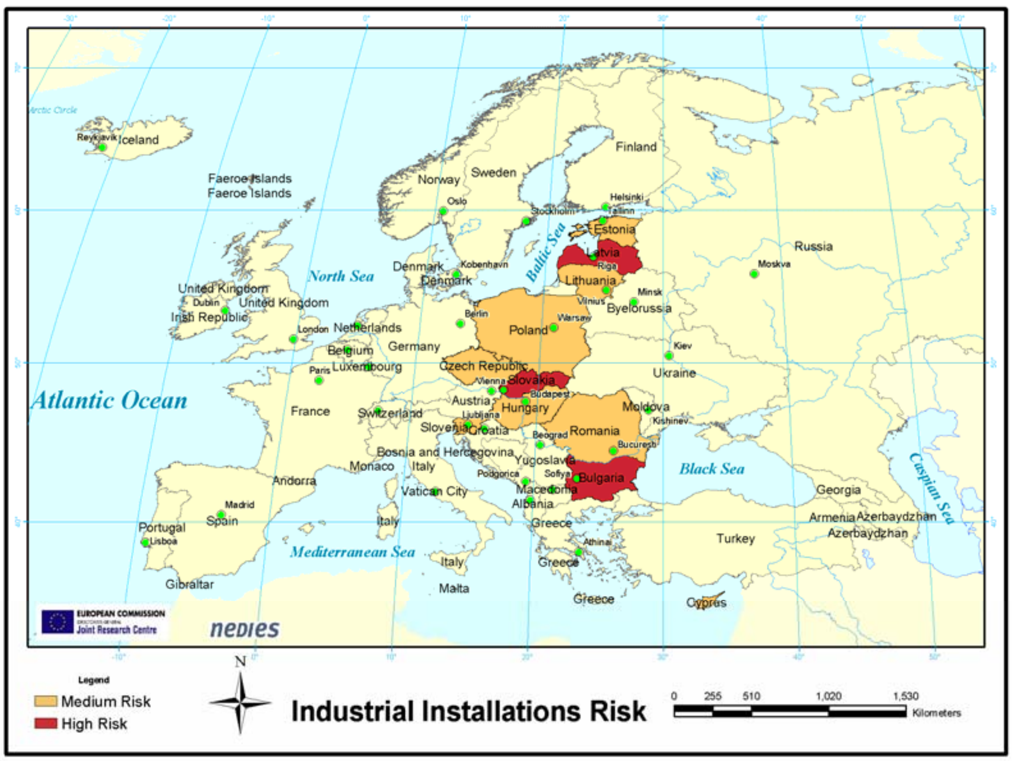


Figure 4: Risk Relevance of Industrial Hazards in the Surveyed Countries According to National Experts

1.2 General Description of the Project

In 2003 the Joint Research Centre performed a survey of mapping practices in eleven (11) countries for eight (8) major hazards. This activity was funded as part of the project entitled "Management of Natural and Technological Risks" under the JRC Enlargement action within the Sixth Framework Programme (6FP) for Research and Technological Development (RTD). This project was a continuation of an activity supported by the JRC Enlargement action programme within the Fifth Framework Programme (5FP) RTD aimed at the 10 "PECO" countries.[2] The two activities were designed to support the efforts of new Member States and Candidate Countries in the creation of compatible regional and national central information systems for supporting authorities in the management of risks and emergency situations due to natural and technological hazards. The 6FP project was expanded to include Cyprus[3].

Under the 5FP project experts from the PECO countries agreed on ten priority hazards as important concerns for the region, as follows (Wood et al. 2003):

Natural hazards	**Technological Hazards**
▪ Floods	▪ Industrial installations
▪ Forest fires	▪ Transport of dangerous goods
▪ Storms	▪ Contaminated lands
▪ Landslides	▪ Pipelines
▪ Earthquakes	▪ Oil-shale mining

The 6FP project aimed to investigate risk mapping practices and policy for priority hazards in these countries. The aim of this activity was to:

- Examine the existing situation, in each surveyed country for mapping of priority natural and technological hazards.
- Compare methodologies used in the different countries for hazard to inform guidelines for establishing compatible national mapping systems.
- Provide a basis for defining a pilot project that would test feasibility of different approaches to harmonizing aspects of mapping practices in regard to specific hazards.

Moreover, it was determined that these objectives could be best fulfilled through the administration of a questionnaire on risk mapping practices and policy for priority hazards to the target countries (Di Mauro et al., 2003).

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[2] PECO countries refer to the 10 Member States in central and Eastern Europe (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia). The acronym is derived from the French translation of "Central and Eastern European Countries" ("Pays de l'Europe Centrale et Occidentale").

[3] The 6FP project could also include Cyprus and Malta (although 5FP was only targeted to PECO countries). Yet for mainly practical reasons, Malta was not included in the 6FP phase of this project, although some bilateral expert exchanges on natural and technological hazards took place outside the context of this survey.

The 6FP project selected eight priority hazards from the 5FP project as the subject of the questionnaire, excluding oil-shale mining and pipelines for practical reasons[4]. The survey and its main results are fully described results of that questionnaire are summarized in the document, "Risk Mapping in the New Member States" (Wood & Jelínek, 2007) although this report focuses only on the industrial hazard portion of the questionnaire.

1.3 Survey Methodology and Content

This section describes the survey process including practical and technical considerations that led to the choice of certain methods and approaches over others.

Method for Soliciting and Verifying Questionnaire Responses

Survey responses were collected over the course of a 10-month period between November 2003 and July 2004. The initial survey was sent to project focal points nominated by the countries to respond to the questionnaire. However, they were not expected to complete on every hazard; rather, they were requested to complete a questionnaire for only those hazards that they identified as priority hazards. For this reason, there is not a complete set of questionnaire responses for any one hazard. (For information on which countries provided information on particular hazards, please see the document. "Risk mapping for natural hazards and contaminated lands: an overview of results from a survey of 11 new Member States and Candidate Countries").

The JRC then organized a meeting in each participating country to discuss the answers to the questionnaires with the responding authorities. These meetings offered an opportunity to clarify questions and responses, gain more comprehensive information, and improve consistency between responses across hazards and respondents.

Following the meeting the questionnaire was revised and reviewed and through an iterative exchange between respondents and the JRC, the responses were finalized and accepted as complete.

Content of the Full Questionnaire

The questionnaire encompassed eight separate sections, each one focused on a particular hazard. However, the same methodology was applied to each hazard. In essence, the questionnaire aimed to identify state-of-the-art mapping practices, priorities, and similarities and differences in mapping practices for each hazard. The data identity and availability based on the questionnaire encompassing more than 35 questions grouped into 6 categories: industrial hazard maps, industrial hazard data, elements at risk from

[4] In the case of oil-shale mining, interest in this hazard was not widespread and it was determined that most respondents would not have a mapping programme aimed at this activity. On the other hand, in many countries the competent authority that manages pipelines and pipeline mapping is quite distinctly apart from those that handle other technological hazards or natural hazards. Therefore, it was considered impractical to include this hazard in the survey based on the additional extra effort that might be required to gain the support and co-operation of these authorities.

industrial hazards, industrial hazard vulnerability maps and industrial risk maps. Each questionnaire was divided into six sections:

- General description of hazard maps
- Data and data collection
- Identification of elements at risk
- Vulnerability mapping and classification
- Risk mapping
- Final considerations (use and accessibility)

Questions within sections were then individualized for each type of hazard.

Description of the Industrial Installation Section Questionnaire

The industrial hazards questionnaire is the subject of this report. Its contents are described in the paragraphs below.

General description of hazard maps

The first part of the questionnaire posed questions about the availability of official industrial hazards maps (i.e., maps made by a government entity, such as a ministry, mapping agency, the army or other), as well as the availability of any other types of industrial hazard maps in the surveyed countries. Standard map parameters such as coverage, scale, format, issuing authority, date of origin, the latest updates and visual representation were also requested. Additionally, a question about the type of coordinate system used for industrial hazard maps was included.

The second part of this section asked respondents to identify the standard components of official maps, that is, whether objects such as chemical plants, oil shale mines, pipelines, topography, hydrological catchments, land use, water bodies are regular features of industrial hazard maps.

In the third part of this section, the respondent was asked to specify how industrial hazard maps are used, the degree of accessibility to such maps to the public and their availability in electronic form.

The final part requested information on existing legislation covering industrial mapping practices in the surveyed countries.

Data and data collection

This part of the questionnaire described information on industrial hazard data sources and related collection process. The section started with questions in regard to reference authorities/contact person for collecting information about industrial hazard sources and its related management.

The second part asked for information on official mechanisms for collecting industrial hazard data. The respondents were allowed to specify the type of information collected (e.g., chemical substances, accidents) parameters and units used, and how data are collected. Furthermore, information was also requested about the area covered by the data, the time period covered, the frequency of update and whether the data are maintained in digital or paper form.

This section also asked questions about the specific way in which data are used in the surveyed countries, and the degree of accessibility of data or constraints on their use.

Identification of elements at risk

This section explored how respondents classify elements ("objects") exposed to industrial hazards and the level of importance assigned to each category (from very low to very high) for the elements selected.

Vulnerability mapping and classification

The first part of this section asked about the availability of official industrial installation vulnerability maps in the surveyed countries and how different levels and types of vulnerability are classified in the country. Respondents were also asked to indicate whether certain types of damage (e.g., to people, to property) were considered reversible (temporary) or irreversible (persistent) in the respondent country.

Risk mapping

This part of the questionnaire aimed to determine whether industrial risk maps are produced in the country and, if so, what the standard features of these maps are. It also sought information on how industrial risk is represented in such maps, public accessibility and how the maps are used.

Use and accessibility (final considerations)

The final part of the questionnaire consisted of general questions related to a harmonized approach to define risk maps and asked about the potential benefit of such integrated risk maps in the surveyed countries.

2. ANALYSIS OF RESPONSES TO THE INDUSTRIAL HAZARD SURVEY

As is shown in Table 1, all eleven countries identified industrial installations as a priority hazard and completed responses to the survey. Among the eight hazard surveys, this survey received the highest response rate demonstrating that industrial installations are a shared concern for nearly all the new Member States and Candidate Countries.

Table 1: Focal Points for Industrial Installations Mapping Questionnaire

Country	Address
Bulgaria	Ministry of Environment and Water 67, Gladstone Street, 1000 Bulgaria www.moew.government.bg
Czech Republic	Ministry of the Environment Vršovická 65, Praha 10, 100 10 Czech Republic www.env.cz
Cyprus	Department of Labour Inspection 12 Apellis, 1480 Nicosia, Cyprus www.mlsi.gov.cy
Estonia	Estonian Rescue Board Raua 2, Tallinn. 10124 Estonia www.siseministeerium.ee
Hungary	Ministry of the Interior Budapest, Mogyoródi út 43 h-1149 Hungary www.bm.hu
Latvia	State Environmental Service Rrupniecibas Street 23, Riga, LV-1045 Latvia www.vvi.gov.lv
Lithuania	Civil Protection Department Pamenkalnio Street, 30, Vilnius LT-2600 Lithuania www.csd.lt
Poland	Chief Inspectorate for Environmental Protection Gdansk, 36/39 Piwna Street,80-831 Poland www.gios.gov.pl
Romania	Ministry of Agriculture and Rural Development B-dul Carol I, No.. 24, Sector 3, Codul Postal 020921, Oficiul Postal 37 Bucharest, Romania http://mapam.ro/
Slovakia	Ministry of the Environment of the Slovak Republic Námestie Ľ. Štúra 1, 812 35 Bratislava, Slovak Republic www.enviro.gov.sk
Slovenia	Ministry of the Environment, Spatial Planning and Energy Dunajska 48, Ljubljana, 1000 Slovenia www.mop.gov.si

Most respondents were from environment or civil protection authorities. Survey responses should also be considered in light of the following observations:

- Responses were generally comprehensive with useful comments, therefore the response quality is considered high.

- Nonetheless, some experts did not answer every question. (When relevant it has been noted in this report when one or more response is lacking for a specific question.)
- Few respondents were able to provide complete information for the sections regarding elements at risk, vulnerability and risk maps.

2.1 Industrial Hazard Maps in Surveyed Countries

Data on the current status of industrial hazard maps and their availability were collected and these are summarized in Table 2 (p.20).

Types of maps

According to the survey, official industrial hazard maps (maps made by a government entity, such as a ministry, a mapping agency, the army or other) are currently available in Bulgaria, the Czech Republic, Hungary, Lithuania, Poland and Romania. Cyprus and Estonia do not have official industrial hazard maps, only inventory maps produced via the SPIRS[5] application. Moreover, included in this category are also maps showing the hypothetical effects of potential accident scenarios[6] and sometimes (but less often) the actual effects of accidents that have already occurred.

Scale, coverage, projection and format of maps

- The surveyed countries are using a variety of scales for industrial installation hazard mapping, ranging from a rather small scale of 1:1,000,000 to a large scale of 1:10,000 or even 1:500.
- The majority of the countries (Bulgaria, the Czech Republic, Hungary, Lithuania and Romania) provide national hazard maps depicting the location of industrial installations. The Czech Republic, Estonia, Lithuania and Romania also have regional maps showing industrial hazards. Provincial maps are available in Poland and Romania. In Lithuania, Poland and Romania, municipal level maps are also produced.
- The most common projection used by respondents is UTM. In some countries multiple systems are used simultaneously. For more information about the map projection and coordinate system used in the surveyed countries, see the report summarizing responses to the general mapping practices section of the risk mapping survey (Wood & Jelínek, 2007).

[5] The Seveso Plant Information Retrieval System (SPIRS) is the official reporting software for submitting information to the European Commission on hazardous installations in terms of their location, economic activity, and presence of dangerous substances. The SPIRS software and database is maintained by the Major Accident Hazards Bureau (MAHB - http://mahbsrv.jrc.it) of the Commission's Joint Research Centre.

[6] Maps are often used to depict the potential consequences of so-called "reference accident scenarios". Reference accident scenarios are accident scenarios that are considered representative of a particular risk associated with a particular industrial establishment and which operators and competent authorities may use to guide their prevention and emergency preparation strategies.

Table 2: Availability of Industrial Installations Hazard Maps

Country	Maps Produced Format – Digital (D) or Paper (P)	Scale	Date Created/ Last Updates	Legal Act Foreseeing Industrial Installations Maps
Bulgaria	Topographical / contours (P)	National: 1:500,000	Created in 2002 / 2003 Not regularly	No
Czech Republic	Topographical / past accidents (D)	National: 1:100,000 Regional: 1:10,000	2001 / 2003 2003 / 2004	Implementation of Seveso
Cyprus	No official national maps	n/a	n/a	n/a
Estonia	Topographical / contours (D and P)	Regional (unofficial) - N.A.	2001 / yearly	Regulation by Ministry of Interior
Hungary	Topographical / SPIRS (D)	National: 1:50,000	2002 / yearly	Government decree and Ministry acts
Latvia	No official national maps	n/a	n/a	n/a
Lithuania	Topographical / contours (D and P)	National: 1:400,000 / 1:50,000 Regional: 1:200,000 Municipal: 1:25,000 / 1:500	Yearly updated	Government Decree, civil protection
Poland	Topographical / contours (few D and P)	Provincial: 1:200,000 Municipal: 1:10,000 Plants: 1:10,000 / 1:5,000	1993 / yearly 3 years or major change (Plants)	Civil protection, environment, land-use planning acts
Romania	Topographical / contours / past accidents (P)	National: 1:1,000,000 Regional: 1:500,000 / 1:200,000 Provincial: 1:100,000 Municipal: 1:50,000 / 1:20,000	1985 / yearly (all)	Government decree, civil protection
Slovakia	No official national maps	n/a	n/a	n/a
Slovenia	No official national maps	n/a	n/a	n/a

Legend: n/a- not applicable

- Maps in paper form are available in Bulgaria and Romania. Maps in digital form are produced in the Czech Republic and Hungary, while both digital and paper maps are available in Estonia, Lithuania and Poland.

Data created and last updated

Results indicate that the most recent industrial hazards maps are available in Bulgaria, the Czech Republic, Estonia, Hungary and Lithuania. These maps are reviewed regularly, usually once a year. Poland and Romania have maps created in 1993 and 1985, respectively, updated yearly. In Lithuania, maps are updated yearly.

Legislative framework

Respondents were asked to describe any legal instruments that mandate or guide official mapping of industrial hazards. Several acts and regulations support industrial hazard mapping in the Czech Republic, Estonia, Hungary, Lithuania, Poland and Romania. These instruments generally contain guidance and obligations for reporting, prevention and notification related to hazard management.

Representation of industrial hazard on maps

Results indicate that the most common representation of industrial hazards is a topographical map showing the location of establishments (7 countries) and contour lines (6 countries). Establishments in which major accidents have occurred in the past are also depicted in the Czech Republic and Romania (see Table 3 below).

Table 3: Representation of Industrial Hazards on Maps

A topographical map showing location of establishments	BG, CZ, ES, H, LT, PL, RO
Contours (e.g. representing Concentrations, Thermal radiations, Overpressure, etc.) describing the hazard potential of various accident scenarios	BG, ES, LT, PL, RO
Establishments in which major accidents have occurred in the past	CZ, RO
Other	H, LT

Map features or symbols and background information on industrial hazard maps

Table 4 contains the description of standard mapping features for industrial hazards and background information visible on industrial hazard maps in the surveyed countries.

A few observations from these data are highlighted below:

- Typical map features or symbols include points to indicate the location of chemical plants, refineries and other relevant sites, lines (e.g., for administrative boundaries and pipelines), polygons (to outline potential concentration—or dispersion—of a released substance, overpressure and thermal radiation for reference accident scenarios), text (to identify municipalities, regions, establishment names) and colour (contaminated areas).

- The background information is generally similar across countries, mainly consisting of water bodies, administrative boundaries, roads and railways (6 to 7 countries); and topography, land use and hydrological catchments (4 to 5 countries).

Table 4: Map Features and Background Information Used in Industrial Hazard Maps

Country	Standard Industrial Installation Map Features and Background Information
Bulgaria	**Industrial hazard-related:** Chemical plants, other industrial sites, pipelines, name of establishment, and concentration of substances, thermal radiation and overpressure (in association with potential or actual accident scenarios) **Background:** Topography (not always), water bodies (major rivers and dams), administrative boundaries, population (rarely), roads, railways
Czech Republic	**Background:** Topography, hydrological catchments, water bodies, administrative boundaries, population, roads, railways, other (protected areas, national parks)
Cyprus	None
Estonia	**Background:** Water bodies, administrative boundaries, population, roads, railways
Hungary	**Industrial hazard-related:** Chemical plants, other industrial sites, names of establishments, types of activities, names of substances **Background:** Water bodies (rivers and lakes), administrative boundaries (state borders, county boundaries), population (settlements), roads, railways
Latvia	None
Lithuania	**Industrial hazard-related:** Chemical plants, other industrial sites, pipelines, , names of establishments, contaminated areas, and concentration of substances and thermal radiation (in association with potential or actual accident scenarios) **Background:** Topography, hydrological catchments, land use, water bodies, administrative boundaries, roads, railways
Poland	**Industrial hazard-related:** Pipelines, dispersion of chemical substances, location and name of establishments, and overpressure (in association with potential or actual accident scenarios) **Background:** Topography, hydrological catchments, land use, water bodies, administrative boundaries, population, roads, railways, other (stadiums, churches, single buildings, etc.)
Romania	**Industrial hazard-related:** Chemical plants, other industrial hazards, pipelines names of establishments, types of activities, substances, contaminated areas, fluid movement, and concentration of substances, thermal radiation (in association with potential or actual accident scenarios) **Background:** Topography, hydrological catchments, land use, water bodies, administrative boundaries, population, roads, railways, other
Slovakia	None
Slovenia	None

Use of industrial hazard maps and their degree of accessibility

Seven countries responded comprehensively to this question. As shown in Table 5, information from industrial hazard maps is used to support mapping needs for civil protection, scientific research, military planning and for communicating about hazards to the public through the media.

The following observations are highlighted:

- The most common uses of the information are preparation of emergency response plans, communication to the public or decision makers, and visualization for various purposes.
- Industrial hazard maps are completely restricted in Romania, partly available to the public in Bulgaria, the Czech Republic and Estonia.
- Lithuania, Hungary and Poland allow public access to industrial hazard maps (although some maps in Poland are restricted).
- Maps used for military purposes are restricted in all of the countries.
- Cyprus has no specific use for industrial hazard maps.
- Although authorities in Latvia, Slovakia and Slovenia produce industrial hazard maps, the maps have no official status and are not a regular input to any particular activity.

Table 5: Use of Industrial Installations Hazard Maps and their Degree of Accessibility

Use of Industrial Hazard Map	BG	CZ	CY	EST	H	LV	LT	PL	RO	SK	SL
Targeted Information Communication to the Public	-	R	-	P	P	-	P	P, R	R	-	-
Targeted Information Communication amongst Decision-makers	-	R	-	R	O	-	P	P, R	R	-	-
Land Use/Spatial Planning	-	-	-	P	-	-	P	P	R	-	-
Emergency Response Plans for Civil Protection	R	P, R	-	R	-	-	P	P, R	R	-	-
Targeted Allocation of Resources	-	-	-	R	-	-	P	P, R	R	-	-
Scientific Research	-	-	-	P	-	-	P	P	R	-	-
Military Purposes	R	-	-	-	-	-	R	R	R	-	-
Visualisation of Information only	P	R	-	P	-	-	P	P	R	-	-

Legend: P- public, R-restricted, O- other, ”-“ - no data provided

2.2 Industrial Hazard Data

Survey responses confirm that all of the surveyed countries have an official mechanism for collecting industrial hazard data as required by the Seveso II Directive. The Seveso Directive specifically requires the following:

- Article 6: Notification of the presence of a major industrial hazard. This article requires an operator to notify the competent authorities (among other things) of the location of the establishment; the name or category of substances involved; the quantity and physical form of the substance; the activity or proposed activity of the facility; and the immediate environment of the establishment (elements liable to cause a major accident or to aggravate the consequences thereof).

- Article 9: Safety report of the establishment. This article requires operators to provide a safety report for establishments that exceed a threshold quantity of a certain substance or category of substances. The safety report includes detailed information about the risks imposed by the presence of hazardous substances at the establishment and the means implemented to minimize those risks.

- Article 14: Reporting of major accidents. Operators of establishments covered by the Seveso Directive must notify the competent authorities of the details of any major industrial accidents occurring within their installations and that fulfil the major accident criteria listed in Annex VI of the Directive.

These data are summarized in Table 6.

Chemical substances

All countries receive some information on chemical substances present on the site, name or hazard category, chemical and physical properties and the quantity stored due to obligations under the Seveso II Directive, although some countries may have additional legislation that goes beyond the Seveso requirements resulting in more complete and extensive databases. Moreover, the table does not comment on accessibility of these data to mapping authorities. Accessibility may vary in different countries depending on which authority actually is responsible for receiving and managing the data and administrative arrangements between institutes for sharing this information.

Accidents

In accordance with Seveso II requirements, all of the countries collect information on past major accidents that occurred in the establishment. Reports by operators are most frequently used for recording accidents.

Measured concentrations

Bulgaria, Estonia, Lithuania, Poland, Romania, Slovakia and Slovenia all collect concentration levels of certain substances in the air to monitor chronic levels of certain contaminants. Depending on the location, these monitoring stations also can be useful in the event of a release of a particular substance in their vicinity. The industry also conducts monitoring activities, particularly in the event of an unplanned release, but these monitoring activities could not be reflected in this survey since the survey was aimed only at competent authorities.

Climatology and Meteorology

Seven countries regularly collect wind speed and temperature data for the country and all but one of these countries also monitors air pressure. Some of them also collect precipitation levels and other details. Most of them have automatic monitoring stations but some data in many countries are also collected manually.

Format

Industrial hazard data are always available in paper format. Additionally, seven countries also store the information digitally.

Area Coverage

All countries collect hazard data on a national basis and it is also can be analysed by region. Only some countries also have data broken down at the municipal level.

Metadata/Standard

Six of the countries have geo-referenced information on industrial installation hazard, however only three of them have associated metadata. The metadata standard is actually only applied in Lithuania. The advantage of using a metadata standard is that data sets will interoperate with other sets that use the same standard.

Table 6: Data Collected Relevant to Industrial Hazard and Risk Mapping (Page 1 of 2)

Country	Chemical Substances	Accidents	Measured Concentrations	Climatology and Meteorology (Collection Method)	Format Area Coverage Geo-reference Metadata/Standard
Bulgaria	Name or category, properties, quantity stored	Required by the Seveso II Directive	Levels in rivers, air, soil	Wind speed, temperature, pressure (automatic and manual)	Digital & paper National, regional coverage Geo-ref: No Metadata: No
Czech Republic	Name or category, properties, quantity stored	Required by the Seveso II Directive	No	No	Digital & paper National, regional coverage Geo-ref: Yes Metadata: Yes
Cyprus	Name or category, properties, quantity stored	Required by the Seveso II Directive	No	No	Digital & paper National coverage Geo-ref: No Metadata: No
Estonia	Name or category, properties, quantity stored, other (radiation levels)	Required by the Seveso II Directive	Levels in air	Wind speed, temperature, pressure, humidity, dew point, cloudiness, precipitation (automatic and manual)	Digital & paper National, regional, municipal coverage Geo-ref: Yes Metadata: Yes
Hungary	Name or category, properties, quantity stored	Required by the Seveso II Directive	No	No	Digital & paper National coverage Geo-ref: Yes Metadata: Unknown
Latvia	Name or category, properties, quantity stored	Required by the Seveso II Directive	No	No	Paper National, regional coverage Geo-ref: unknown Metadata: Unknown

Table 6: Data Collected Relevant to Industrial Hazard and Risk Mapping (Page 2 of 2)

Country	Chemical Substances	Accidents	Measured Concentrations	Climatology and Meteorology (Collection Method)	Format Area Coverage Geo-reference Metadata/Standard
Lithuania	Name or category, properties, other (information about accident consequences, chemical dispersion characteristics, physiochemical forces involved, etc.)	Required by the Seveso II Directive	Levels in rivers, air	Wind speed, temperature, pressure (automatic)	Digital & paper National, regional, municipal coverage Geo-referenced: Yes Metadata: Yes
Poland	Name or category, properties, quantity stored	Required by the Seveso II Directive	Levels in rivers, air, soil	Wind speed, temperature, pressure, other (no data)	Paper National, provincial, municipal coverage Geo-referenced: No Metadata: No
Romania	Name or category, properties, quantity stored, dispersion characteristics	Required by the Seveso II Directive	Levels in rivers, air, soil	Wind speed, wind direction, precipitation, temperature (automatic)	Paper National, provincial, municipal coverage Geo-referenced: No Metadata: No
Slovakia	Name or category, properties, quantity stored	Required by the Seveso II Directive	Levels in rivers, air	Wind speed, temperature, pressure, precipitation (automatic and manual)	Paper National, provincial coverage Geo-referenced: Yes Metadata: No
Slovenia	Name or category, properties, other	Required by the Seveso II Directive	Levels in rivers, air	Wind speed, temperature, pressure (automatic and manual)	Digital & paper National, regional coverage Geo-referenced: Yes Metadata: No

Use of industrial installation hazard data

Seven countries replied comprehensively regarding the use of industrial hazard data. All of the responding countries use the hazard data for targeting communication to the public or to support government decision-making. All but one country (Hungary) use the data for land-use planning, emergency response planning or other purposes specified in Table 7. Data are generally public in Lithuania and completely restricted in Romania and Slovenia. For the other countries, the data are available to the public with some restrictions.

Table 7: Use of Industrial Installation Hazard Data

Use of Industrial Hazard Data	BG	CZ	CY	EST	H	LV	LT	PL	RO	SK	SL
Targeted Communication to the Public	P	-	-	P	P	-	P	P, R	R	-	R
Targeted Communication amongst Decision-makers	R	-	-	R	R	-	P	P, R	R	-	R
Land Use/Spatial Planning	P	-	-	R	-	-	P	P, R	R	-	R
Emergency Response Plans	P	-	-	P	-	-	P	P, R	R	-	R
Targeted Allocation of Resources	-	-	-	R	-	-	P	P, R	R	-	R
Scientific Research	-	-	-	P	-	-	P	P	R	-	R
Military Purposes	R	-	-	-	-	-	R	R	R	-	R
Visualisation of Information only	-	-	-	P	-	-	P	P	R	-	R

Legend: P- public, R-restricted, O- other, ns- not specified, “-“ - no data provided

Experts were also asked if available information is sufficient for defining a national industrial hazards map. Countries that are confident about their data are Bulgaria, Estonia, Hungary, Romania and Slovakia. On the contrary, Czech and Cypriot experts stated that the basic data are available but were not sure whether they are sufficient for making hazard maps.

2.3 Industrial Hazard Vulnerability Maps

Respondents were asked to identify objects considered important vulnerable elements relative to industrial hazards. In general, respondents did not indicate whether the importance rating was based on the element’s perceived value to society or alternatively, on perceptions surrounding distinguish between importance of the element (to the economy, to society) or potential for exposure and resilience. Rather, the responses provide a simple indication of how such objects are prioritised for mapping seismic hazards in each country.

Official classification of vulnerable objects in Hungary and Lithuania

Hungary and Lithuania indicated that they have official classification systems for identifying types of objects considered potentially vulnerable to industrial hazards. These systems are generally described in Table 8.

Table 8: Official Classification of Vulnerable Objects in Hungary and Lithuania

Country	Classification of Vulnerable Objects
Hungary	Population, individual risk, societal risk (housing accommodation and developments with large number of people e.g. at a workplace, in a shopping centre, in a school, in a leisure facility), environmental and natural resources
Lithuania	According to danger and possible risk for contaminated areas, there are three levels of accident: - Local (or municipal) level in which consequences of an accident and the contaminated area are contained within one municipality. - Regional level – the consequences and contaminated area extend across more than one municipality. - National level – consequences and contaminated areas extend across more than one county.

Furthermore, among the surveyed countries, only Poland has an official industrial hazard vulnerability map. However, Poland does not update its vulnerability maps on a regular basis. In Lithuania and Romania, vulnerability is included in hazard and/or risk maps.

Level of importance of the elements at risk exposed to industrial hazards

Respondents were also asked to indicate how various categories of typically vulnerable objects are prioritised for industrial installation risk management in their countries, on a scale of very low to very high. Their answers to this question are summarized in Table 9.

Table 9: Level of Importance of the Elements at Risk Exposed to Industrial Hazards

Country	Humans as Individuals	Humans as Social Targets	Infrastru-cture	Cultural Heritage	Private Property	Natural Resources	Ecology
Bulgaria	VH	VH	H	VH	H	VH	VH
Czech Republic							
Cyprus	VH	VH	H	H	H	L	L
Estonia	H	H	H	M	M	M	M
Hungary	VH	H	H	M		H	H
Latvia							
Lithuania	M	M	L	L	L	VL	L
Poland	L	L	L	VL	VL	L	VL
Romania	VH	VH	VH	H	M	VH	VH
Slovakia							
Slovenia							

Legend: VH: Very high; **H**: High; **M**: Medium; **L**: Low; **VL**: Very low

As observed in the table, perceptions about the importance of elements at risk are very different between countries. In some cases, as in Lithuania and Poland, the elements exposed to risk are generally given a low or very low rating, while other countries have identified all elements as having high or very high importance, e.g., Romania and Bulgaria. Hungary, Cyprus and Estonia also indicated many elements that were of high or very relevance to risk at industrial installations. (The Czech Republic, Latvia, Slovakia and Slovenia did not complete the table.) Figure 5 is a graphical presentation of the results shown in Table 9.

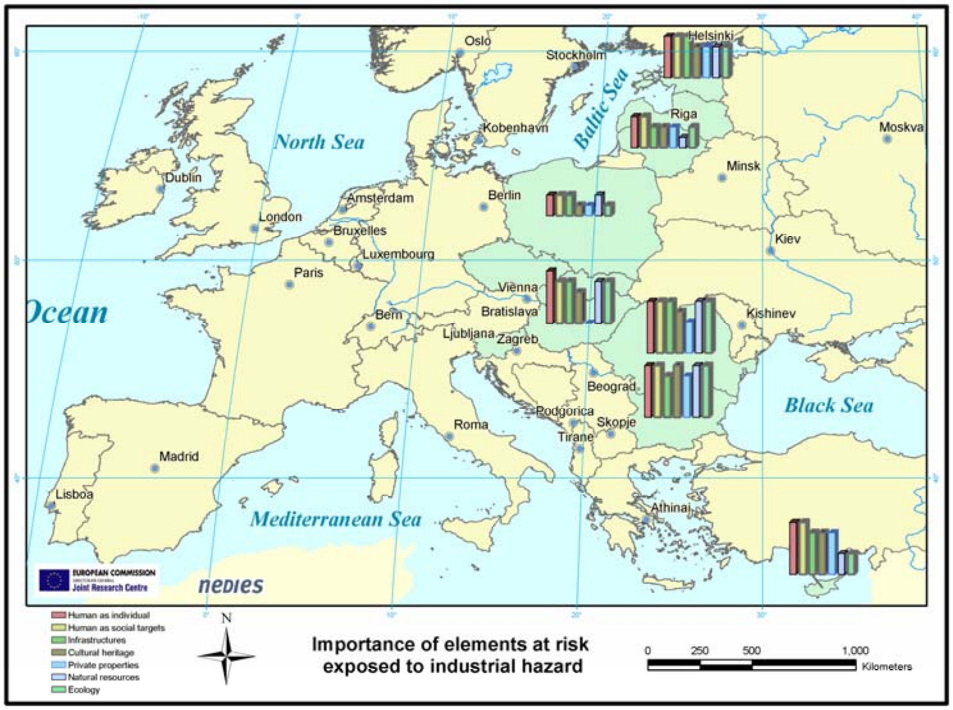

Figure 5: Importance of Elements at Risk Exposed to Industrial Hazard[7]

Classification of damages

Seven countries (Bulgaria, the Czech Republic, Cyprus, Estonia, Lithuania, Poland and Romania) indicated that types of potential damage resulting from industrial accidents are officially classified as reversible or irreversible, as shown in Table 10.

[7] To facilitate graphic display, the risk rankings were quantified based on their category of risk, i.e., very high = 100, high, = 80, medium = 60, low = 40, and very low = 20.

Table 10: Classification of Damages as Reversible and Irreversible

Country	Reversible Damage	Irreversible
Bulgaria	**Human**: Injury, economic loss **Infrastructure:** Loss of functionality, public service interruption **Private property:** Loss of functionality **Natural resources:** Economic loss **Ecology:** Damage to habitats	**Human:** Death, disability **Infrastructure:** Destruction, uneconomical recovery **Cultural heritage:** Cultural loss **Private property:** Other destruction **Ecology:** Loss of biodiversity
Czech Republic	**Human**: Injury, acute effect, economic loss **Infrastructure:** Severe damage, loss of functionality, economic loss, public service interruption **Cultural heritage:** Economic loss, accessibility **Private property:** Economic loss, loss of functionality **Natural resources:** Economic loss, loss of resource **Ecology:** Loss of biodiversity	**Human:** Death, cancer, health chronic effect **Infrastructure:** Destruction **Cultural heritage:** Cultural loss **Natural resources:** Loss of resource **Ecology:** Loss of biodiversity
Cyprus	**Human**: Injury, acute health effect, Economic Loss **Infrastructure:** Severe damage, loss of functionality, economic loss, public service interruption **Cultural heritage:** Economic loss, accessibility **Private property:** Economic loss, loss of functionality **Natural resources:** Economic loss	**Human:** Death, chronic health effect **Infrastructure:** Uneconomical recovery **Cultural heritage:** Cultural loss **Private property:** Economic loss
Estonia	**Human**: Injury **Infrastructure:** Severe damage, economic loss, public service interruption **Private property:** Economic loss	**Human:** Death **Infrastructure:** Destruction **Private property:** Economic loss
Lithuania	**Human**: Injury, acute health effect, Epidemic, Economic Loss **Infrastructure:** Severe damage, loss of functionality, economic loss, public service interruption **Cultural heritage:** Economic loss, accessibility **Private property:** Economic loss, loss of functionality **Natural resources:** Economic loss, loss of resource **Ecology:** Loss of biodiversity	**Human:** Death, cancer, chronic health effect, disability **Infrastructure:** Destruction, uneconomical recovery **Cultural heritage:** Cultural loss, economic loss **Private property:** Economic loss **Natural resources:** Economic loss, loss of resource **Ecology:** Loss of biodiversity
Poland	**Human**: Injury, acute health effect **Infrastructure:** Severe damage **Private property:** Economic loss, loss of functionality	**Human:** Death **Infrastructure:** Destruction **Private property:** Economic loss
Romania	**Human**: Injury, acute health effect, epidemic, economic loss **Infrastructure:** Severe damage, loss of functionality, economic loss, public service interruption **Cultural heritage:** Economic loss, accessibility **Private property:** Economic loss, loss of functionality **Natural resources:** Economic loss, loss of resource **Ecology:** Loss of biodiversity	**Human:** Death, cancer, chronic health effect, disability **Ecology:** Loss of biodiversity

2.4 Industrial Risk Maps

Similar to vulnerability, the questionnaire also sought to understand how countries were approaching risk mapping, and whether in fact, it was of interest to them. The current situation indicates that industrial risk maps are currently available in Bulgaria, the Czech Republic, Estonia and Lithuania. However, the majority of respondents expressed their intention to create risk maps within the next few years. A summary of the results regarding industrial risk maps is contained in Table 11.

Table 11: Availability of Industrial Risk Maps

Country	Type of Map Format – Digital (D) or Paper (P)	Representation of Risk (Parameters)	Areal Coverage/ Scale	Date Created/ Last Updates
Bulgaria	ns (P)	Quantitative (severity)	National: 1:500,000	1.4.2002/1.9.2003
Czech Republic	Zones of external emergency response plans (D and P)	Quantitative (probability, severity)	Regional Municipal	ns
Cyprus	n/a	n/a	n/a	n/a
Estonia	Industrial establishment and population risk maps (P some D)	Quantitative (severity)	Provincial: 1:50,000 Municipal: 1;15,000	ns 2001/ updated yearly
Hungary	n/a	n/a	n/a	n/a
Latvia	n/a	n/a	n/a	n/a
Lithuania	Industrial establishment risk maps (P and D)	Quantitative (severity)	National: different Regional Municipal	Updated yearly
Poland	n/a	n/a	n/a	n/a
Romania	n/a	n/a	n/a	n/a
Slovakia	n/a	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a

Legend: n/a- not applicable, ns- not specified

Types of maps

Industrial risk maps in the surveyed countries are usually available in areas where industrial installations are located.

Representation of industrial risk on maps

Industrial risk is represented on the maps quantitatively. The risk parameters include estimated frequencies of accidents and the severity of potential consequences.

Scale, coverage and format of maps

The surveyed countries use a variety of scales for industrial risk mapping, ranging from a rather small scale of 1:500,000 to a large scale of 1:15,000.

Areal coverage is different in the surveyed countries but municipal coverage is available for all countries (except Bulgaria).

The majority of countries also produce maps in digital and paper form. In Bulgaria maps are only available in paper form.

Data created and last updated

Most countries have recent versions of risk maps (2001, 2002) and in general they are updated on a yearly basis.

Map features or symbols on industrial risk maps

Bulgaria and Latvia are the only countries that report the use of specific symbols for risk mapping. In these two countries, typical map features include points (the location of industrial plants), lines (administrative boundaries and pipelines), polygons (concentration of chemicals, thermal radiation, overpressure and areal dispersion), and text (address and name of establishment).

Use of industrial risk maps and their degree of accessibility

Only four countries (Bulgaria, Czech Republic, Estonia and Lithuania) gave information in response to this question (see Table 12 on the next page). With the exception of Lithuania, the responding countries appear to use risk maps for a limited number of applications. Lithuania offers fairly broad public access to its risk maps whereas the other three countries are somewhat mixed in this regard.

It was agreed among all respondents that a harmonized approach or standardised definition of risk maps could be of assistance in their efforts.

Table12: Use of Industrial Risk Maps and their Degree of Accessibility

Use of Industrial Risk Map	BG	CZ	CY	EST	H	LV	LT	PL	RO	SK	SL
Targeted Information Communication to the Public	-	P, R	-	-	-	-	P	-	-	-	-
Targeted Information Communication amongst Decision-makers	-	R	-	-	-	-	P	-	-	-	-
Land Use/Spatial Planning	-	-	-	-	-	-	P	-	-	-	-
Emergency Response Plans for Civil Protection	R	P	-	P	-	-	P	-	-	-	-
Targeted Allocation of Resources	-	-	-	R	-	-	P	-	-	-	-
Scientific Research	-	-	-	-	-	-	P	-	-	-	-
Military Purposes	R	-	-	-	-	-	R	-	-	-	-
Visualisation of Information only	P	-	-	-	-	-	P	-	-	-	-

Legend: P- public, R-restricted, ”-“ - no data provided

3. CONCLUSIONS AND RECOMMENDATIONS

The analysis of the data shows many differences among the surveyed countries in the availability and quality of maps regarding industrial hazards. All the countries report having systems for data collection of industrial risk. These phenomena can in part be attributed to the requirements of the Seveso II Directive although at least four countries had existing systems for collecting such data prior to implementation of the Directive. Wider differences can be observed in industrial risk mapping practices.

Conclusions and key findings can be summarized as follows:

- **Hazardous installations are considered as either of medium or high relevance for all but one country.** All surveyed countries provided information on mapping of industrial hazards. Bulgaria, Latvia and Slovakia consider themselves to have high exposure to industrial risks. The Czech Republic, Cyprus, Hungary, Lithuania, Poland, Romania and Slovenia perceive industrial hazards as medium risks and in Estonia they are considered a low level risk.
- **Official industrial hazard maps** are currently available in Bulgaria, the Czech Republic, Hungary, Lithuania, Poland and Romania. Other countries like Cyprus and Estonia have inventory maps using the SPIRS application.
- **A variety of formats are available for industrial hazard maps.** Bulgaria and Romania have maps in paper form. Digital maps are produced in the Czech Republic and Hungary, while both digital and paper maps are available in Estonia, Lithuania and Poland.
- **Six countries have legislation that mandates or strongly influences the production of industrial hazard maps** (the Czech Republic, Estonia, Hungary, Lithuania, Poland and Romania).
- **Industrial hazard maps are generally available for public access in three countries** (Latvia, Hungary and Poland), partly available to the public in Bulgaria, the Czech Republic and Estonia and completely restricted in Romania.
- **Features and background information included in industrial hazard maps are similar in the surveyed countries**. Typical map features or symbols include points to indicate the location of chemical plants, refineries and other relevant sites, lines (e.g., for administrative boundaries and pipelines), polygons (to outline potential concentration—or dispersion—of a released substance, overpressure and thermal radiation for reference accident scenarios), text (to identify municipalities, regions, establishment names,) and colour (contaminated areas). Background information mainly consists of water bodies, administrative boundaries, roads and railways.
- **All of the surveyed countries have national authorities responsible for collecting data relevant to industrial hazards.** In general, all countries receive some information on chemical substances present on the site, name or hazard category, chemical and physical properties and the quantity stored.
- **Data relevant to the evaluation of industrial hazards and risks are available to the public in Lithuania and completely restricted in Romania and Slovenia.** For the other countries, the data are available to the public with some restrictions in use.
- **Hungary and Lithuania indicated that they have an official classification system identifying types of objects considered potentially vulnerable to industrial hazards.**

- **The majority of respondents ranked humans as individuals and humans as social targets as elements at high or very high risk when exposed to industrial hazards.** In Lithuania and Poland the elements exposed to risk are given generally a low or very low rating, while others consider that almost all elements have a high or very high exposure to risk, such as Romania or Bulgaria.
- **Vulnerability maps are not available in the surveyed countries,** except in Poland.
- **Seven countries reported having official classifications for potential damages as reversible or irreversible** (Bulgaria, the Czech Republic, Cyprus, Estonia, Lithuania, Poland and Romania).
- **Industrial risk maps are currently available in Bulgaria, the Czech Republic, Estonia and Lithuania.** However, respondents indicated that the information included in such maps is generally not very detailed.
- **Industrial risk is represented on the maps quantitatively.** The risk parameters usually include the severity and frequency of accidents.
- **In general all countries expressed their interest in harmonized approaches for integrated risk mapping in the future.** Some of the issues that have been expressed as particularly interesting to some countries are symbols, scales, harmonized definitions of possible scenarios and hazardous zones for possible industrial accidents, and transboundary effects assessment.

Based on these conclusions, the following recommendations have been developed:

- **It could be helpful to share information on methodologies that are used or that could be used to select which industrial hazards should be mapped.** If possible, it would be interesting to harmonize criteria for classifying and selecting industrial hazards and associated risk levels. For example, introducing methodologies such as ARAMIS, for risk quantification in PECO countries could be proposed.
- **Industrial installations are an important risk in the new Member States and Candidate Countries and represent an opportunity for collaboration on the design and implementation of new tools for mapping these hazards**. Areas of opportunity include:
    - Transformation of maps into digital form is an important step forward for facilitating data exchange.
    - The establishment of minimum features, standards and data for preparing digital maps for industrial installations to facilitate data exchange and use of standardised formats.
- **The experience and knowledge of the surveyed countries should be regarded as a valuable resource in European efforts to advance flood hazard and risk mapping techniques**. Several countries have considerable resources and expertise devoted to analysing the risks associated with industrial installations.
- **There is a potentially strong opportunity for collaboration in the development of a common methodology for risk mapping of industrial hazards.** The surveyed countries are not producing risk maps of industrial hazards; however, they recognise that these types of maps could be valuable tools. The SPIRS database developed by MAHB could be a starting point to achieve this goal.

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Abstract

In 2003 the Joint Research Centre conducted a survey of mapping practices in eleven (11) new Member States (Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia) for eight (8) major natural and technological hazards such as floods, forest fires, storms, landslides, earthquakes, industrial installations, transport of dangerous goods and contaminated lands. This activity was funded as part of the project entitled "Management of Natural and Technological Risks".

One fundamental project objective was to examine the existing situation in each of the surveyed countries, and compare different mapping methodologies in order to define guidelines for establishing compatible risk mapping systems, in particular multi-hazard risk mapping. This report describes the results of the industrial installations section of the risk mapping activity. Responses to the survey provide important information about the current status of industrial hazards and risk mapping in different countries and advantages and obstacles to developing a common methodology for multi-hazard risk mapping including this hazard in each country.

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