JRC Scientific and Technical Reports

Results of the Workshop: Assessing and Managing Natechs (Natural-hazard triggered technological accidents)

Ana Maria Cruz and Elisabeth Krausmann

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European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

The Institute for the Protection and Security of the Citizen (IPSC) provides research-based, systems-oriented support to EU policies so as to protect the citizen against economic and technological risk.

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http://www.jrc.ec.europa.eu/

Luxembourg: Office for Official Publications of the European Communities

JRC 43865
EUR 23288 EN
ISSN 1018-5593

Printed in Italy

Photos on cover page: top and bottom left courtesy of Ana Maria Cruz; top right courtesy of Pavel Danihelka.

ACKNOWLEDGMENTS

The authors would like to thank all the participants and invited guests to the workshop: Assessing and Managing Natechs (Natural-hazard triggered technological accidents). The workshop was organised and hosted by the Major Accident Hazards Bureau (MAHB) of the Institute for the Protection and Security of the Citizen (IPSC) of the European Commission's Joint Research Centre (JRC) on 17-18 September 2007 in Stresa, Italy.

We would like to give special thanks to Dr. Laura J. Steinberg, Dr. Valerio Cozzani, and Dr. Michael Lindell for their valuable contributions before and during the workshop. We would also like to thank the individual contributions on Natech risk management practices prepared by country representatives from Slovenia, Germany, Austria, Romania, Poland, Bulgaria and Greece (in the order they were presented).

Finally, we would like to acknowledge Raffaella Magi-Galluzzi, Lorena Marcaletti, and Laurence Campé for their timely help, and assistance.

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RESULTS FROM THE WORKSHOP:

ASSESSING AND MANAGING NATECHS

(NATURAL-HAZARD TRIGGERED TECHNOLOGICAL ACCIDENTS)

September 17-18, 2007

Stresa, Italy

A. M. CRUZ AND E. KRAUSMANN

Summary

The workshop: Assessing and Managing Natechs (Natural-hazard triggered technological accidents) was organised and hosted by the Major Accident Hazards Bureau (MAHB) at the Institute for the Protection and Security of the Citizen (IPSC) of the European Commission's Joint Research Centre (JRC), on 17-18 September 2007 in Stresa, Italy. The Natech workshop, the second of its kind to be organized the JRC, was carried out in an effort to provide a framework and practical tools for Natech risk assessment and management at the community level. The workshop included invited presentations on country practices which served to help monitor progress in Natech risk reduction since the first workshop in 2003.

In addition to the country presentations, the two day workshop included discussion of key issues, presentations of new concepts/ information, hands-on exercises, and the development of case studies. In the case studies participants carried out a Natech risk assessment of a selected community. Discussion of case study results and possible Natech risk management strategies followed, as well as identification of future priorities for research and tool development.

Objectives

- Provide a framework and practical tools for Natech risk assessment and management at the community level
- Enhance Natech awareness and promote Natech risk reduction
- Promote discussion and improvement of the Natech risk assessment and management methodology presented identifying key Natech risk management strategies

Format

- Country presentations (Sept. 17, AM)
- Preparation for case studies (Sept. 17, PM)
- Case studies, presentation of case study results, and identification of Natech risk management strategies (Sept. 18 AM & PM)

Participants

- Competent Authorities, civil protection authorities, other government officials interested in industrial risk reduction
- Researchers and academics
- Emergency managers and land-use planners

1. INTRODUCTION

The workshop: Assessing and Managing Natechs (Natural-hazard triggered technological accidents) was organised and hosted by the Major Accident Hazards Bureau (MAHB) at the Institute for the Protection and Security of the Citizen (IPSC) of the European Commission's Joint Research Centre (JRC), on 17-18 September 2007 in Stresa, Italy. The Natech workshop was held back-to-back with the 7th IIASA-DPRI Forum on Integrated Disaster Risk Management co-organised and hosted by the JRC. The Natech workshop was attended by 25 participants from 16 different countries. Participants to the workshop came from a variety of institutions including academia, government authorities and private enterprises.

The Natech workshop, the second of its kind to be organized by the JRC[1], was carried out in an effort to provide a framework and practical tools for Natech risk assessment and management at the community level. The workshop included invited presentations on country practices which served to help monitor progress in Natech risk reduction since the first workshop in 2003.

In addition to the country presentations, the two day workshop included discussion of key issues and problems in Natech risk management, presentations of new concepts/ information, hands-on exercises, and the development of case studies. In the case studies participants worked in small groups to carry out a Natech risk assessment of a selected community. Group discussions of case study results and possible Natech risk management strategies followed. Each group identified and prioritized key Natech risk reduction strategies. At the end of the second day the groups convened and proposed a set of key strategies for Natech risk reduction. The workshop agenda is included in Annex 1.

This document contains a summary of the country presentations, group activities, case studies, and case study results.

2. COUNTRY PRESENTATIONS

There were seven presentations on industrial risk management and emergency response practices from the following countries: Slovenia, Germany, Austria, Romania, Poland, Bulgaria, and Greece. The content of these presentations is briefly summarized below. The original

[1] The first Natech Workshop: Analysis of Natech Disasters: Natural Hazards Triggering Technological Disasters was organized jointly by the JRC and the United Nations' International Strategy for Disaster Reduction (UN/ISDR) on 20-21 October 2003 in Ispra, Italy.

presentations are attached in Annex 2. The numbering follows the order of the presentations as in the agenda.

2.1 Slovenia

Dusan Fajfar of IGEA gave an overview of GIS support for emergency management in Slovenia, a joint presentation by the Slovenian Ministry of Defence's Administration for Civil Protection and Disaster Relief, and IGEA. D. Fajfar pointed out that Slovenia has very good background information in terms of maps which led to the development of a web-based system for emergency planning with a GIS core. The system contains hazard and risk maps with respect to natural and technological hazards (including data sheets on the safety of hazardous materials), cartographic background data, geo-located registers, environmentally sensitive areas and infrastructure. It is used by emergency centres in its desktop application; the web-based system is used for emergency planning and by rescue forces. The system also incorporates action plans to assist the decision-making process and which are defined for type of pre-defined event and impacted area (national, regional, local). Emergency response plans that existed only in paper format were digitised to facilitate access and keeping them up to date. By means of an example (a call to the EU emergency number 112) D. Fajfar demonstrated the various steps in support of managing a crisis situation. Furthermore, he presented the planned additions to the system, as well as a short overview of a web-based Emergency Incident Reporting System in which intervention reports by operators of emergency centres and rescue teams are recorded.

In terms of Natech risk management, Milica Slokar provided the following information on two decrees in Slowenia that address chain effects in disasters such as a natural disaster triggering a chemical accident:

a. Decree on the subject matter and compilation of emergency response plans, which defines:

Emergency response plans shall include the determination of the likelihood of the chain of disasters such as fires, explosions, uncontrolled emissions of hazardous substances in the environment, floods, avalanches and land slides, erosion, destroyed water barriers, epidemics and epizootic, damage infrastructure, traffic accidents etc. The likelihood of the chain of disasters is recognized in the national emergency response plans in the event of an earthquake, in the event of a flood, during a plane accident, for a railway accident, in the event of the large fire in the natural environment, in the event of terrorist use of weapons or means of mass destruction and/or in the event of a terrorist attack with conventional means.

b. Decree on the prevention of larger disasters and mitigation of their consequences, which defines:

The Ministry of the Environment and Spatial Planning identifies industrial plants, the distance between which is less than or equal to 700 m, and because of possible chain effects obliges the managers of these plants to exchange data and information and to take this information into consideration in their Environmental Risk plans, safety and security management systems, safety reports and emergency response plans. The Ministry also requires the managers to take part in the preparation of safety measures. This information is also sent to the RS Administration for Civil Protection and Disaster Relief by the Ministry of Environment and Spatial Planning.

2.2 Germany

Roland Fendler of the Umweltbundesamt (UBA - Federal Environment Agency) of Germany presented the results of a UBA project that assessed the protection of selected industrial facilities against floods, earthquakes and storms. The project scope were establishments falling under the Seveso II Directive for all three natural hazards, and installations containing substances hazardous to water or those storing flammable gases in vessels for floods only.

The results of the study revealed that authorities in Germany only consider riverine floods in flood hazard maps but do not consider flooding by flash floods, insufficient draining, and groundwater increase. Furthermore, it indicated that flood-protection requirements are insufficient at the moment and guidance is necessary on how to consider flood risk in safety concepts, safety reports and emergency plans. R. Fendler emphasised that Natechs are currently not adequately considered in the preparation of the safety reports. The study also highlighted the need to better understand the impact of climate change on Natech risk.

The assessment of the protection of Seveso II installations against earthquakes and storms identified technical safety deficits and safety-relevant shortcomings in licensing procedures. As an example, the applied German standards for buildings do not take into account the combined risk of building collapse and the presence of hazardous materials handled or stored, and are therefore inadequate for establishments as defined in the Seveso Directive. Along the same lines these standards may allow plastic deformation as life safety may still be guaranteed. However, deformation may already result in hazardous materials releases to the environment. In addition, emergency plans for establishments need to consider the possible circumstances after an earthquake, and before, during and after a storm.

2.3 Austria

Michael Struckl of the Austrian Federal Ministry for Economics and Labour gave an overview of the situation in terms of facilities with major-accident potential and regulatory requirements with respect to natural-hazard sources in the Seveso II context in Austria. His assessment indicated that earthquakes and floods are the major natural threats with respect to Natech risk. Safety reports usually assume that building codes provide sufficient protection against earthquakes; however, they should be considered explicitly in the hazard-assessment process. While most installations that pose a major-accident hazard lie well beyond the 100-yr flood zone, within which protection measures such as land-use planning or dam measures are required, in the safety reports only a 10,000-year flood is considered to pose a risk. This is justified by the actual siting of the facilities or existing protection measures, identified through a deterministic analysis, coupled with the precautionary principle. M. Struckl added that pipelines do pose problems but since they were not included in the Seveso II Directive he had omitted them from his presentation.

2.4 Romania

Alexandru Ozunu of Babes-Bolyai University in Cluj presented some lessons learned from Natech events in Romania. He pointed out that the major natural hazards for Romania were landslides, earthquakes and in particular floods which have become more intense due to climate warming over the last couple of years. Using case studies A. Ozunu presented the dynamics of recent Natech events and summarised the response measures taken in the aftermath of these events, as well as the lessons learned. The presentation concluded with recommendations on how Natech risk could be reduced. He emphasised that measures need to be implemented at local level for them to be effective. Mr. Ozunu said that guidance on how to deal with hazards has been developed for local decision makers.

2.5 Poland

Slawomir Zajac of the Polish National Headquarter of the State Fire Service presented the main tasks and the organisational structure of the State Fire Service which is the competent authority for responding to accidents in the Seveso II context. There is no special system concerning the protection against Natech events in Poland, because they follow an all-hazards approach. The State Fire Service is the organiser of the National Rescue and Fire–Fighting System, whose main task is the protection of the life of citizens, property and the environment. Among all natural and technological disasters, major accident hazards are of particular importance. The most important natural disasters on Polish territory are floods and forest fires, which are considered in the risk assessment for the safety report of an installation with major-accident potential, as are high winds. Important issues are planning, assessing and mapping the risk, the influence of hazards related to industry (Seveso) and natural hazards (floods, forest fires) on safety planning and their impact on special strategies for critical infrastructure protection.

2.6 Bulgaria

Boyko Ranguelov of the Bulgarian Academy of Sciences gave an overview of the Bulgarian Institutions that play a role in crisis management and discussed the major natural-hazard threats for Bulgarian territory in the Natech context. These are earthquakes, floods, landslides and forest fires. Of those the latter three have resulted in Natechs and damage to lifelines since 2003. B. Ranguelov then compared the current Natech risk-assessment approach in Bulgaria with the one prior to Bulgaria's EU accession, which has resulted in the implementation of EU acquis communautaire. Of particular importance is the Seveso II Directive that requires the assessment of natural threats to facilities processing or housing certain types and amounts of hazardous materials. Facilities for which a Natech risk assessment has been performed are for instance the Kozlodui nuclear power plant, chemical-process installations, high-voltage power transmission lines and main gas pipelines.

B. Ranguelov concluded that Natech (Boyko used the term "Natech" in his presentation) prevention and mitigation measures now include standards in line with EU requirements and maximise the protection of the population. He pointed out that many improvements have been made but that there is still no clear strategy by the government on how to deal with Natech risk. Responsibilities are distributed throughout various ministries and civil-protection services which complicates coordination of activities. Moreover, the focus is still on response rather than prevention.

2.7 Greece

Anna Papachatzi of the Region of Attica, Directorate of Environment and Regional Planning, discussed the problem of Natech risk management in Greece from the point of view of land-use planning. She pointed out that there is a lack of monitoring and assessment of spatial development trends but also a lack of cooperation between the various administrative layers responsible for spatial planning. This poses less of a problem for newer development areas than for old ones where residential zones and technological areas are still mixed. Moreover, the approach to risk management is reactive and focuses on crisis management and not so much on prevention. No specific management systems are in place for the response to Natech disasters. A. Papachatzi highlighted the shortcomings of the current risk-management system using the 2007 wildfires in Greece as example and concluded with proposals for a more effective prevention and mitigation of disasters in general.

2.8 Analysis of country practices

It appears that none of the countries represented at the workshop have adopted any Natech-specific or Natech-related regulations. All countries continue to address natural hazard risk separately from industrial risk, except for the analysis of “external hazards” called for under the Seveso II Directive, which provides, however, no specific actions or methodologies to reduce Natech risk.

Nonetheless, there appears to be more awareness of the Natech problem. At least one country, Germany, has carried out a study to assess to what extent flooding (and earthquakes and storms) are being considered by industries for risk management purposes in that country. A full report of the study is available on line in German with an English summary (see Warm *et al.* 2007), and two papers (Fendler 2008, Beem *et al.* 2008) will soon appear in a special Natech issue of Journal of Natural Hazards. Further activities of the German Government are intended in context of the German Strategy on Adoption to the Effects of Climate Change.

3. INDIVIDUAL AND GROUP ACTIVITIES

This section summarizes the individual and group activities carried out during the workshop. Activities included questions and problem solving, presentation of short videos followed by guided discussion, and presentations of material needed to carry out a Natech risk assessment. The following subsections summarize the activities and their results.

3.1 Workshop expectations

At the beginning of the workshop, participants were asked to respond to the following question: “What expectations do you have concerning the workshop? The following bullets summarize the responses given:

a. Meet people, networking
b. Gain knowledge of country practices, regulations and methodologies
c. Study actual cases and lessons learned
d. Share experiences about best practices and their implementation
e. Discuss prevention and mitigation measures to control exposed populations (e.g., land use planning)
f. Gain knowledge concerning stakeholder involvement

The workshop fulfilled to a great extent these expectations. For example, the workshop offered participants an opportunity to meet and interact with other participants from various disciplines and countries. The country presentations offered an overview of country practices and existing regulations (or lack of) regarding Natech risk reduction. Furthermore, the country presentations, the videos and case study exercises provided material and information concerning actual cases and lessons learned from previous Natech events. The application of the risk assessment methodology to the case studies presented the opportunity to discuss and learn about potential Natech triggering mechanisms, Natech consequences and prevention and mitigation measures to reduce Natech risk to exposed people, property and the environment. During the case studies, participants were asked to discuss the different stakeholders that should be involved in Natech risk assessment and management and to role play various stakeholders during the risk assessment exercise.

3.2 Video presentations and discussion

The second activity involved the presentation of two short videos. One video (6 min) concerned the large earthquake of magnitude Mw 7.4 on August 17, 1999 in Kocaeli, Turkey and the refinery fires that followed. The second video showed the recent flooding and oil spills from a refinery in Coffeeville, Kansas on June 26, 2007. After viewing the films, participants were asked to work in groups to answer the following questions:

- What were the hazards in each case?
- Were the hazards known by government officials; industry owners/operators; and/ or residents living in the vicinity of the industrial plants?
- What prevention and/ or mitigation measures do you think had been taken before the Natech events to avoid damage or losses? Were they successful? Why or why not?

The groups agreed that the natural hazards were a major earthquake and earthquake-triggered fires in the Turkey video; and major flooding and oil spill from a refinery in the second video. In both cases the natural hazard combined with anthropogenic hazards. All groups agreed that government officials probably knew about the natural hazards, or they preferred to "not know" about them; industrial owners/operators knew about plant hazards in their day-to-day operation; the community may or may not have been informed depending on their daily activities, proximity to the plant, and emergency response planning. It was noted that often, knowing that the hazard exists does not mean that you know or can imagine the possible accident scenarios. In the case of the earthquake, industry and government were probably aware of the potential consequences but the community was probably not aware. In the case of flooding the groups agreed that probably government, industry and the community were not fully aware of the hazards.

Based on images from the earthquake video, the groups thought it seemed that mitigation measures existed, but were not designed to current standards, or that the design of the equipment was not adequate for the magnitude of the event. In the case of flooding, they thought that the site was probably evacuated, but no measures to protect the installation had been taken. Furthermore, the groups proposed that probably the dikes around storage tanks had been designed to contain chemicals if released, but had not been designed to keep water out in the case of flooding. Other points that came out of the discussions included that mitigation measures that had probably been taken for internal day-to-day plant operation did not provide sufficient protection for a problem that became larger. Furthermore, mitigation measures that were in place likely failed due to the natural hazards. In the case of flooding, the groups agreed that if evacuation was ordered due to the floods, it also helped to reduce exposure to the hazardous-materials (hazmat) releases. However, contamination of property and homes in the affected area remained.

3.3 Concepts and definitions

One important aspect of disaster risk management, particularly Natech disasters, is that it cannot be tackled by people working in one field alone, but that it requires bringing in expertise from various fields and diverse backgrounds to solve problems. However, often even people working in the same field do not always agree on the meaning of certain concepts or their definitions. Participants were asked to define various concepts including hazard, vulnerability, risk, disasters, and Natech disasters. A summary of the different definitions provided by the workshop participants is presented in Table 1. Some definitions were similar and more general, others were quite specific. For example one participant defined vulnerability as the probability of an item to have structural damage, while another defined it as the ratio between number of casualties and the number of people in a given territory. This was not surprising as the two individuals come from different backgrounds; an engineer and a first responder, respectively.

The purpose of the exercise was not to find a common definition for each of the concepts. Rather, the purpose of the exercise was to allow participants to understand other participants' point of view, to be aware that these differences exist, and that whatever definition is used needs to be clearly stated to avoid misunderstandings or confusion. The following general working definitions were used for the remaining part of the workshop:

- Hazard: A hazard is a source of danger. A hazard does not necessarily lead to harm but represents a potential to result in harm.
- Vulnerability: Vulnerability is the degree to which a system is susceptible to, and unable to cope with, injury, damage or harm.

- Risk: Risk is the combination of the frequency/ probability of occurrence and the consequence of a specified hazardous event. Risk therefore includes the likelihood of conversion of a hazard into actual delivery of injury, damage or harm.
- Disaster: A disaster is a major natural or man-made destruction that far exceeds the coping ability of the affected area.
- Natech: A Natech disaster is a technological accident triggered by a natural disaster which results in significant adverse effects to the health of people, property, and/or the environment. The technological accident can include damage to industrial facilities and damage to lifelines systems that can hamper response to the accident.

In particular, this workshop is concerned mainly with Natechs involving hazardous materials releases triggered by the impact of natural disasters on industrial facilities.

4. DEVELOPMENT OF CASE STUDIES

Case studies were developed in order to carry out a Rapid Natech Risk Assessment of two selected communities. The case studies were set up using real data. However fictitious names were used for the communities to protect their identity.

4.1 Setting the stage, review of materials

Before beginning the case studies, workshop participants were presented material and tools that were considered useful in carrying out a preliminary (or rapid) Natech risk assessment to screen out those areas that pose the greatest threat of a Natech disaster in a community.

Valerio Cozzani presented a simplified methodology which can be used to qualitatively estimate the likelihood of a hazmat release triggered by earthquakes and flooding. Ana Maria Cruz talked about various existing air dispersion models and software programs for accidental chemical releases. These include CAMEO, ALOHA, DEGADIS, BREEZE PRO, SAFER systems, among others. Ms. Cruz noted that CAMEO and RMP*Comp (the latter was used during the case studies for its simplicity) are freely available from the United States Environmental Protection Agency (EPA). All participants were provided with case study materials which contained a description of each case study community including information about the worst case natural hazard and the hazmats present in each case study region. In addition, maps of the case study areas, tables used during the assessment process, and a spreadsheet used for calculations and results were also provided. All documents were made available in digital form for those who requested them. See Annex 2 for the case study materials.

The participants were assigned to five groups. Three groups worked on a case study of a community in California and two on a community in Kocaeli. Before starting the group activities, Ms. Cruz reviewed the case study materials with all the participants. Laura J. Steinberg, Valerio Cozzani, Elisabeth Krausmann, and Michael Lindell, assisted with the case study exercises either as participants in one of the groups or working with the various groups to provide support with any questions concerning the risk assessment process.

Each group was allowed some time to become familiar with the case study community. Participants became familiar with their community maps identifying where each hazmat tank/industry was located. They were asked to note areas of higher population density, location of vulnerability centers (e.g., schools, churches, stadiums), location of critical facilities (e.g., drinking water treatment plant, waste water treatment plant, electrical power station), location of emergency resources (e.g., fire departments, police departments, hospitals), and location of major transportation centers (e.g., airport, central train station, ports) and lifelines.

4.2 Rapid Natech Risk Assessment (RNRA)[2] applied to a case study community

A territory may be subject to Natech risk if there exists in the territory both the risk of a natural hazard and the risk of hazardous materials releases from industrial facilities subject to the natural hazard. In this case, Natech risk assessment involves determining the likelihood of a hazardous materials release given a natural hazard occurring, and identifying possible adverse consequences that may result when establishments that house hazardous materials are exposed to the natural hazard forces. Due to the limited time available for the case study exercise, the natural hazards that each of the case study communities is subject to had already been identified in the case study description as the "worst case scenario" natural hazard.

In the analysis we considered only the Natech risk posed by storage tanks which contain hazmats. We did not consider other parts of the plants such as processing equipment and pipelines where hazmats are processed and transported. Furthermore, due to time limitations, we did not include

[2] Cruz, A. M. and N. Okada (2007). "Methodology for Preliminary Assessment of Natech Risk in Urban Areas." To appear in *Journal of Natural Hazards*

all the hazmat containing storage tanks that were actually present in each of the communities for the case study exercise. Instead, we selected a sample of 20 tanks for each case study for the purpose of demonstrating the application of the methodology.

The proposed methodology involved estimating a Natech risk index for each hazmat containing storage tank given the natural disaster, in both case studies, a major earthquake, according to the following expression:

$$\text{NRI} = [\text{HRL}] * [D + Area\_sc + C] \qquad \text{Eq. (1)}$$

where:

HRL: is a score that indicates the hazmat release likelihood of each hazmat containing storage tank given the earthquake

D: is a score that measures the potential consequences of the hazmat release on other hazmat containing storage tanks given the earthquake

Area_sc: is a score that measures the potential consequences of the hazmat release on the population given the earthquake

C: is a score that measures the potential consequences of the hazmat release on the environment and on essential facilities that are critical for the safety and well being of the community given the earthquake

NRIs for each unit of territory could then be added up to estimate an NRI_{area_sc} area score.

The RNRA involved estimating HRL, and then estimating the potential consequences of the release to people, property and the environment given the earthquake.

4.2.1 Estimating the hazmat release likelihood (HRL)

The first step in the RNRA was to determine the hazmat release likelihood (HRL) from a storage tank due to the worst case natural hazard which could result in offsite impacts to the population. HRL can take a value from 1-5, where 1 is low likelihood and 5 is high likelihood of release. Table 1 was used to guide the qualitative estimate of HRL for each tank.

In determining HRL values, each group considered information regarding the natural hazard, such as the earthquake magnitude and intensity, and the type of storage tank, the type of hazmat, type of storage conditions, presence or lack of safety and mitigation measures, as well as absence of these measures and other emergency response capacity due to earthquake damage.

The groups used the framework developed by Cozzani et al. (2007), and presented by Prof. Cozzani during the workshop, for the assessment of the likelihood of a hazmat release induced by an earthquake. The spreadsheets contained information regarding the type of storage tank (e.g., vertical cylinder, horizontal cylinder), and the expected peak ground acceleration related to the scenario event at each tank location. With this information it was possible to determine a qualitative value from 1 to 5, where 1 was low and 5 was high vulnerability of the storage tank to the natural hazard. The estimated value was input in Row 1 of Table 2 for each tank.

Each group qualitatively estimated a score corresponding to the vulnerability of each hazmat containing storage tank due to the type of chemical (e.g., toxic gas, flammable gas, toxic or flammable liquid), and storage conditions (e.g., atmospheric, pressurized, refrigerated) when subject to the natural hazard forces. Common problems observed during previous earthquakes were discussed to help estimate HRL. For example, intentional releases of refrigerated liquefied gases, such as anhydrous ammonia, have been reported in several cases due to prolonged power outages following earthquakes. Flammable and toxic liquids stored in atmospheric tanks are more likely to be released due to liquid sloshing with consequent damage to the tanks' shells. Flammable gases are often stored liquefied under pressure in spherical tanks, or in horizontal cylindrical tanks. Damage to tank support structures have been observed and may lead to rupture of connected pipelines resulting in hazmat releases. Nonetheless, pressure vessels are generally built to more stringent design standards, and with better quality materials, and are therefore more resistant to external forces. Each group estimated these vulnerability values for each tank, and entered the results in Row 2 of Table 2.

Using information provided for each case study, each group determined the vulnerability of each hazmat containing storage tank due to potential lack of risk management practices in general during normal day to day plant operation. If there was not sufficient information provided for each plant, the group members were asked to make assumptions and to use these assumptions to support their decisions. The estimated values were input in Row 3 of Table 2. Finally, each group estimated a qualitative value for the vulnerability of each hazmat containing storage tank due to the potential impact of the earthquake on the existing safety and mitigation measures and emergency response capacity. Each group input the estimated values in Row 4 of Table 2. The scores in Table 2 were then added up and the total score was divided by the total number of criteria to obtain an average score. HRL values for each tank were then input, by each group, in the spreadsheet provided under the column heading HRL.

4.2.2 Consequence analysis

The next step concerned carrying out a consequence analysis to determine the area that could potentially be impacted by each Natech event. For this purpose the EPA's software RMP*Comp was used.

The extent and consequences of each release will depend on a number of factors including the type of chemical stored (e.g., toxic, flammable, explosive), storage tank type and storage conditions, the quantity present, and the potential to trigger secondary hazmat releases. To estimate the area of impact we need to estimate for toxic gases and liquids the maximum distance that a toxic cloud would travel, or for flammable gases the maximum distance that an overpressure wave would travel from its source and still represent a source of harm to people, property and the environment. This distance value is referred to as the maximum distance to an endpoint (MDE). The MDE will vary depending on the toxic effect threshold, for toxic gases, and over pressure threshold, for flammable gases, used. A common threshold used for accidental hazmat releases is the ERPG2 value set by the American Industrial Hygiene Association (AIHA). According to the AIHA (2007), the ERPG2 value is:

> "The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action."

In the case of flammable substances a common threshold value used for emergency planning purposes is an overpressure wave of 7 kPa (1 psi). According to EPA (2004), an overpressure of 7 kPa is unlikely to have serious direct effects on people; however, this overpressure may cause property damage such as partial demolition of houses, which can result in injuries to people, and shattering of glass windows, which may cause skin laceration from flying glass.

Using the above threshold criteria, each group was asked to estimate the MDE for the 20 hazmat containing storage tanks in their communities. The results were input for each tank in the spreadsheet in the column header MDE. Each group then drew circles of radius MDE around each tank on the maps provided to them to visualize the potential area of impact for each hazmat in their community.

4.2.3 Estimating potential domino effects, *D*

The consequences of a hazmat release could increase depending on whether it can trigger secondary, tertiary, or more events. For the purpose of the analysis we only consider here the potential for secondary chemical accidents (also known as domino chemical accidents) triggered by a fire or explosion of flammable gases liquefied under pressure. A primary event, such as a fire or explosion, can trigger a domino chemical accident due to the blast overpressure wave, fire impingement and heat radiation, impact of fireball, and impact from missiles and projectiles on neighbouring storage tanks.

For the purpose of the case study exercise, we assumed that a domino chemical accident could occur if the distance between a flammable hazmat containing storage tank and any other neighbouring hazmat containing storage tank was less or equal to 1/2 the MDE value. This value was used to demonstrate the application of the methodology, although it would be unlikely to observe domino effects at this threshold value. The closer other hazmat containing storage tanks are to the source (distance below MDE/2) the more likely domino effects are, if an initial hazmat fire or explosion did occur. For further discussion on observed domino effects at various distances from the source see Cozzani and Salzano (2004), Birk (1998), and Birk *et al.* (2007).

For the purpose of demonstrating the methodology, each group determined if there was one or more hazmat containing storage tanks located within it each circle of radius MDE/2 for all flammable gases liquefied under pressure. When the MDE of a potential primary accident involving a flammable gas liquefied under pressure included that of a potential secondary hazmat storage tank, no additional consequence was expected even if domino effect could take place. Table 3 was used to guide the estimation of domino effects, *D*.

The closer a neighbouring storage tank is to the initial chemical accident, the higher the likelihood that it can be affected. A higher number of storage tanks within the MDE/2 circle poses more problems, because there is more property exposed, but also because even if nearby tanks are not affected during the initial event, fires triggered by the first event will require that neighbouring tanks be kept cool to avoid over-pressurization and possible explosion. Keeping tanks cool becomes more and more difficult with an increase in the number of tanks exposed. Each group estimated a score due to the increased hazard and hence potential vulnerability of exposed tanks located within the MDE/2 circle. Estimated values were input in Row 1 of Table 3.

The vulnerability of the population due to potential domino effects could increase if a domino chemical accident increases the overall area affected by the primary technological accident. For every potential domino chemical accident, each group calculated the MDE, and then drew circles of MDE radius around each tank exposed to domino effects. In the cases where all the new circles were completely contained within the first circle the resulting increase in vulnerability due to an increase in exposure area is close to zero. In this case a score of one was entered in Row 2 of Table 3. Scores in Table 3 were added up and the total score was divided by the total number of criteria to obtain an average score for each tank. Estimated domino effects, *D,* values for each tank were input in the spreadsheet under the corresponding column heading by each group.

4.2.4 Estimating an area vulnerability score, *Area_sc*

Everything in the area of radius MDE around the hazmat containing tank is potentially exposed and vulnerable to the Natech event. The next step involved determining what was exposed, and how vulnerable the exposed elements were to the hazmat release given the earthquake scenario. Each group then qualitatively estimated an area vulnerability score, Area_sc. To calculate the Area_sc the groups considered factors such the number of people exposed (or population density when population values were not known) following the earthquake, the distribution of the population during or immediately following the earthquake, presence of population centres (e.g., universities, large enterprises, shopping centres) or more vulnerable population groups (e.g., the elderly, the sick, children) who might have more difficulties in evacuating if needed, or who may be unable to take shelter during the earthquake. Those who live in low income housing may also be more vulnerable because their homes are more likely to suffer damage during the earthquake (e.g., due to lack of seismic restraints or use of lower quality materials) or are less likely to serve as a place for shelter. Area_sc values range from 1-5, where 1 indicates very low vulnerability and 5 is very high vulnerability. Table 4 was used to estimate Area_sc values. The sum of the scores was divided by the total number of factors considered, to obtain an average score for the Area_sc. The Area_sc values were input in the spreadsheet under the Area_sc column heading.

4.2.5 Estimating vulnerability due to impacts on essential facilities, *C*

The next step concerned estimating vulnerability due to impacts on essential facilities, and the environment, *C*. Essential facilities are those that are considered critical for maintaining the safety and well being of the public including public utilities, lifeline systems, emergency resources, emergency response capacity. Furthermore, we include here any potential impacts on the environment, particularly water bodies that constitute sources of drinking water or other natural resources that constitute the livelihood for a community. Potential consequences on essential facilities from the Natech can occur if these lie in areas located within any circle of radius MDE of the hazmat containing storage tank affected by the earthquake. For example, a toxic release might impede the passage of rescue teams trying to help trapped earthquake victims on the other side of the city, while at the same time blocked roads (due to debris from the earthquake) could delay arrival of hazmat teams to a contaminated area.

To estimate *C* the groups determined whether there were any critical facilities including public utilities (e.g., water treatment plants, waste treatment facilities), major lifelines (e.g., major roads and bridges, major water or gas lines), and any important emergency resources located within the area of impact of each potential Natech event. Furthermore, they assessed whether the earthquake effects outside the Natech impact area would result in a reduction of emergency response capacity to deal with each Natech event. Finally, the groups determined if there were any natural/environmental resources or delicate ecosystems affected by each potential Natech event that would result in increased consequences to exposed elements. Table 5 was used to estimate vulnerability due to impact of each Natech on essential facilities and the environment, *C*. The total score was divided by the total number of criteria in the table to obtain an average *C* score. Estimated *C* scores were input under the corresponding column heading in the spreadsheet.

4.2.6 Estimating a Natech Risk Index for each tank

The estimated values for HRL, *D*, *Area_sc*, and *C* were input in Eq. (1) to calculate the NRI value for each tank. Each group was asked to map the estimated NRI values for each hazmat containing tank using symbols proportional to their magnitude on their case study maps.

4.2.7 Case study results

The groups were given about 2.5 hours to work on their case studies and to do the calculations. They were also given time to prepare a short summary of the case study results, and to prepare a 5-10 min presentation of the results.

Due to the limited time available, only two groups actually completed the analysis of the 20 tanks. The other groups completed the assessment of 3-5 tanks. In reviewing the results of the groups some errors were noted; indicating that the methodology needs to be better explained, and that perhaps a few examples need to be carried out jointly before the groups work on the case studies.

It appears that there was little difficulty in understanding and estimating HRL values. It was observed that almost all the groups had at least one engineer. Some participants questioned whether an assessment team that does not include an engineer would be able to understand the procedure for estimating HRLs. The point was well taken and needs to be considered in any future workshops and application of the methodology to a community.

MDE values were estimated using different release conditions and mitigation assumptions by each of the groups. Thus, the results obtained for the same tank by two different groups might vary. For instance, the complete release of 66,000 kg of refrigerated anhydrous ammonia (the methodology called for the worst case, 10 min release, no mitigation measures available) would result in an MDE of 3.2 km However, if a group assumed that there were some mitigation measures in place, such as a containment building, the MDE value would be significantly smaller. The assumption of a worst case scenario was suggested because it made the use of the RMP*Comp much easier, requiring less knowledge, and also to make the results comparable.

In the RNRA methodology, domino effects are considered only for flammable gases liquefied under pressure. However, some of the groups estimated D for other types of materials (e.g., toxic gases) which are not very likely (Kourniotis *et al.* 2000, Khan and Abbasi 1998).

Tables 6a, 6b, 6c and 6d present the completed spreadsheets for four of the groups. The overall results are not comparable between the groups due to differences in the initial assumptions for the consequence and vulnerability analysis, and the fact that the groups did not have time to finish the analysis for all the tanks.

Nonetheless, it is possible to compare some individual NRI estimates. For example, Groups A and B (Cover City), Tables 6a and 6b, respectively, obtained high NRI scores for Tank 1 (T1) and Tank 8 (T8). T1 in Cover City contains 180,000 kg of chlorine gas. If the contents were allowed to be released completely (worst case), the distance to the toxic endpoint (MDE) would be 32 km, putting the entire city's population at risk. Groups A and B estimated Area_sc scores for T1 as 5 and 4.3 respectively. T8 contains butane, a flammable gas stored liquefied under pressure in a spherical tank. The explosion of the tank and its contents would result in damage and minor injuries to people as far as 1.1 km. Domino effects might result if exposed elements are within 550 m from the source. Tanks 6 and 7 are within impact range of Tank 8. Thus, the extra risk from the possible damage caused by T8 on tanks 6 and 7 is reflected in the D scores of 4.5 and 4.33, estimated by groups A and B, respectively, for T8. Annex 4 contains Group B's detailed case study report.

4.2.8 Discussion

Each group was asked to discuss the results and to talk about the difficulties and issues the group had in applying the RNRA to the case study. The groups were also asked to think about the difficulties and issues that might come up in doing a RNRA in their own community. The groups then convened and a short discussion among all participants followed. Because of the short time allowed for discussion, participants were asked to send their comments via e-mail. The following bullets summarize the issues raised and/or discussed:

- All of the participants agreed that the case study exercise was useful for them, and helped to improve their knowledge and understanding of the Natech problematic and its complexity.
- The participants felt that more detail was needed in order to estimate HRL values. They considered that in order to estimate HRL the assessment team needs more engineering/chemical processing knowledge, or more detailed guidance so that assumptions are correctly made and criteria correctly estimated. Thus, they questioned whether or not expert opinion was needed.
- M. Dandoulaki observed that the profile of the assessment team should be somehow taken into account. She asked for example "what disciplines are required at a minimum? Would it be possible for a non-chemical engineer or someone not having knowledge on

chemicals to assess the risk to people regarding the release of chemicals? If not, what information would be useful to help understand the issue better?"

- Dandoulaki also stressed that the same applies with earthquake structural vulnerability of the installations. What information is required to help chemical engineers or other non-engineering team members to understand better the issue. Dandoulaki stressed that she does not mean more tables, but essential information. Sometimes, she notes, tables and numbers can be misleading because they easily hide the complexities.
- Many participants stressed the need to include the effects of the simultaneous natural disasters when estimating values for the various criteria particularly when calculating Area_sc and *C* scores. It is the conjoint natural disaster that makes the Natech situation so different and complex.
- B. Ranguelov suggested that the methodology be converted into a software tool - easy for operation with all details (tables, steps of the algorithm , etc.) in one program. This would be a really nice tool for RNRA exercises.
- E. Laor suggested that local government operational capacity to confront the approaching disaster be included in the assessment. Physical exposure and vulnerability of emergency response resources are considered when estimating the *C* scores. Other criteria can be included to better capture the effect of local government (as well as industrial or private) operational capacity.
- Prof. Gupta suggested that an exercise involving cyclone, flood or any other natural event may be framed in addition to the earthquake one to give a broader background in doing calculations and appreciating the damage these can cause.

5. NATECH RISK MANAGEMENT

The case studies provided a (hands-on) opportunity to carry out a Natech risk assessment of a community. The exercise allowed participants to become familiar with Natech specific issues and to get a feel for the complexity in identifying and assessing Natech risk. The following exercises and group discussions were focused on Natech risk management.

5.1 Probability of a Natech

Following the discussion of the case studies, participants were asked to write down what they considered to be the worst case natural disaster used for planning purposes in the region/jurisdiction where they live. Each participant was asked to specify the type of natural disaster, the expected magnitude, and location with his/her jurisdiction. Then, they were asked to give an approximate estimate from 0-100% of the probability of a Natech occurring as a result of that disaster. Each participant was then asked to describe the potential consequences of the Natech event such as the type of industry affected, chemical released, extent of area impacted and number of people affected. All participants who lived in areas subject to natural and hazmat release hazards considered that Natechs were likely with probability estimates ranging from 1% - 100% depending on local conditions. Table 6 presents a summary of the participants' responses.

5.2 Strategies for Natech risk management

Each group was asked to propose strategies for Natech risk reduction for both community and for industry. Implementing risk reduction generally has a cost. Thus, each group was asked to discuss what would be the main problems and challenges in implementing each of the proposed Natech risk management strategies in their jurisdiction; by government officials and policy makers in charge, and by industry owners/ operators. Groups were asked to think about which of these strategies should be recommended; which should be mandated?

Following this exercise the groups then convened in a plenary session to identify those Natech risk management strategies that were considered priority key strategies to be recommended and /or mandated.

The following bullets summarize key Natech risk reduction strategies proposed for government agencies/ policy decision makers:

- Comprehensive hazard identification and analysis that considers Natechs
- Natech risk assessment
- Land use planning to reduce population exposure (e.g. relocation of people/hazardous facilities)
- Structural and non-structural measures specific for Natechs

- Warning systems and evacuation plans that take into account Natech
- Community Right To Know
- Liability and compensation framework for Natechs
- Enact and enforce enabling legislation (e.g., extra obligations for industry exposed to Natech hazards)
- Research to better understand Natech risk in the face of climate change
- Educational and awareness campaigns

The following bullets summarize key Natech risk reduction strategies proposed for industry owners/ operators:

- Use common cause failure analysis for system design
- Structural safety measures and additional safety barriers (e.g., back up lifelines) for Natechs
- Emergency planning that considers failure of emergency response equipment – "stand alone" plan – i.e. not relying on external lifelines
- Adequate separation between critical elements for Natech scenarios

The participants identified possible barriers to Natech risk reduction strategy implementation including:

- Industry resistance to additional regulatory burden
- Effectiveness versus cost of implementation
- Ignorance (not money)
- Land use planning is limited by existing development
- Belief that nothing is going to happen, or that it will not affect them

6. WRAP-UP AND CLOSURE

The Natech workshop was a learning experience for all those who attended. The workshop provided an open atmosphere where people coming from diverse backgrounds and cultures could share experiences and knowledge on Natech risk management, and learn from each other.

We believe the workshop objectives were reached. The workshop provided a framework and practical tools for Natech risk assessment and management at the community level. The various individual and group exercises and discussions helped to clarify the Natech problematic. Furthermore, participants agreed that the workshop raised their awareness of the need to address Natech risk and to work together to identify strategies for Natech risk reduction.

The country presentations offered an overview of country practices, and pointed out the lack of Natech-specific regulations to address Natech risk. It was encouraging to learn about the work being carried out by the German government in trying to understand the extent of the problem in their territory and identifying possible mechanisms for improved safety and risk reduction.

The workshop has also provided lessons for the organizers. It became apparent that we were too optimistic with respect to time and included too many activities. Thus, in the future, we will need to shorten the amount of material presented and discussed, or divide the workshop into two 2-day workshops allowing more time for discussion, awareness raising, etc. and more time for the presentation of the RNRA methodology, its application and discussion of results, etc.

The Natech workshop was adjourned at 17:30 on 18 September 2007.

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CONCEPT	DEFINITION
HAZARD	- Something which is a potential threat to a person, community, environment or structure - A natural or technological phenomena which imposes risk upon a population - A characteristic condition of a system that can harm people, property or environment - A hazard is for example a characteristic of a plant which can generate an accident. A potential source of accident - Adverse effects resulting in loss of life, property, or causing environmental problems - A potential event that can cause harm
VULNERABILITY	- How able a thing or person/animal is to resist or recover from a particular hazard - Ratio between number of casualties divided by number of people in a given territory - The susceptibility of people, property or the environment to harm from hazards - The vulnerability is the probability of an item to have structural damages - Degree of being affected by hazards - Degree to which an exposed element can suffer from the hazard
RISK	- Probability of something bad occurring - An action that could lead to something bad occurring - The order of hazard to hit a given population - The probability that harm can result from a hazard - The risk is a function which depends on frequency and on magnitude of an event - Possibility of a specific hazard to be realized - The probability of the hazard and its consequences
DISASTER	- A change in the normal routine which changes temporarily or permanently a person's life, the environment or the community - Death, injury, displacement of hundreds of thousands due to materialization of hazard - An event that can cause so much harm that it overwhelms the response capacity - Disaster can not be measured by "response capacity" - A disaster is a situation of big magnitude and low frequency, like a major accident - Events that affect group of people or large extend of the environment beyond the coping capacity of the community - An event that overwhelms the capacity of a community to respond to it
NATECH DISASTER	- A technological disaster triggered by a natural disaster - The same as disaster, only caused by a chain of hazards - The natural hazard *causes* the technological disaster - A Natech disaster is a major [chemical] accident triggered by a natural event - A technological disaster as a consequence of a natural event, i.e. natural hazard or natural disaster. - A natural disaster triggered hazardous material release

Table 1. Concepts and definitions

Table 2. Scoring table which can be used to estimate an *HRL* score for each hazmat containing storage tank. The total score is divided by the total number of criteria to obtain an average score. Weights can be used instead to give more or less importance to each of the criteria.

Scoring Criteria	1 Very low	2 Low	3 Medium	4 High	5 Very High	Total
1. Vulnerability of storage tank (by type) to natural hazard						
2. Vulnerability due to chemical properties and storage conditions						
3. Vulnerability due to loss of safety and mitigation measures due to the natural disaster						
4. Vulnerability due to lack of risk management practices						
5. Other						
Sum						
Average *HRL* score						

Table 3. Scoring table which can be used to estimate vulnerability due to potential domino chemical accidents, *D*, caused by the earthquake triggered hazmat release. The total score is divided by the total number of criteria to obtain an average score. Weights can be used instead to give more or less importance to each of the criteria.

Domino effects are only analyzed for flammable substances.

Scoring Criteria	**1 Very low**	**2 Low**	**3 Medium**	**4 High**	**5 Very High**	**Total**
1. Vulnerability due to presence of hazmat tanks within MDE/2 circle and their proximity						
2. Vulnerability due to increase in impact area due to domino accident						
3. Other						
Sum						
Average *D* score (or weighted *D* score)						

Table 4. Scoring table which can be used to estimate an area vulnerability score, *Area_ sc*, for each area impacted by the hazmat release given the earthquake. The total score is divided by the total number of criteria to obtain an average score. Weights can be used to give more or less importance to each of the criteria.

Scoring Criteria	**1 Very low**	**2 Low**	**3 Medium**	**4 High**	**5 Very High**	**Total**
1. Number of people exposed given the natural disaster						
2. Population distribution given the natural disaster						
3. Presence of population centers, or more vulnerable groups (old, sick, children)						
4. Presence of low income neighborhood which could result in increased exposure						
5. Other						
Sum						
Average *Area_sc* score						

Table 5. Scoring table which can be used to estimate *C*, the vulnerability due to impact of a Natech on public utilities, major lifelines, emergency resources, and emergency response capacity, among others. The total score is divided by the total number of criteria to obtain an average score. Weights can be used to give more or less importance to each of the criteria.

Scoring Criteria	**1 Very low**	**2 Low**	**3 Medium**	**4 High**	**5 Very High**	**Total**
1. Vulnerability due presence of public utilities (e.g., drinking water and waste water treatment, electrical power stations) in Natech area						
2. Vulnerability due to presence of major lifelines (e.g., major roads, oil and gas pipelines, major water pipelines) in Natech area						
3. Vulnerability due to presence of emergency resources (e.g., fire stations, supply warehouses, hospitals) in Natech area						
4. Vulnerability due to loss of emergency response capacity outside Natech area						
5. Vulnerability due to presence of delicate ecosystems and/or environmental Systems (e.g., river, lake, ground water) in Natech area						
6. Other						
Sum						
***C* = Average score (or average weighted score)**						

Table 6a. Spreadsheet for Cover City, Group A

NAME	TANK	PGA	MMI	CHEM_NAME	CHEM_TYPE	TANK_TYPE	STORAGE-CONDITIONS	KG	HRL	MDE (km)	*D*	*Area-sc*	*C*	NRI
CLOR	T1	0.43	VIII	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000	3.75	32	0	5	5	37.5
COYOTE	T2	0.42	VIII	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	36000	3.5	14.3				0.0
DREY	T3	0.50	IX	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	25000	3.5	2.1				0.0
HYPE	T4	0.55	IX	METHANE	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	2900	3.25	0.2	1	2.5	1.67	16.8
HYPE	T5	0.41	VIII	METHANE	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	2900	3.25	0.2				0.0
NICH	T6	0.50	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000	4.25	32				0.0
PARA	T7	0.50	IX	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	200000	4	1				0.0
PARA	T8	0.58	IX	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	290000	4	1.1	4.5	3.5	1.67	38.7
PHIB	T9	0.58	IX	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	66000	4	3.2	0	4	1.67	22.7
PHIB	T10	0.58	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000	3.75	32				0.0
PREC	T11	0.58	IX	HYDROGEN FLUORIDE	TOXIC GAS	Horizontal cylinder	liquified by pressure	12700	3.5	35				0.0
ROW	T12	0.58	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000	4	3.1				0.0
ROW	T13	0.58	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000	3.5	3.1				0.0
SANT	T14	0.57	VIII	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	12500	3.75	1.6				0.0
SHELL	T15	0.46	VIII	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	90200	3.5	3.9				0.0
SHELL	T16	0.39	VIII	NAPHTHA	FLAMMABLE LIQUID	Vertical cylinder	liquid, atm temp-pressure	4000000	3.75	0.2				0.0
SHELL	T17	0.50	IX	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	2000000	3.25	2.1				0.0
SHELL	T18	0.40	VIII	HYDROGEN SULFIDE	TOXIC GAS	Horizontal cylinder	liquified by pressure	5500	3.5	7.4				0.0
SHELL	T19	0.35	VIII	PROPANE	FLAMMABLE GAS	Sphere	liquified by pressure	1000000	3.5	1.7	3.5	1.5	3.67	30.3
UNION	T20	0.39	VIII	ACRYLONITRILE	TOXIC, FL LIQUID	Vertical cylinder	liquid, atm temp-pressure	350000	4.25	31				0.0

Table 6b . Spreadsheet for Cover City, Group B.

NAME	CHEM_NAME	CHEM_TYPE	TANK_TYPE	STORAGE-CONDITIONS	KG	TANK	PGA	HRL	MDE	D	Area-sc	C	NRI
CLOR	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000	T1	0.43	**3.33**	32.0		4.3	3	**24.44**
COYOTES	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	36000	T2	0.42	**2.67**	14.3				
DREY	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	25000	T3	0.50	**2.33**	2.1				
HYPE	METHANE	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	2900	T4	0.55	**2.00**	0.2	0.33			
HYPE	METHANE	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	2900	T5	0.41	**2.00**	0.2	0.33			
NICH	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000	T6	0.50	**3.33**	32.0				
PARA	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	200000	T7	0.50	**2.00**	1.0	3.67			
PARA	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	290000	T8	0.58	**2.00**	1.1	4.33	3.7	2.8	**21.60**
PHIB	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	66000	T9	0.58	**2.33**	3.2				
PHIB	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000	T10	0.58	**3.33**	32.0				
PREC	HYDROGEN FLUORIDE	TOXIC GAS	Horizontal cylinder	liquified by pressure	12700	T11	0.58	**2.33**	10.9				
ROW	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000	T12	0.58	**1.00**	3.1				
ROW	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000	T13	0.58	**1.00**	3.1				
SANT	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	12500	T14	0.57	**2.33**	1.6				
SHELL	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	90200	T15	0.46	**1.33**	3.9				
SHELL	NAPHTHA	FLAMMABLE LIQUID	Vertical cylinder	liquid, atm temp-pressure	4000000	T16	0.39	**1.33**	0.2				
SHELL	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	2000000	T17	0.50	**1.00**	2.1	0.33	3.0	2.4	**5.73**
SHELL	HYDROGEN SULFIDE	TOXIC GAS	Horizontal cylinder	liquified by pressure	5500	T18	0.40	**1.33**	7.4				
SHELL	PROPANE	FLAMMABLE GAS	Sphere	liquified by pressure	1000000	T19	0.35	**0.67**	1.7	0.33			
UNION	ACRYLONITRILE	TOXIC, FL LIQUID	Vertical cylinder	liquid, atm temp-pressure	350000	T20	0.39	**2.67**	31.0				

Table 6c. Spreadsheet for Cover City, Group C.

NAME	TANK	PGA	MMI	CHEM_NAME	CHEM_TYPE	TANK_TYPE	STORAGE-CONDITIONS	KG	likelyhood	properties	mass	Water/access	HRL	MDE-km*	Area**	D Area**	D-redone	C**	NRI**	NRI-redone
CLOR	T1	0.43	VIII	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000.00	2	2	4	3	21	4.7	0.5	0	0	1	0.33	42
COYOTES	T2	0.42	VIII	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	36000.00	2	2	4	3	21	4.7	0.5	0	0	1	0.33	42
DREY	T3	0.50	IX	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	25000.00	1	5	2	1	18	23	1	0	0	2	5.54	72
HYPE	T4	0.55	IX	METHANE	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	2900.00	1	5	1	2	17	1.3	1	0	0	1	0.15	51
HYPE	T5	0.41	VIII	METHANE	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	2900.00	1	4	4	2	21	11.3	1	0	0	1	1.59	63
NICH	T6	0.50	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000.00	1	4	4	2	21	11.3	1	0	0	1	1.59	63
PARA	T7	0.50	IX	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	200000.00	1	3	2	2	15	0.4	1	23	23	2	2.39	750
PARA	T8	0.58	IX	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	290000.00	1	3	1	3	14	0.3	0.5	0	0	2	0.03	42
PHIB	T9	0.58	IX	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	66000.00	1	3	2	3	16	0.6	0.5	0	0	1	0.03	32
PHIB	T10	0.58	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	180000.00	1	5	1	2	17	7.4	0.5	23	0	1	1.73	34
PREC	T11	0.58	IX	HYDROGEN FLUORIDE	TOXIC GAS	Horizontal cylinder	liquified by pressure	12700.00	1	5	2	1	18	23	0.5	0	0	1	1.38	36
ROW	T12	0.58	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000.00	1	5	2	2	19	23	0.75	0	0	1	2.19	47.5
ROW	T13	0.58	IX	CHLORINE GAS	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000.00	3	3	4	3	26	2.9	1	0	0	1	0.50	78
SANT	T14	0.57	VIII	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	12500.00	2	1	3	1	15	0.3	1	0	0	1	0.03	45
SHELL	T15	0.46	VIII	ANHYD AMMONIA	TOXIC GAS	Vertical cylinder	liquified by refrigeration	90200.00	2	1	3	1	15	0.3	1	0	0	1	0.03	45
SHELL	T16	0.39	VIII	NAPHTHA	FLAMMABLE LIQU	Vertical cylinder	liquid, atm temp-pressure	4000000.00	3	3	3	3	24	1.2	1	1.1	0	1	0.28	72
SHELL	T17	0.50	IX	BUTANE	FLAMMABLE GAS	Sphere	liquified by pressure	2000000.00	3	3	3	3	24	1.2	1	4.5	4.5	1	0.55	288
SHELL	T18	0.40	VIII	HYDROGEN SULFIDE	TOXIC GAS	Horizontal cylinder	liquified by pressure	5500.00	1	3	2	3	16	0.5	1	0.6	0	1	0.09	48
SHELL	T19	0.35	VIII	PROPANE	FLAMMABLE GAS	Sphere	liquified by pressure	1000000.00	1	5	1	1	16	3.1	1	0	0	1	0.33	48
UNION	T20	0.39	VIII	ACRYLONITRILE	TOXIC, FL LIQUID	Vertical cylinder	liquid, atm temp-pressure	350000.00	1	3	2	2	15	0.6	1	0.5	0	1	0.09	45
													26	23	1	23		2		
							WEIGHTS		3	2	2	1	2	2	2	2		1		

*MDE values do not correspond to worst case. The group assumed alternative scenarios with mitigation measures in place for each tank. See Table 6b for worst case MDE values. ** *D* should be estimated only for flammable gases liquefied under pressure

Table 6d . Spreadsheet for Ankesi City, Group D.

COMPANY	TANK	MMI	PGA	CHEM	CHEM_TYPE	TANK_TYPE	STORAGE_COND	Kg	HRL	MDE_km	*D**	*D-redone*	*Area-sc***	C**	NRI**
AK	T1	IX	0.32	Acrylonitrile	TOXIC, FL LIQUID	Vertical cylinder	liguid, atm pressure	2000000	3.00	40.0	1.33	0.00	5.00	3.00	24
AK	T2	IX	0.32	Acrylonitrile	TOXIC, FL LIQUID	Vertical cylinder	liguid, atm pressure	2000000	3.00	40.0	1.33	0.00	5.00	3.00	28
AK	T3	IX	0.32	Chlorine	TOXIC GAS	Horizontal cylinder	liquified by pressure	90000	2.75	23.0	4.00	0.00	5.00	3.80	35
IKS	T4	IX	0.30	Anhyd ammonia	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000	2.75	1.3	1.67	0.00	2.75	3.60	22
IKK	T5	IX	0.30	Anhyd ammonia	TOXIC GAS	Vertical cylinder	liquified by refrigeration	1000000	3.00	11.3	1.67	0.00	3.75	3.60	27
IKK	T6	IX	0.30	Anhyd ammonia	TOXIC GAS	Vertical cylinder	liquified by refrigeration	1000000	3.00	11.3	1.67	0.00	3.75	3.60	27
MANU	T7	IX	0.30	LPG	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	10000	2.75	0.4	1.67	1.67	1.00	3.80	18
NUN	T8	IX	0.30	LPG	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	5000	2.75	0.3	0.67	0.67	1.00	3.40	14
PET	T9	X	0.30	Methane gas	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	50000	2.75	0.6	0.67	0.67	1.00	3.40	14
PEK	T10	IX	0.32	Hydrogen sulfide	TOXIC GAS	Horizontal cylinder	liquified by pressure	5000	2.75	7.4	1.67	0.00	3.50	3.00	22
PEK	T11	IX	0.32	Hydrogen fluoride	TOXIC GAS	Horizontal cylinder	liquified by pressure	50000	3.00	23.0	0.67	0.00	5.00	3.40	27
PEK	T12	IX	0.32	Chlorine	TOXIC GAS	Horizontal cylinder	liquified by pressure	90000	3.00	23.0	1.67	0.00	5.00	3.80	31
PEK	T13	IX	0.32	Ethylene	FLAMMABLE GAS	Sphere	liquified by pressure	5000000	3.00	2.9	0.67	0.67	3.00	3.40	21
TUP	T14	IX	0.32	Naphtha	FLAMMABLE LIQUID	Vertical cylinder	liguid, atm pressure	500000	2.50	0.2	1.67	0.00	1.00	3.20	15
TUP	T15	IX	0.32	Naphtha	FLAMMABLE LIQUID	Vertical cylinder	liguid, atm pressure	500000	2.25	0.2	1.67	0.00	1.00	3.20	13
TUP	T16	IX	0.32	Propane	FLAMMABLE GAS	Sphere	liquified by pressure	320000	2.75	1.2	1.67	1.67	2.50	3.40	21
TUP	T17	IX	0.32	LPG	FLAMMABLE GAS	Sphere	liquified by pressure	350000	2.75	1.2	1.67	1.67	2.50	3.40	21
TUP	T18	IX	0.32	LPG	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	32000	2.50	0.5	2.33	2.33	1.00	3.40	17
TUP	T19	IX	0.32	Chlorine	TOXIC GAS	Horizontal cylinder	liquified by pressure	2000	2.75	3.1	1.67	0.00	3.25	3.40	23
TUP	T20	IX	0.32	LPG	FLAMMABLE GAS	Horizontal cylinder	liquified by pressure	35000	2.50	0.6	2.33	2.33	1.00	3.40	17

**D* should only be estimated for flammable gases liquefied under pressure. **These scores need to be recalculated based on the corrected domino effects value ,*D*-redone.

Region	Name	Earthquake and other geological hazards	Floods, storms and other hydro-meteorological hazards	Description of event/ area affected
Emilia Romagna Region	Clarissa Dondi	EQ only mountain area –5% chance of Natechs	Floods – 35% chance of Natechs	EQ hazard only in mountain zone, particularly in the east
Sardinia	Michela Campedel	EQ triggered tsunami - Natechs possible		EQ triggered tsunami impacting coast line where a major refinery is located
Texas	Michael Lindell		F3 tornado - 1% chance of Natechs	Hazmat facilities occupy only a small percentage of the area. However, hazmat facilities located in populated areas
Athens (industrial area), Greece	Anna Papachatzi	EQ – 100%	Floods 100% chance of Natechs	3 very high annoyance factories, residential areas, huge disaster
Istanbul, Turkey	Serkan Girkin	EQ > 7 magnitude – 90% chance of Natechs		Petrochemical industry, chemical industry, gas pipelines – Area affected by Natechs can be small
Dessau-Roßlau, Germany	Roland Fendler		Storm >150km/hr winds – 50% chance of Natechs	Chemical accident triggered by high winds, storm
			Floods, 2m, 100 yr event – 1% chance of Natechs	Only 1 art. 6 Seveso industry. Water contamination scenario likely, high number of people (> 500).
Wuhan, China	Wang Xianhua		Floods	
Cluj County, Romania	Alexandru Ozunu		Flash floods (2-3 days) – 30% chance of Natechs	Natech accident involving chlorine release (50 tons)
Haifa Bay, Ashood Gaza Ramat Hovav, Israel	Efraim Laor	EQ (Mw 6.5-7.5) along Red Sea Fault or Carmel Fault – Natechs possible		
Vienna, Austria	Michael Struckl	EQ – 0.1 % chance of Natechs	Extreme wind or snow loads – 1% chance of Natechs	Winds: roof collapse or foundation collapse of buildings; EQ: collapse of construction, hazmat release; Natech would affect about 10-100 ha and about 500-5000 people
Scaton Delaval, Whirley Bay, UK	Komal Raj Aryal		Floods, high winds, tornado – 15% chance of Natechs	We have a cosmetics plant in 0.5 km radius. If impacted about 400 households would be affected
Athens (centre), Greece	Miranda Dandoulaki	EQ (M 6-7) – 0% chance of Natechs	Storm with strong winds, heat wave (42^{o}C for 3 days), snow – damage to lifelines possible	Lycabetus Hill (center), chain effects, failure of lifelines: EQ: 90%; Heat wave: 100%; Storm/winds: 80%; Snow: 75%
Kanpur, India	J. P. Gupta		Floods – 2% chance of Natechs	Release from paints and raw materials factory, area about 2 km^2; fire and environmental damage
Karlsruhe, Germany	Valentin Bertsch		Storms- 10% chance of Natechs	Potential domino effects: power outage, general infrastructure breakdown, all industrial sectors affected

Table 7. Summary of participants' responses concerning worst case natural disaster and Natech probability in their communities.

ANNEX 1

NATECH WORKSHOP
Stresa, Italy, September 17-18, 2007

Agenda

DAY 1

8:30 – 9:20	Welcome Presentation of workshop agenda and dynamics Introductions and Workshop expectations	AM Cruz E Krausmann Cruz, Krausmann All
9:20 – 10:40	Country Presentations	
	1. Slovenia	D. Fajfar
	2. Germany	R. Fendler
	3. Austria	M. Struckl
10:40 – 11:00	*Coffee break*	
11:00 – 12:30	Country Presentations cont.	
	4. Romania	A. Ozunu
	5. Poland	S. Zajac
	6. Bulgaria	B. Ranguelov
	7. Greece	A. Papachatzi
12:30 – 14:00	*Lunch*	
14:00 – 17:30	Natech risk assessment and management: Tools and skills Preparation for case studies	All Cruz, Cozzani, Krausmann, Steinberg
	15:30 – 16:00 Coffee break	

DAY 2

9:00 – 12:30	Case studies: working groups	All
	10:30 – 11:00 Coffee Break	
12:30 – 14:00	*Lunch*	
14:00 – 15:30	Presentation of case study results Discussion	All
	15:30 – 16:00 Coffee break	
15:30 – 17:30	Natech risk management strategies Conclusions and closing of meeting	All AM Cruz E Krausmann LJ Steinberg

ANNEX 2

COUNTRY PRESENTATIONS

GIS Support for Emergency Management in Slovenia

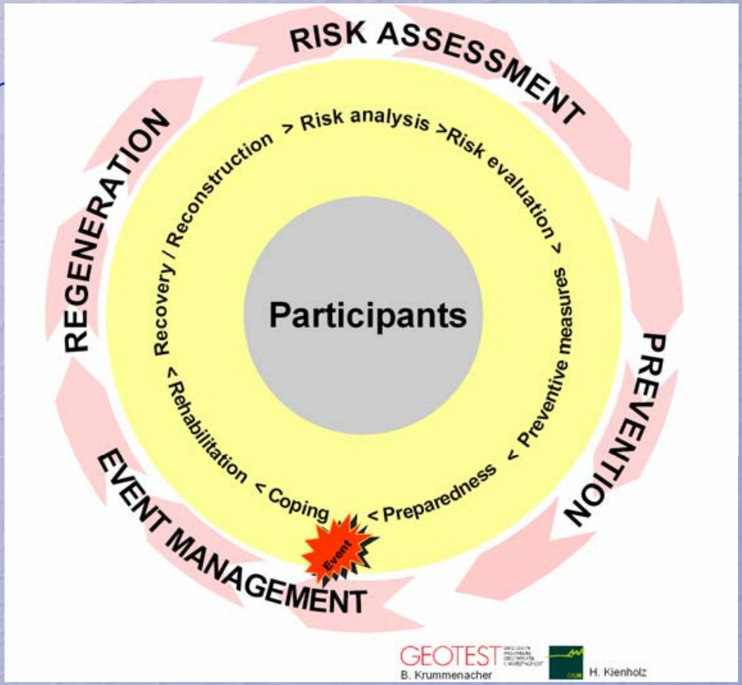
Milica Slokar, Ministry of Defence, Administration of the Republic of Slovenia for Civil Protection and Disaster Relief, Slovenia

Dušan Fajfar, IGEA

UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

Strategy

- **Integrated IT support for Emergency Management**
  - Different IS integrated in functional system used by different subjects:
    - Administration for Civil Protection and Disaster Relief with Emergency centers (112)
    - Rescue forces
    - Ministry of Environment and Spatial Plann
    - Municipalities
    - Public
    - International activities
    - ...
  - Used in all phases of Emergency management



UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

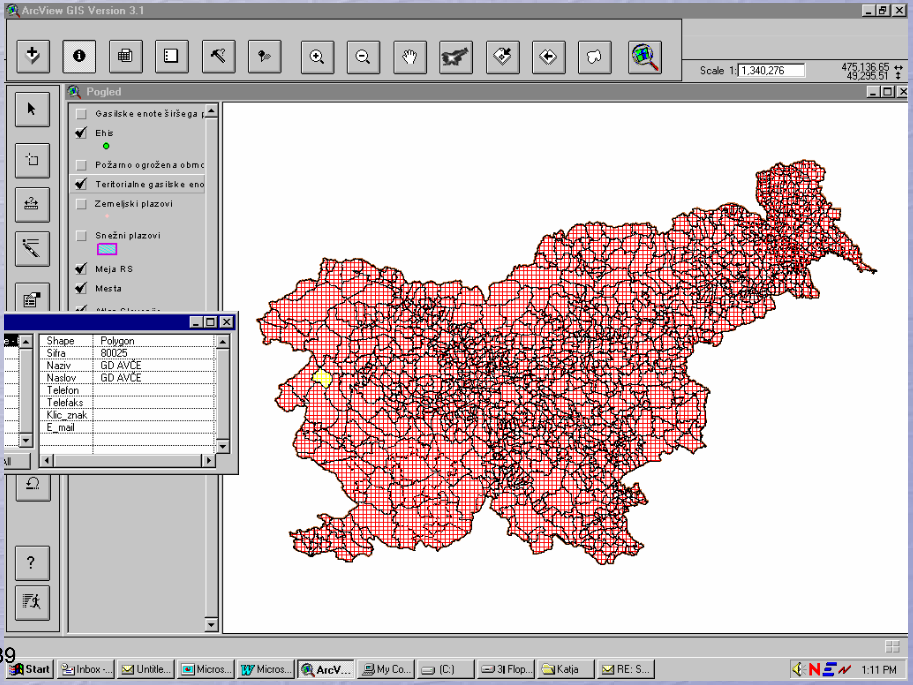
Strategy

- **Integrated IS – common database**
- **Each data is entered only once**
- **Technical solution – central database and replication of data**
- **Content (general):**
  - Rescue units with area of responsibility
  - Rescue personnel
  - Action plans
  - Hazard maps
  - Data about interventions

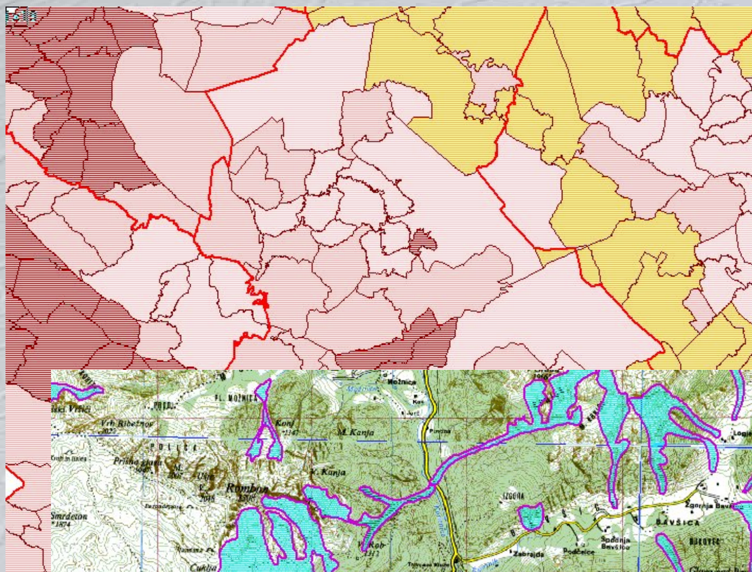
- **GIS - core of the system**

GIS_UJME

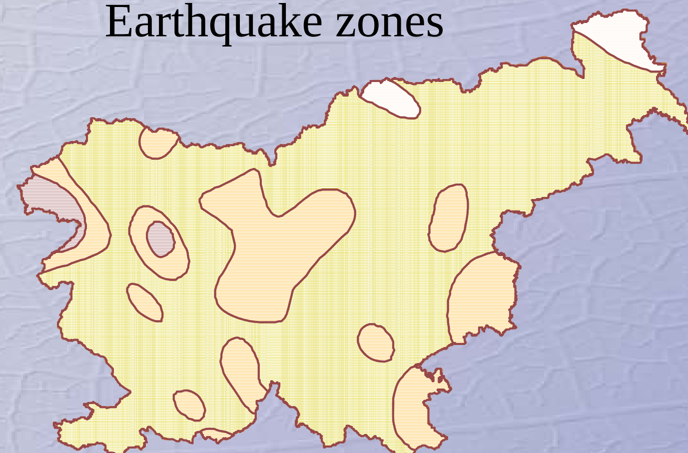
- Development of GIS started in 1996
- Goals:
  - different Risk and Hazards Maps bring to common system
  - underlay with cartographic maps
  - simple application for browsing data
  - Preparation of cartographic output



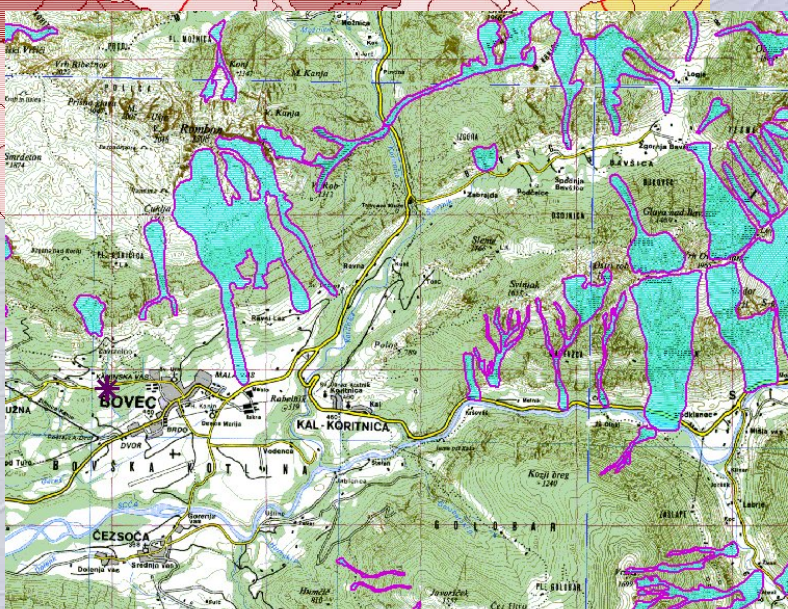
GIS_UJME - Risk and Hazard maps



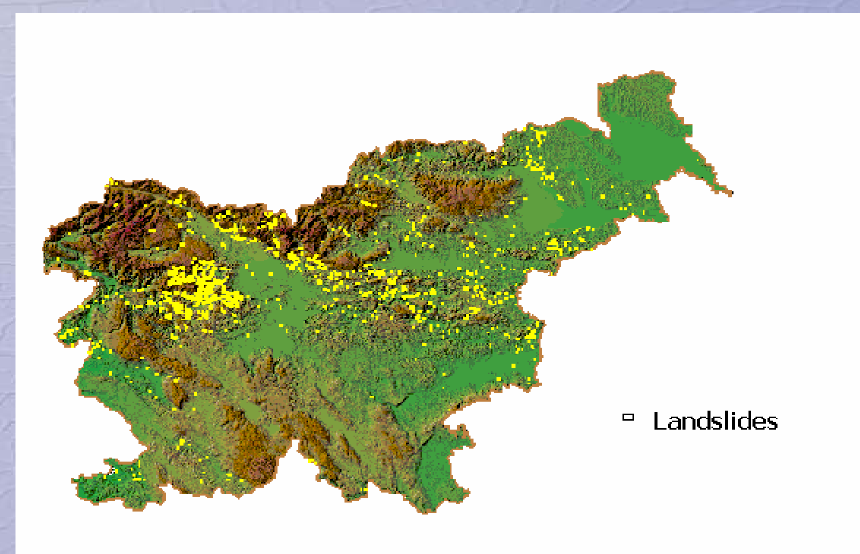
Fire risk areas



Earthquake zones

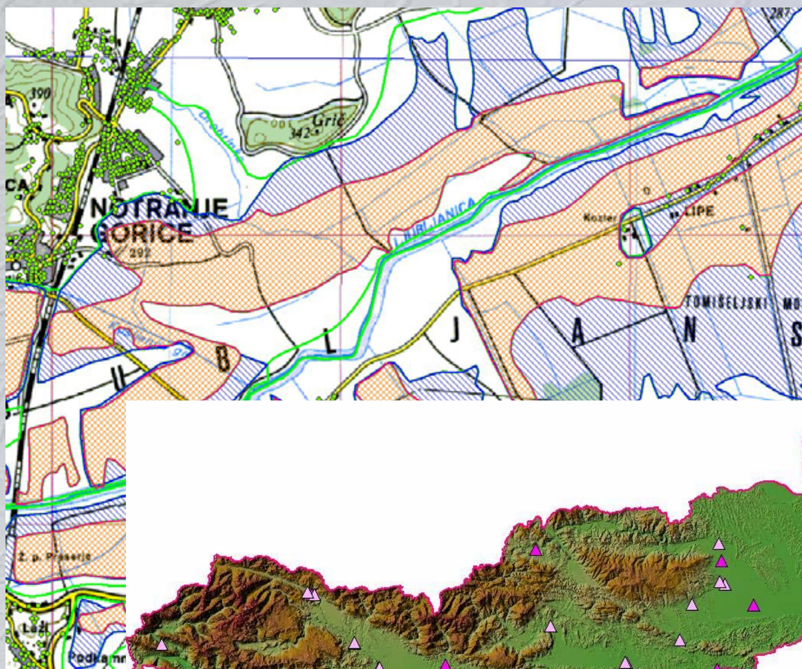


Avalanches

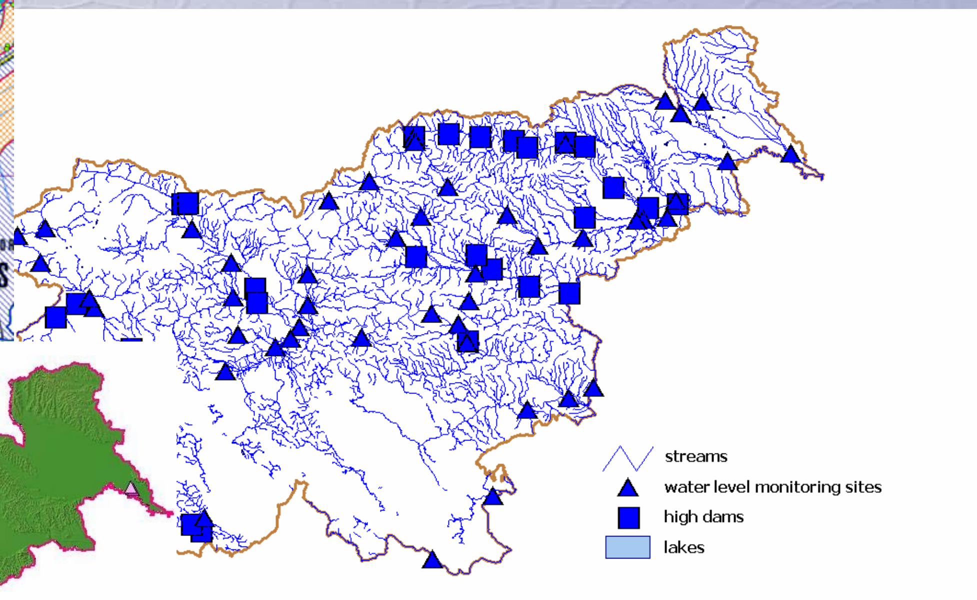


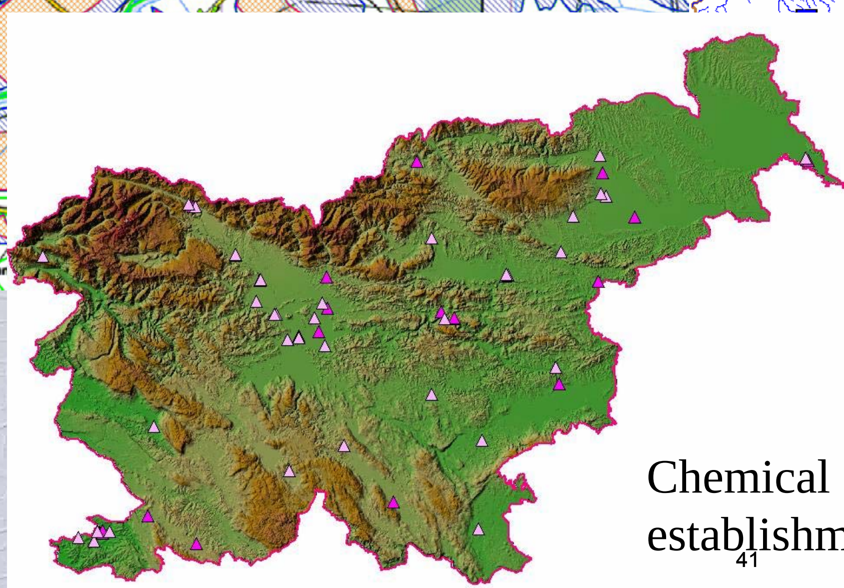
GIS_UJME - Risk and Hazard maps

Flood lines



Dams





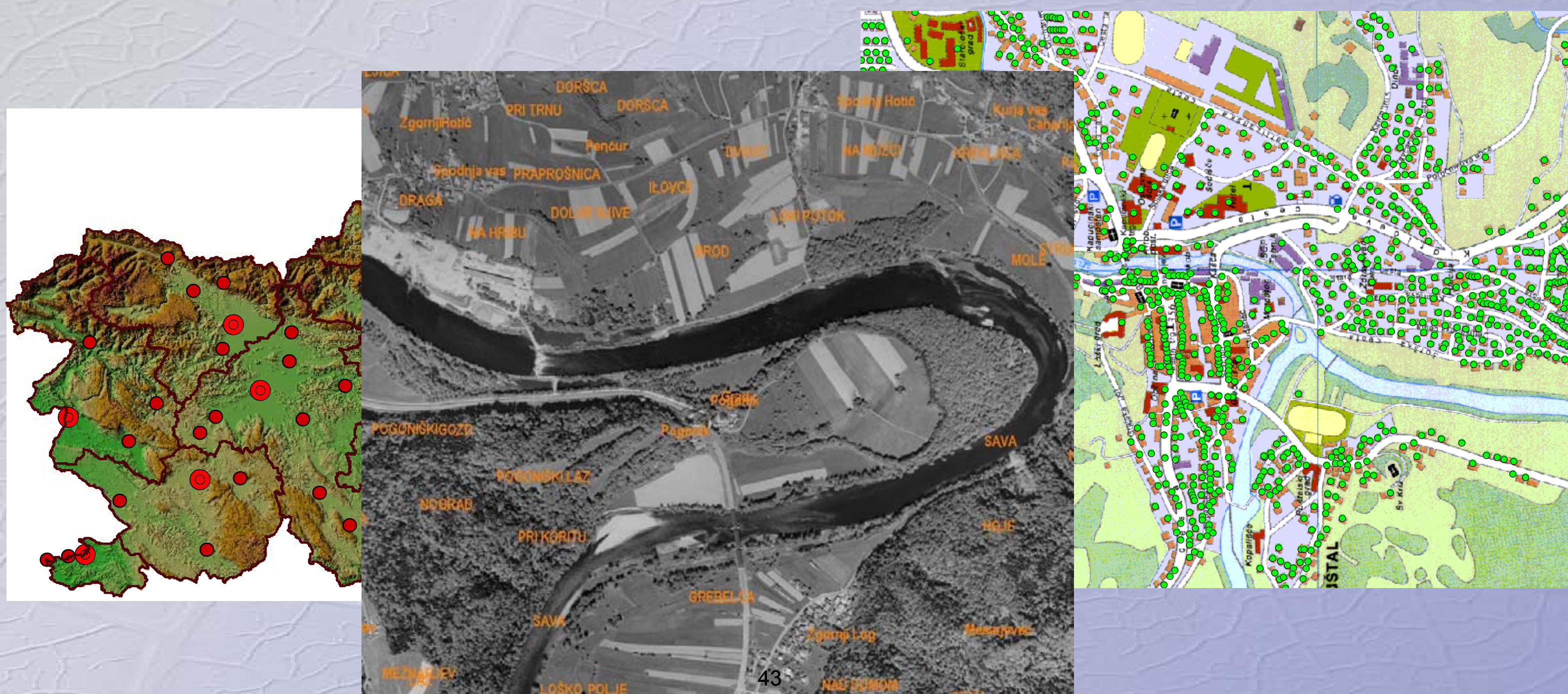
Chemical establishments

GIS_UJME - Cartographic data

- **Cartographic background (raster) data**
  - Topographic maps of scale 1:5000 to 1:750.000
  - Digital ortophoto 1:5000
- Data provided by **Surveying and Mapping Authority** of the RS

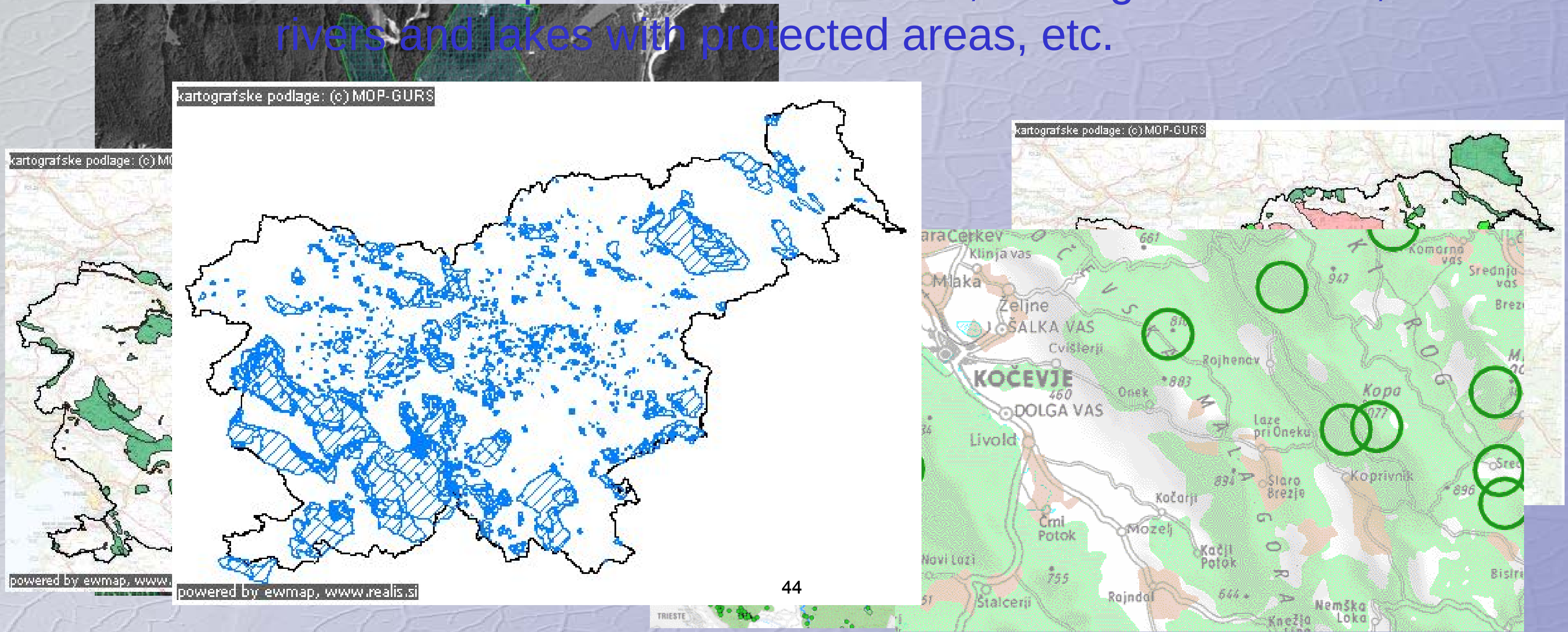
GIS_UJME – Geolocated registers

- **Register of teritorial units**
  - Municipalities, settlements,streets, house number (addresses)
- **Register of geographical names**
- **Register of companies –** linked to geolocated addresses



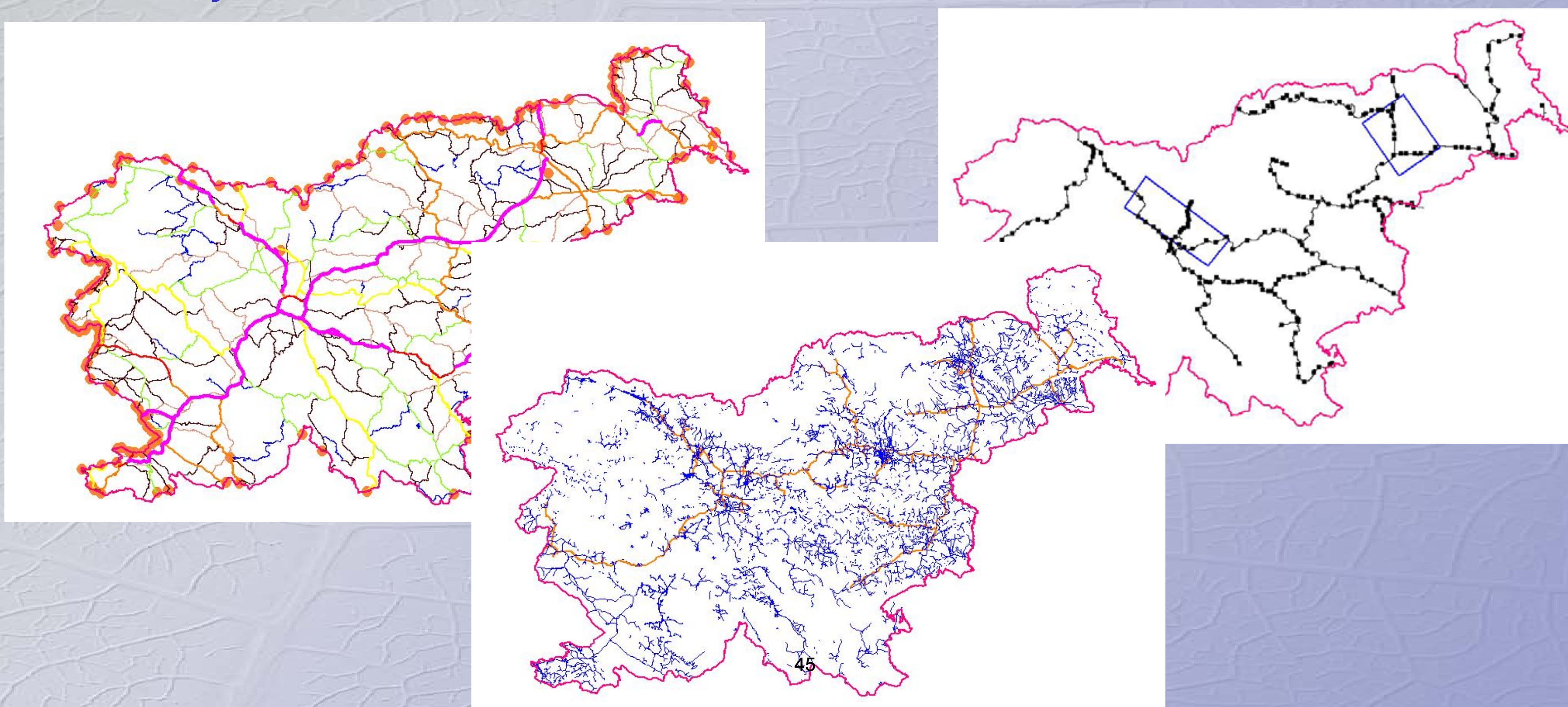
GIS_UJME – other data

- **Environmentaly sensitive areas (protected areas):**
  - national park, regional park, landscape park, nature reserve and natural monuments
  - protected forest
  - Water data: potable water sources, underground water, rivers and lakes with protected areas, etc.



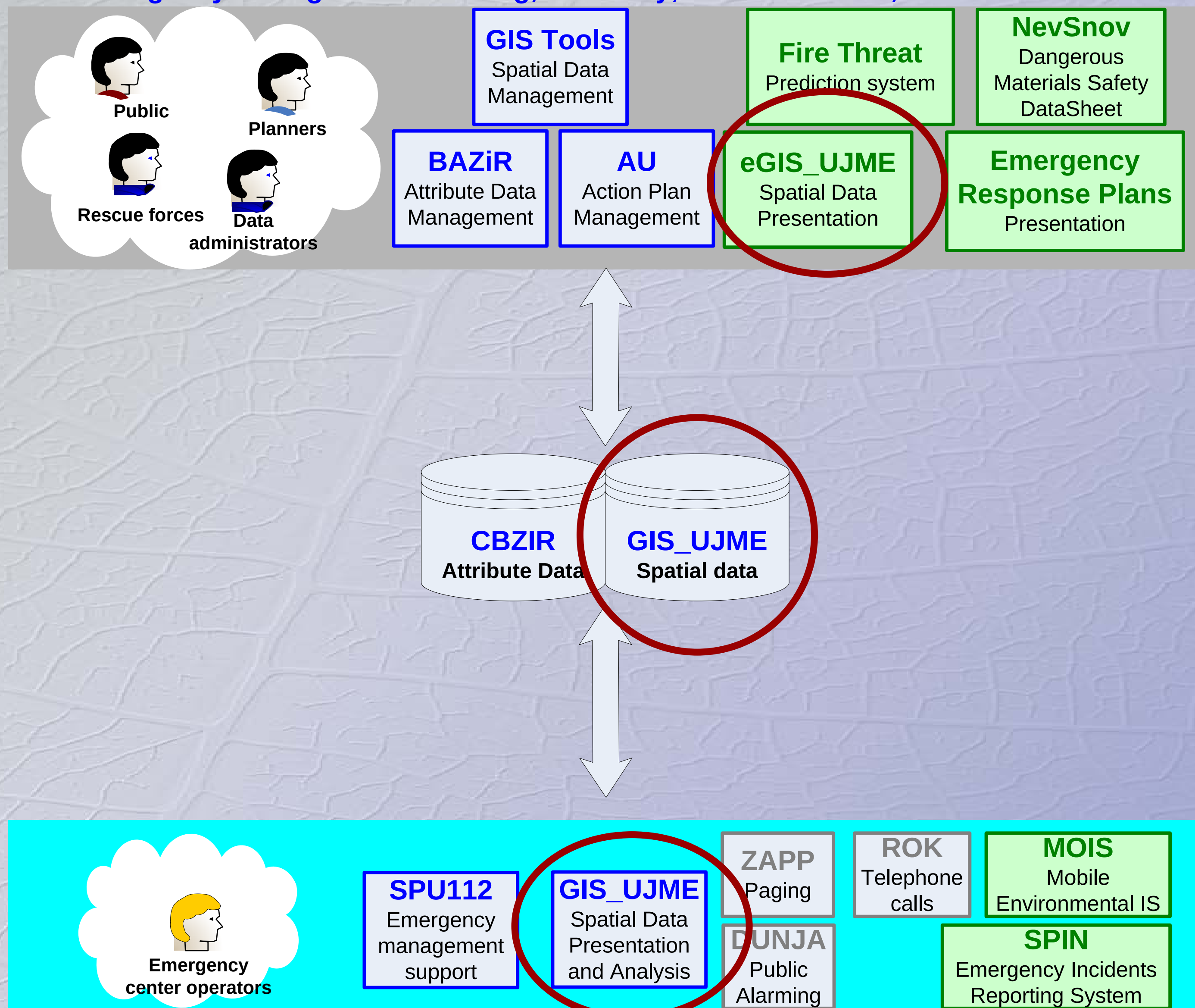
GIS_UJME – other data

- **Infrastructure:** traffic infrastructure: roads, railways, energetic infrastructure: electricity and gas supply, telecommunications network, sewage system, water supply system, air corridors, etc.



UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

Emergency Management Planning, Recovery, Reconstruction, Info Presentation

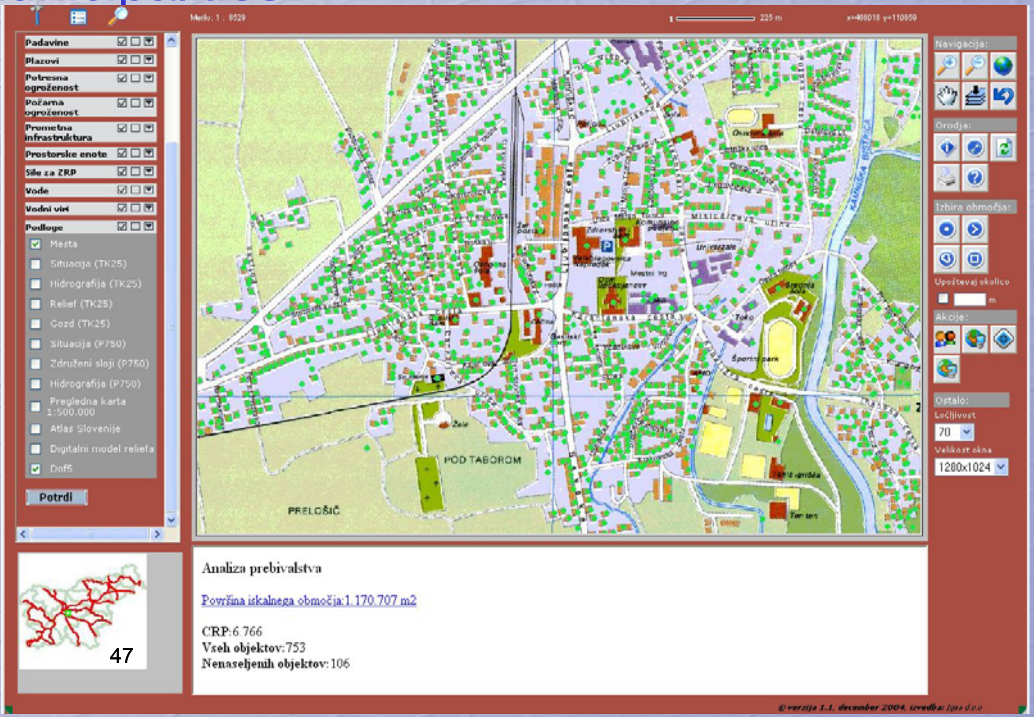


Event Management

UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

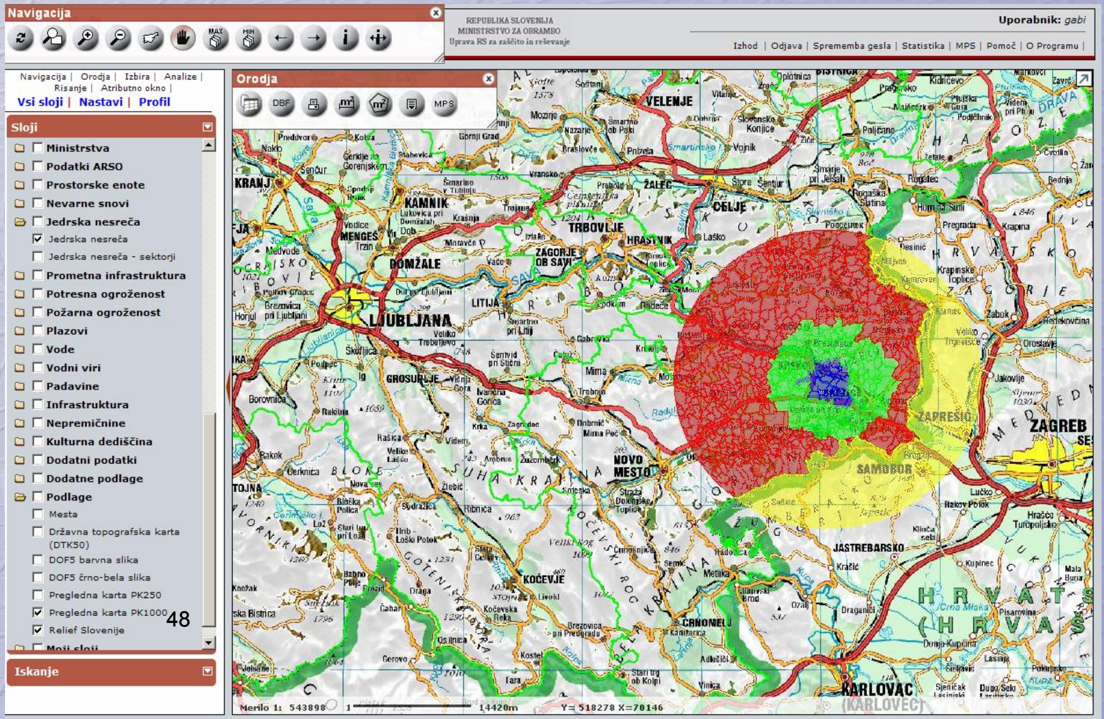
eGIS_UJME

- WEB based solution eGIS_UJME is implemented in 2001
- GIS informations to more users
- Desktop aplication primary for Emergency centers
- WEB aplication for
  - planers in Administration of the RS for Civil Protection and Disaster Relief and in municipalities
  - rescue forces
  - integrated into system for reporting on intervention



eGIS_UJME

- **New version of eGIS_UJME in October 2007**
  - More functionality: spatial analysis, drawing on the map, printing maps
  - More user friendly
- **Supporting systems**
  - GIS_UJME portal; communication with users - news, help, links,
  - Metadata system
  - User rights managment system



UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

BAZIR – Data Managment System

- **Rescue forces with area of responsibility (apr. 40 layers)**
  - Name, address, contact data (phone, pager, etc.)
  - Unit personel with functions, contact data
  - Graphical presentation of areas of responsibility (can depends on type of event)
  - Request permanent maintenance of graphical and attribute data


Podatki o enoti

Uradni naziv	PGD IDRIJA
Enota	IDRIJA
RIC	310016
Nadrejena enota	

Naslov

Občina	Naselje	Ulica	Hišna št.	Pošta
IDRIJA	IDRIJA	VOJKOVA ULICA	2A	5280 Idrija

Kontakti

Tip	Številka	Opomba
služben	053771993	

E-poštni naslovi

Tip	E-pošta	Opomba

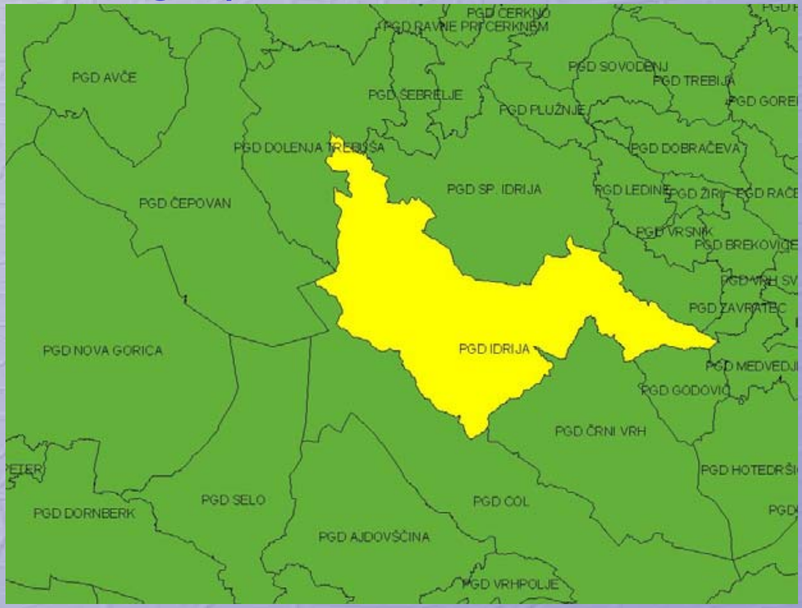
Pripadnost regiji

- SEVERNO PRIMORSKA (ReCO Nova Gorica)

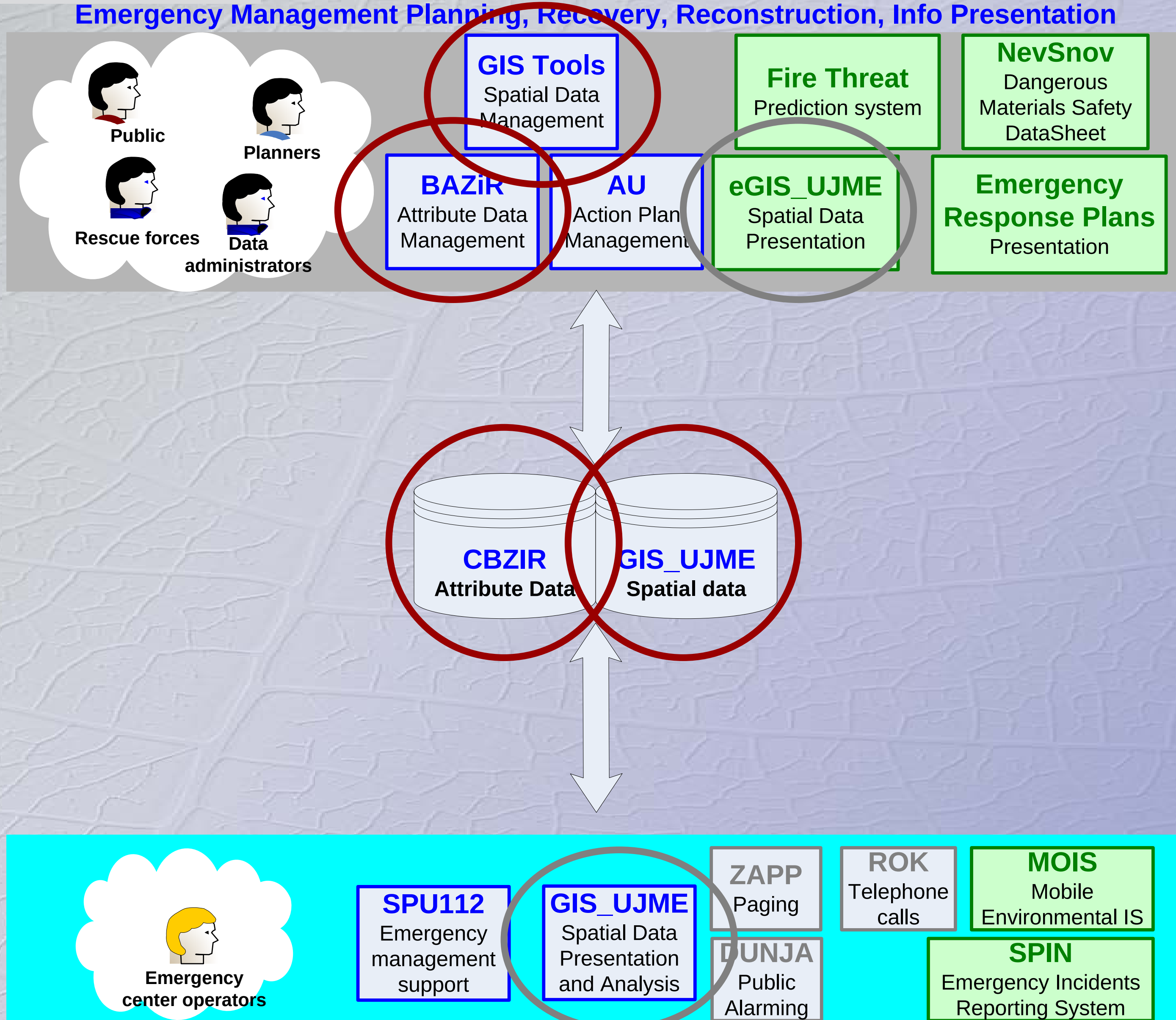
Vrsta

- Teritorialne gasilske enote
- Gasilska enota širšega pomena
- Prostovoljne gasilske enote
- Osrednja gasilska enota

Osebe v enoti | Zapri

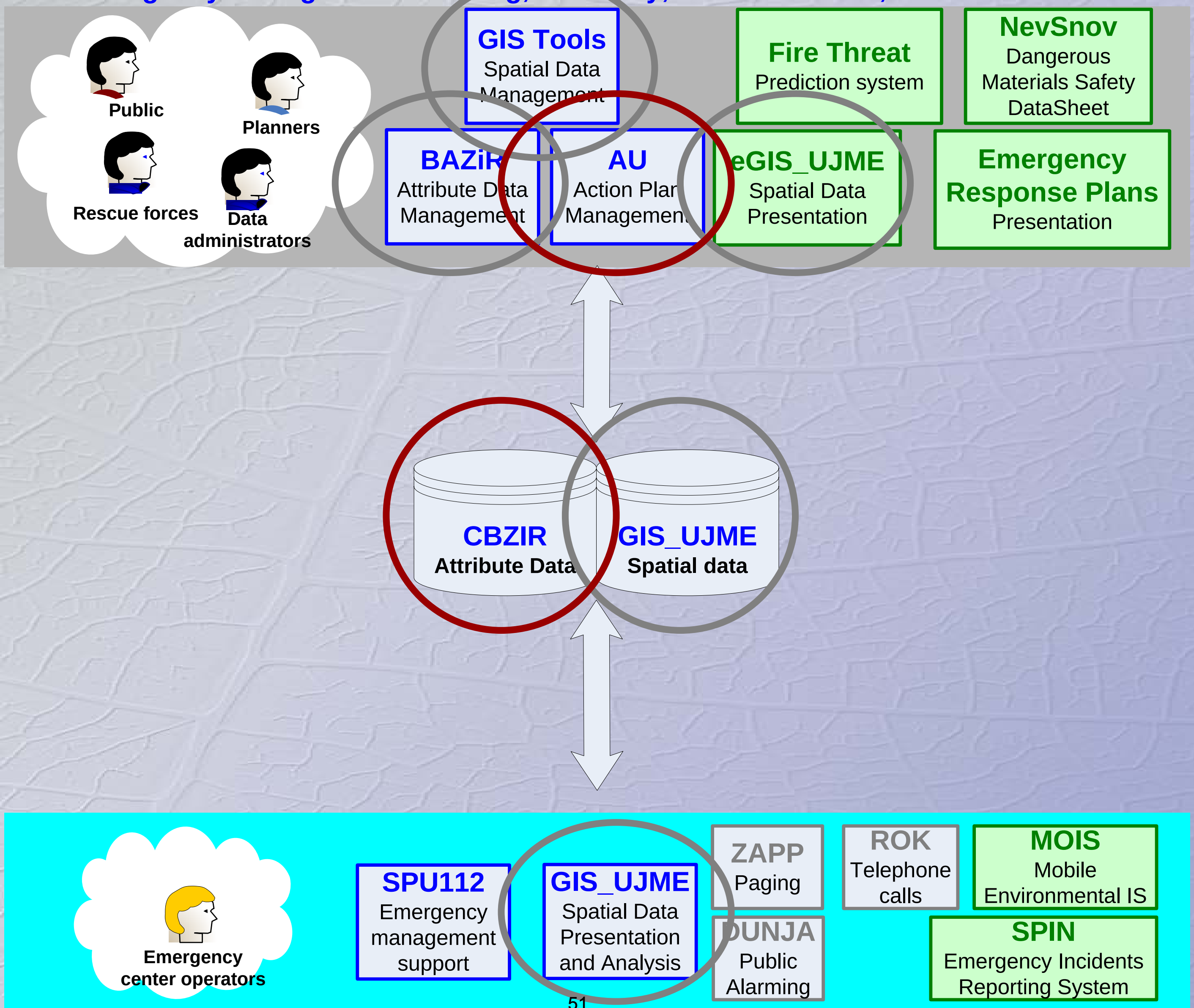


Emergency Management Planning, Recovery, Reconstruction, Info Presentation



Event Management

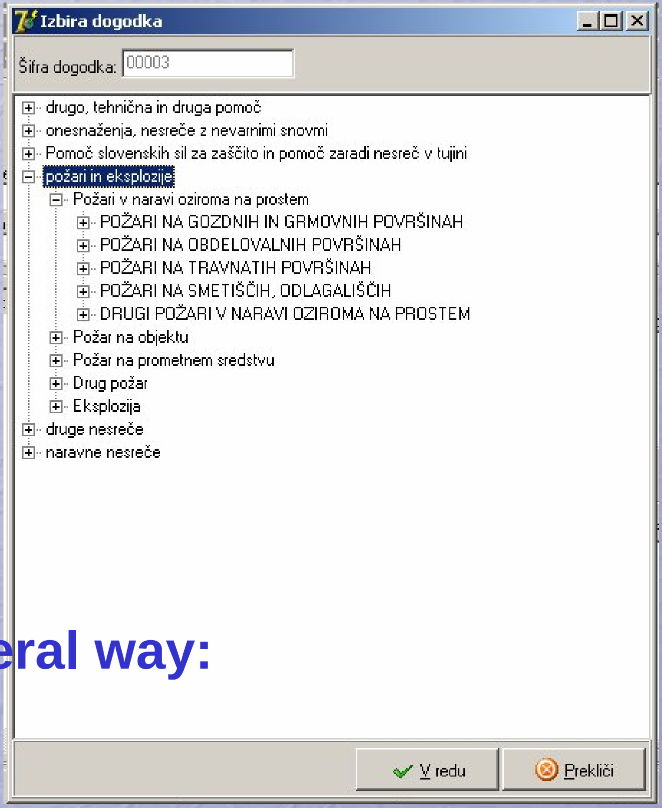
Emergency Management Planning, Recovery, Reconstruction, Info Presentation



Event Management

Action plans

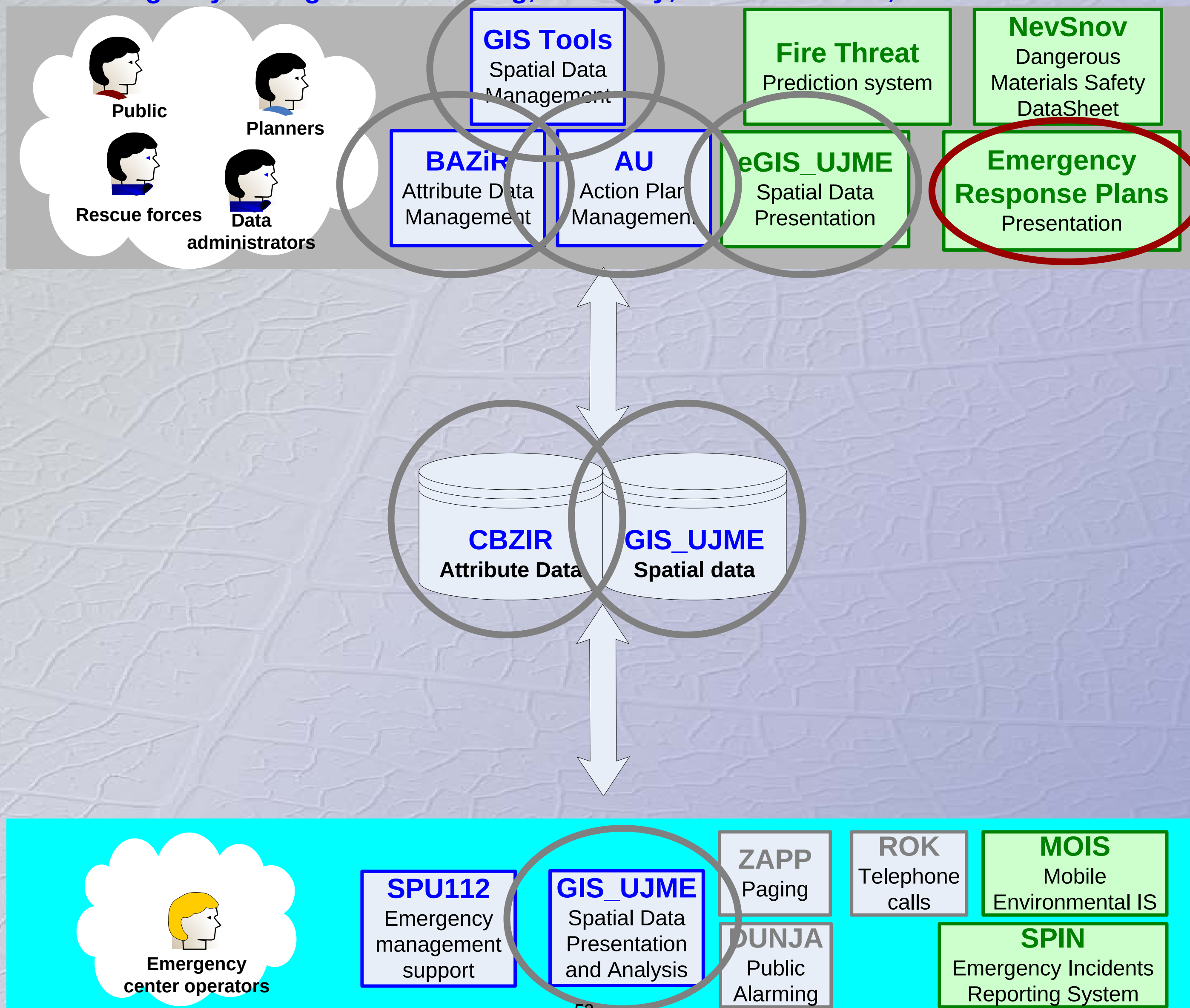
- **Action plan = Digital algorithms**
- **Defined for type of event and area**
  - 3 level index with about 100 events
  - Area on different levels
    - State
    - Regional
    - Municipality
    - Local (area of territorial fire units)
    - Particular location (tunnels, factories with dangerous goods, etc.)



- **In action plans actions are defined in general way:**
  - activate territorial fire brigade
  - activate medical help unit
  - announce major of municipality
  - ...

UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

Emergency Management Planning, Recovery, Reconstruction, Info Presentation



Event Management

NATECH Risk Assessment and Management, 17th of September, 2007, Stresa, Italy

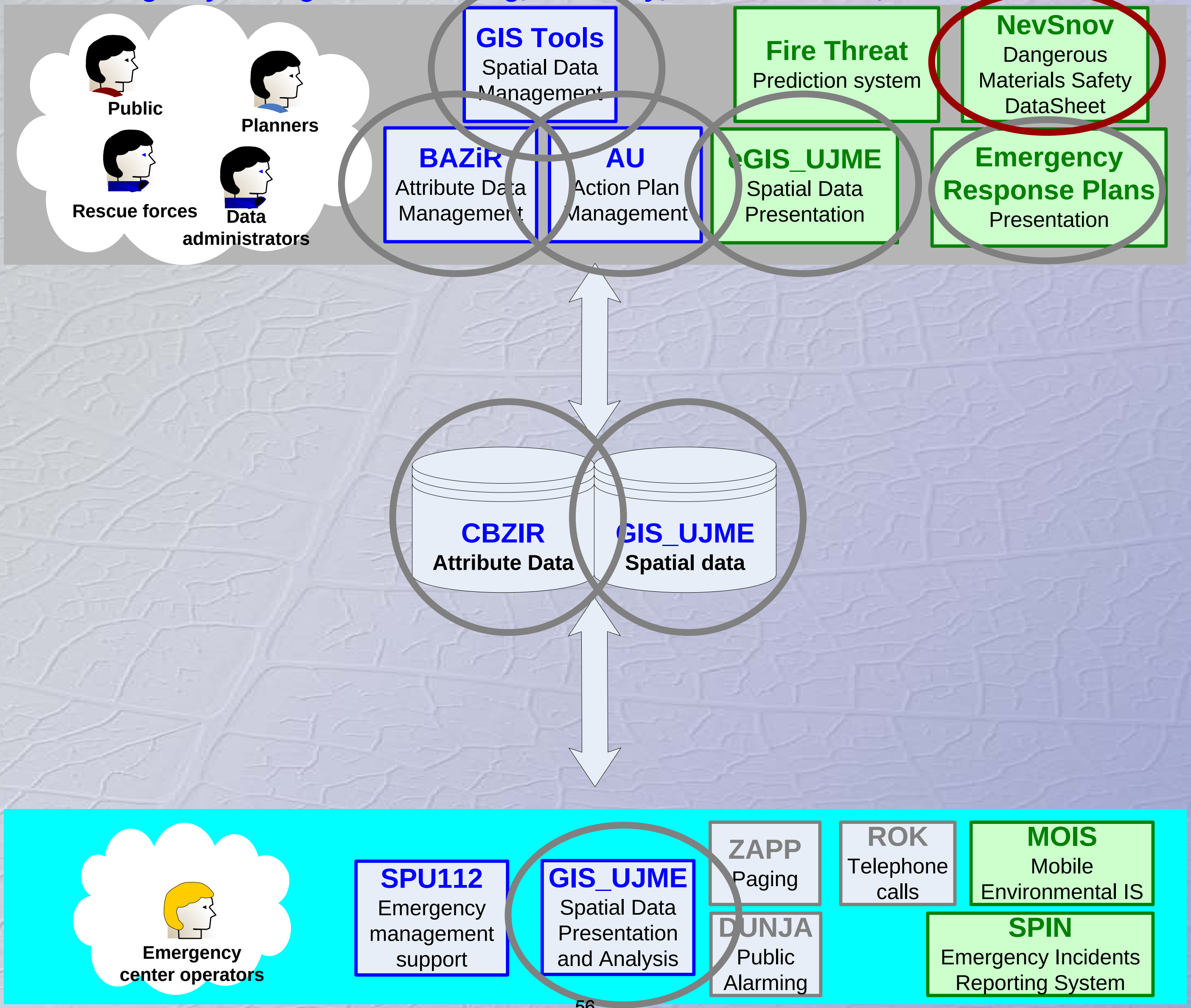
Emergency Response Plans

- **Emergency Response Plans exist in paper form**
  - limited access to materials – need to copy papers
  - hard to search
  - hard to manage (one data change must be done on more places)

Emergency Response Plans

- **Digital portal of Emergency Response Plans**
  - documents transformed to PDF
  - each document and supplements exist just once
  - some suplements are on-line generated:
    - maps (spatial data) from eGIS_UJME
    - lists of units or person (atributte data) from CBZIR

Emergency Management Planning, Recovery, Reconstruction, Info Presentation



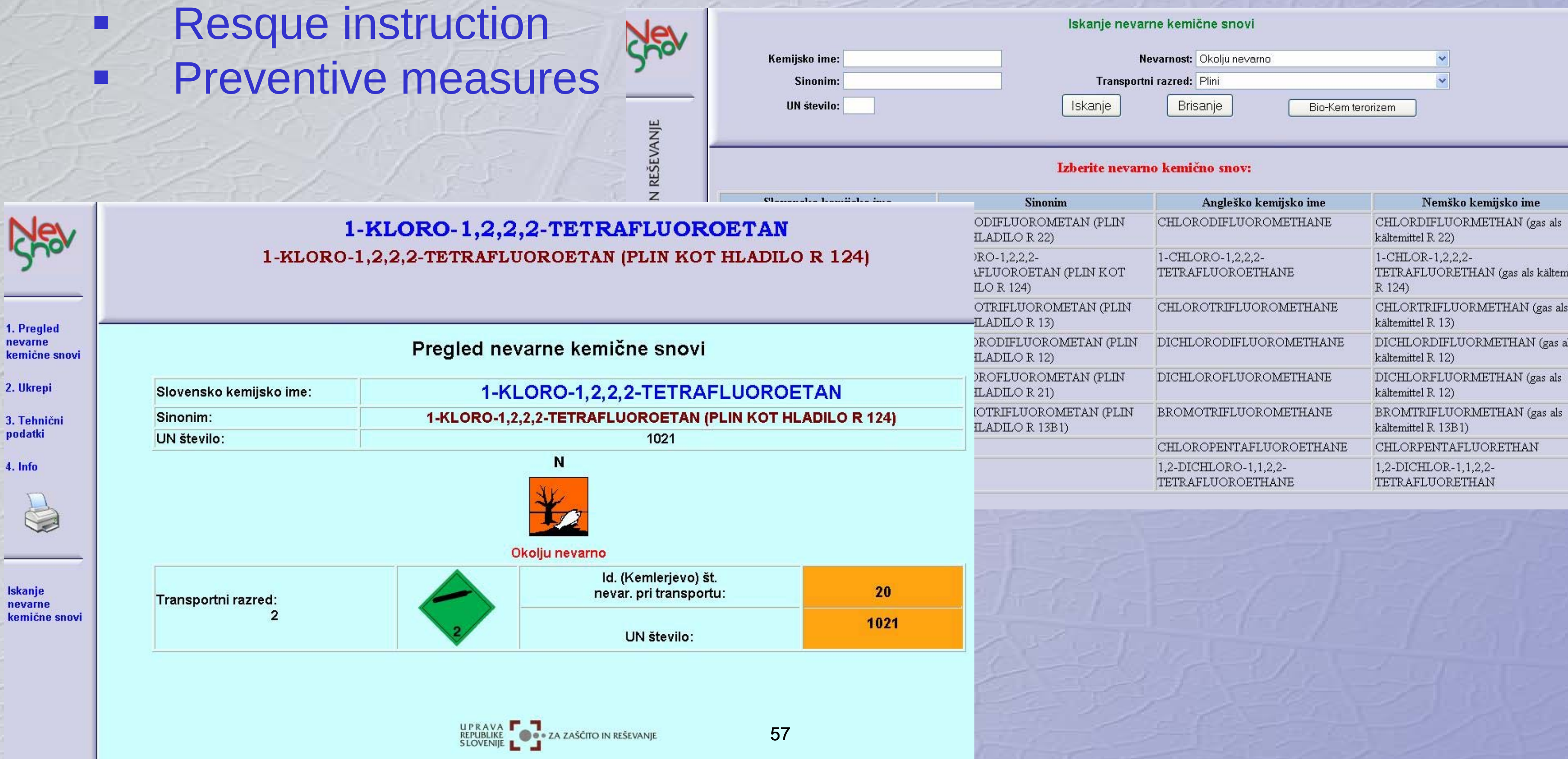
Event Management

UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

IGEA

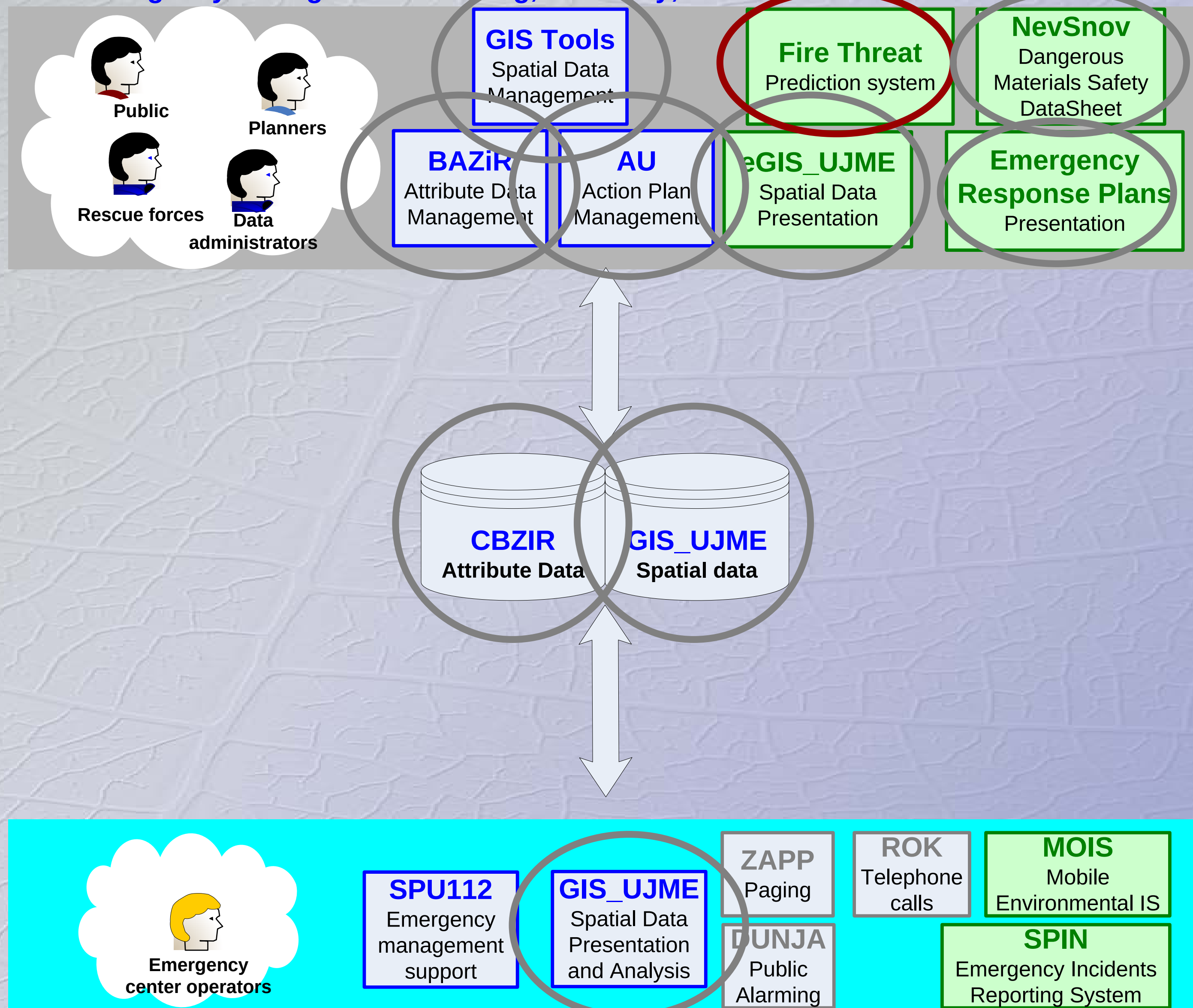
Dangerous Materials Safety DataSheet

- **Internet aplication with data about**
  - Dangerous Materials
  - Resque instruction
  - Preventive measures



UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

Emergency Management Planning, Recovery, Reconstruction, Info Presentation

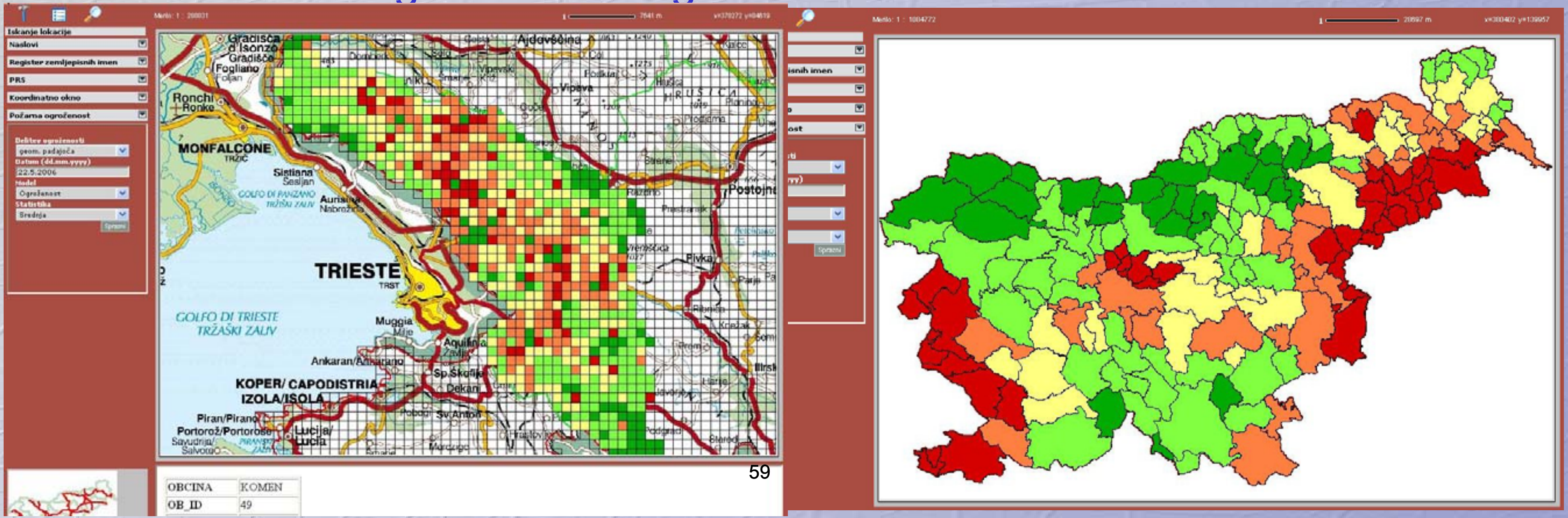


Event Management

UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

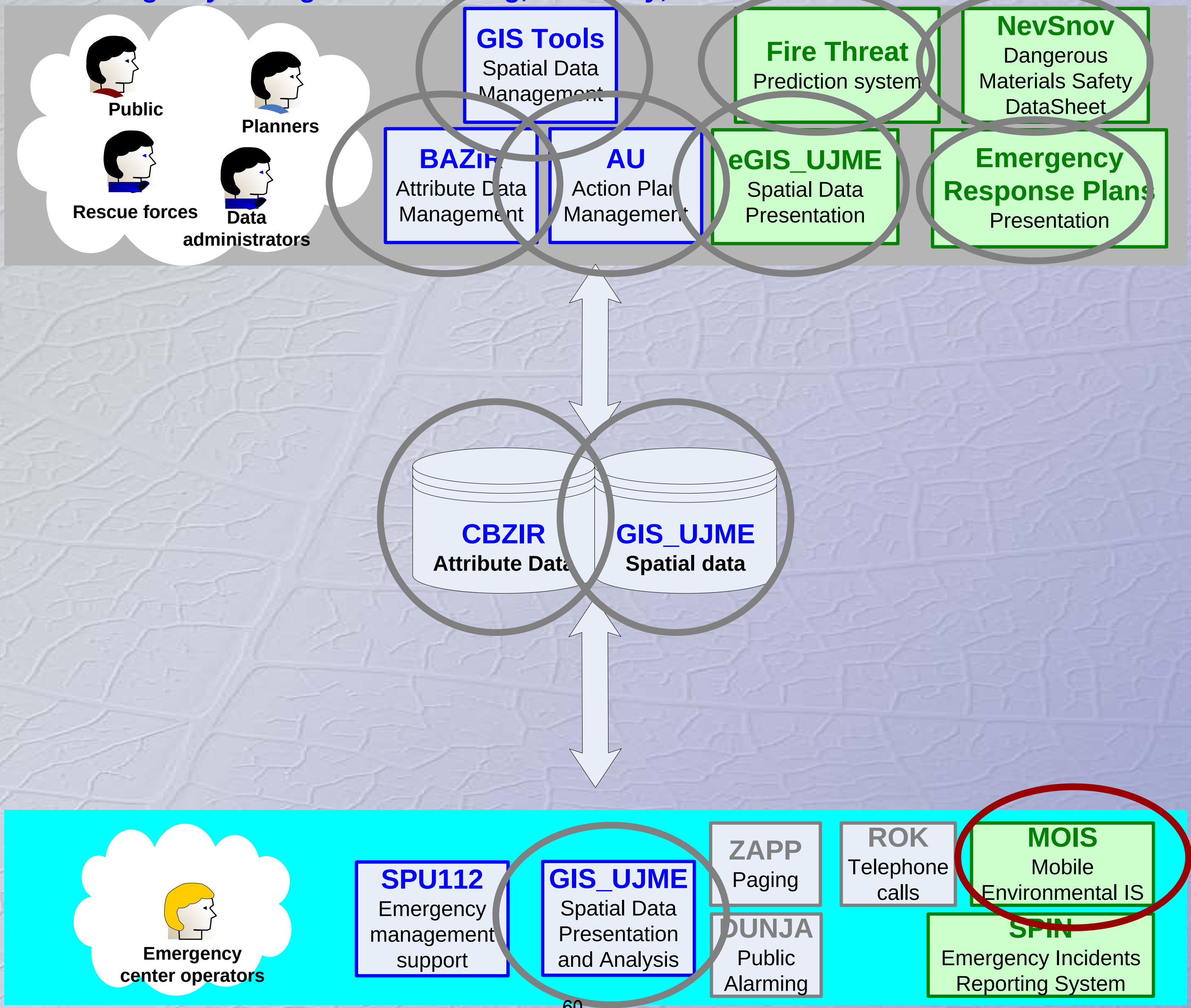
Fire Threat Prediction System

- **Daily estimated prediction for nonurban areas**
  - vegetation, terain,
  - weather data – measurement and prediction for 48 hours (ALADIN)
    - automatic dailly takeover of data from Environmental Agency (Ministry of the Environment and Spatial Planning)
- 2 models:
  - for Slovenia on level of communities
  - for coastal region on 1km grid



UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

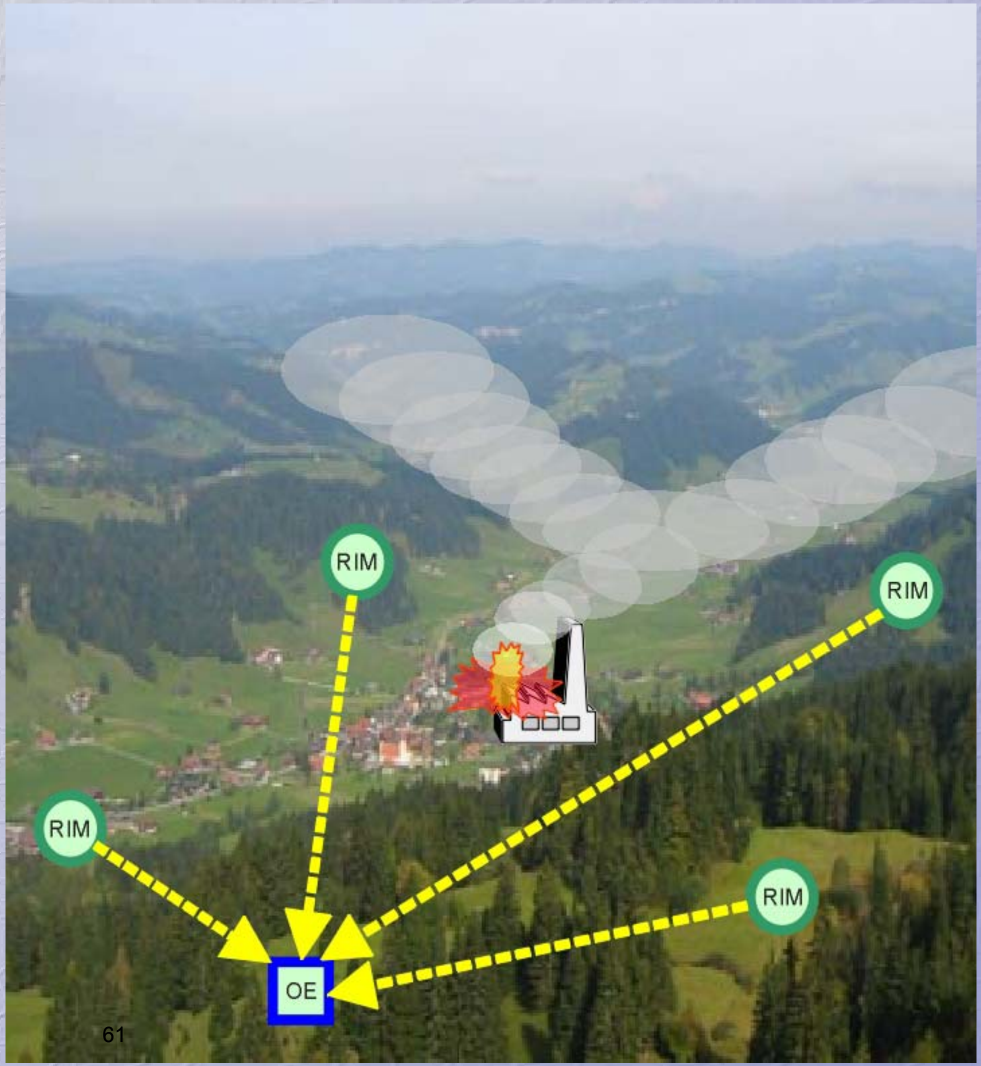
Emergency Management Planning, Recovery, Reconstruction, Info Presentation



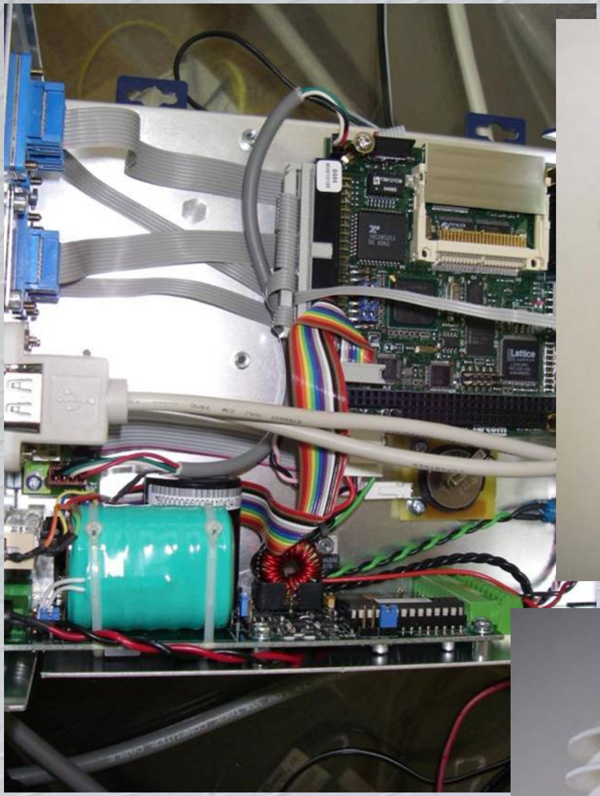
Event Management

Mobile automatic weather and air pollution system

- Mobile weather stations
- Emission estimation
- Dispersion modelling
- Geographical information system
- On-line pollution impact on population



PROTOTYPE

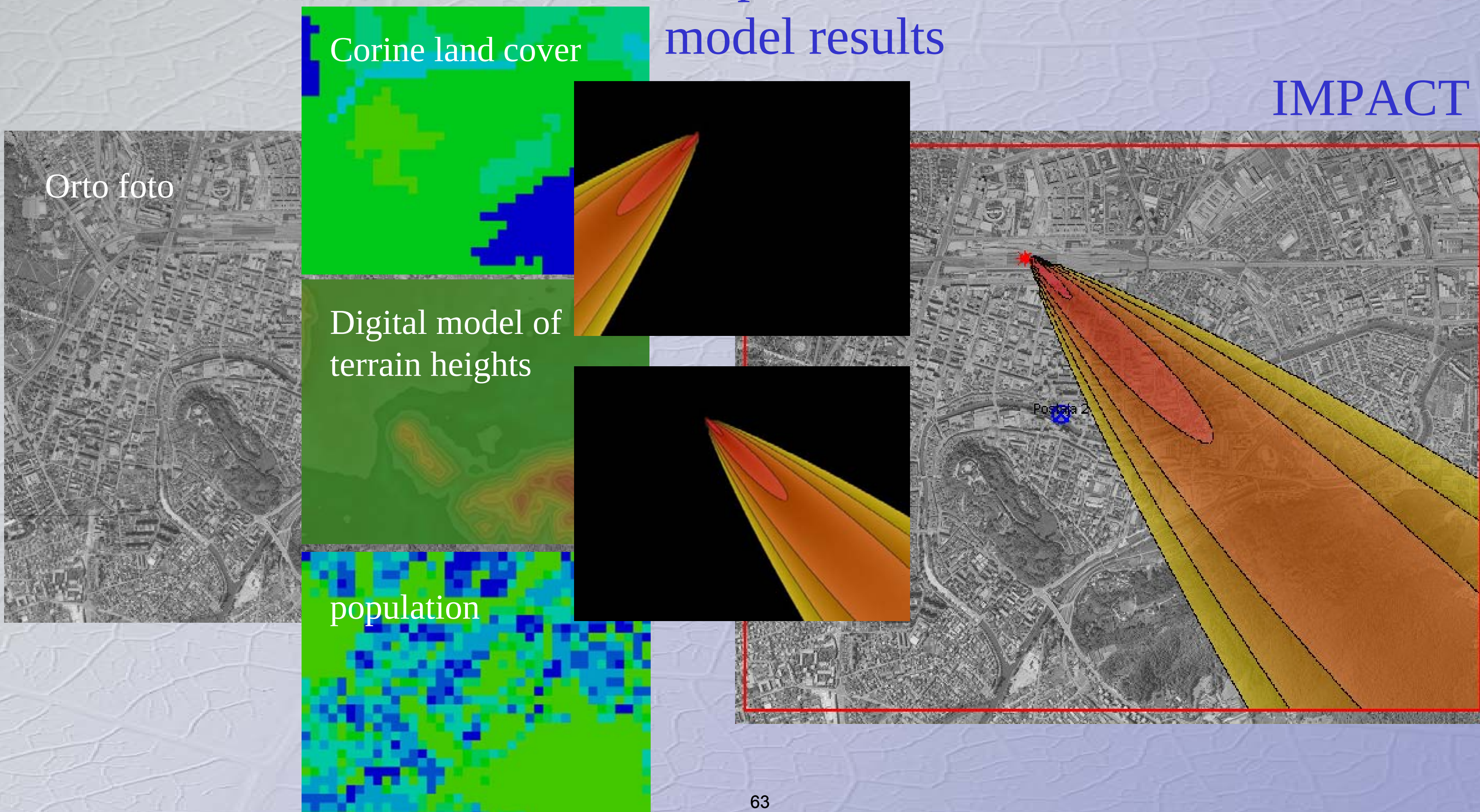


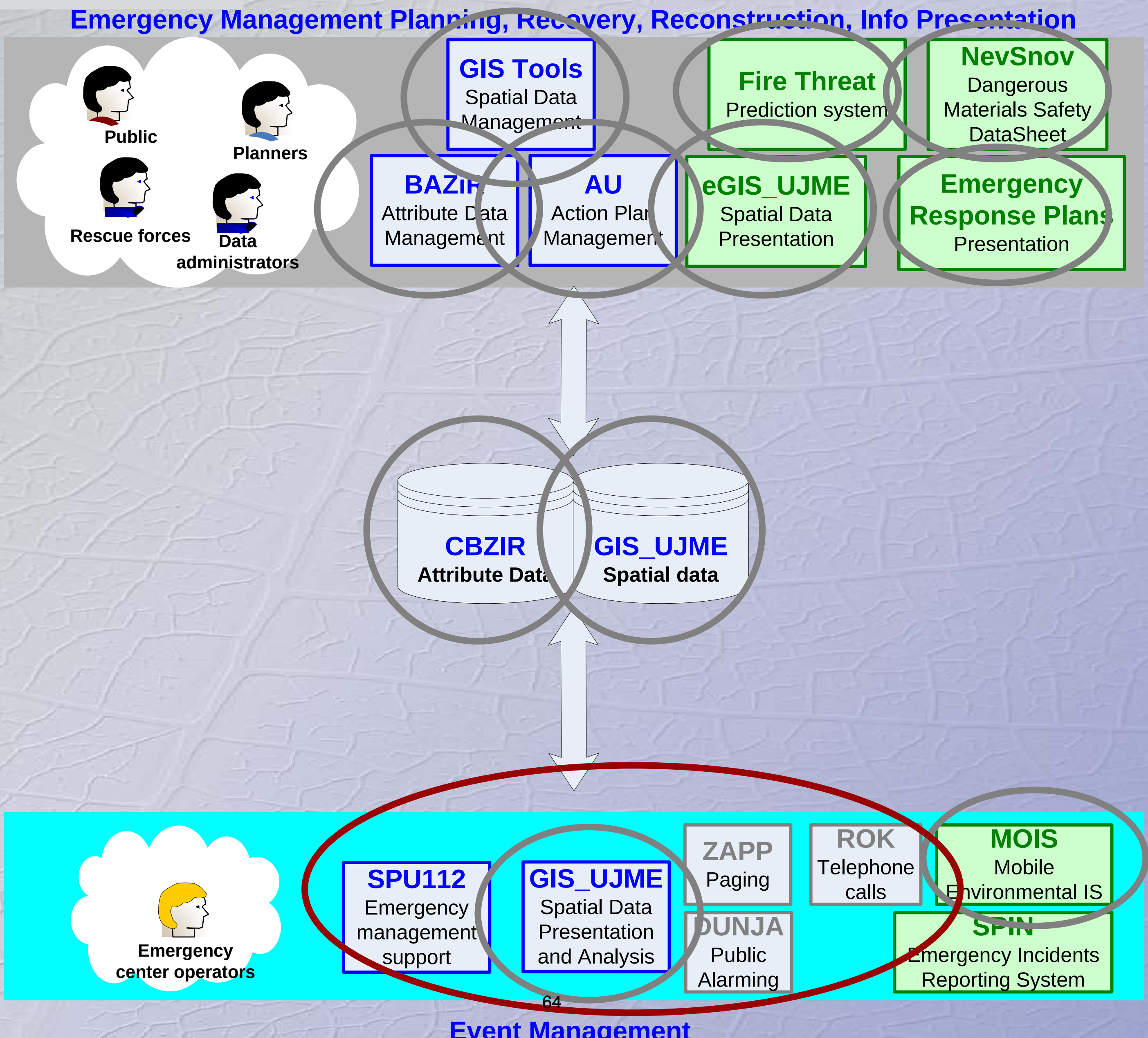
RESULTS: ON-LINE IMPACT ON POPULATION

GIS DATA

Dispersion model results

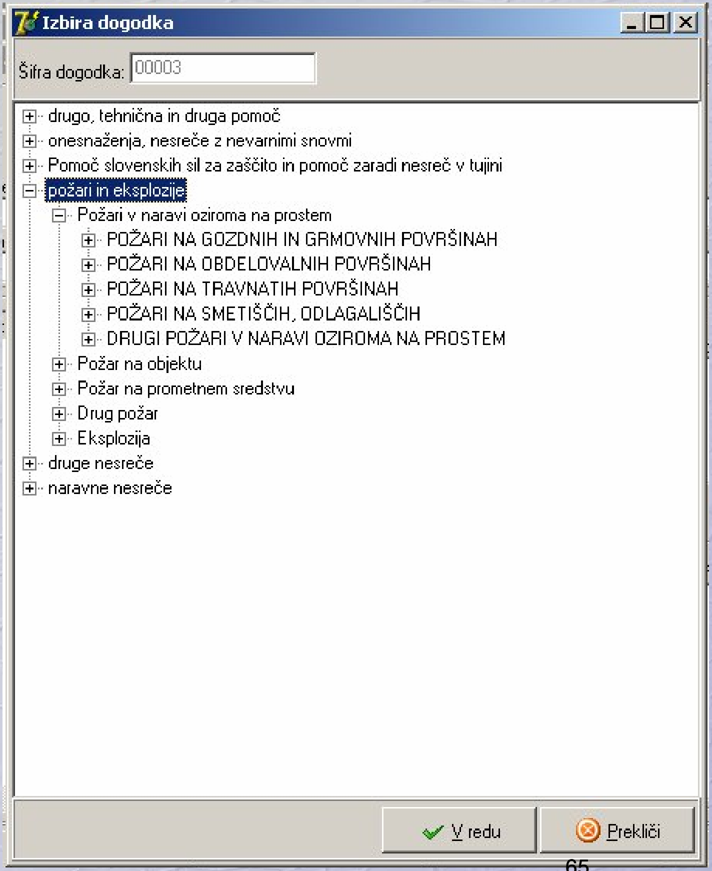
IMPACT




UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE
Emergency Management Planning, Recovery, Reconstruction, Info Presentation
Public
Planners
Rescue forces
Data administrators
GIS Tools
Spatial Data Management
Fire Threat
Prediction system
NevSnov
Dangerous Materials Safety DataSheet
BAZIR
Attribute Data Management
AU
Action Plan Management
eGIS_UJME
Spatial Data Presentation
Emergency Response Plans
Presentation
CBZIR
Attribute Data
GIS_UJME
Spatial data
Emergency center operators
SPU112
Emergency management support
GIS_UJME
Spatial Data Presentation and Analysis
ZAPP
Paging
ROK
Telephone calls
MOIS
Mobile Environmental IS
DUNJA
Public Alarming
SPIN
Emergency Incidents Reporting System
Event Management

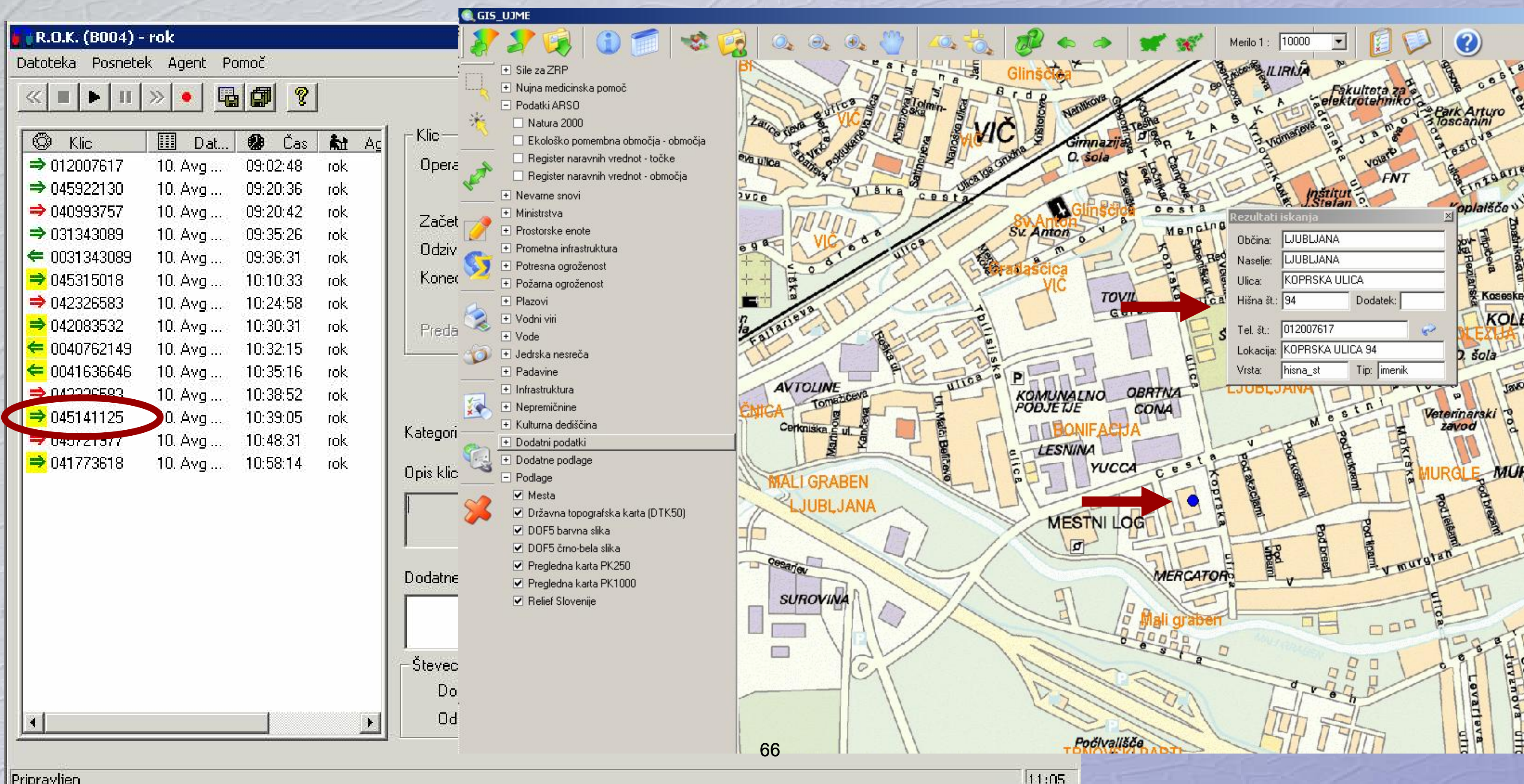
Event support – step 1

- Selection of type of event



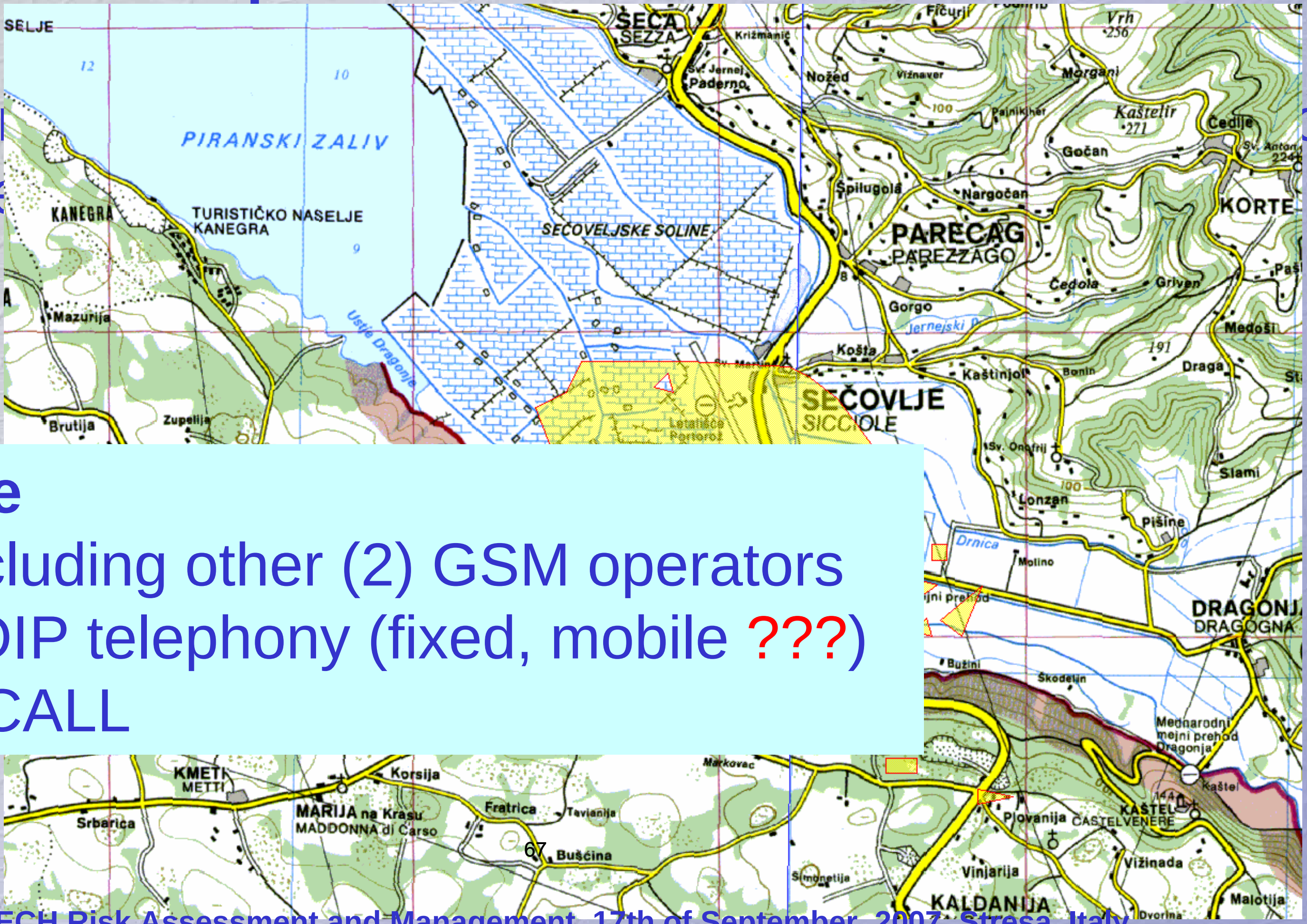
Event support – step 2

- Location of telephone call is presented in GIS



Event support – step 2

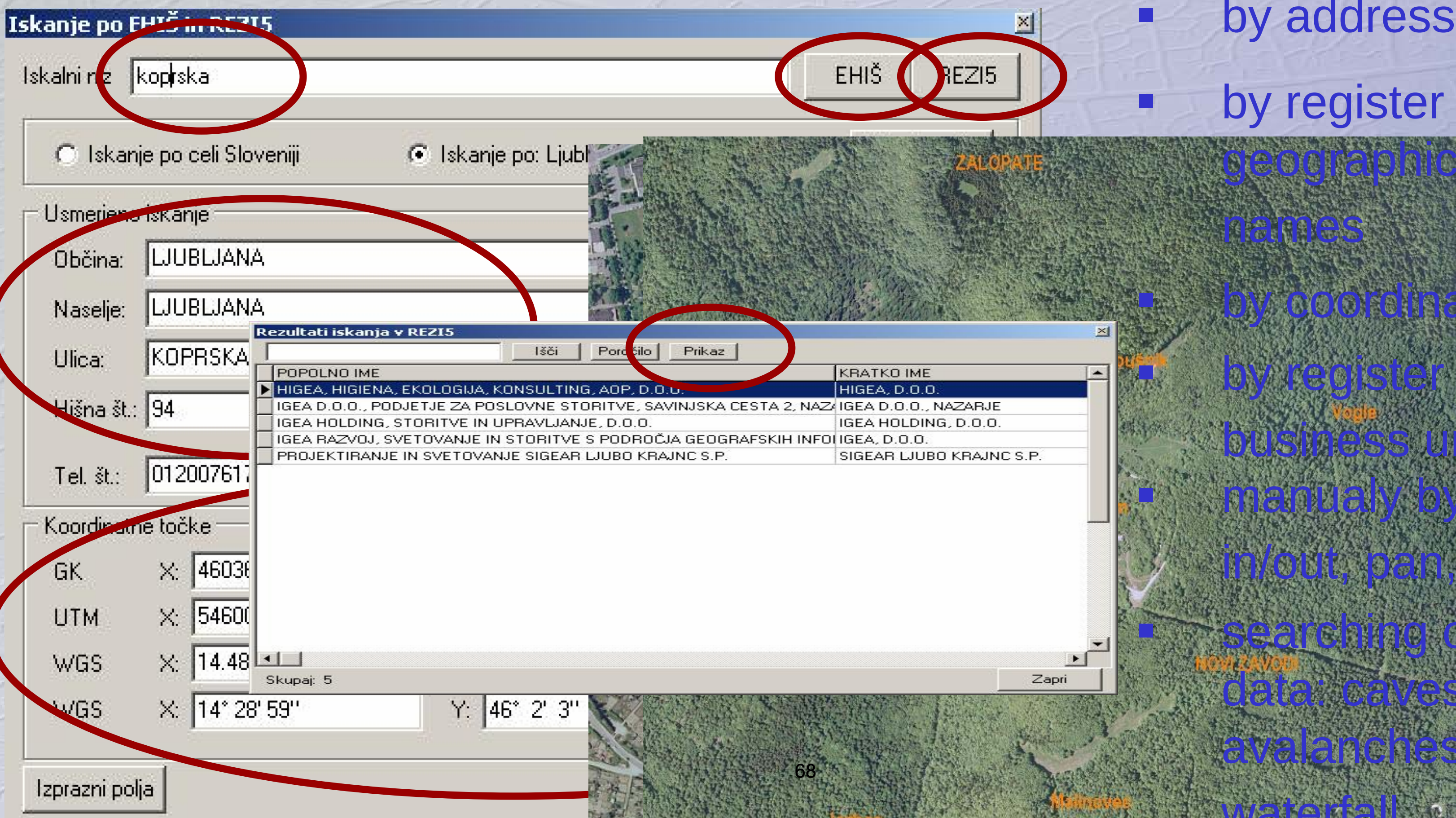
- **Location of telephone call status**
  - Impl
  - For … o the e



- **Future**
  - Including other (2) GSM operators
  - VOIP telephony (fixed, mobile ???)
  - e-CALL

Event support – step 2

- Other ways of finding location of an event



- by address
- by register of geographical names
- by coordinates
- by register of business units
- manualy by zoom in/out, pan, ...
- searching other data: caves, avalanches, ice waterfall, ...

Event support – step 3

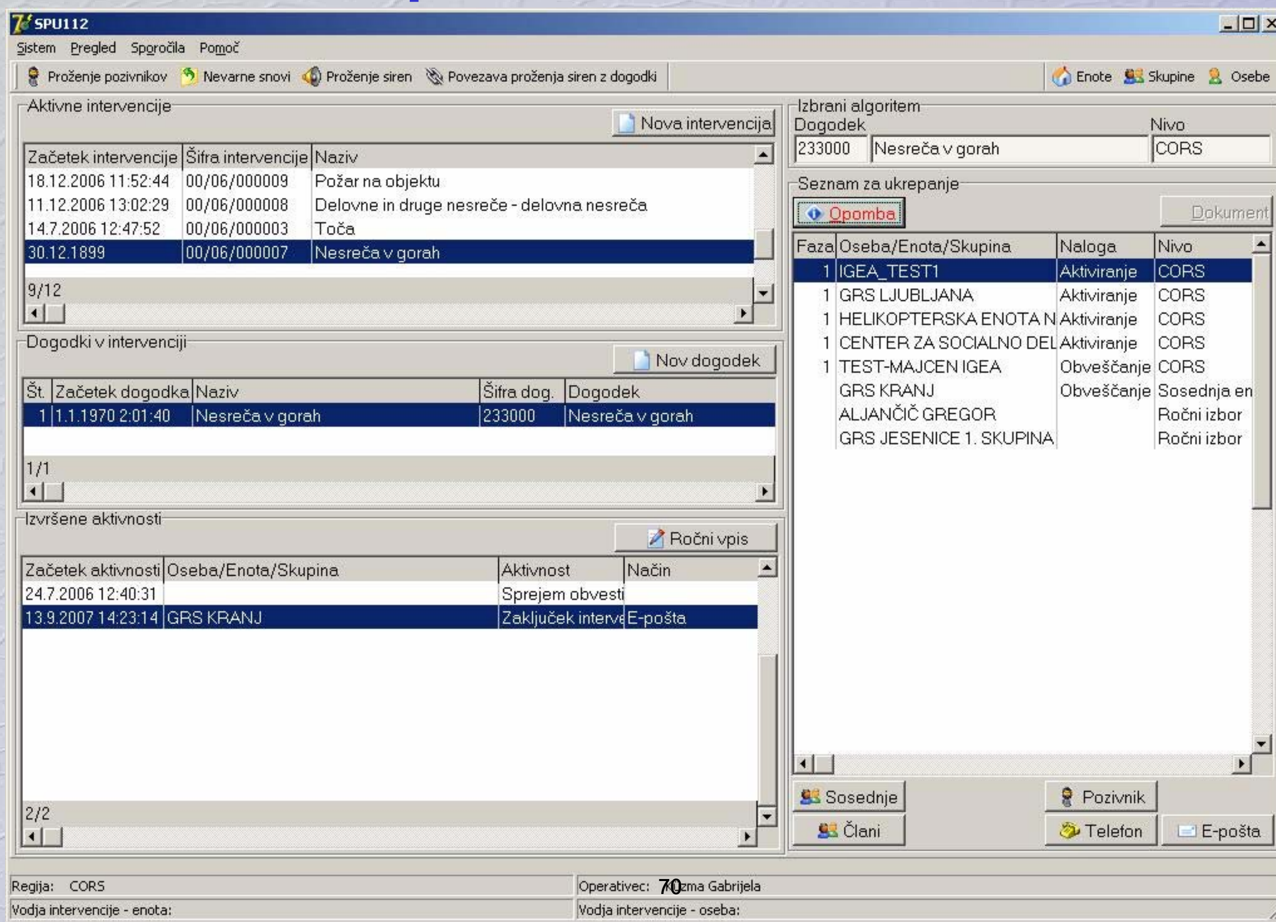
- **Selection of Action plan**
  - selection is done automatically in GIS based on location and type of event
  - search on base of coordinates (x,y) is done from low level area to top level area (local, municipality, region, state)

- **Selection of units responsible in this location**
- From general description to particular unit
- Selection automatically in GIS on the base of areas of responsibility
  - each type of rescue forces (territorial fire brigade, medical help units, municipalities, ...) is represented by GIS layer
  - unit is selected by geographic location (X,Y)

UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

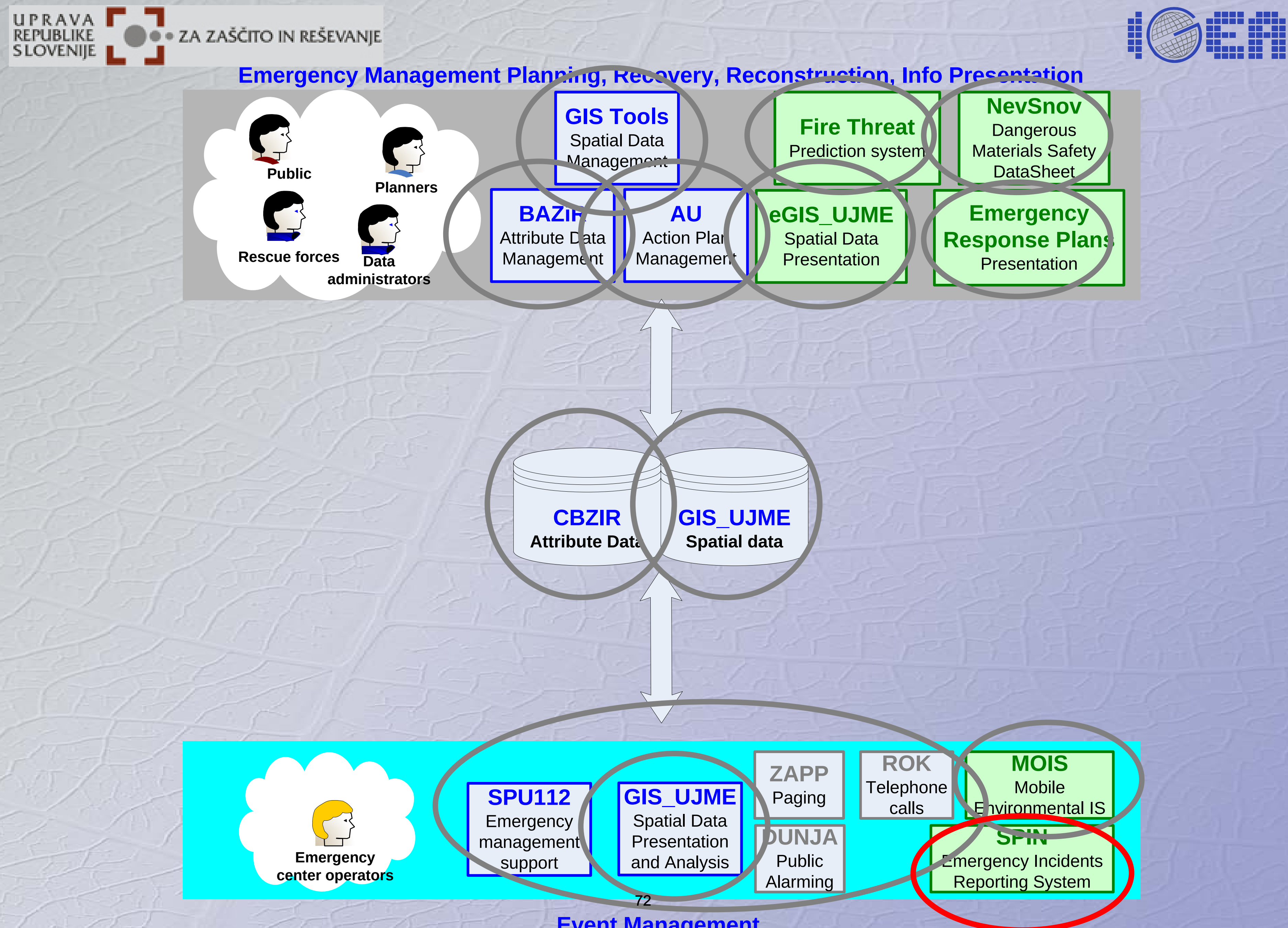
Event support – step 4

- List of units and person to activate/annonce



Event support - Future

- A new integrated information and communication system is in implementation
- Modernization of infrastructure:
  - New telephone centrals
  - Upgrade of radio communications
  - New computers (servers, workstations)
- New integrated SW for Emergency support – 3 displays
  - Communication console (telephone, radio, paging, alarming, SMS, fax,...)
  - Management of intervention (events, action plans, resources, ...)
  - GIS - existing solution will be integrated


UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE
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Public Alarming
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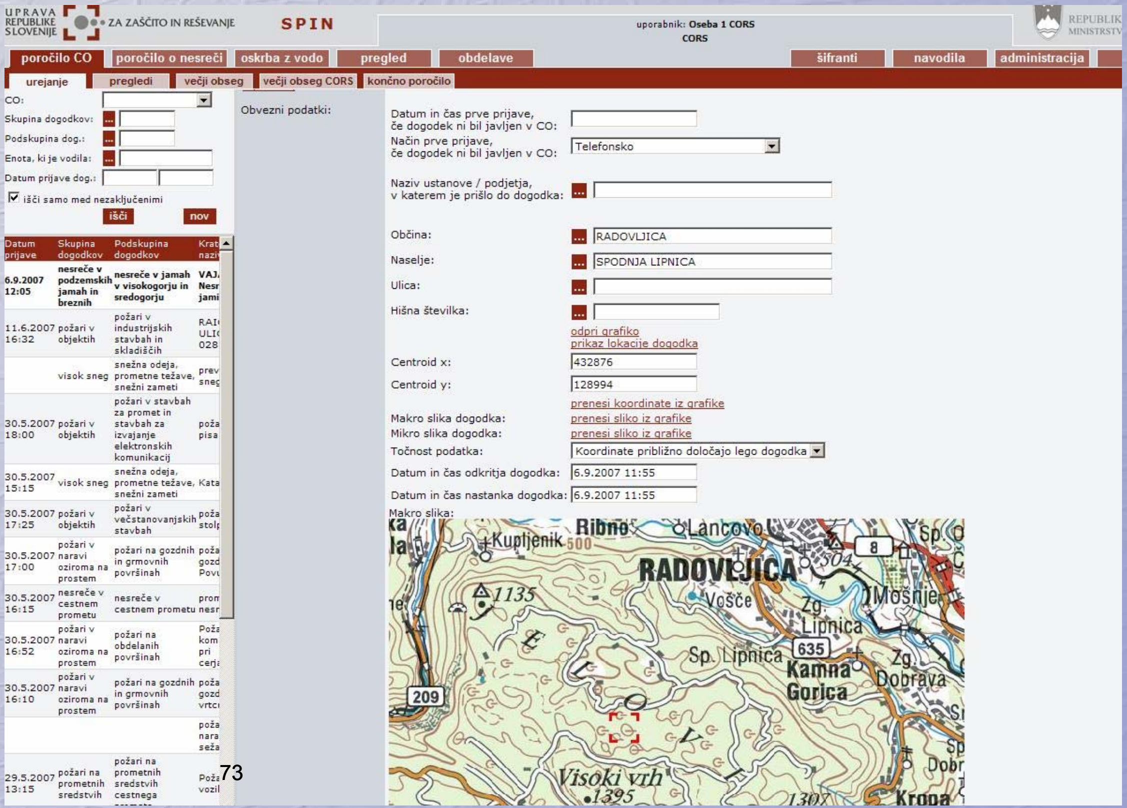
Emergency Incidents Reporting System
Event Management

UPRAVA REPUBLIKE SLOVENIJE ZA ZAŠČITO IN REŠEVANJE

Emergency Incident Reporting System

- **WEB aplication for report of interventions:**
  - 1st report after 2 hours; prepared by operators from Emergency centers
  - Final report, prepared by leader of intervenition (head of primary rescue unit)

- **Integrated with:**
  - **SPU112 -** System for Emergency Support – data source
  - **eGIS_UJME –** location of event



Thank you !

Questions !?

NATECH-Workshop, Stresa, 17.09.07 Germany

UBA-Research Project:

Protection of existing and planned establishments and installations against hazardous environmental impacts, especially flood

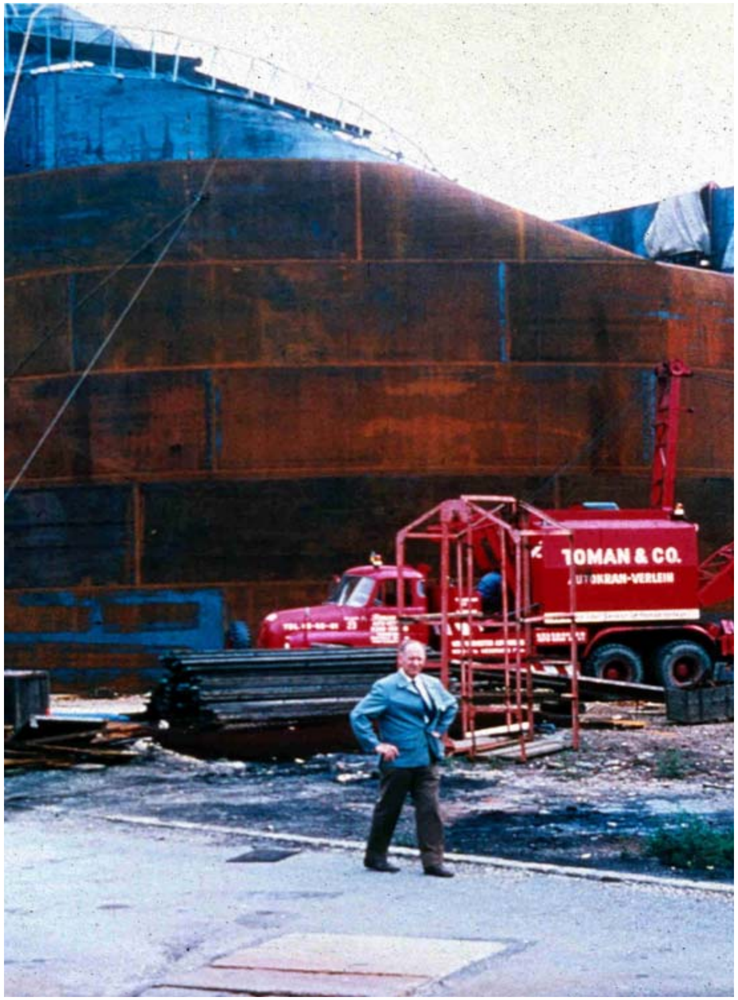
by
Dipl.-Ing. Hanns-Jürgen Warm
Dr. rer. nat. Karl-Erich Köppke

1. Background
2. Project Scope
3. Work Programme
4. Results
5. Next steps

1. Background:

(Flood in 2002)

UBA-Research Project 203 48 362: Establishments and Natural Hazards



Storm

Earthquake

1. Natural hazards are linked to the location of a site.
2. Natural hazards may cause several chemical accidents at the same time.
3. Possibilities of mitigation may be limited.
4. Data for the required risk analysis may be not available or reliable.
5. Kind and severity of natural hazards may be influenced by human activities - climate change.

2. Project Scope

1. Establishments according to the Seveso-Directive (96/82/EU)

→ floods, storms, earthquakes

2. installations containing substances hazardous to water

→ floods

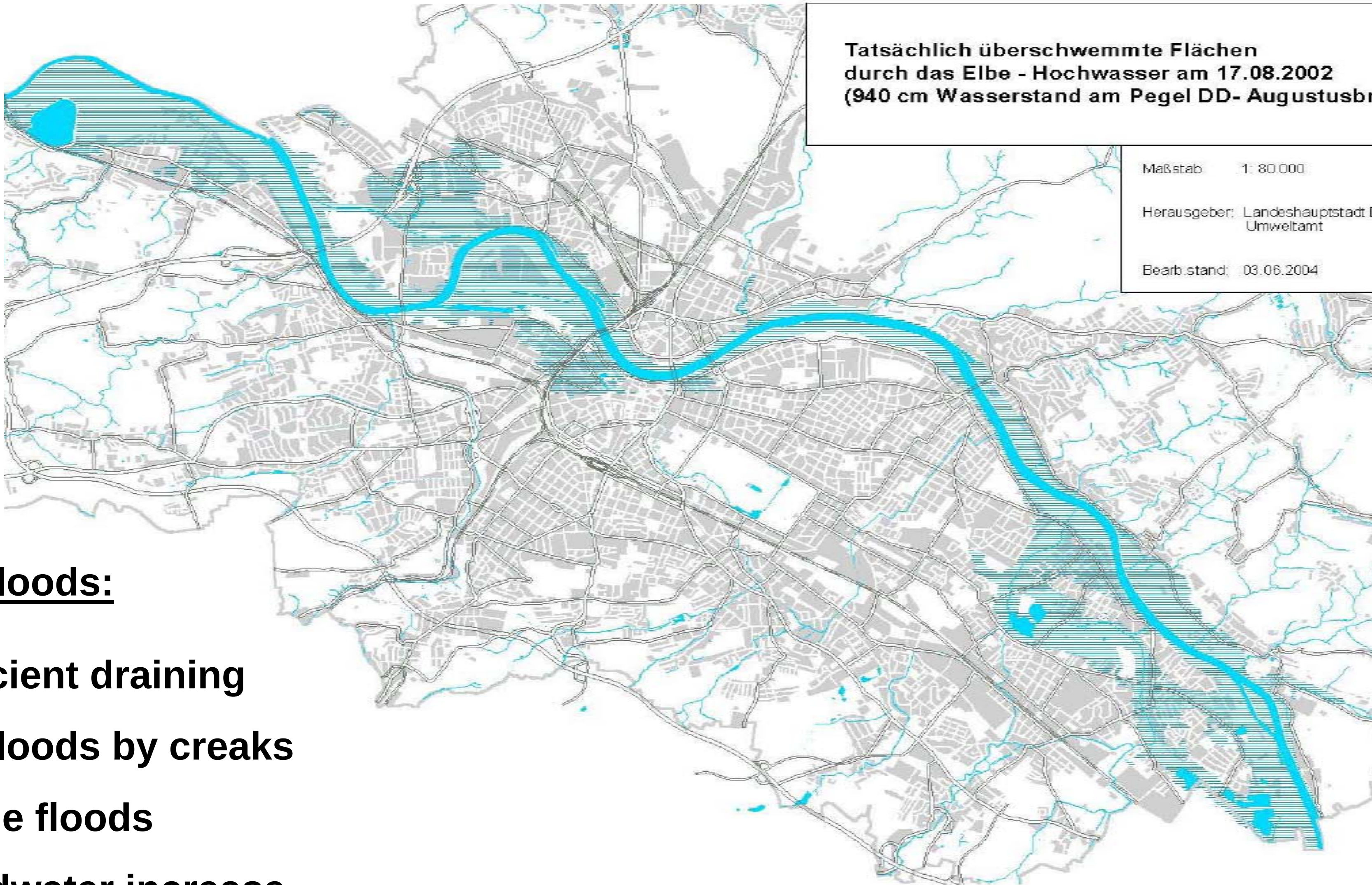
3. installations for storage of extremely flammable gases in vessels

→ floods

3. Work Programme (Floods):

1. an evaluation of the existing legal and technical requirements
2. a survey on the flood risk management at establishments and installations in the catchments areas of the Rhine and the Elbe,
3. a description of flood risk mapping approaches
4. a description of available flood protection and safety technology
5. a discussion of emergency planning requirements
6. recommendations

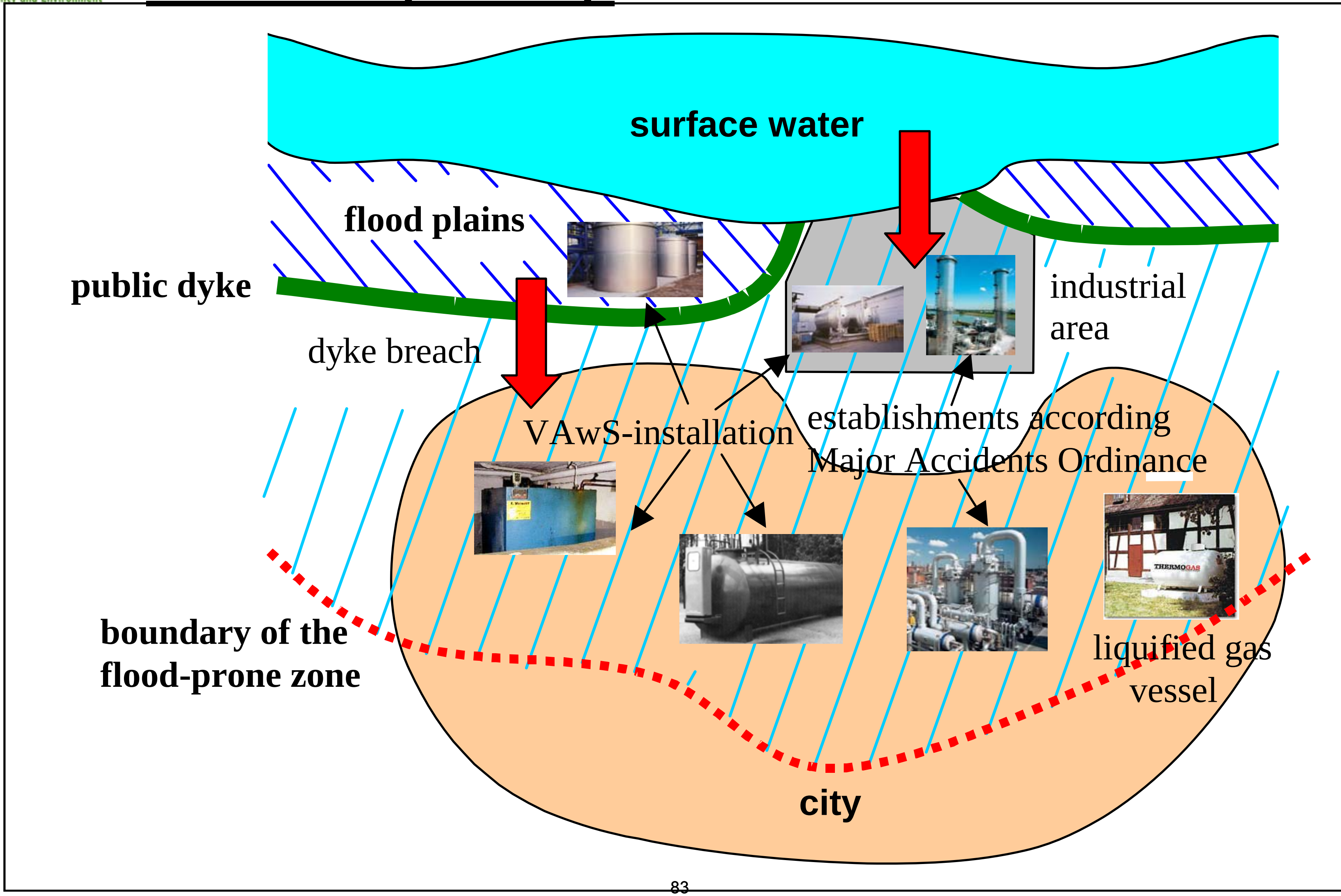
4. Results (Floods):



Types of floods:

1. **Insufficient draining**
2. **Flash floods by creaks**
3. **Riverine floods**
4. **Groundwater increase**

4. Results (Floods):



4. Results (Floods):

1. Flood protection requirements in technical rules are insufficient
2. Operators of establishments have to protect their sites.
3. An obligation for that should be added to the MA-Ordinance.
4. This protection should be equivalent to that of the dykes close to the site.
5. Existing recommendations on flood protection of installations in flood plains have to be made legal requirements.
6. Equivalent obligations need to be defined for flood prone zones.
7. Both types of requirements need to be enforced.
8. Operators of establishments need to consider flood risks in their safety concepts, safety reports and emergency plans.
9. Guidance should be provided for that.
10. More research is needed on the effects of climate change on establishments.

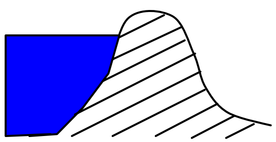
4. Results (Floods):

classes: A, B, C, D

increasing risk potential

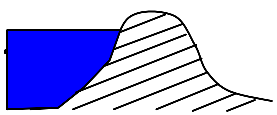
$HQ_{100 \text{ and higher}}$

state-of-the-art of flood protection



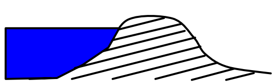
installations with risk potential class D

HQ_{50} -



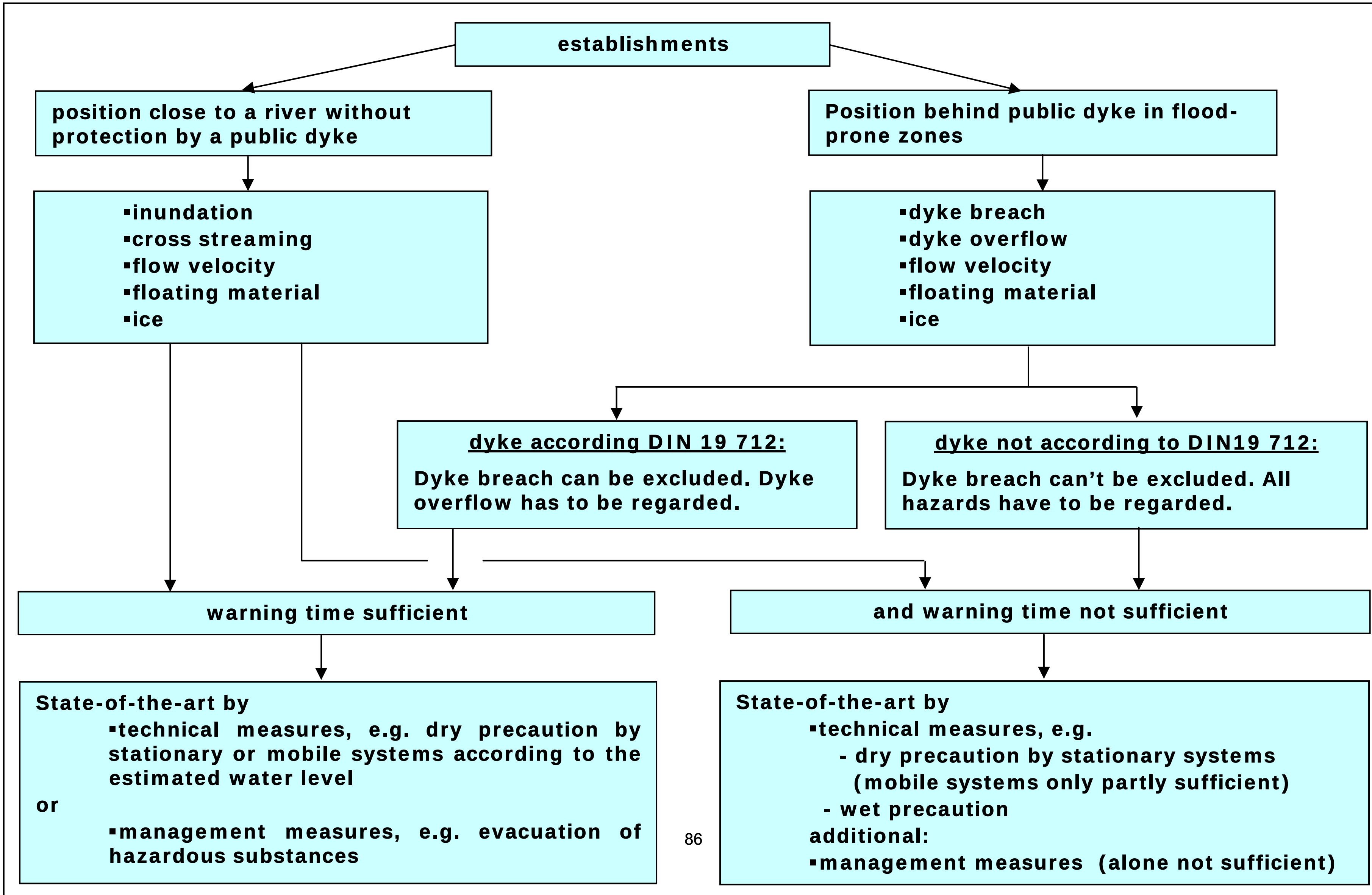
installations with risk potential class B, C, D

$HQ_{<50}$



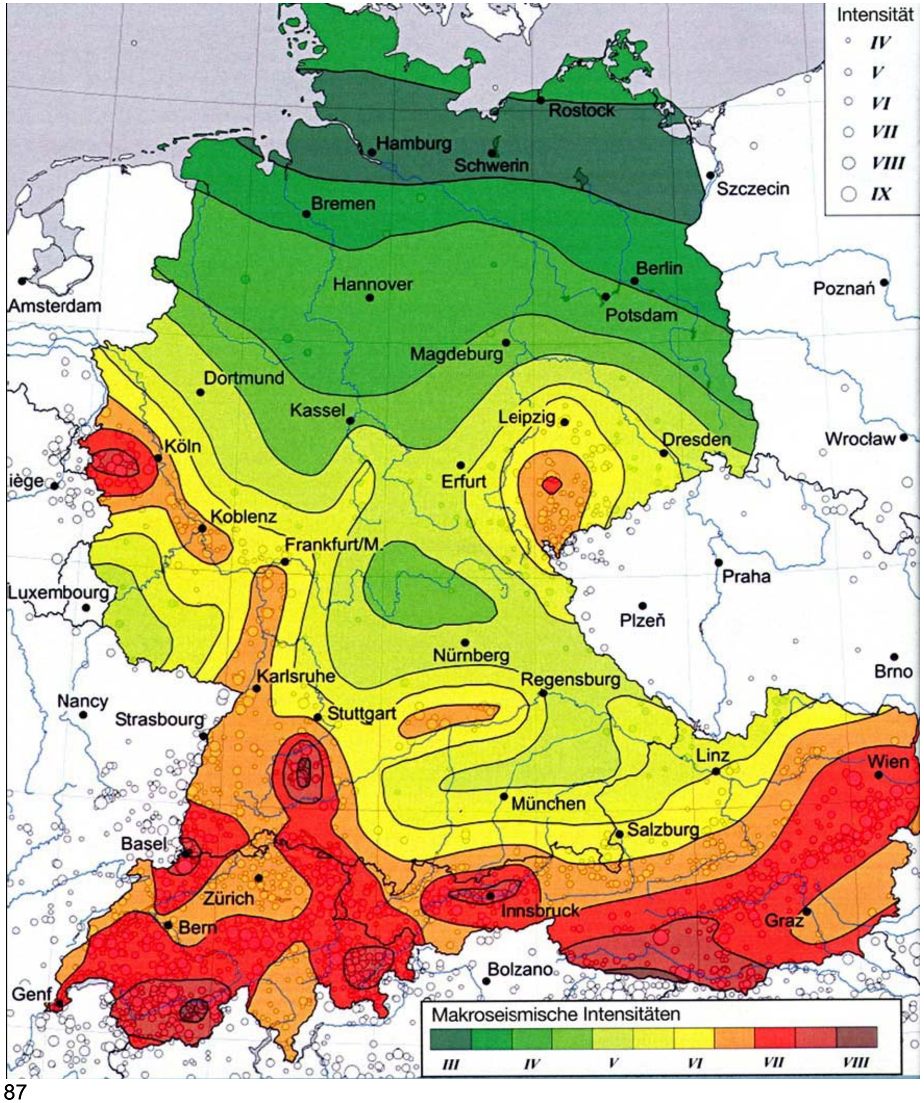
installations with risk potential class A, B, C, D

4. Results (Floods):



4. Results (storms and earthquakes):

DIN 1055-4 2005 (wind)



DIN 4149 2005 (earthquakes)

4. Results (storms and earthquakes):

Technical safety deficits:

1. Conceptional difficulties in the evaluation of combined risks, e.g. construction risk in combination with operational risks due to the presence of hazardous substances.

2. Not suitable protection aim of DIN 4149 (Constructions in German earthquake prone areas) i.e. personal security; in the case of an earthquake considerable plastic deformations can be tolerated according to DIN 4149, which, however, could cause releases in the environment at installations.

3. The favored layout methodology of DIN 4149 is not suitable for installations (answer response methodology combined with not suitable recommened safety measures: seismic resilient design of building structures).

4. DIN 1055-4 includes a frequently inappropriate assessment of storm hazards caused by interferences resulting from the surroundings topology.

5. DIN 1055-4 does not consider rare effects i.e. tornados, DIN 4149 does not consider soil liquefraction.

6. Not suitable risk criteria e.g. the design storm in DIN 1055-4 is a storm once in 50 years.

4. Results (storms and earthquakes):

Technical safety deficits:

7. DIN 1055-4 and DIN 4149 are therefore not suitable for installations in establishments.
8. Load combinations defined by the underlying DIN 1055-100 for the layout of structures are not sufficient for industrial installations (e.g. no combination of snow and storm required).
9. The seismic vulnerability for most establishments and installations located in German earthquake prone areas is unkown.
10. A regulation on emergency management requirements

    a) after an earthquake
    b) in advance, in case and after storms

    is missing.

4. Results (storms and earthquakes):

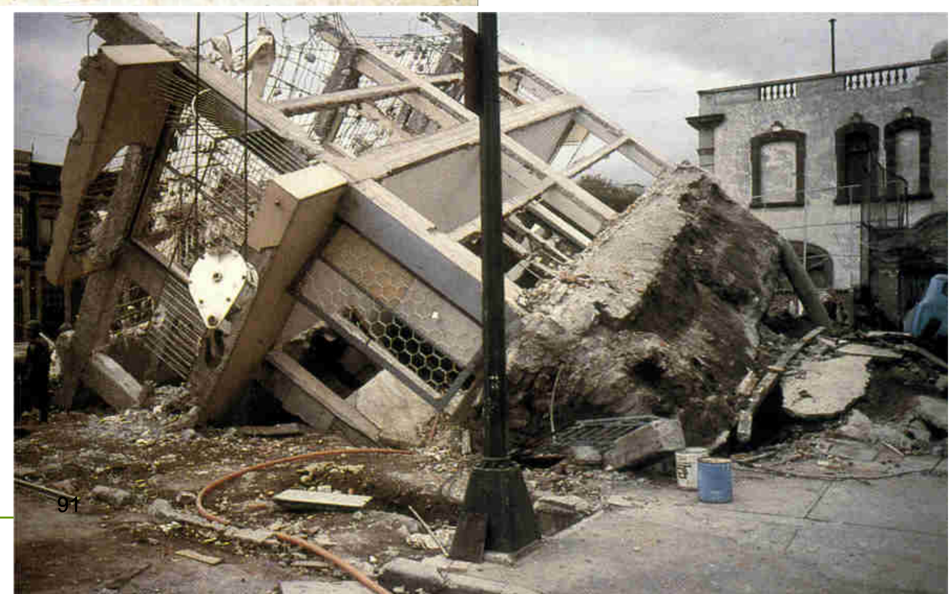
Safety deficits in the licensing proceedures:

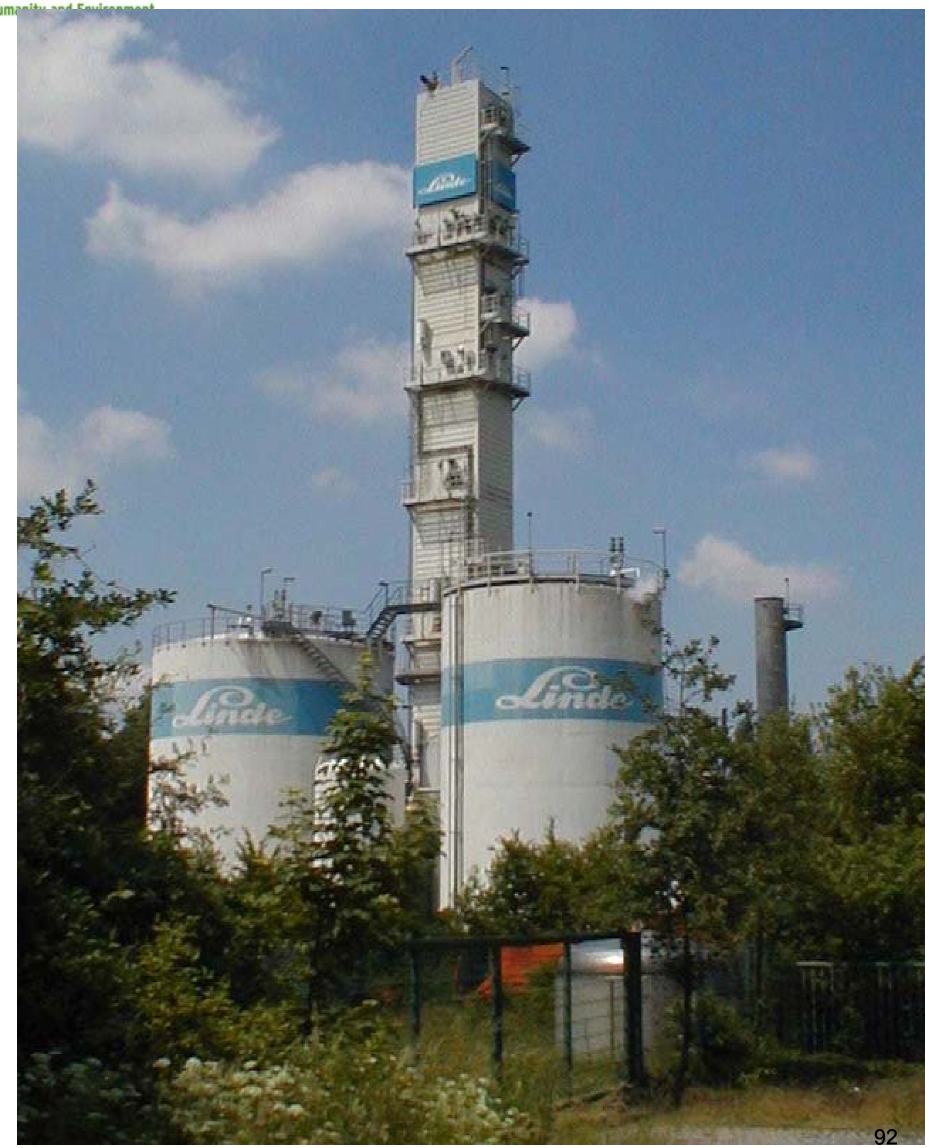
1. construction standards with different state-of-the-art.
2. construction safety deficits caused in the issue of environmental permits (insufficient consideration of the German building regulations for installations).
3. systemic safety deficits in the licensing procedure according to BImSchG like missing consideration of the official expertises on construction safety in the official expertises on installation safety as well as the safety reports according to the Major Accidents Ordinance.
4. insufficient knowledge about protection aims and construction standards in the frame of BImSchG permissions, especially relevant for establishments according to the Major Accidents Ordinance.
5. insufficient information exchange between process engineers and civil engineers during the planning and examination process for installations and establishments.

4. Results (storms and earthquakes):

Plastical deformation is allowed for the adsorption of energy

Soil liquefraction on wet sediments which are considered as low risk ground in DIN 4149





Air liquefaction plant in an earthquake prone zone

The tower was considered as „installation“ and not as „building“:

➔ No check of the structural design in the licensing proceedure!

5. Next steps (?):

1. Research project on the fundamentals for a Technical Rule „Wind and Earthquakes“ for establishments (2008 – 2009)

2. Guidance for safety concepts, safety reports and emergency plans for the consideration of floods, storms and earthquakes

3. Research project on the possible effects of climate change on establishments (???)

4. Resarch project on seismic resilient design and construction of **installations** (???)

Thank you
for your attention!

Roland Fendler

roland.fendler@uba.de

www.umweltbundesamt.de

Natural Disasters – External Hazard Sources for Major Accident Sites in Austria

Michael Struckl

Federal Ministry for Economics and Labour, Austria

NATECH Workshop

Stresa, Italy, September 2007ber 17 - 18

Situation

- 134 industrial sites with major accident potential
- Major accident potential defined by the EU – Seveso II – Directive (exceeding thresholds of hazardous substances)
- Various permit procedures (environmental, planning, industrial etc.)
- Specific requirement from Seveso II: „take all necessary measures“ – demonstrated by a safety report (or similar document)

External Hazard Sources

- Tradition of compliance with Seveso since 1991
- „External hazard sources“ shall be taken into account
- External hazard sources:
  - ➢ Neighbouring establishments
  - ➢ Traffic infrastructure in the vicinity
  - ➢ Cut of public supply (electricity, gas, water etc.)
  - ➢ Natural hazard sources
  - ➢ No external hazard sources: intentional acts

Specific Sources

- Floods
- Lightning
- Earthquakes
- Loads (wind, snow)
- Avalanches
- Landslides, sudden surface change

Assessment

- Avalanches: no relevance (no sites in possibly affected areas)
- Loads: taken into account in building codes (deterministic procedure – predefined values)
- Lightning: appropriate protection measures defined deterministically; no site-specific, only technology-specific assessment
- Land slides, surface changes: brief qualitative assessment (no old mining area, no other indicators)

Assessment (2)

- Earthquakes: 3 regions with higher earthquake likelihood, theoretically it should be considered specifically, in practice assumption that there is sufficient protection by building codes
- Floods: most relevant source, many sites in flood areas of Austrian rivers or in potential “flash-flood” areas of creeks in mountain areas – but during the recent floods in 2003, 2005 and 2007 no damage with severe consequences

Assessment (3)

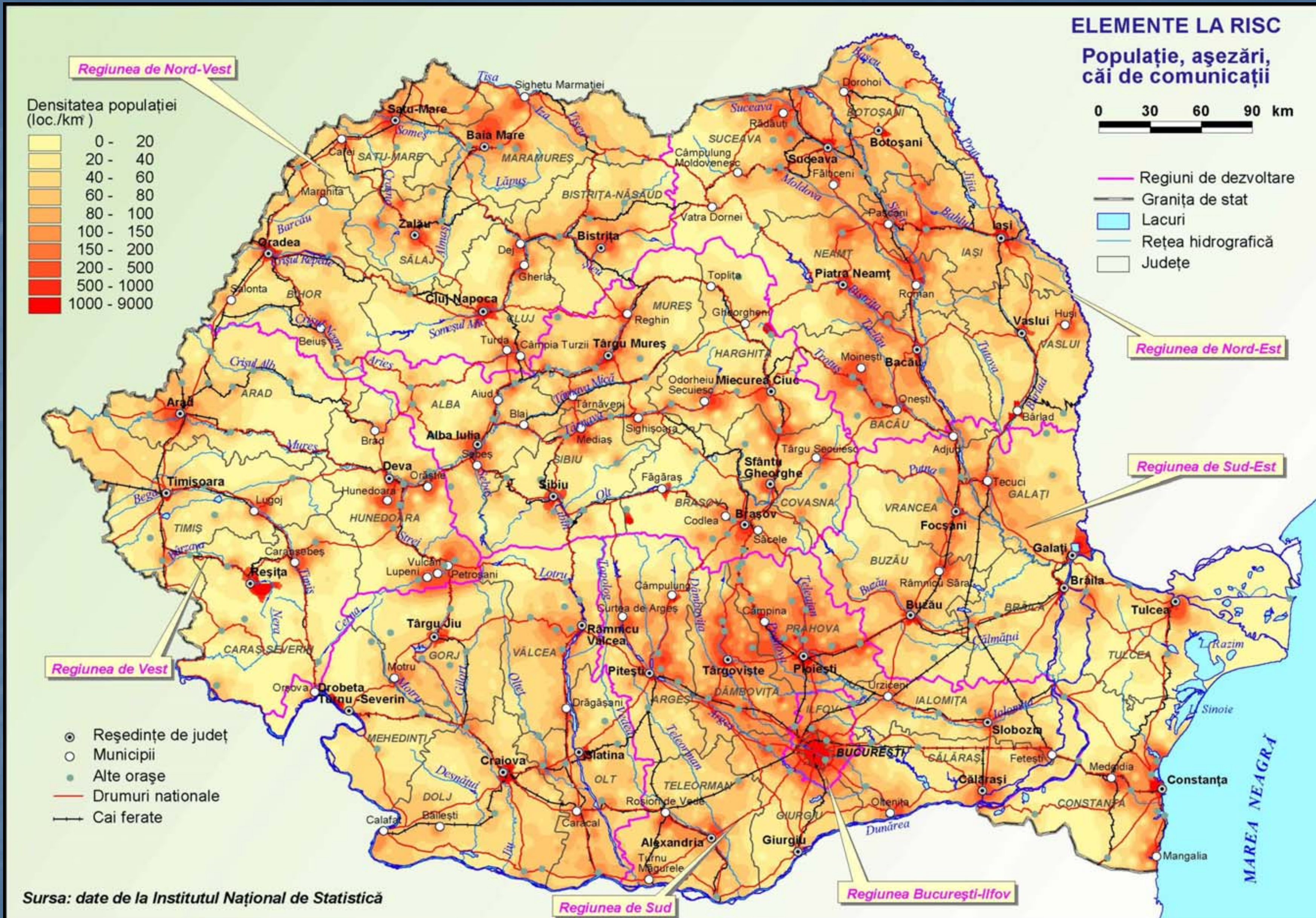
- Floods: Only hazard type with explicit quantitative assessment
- Legislation defines 10^{-2} – events as borderline for “normal” flood protection (requires land use planning restrictions, dam measures etc.)
- Most industrial major hazard sites are well beyond, safety reports indicate a 10^{-4} – flood to represent a concern, more likely floods do not pose a risk (because of the actual siting or existing measures)

Summary

- Tradition in Austria of quantitative assessment only in flood protection
- Other natural hazard sources: “hidden” quantitative assessment in building codes, load assumptions or protection measures defined deterministically combined with precautionary principle
- Quantitative risk communication avoided – legislation/jurisdiction want “fixed” values defined by law (like in the case of flood protection)

LESSONS LEARNT FOLLOWING NATECH EVENTS IN ROMANIA DUE TO CLIMATIC CHANGES

Prof. dr.ing. Alexandru **OZUNU**
Prof. dr. Serban **VLAD**
Septimiu **MARA**
Babes-Bolyai University
Cluj-Napoca, Romania


ELEMENTE LA RISC
Populație, așezări, căi de comunicații
0 30 60 90 km
Densitatea populației (loc./km²)
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 150
150 - 200
200 - 500
500 - 1000
1000 - 9000
Regiuni de dezvoltare
Granița de stat
Lacuri
Rețea hidrografică
Județe
Reședințe de județ
Municipii
Alte orașe
Drumuri nationale
Cai ferate
Regiunea de Nord-Vest
Regiunea de Nord-Est
Regiunea de Sud-Est
Regiunea de Vest
Regiunea de Sud
Regiunea București-Ilfov
MAREA NEAGRĂ
Sursa: date de la Institutul Național de Statistică

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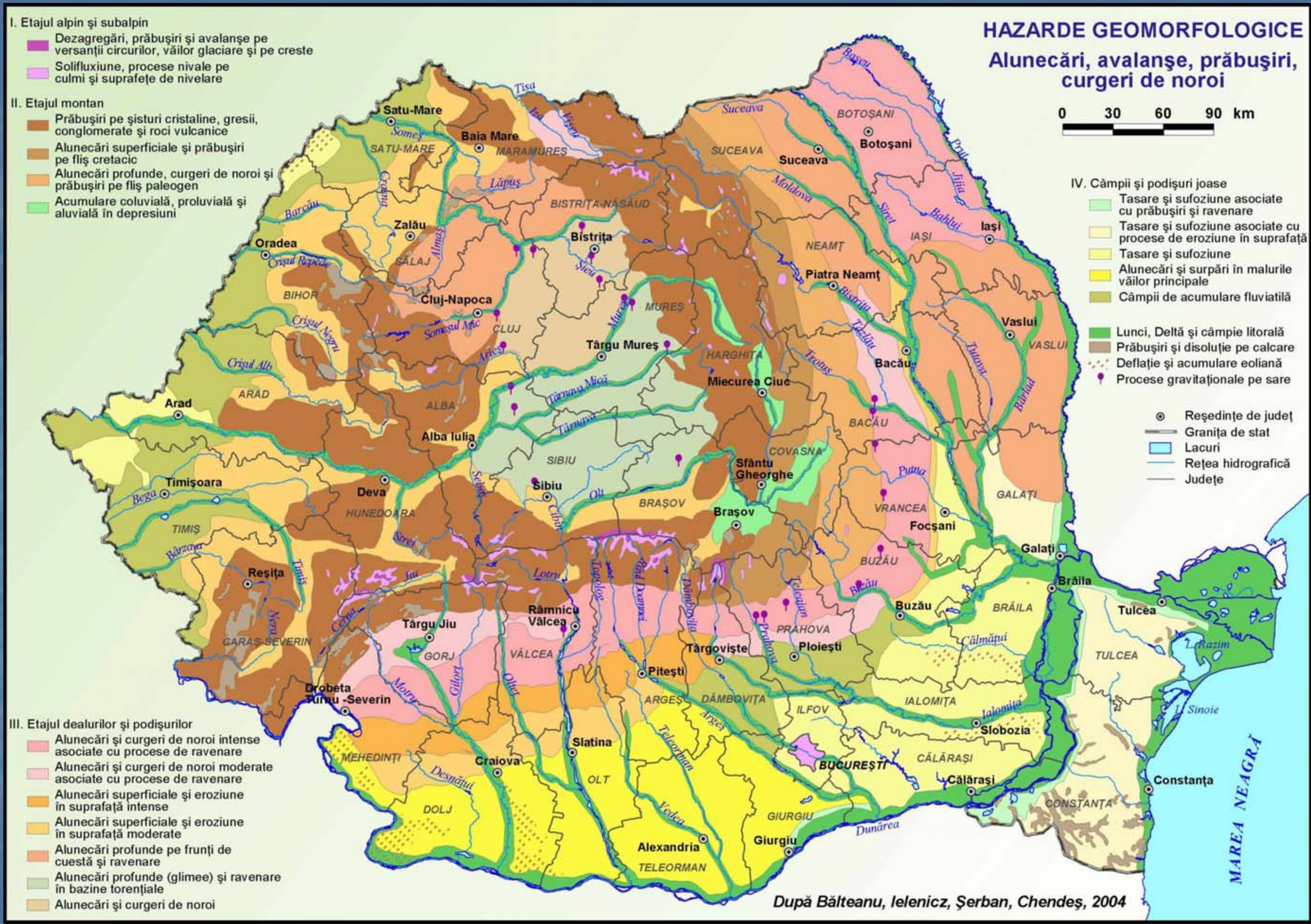
HAZARDE GEOMORFOLOGICE
Alunecări, avalanşe, prăbuşiri, curgeri de noroi
0 30 60 90 km
I. Etajul alpin şi subalpin
Dezagregări, prăbuşiri şi avalanşe pe versanţii circurilor, văilor glaciare şi pe creste
Solifluxiune, procese nivale pe culmi şi suprafeţe de nivelare
II. Etajul montan
Prăbuşiri pe şisturi cristaline, gresii, conglomerate şi roci vulcanice
Alunecări superficiale şi prăbuşiri pe fliş cretacic
Alunecări profunde, curgeri de noroi şi prăbuşiri pe fliş paleogen
Acumulare coluvială, proluvială şi aluvială în depresiuni
III. Etajul dealurilor şi podişurilor
Alunecări şi curgeri de noroi intense asociate cu procese de ravenare
Alunecări şi curgeri de noroi moderate asociate cu procese de ravenare
Alunecări superficiale şi eroziune în suprafaţă intense
Alunecări superficiale şi eroziune în suprafaţă moderate
Alunecări profunde pe frunţi de cuestă şi ravenare
Alunecări profunde (glimee) şi ravenare în bazine torenţiale
Alunecări şi curgeri de noroi
IV. Câmpii şi podişuri joase
Tasare şi sufoziune asociate cu prăbuşiri şi ravenare
Tasare şi sufoziune asociate cu procese de eroziune în suprafaţă
Tasare şi sufoziune
Alunecări şi surpări în malurile văilor principale
Câmpii de acumulare fluviatilă
Lunci, Deltă şi câmpie litorală
Prăbuşiri şi disoluţie pe calcare
Deflaţie şi acumulare eoliană
Procese gravitaţionale pe sare
Reşedinţe de judeţ
Graniţa de stat
Lacuri
Reţea hidrografică
Judeţe
MAREA NEAGRĂ
După Bălteanu, Ielenicz, Şerban, Chendeş, 2004

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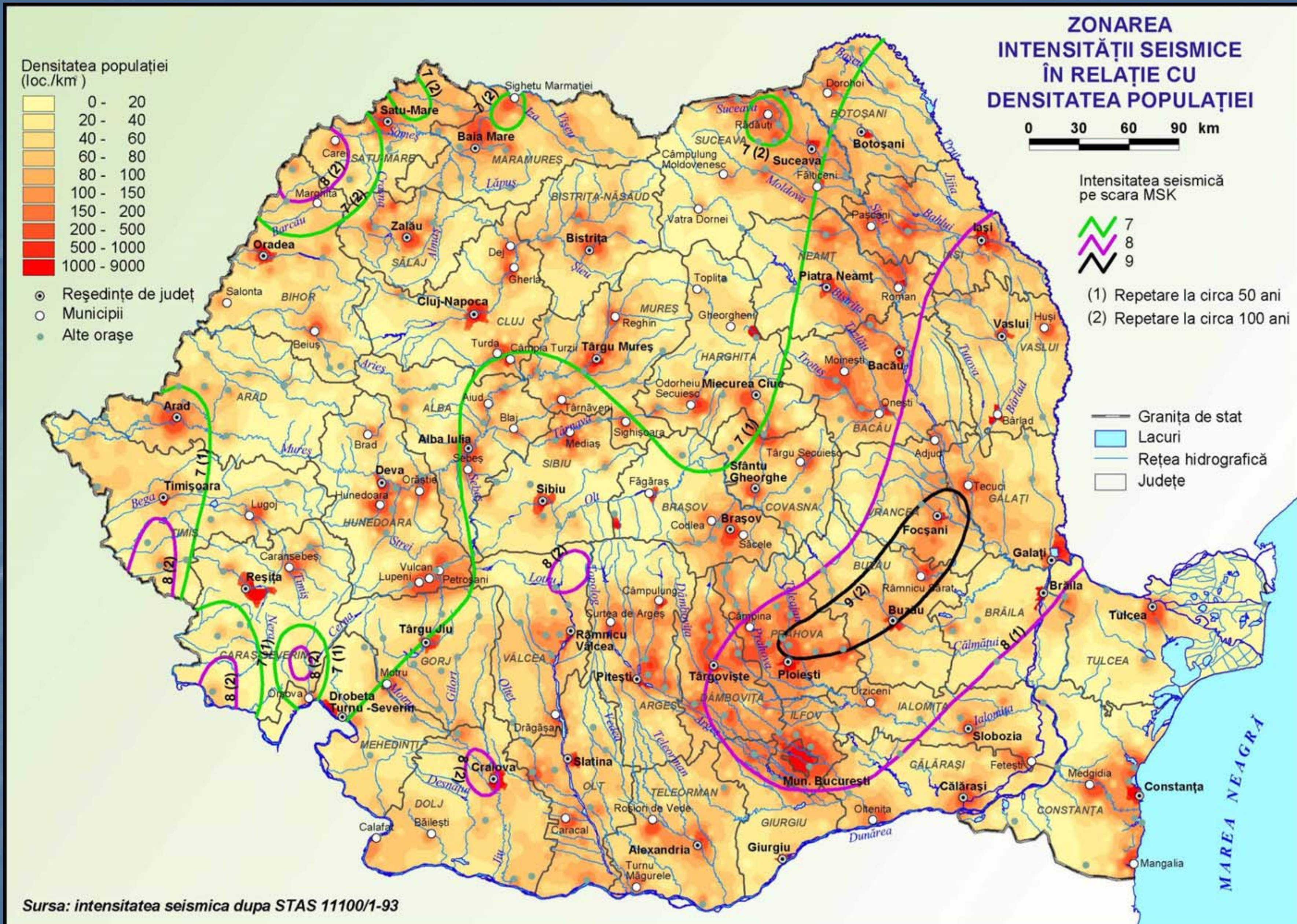
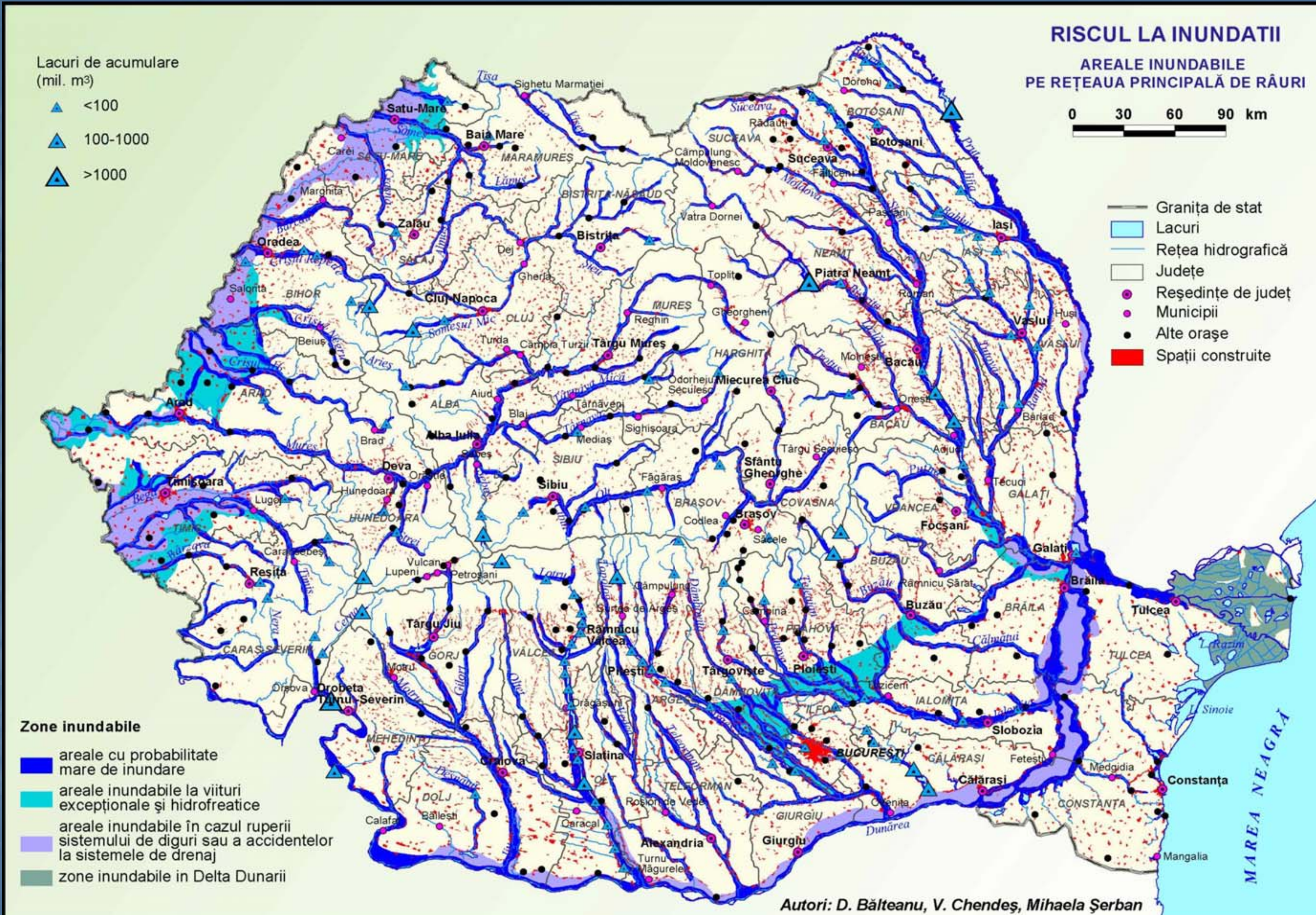

ZONAREA INTENSITĂȚII SEISMICE ÎN RELAȚIE CU DENSITATEA POPULAȚIEI
0 30 60 90 km
Densitatea populației (loc./km²)
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 150
150 - 200
200 - 500
500 - 1000
1000 - 9000
Reședințe de județ
Municipii
Alte orașe
Intensitatea seismică pe scara MSK
7
8
9
(1) Repetare la circa 50 ani
(2) Repetare la circa 100 ani
Granița de stat
Lacuri
Rețea hidrografică
Județe
MAREA NEAGRĂ
Sursa: intensitatea seismica dupa STAS 11100/1-93

106


RISCUL LA INUNDATII
AREALE INUNDABILE
PE REȚEAUA PRINCIPALĂ DE RÂURI
0 30 60 90 km
Lacuri de acumulare
(mil. m3)
<100
100-1000
>1000
Granița de stat
Lacuri
Rețea hidrografică
Județe
Reședințe de județ
Municipii
Alte orașe
Spații construite
Zone inundabile
areale cu probabilitate mare de inundare
areale inundabile la viituri excepționale și hidrofreatice
areale inundabile în cazul ruperii sistemului de diguri sau a accidentelor la sistemele de drenaj
zone inundabile in Delta Dunarii
MAREA NEAGRĂ
Autori: D. Bălteanu, V. Chendeş, Mihaela Şerban

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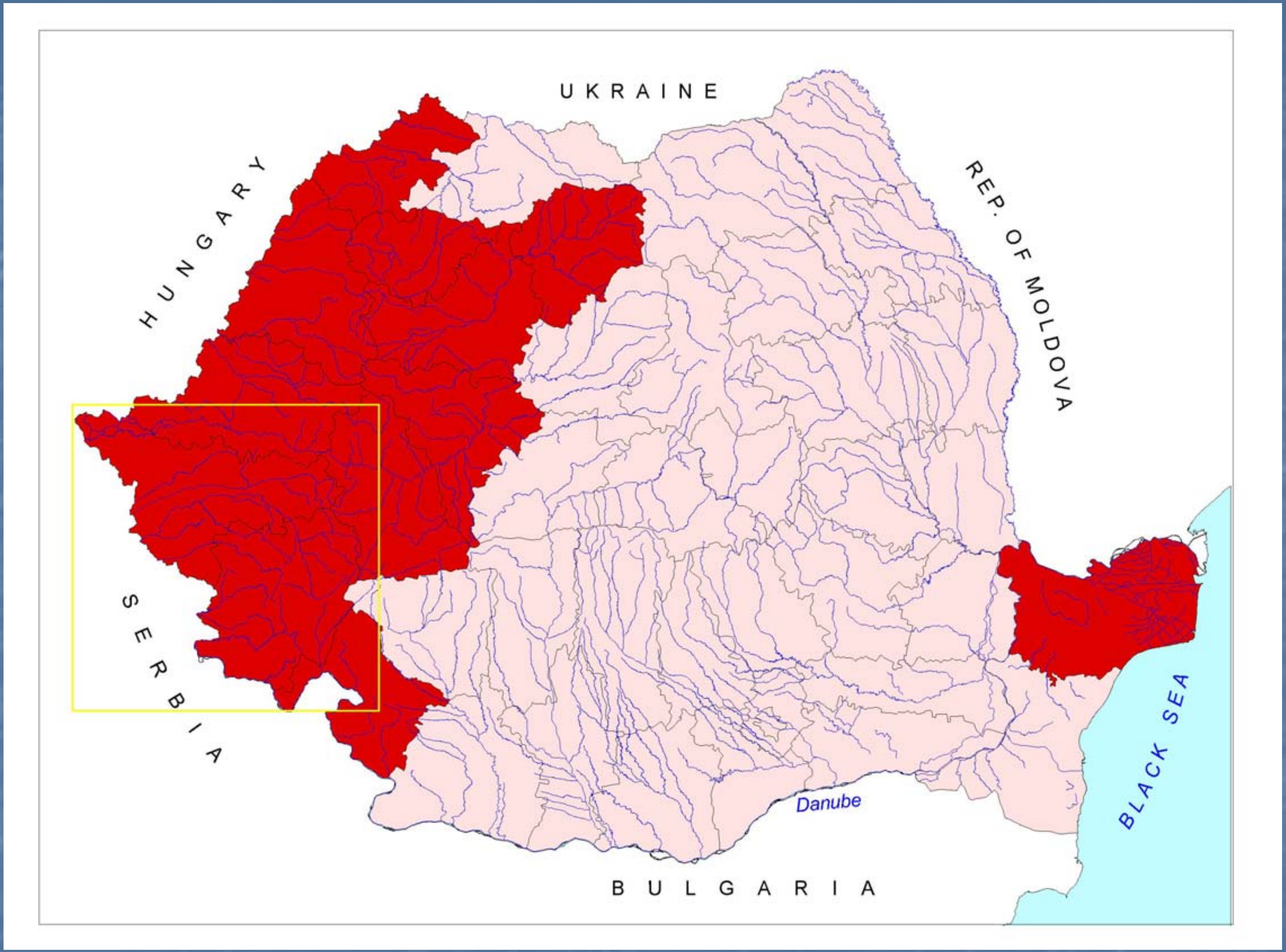

Foods: April, 2005

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Impact of the climate change over the hydro-meteorological regime in Romania over the last years

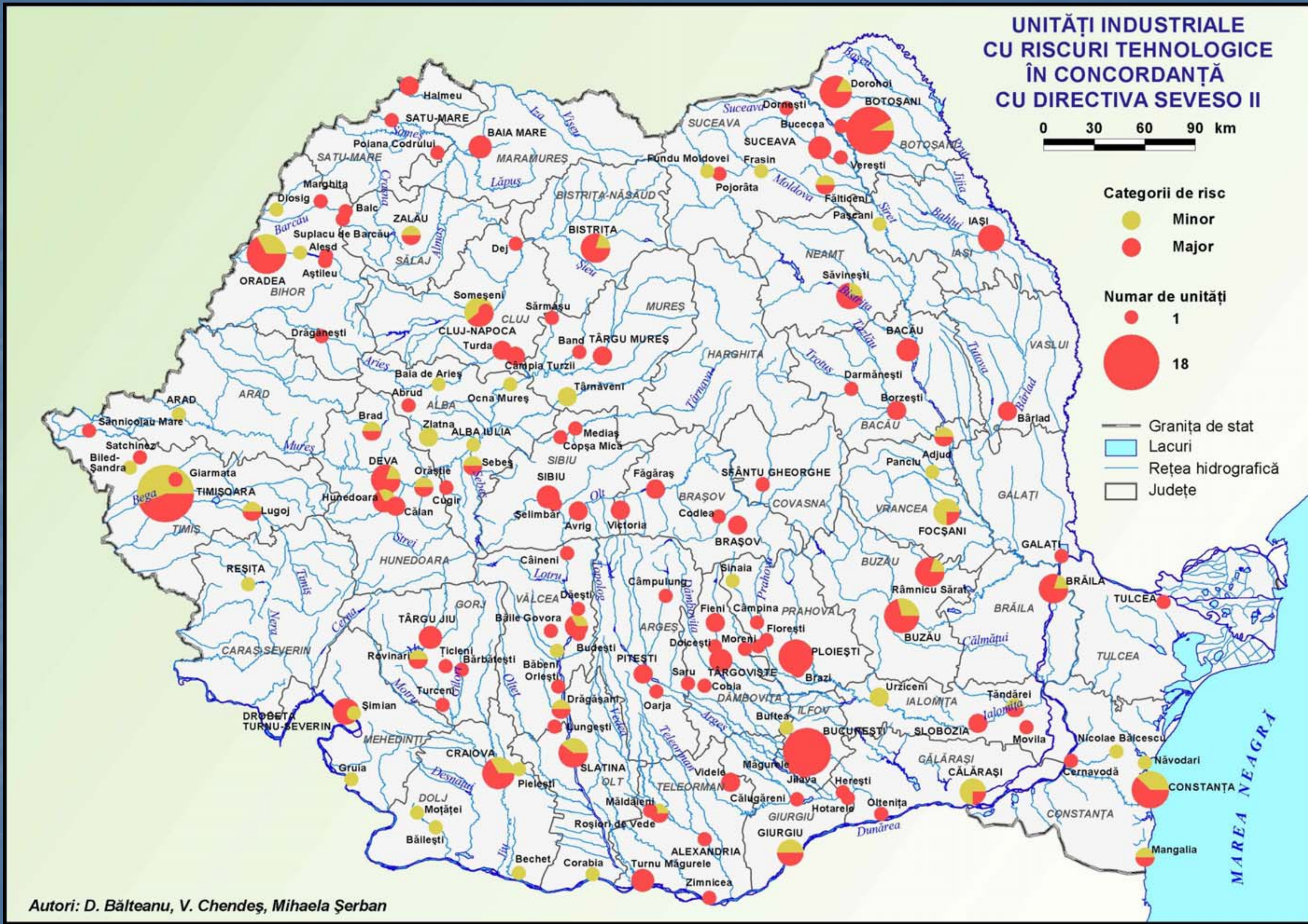
- Extreme rainfalls of 70-200 l/m^2, in many places around Romania;
- Extreme rainfalls over a long period of time (2-3 days);
- Dams and ponds failure due to high water pressure;
- Snow melt over a short period of time due to climate warming.

National level consequences

- 35 counties affected by floods
- 882 towns and villages flooded
- 76 deceases
- Aprox. 13500 persons evacuated
- More then 38000 households were affected, (3500 distroyed)
- 590500 hectars (5900 square kilometers) flooded
- 540 km national roads, 980 km county roads and 1200 km streets flooded
- More then 50 km railways affected
- 1400 bridges affected, of which 34 were distroyed
- 1,8-2 billions EURO estimated losses

Major hazards for NATECH events in Romania

- **Natural:**
  - – Landslides, mudflows and falls
  - – Avalanches
  - – Erosion
  - – Flash floods
  - – Floods
- **Complex:**
  - – Earthquake induced hazards


UNITĂȚI INDUSTRIALE
CU RISCURI TEHNOLOGICE
ÎN CONCORDANȚĂ
CU DIRECTIVA SEVESO II
0 30 60 90 km
Categorii de risc
Minor
Major
Numar de unități
1
18
Granița de stat
Lacuri
Rețea hidrografică
Județe
Autori: D. Bălteanu, V. Chendeș, Mihaela Șerban
Halmeu
SATU-MARE
BAIA MARE
Polana Codrului
SATU-MARE
MARAMUREȘ
Marghita
Diosig
Balc
ZALĂU
Suplacu de Barcău
Aleșd
Aștileu
ORADEA
BIHOR
SĂLAJ
Dej
BISTRIȚA
BISTRIȚA-NĂSĂUD
Someșeni
Sărmașu
CLUJ
CLUJ-NAPOCA
Turda
Câmpia Turzii
Band
TÂRGU MUREȘ
MUREȘ
Drăgănești
Baia de Arieș
Abrud
Ocna Mureș
Târnăveni
ARAD
Sânnicolau Mare
Satchinez
Biled-Șandra
Giarmata
TIMIȘOARA
Lugoj
TIMIȘ
Brad
Zlatna
ALBA IULIA
ALBA
DEVA
Orăștie
Sebeș
Hunedoara
Călan
Cugir
HUNEDOARA
Mediaș
Copșa Mică
SIBIU
Șelimbăr
Avrig
Victoria
Făgăraș
SFÂNTU GHEORGHE
COVASNA
Codlea
BRAȘOV
HARGHITA
REȘIȚA
CARAȘ-SEVERIN
Căineni
VÂLCEA
Băile Govora
Dăești
Budești
Băbeni
Orlești
TÂRGU JIU
GORJ
Rovinari
Ticleni
Bărbătești
Turceni
Șimian
DROBETA TURNU-SEVERIN
MEHEDINȚI
Gruia
CRAIOVA
Pielești
DOLJ
Motătei
Băilești
Bechet
Corabia
Drăgășani
Lungești
SLATINA
OLT
PITEȘTI
ARGEȘ
Oarja
Câmpulung
Sinaia
Fieni
Câmpina
PRAHOVA
Florești
Doicești
Moreni
PLOIEȘTI
Brazi
Șaru
TÂRGOVIȘTE
Cobia
DÂMBOVIȚA
Buftea
ILFOV
BUCUREȘTI
Măgurele
Jilava
Videle
TELEORMAN
Măldăeni
Roșiori de Vede
Călugăreni
Hotarele
Herești
Oltenița
GIURGIU
ALEXANDRIA
Turnu Măgurele
Zimnicea
Dorohoi
BOTOȘANI
Dornești
Bucecea
SUCEAVA
Verești
Fundu Moldovei
Frasin
Pojorâta
Fălticeni
Pașcani
IAȘI
NEAMȚ
Săvinești
BACĂU
Dărmănești
Borzești
VASLUI
Bârlad
Adjud
Panciu
VRANCEA
FOCȘANI
GALAȚI
BUZĂU
Râmnicu Sărat
BRĂILA
TULCEA
Urziceni
IALOMIȚA
Țăndărei
SLOBOZIA
Movila
CĂLĂRAȘI
Nicolae Bălcescu
Năvodari
Cernavodă
CONSTANȚA
Mangalia
MAREA NEAGRĂ
Dunărea
Olt
Mureș
Siret
Prut
Jiu
Argeș
Bistrița
Someș

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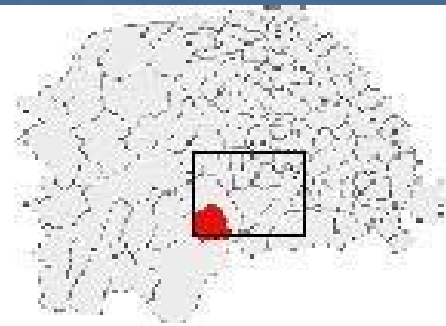
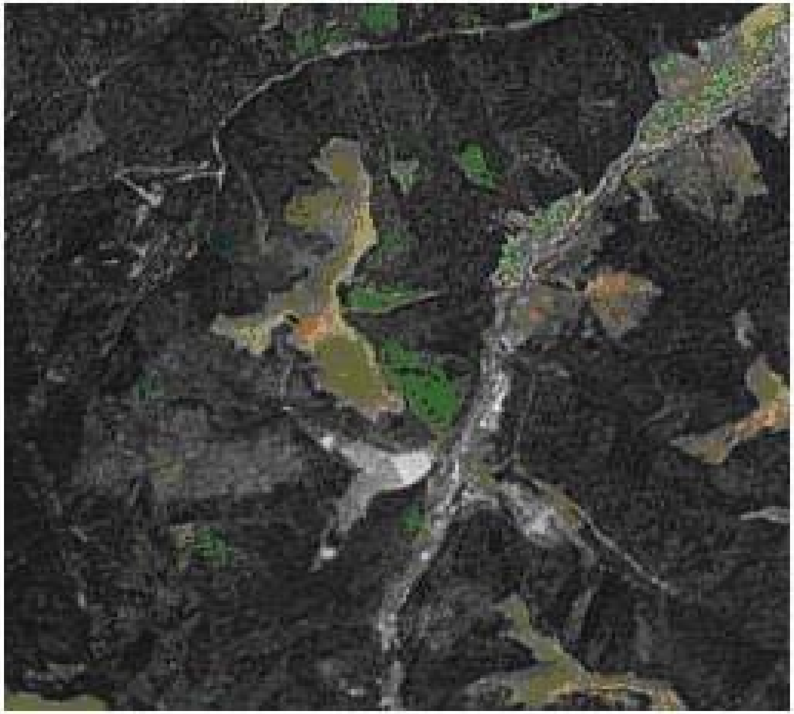
CASE STUDY 1
Tarnicioara tailing dam

27.06. - 02.07.2006 - Heavy rainfall led to torrential flows on the slopes surrounding the Tarnicioara tailing dam

As a result of the heavy rainfall, due to the accumulation of the excess water from the nearby creek, a reservoir of 12 m water deep formed on the top of the tailing dam, which by the strong gust of wind that accompanied the rain storm, started to batter the tailing dam crest, being in danger to overflow and leading to a disaster to the downstream village, Ostra.





Localisation of the Tarnicioara tailing dam and the downstream village Ostra, in Suceava county, Romania

- treat on the almost 5000 people located nearly 3km downstream, in the village of Ostra.
- an imminent collapse of the dam could significantly worsened the environmental conditions, because of the presence of the heavy metals.

The torrential flows on the slopes of the Scaldatori creek

Response actions

- 6 special pumps of ANIF (National Agency for Land Reclamation) were put in place, with a discharge over 1100 cm/h
- a higher capacity pump was brought (1600 mc/h) from a coal mining, specialized for removal of increased water levels
- three additional pipes were installed upstream of the diverting gallery, in order to diminish the inflow in the tailing dam, working at their entire discharging capacity.

Special pumps

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Lessons learnt

- Implementation of the Aquis communitaire is necessary
- Appropriate risk assessment and management is required to assure safe exploitation and operation of mine waste tailings dams
- The obligations of dam owners and operators must be defined so that they can be operated safely and so that adequate measures can be taken to reduce the risks of an accident
- Proper monitoring systems must be in place to assess structural performance

CASE STUDY 2

Tornado type storm at Facaeni

- on 12 August 2002, at around 19:30 a violent storm affected the Facaeni village:
  - two persons lost their lives because their house collapsed,
  - 14 persons were seriously wounded,

- the storm **blocked the railways traffic** in the region because of the trees that had collapsed over the high tension polls,
- trees were uprooted and important surfaces of plots of land has been affected as well,
- a totally of 15 houses was razed from the surface of the earth while another 300 remained without a roof.

Damages of the high voltage power lines in the area.

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Response phase

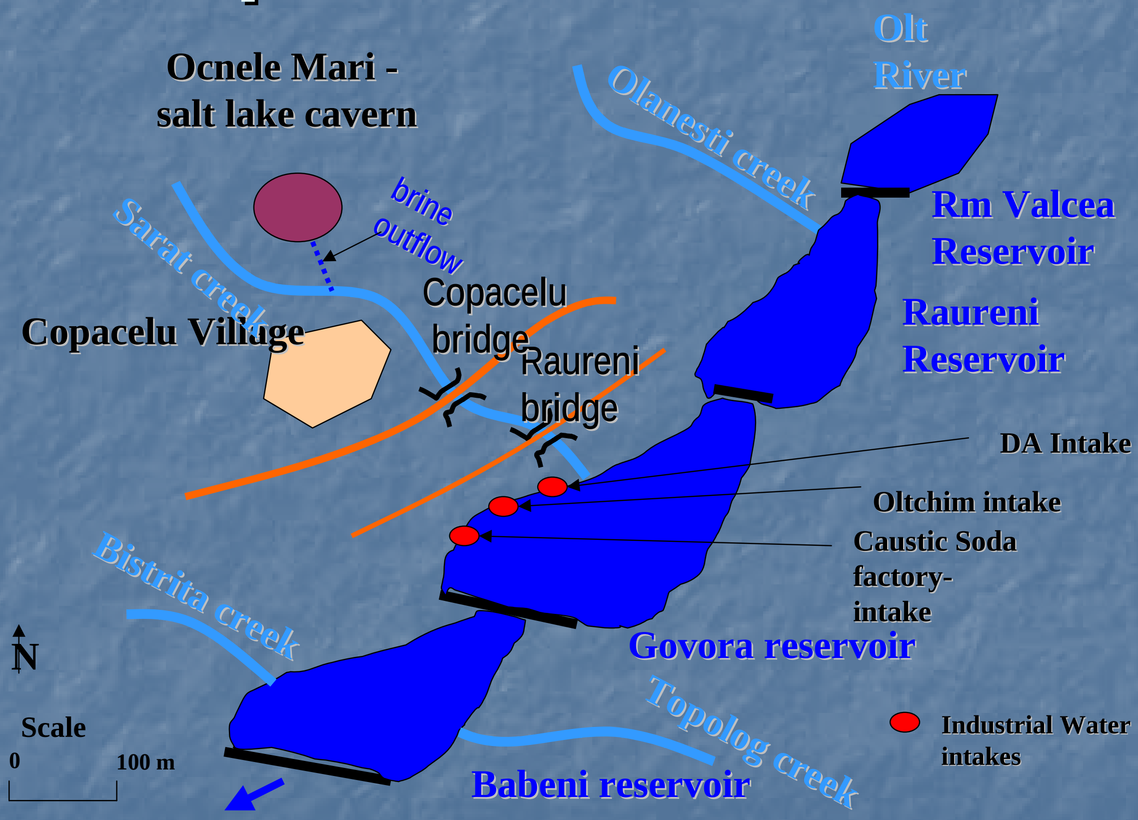
- The interdiction in the area of the vehicles and unauthorised persons and the guide of the traffic on other devious rotes, until the clearance of the main road by the crushed vehicles, pillars and electric lines damaged, the fallen trees and branches.
- The National Society of Red Cross sent a humanitarian aid by emergency to the homeless affected people, consisting of about 22000 EURO and shelters, materials and food supply, being dispatched in less than an hour 24 persons. The aid given permitted the accommodation of the homeless people and the assurance by prime emergency of their survival.

Lessons learnt

- The installation of the warning-alerting systems of the population in the areas with increased risk of producing the natural disasters is necessary.
- The citizens have the following obligations:
  - to participate at training in order to assimilate the necessary knowledge in the field of Civil Protection activity;
  - to respect the rules and protection measures against the disasters.
- The implementation of the system of the damages indemnity in case of disaster through the assurance societies is necessary

CASE STUDY 3
Ocnele Mari – underground salt mining collapse

- Causes:
  - overexploitation by water injection since 1960,
  - the underground accumulations of brine.



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- the roof of the cavern collapsed,
- the excess of the salted water located underground, flowed down to a nearby creek (Salted creek) and afterwards reached Olt river.
- the outflow of brine water severely polluted the downstream water reservoirs of the Olt river

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- Following the first event, in the year to follow many other collapses, triggered by the extreme weather conditions with increased rain over the affected area, finally formed a large crater area, filled with a salt lake with a total surface of 3000 sq. m, and diameter of 80m.

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Measures taken

- the continuos surveillance of the endangered zone;
- the resettlement of the affected households and peoples;
- construction of a retention dam, with almost 80.000 c.m. for the brine in order to don't reach directly the Olt River;
- clean up of the affected area by the spilling brine.

GENERAL LESSONS LEARNT

Efficient informational method of reducing and preventing several types of hazards

- To be effective, measures have to be taken by the local public administration to make such information available.
- Recommendations should be made to the local and regional administration authorities involved in natural disaster management

- A proper endowment with automatic meteorological stations, using the latest advanced technologies is necessary
- It is necessary the insurance of all the goods and properties in the areas prone to natural disasters
- Develop a detailed analysis of the potential consequences and damage distances for possible scenarios of NATECH accidents
- Develop and maintain a good information system on the risks of natural and technological disasters

At the local level (1)

- Reduce or prevent disasters caused by extreme meteorological phenomena, such as floods, and accidental pollution;
- Improve speed and accuracy of flood prediction;
- Improve speed and reliability of emergency response;
- Reduce potential risks and damages;
- Disseminate lessons learned and results via the Internet for easy access;

At the local level (2)

- Develop a system to warn potentially affected people;
- Use simulations to assess emergency action plans;
- Develop what-if scenarios and emergency action plans for potential accidental releases from mining or industrial operations;
- Disseminate and communicate accurate, timely, locally relevant, and reliable assessments of risk.

THANK YOU!

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SOME ASPECTS

OF THE NATECH RISK MANAGEMENT IN POLAND

Sławomir Zając
National HQ of the State Fire Service

THE MOST TYPICAL DISASTERS IN POLAND

- FLOODS
- FIRES
- TRANSPORT OF DENGEROUS GOODS BY ROADS AND RAILWAYS

FLOODS CAN BE EFFECTS OF RAINFALLS, THAWS AND STORMS

To assess a flood hazard:
provide a data given from meteorology stations, concerning hydrological data, flow states, temperatures and total number of rainfalls.

FOREST FIRES

- There is a special assessment methodologies of determination of fire hazard category of forests, regarding type of forest stand, age, number of fires, number of rainfalls and average temperatures, fire hazard index, concerning especially duff humidity, relative air humidity and rainfall ratio.
- A methodology of risk assessment for forest fires is given by the ordinance of Minister of Environment of 22 March 2006 on detailed requirements considering fire protection of forests (OJ. No 58, pos. 405).

NATURAL DISASTERS

- FLOODS
- RAIN STORMS
- STRONG WINDS
- DROUGHT WITH FIRES
- STRONG FROST AND SNOWSTORM
- EARTHQUAKES, LOW MAGNITUDE

The area of Poland is rated among low seismic hazard district:

a) earthquakes occur hardly ever,
b) tremors are not very strong.

The areas of Karpaty and Sudety mountains = higher seismic risk zones

OBSERVATORIES = MONITORING

Activities:

- Study of local earthquakes.
- Observation of large distant earthquakes and reporting the data to international seismological centres.
- Information on our observatories and stations.

TECHNOLOGICAL DISASTERS

RELATED TO:

- THE INDUSTRIAL PRODUCTION,
- STORAGE OF DANGEROUS GOODS,
- FAILURE OF TRANSPORTING DANGEROUS GOODS BY ROADS

  AND RAILWAYS,
- MAJOR HAZARD ACCIDENTS
- CHEMICAL/RADIOLOGICAL SUBSTANCES

NATECH DISASTER

TECHNOLOGICAL DISASTER

- INDUSTRAIL PRODUCTION
- MAJOR HAZARD ACCIDENT
- STORAGE OF DANGEROUS GOODS
- FAILURE OF TRANSPORTING DANGEROUS GOODS
- NBRC SUBSTANCES

NATURAL CALAMITIES

- FLOODS
- HURRICANES
- SNOW STORMS
- EARTHQUAKES
- VULCAO
- TSUNAMI

SIGNIFICANT ADVERSE EFFECTS TO THE HEALTH OF PEOPLE, PROPERTY AND ENVIRONMENT

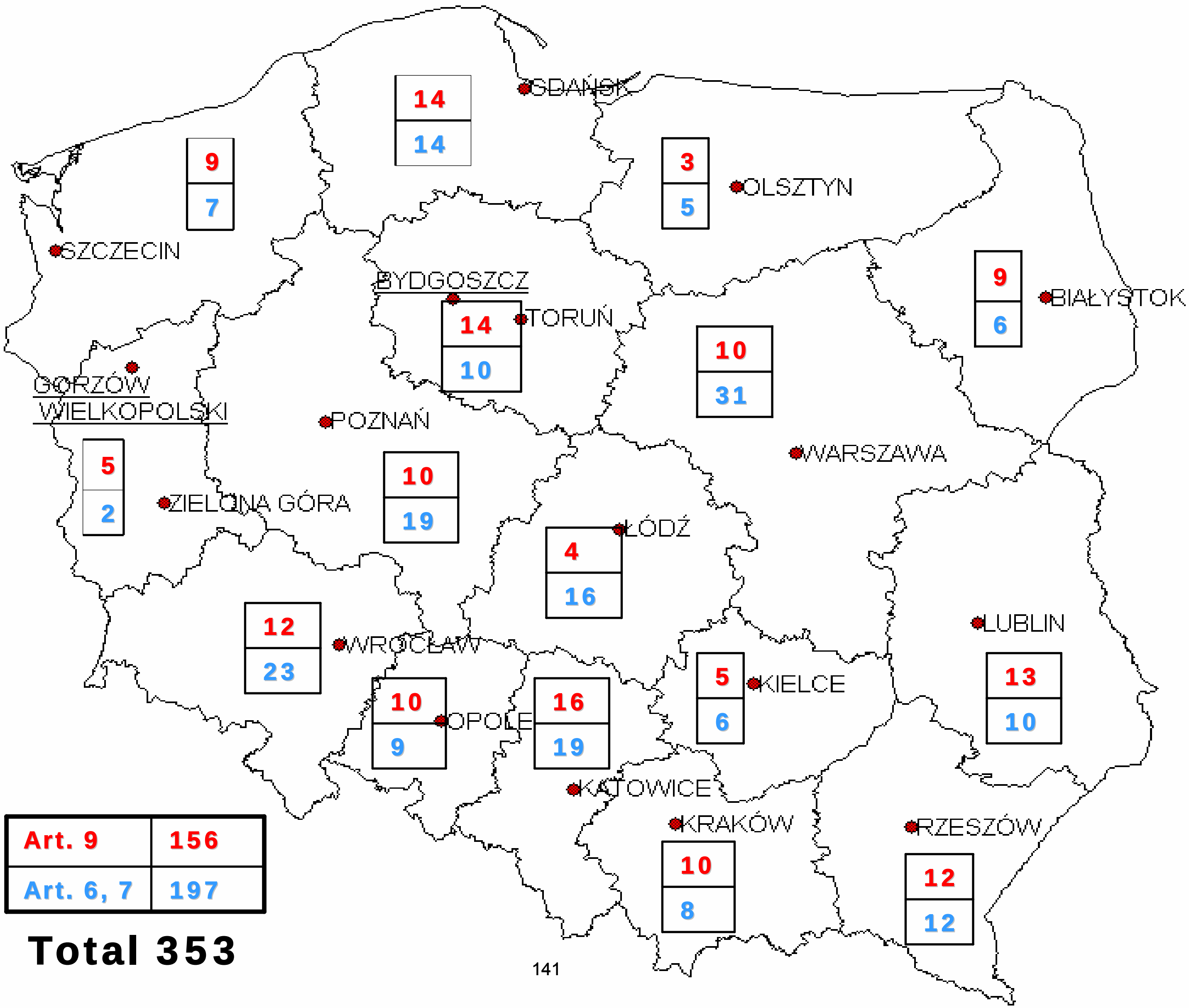
RISK TO REGIONS WHICH ARE UNPREPARED FOR SUCH EVENTS

DIRECTIVE 96/82/EC (SEVESO II)

RISK ASSESEMENT AS A CONCEQUECES OF NATURAL CALAMITIES

- FLOODS
- FIRES (ESPECIALLY FOREST FIRES)
- STRONG WINDS

SEVESO II PLANTS IN POLAND
(31.12.2006)



Art. 9	156
Art. 6, 7	197

Total 353

The National Rescue and Fire-fighting System

is organized by the State Fire Service,

and it main task is protection of life of citizens, properties and environment

The National Rescue and Fire-fighting System

for protection of life , health, property and environment

has duties, which are very crucial to the society, in particular :

- *preparing and conducting rescue operations ,*
  - **warning and alarming population,**
- *fighting against fires and NATURAL DISASTERS (e. g. FLOODS),*
  - **carrying out evacuation of population,**
- *technical rescue,*
  - **supplying people with individual protection resources,**
- *chemical and ecological rescue,*
  - **preparing places of residence for injured,**
- *medical rescue,*
  - **international humanitarian assistance,**

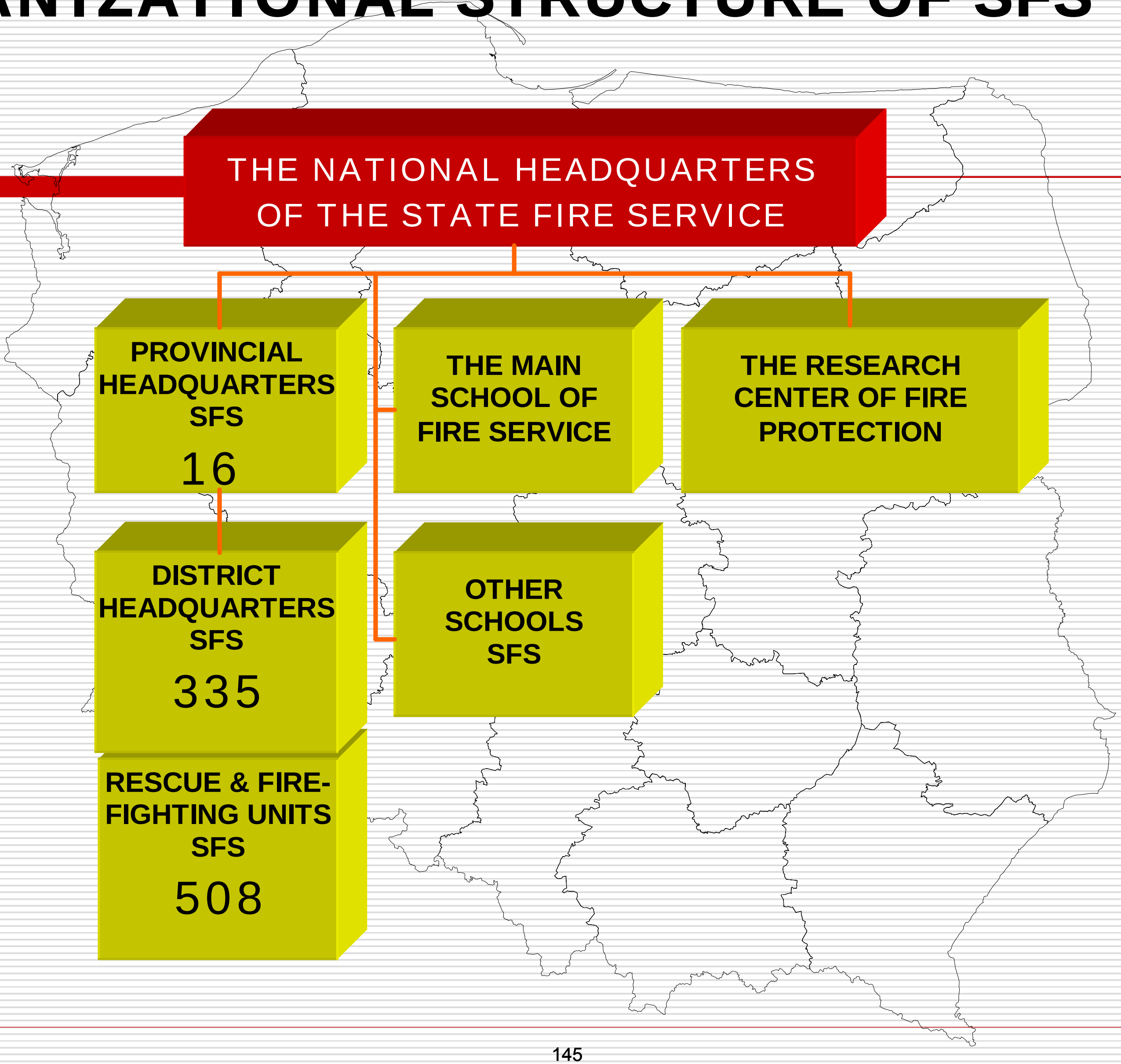
- *international rescue assistance.*

The National Rescue and Fire-fighting System

operates on three Administrative Levels Coresponding with Administrative Structure of the Country

- **DISTRICT –** *main executive level, where are carried out basic tasks on the area of district,*
- **PROVINCIAL –** *coordination and assistance to the rescue operations when resources in the district are insufficient,*
- **CENTRAL –** *rescue operations` assistance and cooperation when resources in the province are insufficient.*

ORGANIZATIONAL STRUCTURE OF SFS



Main tasks of the State Fire Service

- recognition of fire hazards and other local threats,
- organisation and leading rescue operations during fires, natural calamities or mitigation of local threats,
- supporting other rescue services in rescue operations during natural calamities and mitigation of local threats,
- supervision of observing fire safety regulations,
- control of activities preventing major hazard accidents.

SFS PREVENTION ACTIVITIES SEVESO II DIRECTIVE SCOPE

- Notification,
- Major – accident prevention programmes,
- Safety reports
- Internal & External emergency plans
- Public information process
- Domino effect
- Inspections

SFS – SOURCES OF INFORMATION ABOUT THREATS (1/2)

- Inspections on conformity with fire regulations at buildings and other premises,
- Information given by fire protection experts about the acceptance of newly designed buildings,
- Carried out identification of technical, chemical and ecological hazards in selected plants,
- Carried out training exercises,

SFS – SOURCES OF INFORMATION ABOUT THREATS (2/2)

- **Submitted for acceptance rescue plans of industrial plants using hazardous materials, which can cause extraordinary hazard to environment**
- **Monitoring systems, e.g. radiation, water, fire,**
- **Information given by other bodies which deal with various types of threats, e.g. environmental inspection, labour inspection, sanitary inspection, institute of meteorology and water management,**
- **Register of accidents.**

The SFS has organised two main data bases:

- a register of accidents which have dealt by rescue services (mainly by the SFS and voluntary fire brigades),
- a catalogue of hazards.

CATALOGUE OF HAZARD

- A list of industrial plants using dangerous substances,
- A list of transport roads of dangerous goods,
- A list of objects can be in disaster danger especially,
- Data of flooding hazards.

THANK YOU FOR YOUR ATTENTION

NATECH DISASTERS. RISK MANAGEMENT OF BULGARIA (5 years later)

Boyko Ranguelov
Geophysical Institute,
Bulgarian Academy of Sciences

THREATS ANALISYS

THREATS OF THE GREATEST IMPORTANCE FOR THE NATECH DISASTER RISK in Bulgaria:

1. EARTHQUAKES (NO SIGNIFICANT EVENTS OCURRED DURING THIS TIME PERIOD)

   (THIS THREAT IS THE HIGHEST PRIORITY FOR THE TERRITORY OF THE COUNTRY)
2. FLOODS (HEAVY FLOODS DURING 2005)
3. LANDSLIDES (SEVERAL ACTIVATED NOT OF GREAT IMPORTANCE)
4. FOREST FIRES (THE MOST MASSIVE DURING THE FIRST HALF OF 2007)
5. OTHER THREATS THAT COULD BE A TRIGGERING FACTOR FOR A NATECH EVENT

The new governmental policy since 2004

- **LEGISLATION**
- ***NEW LOW ABOUT THE CRISIS MANAGEMENT***
- **ESTABLISHMENT OF A NEW MINISTRY OF THE STATE POLICY FOR DISASTERS AND ACCIDENTS - www.mdpba.government.bg/ - Minister**

  Mrs. Emel Etem

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OTHER INSTITUTIONS RELATED TO CRISIS MANAGEMENT

- **GOVERNMENTAL COMMISSION ABOUT PEOPLE PROTECTION RROM DISASTERS AND ACCIDENTS to CM**
- **CIVIL PROTECTION AGENCY** www.cp.mdpba.government.bg/
- **Ministry of Interior** - www.mvr.bg (**Fire brigades -** http://www.nspbzn.mvr.bg/)
- **Ministry of environment and waters** http://www.moew.government.bg/ - Wastes and pollution
- **Ministry of regional development** www.mrrb.government.bg/
- **Scientific support – (Centre of research to the national security)**
- **National statistics -** www.nsi.bg

CRISIS MANAGEMENT TOOLS DEVELOPED

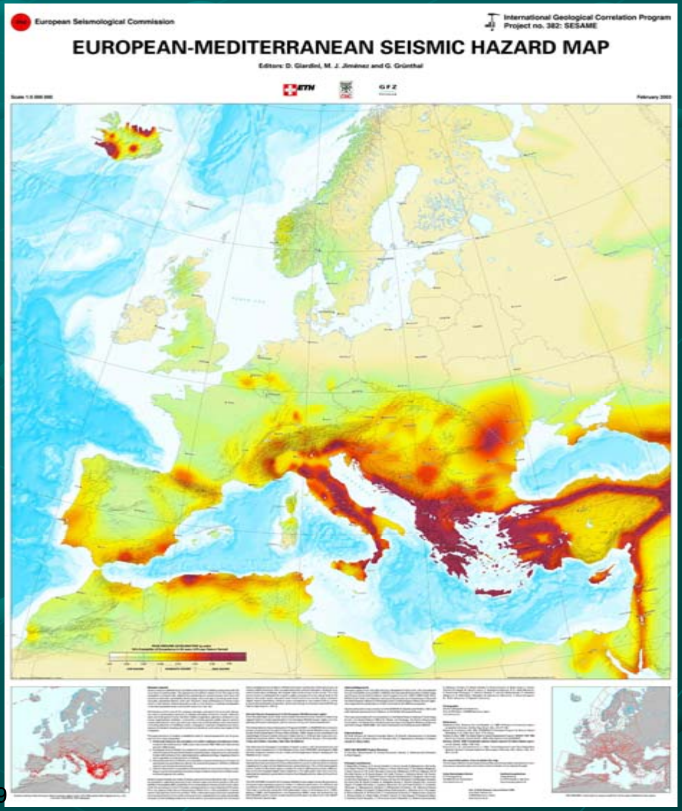
- Emergency phone 112 (up to now works only for Sofia district)
- National crisis management centre (not yet in operation)
- Regional crises management centers (not yet in operation)
- Center for aero and space observations (in operation since 1st August, 2007)

Seismic regions in Bulgaria– THE LAST(OLD) VERSION (1987) OF SEISMIC ZONING

SEISMIC REGIONS IN EUROPA

STANDARDS FOR DESIGN OF NEW BUILDINGS AND FACILITIES IN EARTHQUAKE PRONE REGIONS ACCORDING EUROCODE 8 (NOT YET IMPLEMENTED)

EUROCODE8 -Strictly defines the seismic regions where occurrence of earthquakes of different expected accelerations are possible.



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2. THREAT OF FLOODS

FLOODS FROM QUICK SNOWS MELTING AND HEAVY RAINS (FLASH FLOODS)

SPRING FLOODS ALONG THE DANUBE RIVER – HIGH WATER LEVELS

Floods in Bulgaria - 2005

- ¾ of the country territory flooded during several episodes (May, August, September)
- Damages over 900 MEURO
- More then several hundreds NATECHs occurred – road and railway interruptions, electric lines damaged, gas pipe line stops, etc.
- Rescue operations and evacuations performed
- Recovery work – army included
- Risk mapping surprise

Floods – 2005 – Belovo city – railroad, electric line, bridge, road

Floods – 2005-2006 – the Danube river

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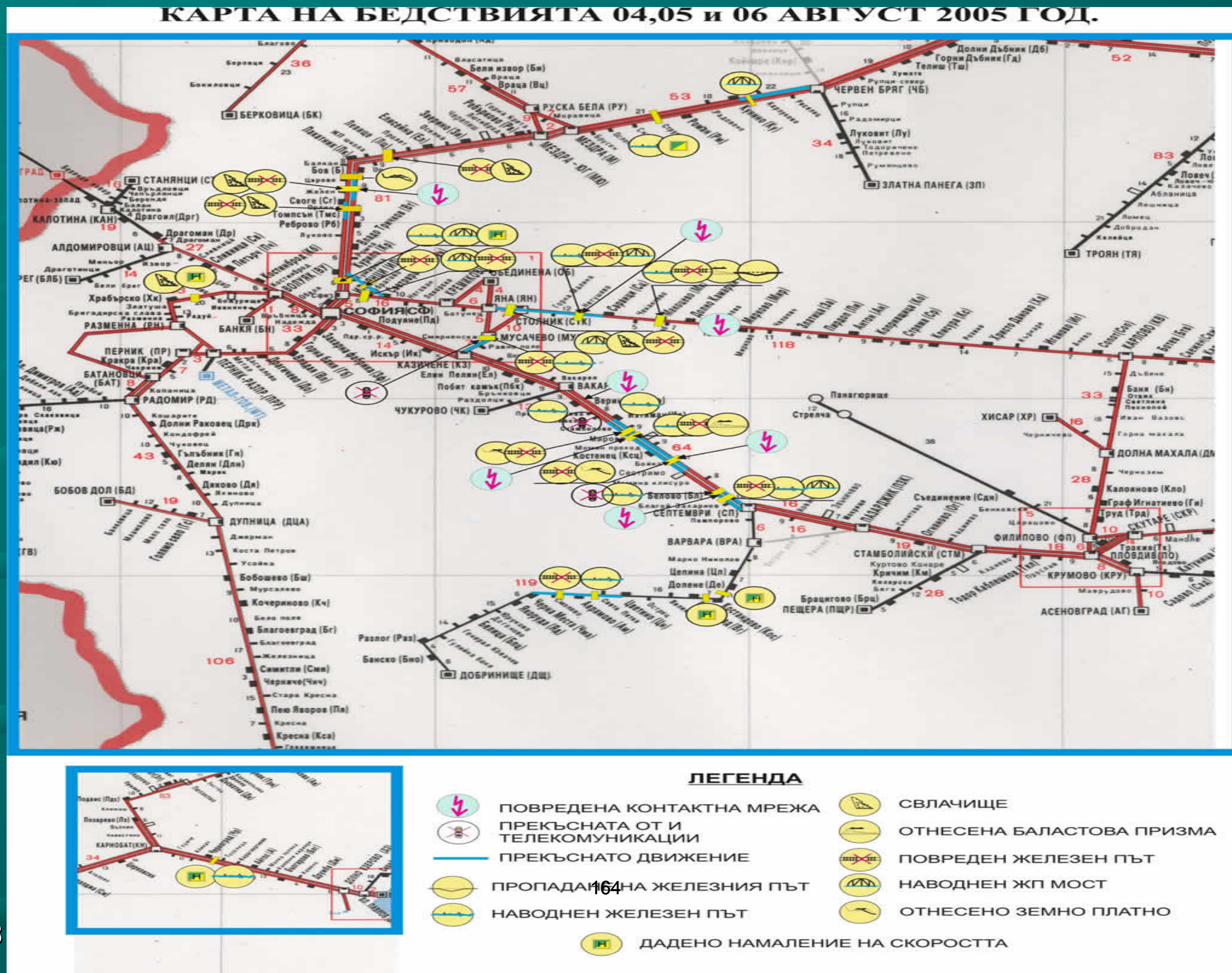
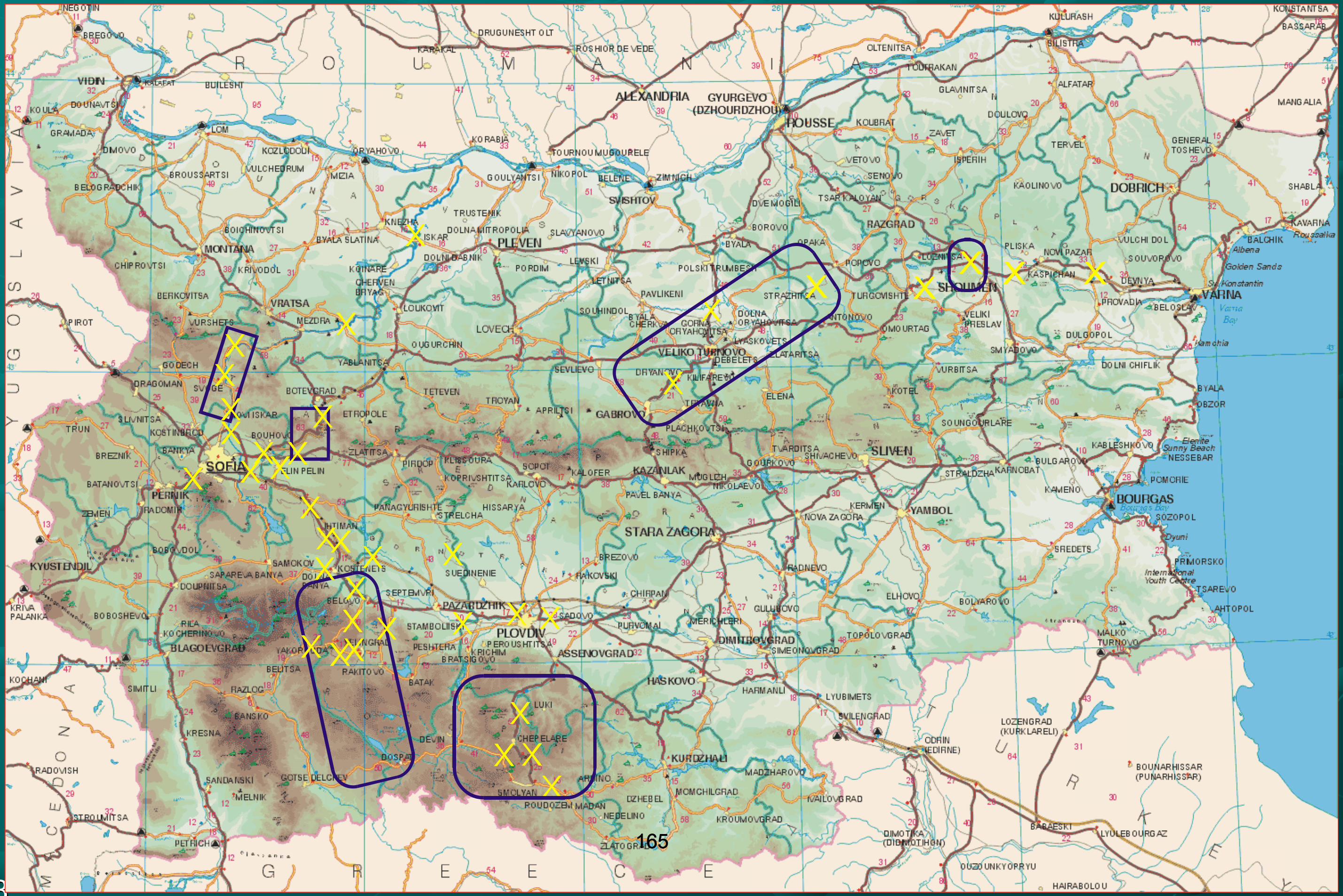
Railroads damages after 4-6th August, 2005 floods



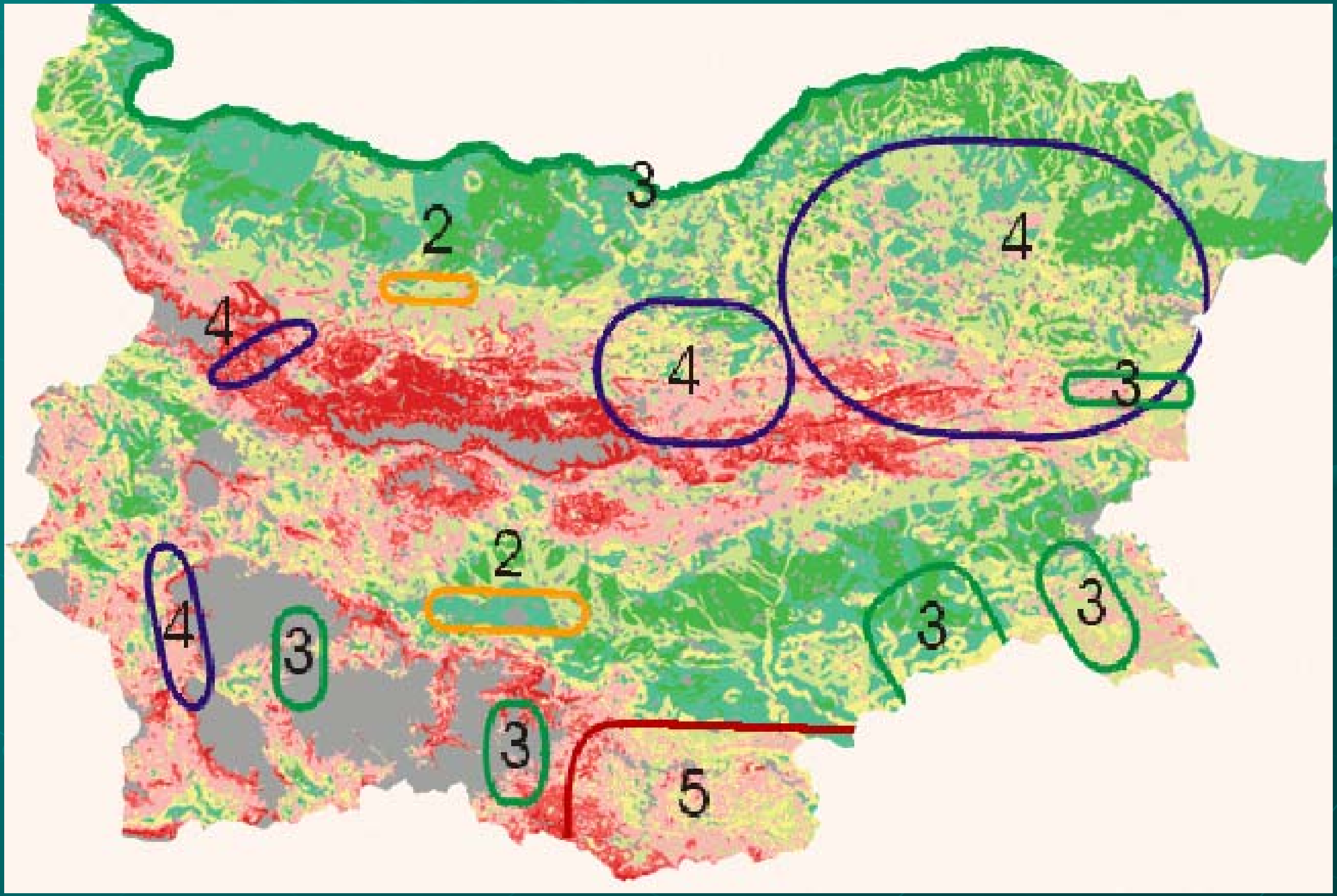
Floods 2005 - Map of the transportation system interruptions -yellow (X's) and landslides (blue areas)



Risk and vulnerability mapping

- Hazards mapping
- Vulnerability mapping
- Risk mapping
- Multirisk mapping

Map of the miltihazards – floods and landslides (2-5 levels)



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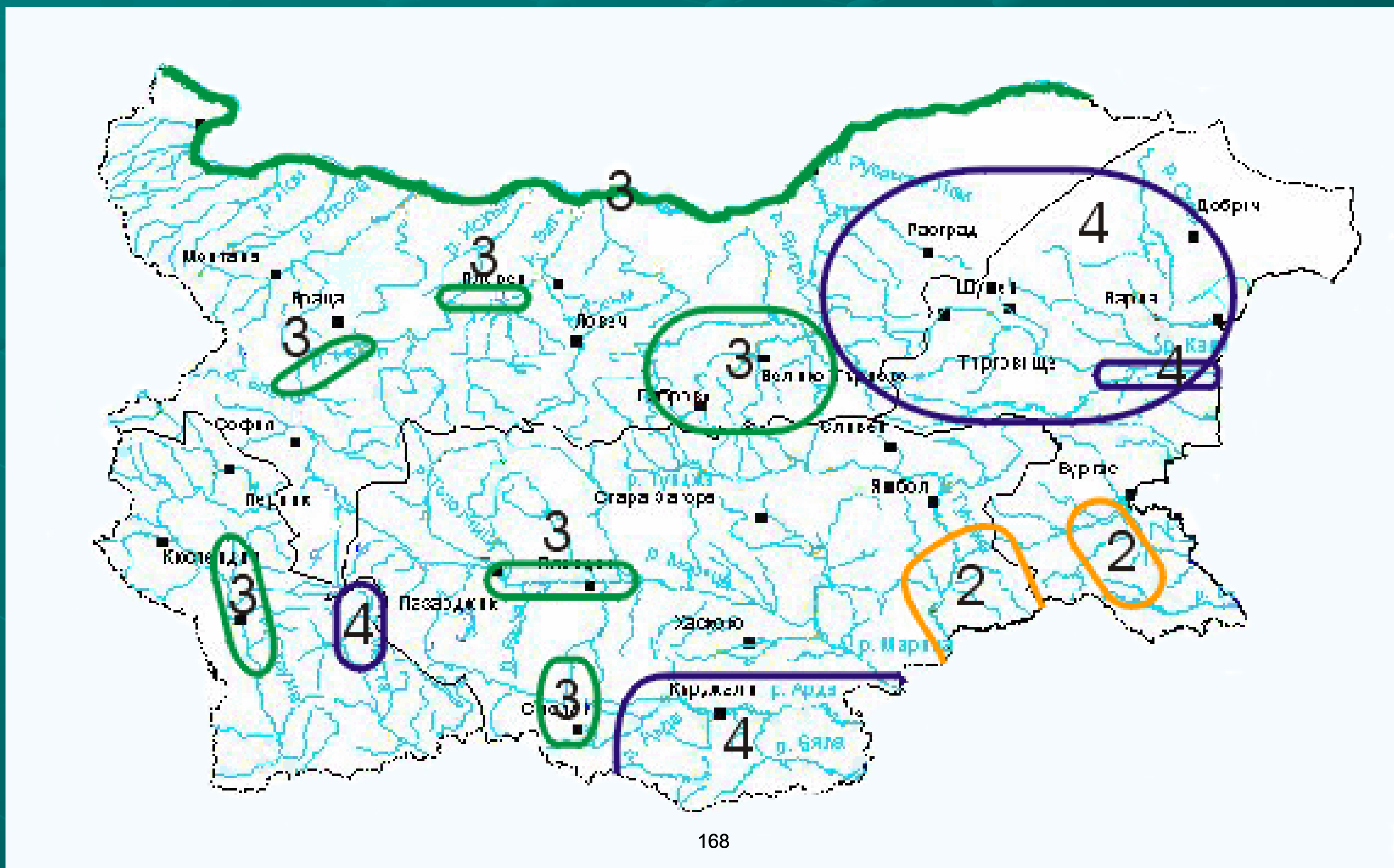
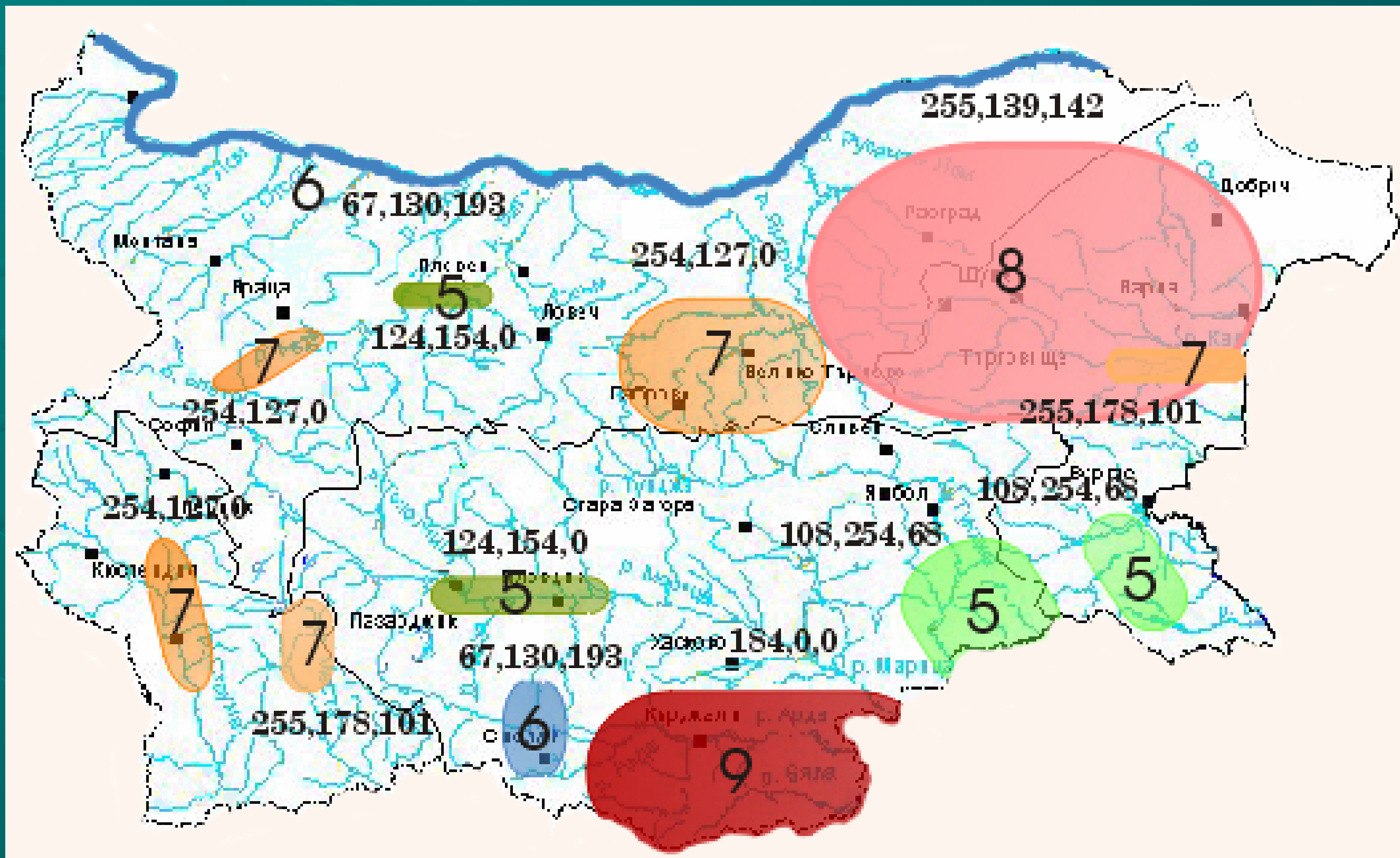
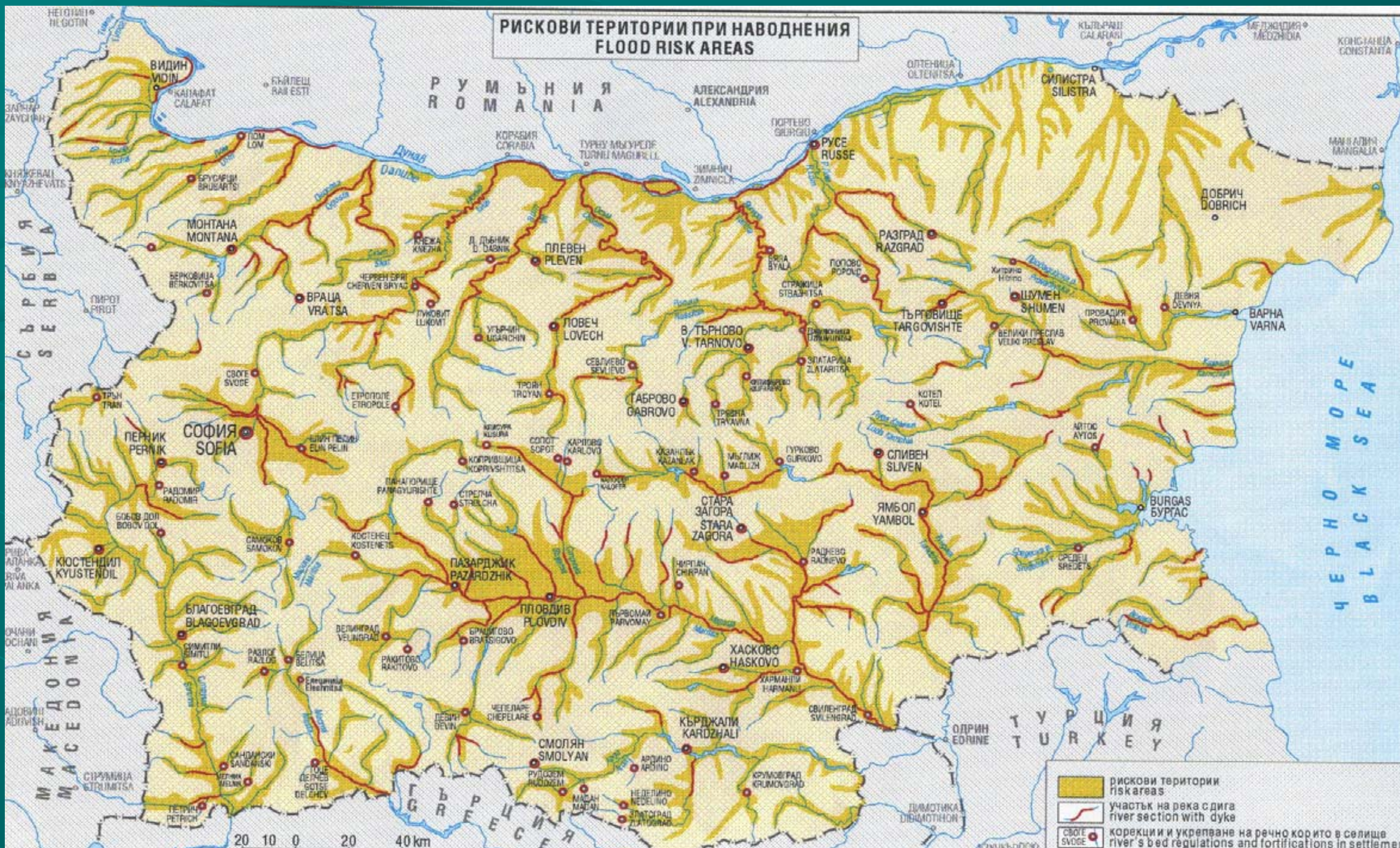
Vulnerability map (considering , density of the population, unemployment and poverty)



Risk map – levels 5-9



NEW FLOODS ZONATION MAP – G. Alexiev (2007-Tender with JRC



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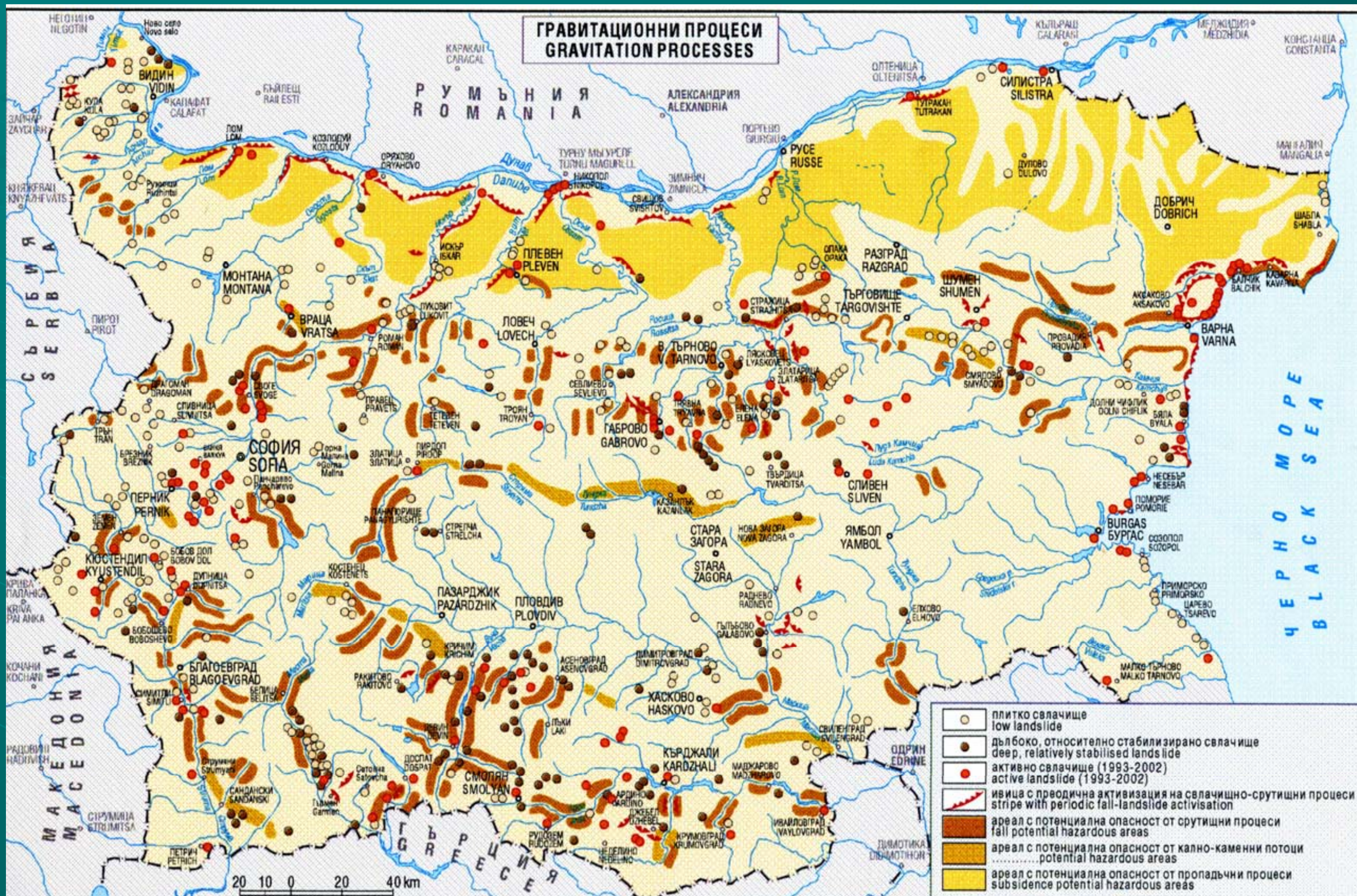
3. THREAT OF LANDSLIDES

- HUNDREDS OF LANDSLIDES AND ABRASIVE REGIONS ARE REGISTERED.
- A GREATER PART OF THEM ARE ACTIVE.
- 350 OF THEM ARE SITUATED IN BUILD-UP AREAS AND HEALTH RESORTS.
- THEY ARE SPREAD ON A TERRITORY OF 20 000 ha.
- USUALLY THEY ARE ACTIVATED WHEN THE LAND LAYERS ARE HEAVILY MOISTENED OR AS A RESULT OF EARTHQUAKES.

NEW LANDSLIDE ZONING MAP – G. Alexiev 2007– Tender JRC



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Analysis and measures

- Not existing up to the moment (2005) flood hazard map
- The average statistics is non applicable to the extreme cases as these ones of 2005
- The river beds must be clear (as a post event and at the same time – as preventive measure)
- Local authorities are first involved in the rescue operations and evacuation (no very big success)
- The recovery funds must be controlled strictly
- The early warning issues are not effective without supporting measures

Forest Fires (Wildfires) - 2007

- More than 300 000 ha fired
- More than 300 MEURO damages
- No effective tools (planes, helicopters, etc.) for fight against large burning areas and heavy access
- No working models about fast assessment of the fire time and space development scenarios
- Several NATECH's generated as: electric lines interruptions, some explosions of old military explosives, road interruptions, etc.

Wildfires July 2007

Some statistics – fires 2004 (left) and 2005 (right)

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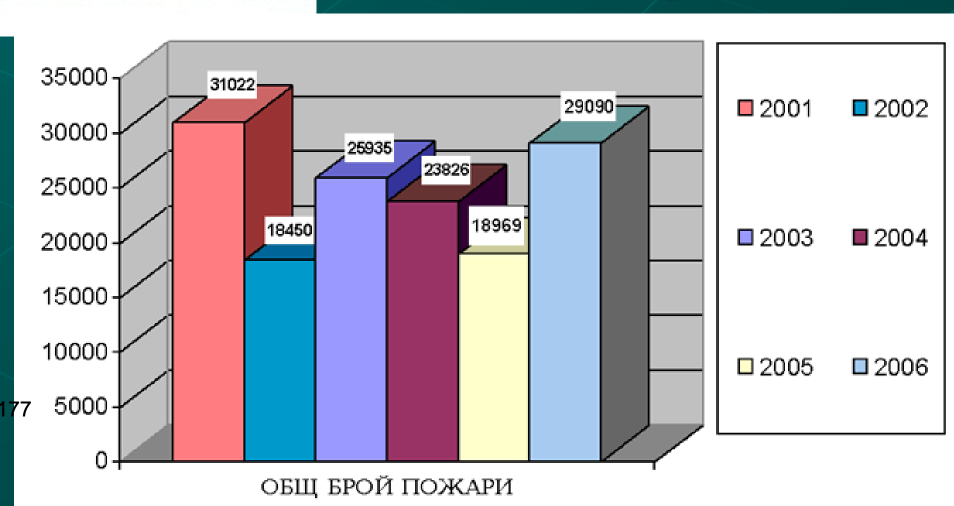
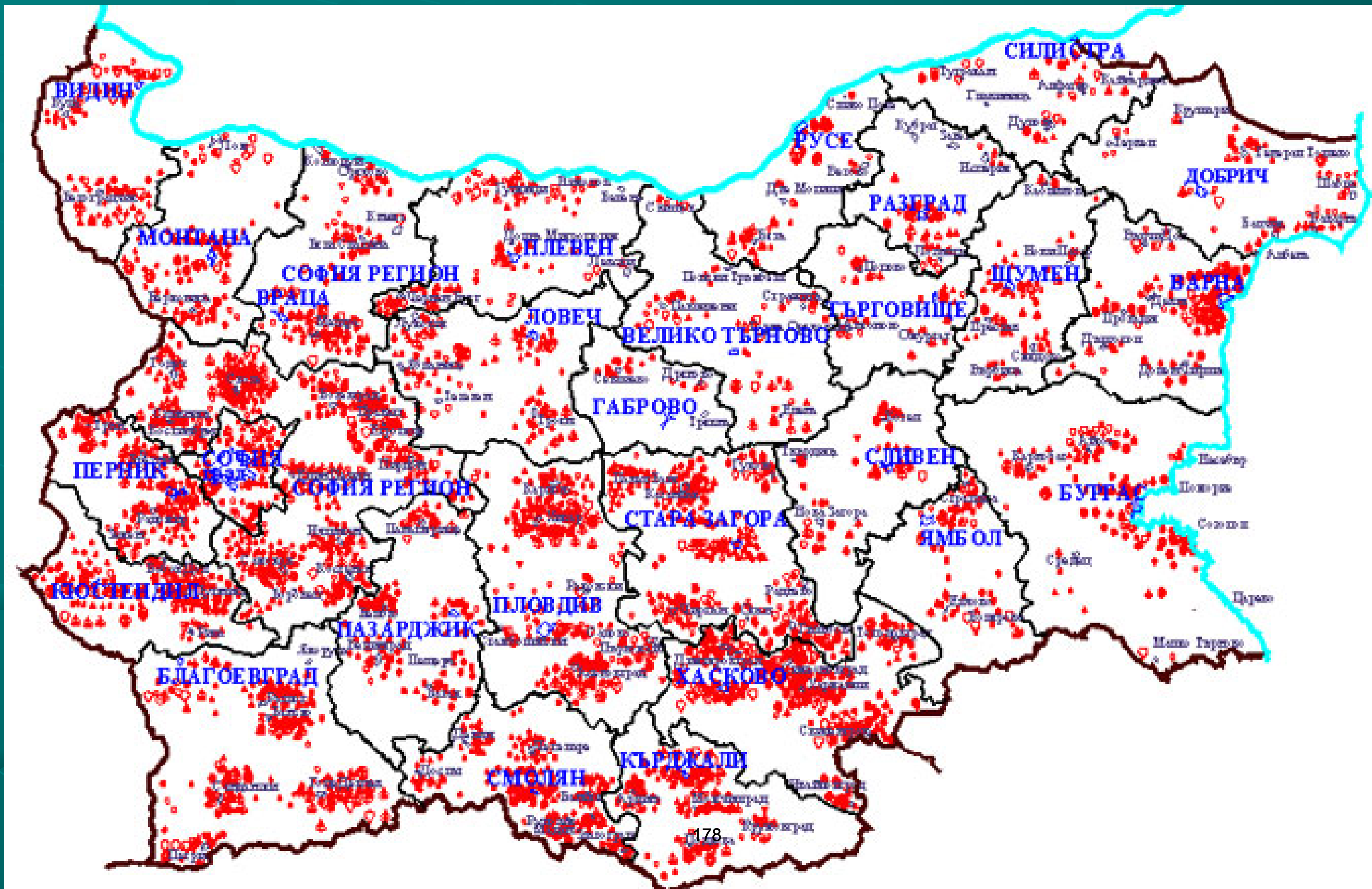
Time distribution of the forest fires 1971-2006 on the territory of Bulgaria (left) and the number for 2001-2006 (right)



Map of the observed forest fires during the time period 1994-2006



Analysis and measures

- No effective tools are available to fight fires on large areas and in heavy access cases – plans to supply the fire brigades with special airplanes and helicopters
- No effective models for fire development in time and space – plans to incorporate land and space information about such purposes
- No effective coordination with the volunteers

4. OTHER THREATS WHICH ON RARE OCCASIONS CAN BE A TRIGGERING FACTOR FOR A NATECH EVENT

- STRONG WINDS

  Rain, snow, hail, dust (rare)

  They are able to disturb electricity and communication links.

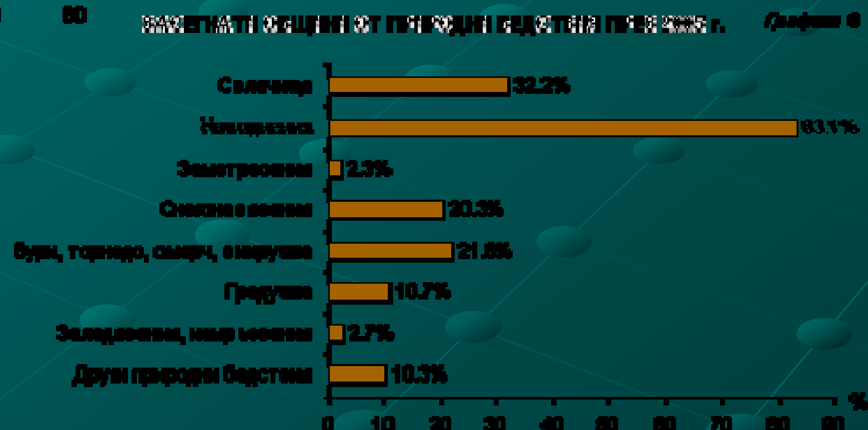
- HEAVY SNOWFALLS, SNOW STORMS, ICE/FROST

  Yearly about 50÷60% of the country is endangered by snowdrifts. Every year NE Bulgaria (in general) has electric interruptions due to the wire icing

- FIRES

  They can be a triggering factor for a natech event at sites of plants and enterprises with technological installations and equipments on them operating with dangerous chemical substances.

National statistics of the natural hazards – 2004 (left), 2005 (right)



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I. NATECH RISK ASSESSMENT ("OLD AND NEW" (X) – after the accession) APPROACHES

- EACH BRANCH OF NATIONAL ECONOMY HAS METHODOLOGIES AND INSTRUCTIONS FOR TECHNOLOGICAL RISK ASSESSMENT. ("OLD CODES AND RULES)

X NEW APPROACH IS APLYED ACCORDING THE EC DIRECTIVES

- THEY CONCERNED ONLY TECHNOLOGICAL RISK WITHOUT TAKING INTO ACCOUNT THE NATURAL DISASTER TRIGGERING FACTOR.("OLD")

X NOW THE NATURAL HAZATRDS MUST BE ASSESSED AS WELL AS (EXAMPLES – NPP's, DYKES, PLANTS WORKING WITH DANGEROUS SUBSTANCES, ETC.)

- FOR ALL SITES WITH DANGEROUS PROCESSES, AN INDIVIDUAL NATECH RISK ASSESSMENT IS DONE ON BASE OF:
  - METHODOLOGIES AND INSTRUCTIONS FOR TECHNOLOGICAL RISK ASSESSMENT
  - EXAMINATION OF THE EXPERIENCE GATHERED AS A RESULT OF DIFFERENT ACCIDENTS

X STARTS TO TAKE INTOACCOUNT THE SEVESOII DIRECTIVE

LOCATION OF SITES WITH DANGEROUS PROCESSES

NATECH RISK ASSESSMENT DEPENDS ON:

A. SITE LOCATION

- EACH SITE LOCATION HAS ITS PARTICULAR DATA BASE CONCERNING:
  - SEISMICITY
  - FLOODS
  - LANDSLIDES

(- NOW STORMS AND FIRE PROTECTION ARE INCLUDED)

- TO CREATE THIS DATA BASE, USUALLY THE GENERAL MAIN INFORMATION ABOUT THE TERRITORY OF THE COUNTRY IS USED.

(NOW – NEEDS UPDATE)

- IN SOME CASES ADDITIONAL INFORMATION IS NECESSARY ABOUT:
  - MICROSEISMIC ZONING OF THE SITE
  - HYDROLOGICAL PROSPECTS AND ZONING
  - GEOLOGICAL PROSPECTS AND ZONING

(NOW – MULTIRISK MAPPING IS CONSIDERED IMPORTANT)

NATECH RISK ASSESSMENT DEPENDS ON:

B. RESULTS OF THE INVESTIGATIONS OF THE GENERAL AND SEISMIC STABILITY OF BUILDINGS, FACILITIES AND TECHNOLOGICAL EQUIPMENTS

- SOME ADDITIONAL FACTORS RESULTED BY PRODUCTION PROCESSES, WHICH HAVE THEIR INFLUENCE AND WHICH ARE TAKEN INTO ACCOUNT, ARE:

  - WEAR OF THE DIFFERENT KINDS OF ELEMENTS
  - CORROSION
  - CONSTRUCTIVE CHANGES OF THE STRUCTURES
  - SUBSTITUTION OF SOME CONSTRUCTIVE ELEMENTS
  - PROHIBITIVE OR SUSTAINED OVERLOAD

NATECH RISK ASSESSMENT DEPENDS ON:

C. **PROGNOSIS** FOR THE NATURAL DISASTER OCCURRANCES ACCORDING TO THE EXPECTATIONS.

D. **SCENARIOS** OF THE TECHNOLOGICAL DISASTER TRIGGERING.

E. **NEW METHODOLOGIES** DEVELOPMENT AND APPLICATION

SITES FOR WHICH THE NATECH RISK ASSESSMENT HAS BEEN DONE:

1. THE NUCLEAR ELECTRIC POWER PLANT AT THE TOWN OF KOZLODUI

   (FOR THE WHOLE SITE AND IN PARTICULAR FOR EACH ONE OF THE TWO (NOW IN OPERATION) UNITS

2. HYDROTECHNICAL FACILITIES

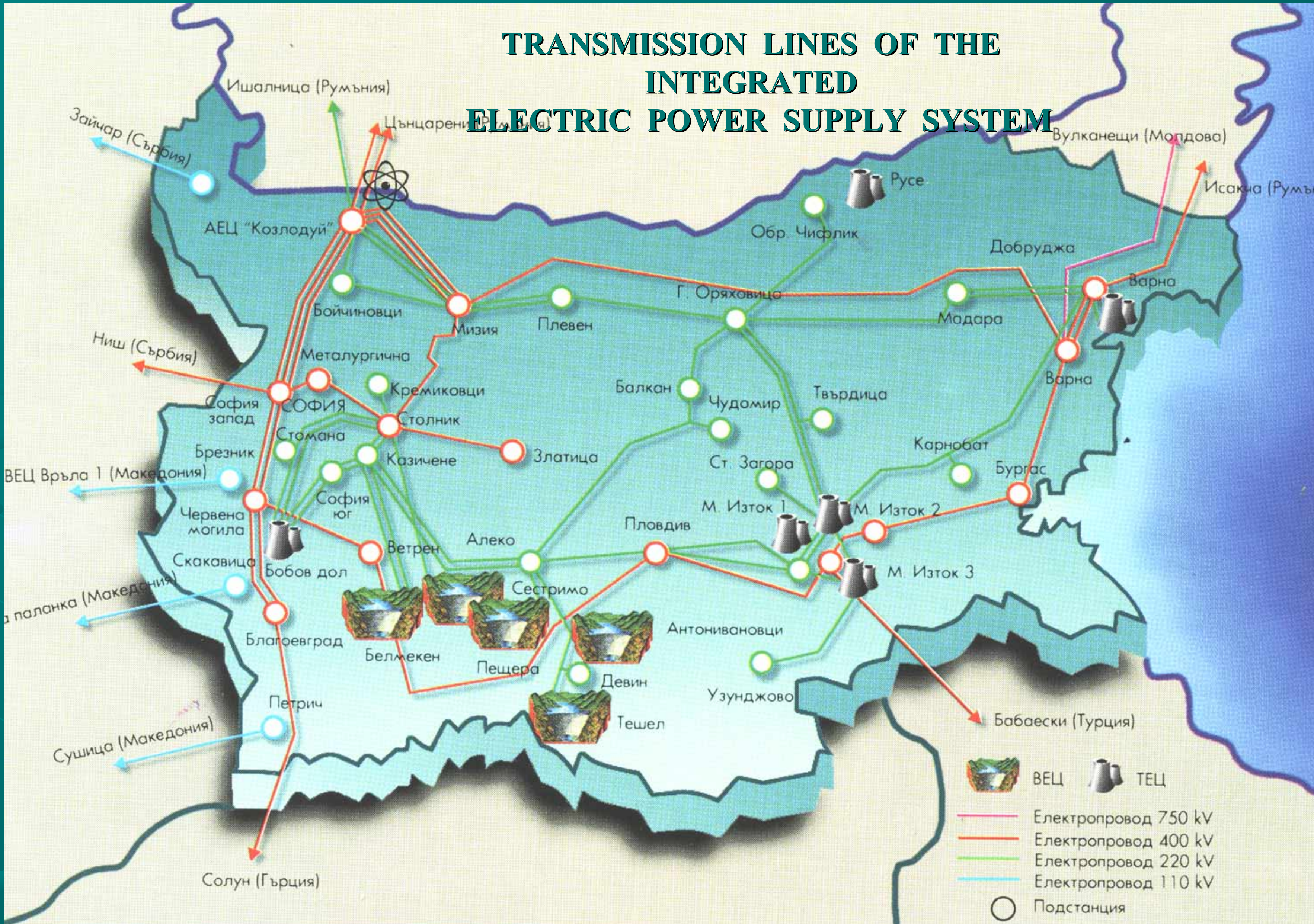
   - DAMS - 215 ITEMS
   - EMBARNKMENTS:
   - ALONG DANUBE RIVER - 295 KM. - 15%
   - OTHER BASINS FOR WASTE DEPOSITS - 72 ITEMS

3. HIGH VOLTAGE POWER TRANSMISSION LINES OF THE INTEGRATED ELECTRIC POWER SUPPLY SYSTEM, AS IT FOLLOWS:

   - 750 VOLTAGE - 85 KM.
   - 400 VOLTAGE - 1 852 KM.

4. LINES OF THE MAIN GAS-PIPE LINES TRANSMISSION SYSTEM

TRANSMISSION LINES OF THE INTEGRATED ELECTRIC POWER SUPPLY SYSTEM



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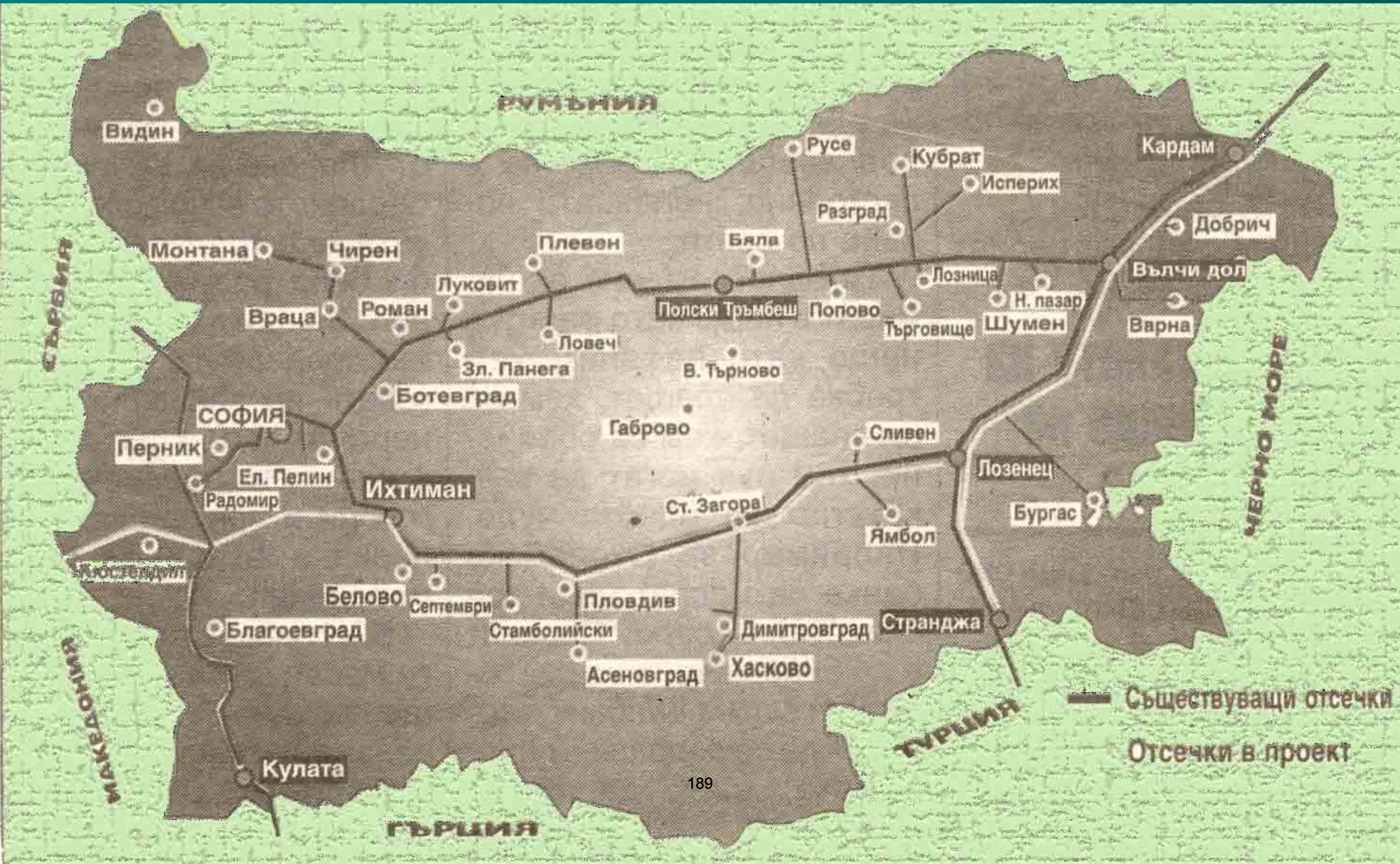
MAIN GAS PIPE- LINES THE TERRITORY OF BULGARIA



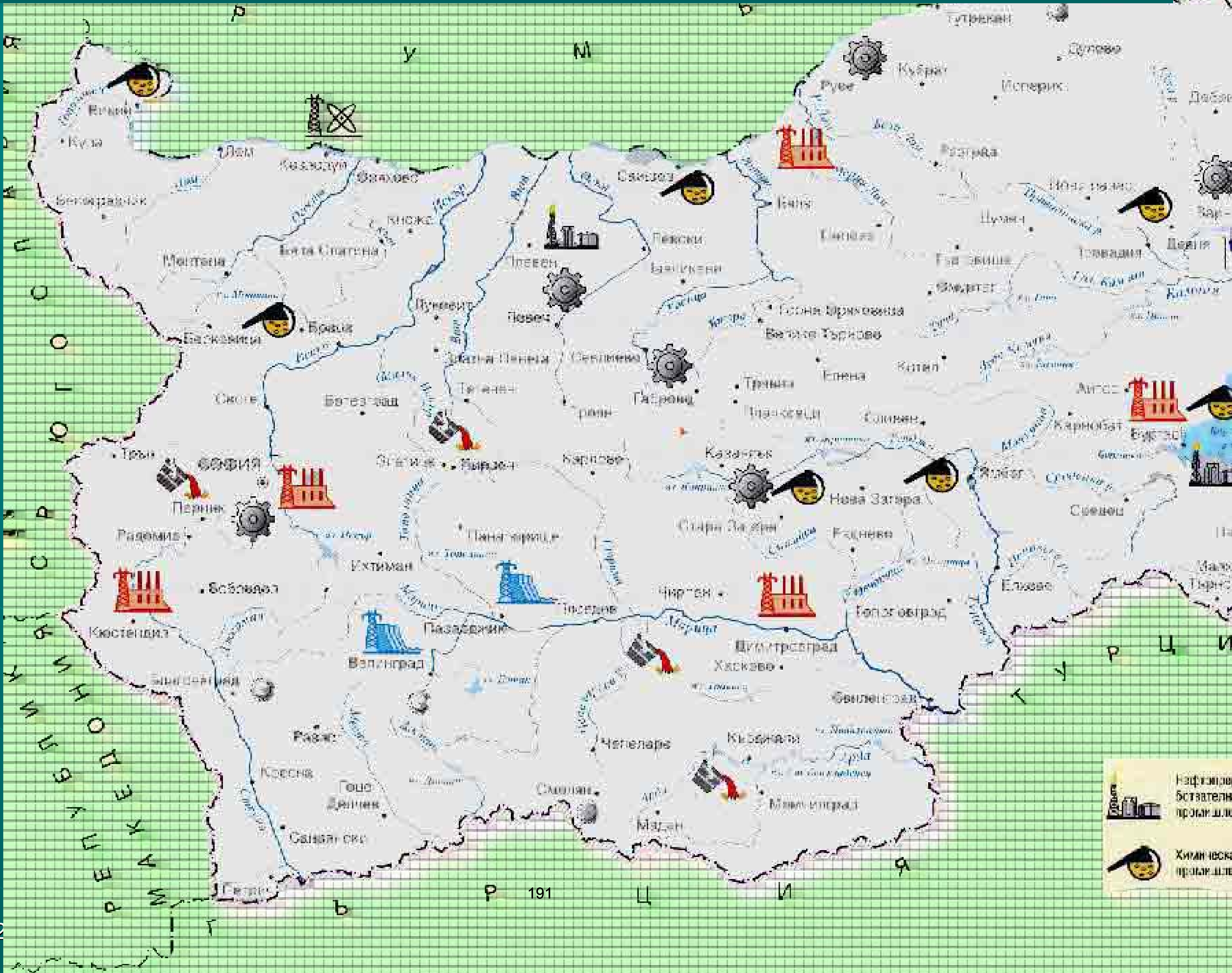
SITES FOR WHICH THE NATECH RISK ASSESSMENT HAS BEEN MADE:

5. PLANTS AND ENTERPRISES WITH TECHNOLOGICAL INSTALATIONS AND EQUIPMENTS, OPERATING WITH DANGEROUS CHEMICAL PRODUCTS – ABOUT 20 ITEMS

IN THIS NUMBER INCLUDED PLANTS OF :

- CHEMICAL INDUSTRY	7 items
- CHEMICAL PHARMACEUTICS INDUSTRY	4 items
- CHEMICAL PERFUMERY INDUSTRY	2 items
- OIL MANUFACTURING INDUSTRY	2 items
- METALLURGICAL INDUSTRY	2 items
- ORE OUTPUT AND PROCESSING INDUSTRY	2 items
- ELECTRONICS	1 item

HIGH RISK DANGEROUS INSTALATIONS (incl. SEVESO II)



II. PREVENTION AND MITIGATION MEASURES WITH REGARD TO POTENTIAL NATECH CONSEQUENCES

- ❑ LEGISLATIVE STANDARDS FOR CIVIL PROTECTION ARE OBLIGATORY

X – NOW THE NEW LEGISLATION IS HARMONISED WITH THE EC REQUIREMENTS

- ❑ THIS STANDARTS PROVIDE A STEADY FUNCTIONING OF THE NATIONAL ECONOMY DURING THE CASES OF CRISIS SITUATIONS

X – NOW THE SAFETY OF POPULATION IS HIGHLY REQUIRED

- ❑ A SPECIAL PART OF THE STANDARTS ARE :

  “ENGINEERING AND TECHNICAL NORMS FOR CIVIL PROTECTION”

X - NOW THE DIRCTIVES OF EC ARE INCORPORATED

II. PREVENTION AND MITIGATION MEASURES WITH REGARD TO POTENTIAL NATECH CONSEQUENCES

"ENGINEERING AND TECHNICAL NORMS FOR CIVIL PROTECTION" ARE DIVIDED IN GENERAL AS FOLLOWS:

1. GENERAL PRINCIPLES.
2. NORMS FOR SETTLEMENTS, PLANTS AND FACILITIES, SETTING UP.
   - SETTLEMENTS PLANNING.
   - LOCATION OF PLANTS, ENTERPRISES, STORES, BASIS AND OTHER PROJECTS.
3. BUILDINGS AND FACILITIES.
4. FACILITIES FOR CIVIL PROTECTION.
5. WATERSUPPLY SYSTEM AND HYDROTECHNICAL EQUIPMENTS.
6. ELECTRICITY SUPPLY.
7. MAIN GAS-PIPE LINES, OIL CONDUITS AND PIPE LINES FOR STUFFS.
8. RAILWAY SYSTEM AND ROADS.
9. TRANSMISSION AND RADIO TRANSMIT RELAY SYSTEM.
10. FORMING AND MAKING UP DOCUMENTATIONS OF DESIGNES AND THEIR CO-ORDINATION WITH THE CIVIL PROTECTION AUTHORITIES.

What is considered NATECHs for the last 5 years?

- Roads interruptions – more than several tens (from floods, landslides, forest fires)
- Railroads interruptions – several tens (floods, landslides)
- Electric lines interruptions – several hundreds – from storms, icing, (including one blackout – from forest fire)
- Gas pipe line stops - several from floods and landslides (including one blast)

One real NATECH case from 2007, 6th August

- Gas pipe line blast near village Bulgarchevo – Southwest Bulgaria, due to the landslide

(Diameter ~ 20 meters, depth ~2 meters)

- About 30 hours gas supply to Greece interrupted
- More then 200 000 lv.(100 000 EUR) rehabilitation works
- No compensations paid due to the natural “unpredictable” circumstances

The real case from 2007, 6th August (gas pipe line blast, due to the landslide)

CONCLUSIONS (“positive”)

- NO MAJOR NATECH EVENTS HAVE BEEN OBSERVED IN BULGARIA DURING THE LAST 5 YEARS. NO VICTIMS REPORTED.
- A LOT OF SMALLER ACCIDENTS HAVE BEEN OBSERVED DURING THE FLOODS (2005) AND FIRES (2006-2007), BUT WITHOUT HEAVY CONSEQUENCES
- THE NEW GOVERNMENTAL POLICY IS SUCCESSFUL, BUT NEEDS CLARIFICATION ABOUT CRISIS CENTRALIZED OR NON CENTRALIZED SYSTEM PERFORMANCE

Conclusions (“negative”)

- Difficult coordination between the different institutions responsible about different NATECH – Ministry of environment and Ministry of emergency (in case of dangerous substances release), fire brigades and civil defense (in case of wildfires), volunteers (in case of floods and fires), etc.
- Duplication of some functions about rescue and emergency measures – Army, Civil Defense, Fire Brigades, Volunteers
- No effective prevention in case of fires and floods.

Thank you for your attention!

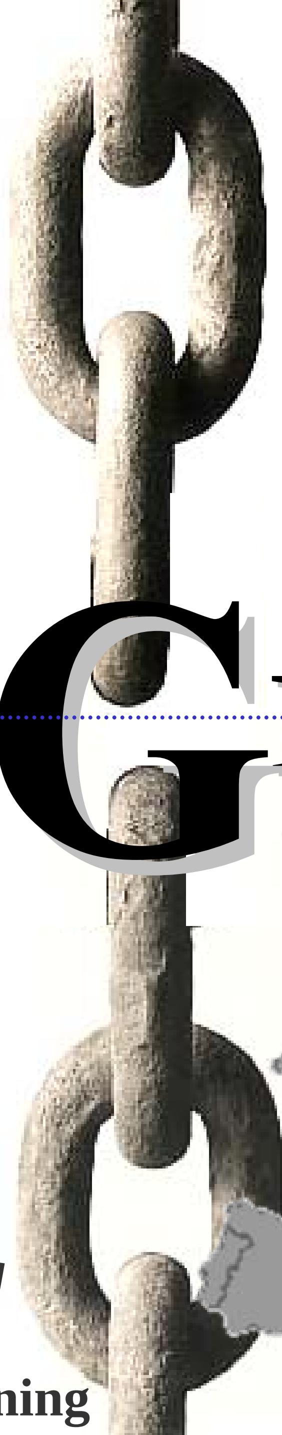
WORKSHOP

"NATECH RISK ASSESSMENT AND MANAGEMENT"

SEPTEMBER 17-18, 2007
Stresa, Italy

LAND USE PLANNING in NATECH RISK MANAGEMENT.

THE CASE OF GREECE



Anna Papachatzi
Architect , MSc in Urban and Regional Planning
Greece, Region of Attica,
Directorate of Environment and Regional Planning

WEAKNESSES OF GREEK SPATIAL PLANNING POLICIES

PRIVATE-INDIVIDUAL BUILDING DEVELOPMENT

Unplanned urbanization__L__ High population density__A__ Illegal constructions __N__Out of plan land development__D__ Proximity of incompatible uses and mutually conflicting interests…

is not the void

between the scattered urban entities,

but a field that integrates the different clusters into a dynamic system.

Parkeharrison, Reclamation, 2003

WEAKNESSES OF GREEK SPATIAL PLANNING POLICIES

Any Luck???

Lack of dynamic monitoring - assessment of spatial development trends.

Lack of concerted action in between the different levels of administrative competences for spatial planning; also between the latter and civil protection.

Lack of multi/inter-disciplinary teamwork and interrelated competences.

Parkeharrison, The marks we make, 2003

EMERGING UNCERTAINTIES about CONTEMPORARY **RISKS**

Parkeharrison, Earth coat, 2002

We have reached an era where

TERRA

confronts

a new kind of

TERRORISM

EMERGING UNCERTAINTIES about CONTEMPORARY RISKS

Parkeharrison, Forest bed, 1998

Has nature of risks changed?

Has the number of risks increased?

Has urban (*physical*, *social*, *institutional*) vulnerability increased?

New risks in the same society ?

New threats in the same framework

… or vice versa?

EMERGING UNCERTAINTIES about CONTEMPORARY **RISKS**

Parkeharrison, Tethered sky, 2003

Communities don’t cope with “familiar”, simple, low range risks.

Risk management occurs only within the context of crisis management and not as a routine action.

EMERGING UNCERTAINTIES about CONTEMPORARY RISKS

Chema Madoz

In contemporary greek reality

the natural, cultural, industrial, technological environments cannot be separated

being all

parts of an integrated human/social structure.

- **Natech risks will occur in the future more often and in many more ways.**

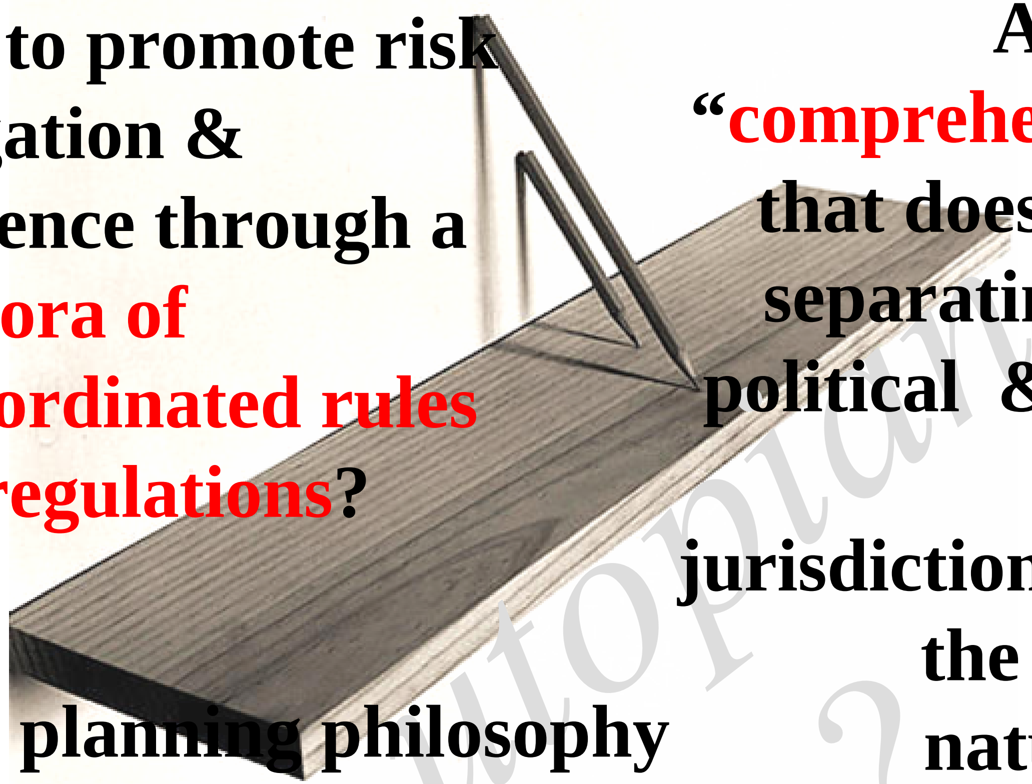
  Risk mitigation actions are needed to control the severity of the effects.

  Resilience enhancement is also crucial for the recovery of the affected entities from whatever effects.

CERTAINTY

Chema Madoz

STRATEGIC & REGULATORY (Land Use) PLANNING to serve Risk Mitigation & Resilience Enhancement



- How to promote risk mitigation & resilience through a **plethora of uncoordinated rules and regulations**?

Which planning philosophy can accommodate the management of **heterogeneous and unprecedented threats**?

A grand vision of "**comprehensive planning**" that doesn't consider the separating lines between political & administrative competences & jurisdictions; also between the origin/nature of natural and human induced disasters whose common denominator are the domino & systemic effects.

Chema Madoz

Parkeharrison,Turning to spring, 2001

is part of spatial planning and an important process,

not only for segregation of residential, agricultural, forestal and industrial areas-uses , but also for guaranteeing their safe proximity, contact, interconnection, interrelation.

NATIONWIDE STATE OF EMERGENCY

GREECE ON FIRE – SUMMER 2007

The worst ecological, economical and human disaster in Greece, since the 2^{nd} World War.

Natech?

http://images.spaceref.c

65 lost lives. Hundreds of environmental refugees.

Disrupted life-lines (water, electricity, telephones)

The whole country threatened by a generalized blackout from the steam - electric station of Megalopolis.

Rural villages, cultivations, fields and 268.834 hectares *(European Forest Fire Informational System)* (12%) of the country's forest land burnt.

NATECH DISASTER?

1. TRIGGERING MECHANISM:

Natural phenomena (drought, high temperatures (3 *concecutive heat waves*), strong-persisting winds)

2. PRIMARY EFFECTS:

DOMINO EFFECTS

Life-line disruption (water, electricity, telephones).

Cut off local and translocal road networks.

Destruction of the local agricultural infrastructure.

Persistent burning of the steam-electric industry’s mine in Megalopolis contaminating the environment.

Potential generalized blackout.

3. SECONDARY EFFECTS:

Potential damages due to future floods and geological risks (landslides, subsidence)

http://newsimg.bbc.co.uk/media/images/44080000/gif/_44080261_greece_fires2_416map.gif

RESPONSE

1. Inadequate co-ordination.
2. Many fire ignitions and proportionally few firemen and fire extinction means.
3. Operational incapacity of the fire-fighting planes and helicopters due to the strong winds, poor visibility…
4. Operational incapacity of firemen and vehicles at the mountainous villages due to the topographic relief.

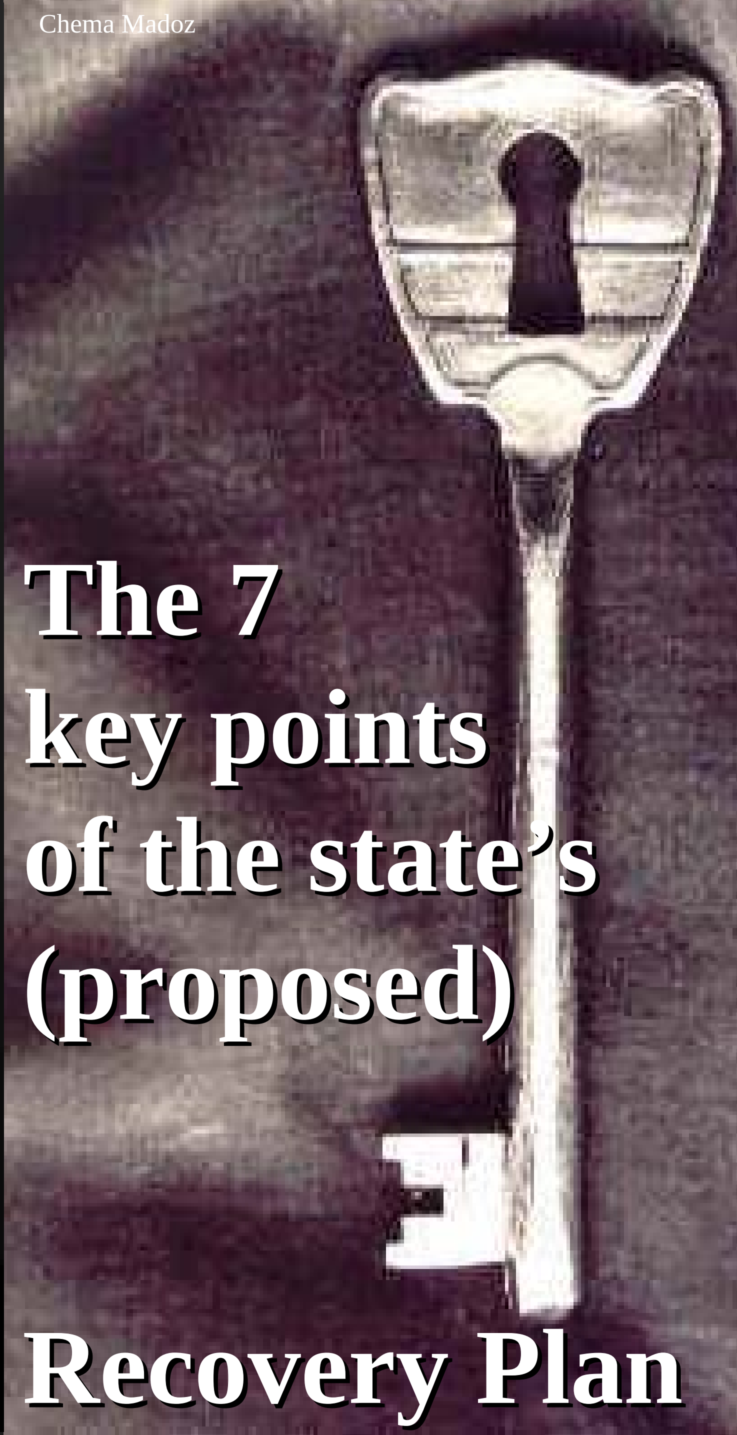
WHAT WENT WRONG ?

No specific management system for natech disasters.

5) Research and implementation of infrastructure works (roads, water supply, irrigation works etc) for the viable and quick development of the area.
Anti corrosion and anti flooding protection works to avoid problems coming from rainfalls.

6) Reinforcement of business initiatives aiming to the area’s development.

7) Support of tourism and the heavy industry of Greece.



GAPS

STARTING FROM SCRATCH

Scientific gaps (*risk assessment*) and lack of social awareness (*perception of social vulnerability, natech scenarios*).

Issues of hierarchies, responsibilities and institutions.

Incompatibility among long term (*sustainable*) and short term (*emergency response*) strategies.

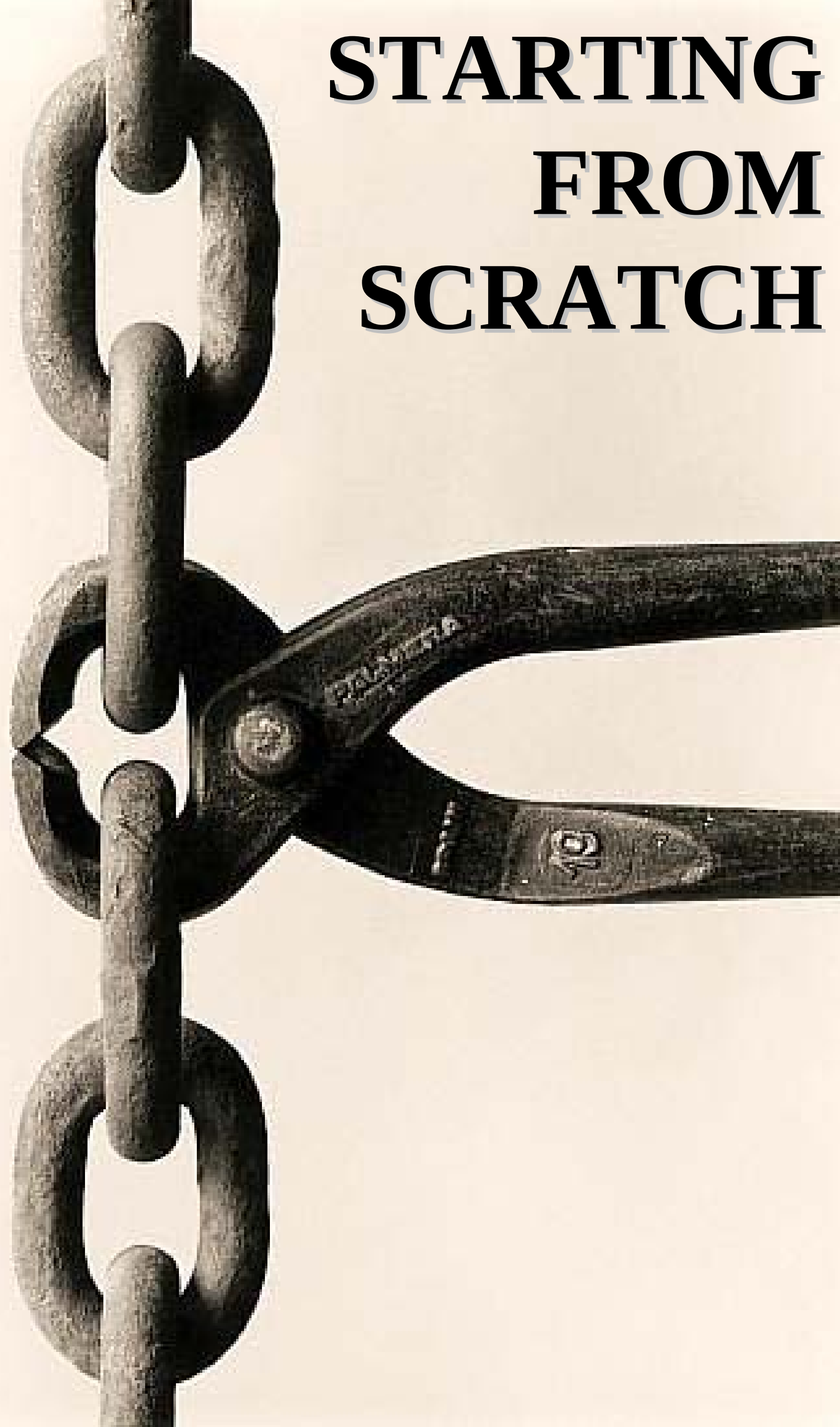
Chema Madoz

STRATEGIES TECHNIQUES TOOLS

More effective measures and tools to reach clear protection goals and objectives.

Integration of stuctural and non-structural hazard prevention and mitigation activities.

Shift from reactive disaster response to proactive risk reduction.



Chema Madoz


thank
you
!
The power of protection

ANNEX 3

CASE STUDY MATERIALS

Definitions

1. Peak ground acceleration (PGA)

Peak ground acceleration is a measure of earthquake acceleration. Unlike the Richter magnitude scale, it is not a measure of the total size of the earthquake, but rather how hard the earth shakes in a given geographic area. Peak ground acceleration can be measured in *g* (the acceleration due to gravity) or m/s^2.

2. Modified Mercalli Intensity scale (MMI)

The Mercalli intensity scale is a scale used for measuring the intensity of an earthquake. The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale of 1 through 12, with 1 denoting a weak earthquake and 12 one that causes almost complete destruction.

3. Moment Magnitude scale (M_w)

The moment magnitude scale was introduced as a successor to the Richter scale and is used by seismologists to compare the energy released by earthquakes. The moment magnitude is now the most often used estimate of large earthquake magnitudes.

4. Hazard

A hazard is a source of danger. A hazard does not necessarily lead to harm but represents only a potential to result in harm.

5. Vulnerability

The vulnerability is the degree to which a system is susceptible to, and unable to cope with, injury, damage or harm.

6. Risk

Risk is the combination of the frequency, or probability, of occurrence and the consequence of a specified hazardous event. Risk therefore includes the likelihood of conversion of a hazard into actual delivery of injury, damage or harm.

7. Natech

A Natech disaster is a technological disaster triggered by any type of natural disaster. The technological disaster can include damage to industrial facilities (including lifelines) which results in significant adverse effects to the health of people, property, and/or the environment.

CASE STUDY 1: COVER CITY, CA, USA

Based on work by A. M. Cruz and L. J. Steinberg

Instructions:

Read the following case study description before we do the actual case study exercise on Tuesday morning, 18 Sept 2007. This is your community. You will need to become familiar with it. If you have any questions you will be given some time for questions and clarification before we start the actual case study exercise.

On Tuesday morning, you will be assigned to a Rapid Natech risk assessment (RNRA) team for your community. Each team member will be given a role to play, for example, head of the fire department, mayor, head of environmental group, representative of community association, or industry owner, among others.

A step-by-step description of the RNRA methodology follows the case study description. Go through the RNRA process with your group mates. All decisions should come from group consensus and should be appropriately supported.

At the end of the exercise you will be given time to prepare a short summary and a presentation of your case study results.

A. Case Study Description

1. Introduction

Cover is a city in California, USA, located within Los Angeles County. There are more than 17 million people living in Los Angeles County, 1.6 million alone live in Cover. Cover is chosen for the analysis because it is highly urbanized (population density is approximately 3041 persons/km^2), it is home to a large number of industrial facilities that handle hazardous materials (hazmats), and it is bisected by several faults placing this region at high earthquake risk.

The City of Cover is intersected by three major faults - NI– PV, and PH – which are capable of producing 7.1 magnitude or greater earthquakes. Careful natural hazard assessment indicates that the greatest risk to the city of Cover may come from a large earthquake on the NI fault. The expected maximum magnitude[1] on this fault is 7.1 with a 5% probability of being exceeded in 50 years. The earthquake's impact is expected to be felt throughout the Los Angeles County. See Figure A3-1 showing a two maps of Cover indicating (a) the location of hazardous material storage tanks and emergency resources, and (b) the expected peak ground accelerations modeled for the earthquake.

Demographic Information

Cover is a city of 1.6 million people, of which about 465,000 are less than 18 years of age. The average age of the population is 47. Sixty five percent of the population in Cover are white, 16. 5 % are of Asian descent, and 5.5 % are African Americans. 11 % of the total population in this area is Hispanic.

There are approximately 600,700 households. About 51% of the heads of households in Cover own their homes. Twelve percent of the households earn less than US$10,000 a year, 32 % make between US$30,000 and US$60,000 a year, and the rest make more than US$ 60,000 a year. The population in Cover are well educated. Only 3% of Cover residents did not complete high school

[1] The expected maximum magnitude is related to the tectonic setting, geometry, and type of the seismic source. Empirical correlations are generally used to determine the expected maximum magnitude based on the *length of rupture* of the fault, and the *total length* of the fault trace or the *area* of the fault rupture zone.

education, twenty percent have at least high school education, and 77 % have obtained a two-year college degree or higher.

Hazardous Materials at Industrial Facilities

There are 40 industrial facilities in Cover subject to risk management requirements for chemical accident prevention according to the United States' Risk Management Planning (RMP) rule. These facilities house over 100 storage tanks containing hazardous materials in quantities that exceed RMP thresholds and thus are regulated by this rule. In addition there are hundreds of smaller industrial facilities that house other hazmats in smaller quantities that do not surpass the RMP threshold and thus are not regulated by the rule. The hazmats present at the many industrial facilities in Cover pose a major threat to its people, property and the environment during a major earthquake (magnitude 7.0 or greater). For simplicity of the case study exercise we will only include 20 hazmat containing storage tanks in the RNRA exercise. See Spreadsheet 1.

2. Potential Consequences of the Earthquake

Casualties

A magnitude 7.1 earthquake on the NI fault is expected to cause over 100,000 casualties, including over 1500 people killed in Los Angeles County. In the city of Cover we can expect about 1000 fatalities, 1200 life threatening injuries, over 11000 hospitalizations, and over 60500 people requiring medical aid.

Building damage

The earthquake is expected to result in moderate damage to over 300,000 residential buildings, with over 70,000 sustaining major damage in the city of Cover. It is estimated that approximately 50,000 commercial buildings will suffer damage, with 15,000 suffering major damage. The scope and damage to residential and commercial buildings has major implications for emergency response (e.g., urban search and rescue, emergency medical services, emergency access).

Displaced Households

An earthquake along the NI fault will potentially displace thousands of families and individuals. Households can be displaced due to several factors including loss of habitability of the residential building, fire following the earthquake, loss of electrical power or water supply, and hazardous materials releases. In the case of a hazardous material release concurrent with loss of habitability of the residential building the threat to individuals is greatly increased particularly if the hazmat release involves a toxic plume. Shelter-in-place which is usually the preferred emergency response action following toxic plume releases may not be possible because homes no longer provide adequate protection. It is estimated that approximately 130,000 households will require shelter.

Debris

A major source of debris from this earthquake will be structures that have been completely damaged or have collapsed. Debris will include building contents as well as structural and non-structural elements. Debris becomes a major problem when it blocks roads and highways, or access to emergency resources. Furthermore, debris from partially damaged or completely damaged buildings often results in damage to adjacent electrical power lines and poles.

Power and water distribution systems

Damage to power and water distribution systems will affect emergency response to earthquake victims and will hamper containment of hazmat releases. Furthermore, damage to power and water systems can exacerbate hazmat problems, as well as become the cause of hazmat releases. Based on experience from previous earthquakes it can be expected that electrical power supply will be severely hampered by the earthquake and that damage to high pressure water mains and water distribution systems will result in little or not water available in many areas of the city.

Oil and gas pipelines

Damage to oil and gas pipelines will result in leaks, fires and explosions. Based on world wide data, Erdik (1998) found that about 0.5-1 gas pipe breaks per one kilometer pipe occur during shaking intensity level MMI VIII, depending on soil and pipe conditions. Rates can increase about 50 % in shaking intensity level MMI IX. During the Northridge earthquake (magnitude 6.8) there were 35 gas system failures in older transmission lines, 123 failures of steel distribution mains, 117 failures in service lines, and 394 corrosion related leaks, during an earthquake that has been considered mild with respect to future earthquakes that can be expected in the region. In addition, there were reports of approximately 110 earthquake-related fire ignitions. It is expected that over 400 gas leak related fires will occur during the NI 7.1 magnitude earthquake in Cover alone. Other gas leaks and fires are expected throughout the Los Angeles County.

Following the earthquake, fires caused by gas line and petroleum pipeline breaks will compete with industrial fires and hazmat releases for firefighting resources, adding an additional burden to already stressed emergency response officials. Furthermore, gas leaks and fires from household distribution lines will contribute to the already precarious situation.

Roads and Bridges

A 7.1 magnitude earthquake along the NI fault can cause extensive damage to bridges and elevated highways. Erdik notes that the Northridge earthquake caused heavy damage to 10 viaducts and 157 bridges. In addition, collapse and other damage (to bridges) resulted in the closing of 11 major roads in downtown Los Angeles. Damage to road overpasses and bridges cut off police department personnel (and other emergency responders) from their homes following the Northridge earthquake. Arrangements had to be made to provide temporary housing and food for emergency response personnel.

Damage to roads and bridges may not always result in isolation of whole areas. However, it will most likely result in traffic congestion, and longer travel times, delaying the arrival of emergency fire and hazmat teams. Use your own judgment to estimate the potential damage caused by the earthquake to roads and bridges.

Critical Facilities

Critical facilities in this case study refers to those facilities that are essential for emergency response and for ensuring public safety. These include drinking water and sewer and waste water treatment plants, airports, hospitals, fire stations, police stations, major shelters, and emergency operations centers.

There are two drinking water treatment plants and one waste water treatment plant in the city of Cover. The drinking sewer/waste water treatment plant is considered one of the biggest in the United States. There are over 60 acute care hospitals in Cover. About 20 facilities, including the drinking water and sewer/waste water treatment plants, are located within 8 km from the NI fault line, and about 90 % are located within 40 km from the fault line. The hospitals in the city of Cover are expected to be 50 % to 75 % functional following the earthquake. The earthquake is expected to affect the entire Los Angeles County area.

3. Emergency Response Resources

The city of Cover' Department of Emergency Management oversees all emergency management operations. There is an Emergency Operations Center building. There is also a separate building used as the emergency call center.

Police Department

The Police Department is responsible for maintaining peace and order, enforcing laws, and preserving life and property. The Police Department works closely with the Fire Department to coordinate evacuation or blocking-off of areas as required for example due to a toxic chemical release. There are over 15 Police Stations in Cover.

Fire Department

Responsibility for enforcement of industrial risk management and emergency response to hazmat incidents, and fire suppression fall under the Cover Fire Department (FD). The Cover FD has 20 local Fire Stations spread out throughout the city with at least some firefighting capacity. Two of these fire stations have hazmat teams. Local fire stations carry out fire suppression, search and rescue operations, provide emergency medical services, and respond to industrial fires and hazmat releases, explosive threats and hazmat releases from transportation and railcar accidents, as well as releases from petroleum and chemical pipelines. It is expected that during the 7.1 magnitude earthquake along the NI fault the FD will most likely be overwhelmed responding to earthquake victims and residential fires caused by gas leaks.

Hazmat Teams

There are 2 hazmat teams in Cover City. The hazmat teams consist of hazmat trained firefighters, which are part of two of the 20 local fire stations in the city. Therefore, in addition to responding to hazmat releases, the hazmat team members respond to residential fires and other non-hazmat related problems, such as medical emergencies.

References

The following documents were consulted to construct the case study. However, in some cases the information and data were modified to protect the privacy of particular cities, industrial facilities, and individuals.

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CASE STUDY 2: ANKESI, TURKEY

A. M. Cruz and E. Krausmann

1. Introduction

The City of Ankesi is located within Kocaeli Province in Turkey. The province is home to over 1.2 million people. The population density of Ankesi is 400 persons/km^2. The whole region is highly urbanized and industrialized, with 30% of Turkey's industrial production being located there. The Kocaeli Province, including the City of Ankesi, is subject to high seismic risk due to its lying on the North Anatolian fault system that has produced large earthquakes in the past. The last one occurred on 17 August, 1999, where a $M_w = 7.4$ earthquake resulted in over 17000 deaths, extensive damage to residential and commercial buildings, as well as multiple hazardous-materials releases due to damage to industrial facilities. The North Anatolian fault is expected to trigger earthquakes in the $M_w = 7+$ range. See Figure A3-2 showing a map indicating the location of hazardous material containing storage tanks, and the Modified Mercalli Intensity (MMI) values for the 17 August 1999 earthquake in Kocaeli Province.

Demographic Information

Ankesi city has a population of approximately 350,000 people. Approximately 67 % of the population is between the ages 15-60 years. A large percentage of the population works in industry and local commerce. Average monthly household income is US$1,484.00. There are slight differences in educational level of men and women. Population data for Turkey indicate that about 90 % of men and 87 % of women complete primary education, and about 61 % men and 52 % women complete secondary education. About 23 % of men and 15.5 % of women have completed college degrees. These numbers are greatly influenced by Turkey's still relatively large rural population. These numbers could be considerable higher for Ankesi. Poverty rates for the Marmara Region is at a low 1.4 %.

Hazardous Materials at Industrial Facilities

Ankesi is home to Turkey's heavy industry, in particular state-owned petrochemical complexes, fine- and general-chemicals industry, metallurgical and automobile industries to name a few. The vicinity of these facilities to an important tectonic fault line and their handling or storing of hazardous materials gives rise to concern over their performance during strong ground-shaking conditions.

Turkey regulates the storage, processing, and disposal of hazardous chemicals and flammable substances under the Environmental Law of 1983. These environmental regulations require facilities to report inventories of hazmats on site, and report any accidental hazmat releases and air emissions. Companies are required to carry out wastewater treatment on-site; and to send hazardous wastes (solid and liquid) to a municipal treatment facility. The implementation of mitigation measures to reduce the risk of accidental hazmat releases, and the establishment of emergency management plans for hazmat releases are mandatory. However, although most of Turkey is at high risk for seismic activity (Tang 2000), there is no law requiring the development of emergency management plans that specifically prepare facilities to respond to hazmat accidents following an earthquake.

In the Kocaeli region there are more than 40 industrial facilities that handle hazardous materials, 15 of these alone are located in Ankesi. These facilities house more than 70 hazmat containing storage tanks. In addition there are hundreds of smaller industrial facilities that house other hazmats in smaller quantities that are not regulated by the Turkish Environmental Law. The hazmats present at the many industrial facilities in Ankesi pose a major threat to its people, property and the environment during a major earthquake (magnitude 7.0 or greater). For simplicity of the case study exercise we will only include 20 hazmat containing storage tanks in the RNRA exercise. See Spreadsheet 1.

2. Potential Consequences of the Earthquake

Casualties

An earthquake of magnitude 7+ in Ankesi city is expected to cause more than 12,000 casualties, including over 5000 fatalities and 7000 serious injuries.

Building damage

The earthquake is expected to result in damage to more than 70,000 residential buildings, and with complete collapse of 15,000 residential and commercial buildings in Ankesi city. The damage to buildings has major implications for emergency response (e.g., urban search and rescue, emergency medical services, emergency access).

Displaced Households

An earthquake along the North Anatolian fault will potentially displace thousands of families and individuals. Households can be displaced due to several factors including loss of habitability of the residential building, fire following the earthquake, loss of electrical power or water supply, and hazardous materials releases. In the case of a hazardous material release concurrent with loss of habitability of the residential building the threat to individuals is greatly increased particularly if the hazmat release involves a toxic plume. Shelter-in-place which is the preferred emergency response action may not be possible because homes no longer provide adequate protection. It is estimated that about 150,000 people will be homeless as a result of this earthquake and will require public shelter.

Debris

A major source of debris from this earthquake will be structures that have been completely damaged or have collapsed. Debris will include building contents as well as structural and non-structural elements. Debris becomes a major problem when it blocks roads and highways, or access to emergency resources. Furthermore, debris from partially damaged or completely damaged buildings often results in damage to adjacent electrical power lines and poles.

Power and water distribution systems

Power and water-distribution systems are particularly vulnerable to a strong earthquake due to strong shaking and soil-liquefaction failures. Damage to power transmission and water distribution systems can affect emergency response to earthquake victims and can hamper containment of hazmat releases. Furthermore, damage to power and water systems can exacerbate hazmat problems, as well as become the cause of hazmat releases. Based on experience from previous earthquakes it can be expected that electrical power supply will be interrupted by the earthquake and that damage to high pressure water mains and water distribution systems will result in little or no water available in many areas of the city.

Oil and gas pipelines

Damage to oil and gas pipelines can result in leaks, fires and explosions. Based on world-wide data, Erdik (1998) found that about 0.5-1 gas pipe breaks per one kilometer pipe occur during shaking intensity level MMI VIII, depending on soil and pipe conditions. Damage percentages can increase about 50 % in shaking intensity level MMI IX.

Following the earthquake, fires caused by gas line and petroleum pipeline breaks will compete with industrial fires and hazmat releases for firefighting resources, adding an additional burden to already stressed emergency response officials. Furthermore, gas leaks and fires from household distribution lines will contribute to the already precarious situation.

Following the Kocaeli earthquake authorities reported only minor residential fires due to gas leaks. A similar situation might be expected from this earthquake.

Roads and Bridges

An earthquake can cause extensive damage to bridges and road overpasses. In addition, the collapse and other damage to bridges can result in the closing of major roads, thereby disconnecting and isolating areas. This was observed both during the 1999 Kocaeli earthquake. Damage to transportation lifelines may not always result in isolation of whole areas. However, it will most likely result in traffic congestion, and longer travel times, delaying the arrival of emergency fire and hazmat teams. Use your own judgment to estimate potential damage to roads and bridges.

Essential Facilities

Essential facilities in this case study refers to those facilities that are critical for emergency response and for ensuring public safety. These include drinking water and sewer and waste water treatment plants, airports, hospitals, fire stations, police stations, major shelters, and emergency operations centers.

Drinking and waste-water systems, in particular water pipelines and sewer pipes are susceptible to heavy damage due to ground deformation during a 7+ earthquake. This may result in a loss of water supply in many areas in Ankesi city. The main water pipeline which supplied water to the Kocaeli area's industry failed in more than 14 different locations during the Kocaeli earthquake rending it useless.

Public hospitals have been retrofitted to withstand increased earthquake loads and are expected to perform better than private hospitals. During the 1999 Kocaeli earthquake 26% of the hospitals in the affected area were damaged beyond repair, so we assume that about 70% of the hospitals in the case study region will be functional following the earthquake.

There is one drinking water treatment plant and one sewer water treatment plant in Ankesi. The drinking water treatment plant is located next to the Marmara Sea. It suffered minor damages during the Kocaeli earthquake and has undergone some earthquake retrofitting.

Emergency Response

The rapidly growing city of Ankesi has a moderately-well developed emergency-response organization. Having suffered through the Kocaeli earthquake, government authorities have made efforts to improve based on lessons learned from the past. Ankesi government officials work closely with industry owners/operators to insure proper response to industrial accidents. The City of Ankesi has 8 fire stations, two of these with some hazmat containment capacity. None the less, with limited economic resources, even one major Natech accident affecting Ankesi will require the aid of private hazmat fighting personnel (two industrial facilities in Ankesi have onsite fire fighting capacity and some hazmat trained personnel) as well as outside aid from other cities or provinces assuming that these have not also been impacted by the earthquake.

Therefore, for the purpose of this case study it is assumed that the emergency response capacity will be quickly exceeded by the earthquake. As an example, during the 1999 Kocaeli earthquake both governmental and non-governmental emergency response organizations were overwhelmed by the demand for their intervention. Fire departments throughout the region, including those in Istanbul where overwhelmed by the magnitude of the disaster.

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CASE STUDY MAPS

Figure A3-1. Maps of Cover City

(a) (b)

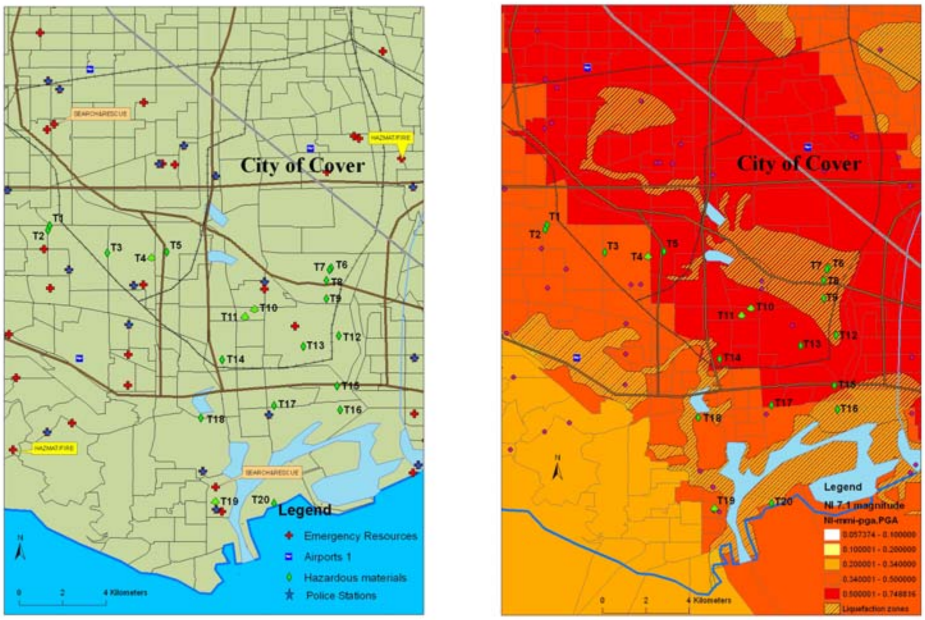
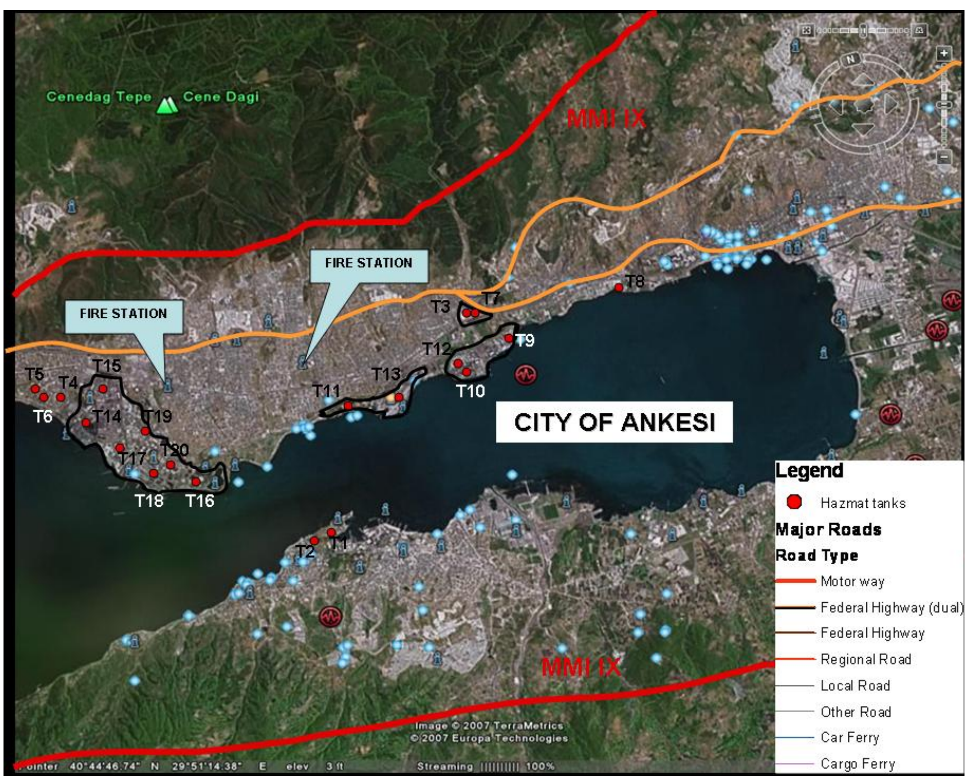


Figure A3-2. Map of Ankesi City



Methodology for estimating vulnerability to earthquake due to storage tank type and design*

*Prepared by V. Cozzani

The vulnerability of equipment to the natural event in the case of earthquakes may be calculated by simplified empirical models, obtained from observational data.

The models relate a parameter of the expected seismic event, the horizontal peak ground acceleration (PGA) to the equipment damage probability (more precisely, to the probability of a given damage state to be caused by the earthquake). These models, named fragility models have the following general expression:

$$F[RS\ or DS \mid \alpha] = f(\mu, \beta, PGA) \qquad (1)$$

where the fragility curve F expresses the cumulative lognormal distribution f, characterized by mean μ and standard deviation β of exceeding the damage or risk state α. Recently, probit analysis was used for the linearization of the distribution f, obtaining a set of vulnerability models based on the following expression:

$$Y = k_1 + k_2 \ln(PGA) \qquad \forall DS, RS \qquad (2)$$

where k_1 e k_2 are the model parameters and PGA is expressed in as a multiple of the gravity constant, g (9.81 m/s^2).

Although several alternative models were proposed [Fabbrocino et al., 2005; Salzano et al., 2003], Table A3-1 summarizes the models more suitable for application in the present framework [Antonioni et al., 2007; Campedel et al., 2007]

Table A3-1: Constants of the probit models (to be used in eq.(2)).

Type of equipment	k_1	k_2
Atmospheric tanks, no details	4.66	1.54
Anchored atmospheric tank	4.66	1.54
Unanchored atmospheric tanks	5.51	1.34
Horizontal pressurized storage tanks	4.50	1.12
Pressurized reactors	4.36	1.22

Thus, equipment vulnerability index may be calculated as follows:

1) obtain the PGA of the reference seismic event considered for the site

2) if necessary, evaluate the PGA value in g units (calculate the ratio of the PGA to the constant g in coherent units)

3) select the proper values of the k_1 and k_2 constants to be used in eq.(2) on the basis of the equipment considered

4) calculate the probit value, Y, by eq.(2)

5) calculate the penalization index using Table A3-2.

Table A3-2: Criteria for the assignment of the penalization index for equipment vulnerability in the case of earthquakes

2. Vulnerability due to storage tank type and design ***(1: low, 5 high)***	**0**	**1**	**2**	**3**	**4**	**5**
Range of damage prob. (%)	0 – 5	5 – 20	20 - 50	50 - 70	70 - 90	90 - 100
Range of probit variable, Y	**< 3.36**	**3.36 – 4.16**	**4.16 - 5.00**	**5.00 – 5.52**	**5.52 – 6.28**	**> 6.28**

Methodology for estimating vulnerability to floods due to storage tank type and design*

Prepared by V. Cozzani

In the case of floods, both the analysis of past accidental events reported in specific databases and structural analysis indicate that the damage probability of process equipment is related to two specific parameters of the flood: the maximum height of water at the site and the velocity of the water. Either parameter characterizes a different type of flood: “flash-floods” or floods in narrow valleys or on hillsides may be characterized by low water height but high water velocities, while extended floods in flatlands are usually characterized by slow water velocities and high water heights.

The two parameters may be correlated calculating an overall pressure acting on the vessel, obtained as the sum of a static pressure (due to water height) and of a dynamic pressure (due to water speed). A preliminary structural analysis of different categories of storage vessels joined to the revision of literature data and of past accidents allowed a qualitative identification of different hazard ranges for the overall pressure values [Campedel & Cozzani, 2007]. Since static pressure is related to water height and dynamic pressure to the square of water velocity, it was possible to obtain the plot reported in Figure A3-3. The plot identifies five different hazard zones, to which different values of the equipment vulnerability penalization index are reported.

Thus, the equipment vulnerability index may be calculated as follows:

1) obtain the values of the maximum water height and of water velocity for the reference event. If only one of these values is provided, assume “0” for the other.

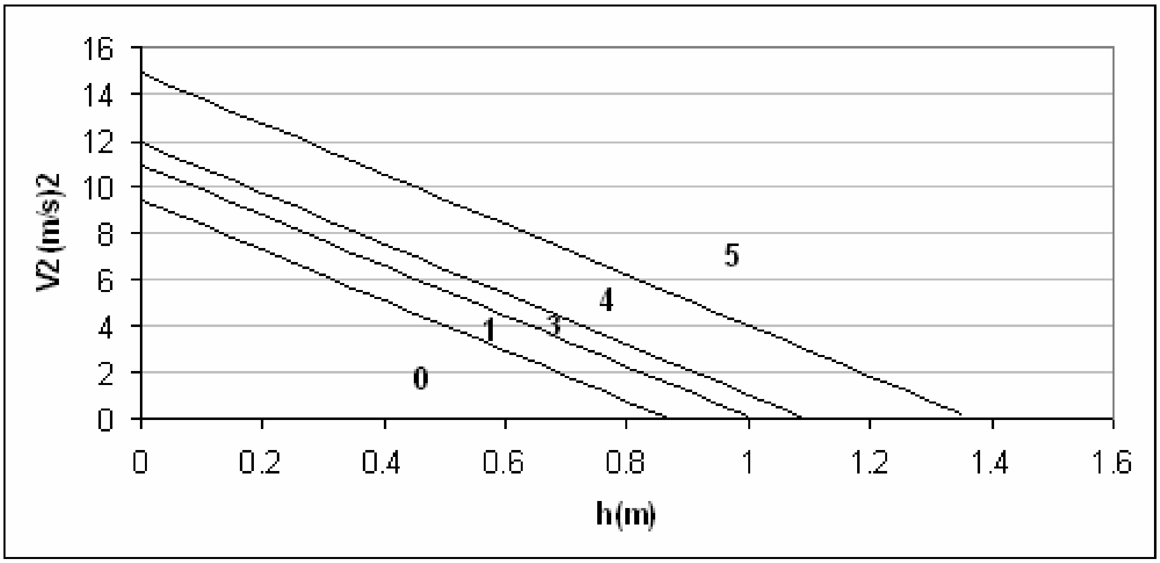
2) if necessary, convert the height value to meters and the velocity value to m/s

3) calculate the square of the velocity value (m^2/s^2)

4) identify on the plot in Figure A3-3 the position of the point that represents the reference event selected (if velocity is 0, the point will be on the x-axis)

5) identify the penalization index associated to the region to which the point representing the reference event is belonging

Figure A3-3: Plot for the calculation of the equipment vulnerability in the case of floods. V2: square of water velocity; h: maximum water height.



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Toxic Chemical Health Effects and Exposure Limits*

*Prepared by A. M. Cruz

To determine the potential impacts of a conjoint natural and technological disaster on an industry and nearby residents, it is important to understand what can happen to the large volumes of hazardous chemicals stored and handled at these industrial facilities during an accidental release. Although flammable chemicals such as propane and butane gases are hazardous, larger vulnerability zones may result from the release of toxic gases that can be transported by the wind. Some of the most commonly used chemicals in large volumes include anhydrous ammonia (NH_3), hydrogen fluoride (anhydrous) (HF), and hydrogen sulfide (H_2S) which are extremely dangerous. Some examples of uses of these chemicals in industry include:

- Anhydrous ammonia is used at refineries to enhance pollution control systems for process heaters and boilers to reduce and control oxides of nitrogen (NO_x). Anhydrous ammonia also results as a product taken out of oil process streams during the manufacturing of petroleum products (Leffler, 1985).
- Hydrogen fluoride is used at refineries in the alkylation unit, which combines low molecular weight olefins with isobutane in the presence of HF to produce gasoline components of high octane rating.
- Hydrogen sulfide is found in crude oil, and is a by product produced during hydrotreating. The process usually involves removal of the hydrogen sulfide from the hydrocarbon stream; and then the conversion of the lethal H_2S to elemental sulfur, a harmless chemical (Leffler, 1985).

The following sections present a brief summary on the toxicity of the above chemicals

Hydrogen Fluoride (Anhydrous)

Hydrogen fluoride is an extremely corrosive acid that can cause severe injury through skin and eye contact, inhalation, or ingestion. Skin contact results in tissue destruction and painful deep burns. HF can cause burn to the eyes, which may lead to permanent damage or blindness (USDHHS, 1978). Lund et al. (1997) found that human exposure to HF concentrations above 2.5 mg/m3 is associated with pronounced symptoms from the upper respiratory tract. The authors also report that exposure to 26 mg/m3 for three minutes induced lower airway irritation and mild symptoms from eyes and nose. Exposure to higher concentrations can result in damage to lungs, and fatal pulmonary edema (Dalbey et al., 1998). 120 ppm (USDHHS, 1978) and 122 ppm (Dalbey et al., 1998) have been reported as the highest concentrations a human can tolerate for 1 minute, because of respiratory and skin irritation, and conjunctiva. Dalbey et al (1998) estimated a short-term (10-minute) exposure limit, similar to the Emergency Response Planning Guidelines (ERPG). Using a low uncertainty factor (UF = 10), they estimated that 130 ppm of HF was a concentration to which most people could be exposed to for 10 min without having severe or irreversible health effects.

Hydrogen fluoride can be absorbed by clothes and hair (Lund et al., 1997). Therefore, clothing contaminated with hydrogen fluoride should be removed immediately, as it can cause burns. Contaminated clothing should be placed in closed containers for storage until it can be discharged appropriately (USDHHS, 1978).

Anhydrous Ammonia

Ammonia is a colorless, slightly flammable gas. It has a strong odor, with an odor threshold of 5 ppm. It is extremely irritating and corrosive to the eyes, skin, and respiratory tract. Exposure by inhalation causes irritation of the nose, throat, and mucous membranes. Lacrimation and irritation begins at 130 ppm. Eye contact is severely irritating and can cause permanent damage and blindness. Skin contact can cause severe irritation and burns (USDHHS, 1992). Toxic effects in vital organs such as the kidneys have also been reported (Boyd, MacLachlan, and Perry, 1944). Appelman, Berge and Reuzel (1982) note that there is inconsistency among reported toxicity data for ammonia. They found reports of exposure to 4500 mg ammonia/m3 air during 30 minutes to be lethal; while another report states that the lowest lethal dose for humans in about 3 hours is 7000 mg/m3. The U.S. Department of Health and Human Services and the U.S. Department of Labor (USDHHS, 1992) report that accidental exposure to concentrations above 2500 ppm for up to two hours has been fatal.

Protective clothing may not provide protection against permeation by ammonia. Additionally, liquid ammonia can attack coatings, and some plastics and rubber. Ammonia can react with certain compounds causing fires or explosions. It should no be allowed to contact copper, brass, bronze, or galvanized steel (USDHHS, 1992).

Hydrogen Sulfide

Hydrogen sulfide is a very toxic, colorless gas with a strong rotten-egg odor at very low concentrations (NIOSH, 1996; ATSDR, 1995). It is produced by the decomposition of organic material, sewer gas, petroleum industries, sulfur hot springs, natural gas, and others (ATSDR, 1995; Yant, 1930). Guidotti (1996) reports that the hydrogen sulfide exposure-response curve for lethality is very steep. The odor threshold is highly variable, between 0.01 – 0.3 ppm, with olfactory paralysis occurring at concentrations of 100 ppm and greater. Eye and lung irritation occur at concentrations between 20 and 50 ppm. Pulmonary edema can occur at concentrations between 250 – 500 ppm especially when exposure is prolonged (Reiffenstein et al., 1992; Guidotti, 1996). Exposure to concentrations of 500-700 ppm can produce intense anxiety, respiratory stimulation, amnesia, and unconsciousness (“knockdown”) (Schneider et al., 1998; Reiffenstein et al., 1992). According to Henderson and Haggard (1927), hydrogen sulfide in small amounts depresses the nervous system, in larger quantities it stimulates it, and in very large amounts it paralyzes the nervous system. Thus, concentrations above 1000 ppm usually result in rapid unconsciousness, cessation of respiration and death in a few minutes (Yant, 1930; Henderson and Haggard, 1927; AIHA, 1963).

Hydrogen sulfide absorption through the skin is not well documented. Yant (1929) found that in studies conducted by exposing skin directly to hydrogen sulfide gas, there were no symptoms of poisoning, discomfort or discoloration of the skin observed. However, Reiffenstein et al. (1992) reports discoloration, spots and rash after exposure to high concentrations.

Exposure Limits

The RMP Consequence Analysis Guidance put out by EPA (May, 1996) specifies toxic endpoints for a list of chemicals. The toxic endpoint specified for HF and NH_3 are based on the Emergency Response Planning Guideline – 2 (ERPG-2) values that will be defined below. Other commonly used toxic endpoints include the Immediately Dangerous to Life and Health (IDLH) values, the Permissible Exposure Limit (PEL) and the Threshold Limit Value – Time Weighted Average (TLV-TWA). For the purpose of the study, the ERPG-2 value was chosen as the specified toxic endpoint for the hazard assessment.

ERPG

The ERPG values are put out by the American Industrial Hygiene Association (AIHA) and updated annually. The AIHA definition is: "The ERPG values are estimates of chemical concentration ranges where it might be reasonably anticipated observing adverse effects as a consequence of exposure to a specific substance." There are three ERPG values for each guide, defined by AIHA as follows:

- ERPG-3 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.
- ERPG-2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.
- ERPG-1 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

IDLH

IDLH stands for immediately dangerous to life or health. IDLHs are established by the National Institute of Occupational Safety and Health. The purpose of establishing an IDLH is to "ensure that an exposed worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment." The IDLH is the maximum concentration from which a person must escape within 30 minutes to avoid irreversible health effects.

PELs and TLVs

OSHA and the American Conference of Governmental Industrial Hygienists establish the Permissible Exposure Limit (PEL) and the Threshold Limit Value – Time Weighted Average (TLV-TWA), respectively, as occupational exposure limits. A PEL or a TLV is the maximum average air concentration that most workers can be exposed to for an 8-hour workday, 40-hour workweek for a working lifetime (40 years) without experiencing significant adverse health effects. PELs are regulatory, while TLV-TWAs are set as guidelines. However, TLVs have been updated frequently, and are usually more stringent that OSHAs PELs. PELs were published in 1968, hence the reason they are not used very often even though they are legally enforceable. Table A3-3 gives the various exposure limit values for HF, NH_3 and H_2S.

Table A3-3. Exposure limits for hydrogen fluoride, ammonia and hydrogen sulfide.

Chemical Name Exposure Limit	HF	NH_3	H_2S
ERPG-1 ERPG-2 ERPG-3	5 ppm 20 ppm 50 ppm	25 ppm 200 ppm 1000 ppm	0.1 ppm 30 ppm 100 ppm
IDLH	30 ppm	300 ppm	300 ppm
PEL	3 ppm	35 ppm	20 ppm
TLV-TWA	3 ppm	25 ppm	10 ppm

Low and high toxic endpoints limits were chosen based on the literature review for the air dispersion modeling for both the Chalmette and Torrance refineries. These values are presented in Table A3-4.

Table A3-4. Toxic Endpoint Criteria Used for Air Dispersion Modeling

Chemical	Concentration	Observed effects at concentration
Hydrogen Fluoride	120 ppm	Highest concentration you can tolerate for 1-10 minutes, because of the onset of conjunctival and respiratory irritation with stinging of the skin (USDHHS, 1978)
Hydrogen Fluoride	20 ppm	30 ppm exposure for three minutes induced lower airway irritation and milder symptoms from the eyes and nose (Lund et al., 1997; Dalbey et al., 1998). The ERPG 2 value was selected for this range of symptoms = 20 ppm.
Ammonia (anhydrous)	300 ppm	Concentrations in the range of 300 to 500 ppm will cause people to leave the area immediately (EPA-CEPPO, 1998). 300 ppm is also the IDLH value.
Ammonia (anhydrous)	130 ppm	Exposure to this concentration caused Lacrimation and nose and throat irritation (USDHHS, 1992)
Hydrogen sulfide	100 ppm	Eye and lung irritation; olfactory paralysis, odor disappears (Guidotti, 1996; Reiffenstein et al., 1992). This is also the IDLH value.

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Overpressure physical effects[2]

20 psi (1.4 bar)	Heavily built concrete buildings are severely damaged or demolished.
10 psi (0.7 bar)	Reinforced concrete buildings are severely damaged or demolished. Most people are killed.
5 psi (0.35 bar)	Most buildings collapse. Injuries are universal, fatalities are widespread.
3 psi (0.21 bar)	Residential structures collapse. Serious injuries are common, fatalities may occur.
1 psi (0.07 bar)	Window glass shatters Light injuries from fragments occur.

1 psi $\cong$ 0.07 bar = 7 kPa

[2] From http://www.atomicarchive.com/Effects/effects4.shtml

ANNEX 4

Case-Study Report

Application of RNRA Methodology to Cover City, CA

Group B: Serkan Girgin, Anna Papachatzi, Xian Hua

Methodology:

For the calculation of RNRA scores, steps given in RNRA methodology document were followed. Case study description was thoroughly examined and based on obtained information, weights were given to scoring criteria by:

- common judgment of the group members,
- results of analytical calculation methods,
- results of accident models.

If available information or expertise is insufficient to assign case-specific weights to a criterion, i.e. evaluated cases can not be differentiated from each other for that criterion, a mean weight can be given to all cases or the criteria can be simply skipped. Since scoring methodology is based on taking the average of weights given to each criterion, leaving a criterion out of calculations does not influence the overall ranking of the average score. Based on this fact, it was decided not to include a criterion into calculation, if:

- little or no information is available on the criteria in the case study description,
- it is difficult to decide on weights in the limited time available for the study,
- criterion is too broadly defined.

The following criteria were skipped:

- HRL Score
    - Vulnerability due to loss of safety and mitigation measures due to earthquake
- Area Vulnerability Score
    - Population distribution
    - Number of highly vulnerable (old, sick, children)
    - Low income neighborhoods

In order to determine weights of vulnerability due to storage tank type and design, vulnerability index calculation methodology given in “Vulnerability due to storage tank type and design – earthquakes” paper was used. Since methodology is straightforward and all information is available, scores were easily calculated. An Excel spreadsheet was utilized to facilitate required calculations.

Determination of vulnerability due to chemical properties and storage conditions qualitatively requires considerable expertise on chemical safety. But these criteria are actually directly related with physical characteristics of accidents, for which extensive technical literature and quantitative calculations methods exist. Although use of advanced accident models requiring detailed input data will not be practical for basic scoring purposes, simple models can be used. This way vulnerability score can be determined more scientifically and in an objective manner. With its simplicity of use and primitive data requirements, all of which are available in case-study documents, RMPComp is a perfect-match for such a model. Hence, it was used to determine scoring weights of vulnerability due to chemical properties, quantity and storage conditions criteria. Maximum distance to endpoints (MDE) were calculated for each case, and based on these distances weights were given.

Although vulnerability due to lack of risk management practices require detailed information on companies, which is not available, an approximation was made based on the size of companies. Companies are divided into two groups as local, small sized companies and well known, large sized, multi-national companies. Large companies are assumed to have adequate risk management practices. However, it should be noted that being a big, multi-national company does not always imply risk management is done properly. As Mr. Gupta mentioned, the worst industrial accident in the history had happened in such a company.

For the calculation of domino effects score, MDE values calculated by RMPComp were utilized. No possible domino effect is assumed to be present if no other tank is found to be present within the MDE/2 distance of a tank containing a flammable substance. Weights of vulnerability due to increase in impact area were given based on MDE values of tanks that will be effected. Since toxic substances have generally larger MDE values compared to flammable substances, higher weights were given for such substances.

In order to determine area vulnerability score, impact areas were calculated from MDE values. Since there was more than 4 order of magnitude difference in impact areas, logarithmic values were used for comparison. Number of people exposed and presence of population centers were determined from given maps. Similarly, vulnerability due to impact of Natech on public utilities, major lifelines, emergency resources, and ecosystems were all determined from the map. Presence of these utilities within the impact area and proximity to the impact area were used as weighting criteria.

Results:

In order to calculate average HRL, domino, area, and utility scores an Excel spreadsheet was prepared. Although Y indices and HRL scores was calculated for all tanks, due to time constraints final calculations could be done only for three selected tanks (T1, T8 and T17). Details of calculations are given in Tables 1- 5.

Table 1. Calculation of Y Indices

Tank	*PGA*	*k1*	*k2*	*ln(PGA)*	***Y***
T1	0.43	4.50	1.12	-0.84397	3.55
T8	0.58	4.36	1.22	-0.54473	3.70
T17	0.50	4.36	1.22	-0.69315	3.51

Table 2. Calculation of HRL scores

Tank	*Crit. 1*	*Crit. 2*	*Crit. 3*	*Crit. 4*	*Sum*	***Index***
T1	1	5	-	4	10	3.33
T8	1	1	-	4	6	2.00
T17	1	1	-	1	3	1.00

Table 3. Calculation of domino effects score

Tank	*MDE*	*Domino*	*Crit. 1*	*Crit. 2*	*Crit. 3*	*Sum*	***Index***
T1	32.0	-	-	-	-	-	0.00
T8	1.1	Yes	5	4	4	13	4.33
T17	2.1	No	1	0	0	1	0.33

Table 4. Calculation of area vulnerability score

Tank	*Area*	*Crit. 1*	*Crit. 2*	*Crit. 3*	*Crit. 4*	*Crit. 5*	*Crit. 6*	*Sum*	***Index***
T1	3217.0	5	3	-	5	-	-	13	4.33
T8	3.8	2	5	-	4	-	-	11	3.67
T17	13.9	3	3	-	3	-	-	9	3.00

Table 5. Calculation of public utility, lifelines, emergency resources score

Tank	*Crit. 1*	*Crit. 2*	*Crit. 3*	*Crit. 4*	*Crit. 5*	*Sum*	***Index***
T1	1	4	4	5	1	15	3.00
T8	1	5	3	4	1	14	2.80
T17	1	2	3	2	4	12	2.40

Based on calculated score indices overall RNRA scores were calculated. Summary of the average and final RNRA scores are given in Table 6.

Table 6. RNRA scores

Tank	*HRL Score*	*Domino Effects Score*	*Vulnerability Score*	*Utility Score*	***RNRA Score***
T1	3.33	0.00	4.33	3.00	24.44
T8	2.00	4.33	3.67	2.80	21.60
T17	1.00	0.33	3.00	2.40	5.73

Results

Among the studies tanks, T1 containing Chlorine has been found to pose the greatest Natech risk in the territory. Although there is no possibility of domino effects for this tank, very large impact area and presence of population centers within the impact zone has been found to be the reasons for high RNRA score. T8 containing butane has also a high RNRA score due to considerable domino effects. RMPComp results show that in case of an explosion this tank will affect three other tanks (T7, T6, and T9) in the vicinity. T6 and T9 contain chlorine and anhydrous ammonia, respectively. Both of these substances are toxic, hence have large MDE values. This increases overall impact area of T8 and results in high RNRA score. Lowest RNRA score has been found for T17, which includes butane similar to T8. Although the amount of butane stored in T17 is a lot more than T8 (almost 10 folds) overall score is much lower, because T17 is away from other tanks (no domino effects) and emergency resources present in the vicinity. Taking these reasonable results obtained from the case study into account and considering that selected tanks have a great variability in chemical properties, storage conditions, location, and natural hazard risks, RNRA methodology can be deemed as satisfactory for rapid assessment of Natech risks.

Recommendations:

As mentioned in methodology part, use of simple analytical tools or models for determination of vulnerability due to chemical properties, quantity and storage conditions may facilitate application of RNRA methodology. As demonstrated in this study, RMPComp software of U.S. EPA can be used for this purpose.

Although presence of ‘Other’ criteria in scoring tables allow one to include additional criteria that are deemed to be important, having a fixed set of criteria can make the use of methodology easier. If the aim is “rapid” risk assessment, limiting the criteria to be considered will facilitate the task. It will also result in better standardization and make scoring results comparable among different studies.

European Commission

EUR 23288 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Results of the Workshop: Assessing and Managing Natechs (Natural-hazard triggered technological accidents).
Author(s): Ana Maria Cruz, Elisabeth Krausmann
Luxembourg: Office for Official Publications of the European Communities
2008 – 248 pp. – 21.0 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1018-5593

Abstract

The workshop: Assessing and Managing Natechs (Natural-hazard triggered technological accidents) was organised and hosted by the Major Accident Hazards Bureau (MAHB) at the Institute for the Protection and Security of the Citizen (IPSC) of the European Commission's Joint Research Centre (JRC), on 17-18 September 2007 in Stresa, Italy. The Natech workshop, the second of its kind to be organized the JRC, was carried out in an effort to provide a framework and practical tools for Natech risk assessment and management at the community level. The workshop included invited presentations on country practices which served to help monitor progress in Natech risk reduction since the first workshop in 2003.

In addition to the country presentations, the two day workshop included discussion of key issues, presentations of new concepts/ information, hands-on exercises, and the development of case studies. In the case studies participants carried out a Natech risk assessment of a selected community. Discussion of case study results and possible Natech risk management strategies followed, as well as identification of future priorities for research and tool development.

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