Organisation for Economic Co-operation and Development

ENV/JM/MONO(2020)4

Unclassified

English - Or. English

21 April 2020

ENVIRONMENT DIRECTORATE

JOINT MEETING OF THE CHEMICALS COMMITTEE AND THE WORKING PARTY ON CHEMICALS, PESTICIDES AND BIOTECHNOLOGY

Natech Risk Management: 2017-2020 Project Results

Series on Chemical Accidents
No. 32

JT03460940

OECD Environment, Health and Safety Publications

Series on Chemical Accidents

No. 32

Natech Risk Management: 2017-2020 Project Results

Environment Directorate

ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT

Paris 2020

About the OECD

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation in which representatives of 36 industrialised countries in North and South America, Europe and the Asia and Pacific region, as well as the European Commission, meet to co-ordinate and harmonise policies, discuss issues of mutual concern, and work together to respond to international problems. Most of the OECD's work is carried out by more than 200 specialised committees and working groups composed of member country delegates. Observers from several countries with special status at the OECD, and from interested international organisations, attend many of the OECD's workshops and other meetings. Committees and working groups are served by the OECD Secretariat, located in Paris, France, which is organised into directorates and divisions.

The Environment, Health and Safety Division publishes free-of-charge documents in eleven different series: **Testing and Assessment; Good Laboratory Practice and Compliance Monitoring; Pesticides; Biocides; Risk Management; Harmonisation of Regulatory Oversight in Biotechnology; Safety of Novel Foods and Feeds; Chemical Accidents; Pollutant Release and Transfer Registers; Emission Scenario Documents;** and **Safety of Manufactured Nanomaterials.** More information about the Environment, Health and Safety Programme and EHS publications is available on the OECD's World Wide Web site (www.oecd.org/chemicalsafety/).

This publication was developed in the IOMC context. The contents do not necessarily reflect the views or stated policies of individual IOMC Participating Organizations.

The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The Participating Organisations are FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

This publication is available electronically, at no charge.

Also published in the Series on Chemical Accidents: link

For this and many other Environment,

Health and Safety publications, consult the OECD's

World Wide Web site (www.oecd.org/chemicalsafety/)

or contact:

OECD Environment Directorate,

Environment, Health and Safety Division

2 rue André-Pascal

75775 Paris Cedex 16

France

Fax: (33-1) 44 30 61 80

E-mail: ehscont@oecd.org

Foreword

This report brings together information collected through a project undertaken by the OECD Working Group on Chemical Accidents (WGCA) relevant to the management of risk for Natural Hazard triggered Technological Accidents (Natechs). It relies in particular on the analysis of the results of a survey conducted in 2017 that collected experiences and good practices for Natech risk management across OECD and non-OECD member countries, and also on the results of a joint OECD-UN Workshop on Natech Risk Management that was organised in Potsdam, Germany in September 2018.

The draft version of the report was prepared by the consultancy company adelphi research GmbH, in particular Ms. Maro Luisa Schulte, Mr. Nils Simon, Ms. Lisa Maria Eckart, Ms. Carmen Morales, in cooperation with Prof. Dr. Karl-Erich Köppke. The report was prepared on behalf of the German Environment Agency.

The final report incorporates input from the WGCA and the Joint Meeting of the Chemicals Committee and Working Party on Chemicals, Pesticides and Biotechnology and is published under the responsibility of the Joint Meeting, which has agreed that it be declassified and made available to the public.

Table of Contents

Tables

Figures

Boxes

List of Abbreviations

APELL	Awareness and Preparedness for Emergencies at Local Level
ARDEX	Association of Southeast Asian Nations (ASEAN) Regional Disaster Emergency response simulation Exercise
ASEAN	Association of Southeast Asian Nations
BBK	Federal Office of Civil Protection and Disaster Assistance
CA	Competent Authorities
COMAH	Control of Major Accident Hazards
EADRCC	Euro-Atlantic Disaster Response Coordination Centre
EC	European Commission
EC ERCC	European Commission Emergency Response Coordination Centre
EEWS	Earthquake Early Warning System
EFAS	European Flood Awareness System
EIA	Environmental Impact Assessment
eMars	Major Accident Reporting System
EPR	Environmental Permitting Regulations
EU	European Union
FEAT	Flash Environmental Assessment Tool
FRD	Lithuanian Fire and Rescue Department
GDACS	Global Disaster Alert Coordination System
GSM	Global System for Mobile Communication
HELCOM	Helsinki Commission
ICCARP	Integration of Climate Change into Regulatory Practice
IED	Industrial Emission Directive
INERIS	Institut national de l'environnement industriel et des risques *(French National Institute for Industrial Environment and Risks)*
IPCC	International Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale *(Italian National Institute for Environmental Protection and Research)*
JEU	United Nations Environment/Office for the Coordination of Humanitarian Affairs (OCHA) Joint Unit
JRC	European Commission Joint Research Centre
LPG	Liquefied Petroleum Gas
Natech	Natural Hazard Triggered Technological Accident
NATO	North Atlantic Treaty Organization
OECD	Organisation for Economic Co-operation and Development
PWIS	Public Warning and Information System

TRAS	Technische Regeln für Anlagensicherheit (Technical Rules on Process Safety)
TWG 2	European Commission Technical Working Group on Seveso II Inspections
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	United Nations Office for Disaster Risk Reduction
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
UK	United Kingdom
US CSB	United States Chemicals Safety Board
WGCA	Working Group on Chemical Accidents

Results from a survey conducted in 2017 on Natech risk management

Background

1. There is increasing awareness about chemical accidents triggered by natural hazards (called Natechs). A growing body of research is available to policy makers, regulators, private enterprises and academics.[1] As shown by the earthquake and tsunami in Japan 2011, for example, or the 2017 hurricane season and specifically Hurricane Harvey, major natural events often lead to the occurrence of Natechs, which further increase the already high damages and may impede recovery and reconstruction. However, relatively minor events such as cold spells, or even localized hazards such as lightning strikes, can cause chemical accidents. Natechs are thus increasingly being recognised as serious risks that require adequate risk management efforts.

2. The OECD has already contributed to research on Natech risk management through a survey conducted in 2009 on Natech risk reduction, the results of which were analysed and published by the Joint Research Center of the European Commission[2], the organisation of a workshop on Natech Risk Management in 2012, and the publication in 2015 of an addendum to the OECD Guiding Principles on Chemical Accident Prevention, Preparedness and Response that specifically addressed Natechs risk management.[3]

3. However, further study was required regarding the extent to which public and private stakeholders are taking Natechs into account, in which areas they are well-prepared and how remaining gaps can be closed. It is also not clear to what extent current regulations, standards, and guidance take into account possible modifications in the occurrence of natural events and their impact. In order to help address those gaps, a second survey on Natech Risk Management was conducted in 2017. The initial deadline for responses was 31 July 2017, later extended to 21 August. The purposes of the survey were the following:

- identify examples of good practices in Natech Risk Management,
- assess risk management practices and awareness of Natechs,

[1] E. Krausmann, A.M. Cruz and E. Salzano (eds.) (2017), *Natech Risk Assessment and Management: Reducing the Risks of Natural-Hazard Impact on Hazardous Installations*. Amsterdam/Oxford/Cambridge: Elsevier.

[2] E. Krausmann and D. Baranzini (2009), *Natech risk reduction in OECD Member Countries: Results of a questionnaire survey*; European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, JRC Report 54120. According to the report from this survey, developed by the EC JRC (European Commission, Joint Research Centre) , many respondents had indeed recognized natural hazards as a potential risk source for chemical facilities, yet the report also cautioned that a more strategic approach to reduce Natech risks was lacking.

[3] OECD (2015): 'ADDENDUM No.2 to the OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response (2nd ed.) to address Natechs', *Series on Chemical Accidents No. 27*.

- identify needs and/or limitations in implementing Natech risk reduction strategies, and identify where progress has been made since the 2009 survey, and where gaps remain.

Design of the 2017 Survey

4. The 2017 survey built on the first survey on Natech Risk Management conducted in 2009. The survey covers 22 areas with relevance for Natech Risk Management and contains 77 questions on Natechs and natural disaster risk management, as well as four questions asking for the respondent's background. The 22 Natech-related areas were organised into four categories:

1. Regulations for the prevention and mitigation of Natechs;
2. Natech events data collection and retrieval;
3. Natech awareness and risk reduction;
4. Consideration of natural hazards and Natech risks.

The survey questions can be found in Annex I of this report.

Differences between the 2009 and 2017 Surveys

5. The 2017 survey is more comprehensive and builds on a higher number of questions than the survey in 2009. It describes where progress has been made since 2009, and where gaps remain (parts I, II and III). Part IV is new and essentially serves to identify examples of good practice. Part III from 2009 was removed since the collection and evaluation of reports about Natechs is not at the core of the 2017 evaluation. The structure of the surveys differ, as shown in table 1.

Table 1. Structure of Surveys in 2009 and in 2017

Survey 2009	Survey 2017
I Regulations for the prevention and mitigation of Natechs	I Regulations for the prevention and mitigation of Natechs
II Natech events data collection and retrieval	II Natech events data collection and retrieval
III Learning from Natech accidents: Case histories	
IV Natech awareness and risk reduction	III Natech awareness and risk reduction
V Identifying needs and limitations	
	IV Consideration of natural hazards and Natech risks

6. 17 countries that replied to the 2009 survey: Australia, Austria, Czech Republic, France, Germany, Iceland, Italy, Korea, Luxemburg, Netherlands, New Zealand, Norway, Poland, Sweden, Switzerland, the United Kingdom and the United States.

7. In 2017, 14 countries and three institutions representing science and industry responded to the questionnaire. The responding countries were: Austria, Colombia, Estonia, Finland, France, Germany, Japan, Korea, Lithuania, New Zealand, Norway, Poland, Sweden, and the United Kingdom. The group of participating countries differed between 2009 and 2017, which means that comparing the results of both surveys may not be representative. The nine countries participating in both surveys are the following: Austria, France, Germany, Korea, New Zealand, Norway, Sweden, Poland, and the United Kingdom. It is observed that issues such as effects of climate change on Natech risks and Natech risks in risk communication were included in the 2017 survey due to their growing relevance at the international level. If a comparison between the surveys conducted in 2009 and 2017 would only be possible for the nine countries, the analysis of the survey results (see chapter below) will still attempt to compare both sets of answers.

8. It must be further noted that the number of responses does not allow reaching robust conclusions about the status of natural hazard and Natech Risk Management across OECD countries.

9. In addition, the quality of answers varied, with some respondents giving detailed accounts of their national-level policies and programmes, providing links to websites with legal texts and further information, while others left entire blocs of questions unanswered. Given the volume of the survey this is not entirely surprising, yet it does pose a challenge to the analysis.

Examples of Good Practices

10. The questionnaire asked for 16 possible areas in which examples of good practices in Natech Risk Management might be found. Replies varied widely, revealing that in some areas many responding countries have taken significant steps, while in others work remains to be done.

11. Of the 14 respondents from governments, 12 replied that their natural hazard and multi-hazard early warning systems would qualify as examples of good practice, and 11 said the same about their systems of natural hazard mapping.

12. There was a mixed picture of regulations and guidelines for chemical accident prevention and mitigation; eight respondents replied that they have examples of good practice. Seven respondents indicated to have examples of good practice of natural hazards taken into consideration in safety management at hazardous installations. Meanwhile, another six noted they had good practice examples on international cooperation in mapping and early warning systems. Four positive answers were given to each of the questions about good practice examples in design and construction of installations, in safety reports and documents, and in emergency plans. Five respondents replied to have examples of good practice in the consideration of natural hazards in operating procedures, while three had positive answers in the field of siting and land-use planning.

13. Effects of climate change on Natech risks have, thus far, rarely been specifically considered in Natech Risk Management. Only three respondents from governments indicated having good practice examples of considerations of effects of climate change in their risk analyses for hazardous installations. While two respondents answered that they held a good practice example considering effects of climate change in licensing of hazardous installations. Other weak spots for examples of good practice appear to be risk analysis for hazardous installations, with only three respondents indicating an example of

good practice, and education and training, which was answered positively by just one respondent, yet without providing any additional information on possible content.

14. The description of the reported examples of good practice in Natech risk management will be subject of a separate outcome.

Results of the 2017 OECD Natech Survey

Regulations for the Prevention and Mitigation of Natechs

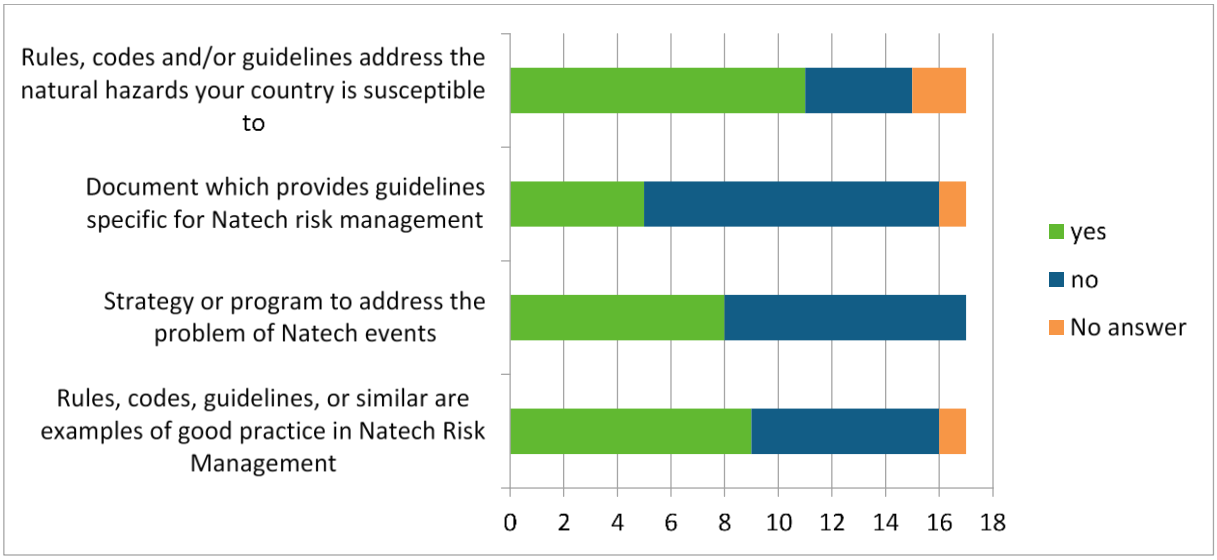
Regulations and Guidelines for Chemical-Accident Prevention and Mitigation and Consideration of Natechs

15. As in the survey of 2009, the first block of questions aims to identify regulations already in place for chemical-accident prevention and natural-disaster management, as well as technical codes and standards that consider the impact of natural hazards. In addition, the 2017 survey also asked participants for information regarding guidelines, strategies, programmes and examples of good practices specific to Natech Risk Management.

16. All of the respondents (n = 17) oversee prevention and mitigation of chemical accidents (question 1a) while almost all country respondents (88%) indicated the rules, codes or guidelines used in the particular country related to chemical accident prevention and mitigation (question 1b). However, only 11 respondents out of 17 (65%) indicated that these rules, codes and/or guidelines also address the natural hazards their country is susceptible to encounter (question 1c). In the 2009 survey, 76% had positively replied to this question. The result of this first component could be interpreted as a lack of rules, codes and/or guidelines that specifically address natural hazards to which countries are especially vulnerable. However, another possible interpretation for the difference between years can be that after undertaking first steps toward Natech Risk Management, stakeholders have become more aware of the shortfalls existing in their countries.

17. On the other hand, only 35% of the respondents in 2017 indicated having a document which provides guidelines specific for Natech Risk Management (question 1d), while 47% are currently developing a strategy or programme to address the issue of Natech events (question 1e).

Figure 1. Consideration of Natech Risks in Regulations and Guidelines for Chemical-Accident Prevention and Mitigation in 2017 (Questions 1c, 1d, 1e, 1f)



18. The following good practice examples were provided by the United Kingdom and Germany as an answer to question 1f on rules, codes, guidelines, technical codes, standards, strategies or programmes that can be an example of good practice in Natech Risk Management. They are included here as an illustration of examples provided.

Box 1. Good Practice Example: Flooding, Safety Reports for Sites in United Kingdom

Since flooding is the most common occurring natural disaster in the UK, the Environment Agency published a guide for sites regulated under EPR (Environmental Permitting Regulations) and COMAH (Control of Major Accident Hazards). It advises the site operators to prepare safety reports for their sites and to take into account environmental hazards at all stages of construction and equipping.

In order to prepare for flooding events, the guide advises site operators to: 1) evaluate the site's flooding risk and check regularly for flood warnings, 2) to obtain site topography and more detailed flood modelling (can be acquired at the UK Environment Agency office), 3) design an emergency plan for the case of flooding events including appropriate action measures and necessary information distribution, and 4) to take measures to improve flood resilience in general, such as optimization of storage for hazardous substances, increasing protection of safety critical utilities, or improved interaction of off-site emergency response.

Box 2. Good Practice Example: Flooding, the 310 Technical Rule on Process Safety in Germany

In 2012, the German Technical Rules on Process Safety 310 ("Technische Regeln für Anlagensicherheit", TRAS 310) entered into force, which sets out a procedure for operators to comply with Germany's Major Accidents Ordinance. The described four-step procedure serves to protect establishments against accidents due to flood and heavy rainfall.

The system and structure of the TRAS describes the operator's obligation within safety management by conducting an adequate hazard source analysis, in which the kind, intensity and frequency of hazard sources (here floods and heavy precipitation) that a site might be susceptible to is analysed, as well as if major accidents can be triggered by the affection of safety relevant parts of the installation through such hazards. Further, a protection concept must be drawn and measures identified and implemented to prevent major accidents. In order to mitigate the effects of major accidents that may occur despite precautions, mitigation measures to be taken in such events must be specified.

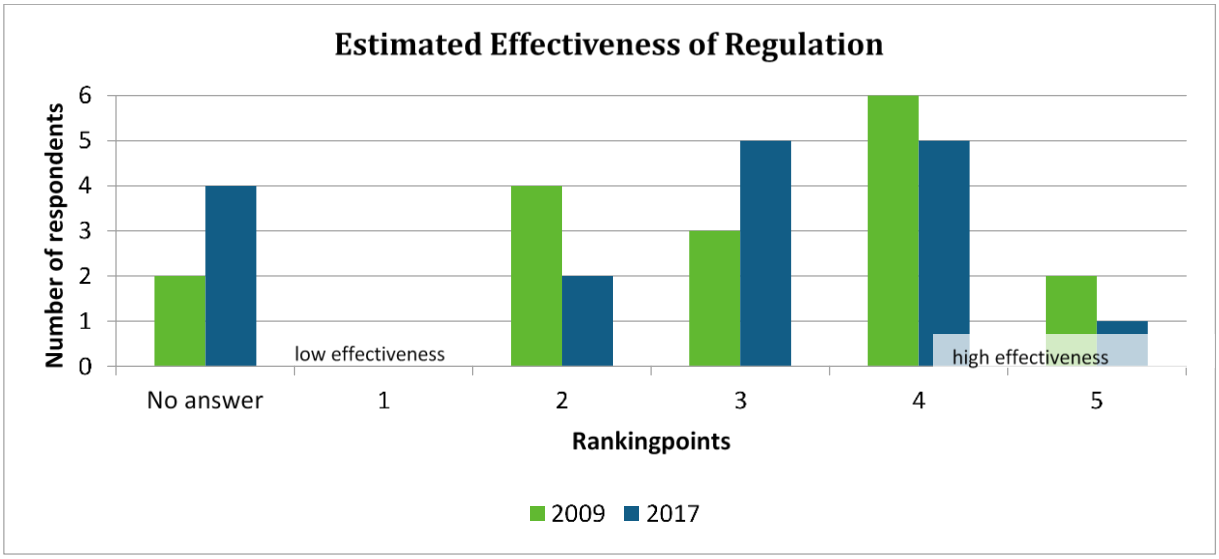
To adapt to climate changing conditions, a factor of 1.2 must be applied to the intensities of flood and precipitation events in the risk assessment for establishments that are planned to be in operation in 2050 and beyond.

Effectiveness of Regulations

19. As mentioned in the results of the survey in 2009 "survey participants [were asked] if they thought that their country's approach to chemical-accident prevention and natural-disaster management had been effective in preventing Natech accidents. Their opinion had to be ranked on a scale from 1 (low effectiveness) to 5 (highly effective)" with (N) representing the respondents that did not reply to the question.[4]

[4] E. Krausmann and D. Baranzini (2009), *Natech risk reduction in OECD Member Countries: Results of a questionnaire survey*, European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, JRC Report 54120.

Figure 2. Self-estimated Effectiveness of Regulation in Preventing Natech Accidents in 2009 and 2017 (Question 2a)



20. As seen in Figure 2, in 2017, 13 participants (76%) provided an answer to question 2a, revealing that six respondents (37.5%) considered their countries' policies and practices to prevent Natech accidents as effective to highly effective. In 2009, eight respondents (47%) had the same opinion. This shows a slight decrease in the perception of specialists looking at the effectiveness of regulations to chemical-accident prevention and natural-disaster management in a timeframe of eight years. However, such changes in the perception of effectiveness may also be attributed to the differences in the sample of countries/institutions that have replied to the survey or even to the fact that the perception of stakeholders towards Natech risks prevention might be different since the last survey.

21. When asked if any gaps or shortcomings in the country's rules or codes should be addressed to ensure effective Natech risk reduction (question 2b), 47% of the respondents replied affirmatively.

22. Some countries thought that European regulations (Seveso-III-Directive (2012/18/EU) or other) should define more precisely the return period or frequency of events to be taken into account for natural hazards such as earthquakes or floods. Another mentions the necessity of guidelines such as a (i) guideline on the consideration of natural hazards in safety documents (Seveso-Directive: safety reports) and emergency plans of operators and (ii) a guideline on the consideration of natural hazards in inspecting establishments according to the Seveso-Directive.

23. It can be noted that the gaps and shortcomings have become more specific compared to the results in 2009 where respondents mention issues such as: (i) implementation and enforcement of specific regulations for Natech risk reduction, (ii) preparation of guidelines for industry and specific technical codes that address Natech risk, (iii) the development of methods for Natech risk assessment, (iv) land-use planning that explicitly addresses Natech risk, (v) better preparedness and training for the mitigation phase, as well as (vi) the development of best practices for Natech risk reduction.

24. Furthermore, in 2017 one respondent indicated that there was an amendment in their country's rules or codes considering the publication of the Natech Addendum to the OECD Guiding Principles (2c), whereas 65% of respondents answered in the affirmative to the question (2d) regarding an amendment in their country contemplating the requirement of the Seveso-III-Directive (2012/18/EU) to consider natural hazards in Safety Reports.

Natech Events Data Collection and Retrieval

Database or Records for Chemical Accidents

25. In 2017, 15 respondents (88%) mentioned a database that can be used to record and retrieve information on chemical accidents (question 3) while 14 of these gave further descriptions, provided the respective link to the database, or indicated a contact person. In addition, nine respondents (53%) replied positively that the database could be used to identify and retrieve information on Natechs.

26. In 2009, 13 out of 17 respondents (76%) indicated having databases for chemical accidents. With respect to maintaining a database specific for Natech accidents, 15 respondents replied in the negative. The Seveso III-Directive compliant solution was to suggest a database of chemical accident reports that included Natechs. Hence, policy makers at the EU level were of the opinion that it made little sense for the Member States to have a separate database for Natechs, which is why the 2017 survey did not investigate whether states have a database for Natechs specifically. It should however be mentioned here that it might be helpful to have a Natech-specific database.

Natech Awareness and Risk Reduction

Statements on Natech Awareness and Risk Reduction

27. In order to assess the level of awareness and knowledge of Natech risk and risk reduction, the 2009 survey asked respondents to answer 10 targeted questions by ranking their answers from 1 (Disagree strongly) to 5 (Agree strongly). Likewise, in 2017, nine similar questions were asked in order to assess Natech awareness and risk reduction using the same rankings (question 4). Here, the survey deliberately asked for an opinion of the respondents and not for facts. The results can be drawn from Figures 3, 4 and 5:

Figure 3. Agreement or Disagreement to a Set of Questions (Question 4 a-h) Regarding Natech Awareness and Risk Reduction Level from the Survey in 2017

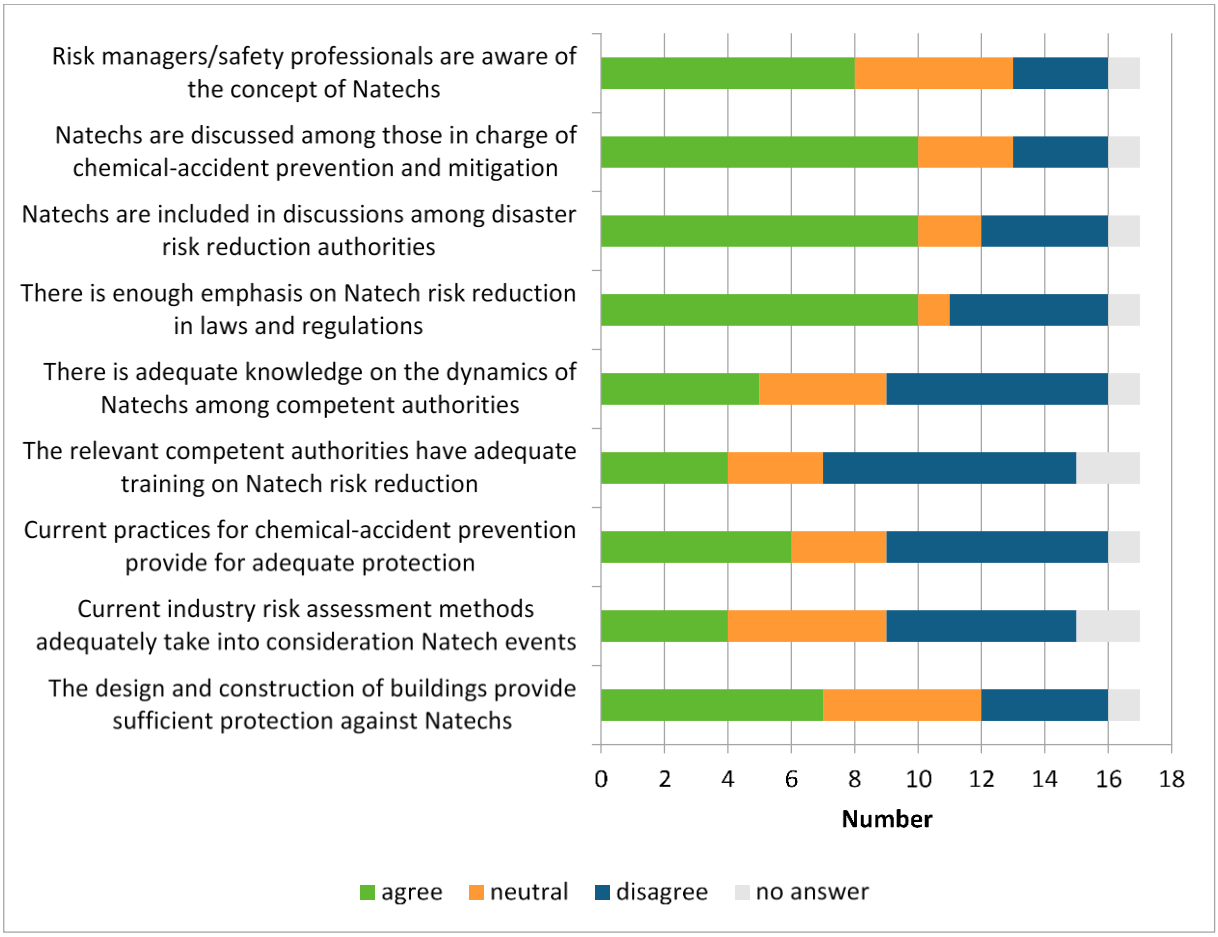
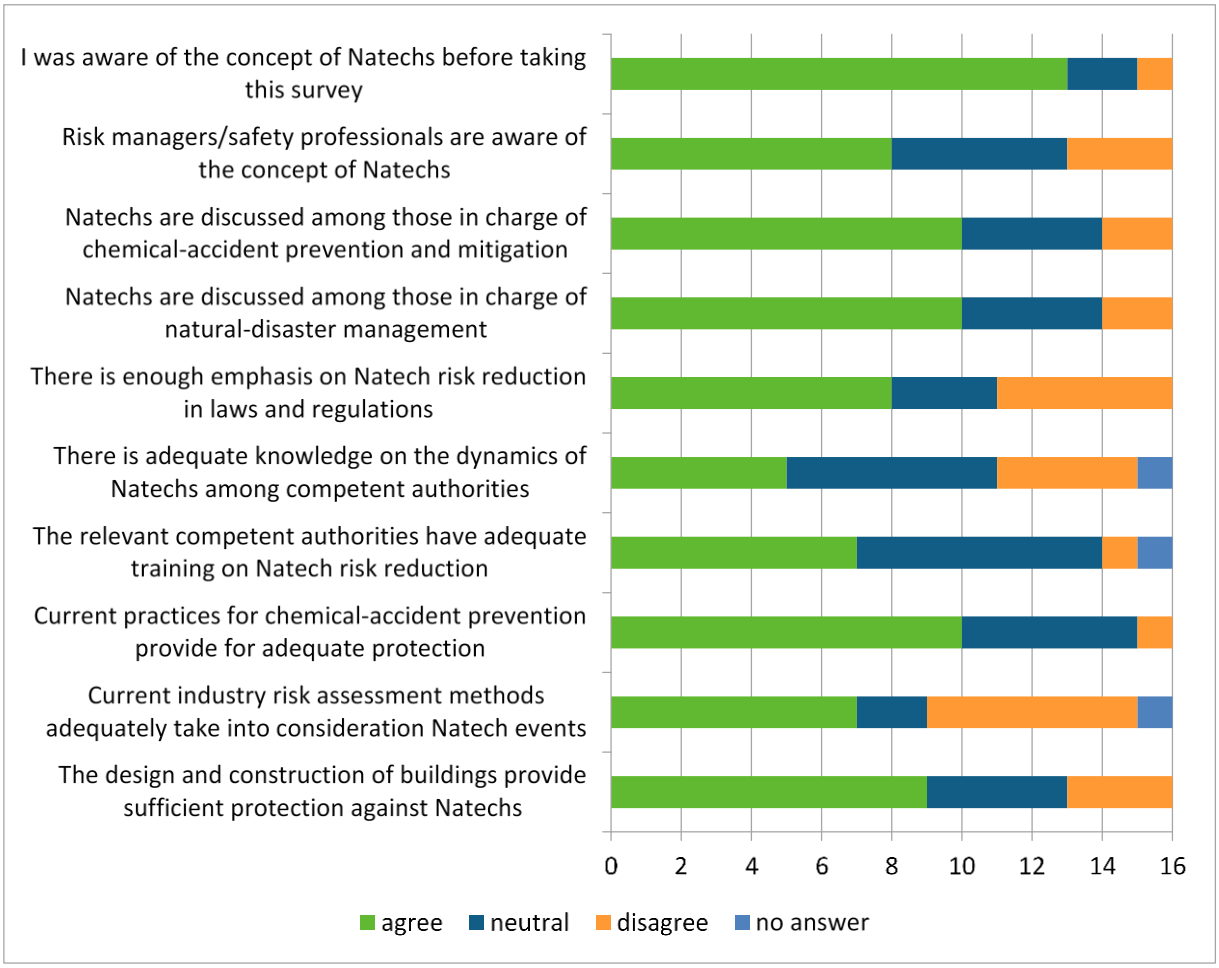
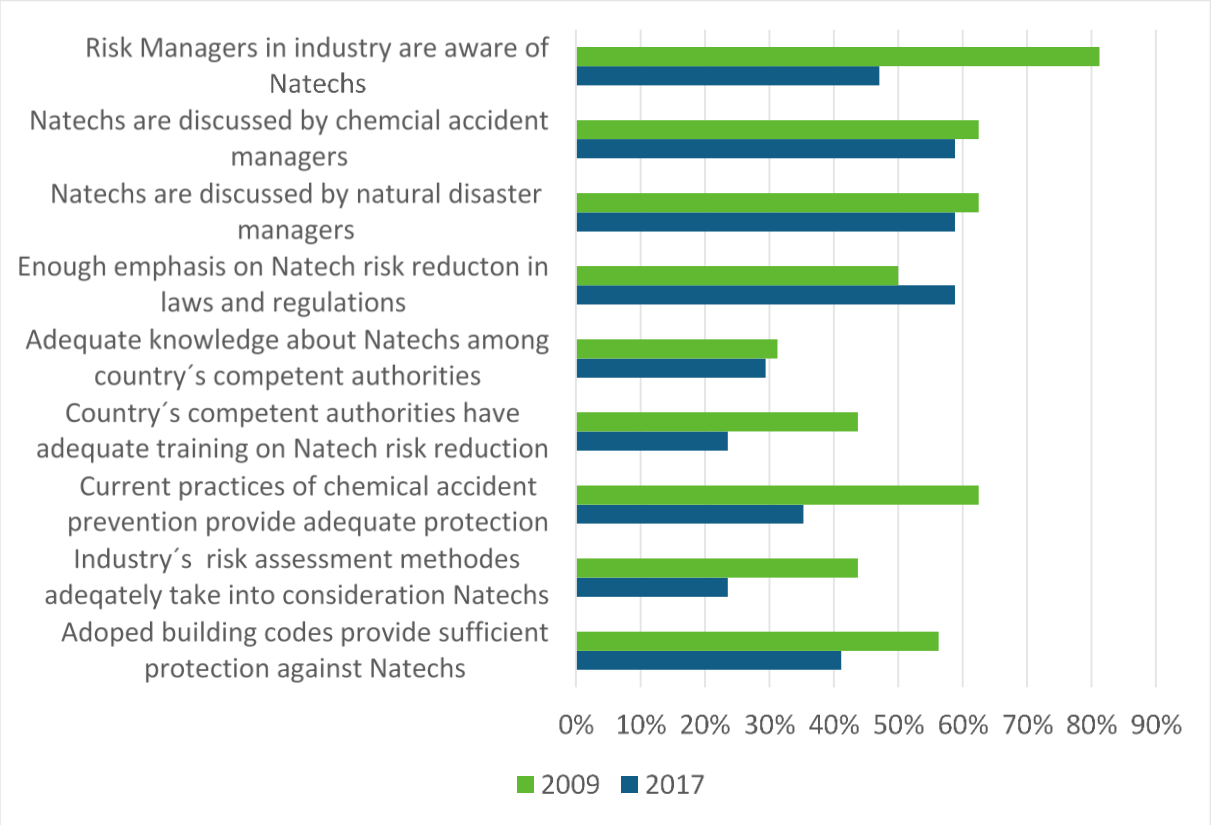


Figure 4. Agreement or Disagreement to a Set of Questions Regarding Natech Awareness and Risk Reduction Level from the Survey in 2009[5]



[5] Here are considered the 16 responses from competent authorities (CA) in the respective countries.

Figure 5. Agreement to the Statements on Natech Awareness and Risk Reduction Level in 2009 and in 2017



28. Figure 5 shows that 50% or more of the respondents agree or strongly agree that:

- (question 4a) industry risk managers/ safety professionals in their country/organisation are aware of the concept of Natechs;
- (question 4b) Natech events are discussed among those in charge of chemical-accident prevention and mitigation in their country/organisation;
- (question 4c) Natechs events are discussed among those in charge of natural-disaster management in their country; and
- (question 4d) there is enough emphasis on Natech risk reduction in the laws and regulations for chemical-accident prevention and mitigation.

29. In most of the cases, there is little difference from the results in the 2009 survey, where 50% or more agreed on these hypotheses as well. However, in question 4a, the difference in the answers between 2009 and 2017 is large. Thirty percent more industry risk managers/ safety professionals in the countries/organisations were aware of the concept of Natechs in 2009 compared to 2017. The only question in which there was more awareness in 2017 is question 4d that points out emphasis on Natech risk reduction in the laws and regulations for chemical-accident prevention and mitigation.

30. On the other hand, the other questions show less awareness. In 2017 more than 50% disagree or strongly disagree that:

- (question 4e) there is adequate knowledge on the dynamics of Natechs among the country's competent authorities;
- (question 4f) the relevant competent authorities in the countries have adequate training on Natech risk reduction to enable effective Natech Risk Management;
- (question 4g) current practices for chemical-accident prevention and mitigation in the countries/organisations provide for adequate protection of citizens against possible Natech events;
- (question 4h) current industry risk assessment methods adequately take into consideration Natech events.

31. Lastly, under the question, if the design and construction of industry buildings and other structures provide sufficient protection against Natech accidents (question 4i), 24 % of respondents disagreed or strongly disagreed in 2017 with the comparison of 47% in 2009.[6]

32. When looking more closely at the differences between the 2009 and 2017 survey in Figure 5, it appears that there was more awareness on Natech risks in 2009, with differences of more than 20% in the questions 4e to 4i. In particular, there is a large difference in the 2017 responses to question 4g, which deals with current practices for chemical-accident prevention and mitigation in the countries/organisations that provide for adequate protection of citizens against possible Natech events. These results might indicate that respondents' awareness of the characteristics and risks of Natechs has risen, and so self-estimation of protection level is considered lower. Again, however, not all of the same countries responded to both surveys, and therefore the results are not fully comparative in a quantitative manner.

Recommendations on Natech Risk Reduction

33. The survey asked the participants to indicate their top three recommendations in order to further reduce their country's or organisation's susceptibility to Natechs. In 2017, 71% of the surveyed respondents indicated specific Natech risk reduction strategies/recommendations. In 2009, 77% of respondents indicated specific measures. The majority of the 2009 respondents mentioned raising awareness on Natech risk at all authority levels -- as well as in industry -- and improving risk communication as a crucial Natech risk reduction strategies.

34. Considering examples of Natech risk reduction strategies/recommendations, the following seem particularly relevant in 2017:

1. **Natural Hazards in Risk Analysis:** Four out of 12 respondents mentioned recommendations related to natural hazard risk assessments. One country recommended the consideration of Natechs in the risk assessment of major hazard facilities conducted by the operator of the facility. Another advised the development

[6] In 2017, 29% responded neutrally.

of guidelines for Natech risk analysis and the learning from Natech risk analysis experiences.

2. **Natech Awareness and Risk Reduction:** Recommendations on Natech awareness and risk reduction were also made by four out of 12 respondents. One example given is the improvement of general awareness of Natech initiators and their impacts. Additionally, there was a proposal to increase the exchange of ideas and knowledge between the natural hazard and the major chemical accidents competence areas and use this competence further in the permitting process.

Consideration of Natural Hazards and Natech Risks

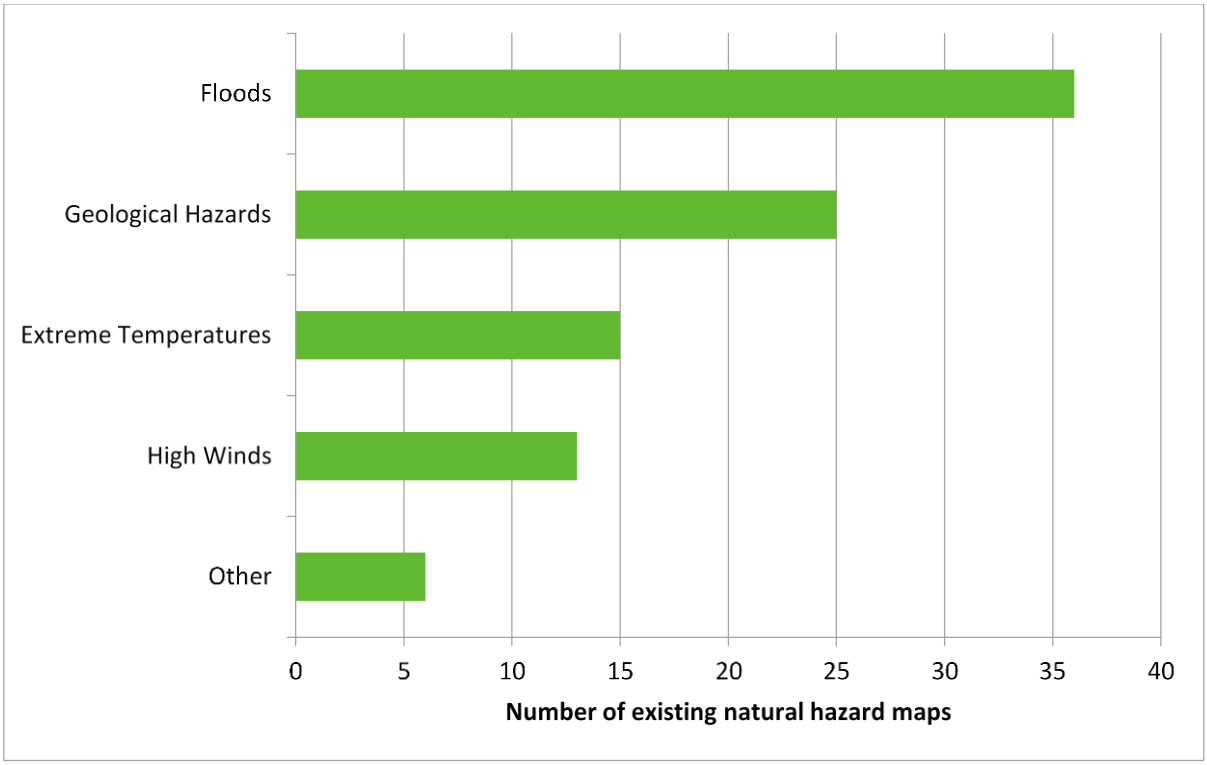
Natural Hazard Mapping and Early Warning Systems

35. As mentioned earlier, the respondents make use of natural hazard maps and early warning systems (question 6a, 7a). Based on the results of this survey, it would be interesting to identify if these early warning systems trigger any kind of Natech risk management action. One indicator of a positive answer to this question might be that 13 respondents indicated that operators made use of early warning systems for their emergency management (question 7f).

36. The information on natural hazard mapping integrated in the following Figures 6 and 7 (questions 6b, 6c, 6d) explain which types of hazards are mentioned, which scope they cover (national, regional, local) and if there are operators of hazardous installations involved in the drafting and amendment.

37. The natural hazard maps (question 6b) in the mentioned countries consider different hazards such as geological and seismic hazards (earthquake, mining-based or volcanic threats, mass movements, avalanches, tsunamis) and hydro- and meteorological hazards (floods, winds, typhoons, high tides, snow load).

Figure 6. Consideration of Natural Hazards in Mapping

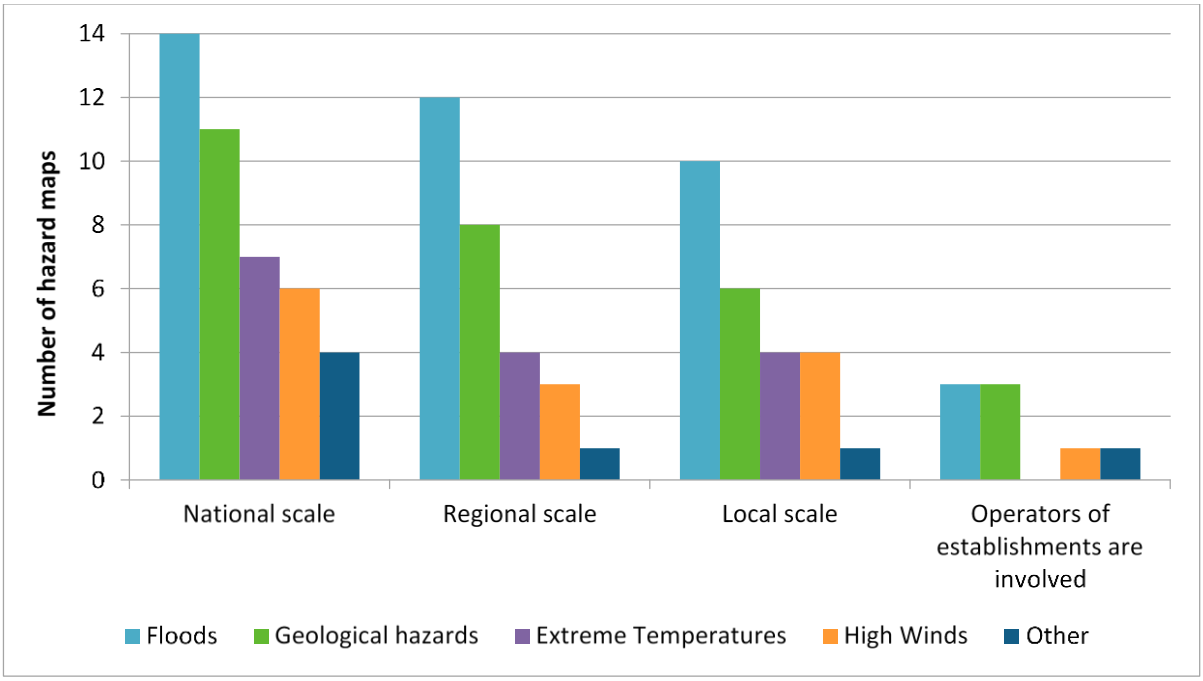


38. As seen in Figure 6, floods are the most commonly mapped hazard. This might be related to the EU Floods Directive[7] (2007/60/EC) that entered into force in 2007; these flood maps probably were the first hazard maps drafted. Based on the EU Floods Directive, countries of the EU must develop flood hazard maps and flood risk maps for risk areas by 2013. The Directive applies to all kinds of floods (river, lakes, flash floods, urban floods, coastal floods, including storm surges and tsunamis), on all of EU territory. Geological hazards are the second most relevant hazards to be mapped. At the EU level earthquakes and tsunamis seem to be the most relevant ones, but there are no specific directives in place. It should be noted here the probability that the maps indicated by countries and institutions do not include all manner of geological hazards in one map. Instead the maps are expected to cover, for example, only earthquakes, but not avalanches or mass movements, leaving room for improvement of such hazard maps. There are12 good practice examples indicated for natural hazard mapping by the participating countries. Seven of them focus only on one natural hazard risk (five on flooding), while the four others are multi hazard maps each illustrating several natural hazards (e.g. flooding, earthquakes, avalanches, tsunamis).

39. Finally, Figure 7 shows a trend in the number of natural hazard maps, while a larger number of maps are available at the national level and a lower number at the regional and local level. Very few of these maps involve operators of establishments directly during the drafting or amendment of these maps.

[7] http://ec.europa.eu/environment/water/flood_risk/implem.htm

Figure 7. Information on Natural Hazard Mapping

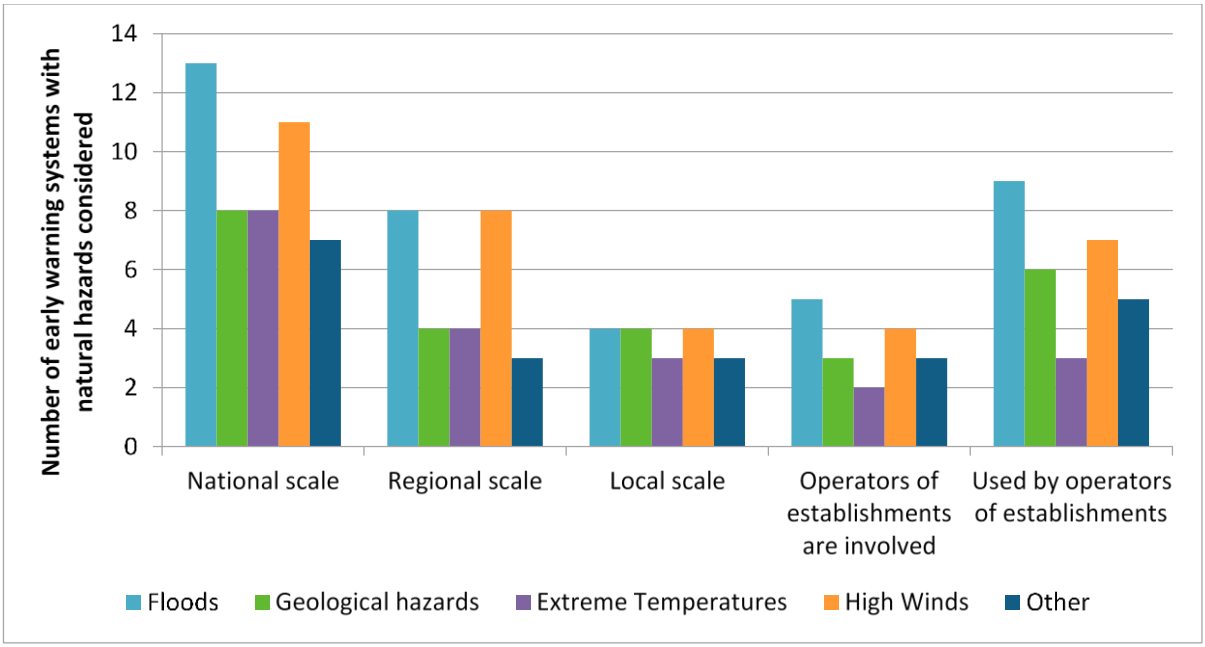


Box 3. Good Practice Example: Interactive Flood Risk Map (Saxony-Anhalt, Germany)

The Ministry of water protection and water management of Saxony-Anhalt (Germany) runs an interactive flood map showing flood risk of high, medium and low probability. Along with information about population, conservation areas and land use, the map also provides the location of risk sources like installations that fall under the EU-directive on industrial emission (2010/75/EU, IED) (replacing the EU-directive for Integrated Pollution Prevention and Control (2008/1/EC, IPPC)). Furthermore, objects that require special protection/concern like UNESCO heritages or swimming waters are illustrated as well.

40. In Figure 8 regarding natural hazard early warning systems, similar patterns to those in Figure 7 can be identified on natural hazard mapping, with a decreasing number of early warning systems as scales decrease. It appears, however, that operators of establishments are involved more often in early warning systems than in the drafting of natural hazard maps (17 compared to 8). The question -- if operators of hazardous installations use these early warning systems for their emergency management (7f) -- was answered positively for the four main hazards (geological hazards, high winds, floods and extreme temperatures) but also for other hazards.

Figure 8. Information on Natural Hazard Early Warning Systems



41. The survey in 2009 asked countries directly if they had developed Natech risk maps. The replies showed that "while many countries have natural hazard/risk maps for some natural hazards, hardly any of them have specific Natech risk maps. Where these Natech risk maps exist they are usually a simple overlaying of natural and technological hazard maps. While this gives an indication of possible Natech hot spots it may not allow a realistic assessment of the Natech risk. The conclusion from this question would be that there is a lack of Natech-specific risk maps in the responding countries."[8] Nevertheless, a lot of Natech risks (due to risks of "chemical" accidents) may be included in general "Chemical Accident risk maps".

[8] E. Krausmann and D. Baranzini (2009), *Natech risk reduction in OECD Member Countries: Results of a questionnaire survey*, European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, JRC Report 54120.

Box 4. Good Practice Example: Public Warning and Information System via mobile phones (Lithuania)

The Public Warning and Information System (PWIS) was installed by the Fire and Rescue Department under the Ministry of the Interior of the Republic of Lithuania. Its purpose is to alert in real time residents and visitors to the Lithuanian territory to dangerous situations by using cell broadcasting technology in mobile networks. Advantages of this technique are its very high level of reach because of full GSM (Global System for Mobile Communication) coverage in the country and a very high level of mobile phone usage by inhabitants. Additionally, people can directly receive useful information concerning the level of risk, behaviour recommendations, and how to avoid the hazard zone. Furthermore, the PWIS can be used for preventive message delivery to inform recipients of potential dangers.

International Cooperation in Mapping and Early Warning Systems

42. In the "Sendai Framework for Disaster Risk Reduction 2015-2030", "the scope of disaster risk reduction has been broadened significantly to focus on both natural and man-made hazards and related environmental, technological and biological hazards and risks"[9]. This demonstrates that the international disaster risk reduction community is considering Natechs in its most relevant agreement. It should be emphasized that transboundary cooperation in the context of natural hazards is especially relevant. Since natural hazards do not respect national borders, it may make sense to draw up or at least coordinate hazard maps across borders, e.g. flood hazard maps or flood warning systems for river basins.

43. The results of the survey show that, international cooperation on both natural hazard maps and early warning systems could be enhanced, though. Regarding the subject of transboundary or international co-operation in the development of natural hazard maps and natural early warning systems (questions 8a and 8b), only 53% (hazard maps) and 41% (early warning systems) of respondents respectively replied positively to this question.

***Natural hazard maps*:** The Sendai Framework for Disaster Risk Reduction promotes the development of periodically updated location-based disaster risk information, including risk maps. Concerning natural hazard maps, Colombia for example cooperates with Japan on a project for the application of State of the Art Technologies to Strengthen Research and Response to Seismic, Volcanic, and Tsunami Events and with the United States Geological Survey to improve monitoring of volcanos. Finland collaborates with the other Baltic Sea States through HELCOM and Environmental and Rescue authorities. France works on maps for industrial risks with Germany.

***Early warning systems*:** One of the goals of the Sendai Framework for Disaster Risk Reduction is to "substantially increase the availability of and access to multi-hazard early warning systems by 2030"[9]. Japan, for example works with Indonesia and Myanmar in early warning systems (e.g. for tsunamis). In Lithuania, the Fire and Rescue Department (FRD) established the Situations Coordination Division for the Transboundary Effects of

[9] UNISDR (2016), *Sendai Framework for Disaster Risk Reduction 2015-2020*, see https://www.unisdr.org/we/coordinate/sendai-framework.

Industrial Accidents. The Division transfers information on emergency situations to/from coordination centres of neighbouring countries, NATO EADRCC, UN OCHA and EC ERCC. The Lithuanian Hydrometeorological Service under the Ministry of Environment is a member of Meteoalarm (for meteorological events) and EFAS (for hydrological events).

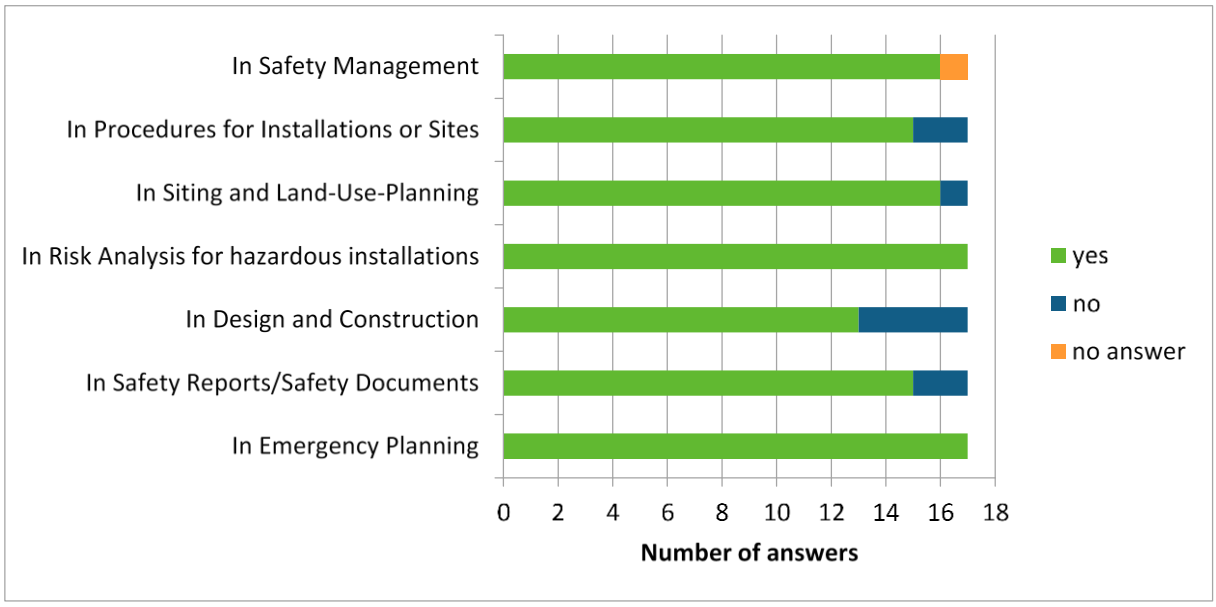
Box 5. Good Practice Example: The Global Framework for Climate Services

The Global Framework for Climate Services is a global partnership of governments and organisations. It aims at the incorporation of researchers, producers and users of climate services such as forecasts and climate change scenarios to increase both quantity and quality of climate information worldwide, especially for developing countries. To achieve this, an active exchange of good-quality data from national and international databases of climate parameters as well as long-term historical average data is pursued.

Consideration of Natural Hazards in Safety Management

44. This includes consideration in (operating) procedures for installations or sites, in siting and land-use-planning, in risk analysis, in design and construction, in safety reports / safety documents, and in emergency plans.

Figure 9. Information on Consideration of Natural Hazards in Different Risk Management Components (Questions 9a, 10a, 11a, 12a, 13a, 14a, 15a, 16a)



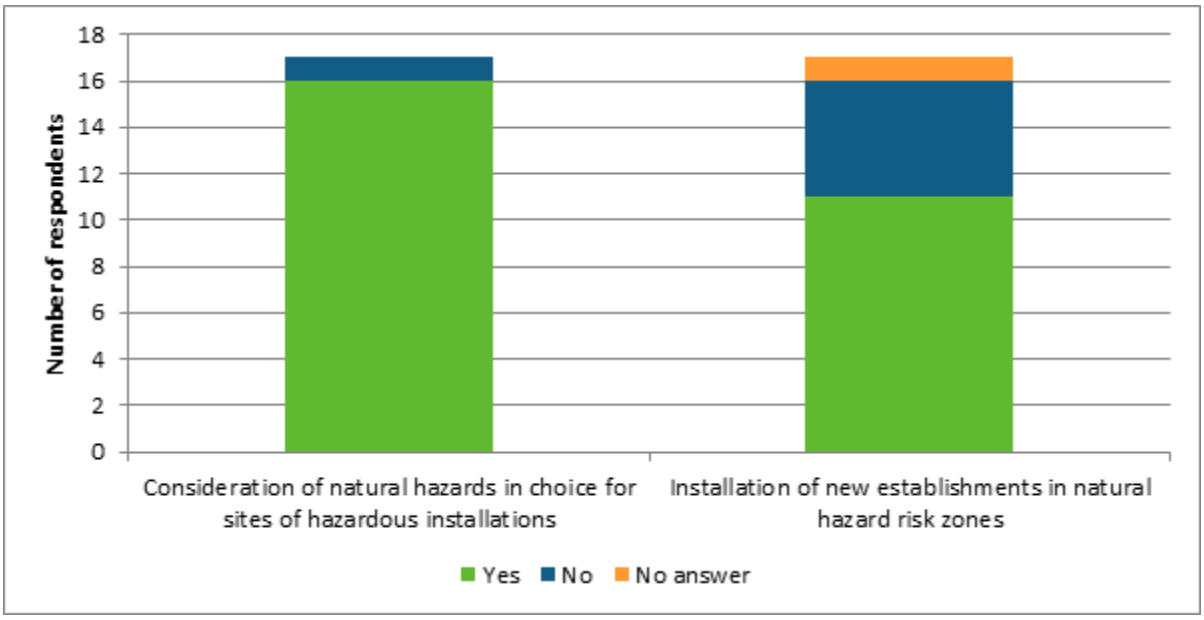
45. As can be drawn from Figure 9, most of the respondents agree that natural hazards are taken into consideration in all the mentioned risk management issues.

***Safety Management at hazardous installations*:** 94% of respondents consider that natural hazards are taken into consideration in safety management at hazardous installations

(question 9a). However, only 47 % reported these as good practices in Natech Risk Management (question 9b).

***(Operating) procedures for installations or sites*:** Natural Hazards are considered in operating procedures in 88% of cases (question 10a). Special operating procedures for impacts of natural hazards exist in 71% of cases (question 10b). Nevertheless, only 29% think that these procedures can be a good practice in Natech Risk Management. The high number of positive replies might indicate that only those countries already aware and/or active in the field of Natech Risk Management responded to the survey.

Figure 10. Consideration of Natural Hazards in Choice for Sites of Hazardous Installations (Question 11a) and Consideration of New Installations Sites in Natural Hazards Risk Areas (Question 11b)



46. Figure 10 shows that:

***Siting and land-use-planning*:** Figure 10 shows that almost all respondents state that natural hazards are considered in the choice of sites or in land-use-planning of areas for new hazardous installations (question 11a). Sixty-five percent of respondents state that new installations sites are considered in natural hazards risk areas (question 11b). In this case, only 18% of the respondents consider having a good practice in terms of evaluations or analyses in Natech Risk Management regarding siting and land-use-planning (question *11c).*

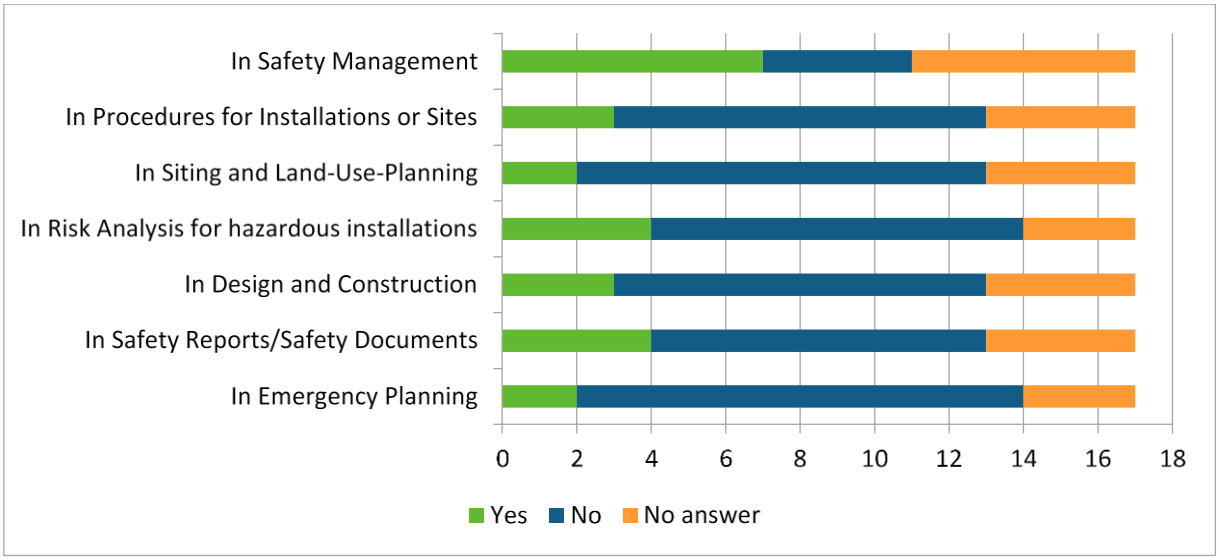
***Risk analysis for hazardous installations*:** Natural hazards in risk analysis for hazardous installations are widely considered in the responding countries (question 12a). Furthermore, 59% of the respondents agree that Natech risks are taken into account in the mapping of risks identified by this analysis (questions 12b).

***Design and construction*:** In 76% of the cases, natural hazards are considered in the design and construction of hazardous installations. However, only 29% of respondents were able to list technical codes or standards that could be the basis of this consideration (questions 13a). Question 13c asks if these procedures, codes or standards could be a good practice in Natech Risk Management, and 24% replied in the affirmative

***Safety reports / safety documents*:** Figure 9 shows that 88% of the respondents consider natural hazards in safety reporting or documentation. According to Figure 12 "presentation of the environment of the establishment" and "identification and accidental risks analysis and prevention methods" are the categories in safety reports or documents in which natural hazards are most commonly mentioned (question 14a). However, only 24% of the respondents could provide good practice examples based on safety reports/documents in Natech Risk Management (question 14b).

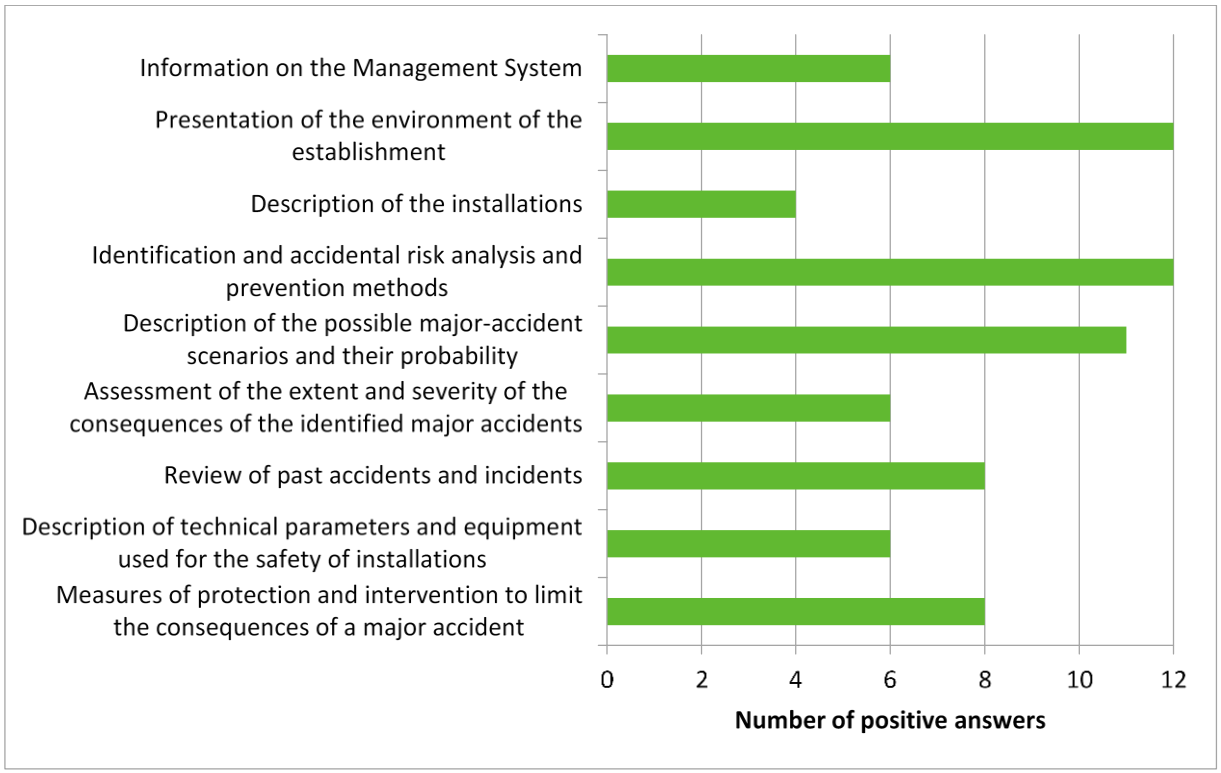
***Emergency plans*:** All respondents agree that natural hazards are considered in the drafting of emergency plans for hazardous sites or installations (question 15a), but only two submitted good practice examples regarding this issue (question 15b).

Figure 11. Specification on a Good Practice Example Considering Natural Hazards in the Following Fields



47. As seen in Figure 11, though many of the respondents consider natural hazards as an important factor of risk management, they did not provide a good practice examples in their countries, which may indicate room for improvement in the consideration of Natechs.

Figure 12. Consideration of Natural Hazards in Safety Reports/Documents (Question 14a)



48. Figure 12 shows that natural hazards are considered more frequently in the description of the environment and at the beginning of the risk analysis than in the description of accident scenarios and the measures to limit their effects. Again, this may be because the survey was answered by countries that are already active in Natech Risk Management.

Box 6. Good Practice Example: National Planning Policy Framework (UK)

In February 2019, the Ministry of Housing, Communities and Local Government revised the national planning policy framework that provides for all planning to bring together social, economic and environmental concerns to ensure sustainable development. This includes reductions of greenhouse gas emissions as well as risk minimisation of the vulnerability of projects against flood and coastal change.

In this context, principles are also mentioned that must be taken into account in planning or site development for flood-prone areas. Future site developments should be for sites that are located, as far as possible, outside of flood risk areas. Although Natech establishments are not explicitly mentioned for this strategy, it can nevertheless be assumed that this also applies to Natech establishments.

The goal is to steer the buildings into areas with the lowest flood risk. Exceptions should only be allowed if there are not sufficiently available locations with lower flood risk. In individual cases, this would have to be proven by the applicant, taking into account certain criteria. One criterion is that, in planning applications, local authorities should ensure that flood risk is not increased elsewhere.

49. Questions regarding effects of climate change were not raised in the 2009 survey. Due to increasing international interest in climate change issues, this topic has become more prominent in recent years and is being mainstreamed into the disaster risk management community. The IPCC report "Managing the risks of extreme events and disasters to advance climate change adaptation"[10] from 2012 mentions Natechs in particular when referring to the importance of knowledge in issues such as: "How climate change affects hazards, particularly regarding processes by which human activities in the natural environment or changes in socio-ecological systems lead to the creation of new hazards (e.g., NaTech hazards), irreversible changes, or increasing probabilities of hazard events occurrence".

50. Climate change is indeed being considered in Natech risk management by some countries. Fifty-three percent of respondents said that the effects of climate change are being taken into account in the risk analysis for hazardous installations (question 16a), though only 18% acknowledged these analyses as good practice examples in Natech Risk Management and 12% submitted a copy or provided links to relevant documents of good practice examples (question 16b). Finally, 53% of respondents indicated that risk analyses or emergency plans are reviewed and updated – if necessary – to consider climate change (question 16c). It might be that risk analysis for hazardous installations with the inclusion of effects of climate change on natural hazards are still under development as standardised approaches and methodologies for climate change risk assessments evolve.

[10]IPCC (2012), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

51. Along with the question on climate change consideration, the survey asked whether Natech risks or climate change were considered in the licensing of hazardous installations. Fifty-three percent of the respondents answered positively (question 17a). However, in total, only 24% of the respondents were able to provide documentation on regulations or specific guidance to this issue (question 17a). And again, only 12% provided good practice examples of these regulations or guidance (question 17b).

Natechs in Inspections Systems and Inspections and Natech Risks at Existing Installations / Sites

52. **Natechs in inspections systems and inspections:** Eighty-eight percent responded positively to question 18a, which asked if Natechs in inspection systems and inspection are widely taken into account. However, only four respondents are doing so on the basis of regulations or specific guidance. When asked if these inspection systems or plans, regulations or guidance could be a good practice in Natech Risk Management, only 29% of the respondents gave a positive answer (question 18b).

Box 7. Good Practice Example: Common Inspections Criteria for Natech

The European Commission's Technical Working Group on Seveso II Inspections (TWG2) has launched the preparation of Common Inspections Criteria for Natech. The European Commission's Joint Research Centre (lead), along with representatives of the EU Member States, will produce this guidance document for inspectors, with a specific focus on Natech risks. The Common Inspections Criteria are expected to be released within 18-24 months after the start of the activity.

53. **Natech risks at existing installations/ sites:** Eighty-eight percent of the respondents agree that Natech Risks are considered at existing sites or installations (question 19a). Furthermore, 24% of the respondents think that regulations or guidance in their country regarding Natech risks at existing installations/ sites would be an example of good practice, and 18% could actually submit an example (question 19b). However, these numbers do not lead to any conclusions about the detail/extent to which Natechs are considered at existing sites or installations, or the quality of the considerations. Fifty-three percent of the respondents said they have experience with retrofitting of installations, design requirements or increased design requirements due to natural hazards (question 19c). Four respondents were able to submit a copy of or provide links to relevant documents.

Natech Risks in Risk Communication

54. According to the survey conducted in 2009, the top Natech risk reduction strategies were:

- Raising awareness at the government and industry levels and improving risk communication among others
- Improvement and integration of natural and technological risk maps
- Improvement of existing regulations and development of specific guidelines by means of good practice examples

55. These results illustrated the need for the government and the private sector to work together in order to improve Natech risk reduction strategies, to implement risk map methodologies and to collect good practice examples based on countries' experiences with Natechs.

56. However, in 2017, only 35% of the respondents agree that:

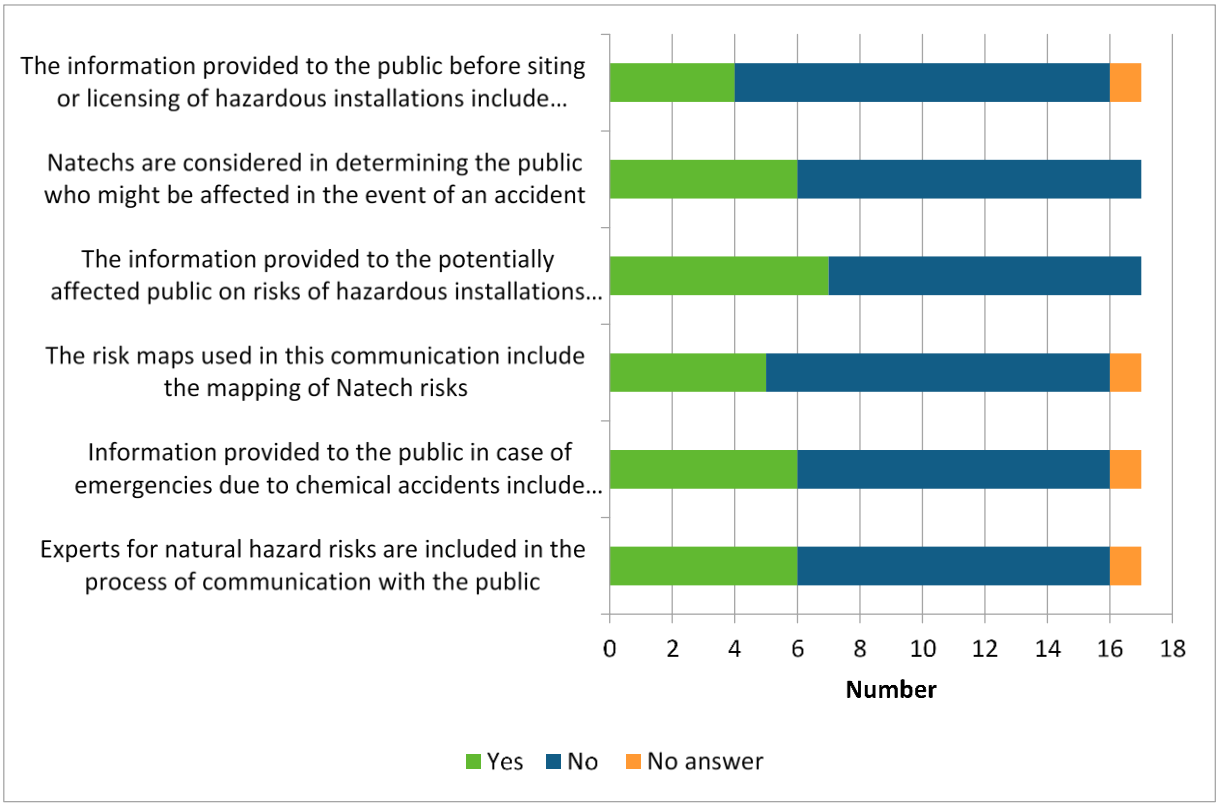
- Information provided to the potentially affected public in case of emergencies due to chemical accidents includes specific guidance for Natechs, if relevant (question 20e);
- Information provided to the potentially affected public on risks of hazardous installations includes information on Natechs risks, if relevant (question 20c).

57. Forty-one percent of respondents state that experts for natural hazard risks are included in the process of communication with the public, if Natech risks are relevant (question 20f).

58. Finally, only 24% replied that information provided to the public before siting or licensing of hazardous installations includes information on Natech Risks (question 20a).

59. All these results demonstrate the low visibility of Natech events in the risk communication systems.

Figure 13. Consideration of Natech Risks in Risk Communication

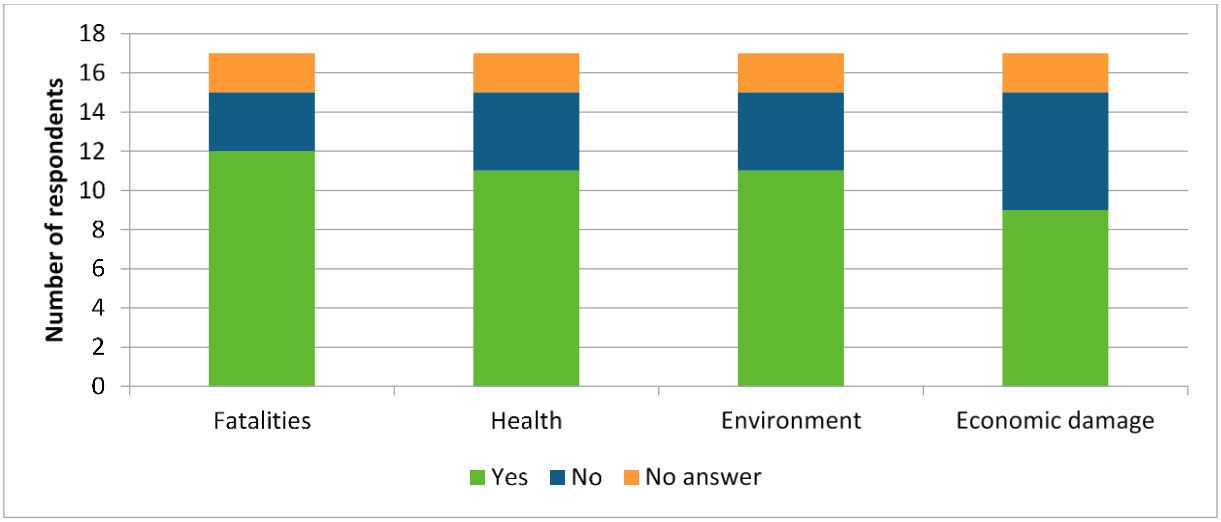


Natechs in Follow-Up of Natural Disasters

60. The survey in 2017 shows that Natech accidents are reported in 82% of cases of natural disasters (question 21a). One common problem in this kind of reporting is that other natural hazard effects are frequently more relevant; consequently Natechs are not given much importance.

61. Figure 14 shows the kind of information included in reports on effects of these Natechs. The most common regards fatalities, followed by health and environmental issues and economic damages (question 21b).

Figure 14. Effects of Natechs Reported in Case of Natural Disasters Reports (question 21b)



62. Question 21c asks if there is an analysis of the causes of and lessons to be learnt from these Natechs, and which authority/authorities collects the results of the analysis. 47% and 41% respectively replied in the affirmative to this questions.

Natechs in Education and Training

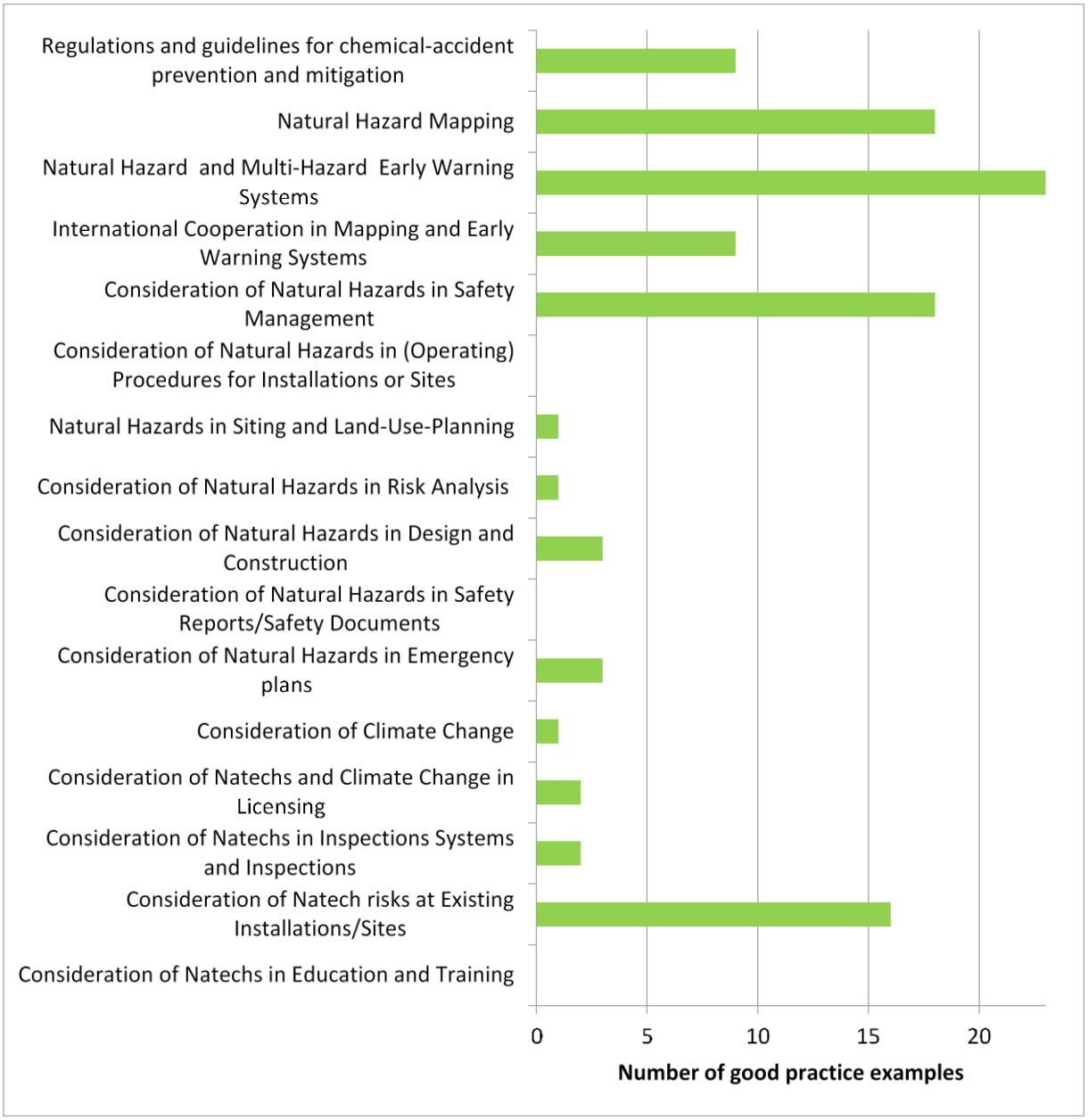
63. In the survey conducted in 2017, 59% of respondents mention that Natech Risks are considered in education or training of persons in charge of the safety of hazardous installations (question 22a). Furthermore, 71% of respondents mentioned that Natech risks are considered in education or training of persons in charge of disaster (risk) management (question 22b).

Main Conclusions from the Survey

Good Practices in Natech Risk Management

64. The survey asked for 16 possible areas in which examples of good practice in Natech risk management might be found. Figure 15 shows wide variation in replies, revealing that in some areas many countries have taken significant steps, while in others work remains to be done.

Figure 15. Number of Specifications on Good Practice Examples



65. Most of the good practice examples relate to fields that address general natural hazard issues such as natural hazard maps, early warning systems and consideration of natural hazards in emergency plans. It can further be seen that questions, which asked for specifically Natech-concerning issues, the naming of good practice examples gets very low to no naming at all among respondents. Respondents provided almost no examples of good practice to questions that dealt specifically with Natech issues. When positive answers about existing good practice examples were given, but no specification further indicated, the answers were not counted in the evaluation. In general, the evaluation shows that there is still much room for improvement of consideration of natural hazards -- and especially Natechs -- and that improvements were mainly in natural hazard identification and communication.

Consideration of Natech Risks in Regulations and Guidelines for Chemical-Accident Prevention and Mitigation

66. According to about 60% of the answers, rules, codes or guidance on chemical accident prevention or mitigation address natural hazards in some way. But only 30% of the respondents can name documents specific to Natech Risk Management. Since 2009, the perception regulation of Natech risks is effective has decreased among respondents. This indicates that in many cases Natech risks and Natech Risk Management are regulated only on a general level. There may be a lack of guidance regarding Natech Risk Management and implementation of regulations on Natech risks.

Risk Management Practices and Awareness of Natechs

67. The results from the surveys in both 2009 and in 2017 show general awareness and knowledge of Natech risk and risk reduction. Data collection systems concerning chemical accidents are established in most of the responding countries.

68. In 2017, more than half of the respondents agreed that:

- professionals are aware of the concept of Natechs
- Natech events are discussed among those in charge of chemical-accident prevention and mitigation and natural-disaster management
- there is enough emphasis on Natech risk reduction in the laws and regulations for chemical-accident prevention and mitigation

69. Nevertheless, more than half of the respondents also disagree that:

- dynamics of Natechs among the country's competent authorities are adequately known
- competent authorities have adequate training on Natech risk reduction
- there are current practices for chemical-accident prevention and mitigation provide for adequate protection of citizens against possible Natech events in place
- current industry risk assessment methods adequately take into consideration Natech events
- the design and construction of industry buildings and other structures provide sufficient protection against Natech accidents

70. Aside from the two questions on the discussion of Natech risks by "chemical accident managers" and on the emphasis on rules and regulations, agreement to the other questions decreased from 2009 to 2017.

71. This may be due to increased awareness of the risk characteristic of Natechs, which has led to lower estimates of protection levels by respondents.

Needs and/or Limitations in implementing Natech Risk Reduction Strategies

72. **Natural Hazard Mapping and Early Warning Systems:** There is a trend in the number of natural hazard maps and early warning systems. While a larger number of natural hazard maps and warning systems are available at the national level, a lower number is available at the regional and local level. Only in very few cases does mapping or maps directly involve the operators of hazardous facilities. According to about two-thirds of the answers, operators use warning systems, but in many cases that may refer to the systems on the national level -- not the local level -- addressing situations at sites of hazardous facilities.

73. **International Cooperation in mapping and Early Warning Systems:** As the international disaster risk reduction community is considering Natechs in the "Sendai Framework for Disaster Risk Reduction 2015-2030", the survey shows that international cooperation on both natural hazard maps and early warning systems could be enhanced. Nevertheless, some countries responding to the survey gave examples of good cooperation. Transboundary cooperation in the elaboration and implementation of hazard maps or warning systems, e.g. along riverine systems, is essential and should be promoted by international organisations.

74. **Consideration of Climate Change, consideration of Natechs and Climate Change in licensing:** Climate change is being considered in Natech and natural disaster risk management by some countries. However risk analysis for hazardous installations with the inclusion of climate change influenced hazards may still be under development as standardised approaches and methodologies for climate change risk assessments evolve.

75. **Natech risks in Safety Reports/Documents, emergency plans, and inspections:** According to 88% of the respondents, natural hazards are considered in safety reports/documents. Furthermore, 25% of respondents recognize these safety reports/documents to be good practice examples in Natech Risk Management (question 14b). All respondents agree that natural hazards are considered in the drafting of emergency plans for hazardous sites or installations (question 15a), but only two submitted good practice examples regarding this issue. Eighty-eight percent of the respondents say that Natechs are widely taken into account in Inspection Systems and Inspections. However, only three respondents do so on the basis of regulations or specific guidance. Only 29% of the respondents state that these inspection systems, plans or guidance could be a good practice in Natech Risk Management.

76. **Natech risks in risk communication:** In the 2017 survey, only a little more than one third of the respondents agree that:

- Information is provided to the potentially affected public in case of emergencies due to chemical accidents that includes specific guidance for Natechs, if Natech risks are relevant.

77. Information is provided to the potentially affected public on risks of hazardous installations, including information on Natechs risks, if relevant . Experts on natural hazard risks are included in the process of communication with the public, if relevant. Only 24% replied that information provided to the public before siting or licensing of hazardous installations includes information on Natech risks.

78. The 2017 survey results demonstrate the low visibility of Natech events in the risk communication systems put in place.

79. **Natechs in education and training:** Finally, Natech risks shall be considered in education and training of persons in charge of safety of hazardous installations and of disaster (risk) management.

Progress since the First Survey in 2009 and Remaining Gaps

80. The publication in 2015 of an addendum to the OECD Guiding Principles on Chemical Accident Prevention, Preparedness and Response dedicated to Natechs risk management is a substantial milestone in supporting the prevention of Natechs.

81. The results of the survey show that more could be done to support risk management of Natechs in terms of rules, codes and/or guidelines that specifically address natural hazards to which countries are especially vulnerable. Neither a document providing guidelines specific to Natech Risk Management nor strategies/programmes to address the issue of Natech events are widely available among the countries.

82. The self-estimated effectiveness of regulations for Natech accidents prevention slightly decreased between 2009 and 2017. This may be due to increased awareness among policy makers that Natechs are being recognised as serious threats that require adequate risk management efforts. However, the differences in the sample of countries/institutions that replied to the survey may also account for such changes in the perception of effectiveness. The gaps and shortcomings have become more specific and better-defined as compared to the results in 2009.

Proposals for Further Improvement in Natech Risk Management from the Survey

83. Based on the conclusions drawn from needs and/or limitations for implementing Natech risk reduction strategies, some recommendations can be made. These are specifically related to guidance on the consideration of Natechs in:

1. **Safety Reports/Safety Documents and Emergency Plans:** The results of the survey (questions 14 and 15) indicate that risk management stakeholders expect guidance for the consideration of Natechs in Safety Reports/Safety Documents and Emergency Plans. Natechs are widely considered in this kind of reports, documents and plans. Nevertheless, specific guidance on how to consider them is an issue that should be addressed in order to improve Natech Risk Management.
2. **Inspections Systems and Inspections:** The survey shows that Natechs are widely taken into account regarding Inspection Systems and Inspections, but regulations or specific guidance are lacking in the majority of the cases (questions 18). Recognising this gap, the European Commission's Technical Working Group on Seveso II Inspections (TWG2) has launched the preparation of Common Inspections Criteria for Natech, a guidance document for inspectors with a specific focus on Natech risks.

84. Keeping in mind examples of Natech risk reduction strategies/recommendations, the following seem particularly relevant in order to further reduce country's or organisation's susceptibility to Natechs (question 5):

3. **Natural Hazards in Risk Analysis**: One country recommended the consideration of Natechs in the risk assessment of major hazard facilities conducted by the operator of the facility. Another country advised the development of guidelines for Natech risk analysis, and learning from the experience of Natech risk analysis.
4. **Natech Awareness and Risk Reduction:** One country provides as an example the improvement of general awareness of Natech initiators and their impacts. Another country proposes to increase the exchange of ideas and knowledge between the natural hazard and the major chemical accidents competence areas and use this competence further in the permitting process.

Highlights from the joint OECD-UN Workshop on Natech Risk Management, Potsdam, Germany, September 2018

85. The joint OECD-UN Workshop on Natech Risk Management that took place in September 2018 in Potsdam, Germany, was divided into eight sessions:

- Session 1: Natech Risk Management in Industry
- Session 2: Natech Risk Analysis
- Session 3: Consideration of Climate Change, Consideration of Natech Risk in Adaption to Climate Change
- Session 4: Warning systems, Natech Emergency Planning, Preparedness and Response
- Session 5: Follow-Up of Events, Event Analysis, Recovery, Rehabilitation, and Reconstruction
- Session 6: Transboundary and International Cooperation
- Session 7: Natech Risks: Communication and Education
- Session 8: Natech Risk Management in the Public Sector: Natech Risk Governance, Enforcement, and Reduction

86. The chapter below presents some of the main conclusions from the workshop.

Session 1: Natech Risk Management in Industry

87. Natech Risk Management covers prevention of, preparedness for, and response to chemical accidents. From the view of an operator, one part of prevention is a risk analysis. Prevention includes the dimensioning of technical and the planning of organisational measures. Response to chemical accidents refers to measures to mitigate the consequences of chemical release in case of an accident.

88. In the first OECD workshop on Natech Risk Management that took place in Dresden, Germany in 2012[11], it was pointed out that Natech risks are critical amongst other industrial risks (caused e.g. by technical failure) and should be part of the operator's risk analysis. Risk analysis should be performed before siting of a new facility and reviewed for existing plants under the aspect of natural hazards and climate change aspects. It was also mentioned that operators are responsible for managing the risks related to their facilities including Natech risks. They should not only rely on protection measures against natural hazards provided by authorities. Furthermore the Natech workshop in 2012 pointed out that, "Risk analysis methods or tools for industrial facilities should be developed and implemented."

[11] OECD (2012), 'Report of the Workshop on Natech Risk Management (23-25 May 2012, Dresden, Germany)', *Series on Chemical Accidents No. 25*, ENV/JM/MONO(2013)4

89. Establishing an effective Natech Risk Management is a difficult task and requires knowledge that operators may not have. This is particularly true for risk analysis. Therefore, it seems useful to provide operators with guidance to help them safeguard their plant against natural hazards. Guidelines or detailed methodological approaches are of great importance for an effective Natech Risk Management.

90. In this context, the Natech workshop in 2018 in Potsdam raised the topic of failure of utilities or safety barriers caused by natural hazard, which in many cases had triggered chemical accidents. Consequently, the roles of utilities and safety barriers should be recognised as key points in the assessment of Natech scenarios. A specific assessment of safety barrier performance in Natech conditions is thus needed for an appropriate management of Natech risk. Besides the critical equipment, more attention should be devoted to the design and protection of critical utilities in Natech conditions.

91. The workshop highlighted a specific issue for Natech Risk Management, which is the exposal of pipelines to geological hazards. Earthquakes, volcanism, landslides, avalanches of mud or debris, erosion, floods and rain are examples of natural hazards with impacts on the integrity of pipelines. The strength and stiffness of the pipelines allow them to tolerate the effects of natural hazards for some period of time. The amount of time depends on the strength and deformability, the stress state, the age, the conditions of the installation and operation of the pipelines and their geometric arrangement with regard to the hazardous processes.

92. In the programmes for pipeline integrity management, the risk is defined as a function that relates the probability of the pipeline rupture and the consequences of the failure. A general function was proposed: the product of the probability of occurrence of the threatening process, the vulnerability of the pipeline (expressed as the fraction of the potential damage the pipe can undergo), and the consequences of the pipeline failure (represented in the sum of the costs of the spilled product, its collection, the pipeline repair, and damages caused by the rupture).

93. Another approach for pipeline risk management presented at the workshop was a model to assess the loss of containment due to natural hazards under specific condition: vulnerability of the pipeline, geotechnical susceptibility and triggering agents' activity (e.g. rains, earthquakes, human processes). The model allows to integrate the actions carried out to know the pipeline integrity condition and its exposure degree to environmental conditions, to processes of instability susceptibility and, in some cases, the geohazards criticality degree in the face of its existence, and the monitoring of agent activity results (e.g. climatic variability phenomena).

Session 2: Natech Risk Analysis

94. Hazard maps provided by national authorities form the basis for operators to assess the vulnerability of establishments in facilities. Due to different types of equipment and different types of natural hazards, there are many approaches for Natech Risk Analysis.

95. Using the example of the chemical accident of ARKEMA at their site at Crosny, which was triggered by the hurricane Harvey, the workshop addressed the causes that led to the failure of the cooling systems on three trucks loaded with organic peroxides. It was pointed out that in this case, flood information including the water level should have been

incorporated into the disaster plan. Environmental impact assessment (EIA) should, thus, consider Natech events.

96. Another presentation considered domino effects in case of a chemical accident, and included non-process hazards such as earthquake and tornado, and process hazards like fire, blast, toxic smoke, and loss of containment. First, the risk of each individual hazard is quantified, and subsequently, the risk for domino effects triggered by fire, blast, and earthquake is assessed. For instance, in case of a fire, the domino effect can be estimated by calculation of the time to failure of tanks as a function of thermal radiation for different levels of utilization. Further, in case of an earthquake, the approach uses fragility curves to estimate the damage of tanks. With this information, the presented risk analysis method can estimate the probability of escalation of primary accidents.

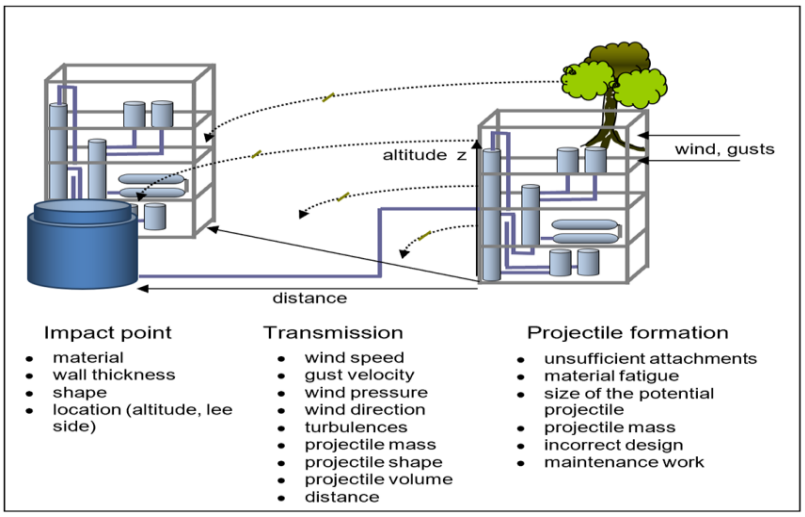
97. The workshop included a presentation on Natech risk analysis and mapping with the RAPID-N system developed by the Joint Research Center of the European Commission. RAPID-N analyses Natech risks at local (single installations) or regional (multiple installations) level. It covers all functionalities required for Natech risk assessment including natural-hazard assessment, industry damage severity and probability estimation, accident scenario building, and consequence analysis in one tool. The output of the RAPID-N assessment is a risk summary report that features all parameters supplied by the user and is utilized by RAPID-N for the analysis and an interactive risk map showing the specific impact areas for all potential Natech scenarios. RAPID-N is currently implemented for earthquake- and flood-triggered accidents in the chemical and process industry, as well as for overland pipelines. It supports land-use and emergency planning and in case of a natural disaster it facilitates decision making based on near real-time damage assessment.

98. In particular, the intensities of earthquakes are easily measurable. The peak ground acceleration is of special interest. The damages of equipment are divided into different damage states, assigned to the peak ground acceleration and statistically evaluated. With these parameters the probabilities of the impacts on the environment, like release of chemicals, fire, and explosion, can be estimated.

99. With the help of such vulnerability curves the degree of loss of integrity including the release of chemicals can be estimated. Even in the case of a fire or explosion the thermal radiation can be calculated with the help of Rapid-N. In this way, hazard maps are created that illustrate the critical radius of thermal radiation.

100. Other risk analysis methods are also being developed for specific issues, for example, the hazard of windborne debris triggered by extreme wind. As storms have a huge impact on structures and industrial installations, insufficiently attached parts may tear off. If these parts are safety-relevant equipment, this may cause the loss of safety-relevant functions. Additionally, the storm may carry these parts away as windborne debris, which may damage safety-relevant equipment, either containing hazardous substances or having other safety-relevant functions.

Figure 16. Potential Threats Caused by Windborne Debris



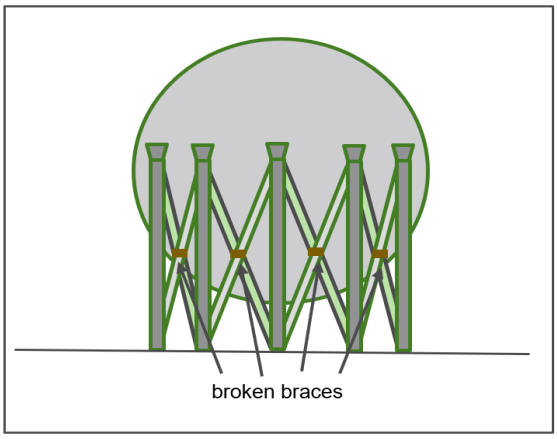
Source: Prof. Dr. Köppke & Krätzig & Partner Ingenieursgesellschaft mbH, 2016.

101. The hazards presented by windborne debris were particularly investigated in the United States due to the high number of tornados and hurricanes in order to develop design requirements for community safety rooms. In contrast to tornados no data and design objects exist for windborne debris generated by other storms and only horizontal air flow. A method was developed in order to generate the necessary data and to estimate the impact of windborne projectiles (pipe) on e.g. tanks. It is an approach to allow a first risk analysis. For this purpose an Excel-based program was developed, which was tested for a refinery close to the coast in the northern part of Germany.

102. Another presentation discussed the new Technical Rule on Process Safety developed in Germany, which examines the three natural hazard sources wind, snow loads, and ice loads. As a matter of principle, construction works are designed to withstand the wind loads detailed in DIN EN 1991-1-4 (December 2010, previously DIN 1055-4) and the snow loads detailed in DIN EN 1991-1-3 (December 2010) (previously DIN 1055-5 (July 2005), which covered snow loads and ice loads). Safety-relevant technical installations of the kind that are subject to the German Major Accidents Ordinance are not explicitly mentioned in the standards above. These installations have a higher hazard potential on account of the hazardous substances that are present in them. So, particular examination, precautions, and measures to guarantee safety are necessary. These installations, including structures and enclosures, therefore need to be designed with particular allowances being made for the static and dynamic loads to which they are exposed.

103. New research projects resulted from the 2011 tsunami that struck Japan. One project dealt with countermeasures against large-scale earthquakes at high pressure gas facilities. Significant fire and explosion accidents involving spherical tanks for Liquefied Petroleum Gas (LPG) storage were triggered by the strong ground motion of the 2011 Great East Japan Earthquake. Steel pipe braces broke due to the strong seismic inertia force, the spherical tank lost the horizontal stiffness, and buckling of support legs occurred.

Figure 17. Broken Braces That Supported the Legs Holding the LPG Tank



Source: Cosmo Energy Holdings © Karl-Erich Köppke

104. This research evaluated prevention of similar accidents, improving seismic capacity of the spherical tank, The seismic capacity of spherical tank was assessed, and evaluation methods and seismic reinforcement methods were proposed.

105. Seismic design standards of high-pressure gas equipment in Japan were revised each time earthquakes cause damage. However, the East Japan Great Earthquake highlighted the importance of advance measures to prevent unexpected damage. Therefore, equipment designed based on the current seismic design standards was examined could withstand a huge future earthquake.

106. The tsunami that followed the earthquake caused further damage and major floods in the coastal areas. Flooding can damage cylindrical storage tanks in such areas. Since those storage tanks have a large amount of oil or gas, damage could lead to serious fires. In Japan, a tsunami as large as the 2011 Earthquake Tsunami is predicted to strike again in the near future. Therefore, it is essential to investigate tsunami wave load acting on storage tanks.

107. An abstract was submitted for the workshop which attempted to assess the hazard of tsunami-induced oil spill fires in the vicinity of petroleum industries at Osaka Bay, Japan. The huge tsunami caused large-scale oil spill fires, including in evacuation buildings, and people who had escaped from the tsunami to the buildings were exposed to the fires. As such tsunamis are also expected to affect Japan in the near future due to megathrust earthquakes, there is a concern about the damage by tsunami-induced oil spill fires in the vicinity of petroleum industries. In order to numerically analyse the thermal impact of tsunami-induced oil spill fires on the surrounding environment, a numerical simulation model has been developed predicting the behaviour of tsunami-induced oil spill fires. This model is a coupled simulation of tsunami propagation and inundation, oil spill and fire spread, and heat transfer by radiation and convection. It is confirmed that the model is able to reproduce the dynamic states of the tsunami-induced oil spill fires at Kesennuma Bay in 2011 through numerical simulation.

108. Another presentation discussed storm surges and their causes in Osaka Bay, Japan i.e. sea level rise caused by low atmospheric pressure and strong wind due to typhoons,

for example. Typhoon JEBI recorded a sea level rise of about 270cm above the normal tide level. In this presentation, cooperative action for risk reduction by local governments, companies and residents was stressed as the most important first step to protect both civil society and industry from Natechs.

109. Another presentation reported on measures taken due to flood hazards at Seveso-sites in the Netherlands, with a primary focus on the analysis of effects of floods on chemical industry plants. The analysis focused on questions about the extent of the flood risks for Seveso-sites, how industry can be informed of the risks, what the effects for industry are, and what kind of measures are taken. Also, guidance on analysis of flood risk is available, where the basis for a flood scenario is an event which occurs once in 1.000 or 10.000 years.

Session 3: Consideration of Climate Change in Natech Risk Management, Consideration of Natech Risk Adaption to Climate Change

110. The first OECD Workshop on Natech, held in 2012, raised the link between climate change and risk management of Natechs. Facilities can be subject to extreme meteo- and hydrological events, which can trigger a second disaster by release of chemicals, fire, and explosion. The following two recommendations from the Natech workshop in 2012 are of great importance:

1. New national regulation including Natechs should take climate change aspects into account.
2. The consideration of climate change in Natech Risk Management should be part of a climate change adaptation process of an enterprise.

111. The beginning of Session 3 of the Natech workshop in 2018 focused on whether robust trends of climate change can be deduced from the numerous studies, which all have greater or lesser uncertainties. One of the presenters described a study in which the different climate-related sources of uncertainty are quantified and discussed when projecting flood hazard and risk. It was demonstrated how these results can be applied in adaptation strategies in the public and private sectors, for example when looking at critical infrastructure.

112. A project was presented on the integration of climate change into regulatory practice (ICCARP). This project considers the extent to which adapting to climate change is integrated into environmental permitting practice across Europe. The project focuses on the Industrial Emissions Directive (2010/75/EU) legislation, Integrated Pollution and Prevention Control guidance and analogues.

113. An abstract about the simulation of river floods in Moldova under the aspect of climate change was submitted for the workshop. The results of investigations of the compilation of hazard and flood risk maps are presented for different probabilities. The hydrological specificity of the Republic of Moldova means that the floods caused by the overflowing of the rivers produce less damage and are better managed than the flash floods.

Session 4: Warning Systems, Natech Emergency Planning, Preparedness, and Response

114. Natech emergency planning is a difficult task, because the specific characteristics of Natech accidents differ significantly from "conventional" technological accidents. Often, several facilities are affected simultaneously by one natural hazard event. This can lead to multiple and simultaneous loss-of-containment events in different locations, creating difficulties for response. In addition, there can be cascading events -- one natural hazard can trigger another, and one Natech may trigger other ones. Finally, in case of a natural disaster, the response to a Natech will be just one part of the overall response to the disaster. The workshop presented an overview of some Natech events in the past including the main lessons learned for each event. Besides the necessity of on-site emergency plans and their periodic revisions, the health risks for the population and responders caused by chemical release must be considered. Hence, medical services should be involved in the preparation of disaster management and external emergency planning.

115. An overview of the Georgian law on Civil Safety and its relevance for Natech incidents was also given, including the specifics of emergency plans, and work concerning Natech risk reduction. Special focus was on population vulnerability and risks of technical accidents during natural emergencies. The presentation also covered early warning systems in Georgia for flood, erosion, landslide and mudflow. A Geo-informational portal has been established and updated with various geographical data, hazard maps, critical infrastructure, dangerous facilities and objects. Also, a new communication system has been installed for dissemination of warnings.

116. In a heavy industrial and populated area of Indonesia, Natech disasters are simulated by ARDEX (ASEAN Regional Disaster Emergency Response Simulation Exercise). The workshop reported the scenario development and the resulting Natech disaster risk management. The simulations have been executed in the Cilegon area, a region with many facilities and a high risk of earthquakes and tsunamis. One basis for the different simulations are maps with information about the chemical disaster prone areas.

117. An international platform on earthquake early warning systems was presented, launched by UNESCO. The main objective of the platform is to assess the current state-of-the-art in the development and operationalisation of earthquake early warning systems (EEWS) globally, to foster dialogue and international cooperation for capacity building around these systems, and therefore to promote and strengthen EEWS in earthquake-prone countries worldwide.

118. Early warning systems are successfully in operation all over the world. The workshop noted that none of them considers the consequences of Natech disasters. There are investigations of the Joint Research Center of the European Commission to combine early warning systems for flooding, for example, with the Rapid Natech Risk Assessment and Mapping System (RAPID-N), which is an operational system for rapid local and regional Natech risk analysis. In two studies, the interoperability of RAPID-N was assessed. The studies show that Natech-related damage and consequences can be successfully assessed by RAPID-N by using the natural hazard data provided by other systems like the European Flood Awareness System (EFAS) and the Global Disaster Alert Coordination System (GDACS).

119. One of the workshop presentations described the attempt to estimate the facility downtime after Natech accidents. The starting point is the assumption that normally, the

individual parts of a plant have a defined repair time. Also, certain resources are needed to repair the individual parts. Furthermore, the damage to the individual parts often depends on other damaged parts. For example, a leaking fuel tank cannot supply a generator. The core elements of the model are fragility curves for tanks in case of an earthquake, and restoration curves for tank farms. However, the considerations presented are only a first step in the estimation of facility downtimes, because more information (material properties, internal constraints, external resource requirements etc.) is required to estimate realistic downtimes after Natech accidents.

120. One of the presentations pointed out that during the first hours after an earthquake, there are minimal numbers of specialists and means but many life-saving missions and after 48 - 72 hours, there are a lot of specialists and means, but very low chances to save lives. The first hours after an earthquake are most important, but there are a limited number of professionals (civil engineers), who can evaluate the situation. The solution for this paradox is to establish a cascade process of evaluation, using non-professional staff (not civil engineers) during the first critical hours and using the professionals only for special plants or special situations. Therefore, authorities in Israel have prepared a course of HazMat plants post-earthquake evaluation for non-engineers. The engineers' issues were determined in the simplest way in order to explain the basic principles and to determine/set the go/no go instructions. A pocket handbook, prepared especially for non-engineers, was presented in this session.

Session 5: Follow-Up of Events, Event Analysis, Recovery, Rehabilitation, and Reconstruction

121. In this session, a number of reports were given regarding important Natechs linked to floods – for example the investigation undertaken by the US Chemical Safety Board (CSB) at the Crosby site of the ARKEMA company. One of the main failures was linked to the unexpected water level after Hurricane Harvey. Although information about flood hazards is often available, this information is not required to be used in process hazard analyses. The workshop pointed out that guidance to industry would be a necessary support.

122. From the perspective of insurance companies, the workshop highlighted that large amounts of money must be spent every year to industry-clients to compensate losses caused by natural catastrophes. Many of these events are predictable. The workshop asked whether is it necessary to suffer losses from events when loss prevention is possible? Losses are analysed to indicate what hazards effectively impact chemical and petrochemical industries and what loss prevention technics are developed. Positive and negative examples indicate the value of the loss prevention measures for different hazards and conditions.

123. A specific event analysis was carried out for the Cosmo Oil Refinery in Chiba prefecture affected by the earthquake on 11 March, 2011. In the accident, an initial earthquake caused fires, which in turn caused the burnout of all of 17 liquefied petroleum gas (LPG) tanks.

124. Activities in Japan to understand the propagation of dynamics of the accident in order to develop effective countermeasures to prevent such Natech accidents in the future were presented. A research project is starting to analyse the dynamics of this accident, including the consequences analysis using Bayesian Network.

Session 6: Transboundary and International Cooperation

125. There was a presentation of the UNECE Convention on the Transboundary Effects of Industrial Accidents to support prevention, preparedness and response to Natech events, and to promote cooperation between countries in this regard. The convention supports countries in identifying and assessing Natech hazards and in taking preventive measures to adjust preparedness and response actions. Seminars on land-use planning and industrial safety, as well as guidance development (the safety guidance and good practices on specific industry sectors) are examples of UNECE activities.

126. The project 'Hazard Map' was presented, which was jointly prepared by the Republic of Moldova, Romania and Ukraine under the UNECE Project on Hazard and Crisis Management in the Danube Delta (2010–2015), within the framework of the UNECE Industrial Accidents Convention's Assistance Programme. The key project objective was to protect the Danube Delta, Europe's largest remaining natural wetland, from industrial accidents and to improve cooperation on industrial accidents between the three countries. A major outcome of the UNECE project is the hazard map that visually represents the hazardous industrial activities in the three project countries, and identifies them in a harmonised way.

127. This session was also an opportunity to learn about the activities of the UN Environment/ OCHA Joint Unit (JEU). The JEU supports Member States in responding to environmental emergencies whenever international assistance is requested. This includes readiness for response through specialised training, complex simulation exercises, policy guidelines, and contingency planning. Notably, the JEU has co-led the development of the UNISDR Words into Action Guide on Man-made and Technological Hazards, which also addresses Natechs; developed tools for rapid environmental assessment, such as the Flash Environmental Assessment Tool (FEAT); and provides online e-learning modules via its online Environmental Emergencies Centre. The JEU further engages with UN Environment on the Awareness and Preparedness for Emergencies at Local Level (APELL) programme, as well as with the OECD through the Working Group on Chemical Accidents and on the OECD Natech project.

128. An abstract was submitted for this session that describes an agreement between the Republic of Kazakhstan and the Kyrgyz Republic on the establishment of a centre for emergency situations and disaster risk reduction. The centre's tasks include harmonisation of legislation, strengthening local and national capacities for emergency management, and coordination of an effective response to emergencies.

Session 7: Natech Risks: Communication and Education

129. Due to the complexity of the science linked to Natechs, the workshop discussed the need for Natech-specific education and capacity building. This includes communication between all involved disciplines, such as technology, geology, hydrometeorology, and management.

130. Also presented was the National Risk Atlas in Mexico, a tool for the identification of risks and the preparation of decisions. The atlas consists of databases, geographic information systems, and tools for analysis and simulation of scenarios, as well as the estimate of losses due to disasters. For example, the user can obtain information about the location of companies that use highly hazardous substances (flammable or toxic) and the

danger they pose to the population and natural systems. Another example is the identification of the vulnerability of the population and systems to rain and tropical cyclones according to their exposure, as well as their social- and geographical conditions. Given the dynamic nature of these risks, the Atlas must be maintained as a permanent updating instrument. It also includes tools, such as the National Alert System for cold fronts, slope slides, rain and tropical cyclones, to improve the safety of the population in case of imminent risk.

131. The workshop discussed the relationship between the industry and the local community for building a Natech early warning system. One of the main problems of early warning systems is the dissemination of warnings. A survey was conducted in Cilegon City located in Banten Province, which is known as one of the most famous petrochemical industrial areas in Indonesia. This area is susceptible to earthquakes und tsunamis. These major hazards may increase risks in communities surrounding industrial areas. The aim of the survey was to empirically clarify the relationship between the industry and the local community and to obtain implications for developing a Natech early warning system. Cilegon is potentially exposed to natural and industrial hazards and considered as an adequate place to study Natechs. Participants discussed how the implementation of simulation and trainings at the community level is useful to raise awareness of the Natechs and to identify practical actions.

132. The workshop highlighted barriers and challenges to risk information, disclosure and communication concerning Natechs.

Session 8: Natech Risk Management in the Public Sector: Natech Risk Governance, Regulation, Enforcement, and Reduction

133. The following session included an introduction to French regulations for earthquakes in industrial establishments (including Seveso establishments), and an explanation of concrete prevention of Natech Risks due to earthquakes at Seveso establishments. In France, seismic-related legislation requires that “special risk” equipment in specific hazardous areas must be analysed. The objective of these analyses is to prove the non-vulnerability of special risk equipment to seismic hazards or, if necessary, to define a certain number of reinforcement measures. In order to help stakeholders in these studies, a consortium gathering industry and trade associations, with the participation of INERIS, has developed methodological and technical guides to help industrials in these studies.

134. Besides the French activities, there was a presentation of Natech Risk Management in Italy. With the implementation of the Seveso III Directive (2012/18/EU) in 2015, and with the occurrence of several sizeable earthquakes in Italy during the last 10 years, the responsible authorities started activities to reduce the potential risk of Natech accidents. Rules, guidelines, and technical standards should enable operators to apply uniform mitigation prevention strategies and response to accident hazards triggered by a natural event. The presentation described the technical scientific activities carried out by ISPRA, the technical body of the Ministry of Environment of Italy, to support operators and authorities implementing prevention and mitigation action of Natech events.

135. The following presentation focused on current Natech Risk Management status in Colombia. The Colombian government passed Law 1523 in 2012 in an effort to create a national disaster risk management system. This law expressly establishes the obligation for all public and private installations involved in industrial activities to carry out risk analysis.

This analysis must consider the possible effects of natural hazard events on the exposed infrastructure and the potential external consequences on the surrounding areas. As this law is relatively new, many deficits can still be identified in practice. All in all, a lack of knowledge on the specificities of Natech scenarios has shown the need to clarify this issue in order to improve preventive mechanisms and response capacities in the Colombian context. Although there is increased awareness among governmental organisations on the importance of assessing and managing Natech risks, efforts still need to be directed towards consolidating Colombia's Natech Risk Management system.

Recommendations from the survey results, the Natech workshop in 2018 in Potsdam, and from follow-up discussions of the OECD Natech project steering group

136. Prior to the Natech workshop in 2018, a thorough examination of the 2017 survey and of the workshop abstracts had suggested some deficiencies in Natech Risk Management. Chapter 4 of the discussion document, prepared for and presented at the Potsdam Workshop, had suggested possible options to address these deficiencies, while referring also to the already existing recommendations in chapter 18 of the OECD Guidance on Chemical Accident Prevention, Preparedness and Response on Natechs (see table below)). Chapter 4 was then updated to reflect the presentations and recommendations made during the workshop and the following discussions in the project steering group.

137. The recommendations already included in chapter 18 of the OECD Guiding Principle are given below in *italics and grey*. The additional recommendations from the workshop at Potsdam are in ***italics and bold*** and base on the results of the survey, the discussion document, the evaluation of the workshop abstracts, the discussions at the workshop, and the review of the UN/OECD Natech project steering group. These recommendations are an important outcome of the Natech Project, but will require further discussion in the OECD Working Group on Chemical Accidents before they may be formalised and added to the OECD Guiding Principles on Chemical Accidents Prevention, Preparedness and Response.

Principles from Chapter 18 on Natech Risk Management of the OECD Guiding Principles on Chemical Accidents Prevention, Preparedness and Response[12]

a. Hazard Mapping

18.a.1 Public authorities should collect data related to natural hazards and natural disasters, and use this to develop natural hazard maps, which are important tools for the dissemination of information on natural hazards.

18.a.2 Adequate training should be provided to those responsible for preparing and using natural hazard maps in the context of, for example, siting of hazardous installations, land-use planning, designing and operating hazardous installations, and emergency planning.

18.a.3 Further efforts should be undertaken to improve the methodologies and tools for preparing hazard maps and for Natech risk analysis.

[12] OECD (2015), "ADDENDUM No.2 to the OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response (2nd ed.) to address Natechs", *Series on Chemical Accidents No. 27*.

b. Risk Assessment

18.b.1 When undertaking risk assessments related to hazardous installations, management should take account of Natech risks.

18.b.2 Management should use a clear methodology for identification and assessment of Natech risks.

18.b.3. Management should be aware, and take account, of the fact that climate change may increase natural hazards. For example, climate change might affect the intensity, frequency and geography of natural hazards. Therefore, management should consider: assessing regional climate change projections; developing an adaptation strategy; implementing enhanced safety measures; and updating assessment and measures as further information becomes available.

18.b.4 Management of existing installations should periodically review their risk assessments and safety management systems, in light of new information and experience related to natural hazards.

18.b.5 Management should maintain a dialogue with the public authorities with regard to the status of natural hazard assessments such as seismic zone maps and flood risk maps.

c. Risk Management

Design and Construction

18.c.1 Management should take into account natural hazards in the design and construction of hazardous installations.

Operation

18.c.2 Management should develop appropriate measures to address natural hazards. For example, special procedures may be needed for extreme meteorological conditions such as heavy precipitation, high winds, and low or high temperatures.

d. Siting and Land-Use Planning

18.d.1 Management should perform a Natech risk analysis before siting a new installation, to identify what location would be the most effective and least expensive approach to Natech risk reduction.

18.d.2 When establishing land-use planning arrangements and policies related to hazardous installations, public authorities should take into account natural hazards such as floods, extreme temperatures, high winds, earthquakes, and wildfires as well as the possible impacts of climate change.

18.d.3 Adequate training in Natech Risk Management should be provided to those responsible for the siting of installations and land-use planning.

e. Regulations

18.e.1 In developing and reviewing regulations and guidance concerning chemical accident prevention, preparedness and response, public authorities should take into account risks associated with Natechs.

f. Preparedness and Response

Preparedness Planning

18.f.1 Existing emergency plans should be reviewed to be sure they address the possible consequences of earthquakes, floods, extreme temperatures and other natural hazards that might trigger Natechs.

Warning Systems

18.f.2 Natural hazard warning systems should be regularly tested, maintained, and updated to inform companies and communities of impending natural hazards or disasters, to the extent practicable.

Response

18.f.3 Response personnel should be provided with available information to be most effective in addressing Natechs.

G. Transboundary Co-Operation

18.g.1 Neighbouring countries should cooperate in Natech prevention, preparedness and response.

18.g.2 Countries should exchange experience concerning good practices for Natech prevention, preparedness and response including natural hazard identification, hazard mapping and natural disaster management.

H. Polluter Pays Principle

18.h.1 Countries should consider how to apply the Polluter Pays Principle in the context of chemical accidents triggered, or made worse, by natural hazards.

Overall recommendations from the project

138. During the workshop, many participants felt it necessary to express what distinguishes Natechs from other chemical accidents. Natech Risk Management may require measures usually not covered by chemical accident management. Natech risks have certain properties that set them apart from other chemical accidents.

139. Some elements to consider:

- The triggering, propagation and consequences of Natechs may not be covered by "conventional" chemical accident scenarios used for design and layout of facilities;
- Natech risk management requires the involvement of experts for natural hazards, in many cases civil or hydraulic engineers; the knowledge of these experts must be integrated in risk studies for "chemical" installations;
- Natural hazards that are not extreme also have the potential to cause Natechs;
- Natural hazards can affect several installations at the same time, and cause a series of Natechs;
- Natural Hazards can cause cascading events, so one natural hazard may trigger another one;
- Climate change might cause some natural hazards to occur more severely or more frequently;
- In case of natural disasters, the vulnerability of the population will be increased; a Natech in these situations will have more severe consequences then an equivalent chemical accident at other times;
- During natural hazards/natural disasters, the availability and capability of emergency responders can be limited.

140. The first recommendation made during the workshop was:

> ***1. Awareness needs to be raised of the specific characteristics of Natech risks compared to other chemical accident risks, such as different causes, scenarios, and consequences.***

141. As the 2017 Natech Risk Management survey showed that less attention is paid to the abovementioned recommendations than to binding regulations e.g. the requirements of the EU Seveso-Directive (2012/18/EU) (question 2), it was recommended that:

> ***2. Governments, authorities, and industry [management] should develop methods and instruments to support the implementation of the already existing recommendations on Natech Risk Management in the OECD Guiding Principles on Chemical Accident Prevention, Preparedness and Response (Guiding Principles). This can reach from consideration in legislation, guidance, safety management, siting and land-use planning to education and training of staff, operators, and authorities.***

142. Survey respondents seemed to regard the level of preparedness for Natech Risk more sceptically in 2017 than in 2009.

143. Part IV of the 2017 survey showed that several countries have measures and instruments considering Natech Risk in place, but few of them regard examples of them as good practice.

3. ***There is a need to improve the quality in Natech Risk Management (even where it is in place) by development, identification, communication, dissemination, and implementation of good practice examples. This should include:***

   a) regulations and guidance,

   b) siting of and land use planning for hazardous facilities,

   c) safety management at hazardous facilities,

   d) consideration of Natech risk in risk analysis for hazardous facilities [including in safety reports/documents, and emergency plans],

   e) consideration of climate change in Natech Risk Management,

   f) consideration of natural hazards in special operation procedures for hazardous facilities [e.g. extreme weather conditions],

   g) design and construction of installations,

   h) consideration of Natech risks in inspection systems and inspections,

   i) enforcement of Natech Risk Management requirements at existing installations / facilities,

   j) cross border and international cooperation in natural hazard mapping and warning systems, and

   k) education and training of staff of authorities and of hazardous facilities.

4. ***A database of good practice examples in Natech Risk Management should be elaborated and accessible online.***

Recommendations on Natural Hazard Mapping

144. One of the most important sources of natural hazards identification and for Natech risk analysis are natural hazard maps (including electronic information systems). These maps are necessary for the operators for siting of facilities (e.g. to avoid earthquake or flood hazard prone areas), layout of installations, dimensioning of protection and prevention measures (e.g. dikes in case of flood hazards), and to prepare for response and mitigation activities including emergency planning. It is important that operators understand the information provided. Depending on the specific location, it should be recommended that natural hazard maps address all relevant types of hazards that may cause major accidents. Information about multi-hazard risks seems necessary.

145. As the basis of hazard mapping can differ, it was recommended during the workshop to develop consistent requirements for natural hazard mapping. This can be done, for example, by specifying probabilities. Natural hazards do not stop at national borders. Transboundary and international cooperation is recommended for natural hazard mapping, which requires using same basis. This would be particularly useful for extreme precipitation events, as they occur more and more frequently.

146. The existing recommendations on Natural Hazard Mapping in chapter 18 of the OECD Guiding Principles are:

18.a.1 Public authorities should collect data related to natural hazards and natural disasters, and use this to develop natural hazard maps, which are important tools for the dissemination of information on natural hazards.

18.a.2 Adequate training should be provided to those responsible for preparing and using natural hazard maps in the context of, for example, siting of hazardous installations, land-use planning, designing and operating hazardous installations, and emergency planning.

18.a.3 Further efforts should be undertaken to improve the methodologies and tools for preparing hazard maps and for Natech risk analysis.

147. The 2017 survey makes aware of existing deficiencies in implementation of these recommendations:

5. Thence, there is a need for:

a) elaboration and implementation of multi-hazard maps,

b) development of criteria for the elaboration of natural hazard maps to reach standards in natural hazard mapping,

c) improvement in cooperation between neighbouring countries for cross-border natural hazard maps,

d) improvement in the communication of natural hazard maps/information between authorities, experts and operators of industrial facilities in identified risk zones, and

e) improvement in understanding by the operators of the probability and intensity of natural hazards threatening their sites.

Recommendations on Natech Risk Management in Industry

148. As the survey in 2017 showed, nearly 70% of the responding countries have no guideline specific to Natech Risk Management in their country. On the other hand, 100 % of the answers declare that natural hazards are taken into consideration in risk management at vulnerable installations. It can be assumed that in many cases such considerations are rather intuitive.

149. To ensure certain minimum standards for Natech Risk Management, guidance should be developed. It is also conceivable that certain methodological approaches or tools should be recommended in technical guidelines. This would also facilitate the inspections by authorities.

150. As shown in the presentations in session 1 of the Natech workshop in 2018, there are certain areas, such as pipelines, for which interesting approaches have been developed for Natech Risk Management in industry. However, these usually do not cover all safety-relevant installations and their systems. This would concern, for example, the electrical system, process control technology, cooling systems, etc. Therefore, it seems necessary to develop a general guideline, to be applied in principle. The guideline should respond to, for example, the following questions:

- What potential Natech risks exist at the location of safety relevant establishments? How can these be identified, analyzed, reduced, and managed?
- What are the obligations for operators to ensure successful Natech Risk Management?
- What preconditions need to be fulfilled to ensure that operators can meet such obligations?
- What technical and operational measures can be applied to reduce Natech risks?
- Which possibilities exist to mitigate release of chemicals or the consequences of fire and explosion?

151. Regarding Natech Risk Management in industry, the following recommendations are in chapter 18 of the OECD Guiding Principles**:**

18.a.2 Adequate training should be provided to those responsible for … siting of hazardous installations, … designing and operating hazardous installations …

18.b.1 When undertaking risk assessments related to hazardous installations, management of should take account of Natech risks.

18.b.2 Management should use a clear methodology for identification and assessment of Natech risks.

18.b.3. Management should be aware, and take account, of the fact that climate change may increase natural hazards. For example, climate change might affect the intensity, frequency and geography of natural hazards. Therefore, management should consider: assessing regional climate change projections; developing an adaptation strategy; implementing enhanced safety measures; and updating assessment and measures as further information becomes available.

18.b.4 Management of existing installations should periodically review their risk assessments, and safety management systems, in light of new information and experience related to natural hazards.

18.c.1 Management should take into account natural hazards in the design and construction of hazardous installations.

18.c.2 Management should develop appropriate measures to address natural hazards. For example, special procedures may be needed for extreme meteorological conditions such as heavy precipitation, high winds, and low or high temperatures.

18.d.1 Management should perform a Natech risk analysis before siting a new installation, to identify what location would be the most effective and least expensive approach to Natech risk reduction.

18.d.3 Adequate training in Natech Risk Management should be provided to those responsible for the siting of installations and land-use planning.

152. Point 18.b.2 requires the use of a clear methodology for identification and assessment of Natech risks. Furthermore, the management should observe climate change, which might affect the intensity, frequency and geography of natural hazards (18.b.3). This includes the design and construction of hazardous installations (18.c.1).

153. However, an evaluation of these recommendations through the 2017 survey reveals that enterprises often do not know how to implement them. Therefore, guidelines for Natech Risk Management would be a useful support. These guidelines may in particular give advice for the consideration of Natech Risk Management:

- in elaboration and updating of safety documents (EU Seveso-Directive: safety reports) including Natech risk analysis and assessment.
- in emergency plans of operators of hazardous facilities.

154. The guidelines could be supplemented by individual good practice examples.

155. The recommendation related to Natech Risk Management in industry is thus the following:

> ***6. On the basis of identified good practice examples in Natech Risk Management, international or national guidance for Natech Risk Management in industry should be elaborated.***

156. This may include different guidance for different levels of management, which could mean guidance on Natech Risk Management for the level of corporate governance as well as for the technical management.

Recommendations on Natech Risk Analysis

157. Session 2 of the Natech workshop in 2018 introduced new application examples for Natech risk analysis. These include, for example, the methods according to Rapid-N for tanks in case of an earthquake, risk analysis for pipelines, risk analysis for windborne debris, the design for LPG-tanks, and evacuation shelters. However, there are also other safety-relevant parts of hazardous facilities not included in the presented risk analyses.

158. Regarding Natech Risk Analysis, the following recommendations are listed in chapter 18 of the OECD Guiding Principles**:**

18.b.2 Management should use a clear methodology for identification and assessment of Natech risks.

18.a.3 Further efforts should be undertaken to improve the methodologies and tools for … Natech risk analysis.

159. As the abstracts and presentations of session 2 show, Natech risk analysis often focuses on particular natural hazards such as earthquakes, and special parts of a facility such as tanks or pipelines. But Natech risk analysis needs to consider all natural hazards relevant at a site, and all parts of installations or facilities that contribute to risk.

> ***7. Natech risk assessment, including risk analysis, will require further development of, for example:***
>
> ***a) scenarios unique for natural hazards [e.g. multi-hazard scenarios],***
>
> ***b) Natech scenarios for complex installations or***
>
> ***c) Natech scenarios that can be more complex than other accident scenarios.***

160. ***Hence, it is recommended:***

8. to collect and evaluate examples of Natech risk analysis approaches to identify good practice methods that should be addressed in the guidance for Natech Risk Management in industry (see above),

9. that industry update their safety management to consider changes observed or expected in the surrounding area [e.g. land-use change, climate, environment],

10. that industry consider, in their risk analysis, the potential unavailability of safety barriers and lifelines due to natural hazard impact.

Recommendations on Consideration of Climate Change in Natech Risk Management, Consideration of Natech Risks in Adaption to Climate Change

161. As discussed in the Natech workshop in 2012, climate change is estimated to affect the intensity, frequency and geographical occurrence of a range of natural hazards. This means that facilities already subject to extreme meteo- and hydrological events may be the most affected.

162. It is challenging to transform the need for regulations that consider aspects of climate change into concrete actions. There are interesting developments, such as the integration of climate change into regulatory practice (ICCARP) in connection with the permitting practice according to the Industrial Emissions Directive (2010/75/EU) or the EU Directive 2014/52/EU, in which climate change should also be included in the Environmental Impact Assessment (EIA) as a part of permitting practice. However, at the moment, these lack concrete examples of implementation.

163. In practice, some internationally operating chemical enterprises already monitor changes, for example, in water-stressed areas, to evaluate how to adapt their facilities to the changes. This includes regular updates of emergency plans for extreme meteorological and hydrological events. As a recommendation, it would be desirable if more enterprises operated accordingly.

164. At the same time, there is a need for information on the different adaptation measures that can be taken, in light of the expected impacts of climate change on natural hazards.

165. Regarding climate change in Natech Risk Management, the following recommendations are in chapter 18 of the OECD Guiding Principles**:**

18.b.3. Management should be aware, and take account, of the fact that climate change may increase natural hazards. For example, climate change might affect the intensity, frequency and geography of natural hazards. Therefore, management should consider: assessing regional climate change projections; developing an adaptation strategy; implementing enhanced safety measures; and updating assessment and measures as further information becomes available.

18.d.2 When establishing land-use planning arrangements and policies related to hazardous installations, public authorities should take into account natural hazards such as floods, extreme temperatures, high winds, earthquakes, and wildfires as well as the possible impacts of climate change.

166. In addition, the Natech workshop in 2018 brought up three additional recommendations:

11. Consideration of climate change in regulations, licensing, permitting, and inspections. This includes the definition of probabilities / intensities of natural hazards used for design of installations/facilities, the protection objectives for the relevant installations, and the requirement for protection measures.

12. Operators should stay informed of, interpret, and act upon information on local climate change. In this context, it is important to look into to what extent climate change is already addressed in the OECD Guiding Principles, the Sendai Framework for Disaster Risk Reduction, and the related Words-into-Action Guide on man-made/technological Hazards.

13. Dissemination of information on kinds, effectiveness, and costs of adaptation measures for hazardous facilities due to the possible effects of climate change on natural hazards.

Recommendations on Warning Systems, Natech Emergency Planning, Preparedness, and Response

167. Participants in the Natech workshop in 2012 recommended that: "a specific Natural Disaster Response Plan [for a hazardous facility] may be useful and should be based on the careful evaluation of all possibilities to mitigate the effects of Natech accidents." They also recommended that "safety documents [should] consider the aspect of training staff to coordinate all activities in case of an extreme natural event."

168. In the survey in 2017, all respondents agreed that natural hazards are considered in the drafting of emergency plans for hazardous sites or installations (question 15a), but only two are submitting good practice examples regarding this issue.

169. Regarding warning systems, Natech emergency planning, preparedness, and response, the following recommendations are listed in chapter 18 of the OECD Guiding Principles:

18.a.2 Adequate training should be provided to those responsible for preparing and using natural hazard maps in the context of, for example, siting of hazardous installations, land-use planning, designing and operating hazardous installations, and emergency planning.

18.f.1 Existing emergency plans should be reviewed to be sure they address the possible consequences of earthquakes, floods, extreme temperatures and other natural hazards that might trigger Natechs.

18.f.2 Natural hazard warning systems should be regularly tested, maintained, and updated to inform companies and communities of impending natural hazards or disasters, to the extent practicable.

18.f.3 Response personnel should be provided with available information to be most effective in addressing Natechs.

170. Several early warning systems exist at the national or regional level, but fewer early warning systems exist at the local level.

14. Local conditions and effects need to be considered in early warning systems to improve their value for operators of hazardous facilities.

15. The use of early warning systems by operators should be improved. Early warnings should be directly sent to endangered facilities.

16. The development of cross border early warning systems for natural hazards should be promoted.

17. Operators should be able to interpret early warnings and to decide what course of action to take in accordance with their safety management systems.

Recommendations on Follow-Up of Events, Event Analysis, Recovery, Rehabilitation, and Reconstruction

171. It may seem that there should be no difference between follow-up of Natechs and other major accidents, but this is not necessarily the case. When a Natech is caused by a long-lasting or severe natural disaster, this may limit the resources of authorities to conduct a proper event analysis. However, according to the survey, Natech accidents are reported in 81% of cases of natural disaster (question 21a).

172. Also, natural hazards often affect more than one part of a facility, and may even destroy several, if not all parts. Similarly, it has to be considered after such an event, whether it would be useful to change the facility's location. This is even more applicable when considering the routes of hurricanes, flood or earthquake prone areas and the locations of chemical and petrochemical industries. Consequently, not only the owners of facilities, but also the authorities should examine whether those areas are suitable for productions using hazardous chemicals. The authorities are responsible for land-use planning and they should integrate Natech risks therein. For coastal areas in particular, it is extremely important to consider the consequences of the climate change (rise of sea level, intensity of storms and hurricanes, precipitation and flooding, etc.).

173. The following additional recommendations were made during the Natech workshop in 2012:

18. In particular with respect to climate change, operators of hazardous facilities should not rely on individual employees' experiences with past events to predict future risk.

19. After a major Natech accident, there should be an assessment of reconstruction versus change of location.

Recommendations on Transboundary and International Cooperation

174. International cooperation should extend to support governments, authorities and operators to effectively implement Natech Risk Management. Recommendations from the Natech workshop in 2012 state that "a multi-stakeholder approach, including coordination between governments, is important for Natech Risk Management."

175. Regarding transboundary and international cooperation, the following recommendations are in chapter 18 of the OECD Guiding Principles:

18.g.1 Neighbouring countries[13] should cooperate in Natech prevention, preparedness and response.

18.g.2 Countries should exchange experience concerning good practices for Natech prevention, preparedness and response including natural hazard identification, hazard mapping and natural disaster management.

176. These should be more concrete. Numerous recommendations have already been proposed in connection with the other sessions. The recommendations for improved transboundary and international cooperation are as follows:

20. Countries should work together to draft transboundary natural hazard maps e.g. for international riverine systems.

21. Information on Natech accidents and Natech Risk Management should be made internationally available [e.g. on an online-based portal].

22. Countries should make use of the policy forums provided by international and regional organisations to continue to foster the exchange of experiences and good practices in Natech Risk Management.

23. Existing legal obligations, guidance and tools addressing Natech Risk Management should be implemented by governments, industry, authorities and practitioners.

24. There is a need for dedicated guidance on Natech Risk Management to be developed for industry (management), authorities, policy-makers, and practitioners. Such guidance should build on existing legal obligations, guidance and tools addressing Natech.

Recommendations on Natech Risks: Communication and Education

177. One important aspect in Natech Risk Management is the communication between all involved technical disciplines, industry and authorities. Furthermore, for construction of a Natech early warning system, informing the population is necessary.

178. Considering Communication and Education, the following recommendation is listed in chapter 18 of the OECD Guiding Principles:

18.b.5 Management should maintain a dialogue with the public authorities with regard to the status of natural hazard assessments such as seismic zone maps and flood risk maps.

179. Question 20 in the Natech survey in 2017 focused on the consideration of Natech risk in communication with the concerned neighborhood, the media, and the public. Only 25% of the responding countries replied that information on Natech risks was provided to the public before siting or licensing of hazardous installations (question 20a). Meanwhile, only 38% of the respondents agreed that:

a) information provided to the potentially affected public on risks of hazardous installations includes information on Natechs Risks, if relevant (question 20c)

[13] Including riparian countries that share a transboundary watercourse.

b) information provided to the potentially affected public in case of emergencies due to chemical accidents includes specific guidance for Natechs, if Natech risks are relevant (question 20e)
c) the process of communication with the public includes experts for natural hazard risk, if Natech risks are relevant (question 20f)

180. The answers show a need for improvement of communication of Natech risks if they are relevant at hazardous facilities. For example, maps provided by the industry to authorities and the neighbourhood around their sites that hazards due to chemical accident risks should include additional information on hazards caused by Natechs. Recommendations from the workshop were:

25. Where Natech risks exist, they should be communicated to any potentially affected neighbourhood, the media, and the public during siting, licensing, and preparedness activities.

26. In particular, information provided to prepare the potentially affected public for cases of emergencies due to chemical accidents should include specific guidance for Natechs, if relevant.

27. Experts for natural hazard risks should be included in the process of communication with the potentially affected neighbourhood, the media, and the public, if Natech risks are relevant.

181. In the 2017 survey, 62% of respondents state that Natech Risks are considered in the education or training of persons in charge of the safety of hazardous installations (question 22a). Furthermore, 75% of respondents mentioned that Natech risks are considered in education or training of persons in charge of disaster (risk) management (question 22b). Nevertheless,

28. There is a need for more education and training for technical management of industry and public authorities in Natech Risk Management.

182. On the issue of Natech research, it was furthermore recommended that:

29. Successful research on Natech Risk Management needs an interdisciplinary approach, including social sciences.

Recommendations on Natech Risk Management in the Public Sector: Natech Risk Governance, Regulation, Enforcement, and Reduction

183. The multitude of tasks of the authorities is reflected in the numerous recommendations in chapter 18 of the OECD Guiding Principles:

18.a.1 Public authorities should collect data related to natural hazards and natural disasters, and use this to develop natural hazard maps, which are important tools for the dissemination of information on natural hazards.

18.a.2 Adequate training should be provided to those responsible for preparing and using natural hazard maps, … land-use planning … and emergency planning.

18.a.3 Further efforts should be undertaken to improve the methodologies and tools for preparing hazard maps …

18.d.2 When establishing land-use planning arrangements and policies related to hazardous installations, public authorities should take into account natural hazards such as floods, extreme temperatures, high winds, earthquakes, and wildfires as well as the possible impacts of climate change.

18.d.3 Adequate training in Natech Risk Management should be provided to those responsible … land-use planning.

18.e.1 In developing and reviewing regulations and guidance concerning chemical accident prevention, preparedness and response, public authorities should take into account risks associated with Natechs.

18.f.2 Natural hazard warning systems should be regularly tested, maintained, and updated to inform companies and communities of impending natural hazards or disasters, to the extent practicable.

18.f.3 Response personnel should be provided with available information to be most effective in ad-dressing Natechs.

18.h.1 Countries should consider how to apply the Polluter Pays Principle in the context of chemical accidents triggered, or made worse, by natural hazards.

184. The answers to question nine of the survey in 2017 illustrate that in many cases, Natech risks and Natech Risk Management are regulated only on a general level. There may be a lack of guidance specific for Natech Risk Management and implementation of regulations on Natech risks. Regarding inspection systems and inspections, the survey shows that Natechs are also widely taken into account, but regulations or specific guidance are lacking in the majority of the cases. Since several recommendations from other sessions can be listed here as well, only one additional recommendation was made during the workshop:

30. Development, communication, dissemination and implementation of good practice examples (see recommendation 3) for effective Natech risk reduction.

General Conclusions and Recommendations

185. Below are six recommendations on possible further activities of the involved UN organisations, and the OECD Working Group on Chemical Accidents. They are based on the results of the survey, the discussion document, the evaluation of the abstracts, the discussions at the Natech workshop in 2018 and the review of the UN/OECD Natech project steering group.

1. *Natech Risk Management is regarded as an aspect of both Chemical Accident Prevention, Preparedness and Response and of Disaster Risk Reduction. Both groups should thus be aware of the activities of the other. Therefore, cooperation is recommended in activities for Disaster Risk Reduction and for Chemical Accident prevention, preparedness and response, especially in:*
    a) *Development of rules or recommendations*
    b) *Development of guidance*
    c) *Support of their implementation*

186. This is relevant for all aspects of Chemical Accident Prevention, Preparedness and Response, not only Natechs.

2. *Awareness needs to be raised of the specific characteristics of Natech risks compared to other chemical accident risks, such as different causes, scenarios, and consequences.*
3. *Development, communication, dissemination, and implementation of good practice examples in Natech Risk Management may be useful, in areas such as:*
    a) *regulations and guidance,*
    b) *siting of and land use planning for hazardous facilities,*
    c) *safety management at hazardous facilities,*
    d) *consideration of Natech risk in risk analysis for hazardous facilities [including in safety reports/documents and emergency plans],*
    e) *consideration of climate change in Natech Risk Management,*
    f) *consideration of natural hazards in special operation procedures for hazardous facilities [e.g. extreme weather conditions],*
    g) *design and construction of installations,*
    h) *consideration of Natech risks in inspection systems and inspections,*
    i) *enforcement of Natech risks management requirements at existing installations / facilities,*
    j) *cross boarder and international cooperation in natural hazard mapping and warning systems,*
    k) *education and training of staff of authorities and of hazardous facilities, and*

l) effective Natech risk reduction.

A database collecting these good practice examples could be developed and made accessible online.

4. *On the basis of the results from both Natech Workshops and the identified good practice examples in Natech Risk Management, further guidance for Natech Risk Management could be elaborated. This may include guidance how to consider Natechs in:*

   a) the development of policies, legislation, and regulations,

   b) siting of industrial facilities,

   c) risk analysis and assessment methods,

   d) the elaboration and updating of safety documents (e.g. EU Seveso-Directive: safety reports),

   e) emergency plans developed by operators of hazardous facilities,

   f) joint emergency plans between neighbouring or riparian countries,

   g) transboundary cooperation on Natech Risk Management, and

   h) transfrontier hazard communication and mapping.

This may include general guidance and further guidance for special stakeholders or on special subjects. e.g. a guidance on Natech Risk Management in industry may include a section for corporate governance and for technical management.

5. *Contributions from the Natech workshop in 2018 showed different levels of Natech Risk Management of the stakeholders in different countries. There is a need to improve communication concerning research and implementation of Natech Risk Management tools. In particular, cross-border and international cooperation should be supported by international organisations, governments, and industry.*

6. *The Natech steering group should evaluate which recommendations from part two of the Natech project should be considered in the 3rd edition of the Guiding Principles, in addition to those already included (once a draft is established).*

Annex I: Questionnaire of the Survey 2017

Survey on Natech (Natural Hazard Triggered Chemical Accidents) Risk Management

The purpose of this survey is:

- to assess Natech risk management practices and awareness of Natechs,
- to identify needs and/or limitations in implementing Natech risk reduction strategies, and
- to identify examples of good practices in Natech Risk Management.

This questionnaire supports the OECD Working Group on Chemical Accidents Project on Natech Risk Management. The results of the survey shall give examples of good practices in Natech Risk Management and will therefore lead to better designed and targeted Natech risk reduction strategies. A report based on the evaluation of the answers to this questionnaire will be provided to the OECD Working Group on Chemical Accidents.

The results from the evaluation of the answers and the examples on good practices in Natech Risk management shall be presented at an OECD/UN Natech Workshop planned for 2018.

Needless to say, the success of this survey depends on your contribution. Thus, it is important that you answer each question in as complete a way as possible. **We understand that sometimes the information may not be available or not in the level of detail required by the question. In this case, please answer the question to the best of your ability.** If you want to provide additional information or need more space to explain your answers please feel free to add as much information as you need.

This questionnaire is absolutely confidential.

All presentations of the results of this survey will represent data anonymously. Access to the completed questionnaire will be restricted to the secretariat of the OECD Working Group on Chemical Accidents and the Natech-project steering group only.

If you have any questions on the questionnaire please contact the project leader Mr. Roland Fendler, UBA Germany (Roland.Fendler@uba.de).

Please send the completed questionnaire to the OECD Secretariat of the WGCA (Ms. Marie-Ange BAUCHER at Marie-Ange.BAUCHER@oecd.org).

Please complete your answers by Monday, 31.07.2017.

If you or your country or organisation answered the first survey on Natech Risk Management of the EC Joint Research Center/OECD in 2009 you may give only additional or up-dated information. Please note if there was no change since 2009.

Please carefully read the following definition for "Natech" and "chemical accident":

A "Natech" is defined as a chemical accident, including spills of oil and oil products, triggered by a natural hazard or natural disaster (such as extreme temperatures, high winds, floods, storms, earthquakes, or wildfires).

WE ASK NATIONAL AUTHORITIES TO ANSWER FOR THEIR COUNTRY, AND INDUSTRY, INTERNATIONAL ORGANISATIONS AND OTHER STAKEHOLDERS FOR THEIR ORGANISATION WHERE APPLICABLE

I. Regulations for the Prevention and Mitigation of Natechs

a. Regulations and guidelines for chemical-accident prevention and mitigation

- Which government institution(s) in your country oversee(s) chemical-accident prevention and mitigation? Please provide a brief description of their responsibilities.
  (Note: If there is more than one institution, please list them and their responsibilities.)

Institution	Responsibilities

- Please indicate which rules, codes or guidelines (incl. international agreements) are used in your country to regulate or guide *hazardous-substances* production, use or storage in order to prevent or mitigate chemical accidents with impacts on the public and/or the environment.

Issued by (year)	Rule, Code, Guideline

- Do any of these rules, codes and/or guidelines address the *natural hazards* your country is susceptible to? .....**Yes ☐ No ☐**

  If yes, please indicate title and year of the applicable document, type of natural hazard(s) considered, and how day-to-day hazardous-substances handling is affected (e.g. no chemical storage facilities in floodplains or seismic zones, etc.):

Title and year of document	Natural hazard(s) considered	Impact on hazardous-substances handling

- Does your country/organisation have a document which provides guidelines *specific* for Natech risk management? .....**Yes ☐ No ☐**

  If yes, please indicate title and year of document and indicate for which natural hazard(s):

Title and year of document	Natural hazard(s) considered

- Is your country/organisation developing a strategy or program to address the problem of Natech events?.....**Yes ☐ No ☐**

  If yes, for which natural hazard(s): …….

- Could one of these rules, codes, guidelines, technical codes, standards, strategies or programs be an example of good practice in Natech Risk Management? ..... **Yes ☐ No ☐**

  If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

b. Effectiveness of regulations

- In your opinion has your country's approach to chemical-accident prevention and natural-disaster management been effective in preventing Natech accidents? *Please indicate the level of effectiveness (1, low or not effective, and 5, high effectiveness)*. Please choose a value.
- Are there any gaps or shortcomings in your country's rules or codes that should be addressed to ensure effective Natech risk reduction? .....**Yes ☐ No ☐**

If yes, please explain: ……

- Has there been an amendment in your country's rules or codes considering the publication of the Natech Addendum to the OECD Guiding Principles? .....**Yes** ☐ **No** ☐

II. Natech Events Data Collection and Retrieval

c. Database or Records for Chemical Accidents

Does your country/organisation maintain a database which can be used to record and retrieve information on chemical accidents? .....**Yes** ☐ **No** ☐

If yes, please describe (name of database, owner, access): ……..

If yes, can this database be used to identify and retrieve information on Natechs? .....**Yes** ☐ **No** ☐

III. Natech Awareness and Risk Reduction

If you answered these questions in 2009 please do that again according to the actual situation. This may allow to estimate how much progress was made since 2009.

d. Statements on Natech Awareness and Risk Reduction

Please answer the items below by marking the box at the end of each item that best reflects your opinion.									
A Disagree Strongly	**B Disagree Slightly**	**C Neutral**	**D Agree Slightly**	**E Agree Strongly**	**A**	**B**	**C**	**D**	**E**
1. Risk managers/ safety professionals in industry in my country/organisation are aware of the concept of Natechs.					☐	☐	☐	☐	☐
2. Natech events are discussed among those in charge of chemical-accident prevention and mitigation in my country/organisation.					☐	☐	☐	☐	☐
3. Natechs events are discussed among those in charge of natural-disaster management in my country.					☐	☐	☐	☐	☐
4. There is enough emphasis on Natech risk reduction in the laws and regulations for chemical-accident prevention and mitigation.					☐	☐	☐	☐	☐
5. There is adequate knowledge on the dynamics of Natechs among our country's competent authorities.					☐	☐	☐	☐	☐
6. The relevant competent authorities in my country have adequate training on Natech risk reduction to enable effective Natech risk management.					☐	☐	☐	☐	☐
7. Current practices for chemical-accident prevention and mitigation in my country/organisation provide for adequate protection of citizens against possible Natech events.					☐	☐	☐	☐	☐
8. Current industry risk assessment methods adequately take into consideration Natech events.					☐	☐	☐	☐	☐
9. The design and construction of buildings and other structures in industry according to the adopted building codes in my country provide sufficient protection against Natech accidents.					☐	☐	☐	☐	☐

e. Recommendations on Natech Risk Reduction

In order to further reduce your country's or organisation's susceptibility to Natechs, what would be your top <u>three</u> Natech risk reduction strategies/recommendations? Please list: ……

IV. Consideration of Natural Hazards and Natech Risks

f. Natural Hazard Mapping

1. Are there natural hazards maps in your country? .....**Yes** ☐ **No** ☐
2. If Yes, which type(s) of hazards do they consider?
3. If Yes, which scope do they cover (National, regional, local)?
4. If Yes, are operators of hazardous installations involved in drafting and amendment?

Please use the table for your answers to allow simple evaluation of the answers:

Natural Hazard Maps	Scope			
Hazards Considered	National	Regional	Local	Involvement of operators
☐ Geological[14]: ……	☐	☐	☐	☐
☐ High winds[15]: ……	☐	☐	☐	☐
☐ Floods[16]: ……	☐	☐	☐	☐
☐ Extreme temperature and related[17]: ……	☐	☐	☐	☐
☐ Other[18] (specify): ……	☐	☐	☐	☐

5. Could one of these kind of maps be an example of good practice? .....**Yes** ☐ **No** ☐

   If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

g. Natural Hazard[19] and Multi-Hazard[20] Early Warning Systems

a) Are there natural hazard early warning systems in your country? .....**Yes** ☐ **No** ☐

b) Are there multi-hazard early warning systems in your country? .....**Yes** ☐ **No** ☐

c) Which type(s) of hazards do they consider?

d) Which scope do they cover (National, regional, local)?

e) Are operators of hazardous installations involved in their development?

f) Do operators of hazardous installations use these early warning systems for their emergency management?

Please use the table for your answers to allow simple evaluation of the answers:

[14] Like: Earthquake, Volcano, Landslide, Tsunami, Subsidence

[15] Like: Storm, Thunderstorms, Tornado

[16] Like: Flash flood, River flood, Storm surge, "urban floods"

[17] Like: Heat, Cold, Snow, Ice, Drought

[18] Like: Heavy rain, Lightning, Wildfire

[19] **Early warning system:** An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events. See: http://www.preventionweb.net/drr-framework/open-ended-working-group/

[20] **Multi-hazard early warning systems** address several hazards and/or impacts of similar or different type in contexts where hazardous events may occur alone, simultaneously, cascadingly or cumulatively over time, and taking into account the potential inter-related effects. A multi-hazard early warning system with the ability to warn of one or more hazards increases the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for updated and accurate hazards identification and monitoring for multiple hazards.

Warning Systems	Scope				
Hazards Considered	National	Regional	Local	Involvement of Operators	Used by Operators
☐ Geological: ……..	☐	☐	☐	☐	☐
☐ High winds: …….	☐	☐	☐	☐	☐
☐ Floods: …….	☐	☐	☐	☐	☐
☐ Extreme temperature and related:	☐	☐	☐	☐	☐
☐ Other (specify): ……	☐	☐	☐	☐	☐

g) Could one of these early warning systems be an example of good practice? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

h. International Cooperation in Mapping and Early Warning Systems

a) Is there transboundary or international co-operation in the development of natural hazard maps? .....**Yes** ☐ **No** ☐

If yes, which countries and authorities cooperate in which type of maps? Please list: ……

b) Is there transboundary of international cooperation in the development of natural hazard early warning systems? .....**Yes** ☐ **No** ☐

If yes, which countries and authorities cooperate in which type of systems? Please list: ……

c) Could one of these co-operations be an example of good practice? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

i. Natural Hazards in Safety Management

a) Are natural hazards taken into consideration in safety management at hazardous installations? **Yes** ☐ **No** ☐

b) If yes, could one case be good practice in Natech Risk Management? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

j. Natural Hazards in (Operating) Procedures for Installations or Sites

a) Are Natural Hazards considered in operating procedures? .....**Yes** ☐ **No** ☐

b) Are there special operating procedures for impacts of natural hazards (e.g. special operating procedures in case of cold, heavy rain, high winds)? .....**Yes** ☐ **No** ☐

c) Could one of these procedures be good practice in Natech Risk Management? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

k. Natural Hazards in Siting and Land-Use-Planning

III. Are Natural Hazards considered in the choice of sites or in land-use-planning of areas for new hazardous installations? .....**Yes** ☐ **No** ☐

If yes, which types of hazards are considered? Please list them: ……...

IV. Are new installations sited in natural hazard risk areas (e.g. presented in maps according to question 0)? .....**Yes** ☐ **No** ☐

If yes, is there an evaluation of these hazards or a special risk analysis made? .....**Yes** ☐ **No** ☐

V. Could one of these evaluations/analyses be good practice in Natech Risk Management? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

l. Natural Hazards in Risk Analysis

a) Are natural hazards considered in Risk Analysis for hazardous installations? .....**Yes** ☐ **No** ☐

b) Are Natech risks considered in the mapping of risks identified by these analyses? .....**Yes** ☐ **No** ☐

c) Could one of these analyses be good practice in Natech Risk Management? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

m. Natural Hazards in Design and Construction

a) Are natural hazards considered in the design and construction of hazardous installations? .....**Yes** ☐ **No** ☐

If this is done on the basis of technical codes or standards please list them: …….

b) Are the special risks of hazardous installations taken into consideration in these codes and standards (e.g. by increased design requirements)? .....**Yes** ☐ **No** ☐

c) Could one of these procedures, codes or standards be good practice in Natech Risk Management?.....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

n. Natural Hazards in Safety Reports / Safety Documents

a) Are natural hazards considered in safety reports/documents? .....**Yes** ☐ **No** ☐

If yes, in which part of the safety report/document?

1.	Information on the management system	☐
2.	Presentation of the environment of the establishment	☐
3.	Description of the installation	☐
4.	Identification and accidental risks analysis and prevention methods	☐
a)	Description of the possible major-accident scenarios and their probability	☐
b)	Assessment of the extent and severity of the consequences of identified major accidents	☐
c)	Review of past accidents and incidents	☐
d)	Description of technical parameters and equipment used for the safety of installations	☐
5.	Measures of protection and intervention to limit the consequences of a major accident	☐

a) Could one of these safety reports/documents be good practice in Natech Risk Management? ....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

o. Natural Hazards in Emergency plans

a) Are natural hazards considered in the drafting of emergency plans for hazardous sites or installations? .....**Yes** ☐ **No** ☐

a) Could one of these emergency plans be good practice in Natech Risk Management? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

p. Consideration of Climate Change

a) Is climate change considered in the Risk Analysis for hazardous installations? .....**Yes** ☐ **No** ☐

b) If yes, could one of these analysis be good practice in Natech Risk Management? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

c) Are risk analyses or emergency plans reviewed and updated – if necessary –to consider climate change? .....**Yes** ☐ **No** ☐

q. Natechs and Climate Change in Licensing

a) Are Natech Risks or Climate Change considered in the licensing of hazardous installations? ...**Yes** ☐ **No** ☐

If this is done on the basis of regulations or specific guidance, please list them: ……..

b) Could one of these regulations or guidance be good practice in Natech Risk Management? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

r. Natechs in Inspections Systems and Inspections

a) Are Natech Risks considered in inspections? .....**Yes** ☐ **No** ☐

If this is done on the basis of regulations or specific guidance please list them: ……

b) Could one of these inspection systems or plans, regulations or guidance be good practice in Natech Risk Management?.....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

s. Consideration of Natech risks at Existing Installations / Sites

a) Are Natech Risks considered at existing sites or installations? .....**Yes** ☐ **No** ☐

b) Could one of these regulations or guidance be good practice in Natech Risk Management?.....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

c) Is there any experience with retrofitting of installations to design requirements or to increased design requirements due to natural hazards? .....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

t. Consideration of Natech Risks in Risk Communication

a) Does the information provided to the public before siting or licensing of hazardous installations include information on Natech Risks? .....**Yes** ☐ **No** ☐

b) Are Natechs considered in determining the public who might be affected in the event of an accident? .....**Yes** ☐ **No** ☐

c) Does the information provided to the potentially affected public on risks of hazardous installations include information on Natechs Risks, if relevant? .....**Yes** ☐ **No** ☐

d) Do the risk maps used in this communication include the mapping of Natech risks, if relevant? .....**Yes** ☐ **No** ☐

e) Does the information provided to the potentially affected public in case of emergencies due to chemical accidents include specific guidance for Natechs, if relevant? .....**Yes** ☐ **No** ☐

f) Are experts for natural hazard risks included in the process of communication with the public, if Natech risks are relevant? .....**Yes** ☐ **No** ☐

u. Natechs in Follow-Up of Natural Disasters

a) Are Natech accidents reported in case of natural disasters? .....**Yes** ☐ **No** ☐

If yes, which authority/authorities collects these reports? .....

b) Which information on the effects of these Natechs is included in these reports?

fatalities ☐ Health ☐ Environment ☐ Economy/economic damage ☐

c) Is there an analysis of the causes of and lessons to be learnt from these Natechs? .....**Yes** ☐ **No** ☐

If yes, which authority/authorities collects the results of the analysis? ……

v. Natechs in Education and Training

a) Are Natech Risks considered in education or training of persons in charge of the safety of hazardous installations? .....**Yes** ☐ **No** ☐

If this is done on the basis of regulations or guidance please list them: ……..

b) Are Natech Risks considered in education or training of persons in charge of disaster (risk) management? .....**Yes** ☐ **No** ☐

If this is done on the basis of regulations or guidance please list them: ……...

c) Could one of these regulations or guidance be good practice in Natech Risk Management?.....**Yes** ☐ **No** ☐

If yes, please provide more information, e.g. submit a copy of or provide links to relevant documents: …….....

V. Background Information

In order to analyse the data it is important that we have some background information so that we can group opinions together.

We would like to remind you that all responses are completely confidential.

w. Contact information

Contact information of the person filling in the questionnaire:

Name:
Organisation:
Country:
Address:
Phone:
Email:

x. Natech Awareness

Were your aware of the concept of Natechs before taking this survey? ..... **Yes** ☐ **No** ☐

y. Affiliation

Your organisation belongs to:

a. Public sector ☐

Please indicate in which area your organisation's responsibilities mainly fall in:

Please choose from the list.

b. Private sector ☐

Please indicate in which area your organisation's responsibilities mainly fall in:

Please choose from the list.

c. Your organisation is at which level:

Please choose from the list.

z. Process to Answer the Questionnaire

What process did you use to complete the answers to this survey (please check all that apply)?

☐ To answer some questions I used my own knowledge from ……years of work experience.

☐ I discussed several/all questions with different colleagues individually.

☐ I had to look through our records to answer some of the questions.

☐ The questions and answers were discussed in a meeting.

☐ Other (please specify): ……