iNTeg-Risk project: How much nearer are we to improved "Early Recognition, Monitoring and Integrated Management of Emerging, New Technology related Risks"?

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Abstract

The paper provides a summary of the achievements, and highlight the open issues and possibilities opening at the end of the European research project iNTeg-Risk ("Early Recognition, Monitoring and Integrated Management of Emerging, New Technology related Risks"). The project, joining efforts of 87 companies and organizations has delivered over 240 official deliverables (documents, software, demonstrators…), has fulfilled fully its work plan, and, at the same time, shown that there are a number of open issues, which will require further attention of the research community, institutions and industry in the future. As the basis for these future efforts, iNTeg-Risk has summarized its results in a set of major deliverables, labeled, at the end of the project by the developers, as the "Big 7" of iNTeg-Risk. They are: (1) iNTeg-Risk Catalogue of Emerging Risks – RiskEars system, (2) iNTeg-Risk Framework for Emerging Risk Management, (3) the library of iNTeg-Risk Methods, Handbooks and Guidelines for emerging risk analysis, (4) iNTeg-Risk dynamic library of emerging Risks Key Indicators (KPIs – Key Performance Indicators), (5) iNTeg-Risk CWA (CEN Workshop Agreement) document – the European pre-standardization document for Emerging Risk Management, (6) European Master and Certification in the area of Risk Engineering and Management – education and training for improved emerging risks management in the EU, and, (7) iNTeg-Risk Risk Radar & 1StopShop – the web-based prototype system-of-systems for early detection, recognition, monitoring and management of emerging risks. The paper puts the main deliverables into context of an overall improvement of the emerging risk management which took place in the last years, within and outside iNTeg-Risk project, and, in particular, to the improvements expected to contribute to the development of "risk radars". In that sense, the project results definitely bring us "nearer to improved Early Recognition, Monitoring and Integrated Management of Emerging, New Technology related Risks".

1 Introduction

The large European project iNTeg-Risk [1] [29] [49] has clearly shown that the global challenges of the recent years, new technologies being among them, have contributed to an expanding focus on risk governance [48], across the society, research, institutions and all industries. The project has shown that many of these are still struggling to reconcile traditional approaches and legacy systems with the rapid pace of change. Traditional approaches, characterized by siloed views, are facing difficulties when trying to manage the complexity of the globally interconnected modern world. iNTeg-Risk has proven that new methods and tool (for integrated management of emerging risks) are definitely needed, but not enough. The issues related of international and national mandates ("emerging risks often have no mother and no father"), industry standards, and internal policies, some of them directly affecting the project, its results and their deployment in the post-project phase. The project has shown that there is an imminent need to adopt approaches proposed by the project, e.g. in its CEN Workshop Agreement, on a broader (international) scale – many emerging risks are global in their very core and they require global response. In iNTeg-Risk, this fact was largely recognized by the, e.g., insurance industry participating in the project and by the international organizations like OECD. The issues related to compliance and (often poorly defined) liability have needed and will need further attention in the future, especially at the level of the organization "in charge of certain risks", struggling with the questions like "do the emerging risks, e.g., in food safety need to be treated in a same or a different way as those in, e.g., occupational safety?".

Risk intelligence (e.g. the one built into the iNTeg-Risk social media based tools like RiskTweet and RiskRadar) and/or advanced risk reporting as proposed by the project will certainly provide ways for gaining better understanding among different stakeholders and of the key factors that may affect the performance of practical management of emerging risk management. This will be of a particular importance for the future initiatives resulting from iNTeg-Risk, primarily those related to the possible use of iNTeg-Risk results in the E2R2 (European Emerging Risk Radar) and/or other "risk radars" in the future (e.g. in the area of future energy options, occupational safety, insurance, etc.).

At the end of the research, the project brought results which will definitely significantly contribute to further discoveries on emerging risks and foster the confrontation of ideas necessary to advance both research and public debate, because the project has yielded

- a great amount of research results ready to be disseminated,
- results which contain major discoveries on methodologies and tool helping to manage better the key, new technology related emerging risks and
- an excellent foundation to advance both research and public debate.

The work on the project has lead almost 200 approved deliverables so far (May 2013, about 50 further deliverables in the process of approval) in the project, listed in Annex 1, most of them contributing to the "Big 7" of iNTeg-Risk, being:

(1) iNTeg-Risk **Catalogue of Emerging Risks** – RiskEars system,

(2) iNTeg-Risk **Framework for Emerging Risk** Management,

(3) iNTeg-Risk **library of Methods, Handbooks and Guidelines** for emerging risk analysis,

(4) iNTeg-Risk dynamic **library of emerging Risks Key Indicators** (KPIs – Key Performance Indicators),

(5) **iNTeg-Risk CWA (CEN Workshop Agreement)**– the document summarizing the European pre-standardization approach to Emerging Risk Management "Managing emerging new technology-related risks" (initial title: "CEN Workshop 67 - General Framework and Guidelines for Early Recognition, Monitoring and Integrated Management of Emerging New Technology Related Risks (iNTeg-Risk)", http://www.cen.eu/cen/Sectors/TechnicalCommitteesWorkshops/Workshops/Pages/WS67-IntegRisks.aspx)

(6) **European Master and Certification** in the area of Risk Engineering and Management – education and training for improved emerging risks management in the EU, and,

(7) **iNTeg-Risk Risk Radar & 1StopShop** – the web-based system-of-systems for early detection, recognition, monitoring and management of emerging risks.

The full list of all deliverables is available at http://www.integrisk.eu-vri.eu/home.aspx?lan=230&tab=996&pag=0 (Figure 1).

The results of the research work in the project, until May 2013 (see http://www.integrisk.eu-vri.eu/Publications.aspx?ss=35&lan=230&tab=996&itm=2202&pag=1269), have been published in

- **7 books**
- **over 30 articles** in peer-reviewed journals
- **1 special issue** of Journal of Risk Research
- **1+ 6 pre-standardization documents** and o
- **over 200 publications and presentations** at conferences [32] [34] [35] [36]

Further publications (about 20) are assessed to be in the pipeline, as well as about 30 further communications at conferences, workshops and symposia.

In particular, the project results have been liaised and aligned with other important projects and activities, such as:

- **OECD** project on Future Global Shocks and OECD High Level Risk Forum, http://www.oecd.org/governance/48256382.pdf, http://www.oecd.org/gov/risk/ [31] [33]

- **IRGC** work on Risk Governance and Emerging Risks and IRGC Risk Governance Framework [4] the principles of which have been fully applied in INTeg-Risk, e.g. as for unconventional gas http://www.irgc.org/event/ug-workshop/
- **ISO** 31000 (TC262)
  The standardization work ISO related to integrated risk management (ISO 31000 [3])
  http://www.iso.org/iso/iso_technical_committee?commid=629121
- The risk management systems developed in the financial world, in particular **Basel II/III** [5], **Solvency II** [6] and in/for **WEF** World Economic Forum [7]
- **EU directives and initiatives** such as: INSPIRE, EU projects in the area of LCA (Life cycle Assessment) [40], Seveso

The above alignment has been particularly challenging in societies as risk-averse as the European one, where lack of confidence in the ability of industry and authorities to identify and manage emerging risks may prolong time to market or prevent success of new technologies. If the technology is concerned by both EU "market policy" and the national "safety policies", possible conflict of policies may arise, and it is often worsened due to the lack of commonly accepted approaches to management of emerging risks (different approaches, fragmentation over countries, branches, sectors…). The EU, therefore, has needed a unified, consensus-based, validated and operational iNTeg-Risk framework that puts together principles, guidelines and tools for managing emerging risks, readily available to all stakeholders, and that is what the project has delivered.

2 Emerging Risks looked at (Big7 #1)

The particular emerging risks treated in the project has three main levels:

a. 17 Emerging risks IDENTIFIED BEFORE the project
   These are the 17 so-called "iNTeg-Risk ERRAs" [2] (Emerging Risk Representative industrial Applications), providing the basis for the development, test-bed for the developed integrated methods, tools and the verification basis for whole the iNTeg-Risk system. The ERRAs are listed in Table 1.

b. 7 + 196 additional Emerging risks identified and EXPLORED DURING the project
   Further 7 ERRAs have been identified during the work on the project and these have been explored in detail within the group of 196 so-called iNTeg-Risk ERIs (Emerging Risk Issues, Annex A.2.1), representing the scenarios leading to manifestation of possible emerging risks;

c. Over 900 additional Emerging risks CONSIDERED FOR ANALYSIS DURING the project
   These are the Risk Notions which have been at the "risk horizon" of iNTeg-Risk (s. Annex A.2.2);

d. Some of the risk were included into the iNTeg-Risk CWA, either as elaborated single examples (e.g. Annexes)

The above risks, according to the project plan, were tackled from the 4 sides of the iNTeg-Risk Emerging Risk Management Framework: T – the technical one (early warnings ignored, technical response inadequate), C – the communication related one (restricted, biased and distorted communication), H – the human and management related one (unclear distribution of responsibilities, poor management of the crises both on short and long term) and R – the regulatory, governance related one.

Table 1: ERRAs – Emerging Risk Representative industrial Applications considered as sources of "multiple risks" in iNTeg-Risk project

Nr	ERRA or ERRA Group Name
A	***Emerging Risks - New Technologies***
A1	CO2 capture and sequestration, both technical risks and governance risk
A2	Insurance and re-insurance aspects of emerging risks including the security-related (HSSE) emerging risks of new technologies
A3	Emerging risks related to the industrial use of automated and un-manned surveillance of industrial infrastructure [38]
A4	Liquid Natural Gas (LNG) regasification in sensitive areas on-shore and offshore

Nr	ERRA or ERRA Group Name
A5	Safety and security of underground hubs with interconnected transportation services and shopping centers
B	***Emerging Risks - New Materials And Products***
B1	Public health and medical issues related to monitoring of emerging risks in production, storage and transport of nano-materials on industrial scale in small and medium enterprises (SMEs)
B2	Emerging risks related to advanced storage technologies for hazardous materials (including H_2) [39] [42]
B3	Emerging risks related to development and use of advanced engineering materials, composite materials
C	***New Technologies & Production Networks***
C1	Challenges to safety posed by outsourcing of critical tasks – in oil, gas, petrochemical and construction industries
C2	Remote operation in environmentally sensitive areas [47]
C3	On-line risk-monitoring and assessment of emerging risks in conventional industrial plants – monitoring of risks beyond the design/regulatory basis
C4	Atypical, one-of-the-kind major hazards/scenarios (post-Buncefield implications) and their inclusion in the normal HSSE practice [50]
C5	Security of energy supply and related emerging risks
D	***Emerging Risks - Related Policies***
D1	Definition of KPIs for emerging risks for selected industry case studies, including CSR aspects of emerging risks
D2	Integrated approach on emerging risks related to the implementation of European safety legislation on SMEs and its application on companies working in Distributed Energy Resources (DER)
D3	Emerging risks related to interaction between natural hazards and technologies at community level
D4	Emerging risks related to hazardous substances, impact on public health and relations with REACH and GHS
I	***INTEGRATIVE ERRAs***
I1	Integrative ERRA #1 for the validation of emerging risk assessment and management tools in the area of Mantova
I2	Integrative ERRA #2: Harbor zone of Luka Koper
I3	Integrative ERRA #3: Industrial zone of Pančevo-South
N	***NEW ERRAs***
N1	RiskEars application cases in insurance industries
N2	Characterization of the emerging risks related to the production of biogas
N3	iNTeg-Risk ERMF and 1StopShop as a tool to implement key recommendations of the OECD Future Global Shocks Report to explore potential role of space based technologies and related ICT technologies in coping with 25-35 identified potential global threats / hazards
N4	Develop and demonstrate a framework for robust infrastructures for emerging technological risks, based on case study with nanotechnology
N5	Assess emerging occupational risks associated with the production of electric power from selected renewable sources and in particular wind power and photovoltaic solar power
N6	Fracking- drilling technique, which is used for most natural gas wells can cause underground water contamination
N7	Use of new technologies for Unconventional gas development

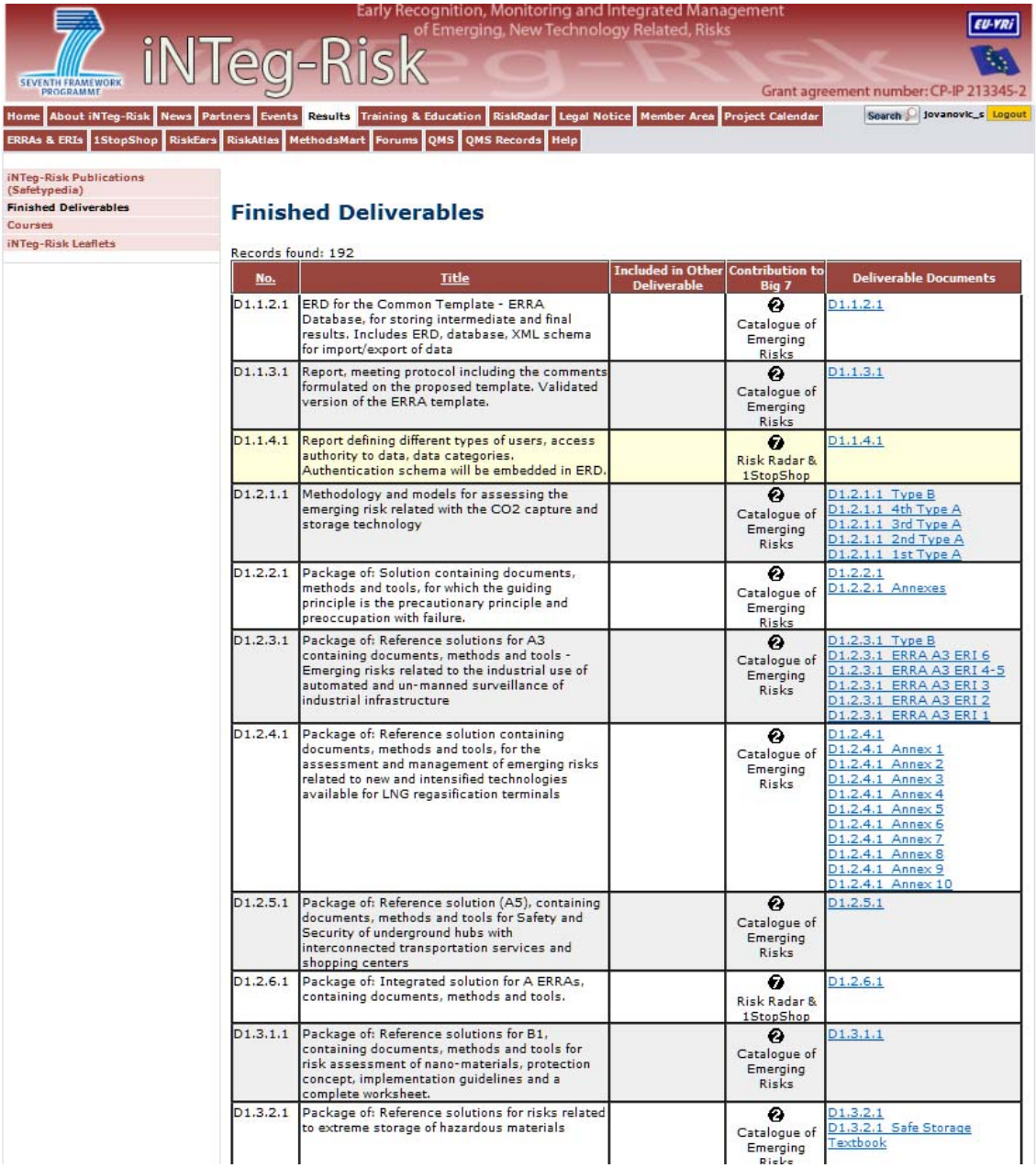


Figure 1: iNTeg-Risk deliverables on-line (access depends on user's rights)

3 The way to analyze and manage emerging risks proposed by iNTeg-Risk project (Big7 #2, #3, #4 and #5)

3.1 General

The main objective of iNTeg-Risk project has been to improve the management of safety of new technologies and related emerging risks. iNTeg-Risk has matched this goal by providing a common paradigm and a common "framework" for managing emerging industrial risks. As the other EU approaches to more conventional industrial risks (cf. Seveso, REACH, IPPC, or GHS… see references [8], [9], [10], [11]), iNTeg-Risk approach has been also based on the consensus among main stakeholders. Thus, in the area of emerging risks, it has proposed the scientific and technical "state-of-the-art-consensus" as the basis for the future regulation, standardization and education. The above objectives are in accordance with the Community strategy 2007-2012 on health and safety at work (reduction by 25 % of the total incidence rate of accidents in the EU-27) and concepts of the EU [12], its agencies [13], as well as with those of ETPIS specified in its Strategic

Research Agenda (SRA) [14]. Particular emphasis of the project is on providing common documents in the form of guidelines, recommendations and pre-standardization documents.

The above should ensure reaching acceptance and sustainability by new technologies, especially those "made in Europe". This acceptance can be reached only if the stakeholders are convinced that possible or perceived emerging risks related to these technologies can be managed in safe, responsible and transparent way. The term emerging risks refers to new and/or increasing risks, as defined by EU-OSHA [13], ETPIS [14] and OECD [15].

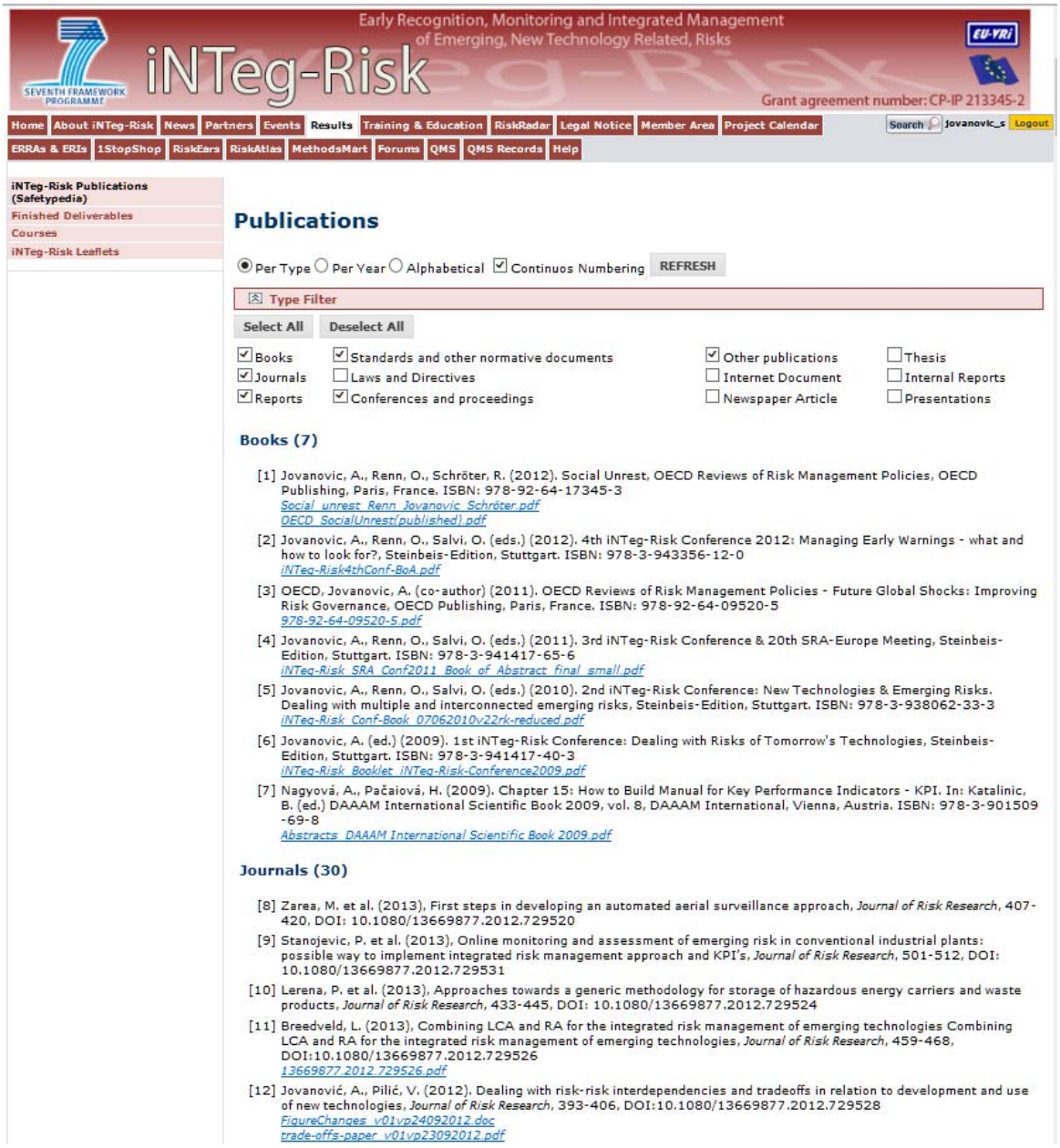


Figure 2: iNTeg-Risk publications on-line (access depends on user's rights)

3.2 Vocabularies, definitions, word cloud

The Consolidated iNTeg-Risk Vocabularies include over 5,000 entries related to risks as used in iNTeg-Risk project, coming from the following main sources (Figure 3):

1. The basic set of definitions adopted in iNTeg-Risk CWA
2. The definitions from ISO 31000
3. The definitions from GEMET (http://www.eionet.europa.eu/gemet/)

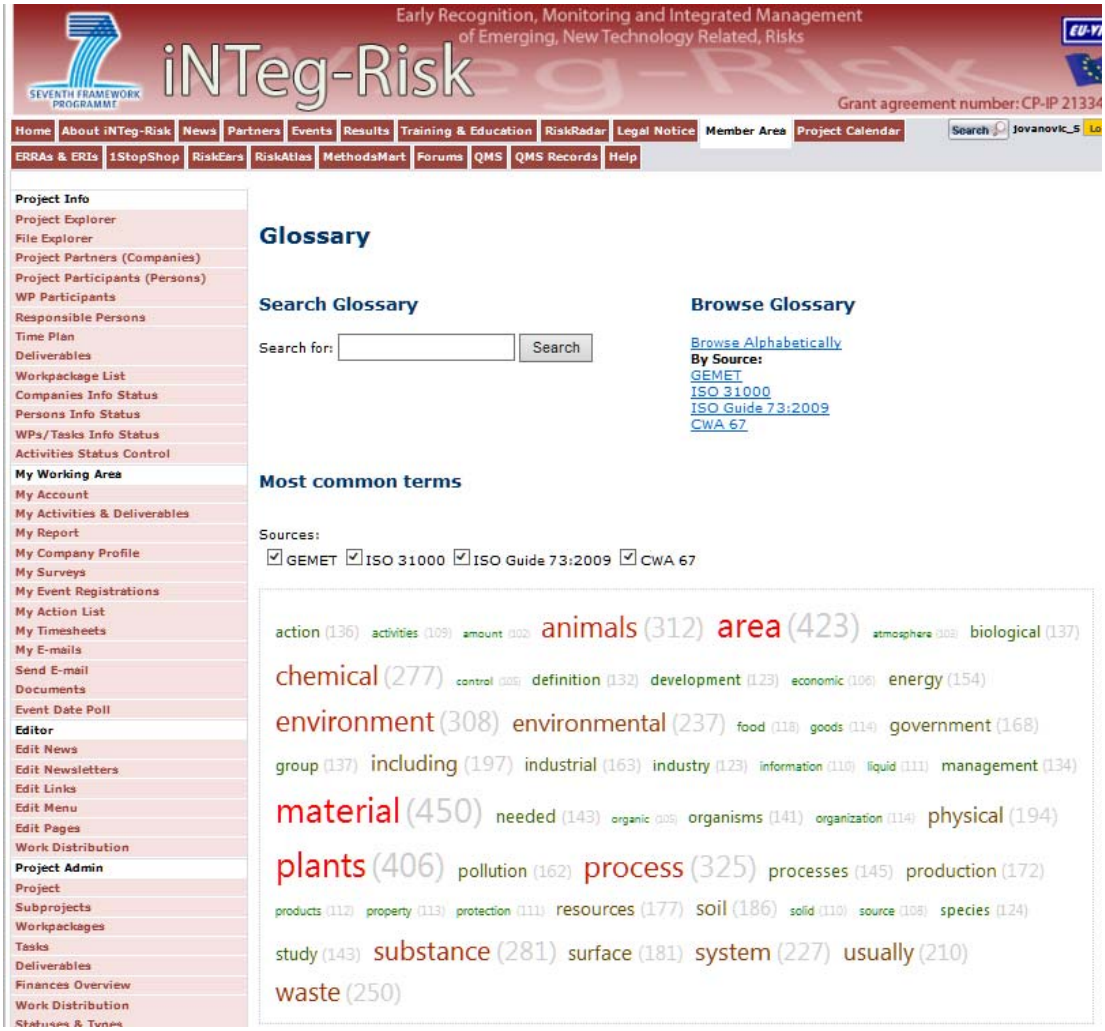


Figure 3: iNTeg-Risk glossary and word cloud – ISO, GEMET and own glossaries included

3.3 Emerging risks, emergence

When iNTeg-Risk project was proposed in 2008, the definition of emerging risks proposed by OSHA in 2005 [18], adapted to major accident risk, was stipulating that a risk was to be considered new and emerging if:

a. the risk was previously not recognized and is caused by new processes, new technologies, new ways of working, or social or organizational change (e.g. risks linked with nanotechnology, biotechnology, ICT technologies, new chemicals, effects of globalization etc.) or

b. a long-standing issue is newly considered as a risk due to a change in social or public perceptions (e.g. stress, bullying) or

c. a new scientific knowledge allows a long-standing issue to be identified as a new risk, e.g. in the situations where cases have existed for many years without being identified as risk because of, e.g., lack of scientific knowledge.

The risk was considered to be increasing if:

a. the number of hazards leading to the risk is growing, or

d. the likelihood of exposure to the hazard leading to the risk is increasing, (exposure level and/or the number of people exposed), or

e. effect of the hazard is getting worse (e.g. seriousness of health effects and/or the number of people affected).

Current OSHA definition [19] of emerging risks stipulates that an emerging risk is any risk that is new and/or increasing. In this context (and adapted to major accident and technological risk) "new" means that the risk did not previously exist and is caused by new processes, new

technologies, new types of workplace, or social or organizational change; or that a long-standing issue is newly considered as a risk due to a change in social or public perception; or that new scientific knowledge allows a long-standing issue to be identified as a risk. The risk is increasing if the number of hazards leading to the risk is growing, or if the exposure to the hazard leading to the risk is increasing, or that the effects/impacts of the hazards are getting worse (e.g. seriousness of health effects and/or the number of people affected). In iNTeg-Risk project the above definition [13] applies generally, and is taken as a starting reference point.

On the governance side, the definition of emerging risks provided by IRGC is [21]: "[...] a risk that is new, or a familiar risk that becomes apparent in new or unfamiliar conditions. Of particular interest to IRGC are emerging risks of a systemic nature, which typically span more than one country, more than one economic sector, and may have effects across natural, technological and social systems. These risks may be relatively low in frequency, but they have broad ramifications for human health, safety and security, the environment, economic well-being and the fabric of societies."

For the extension of the original OSHA definition used for ERMF, the following issues mentioned by IRGC [43] have been taken into account:

- the systemic nature of emerging risks;
- link of emerging risks to high-impact-low-probability-events (HILP events, HILPs);
- multidisciplinary character;

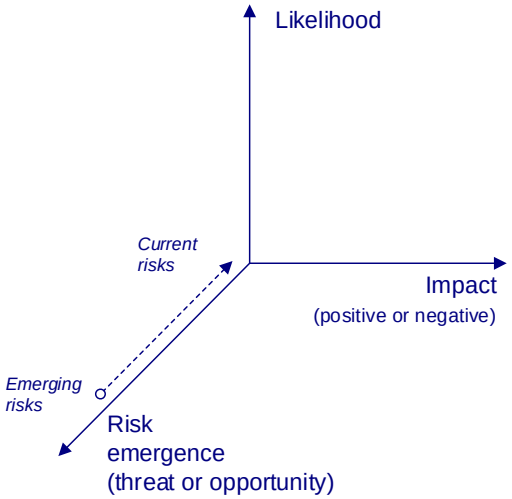


Figure 4: Emergence as 3rd dimension of emerging risks

Both the ENISA [20] and IRGC definitions of emerging risks have provided useful inputs for the definition of the approach proposed by ERMF. ISO 31000 basic definition of risk as effect of uncertainty on objectives is essentially including the emergence of emerging risk. The emergence, in that context, becomes just one aspect (or factor, or driver) of the overall uncertainty affecting the achieving of the objectives. For emerging risks it is necessary to consider the two main characteristics describing their emerging character, namely their "emergence" (Figure 4) and their "maturation" with time (Figure 7 and Figure 8).

Emergence, as a new term (dimension) in the consideration, is understood and defined as the act or an instance of emerging or the act of becoming known or coming into view: the act of emerging; e.g., "the emergence of the Internet as an important means of communication". In the philosophy, systems theory, science, and art, emergence is often considered [22] as the way complex systems and patterns arise out of a multiplicity of relatively simple interactions including concepts like novelty, surprise, spontaneity, agency, even creativity itself. Emergence is central to the theories of integrative levels and of complex systems. Practically, for two risks having the same impact and likelihood, the emergence (as related to the risk threat[1)] or as opportunity) defines which of the two risks may deserve to be handled with higher priority. This document proposes that for each dimension (impact, likelihood and emergence) of emerging risk we define scales, on the scales, we define classes, and for risk (as threat or opportunity) we define levels. Formalizing the process

1) *UNI 11230:2007 defines Hazard, danger,* ***threat*** *(3.1.2)* as potential source of harm*; which is the same as definition 3.8 in this document*

includes application of specific scales and scoring systems (e.g. scales, classes and levels used as shown in Figure 5).

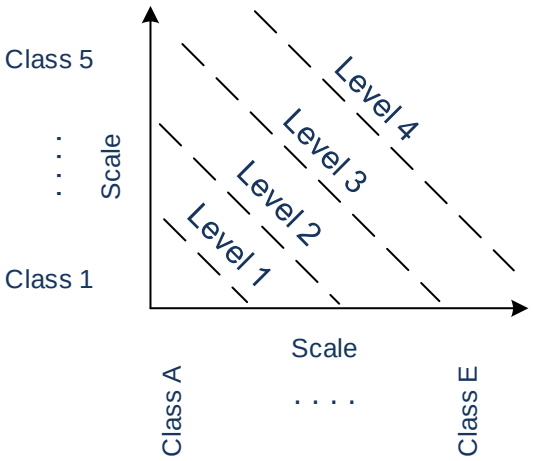


Figure 5: General understanding of scales, classes and levels as applied to emerging risks in iNTeg-Risk CWA

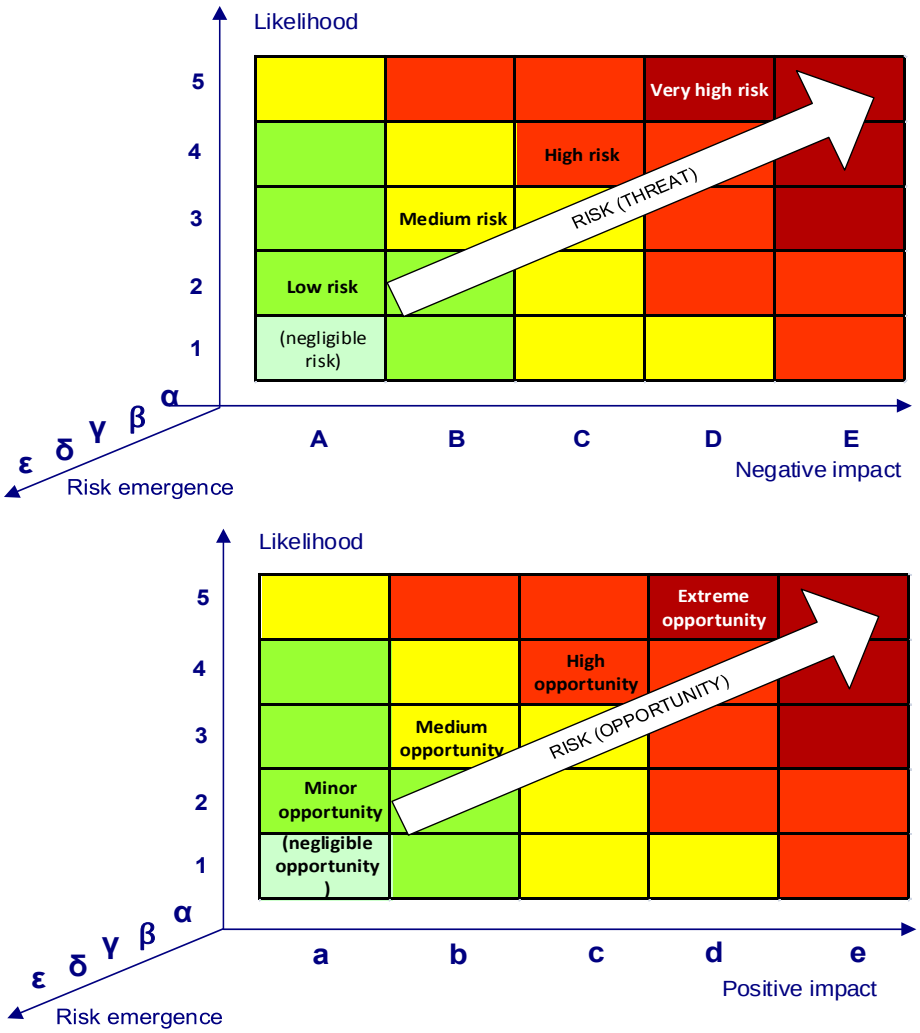


Figure 6: Threat-opportunity based representation, combined with emerging character (emergence) of risks (threat and opportunity)

The figure shows that a "scale" orders "classes" (e.g. of likelihood or impact) and the "levels" measure e.g. "magnitude of risk or combination of risks, expressed in terms of combination of

consequences and their likelihood" as per ISO 31000:2009 definition 2.23. The scale and proposed scoring relies very much on the one proposed for the current risks (known risks, not considered as emerging, see [23]). The practical use of the scoring system generally requires the definition of application specific scales/scores. It should also be clearly indicated at which level they should be applied since e.g. an adverse effect to local communities may be a benefit at a regional level. In practical use, conventions such as using, e.g. 5x5 risk matrices and/or a color-code can be beneficial.

3.4 Maturation of emerging risks

Defining the starting point of an emerging risk can be a challenging task because at the very beginning, there is nothing emerging and no risk. Theoretically, it can be very challenging to define the point where an emerging risk starts to emerge. Practically, however, it is assumed that a risk would start its existence as an emerging risk, when the first indication of that risk is recorded for the first time. After that moment, any new evidence (notion, in terms of ERMF), early warnings, indications, weak signals, signals, precursors, incidents, etc., recorded and processed will contribute to emerging risk's maturation (see Figure 7, Figure 8).

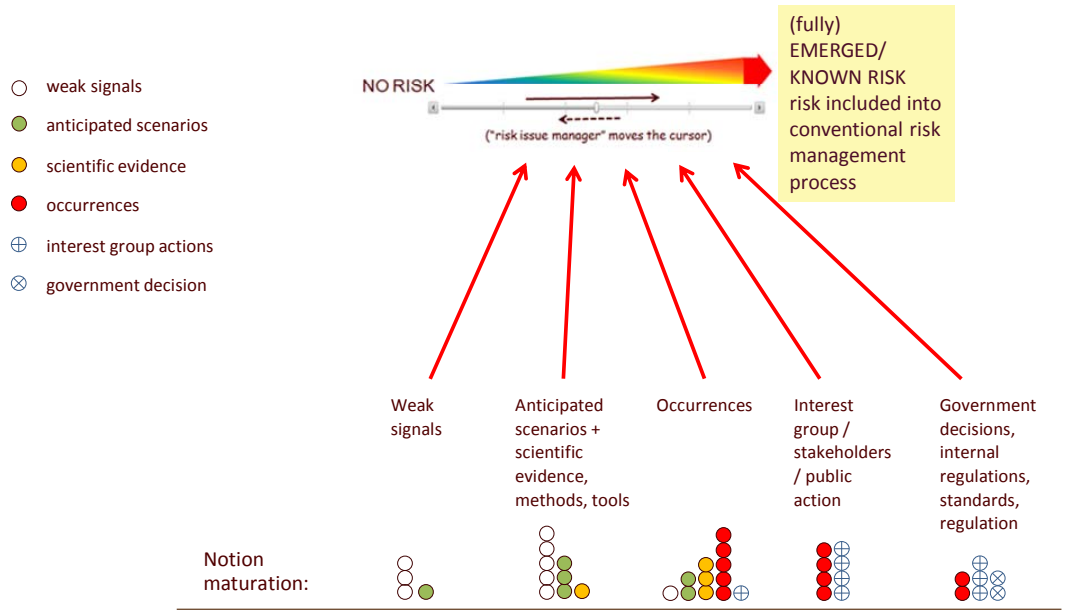


Figure 7: Maturation of emerging risk through accumulation of knowledge

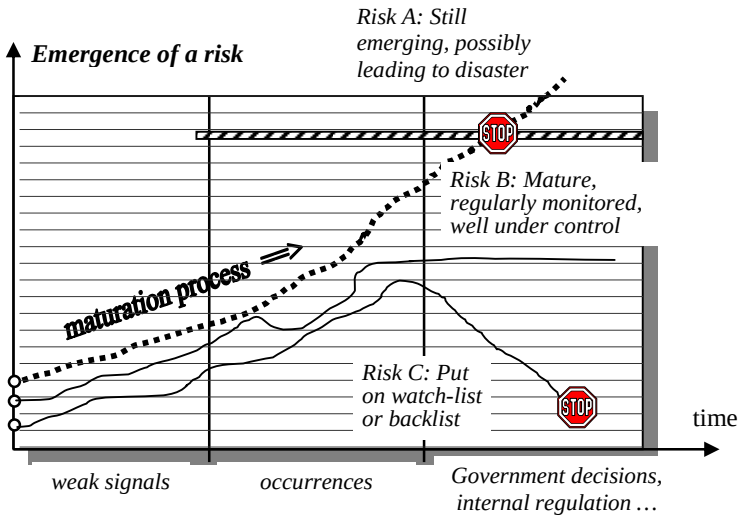


Figure 8: Example of three different maturation paths for emerging risks: archived or back-listed notion (C), emerging risk which have achieved stable (mature) status (B), and risks still emerging (A)

In most of the cases, the evidence collected will be heterogeneous and incomplete, often contradicting, and it is therefore necessary to ensure that each piece of evidence is stored in a structured manner, in order to obtain a meaningful and consistent picture of an emerging risk as soon as possible. As shown in Figure 7 the process usually starts with weak signals, leading to the first anticipated scenarios, usually formulated by the potentially involved stakeholders, who start to feel threatened by the scenario(s). If the occurrences of the scenarios or their parts start appearing, further development (maturation) might lead to the creation of interest groups taking the stance in the situation and undertaking actions in order to clarify and/or prevent the emerging risk. Once this process leads to e.g. new or changed regulation, legal decisions and similar, one can talk about a fully emerged risk, fully included into the scope of known, and thus conventional, risks. The "signal strength", in such a case, as shown in Figure 8 (left part), increases towards the end of the maturation process.

The maturation of a risk notion does not necessarily need to have a constantly ascending character: if the initial threat indication ends up by becoming false (e.g. no occurrences happen or counter evidence becomes available) the maturation process can start decaying and the emerging risk may, eventually, disappear at the end (Figure 8).

An emerging risk notion (a notion) is, thus, any piece of evidence indicating that a risk may emerge in a given context or situation. The notions can include weak signals, precursors and other forms of collected evidence about possible or imagined threats. Press releases about unknown health problems in the areas where new gas exploitation technologies (unconventional gas) are taking place can represent sources of notions related to possible emerging risks related to a topic such as hydraulic fracturing (fracking). The notions need to be processed in order to obtain clearer ideas about possible scenarios (denoted as iNTeg-Risk ERIs, Emerging Risk Issues, in iNTeg-Risk project) of how things could go wrong. In the example of fracking, these could be separate scenarios leading to water pollution or micro-seismicity.

3.5 The 10 steps of ERMF (as from iNTeg-Risk CWA)

The 10 steps of the ERMF are illustrated in Figure 9 and defined as shown in the Table 2. Annexes to the CWA document (A, B, C, D, and E) provide use cases of the ERMF in different practical applications; explaining and giving examples to each of the 10 steps. The process (Figure 9) starts with Emerging Risk Horizon Screening provided in Step 1 Early warnings – notions, followed by Emerging Risk Pre-Assessment (Steps 2 to 4) and Emerging Risk Assessment (Steps 5 to 8). This forms the basis for and includes making management decisions about risk treatment (Step 8) and a follow-up and improvement through Step 10 (of both the risk itself, the implementation and effect of the treatment, and all other steps in the process). Finally, communication and consultation (Step 9) is an overarching activity throughout the entire process.

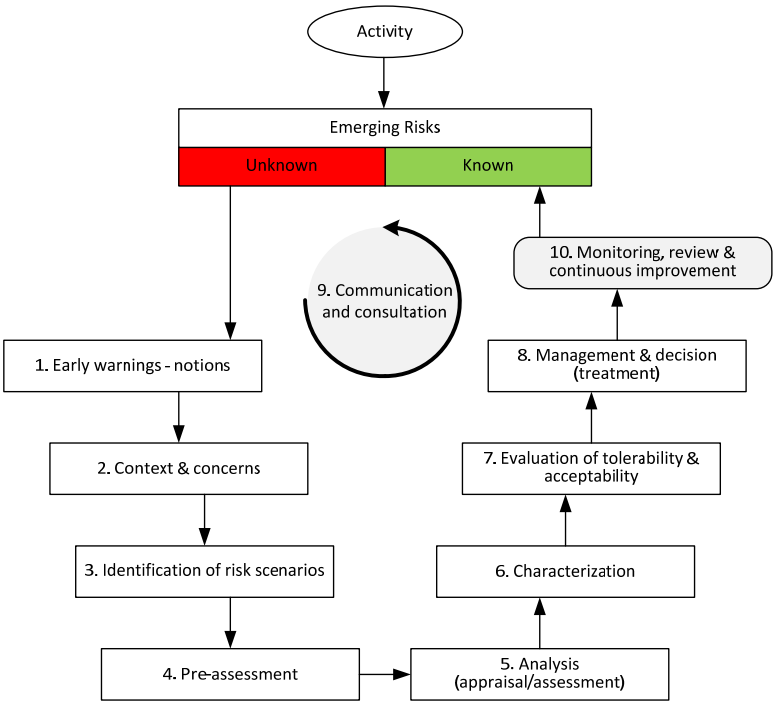


Figure 9: Main distinctive characteristics of the ERMF process

3.6 Comparing the iNTeg-Risk ERMF with general risk management frameworks

The iNTeg-Risk ERMF is strongly influenced by the IRGC risk governance framework and the ISO 31000 risk management process. The main difference is that some issues that are included in other steps in IRGC and/or ISO 31000 have been explicitly addressed as a separate step in the iNTeg-Risk ERMF, and a particular focus on capturing the earliest signs of an emerging risk. To compare the IRGC risk governance framework and the ISO 31000 risk management process with the iNTeg-Risk ERMF, Figure 10 provides an IRGC and ISO 31000 representation of the ERMF.

Table 2: Short description of 10 steps of the ERMF

Step	Short description
Horizon screening	
1) Early warnings - NOTIONS (including preliminary hazard identification)	Emerging risks need to be detected as early as possible and their evolution needs to be constantly monitored, also with respect to different spheres (technical, social, economic, etc.). The warnings should be properly aggregated, classified and monitored in order to enable the stakeholders to keep the process of risk maturation under control.
Pre-Assessment	
2) CONTEXT establishment and CONCERN assessment	By establishing the context, the organization articulates its objectives, defines the external and internal parameters to be taken into account when managing risk, and sets the scope and risk criteria for the remaining process. Concern assessment will provide decision makers with relevant knowledge regarding stakeholders' expectations and the potential risks they perceive that might threaten sustainable development.
3) IDENTIFICATION of emerging RISK SCENARIOS	The outcome of the risk maturation is the risk scenario(s) for which all further considerations are made. The scenario is based on corroborated evidence about one or more early warnings.
4) PRE-ASSESSMENT of selected risks scenarios (screening)	Pre assessment needs to identify all relevant dimensions of risk, or at least, all the dimensions of interest for the various stakeholders identified.
Appraisal/Assessment	
5) Emerging Risk APPRAISAL/ ASSESSMENT/ ANALYSIS	The analysis of risk governance models revealed the importance of considering the whole life cycle of a product and the need to develop cumulative risk assessments; this step should include likelihood analysis and impact analysis for emerging risks.
6) Emerging Risk CHARACTERI-ZATION, Risk categorization/ classification	Risk characterization allows decision makers to distinguish scientific facts from policy orientations when analyzing risk assessment results. Better decisions can thus be taken. Risk categorization/classification is an optional part of the process, especially important if large amounts of risks or early warnings are to be dealt with simultaneously; also important for monitoring legal or other allowable limits (monitoring compliance).
7) Evaluation of emerging risk TOLERABILITY & ACCEPTABILITY	In the lack of reliable data, use of conventional methods such as risk matrices or the ALARP principle might be difficult. Furthermore, the assessment of acceptability and tolerability should go beyond the technical dimension of risk to consider social, regulatory, cultural or ethical dimensions.
8) Management & DECISION (TREATMENT)	Based on the previous steps results, decisions are made to manage risk in order to keep it at an acceptable or tolerable level. The approaches applied in emerging risk management should: — integrate both qualitative and quantitative data; — combine different type of criteria; — carefully address compensation; — consider variations/alternatives in risk scenarios; — treat uncertainties; — help make robust decisions.
Continuous activities	
9) Emerging risk COMMUNICATION & CONSULTATION	Communication is an increasingly important element of dealing with emerging risks. It takes place in all phases of the overall process and among all the stakeholders, although in the way and scope adapted to the respective stakeholders' roles.
10) Emerging risk MONITORING, REVIEW & CONTINUOUS IMPROVEMENT	This requirement means that the procedures to be established have to ensure — continuous improvement, — effectiveness & efficiency, — sustainability & evergreening.

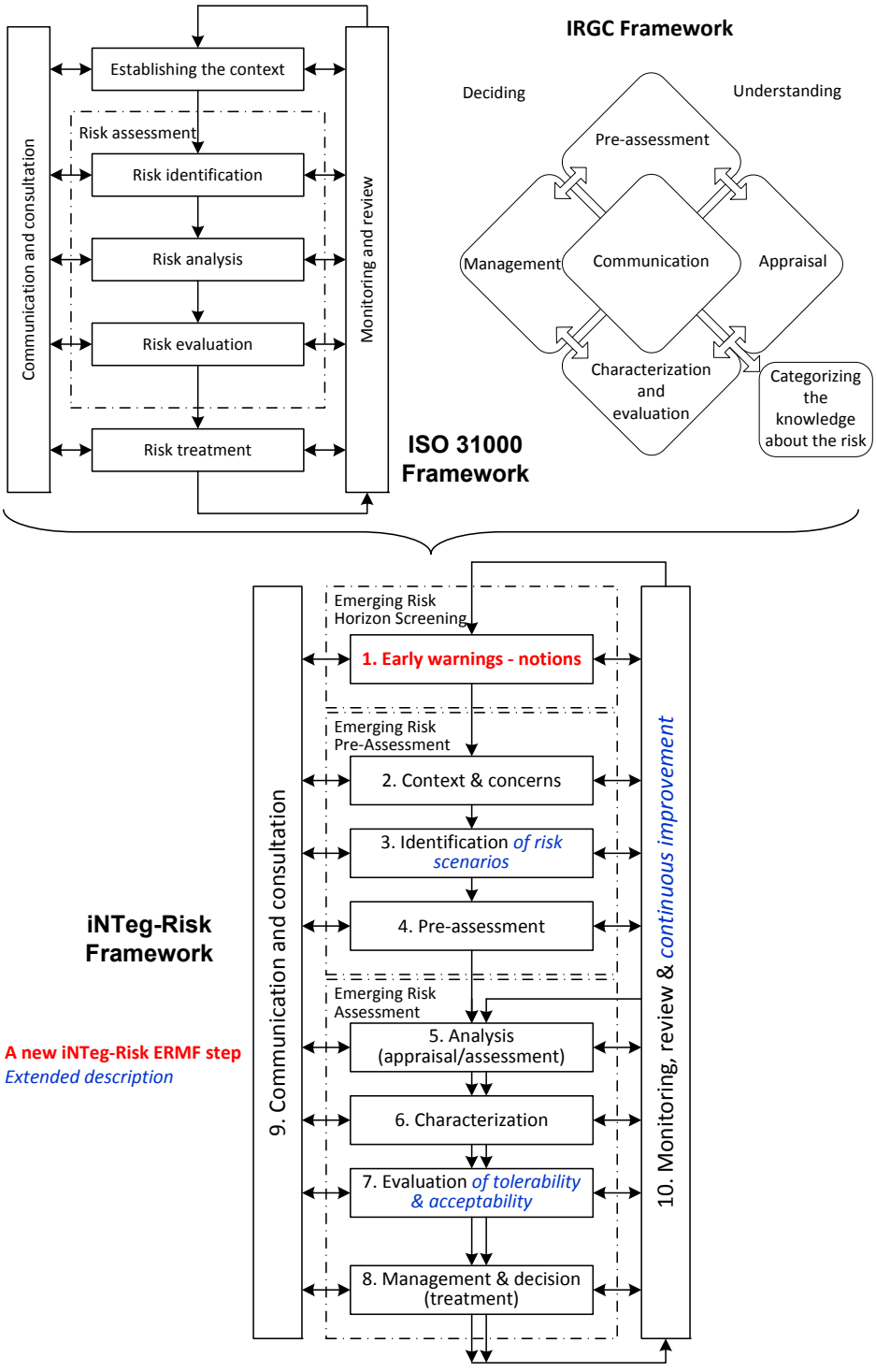


Figure 10: ISO 31000 and IRGC frameworks as basis for creating iNTeg-Risk ERMF

The most distinctive difference is the active search for an extreme vigilance for any signs of an emerging risk, represented by Step 1 Early warnings – notions.

The 10 step process of ERMF has a particular advantage when dealing with unknown risks, providing the continuous way from Step 1 to Step 10 (Step 1 recognizes emerging risk as early as possible, in a systematic manner, whereas in Step 10 the emerging risks are monitored and followed-up in an optimized manner).

Also for Step 10, as for Step 1, there is an aim to recognize potential dangers as early as possible to avoid accidents. Thus, there are certain similarities between Step 1 and Step 10. Early warning (indicators) is a key issue in both steps.

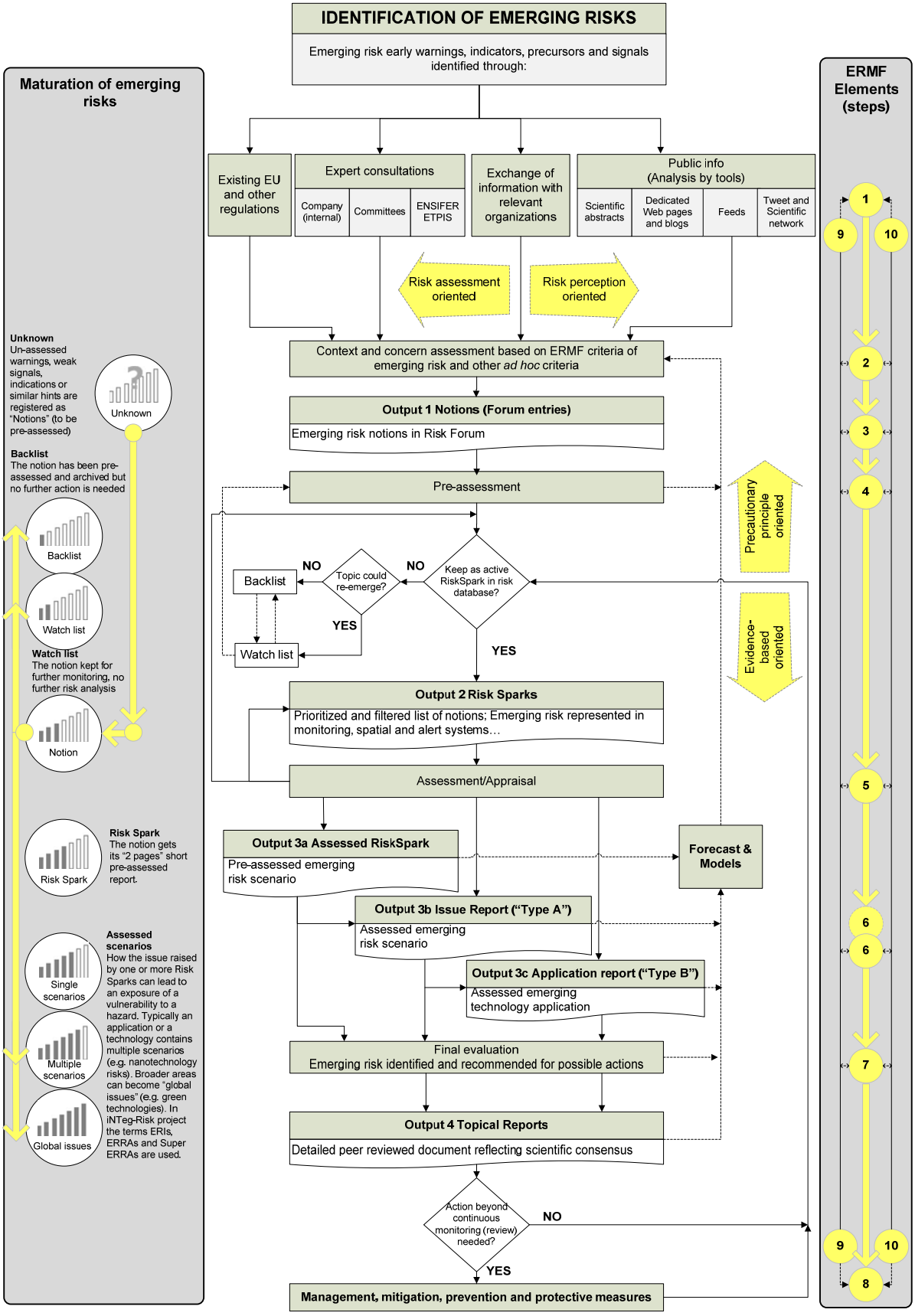


Figure 11: Example of process for management of emerging risks based on ERMF and illustration of the maturation of emerging risks

The other main distinctions from general risk management within industrial safety are related to Steps 2 and 5. In the context description emphasis is put on identifying/knowing the new risk

influencing factors (triggers, factors and drivers) and to follow-up these factors in subsequent steps. Concern identification (Step 2) and assessment (Step 5) play a major role due to the potential controversy of emerging risks. This includes a systematic interlinking between the stakeholders and their main concerns (hazards/ vulnerabilities/fears) to ensure that the relevant issues are included in the assessments.

A final characteristic of the ERMF process is related to step 3 where methods for systematic scenario identification have been developed, which also captures unknown-known scenarios (i.e. they have occurred somewhere, but have not been recognized for the specific activity in question). This ensures a better identification of the most critical emerging risks.

The elements of ERMF can be represented both in a way similar to the one in ISO 31000 and in the IRGC-like way, as shown in Figure 10.

Details on the implementation of the ERMF that may apply in certain contexts are illustrated in Figure 11.

4 Education for emerging risks proposed by iNTeg-Risk project (Big7 #6)

The iNTeg-Risk *European Master and Certification Program in Risk Engineering and Management* is envisaged to match the current needs of industry, R&D and regulators in the areas of

1. Safety of complex industrial systems,
2. Asset/plant and Health/hazard oriented risk management,
3. European and international regulation/standards and risk governance, and
4. Other topics covering risk communication, risk analysis and management techniques.

Focusing on emerging risks related to new technologies.

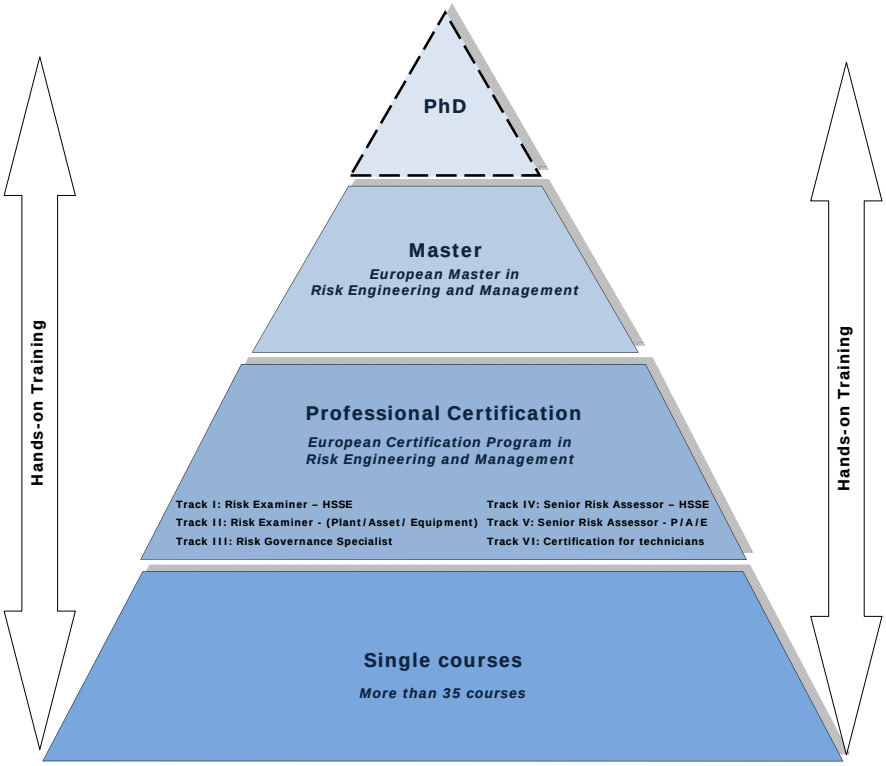


Figure 12: Structure of the Training and education system

The curriculum is designed for students who wish to develop their knowledge, skills and competences in the fields of modeling, formulation, analysis and implementation of simulation tools for advanced risk problems, as well as skills for understanding these approaches in the broader context of engineering science. Students may take the Master as a distinctive step in their professional career, or in preparation for a Ph.D. degree. The iNTeg-Risk European Master and Certification Program in Risk Engineering and Management has been based on several international as well as European industrial projects, whereby the curriculum design is in compatibility with

several educational projects. The program is being accredited in Germany, with Steinbeis University Berlin (SHB), acting as the coordinator of the joint activities. The activities are accompanied by hands-on training which reiterates the Steinbeis educational model, based on the principle of the German "dual/integrated education" concept. That is, the professional and academic educational tracks are well-aligned and going hand-in-hand.

The educational scheme of the European Master and Certification Program in Risk Engineering and Management provides both, academic career and professional certification. Both lines of education are supported by hands-on training through participation in industrial projects. On Figure 12: Structure of the Training and education system the structure of the whole system of training, Technology Transfer, education and qualification is depicted. The coordination is done by Steinbeis Transfer Institute Advanced Risk Technologies (STI R-Tech), as a part of SHB. STI runs most of the courses offered, coordinates activities with participating universities and is responsible to ensure compliance with the Study and Examination Regulations of SHB.

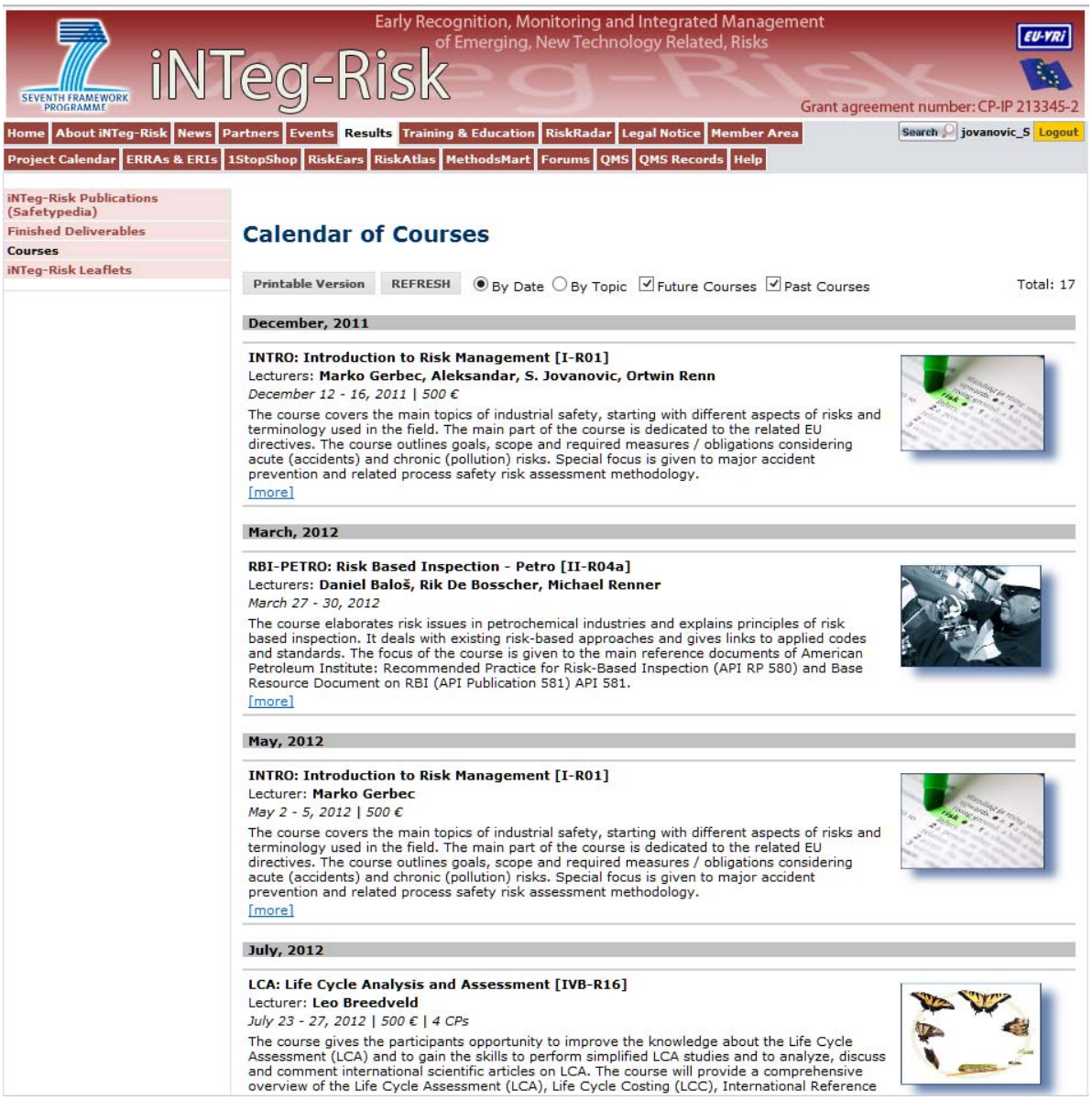


Figure 13: Calendar of course in iNTeg-Risk project

The students are expected to attend theoretical courses and to pass the related exams, to work during the study and to apply their knowledge directly in real-life situations. This is the innovative dual concept promoted by Steinbeis University Berlin (called the Project Competence Concept). The curriculum consists of modules of theoretical education, which are combined with project work. Courses from the curriculum last 2-5 days, and they end with a concluding exam. The project work includes practical occupation on relevant problems in the sponsoring company followed by preparation of project study papers and the master thesis.

Lecturers of courses and coaches supervising the students in the project work are selected among leading experts in corresponding fields. They possess both academic and practical background which provides the genuineness of the study program. This combination allows students to absorb working knowledge fast and to gain skills for practical implementation and relevant problem-solving. The courses, over 30 of them, are scheduled during the whole year. They are grouped in modules and lead the student from introductory and basic risk issues to specific risk topics. A student can build his own professional profile by careful selection of courses to attend. Short description of each course is available in the curriculum.

Within the Master study curriculum, currently over 30 courses as well as project work and thesis are offered in main modules dealing with:

- **Intro** – general concepts, emphasis on the petrochemical and power industry
- **Assets** – plants/systems/equipment, emphasis on petrochemical and power industry
- **HSSE** – Health, Safety, Security, Environment; hazard oriented risk management
- **Business/governance** – concepts and practical application of business and governance oriented risk management
- **Specific (Additional) topics** – additional facultative courses
- **Master thesis** and **projects** aligned with the hands-on training

5 The tools to analyze and manage emerging risks developed in iNTeg-Risk project (Big7 #7)

5.1 Basic concept

The implementation of iNTeg-Risk ERMF relies largely on the iNTeg-Risk 1StopShop (Figure 14) and the tools contained in it. The main elements are (Figure 14):

1. RiskRadar
2. (1StopShop main) Tools
    a. RiskEars
    b. RiskAtlas
    c. MCDM Tools
    d. New Technologies Acceptance Tools
    e. Notion clustering (S-RDI) Tools
3. Specific Tools (of iNTeg-Risk project)
4. Background Tools
    a. Safetypedia
    b. KPI Library
    c. MethodsMart & Glossary
    d. iNTeg-Risk Education
    e. ENISFER
    f. Survey Tool

1StopShop is organized as a "system of systems", managing

- Data
- Information
- Knowledge

- Meta-information
- Analyses/work
- Communication

A system of systems means that a group of independently operating systems - comprised of people, technology, and organizations - are connected, enabling emergency responders to effectively support day-to-day operations, planned events, or major incidents. All the tools that have been developed under 1StopShop are independent systems that can work together but still be unique in its operation, thus supporting interoperability.

The meta-information approach is applied in various tools. Meta-information-based means here:

- Meta-information is descriptive information about resources in the universe of discourse.
- Structure given by a meta-information model that depends on a particular purpose.

Meta-information is used for discovery (including search and navigation) of core information, access, storage and service invocation of core information, integration of core information, interpretation of core information, user profiling, authentication, authorization, accounting and quality control/management.

Figure 14: The integrated system concept of iNTeg-Risk 1StopShop (part 1)

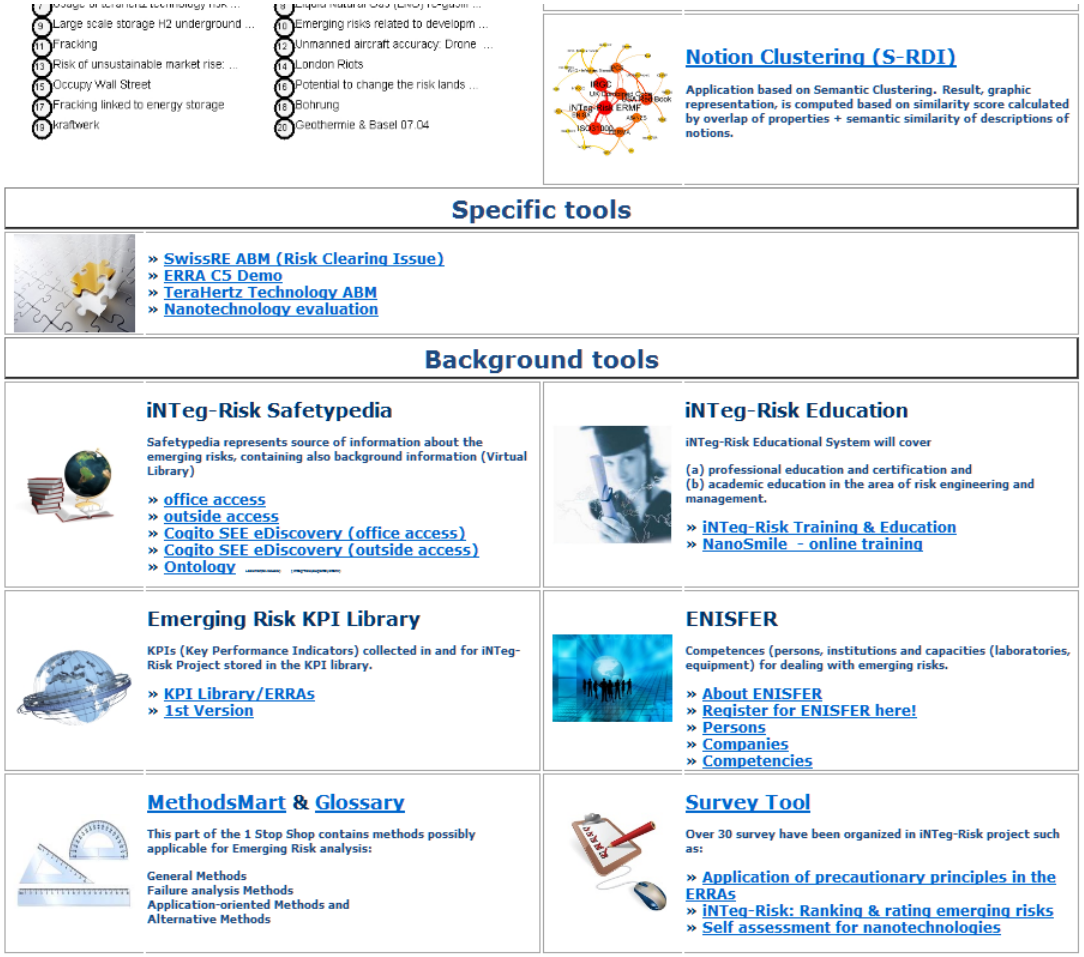


Figure 15: The integrated system concept of iNTeg-Risk 1StopShop (part 2)

5.2 Risk Radar

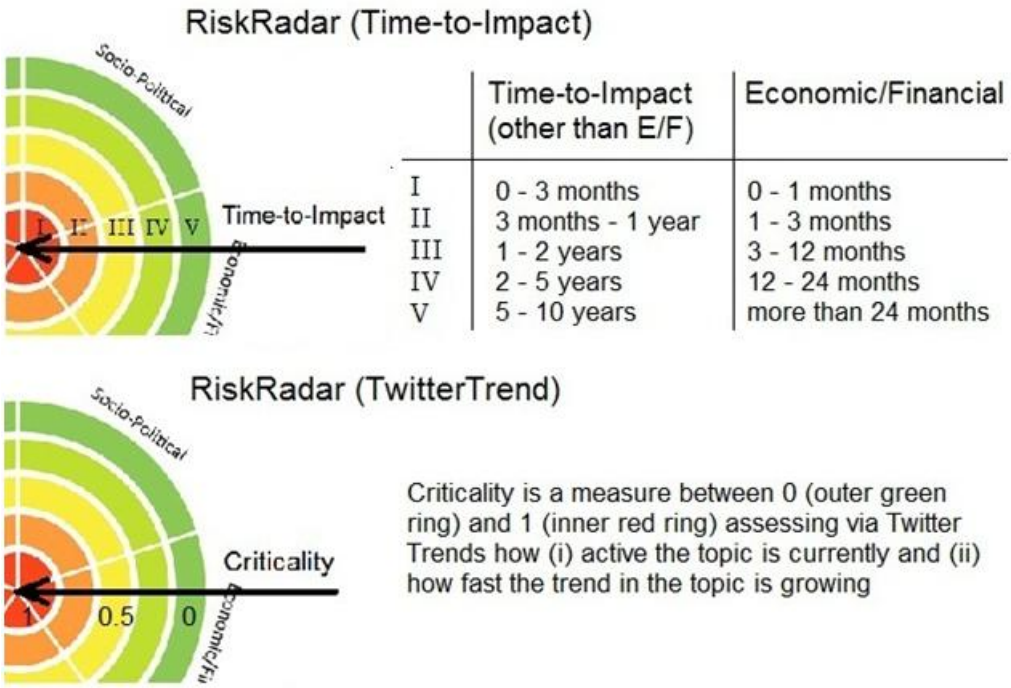
Purpose: Risk Radar is a monitoring tool to identify/locate/assess the risk according to the criticality of the issue based on the following factors:

- Environmental
- Socio-political
- Economic/Financial
- Regulatory/Legal
- Technological

Emerging risks that are identified in new technologies have been assessed according to the criticality of the respective risk. Here risks are categorized in five clusters, the nearer to the center, the more critical the issue.

Functionality:

- A sample of notions can be selected and the selection for comparison can be displayed; or
- The most critical Risk Tweet entries can be automatically retrieved, if the values of the risks peak more than the alarm/alert levels set.



	Time-to-Impact (other than E/F)	Economic/Financial
I	0 - 3 months	0 - 1 months
II	3 months - 1 year	1 - 3 months
III	1 - 2 years	3 - 12 months
IV	2 - 5 years	12 - 24 months
V	5 - 10 years	more than 24 months

Figure 16: Legend for Risk Radar

5.3 Risk Tweet

Purpose: Risk Tweet is a part of the iNTeg-Risk 1StopShop that monitors tweets posted in Twitter, as one of the possible indicators showing the current 'hot' topic in the community. Risk Tweet also provides information about the amount of tweets per day/month on the followed topic and other relevant details: including possible links/cross-references to other media or information available in Google trends, Figure 18.

Functionality: This enables a decision maker to decide on how a certain topic, for example, "fracking" or "LNG", Figure 17, is a hot topic for users of the Social Media network. The **yellow** and the **red** line are customizable alert and alarm levels that can be introduced for creating automatic notifications.

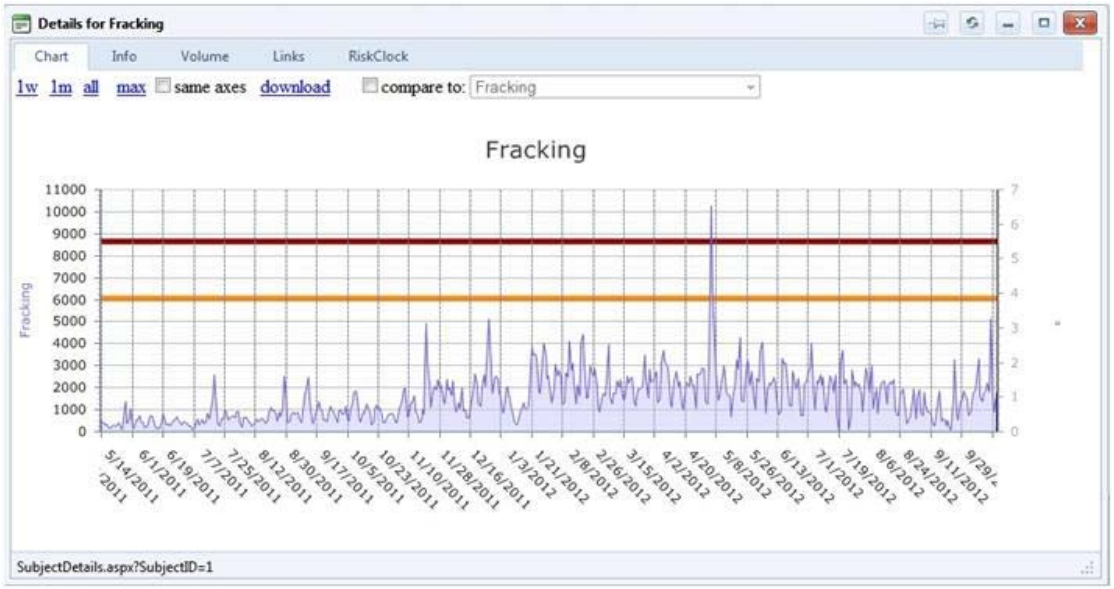


Figure 17: Risk Tweet, with collected information on tweets related to "Fracking" from Twitter service

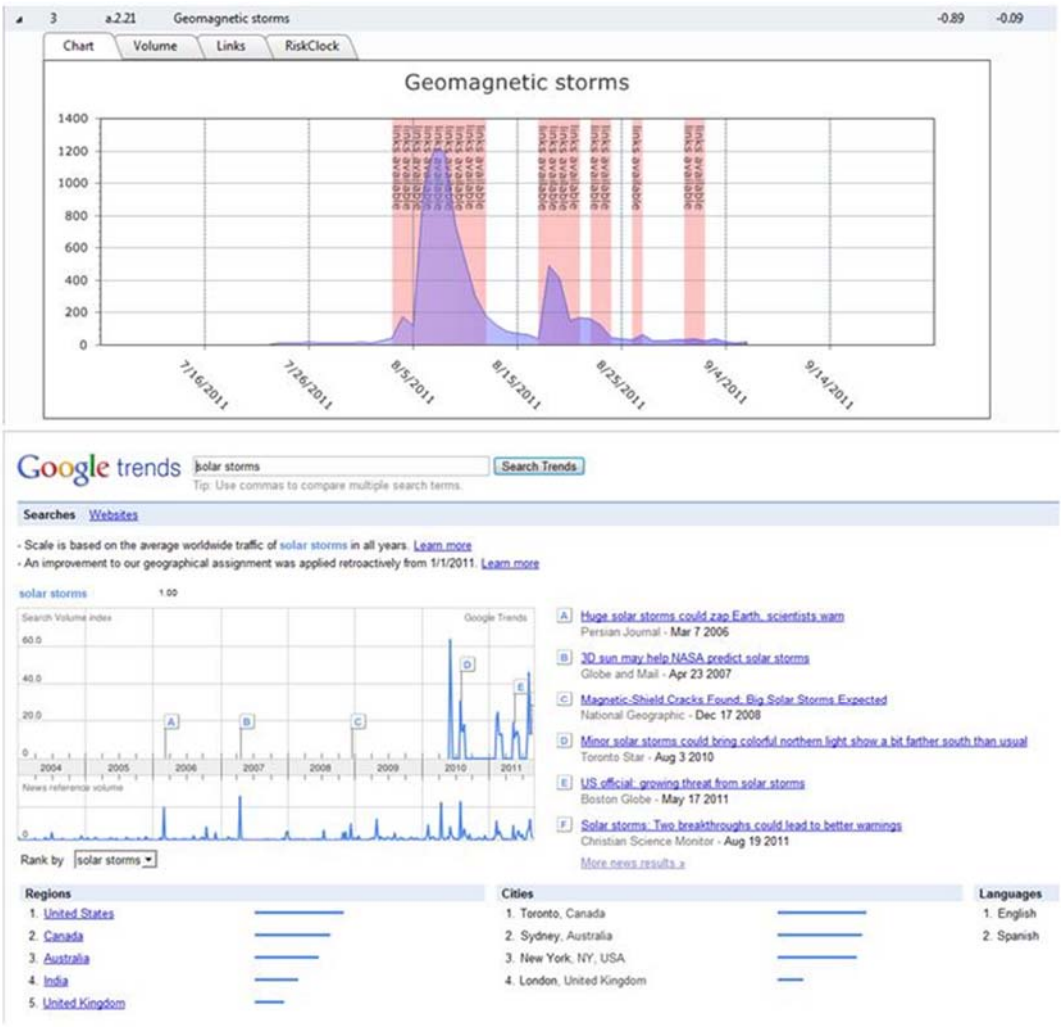


Figure 18: Example notion: Geomagnetic storms, with reference to Google trends results

5.4 RiskEars

Purpose: If a technology is new or has just few historical data about potential risks and occurred accidents, the companies which are developing the technology and authorities who are providing the permission to do so, have to watch for notions of potential risk scenarios related to the new technology and have to discuss these with experts on specific platforms dedicated to such activities.

iNTeg-Risk RiskEars Forum is offering such a platform with highly sophisticated user management and supported by mapping of relevant experts for different areas. RiskEars, the Emerging Risk Early Warning & Monitoring System of iNTeg-Risk 1StopShop is a database system for acquisition and monitoring of early warnings. The word "notion" indicates something that can become a threat.

Functionality: RiskEars enables to manage and follow the further development or maturation of the notion towards a full-scale risk. Approximately 900 *"notions*" collected are analyzed in the project. The system allows to gather notions of emerging risks coming from different sources, usually persons and/or organizations "of confidence", registered as the so-called iNTeg-Risk emerging risk sentinels, i.e. professionals rated as credible sources of notions about emerging risks.

Based largely on the work done for ERRA A2 and the IT-platform developed for the whole project, the module has reached the level of realistic test applications. RiskEars allows monitoring of the evolution of risks (e.g. from early notion to a litigation case), an appropriate example for this would be "Fracking".

Map of gas reserve

Graph of gas production

Figure 19: Development of previously non-exploitable shale gas and the growth in the liquefied-natural-gas (LNG) market.

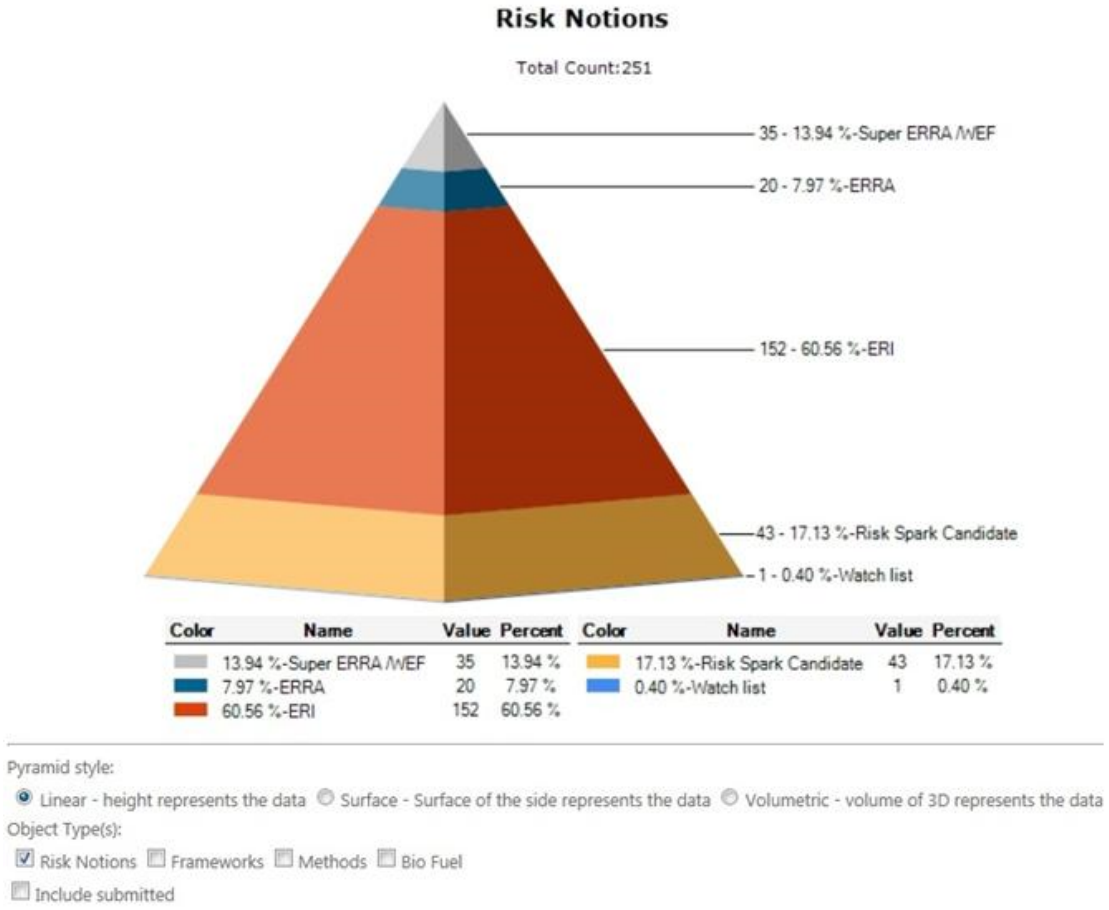


Figure 20: Overview of the notions' status

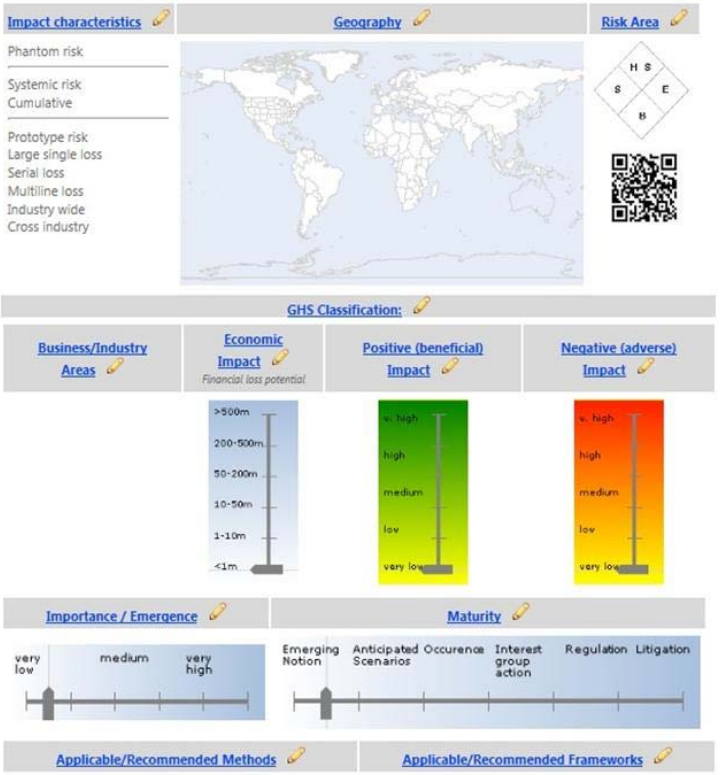


Figure 21: Advanced assessment / criteria using RiskEars tool

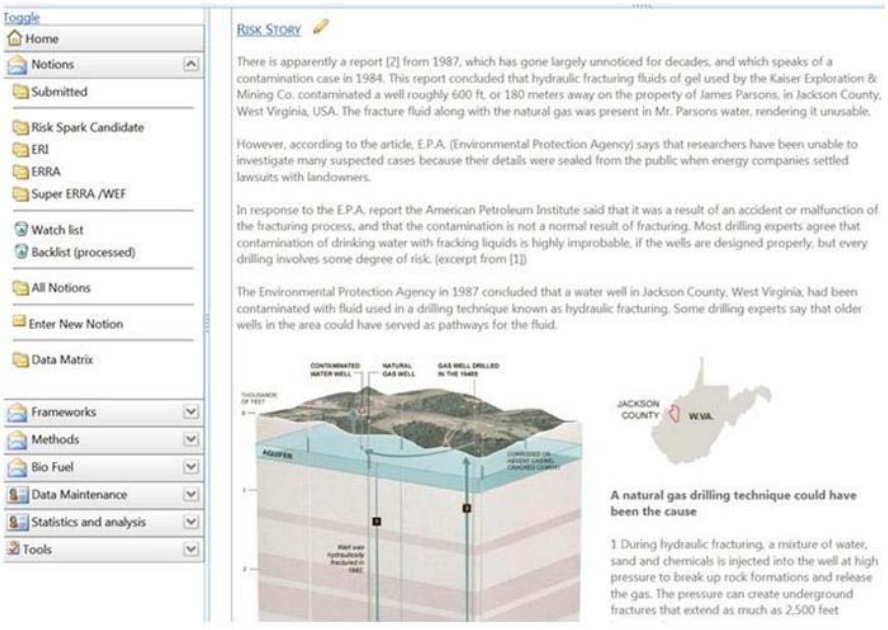


Figure 22: Risk Story from RiskEars (describing an Emerging Risk Scenario) about the contamination of underground water (Fracking)

"Advance" assessment part of the RiskEars notion comprises

(1) Risk Story – Providing an overall picture of the emerging risk and context.

(2) Impact scenario – Describing the key loss scenarios.

(3) Risk Perception – Describing how the risk is perceived by the general public, key stakeholders or experts [44].

(4) Recommendations – Proposing any (existing/own) recommendations for the risk.

(5) Reference and Further Reading – Providing references for sources of information, and provide sources for further reading, if any.

(6) Decisions and Measures – Providing any proposed "decisions" or measures to control and reduce this emerging risk, or mitigate the consequences of the identified loss scenarios.

5.5 RiskEars Forum

The Risk Ears forum is a discussion platform which allows people to post risk-related topics and start a discussion (threads) which they find interesting and/or important. The RiskEars forum functions like any other discussion forums found in the web whereby people are able to respond to a discussion topic, propose further references, or provide their opinions about an issue.

5.6 RiskClock

Purpose: "RiskClock" displays the trajectory of a risk issue in terms of "Trend" and "Activity" over time span of one week, one month or all data.

Functionality: A sample of notions can be selected and the selection for comparison can be displayed, or the most critical Risk Tweet entries can be automatically retrieved.

5.7 RiskAtlas

Purpose: The GIS (geographic/geospatial information system) based part of the iNTeg-Risk 1StopShop helps to visually represent emerging risks and their possible interactions and impacts. Risk Atlas is a system for mapping emerging as well as conventional risks.

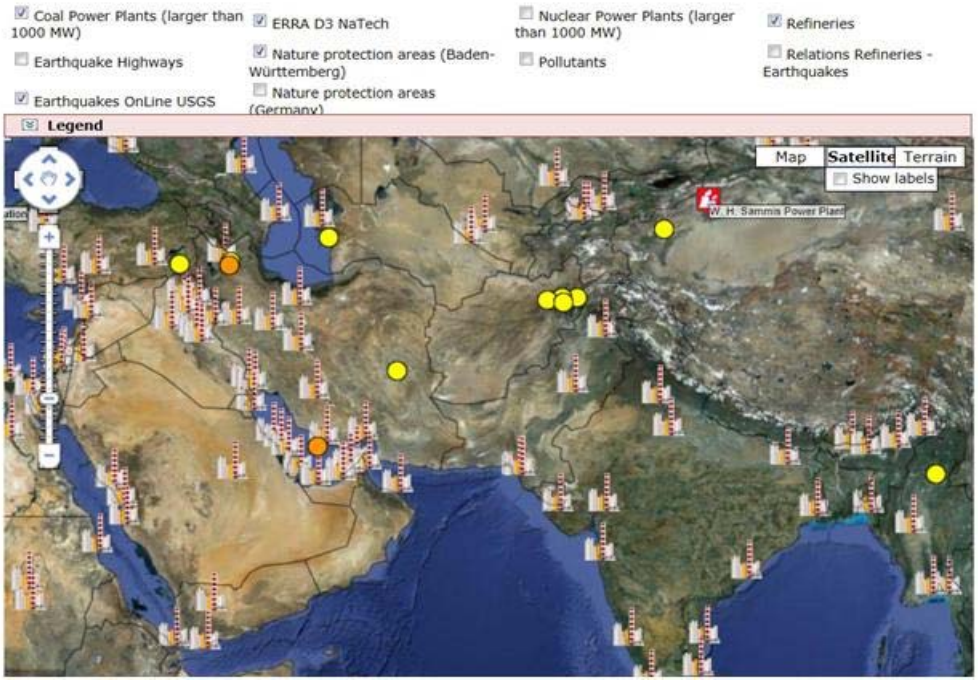


Figure 23: Risk Atlas

Data collection: In order to identify companies and organizations that are involved in using emergent technologies that may pose a safety risk, diverse information sources including: the Internet, company literature, trade journals, trade catalogues, technical journals, industry bodies etc. were trawled. iNTeg-Risk ERRA workpackage results [24] as well as national and European data trends on emerging risks were also searched. Demographic and infrastructure data were gathered using both national and EU official statistics. General information, relating to safety was extracted from these sources, e.g. in the case of LNG, output quantity, number of tanks, storage capacity etc. This allowed to built up a picture about that particular facility and the potential risk it presents. Google maps were then used to provide geographical location coordinates for entry into a database. Where precise geographical locations could not be determined through any of the sources used, the town or city in which the site was situated is given. It was also recognized that not all organizations were fully forthcoming with supporting information, e.g. output quantities, and

pipe diameters etc.; they may consider this to be commercially sensitive. All information was then transferred to a database for incorporation onto the Risk Atlas.

Functionality: RiskAtlas performs mapping over 200 layers of data related to hazards and vulnerabilities, such as earthquakes, hazardous materials, and industrial plants and similar; the emerging risks can be recognized by screening the list of calculated *risk distances* for the hazard-vulnerability pairs of points in the respective layers as shown in the figure

Figure 24: Risk Distances in RiskAtlas

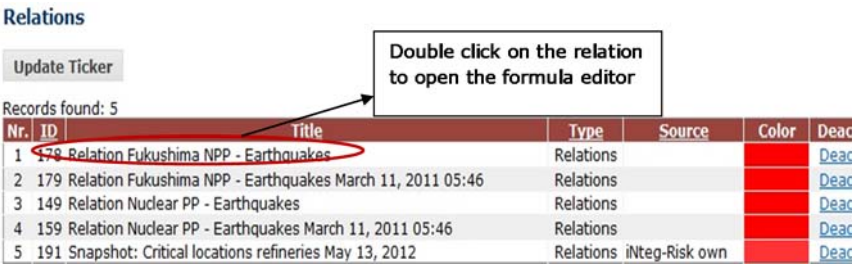


Figure 25: Relations between layers in RiskAtlas

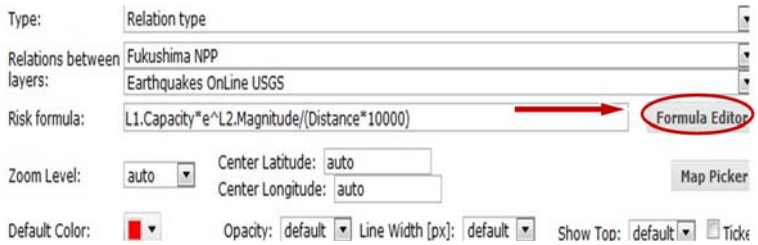


Figure 26: Formula editor option in the "Edit/Add new layer"

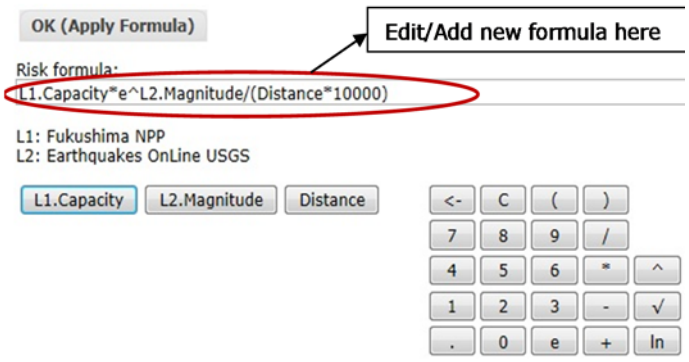


Figure 27: Formula editor window of RiskAtlas

Security features for restricted user access: The access to the RiskAtlas has been restricted to a limited number of users and mostly the rights are available only to the administrators and not even to every individual involved in the project. This provides a safe platform for the partners of EU-VRi to share the information on the RiskAtlas, which ensures information security (i.e.) protects

the information from unauthorized access, modification, destruction, use or any kind of unsafe acts.

For example, the layers in the RiskAtlas can be restricted to certain users by changing the visibility of the layer, not all layers are visible to everyone.Currently, there are about 200 layers on the Risk-Atlas.

RiskAtlas – Formula Editor: The concept of the risks distance is introduced in ERMF as a means to discover the "hazard-vulnerability couples" which may be critical in geographical or conceptual risk map. Here the RDI (Risk Distance Index) is calculated by applying a user-defined formula to the layers in the RiskAtlas and as per the RDI, the criticalities of the risks are shown in the RiskAtlas as visual representations. Formula editor provides user-flexibility by allowing the user to set the formula under the formula editor, which gives a wider range of options to perform different analyses.

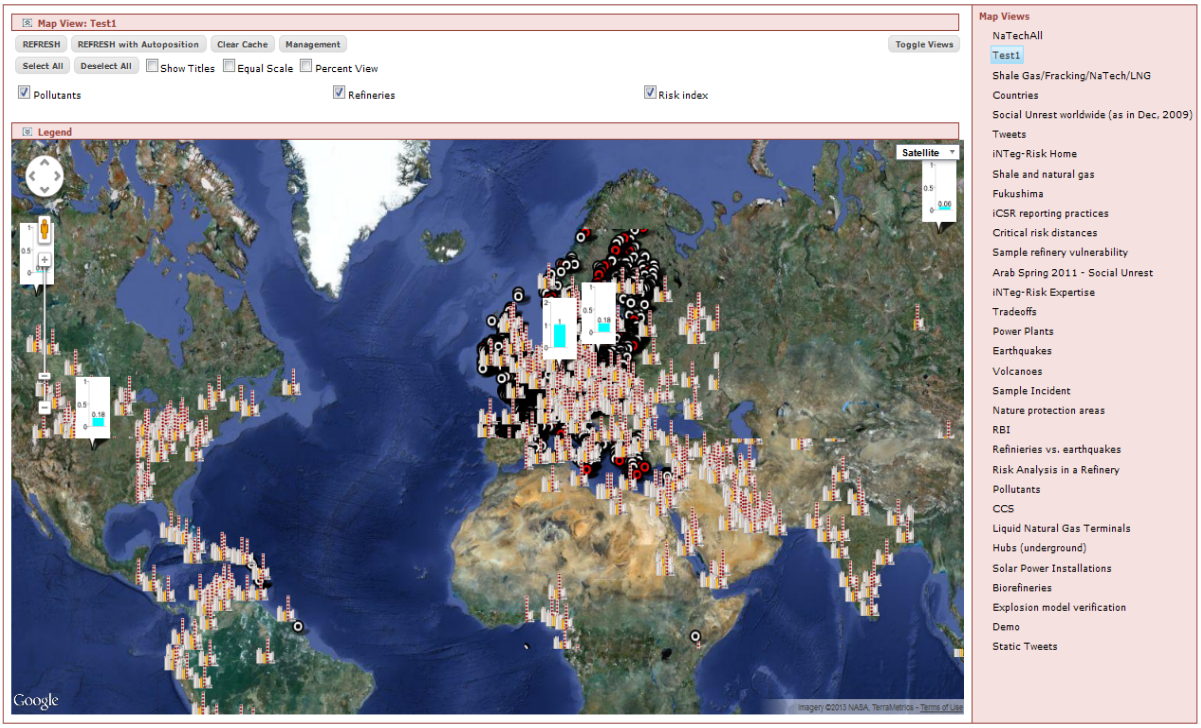


Figure 28: Map View in RiskAtlas

5.8 RiskTicker

Purpose: RiskTicker is a web-tool that receives alerts from RiskAtlas and displays it as short news on the home page of iNTeg-Risk website.

Functionality: Each RiskTicker contains all the statistical information of the instrument such as location, date, time, capacity, magnitude, distance and risk distance or risk factor it represents.

5.9 iNTeg-Risk Safetypedia

Purpose: Safetypedia represents source of information about the emerging risks, containing also background information (Virtual Library). Safetypedia concept is derived from Wikipedia. However, as Wikipedia is (allegedly) free uncontrolled encyclopedia, the Safetypedia community is a validated integrated knowledge source. This knowledge is represented to the public and experts.

Functionality: The Safetypedia community fuses various disciplines under "one roof". In that sense, to begin with, the Safetypedia community is integrating knowledge from iNTeg-Risk dimensions and various ERRAs into one coherent source.

Safetypedia is divided into categories and pages of tangible project results that in turn allow fast and efficient knowledge retrieval. The Safetypedia enables connectivity to other information sources on the web.

Safetypedia community is an online web-tool, and is divided into three types of pages accessibilities (as is the case for virtually all other parts of 1StopShop):

- "***Open to Public***": those pages are free pages that anyone can read, even unregistered users. Unregistered users can view pages and their discussions, but cannot contribute to the discussion. To contribute to discussion, one must register as Open to Public users. Those users can not contribute new pages.
- "***Open to Project***": those pages are open to iNTeg-Risk project members only, and allow those users to add pages and conduct freely professional discussions within the community.
- " ***Admin Only***": Those pages are created by the project team who initiated the community and works on its sustainability. Page like the Safetypedia home page, the Safetypedia categories, establishment of community behavior and alike. In addition, pages who should be debated prior to publishing to public. For example, assume (God forbid) a major safety risk in a nuclear technology. Among professionals, a debate is required. However, publishing content to public may cause more damage, due to panic and incorrect political pressure. The "Publisher Admin Only" group will struggle hard on the ethical questions between the right to know, and the wisdom to share.

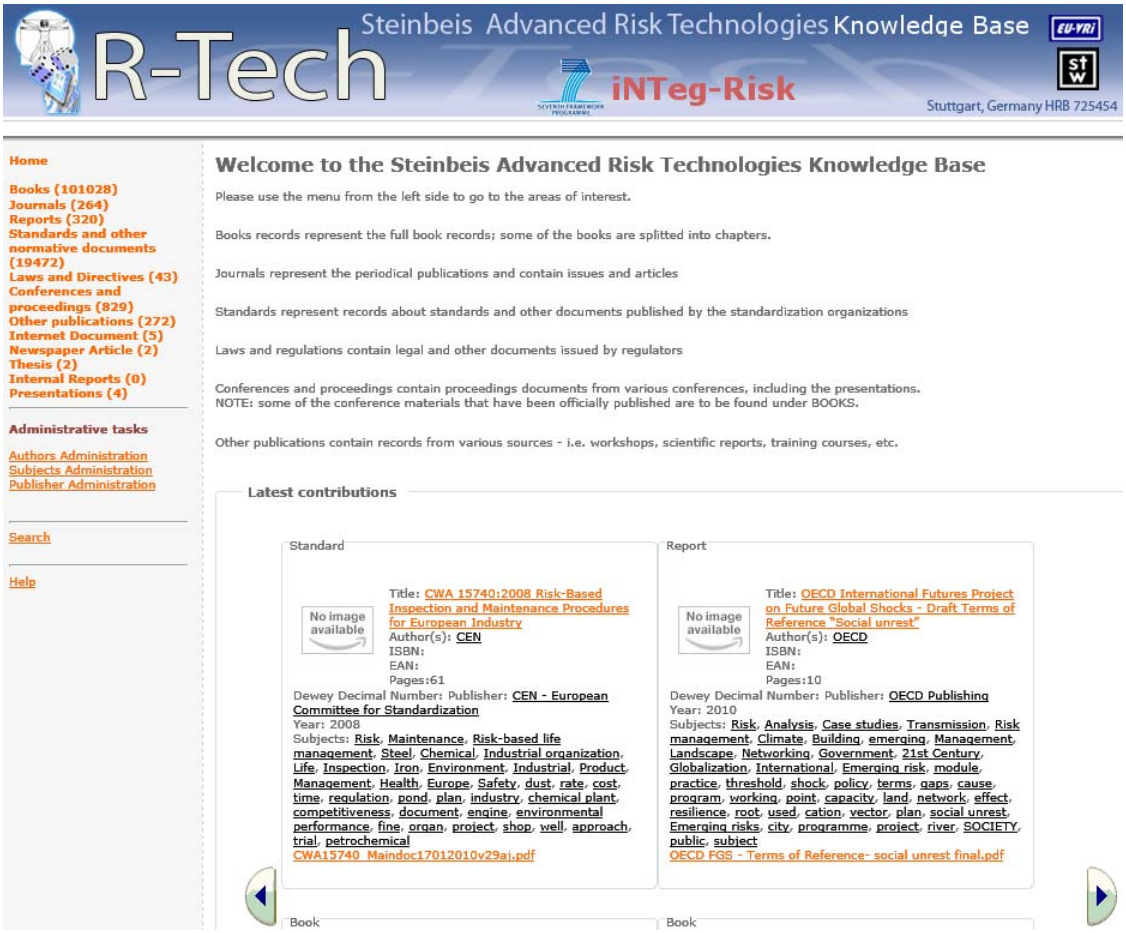


Figure 29: Safetypedia – the iNTeg-Risk Knowledge Base

5.10 Notion clustering (S-RDI)

Purpose: Most of the scenarios are traditional scenarios for which classical risk assessment tools are applied for likelihood and consequence assessment of emerging risks.

However, for most new and emerging risks related to new technologies it is very difficult and resource consuming, if not impossible, to carry out a sound and meaningful likelihood /consequence analysis. When missing historical data as input for such an analysis is an issue, tools based on Semantic Clustering can be very helpful. Authorities and companies willing to introduce a new technology to the market need to learn about similar technologies, potentially similar risks related to the new technology and the respective ways to deal with them.

The **S-RDI tool (Semantic Risk Distance Index)** developed within iNTeg-Risk project provides graphical representations based on similarity score calculated by overlap of properties plus

semantic similarity of text in order to identify similarities between well know and well managed risk scenarios and new, emerging risk scenarios related to the to be introduced technology.

Functionality: A technique for developing relevant terms, by focusing tightly on keywords and keyword phrases that are associative and closely related, referred to as "**semantic clustering**".

Semantic clustering is a technique that has been adapted by S-RDI tool. The S-RDI tool measures the *semantic similarity* between keywords that have been given as input to the tool. Using these result a graph is mapped. *Node size* is proportional to its *eigenvector centrality* (~ Google's page rank - a measure for importance). The color indicates the node's degree (the deeper the red, the higher the degree). Thickness of links indicates similarities among the described network nodes.

The S-RDI tool is designed to visualize and analyze similarities and interconnections between vast numbers of elements for which a textual description is available. Suppose one is confronted with, say, thousand documents containing descriptions about different emerging risks and one is interested in finding connections between individual risks in this dataset, one needs to cluster these documents around a given number of themes or find out which of them have the largest potential to contribute to systemic risks. The S-RDI tool provides a fully automated way aiding this process.

The strategy implemented here can be roughly outlined as follows. For the data it is only required to be a structured text with identifiable labels and content, such as provided by the iNTeg-Risk RiskEars system. Each pair of texts is searched for keywords co-occurring in both of the documents. From this similarity score the S-RDI (semantic risk distance index) is computed. Based on this measure the documents are clustered by a complete linkage algorithm. To visualize these results network theoretic tools are employed. From the matrix of pair-wise similarity scores the maximum spanning tree is constructed, that is the network with the smallest number of edges with the highest values of similarity scores spanning the entire set of documents. This maximum spanning tree is made ready for visualization by a force-directed drawing algorithm.

Example

The technology used for "Fracking" topic, for the first basic analysis was semantically comparing risk scenarios related to fracking with the following Emerging Risk Representative industrial Applications (ERRA) and their related emerging risk scenarios considered in iNTeg-Risk project:

A1: Carbon Capture and Storage

A2: (Re) Insurance issues related to emerging risks

A3: Automated surveillance of industrial infrastructures

A4: Liquid Natural Gas re-gasification

C2: Remote operations in environmentally sensitive areas

C4: A typical, one-of-the-kind major hazards/scenarios

D3: Emerging risks related to interaction between natural hazards and technologies

For this analysis "Fracking" scenarios are connected with at least three other above mentioned ERRAs. The S-RDI tool calculates that the strongest link is with Carbon Capture and Storage applications, second strongest with scenarios related to Liquid Natural Gas re-gasification and third strongest with Remote operations in environmentally sensitive areas. Result of this analysis is shown in Figure 30.

This means that, if needed, tools and methods used for assessing likelihood/consequence analysis in "closest" technology related emerging risk scenarios may be applicable for first assessment for emerging risk scenarios on "Fracking" as well, thus giving decision maker a possibility on how to tackle risks emerged from fracking process.

5.11 Emerging Risk Key Performance Indicators (KPI) Library

Purpose: In an increasing complexity of production, usage of hazardous materials and security risks, KPI enhances the buildup of adequate corporate governance [37]. In order to illustrate that an organization is in control of its procedures, it is recommended that regular reporting on the performance takes place as mean for validation [25]. Results are primarily meant for quality control of internal procedures. Clearly defined KPI can contribute to an improved sense of understanding and communication within and between departments and the company management.

Functionality: An online database was built to store all of the KPIs collected during the iNTeg-Risk Project. Such database will facilitate stakeholders across the broad spectrum of industries and organizations in selecting and using those KPIs, which are relevant to their specific case.

Each KPI is inserted into the database according to a defined template covering various relevant aspects for application in Emerging Risk Management. Users can also insert new KPIs. The database also visualizes the KPIs grouped under a particular framework (e.g. IRGC, ERMF) and area (e.g. business, risk).

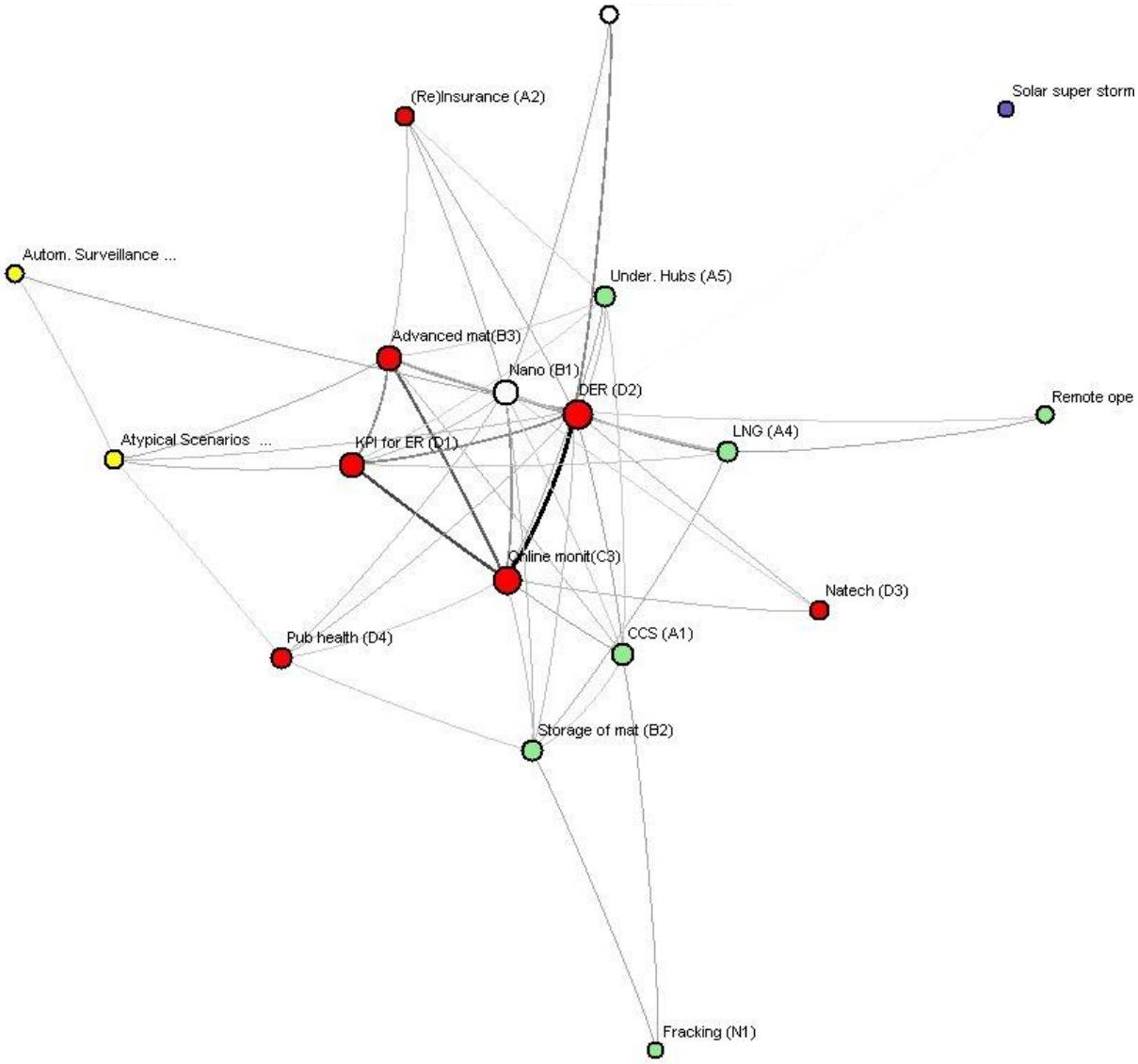


Figure 30: Example of Step 5: S-RDI analysis for "Fracking" topic from Unconventional Gas in connection with risk explored in iNTeg-Risk, indicating links with carbon capture and storage, underground storage dangerous materials, public health, LNG…

5.12 ENISFER

The European Network of Industrial Systems and Facilities for Exploration of Emerging Risks (ENISFER) offers a wide range of services to industry and the European Community for the study and expertise on conventional and emerging technology-related risks. It includes interested reference research and consulting organizations with facilities, expertise and capacities for the study of emerging risks, such as laboratories dedicated to the study of safety of nano materials, renewable energies, NaTech risks [45] etc. Organizing these reference institutes in a network with

an easy flow of information and making this expertise visible and available to the industry and the European Commission and/or other public bodies is a key objective of ENISFER.

ENISFER is practically implemented through a set of tools allowing for an easy access to and management of human and technical resources, knowledge and information relevant for the operation of ENISFER. The ENISFER stakeholders benefit from the alliance of its partners and its broad geographical and technological extension.

ENISFER provides means for industry and relevant stakeholders to better identify and monitor emerging risks by sharing information regarding occurrences, concerns and scientific evidences. The network is in a position to launch alerts and stimulate the scientific community to address these emerging risks.

5.13 MethodsMart

MethodsMart in 1StopShop contains methods possibly applicable for emerging Risk analysis organized in 4 different groups (in brackets number of methods currently available are given):

- General Methods (27)
- Failure analysis Methods (17)
- Application-oriented Methods (22) and
- Alternative Methods (45).

Table 3: Collection of methods available for analysis of emerging risks as collected in the MethodsMart of 1-Stop-Shop

Methods described and partly supported in 1-Stop-Shop		
General Methods		
Bayesian Analysis Brainstorming Checklists Decision Tree Delphi Techniques Environmental Risk Assessment Formal Safety Assessment (FSA)	General Statistical Functions Human reliability analysis Markov analysis (IEC 61665) Method of Steuer Missing values Monte Carlo MOSAR Probabilistic Safety Assessment	Qualitative Risk Analysis Quantitative Risk Analysis Rapid Risk Ranking/Screening Scenario Analysis Signal Processing Structured or Semi-Structured Interviews SWIFT
Failure analysis Methods		
Bow Tie Analysis Cause and Consequence Analysis Cause and Effect Analysis Consequence/Likelihood Matrix Digraph/Fault Graph Dynamic Event Logic Analytical Methodology	Dynamic Event Tree Analysis Method Event tree analysis Failure mode and effect analysis (IEC 60812) // Failure mode, effect and criticality analysis (IEC 60812) Fault tree analysis (IEC 61025)	HACCP LOPA Preliminary hazard analysis Root Cause Analysis
Application-oriented Methods		
Business Impact Analysis Chemical Exposure Index Fire and Explosion Index	Hazard and operability studies (HAZOP) (IEC 61882) Reliability centred maintenance (IEC 60300-3-11) [30]	Risk-based inspection (RBI) Safety Management Organization Review [27] [28]
Alternative Methods		

Methods described and partly supported in 1-Stop-Shop		
Analytic Hierarchy Process (AHP)	Hierarchical Trade-offs "Intelligent" Analysis components	Multilayer Perceptron (neuronal network)
Conjunctive Method	Kohonen Feature Map (neuronal network)	Parametric Method
Cross-Impact Balance Analysis	Lexicographic Method	Precautionary vs. Evidence-Based Approaches
Disjunctive Method	Linear Assignment Method	Psychometric paradigm
Distance from Target	Management Oversight Risk Tree	Scenario Planning
Dominance	MAXIMAX	Simple Additive Weighting Method (SAW)
Eigenvector Method	MAXIMIN	Sneak Circuit Analysis
ELECTRE	Method of Geoffrion	STEM
Elimination by Aspects	Morphological analysis	SWOT Analysis
Fuzzy C-Means	Multi Attribute Decision Making	TOPSIS
Fuzzy Kohonen network	Multi Criteria Decision Making	Utility Function
Fuzzy Rule Base	Multi Objective Decision Making	Weighted Product
Global Criterion Method		
GO method		
Goal Programming		

5.14 Agent Based Models

Purpose: Agent Based Models (ABMs) are a class of computational models simulating (inter-) actions of individual agents and their environment. The focus lies on understanding, reproducing and predicting complex patterns of the entire system from the individual agents' behavior. It is also the easiest route to model systems exhibiting path dependence, memory, fractal behavior and other complex phenomena. They are especially suited if one is interested in systemic, large scale properties (macro-level) of systems composed of a large number of heterogeneous, interconnected stakeholders.

Functionality: Each agent is an autonomous decision-making unit. The agent evaluates his situation and takes actions based on a pre-defined set of rules.

> Step1: The first point is to identify the relevant agents or key stakeholders and get a theory of their behavior. *An important principle to bear in mind at this point is parsimony. One should only include those agents with the largest influence or importance*. Each agent is to be described by a set of quantifiable properties which can be used to express the agent's utilities and payoffs.
>
> Step 2: The next step in developing an ABM is to identify relations between the agents and get a theory of their interactions. Again, this should be done in a *parsimonious way* by including only key relations which can be quantified. It is crucial to validate the agent behavior and interaction models with real-world data.
>
> Step3: To this end data needs to be acquired from reliable and unbiased data sources. This data should be fit to allow comparison with the model data in order to validate the ABM. Social web mining techniques offer an interesting avenue to explore data acquisition and model validation of ABMs.

Output Analysis: The model's output should be analyzed in terms of linking individual agent behavior to large scale patterns of the system. *Special attention has to be paid to the robustness of these large-scale patterns with respect to changes in model parameter*.

If these patterns are robust and not sensitive to special choices of model parameters and assumptions, one can attempt to draw conclusions to the real-world problem from the model. If successful, ABMs can play a vital and important role in singling out key factors and components in complex scenarios with a vast number of interdependent entities.

The general strategy in conducting simulations of "What-If" scenarios is to initialize the simulation and simulate a couple of time steps. One may then re-adjust some agent properties and observe the consequences.

ABMs have to be developed on a case-by-case basis for specific problems. To give a better idea of this process it is instructive to look at a concrete example of agent-based modeling in the case of public acceptance of Terahertz Technology.

Example: An ABM for perception of emerging risks related to Terahertz Technology.

In the scenario of Terahertz Technology five (sets of) agents can be identified

- Public individuals or passengers,
- Industry or Terahertz Technology manufacturers
- Regulators
- Terrorists
- Media

The focus lies on the public, that is, on the passengers. Each passenger holds an internal state indicating his/her current level of acceptance of Terahertz Technology. The agents live on a two dimensional model world where they walk around and engage in discussions with each other. How they change their views of Terahertz Technology depends on three factors:

(i) Their views currently held,

(ii) The views of people they encounter

(iii) External information stemming from media sources about the terrorist threat level, technological efficiency, or the degree of regulation and convenience loss they experience at airports.

The social interactions are modeled following two principles

(i) Peer pressure
Peer pressure implies that individuals tend to conform to group norms, attitude and values and will change their opinions in a way to decrease discrepancies with their peers.

(ii) Bounded rationality
Bounded rationality in this context means that two agents may only influence the other if their initial opinions are close enough to each other.

The idea is that one is more likely to trust another person if he/she comes from a similar background. Another property is that agents have a built-in inertia or "stubbornness" when it comes to changing their opinions.

A high efficiency of Terahertz Technology (that is a vanishingly small number of false positives and negatives at airport security controls) and a high level of terrorist threat increase the probability of public acceptance of full-body scanner. A high degree of regulation or a high level of perceived infringement of privacy decrease acceptance of full-body scanners. In addition, the agent's stubbornness and the current level of media hype or press coverage surrounding this technology catalyze and re-enforce ongoing trends.

The ABM allows exploring how public risk perception related to Terahertz Technology may change if one of these factors changes.

Assumptions taken to create an ABM were:

(i) The ABM world consists of a two-dimensional grid populated by *N* passengers/agents.

(ii) The grid has $L \times L$ fields and *N* will typically be chosen at the order of L^2 such that there is on average less than one agent per field on the grid.

(iii) Each agent *i* has a continuous opinion state $\sigma_i \in (-1,1)$ with $\sigma_i = -1$ indicating absolute rejection of Terahertz Technology and $\sigma_i = +1$ representing unconditional support

(iv) Initially the agents are randomly distributed on the grid with an opinion state randomly chosen from the range $(-1, +1)$.

The other properties are mapped onto continuous values in the same manner.

(v) Let us denote these properties p_{eff} (efficiency of Terahertz Technology), p_{reg} (degree of regulation), p_{ter} (current terrorist threat level), p_{med} (current level of media coverage), p_{pri} (perceived infringement of privacy) and p_{stu} (stubbornness)

(vi) All these properties p_x are defined over the range $p_x \in (0,1)$ and the actual choice of the properties p_x defines the scenario. One time-step of the ABM consists of the application of the following rules to each agent in a random sequential order.

Rule 1: Movement

An agent is chosen at random, say agent i with opinion stateσ_i. Say the current coordinates of this agent on the grid are (x, y) with $x, y \in \{1, \ldots, L\}$. The agent will then move to one adjacent field (x', y') of its von Neumann neighborhood with equal probability, one of the fields $(x', y') \in \{(x, y+1), (x+1, y), (x, y-1), (x-1, y)\}$ as long as $x', y' \in \{1, \ldots, L\}$.

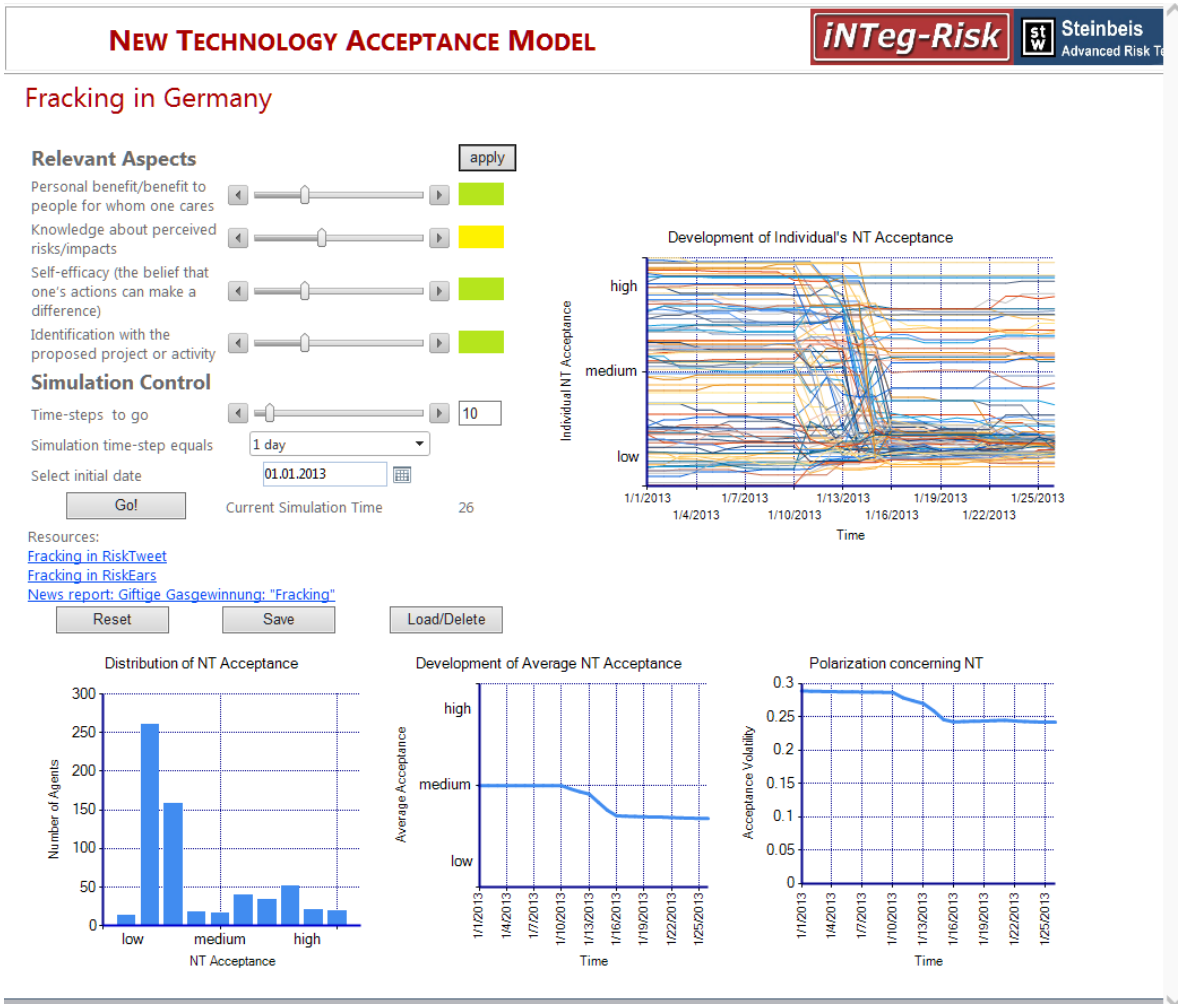


Figure 31: A simulation run leading to total acceptance of Terahertz Technology. The model dynamics of public opinions can be observed in the "Opinion Trajectories" diagram.

Rule 2: Interaction (I)

On the new position (x', y') agent i inspects again his/her von Neumann neighborhood and chooses at random one of the agents which are currently within this neighborhood, say agent j with opinion σ_j is picked. By bounded rationality they only interact if the distance between their opinions is smaller than a given value, say h. In addition if a public debate is currently ongoing, that is media attention p_{med} is high, they are also more likely to interact. Therefore interaction between i and j takes place whenever

$$|\sigma_i - \sigma_j| \leq h + p_{med} .$$

If this is not fulfilled, i chooses another neighbor and checks again if an interaction can take place, and so on.

The social interaction protocol mimics the Kuramoto synchronization model and is implemented as follows. Agent i takes j's opinion into account and updates his own opinion to σ_i' like so,

$$\text{if } \sigma_i < \sigma_j \text{ then } \sigma_i' = \sigma_i + p_{sec} + p_{ter} ,$$

$$\text{if } \sigma_i > \sigma_j \text{ then } \sigma_i' = \sigma_i - p_{reg} - p_{pri} .$$

Note that σ_i' is still bound by $(-1,1)$. Agent i will only accept this new opinion σ_i' if he overcomes his inertia or stubbornness and it satisfies his need to comply with his peers. Let us define the utility function U_i of agent i in interaction with agent j as

$$U_i = p_{stu}(\sigma_i' - \sigma_i)^2 + |\sigma_i' - \sigma_j| - |\sigma_i - \sigma_j| .$$

This function compares a potential increase in compliance with a threshold to overcome one's old opinion. In this model one can also introduce irrational behavior by allowing the agent's to adopt the new opinion with a small probability even if it decreases their utility. To this end define a positive number β as an analog to the physical temperature. We have

$$\text{if } U_i > 0 \text{ then } \sigma_i \to \sigma_i' ,$$

$$\text{if } U_i < 0 \text{ then } \sigma_i \to \sigma_i' \text{ with probability } e^{(-\beta U_i)} .$$

One time-step of the ABM consists of the random sequential application of rules M and I to each agent. The ABM was implemented in Microsoft .NET Framework as a Silverlight application. A screenshot of the application is shown in Figure 31. The properties p_x of the agents can be adjusted with the sliders in the panels labeled "Stakeholders" and "Public/Passengers". They are linked to (in the order top to bottom, left to right) $p_{eff}, p_{reg}, p_{ter}, p_{med}, p_{pri}$ andp_{stu}. The buttons below the sliders allow start/pause and resetting the simulation. There is also the possibility to save or open former runs. The upper right part of the screen shows a dynamic bar diagram of the main opinion clusters of the public. As a general, large-scale pattern, which is robustly observed for a wide range of property values, the agents' opinions tend to cluster into several groups. These clusters or groups of people may then change their opinion states, and merge or separate over time. The general strategy in conducting simulations of "What-If" scenarios is to initialize the simulation and simulate a couple of time steps. One may then re-adjust some agent properties and observe the consequences.

6 Main "lessons learned" resulting from or being confirmed by iNTeg-Risk project

The work performed in iNTeg-Risk has clearly confirmed the concepts suggested in reference works like Graham & Wiener [26], stating that there is a great need for assessing and managing of risk tradeoffs and that these needs have been well recognized, but the practical applications of tradeoff assessment rarely go beyond ad hoc considerations of 2 to 3 risks. Modern world, however, confronted with global threats related to economy, geopolitics, environment, society and technology needs the tool to face the issue of complex risks. That makes the results of iNTeg-Risk project turn into the need for future research in this direction, which will definitely need integrated approaches and good tools for dealing with emerging risks in order to succeed. In fact, the World Economic Forum [7] emphasizes that *"... interconnections among risks means a higher level of systemic risk than ever before*". In other words: overlooking the interdependencies (tradeoffs) is a system is a risk in itself, higher than ever before, and there is an urgent need for an integrated and more systemic approach to risk management and response, both by the public and by the private sector [41] [46]. So far, iNTeg-Risk results fully confirm this position.

Two additional factors are emphasizing the role of tradeoffs. The first one is increased vulnerability of the global economy, environment, social and political systems with respect to "black swan" like events. The second factor are risks from slow failures or the so-called creeping risks, emerging over a long period of time, having potentially enormous impact and long-term implications which can be easily underestimated. The global population growth, ageing and the ensuing rise in consumption, which are typical examples of these risks, can have implications for resources, climate change, health and fiscal policy.

The approach proposed in the project, targets the recognized need to systematically manage risk tradeoffs in modern risk management. It takes as the baseline the cases known from the last two decades in which some of the most well-intentioned efforts to reduce identified ("target") risks actually lead to increasing of overall risks or at least to significant increase of other ("ancillary") risks. These "risk tradeoffs" have often been downplayed as "side effects" or "unintended consequences" - and, even more often, poorly examined, let alone quantified or managed. The experiences from these cases (e.g. estrogen therapy, recycling lead, regulating pesticides or protecting global environment), however, offer an excellent, albeit not fully exploited basis of lessons (not necessarily) learned. And the paper proposes the way how to transfer this experience to the (emerging) risks of new technologies, where, eager to reduce the main target risks and "sell" the technology, the decision makers often fail to explore the full set of possible outcomes.

The global perspective including as many risks as possible is an appealing option, but this may significantly reduce the practical applicability of results. The complexity of the results related to the tradeoffs may be due not only to the complexity of the network, but also due to the need to assess the single tradeoffs differently. In many cases, e.g. in industrial applications looking for "domino effects" [8] a quantitative assessment of the tradeoffs is a possible and usual way.

The above has been largely confirmed in iNTeg-Risk project and the main "lessons learned" of which will be summarized in the final reporting phase of the project.

Starting from

- almost 1,000 emerging risks considered in the project,
- about 200 of them considered in detail, looking at
- over 100 methods potentially applicable, evaluating
- over 30 different recognized frameworks, and contacting and talking to
- over 30 main stakeholders (see chapter 7.4),

the "lessons learned" will be elaborated (and examples provided) in the final report, mainly along the following principal directions:

i. Emerging vs. conventional risks, perceived vs. real risks – false semantics?

   The pre-concepts based on setting a strict limit line between emerging and conventional risks, or distinguishing between the perceived or "real" risks are often misleadingly describing the risks: describing the (lack of) knowledge about the risk is not necessarily describing the risks.

   Example: Differences in definitions used by ISO 31000, ISO Guides 51, 51-2, 73, IRGC…

ii. Likelihood-consequence-emergence vs. uncertainty-complexity-"change-of-context", which metrics should be used?

   iNTeg-Risk has introduced the concept of "emergence" as the 3rd dimension of risk, but has at the same time, on many emerging risks explored, shown that measuring any of the 3 dimensions is a difficult task; in terms of quantitative assessment, the uncertainty-complexity-"change-of-context" does offer not much easier solutions, but it offers more consistency on the qualitative, descriptive level.

   Example: Differences in notion assessments (by different experts) in iNTeg-Risk RiskEars system.

iii. All risks are multiple risks, where is the risk horizon?

   The iNTeg-Risk tools like S-RDI have shown that the interrelationships among all the risks exist, identifiable and even "measurable" (in terms of semantics, at least); the horizons must set (e.g. in terms of risks kept on the horizon/"radar", or in terms of time horizon) and the balance between the principles and practicality agreed.

   Example: Linking "everything with everything" in S-RDI blurs the conclusions.

iv. Periphery vs. focus (real risks of the future are in the trade-offs), should one "focus onto the periphery"?

   Peripheral view on emerging risks is more important than the focused one – the new risks arise on the periphery of the horizon, over-focusing, therefore, can be damaging.

   Example: Results of DYPASI application in iNTeg-Risk.

v. This is not my risk, this is my risk – who is the owner of emerging risks?

   The project has clearly shown reluctance of "official institutions" to look at the emerging risks, not already in the respective "mandates" of the respective institutions. Even insurance industry, which by its nature should be interested in new risks, often preferred to focus on monitoring of known "suspect risks", rather than search for completely new ones. However, once the new/emerging risk is identified, and included into the mandate, the attitude may completely change:

from "it is not my risk" to "hands-off my risks", leading to claiming monopoly over the new risk and information about it.

Example: Emerging risks in the area of occupational safety.

vi. Is (extractive) risk management an emerging risk?

The above may lead to "extractive" management of new risks, i.e. the management excluding real participation and leaving the mandate for a given risks in few hands – this represents a risk in itself.

Example: Emerging risks in the area of environmental risks.

vii. Is inclusion more than participation and using social media?

In their defense, being aware of the new realities (such as social media), the institutions try to open their processes, but the effort is often falling short of real inclusiveness; participation in surveys, commenting web pages and/or "liking or disliking" the institution page on the web is not necessarily meaning including all the stakeholders. For the sake of fairness, it must be said that the whole process is far from having established recognized "rules of the game".

Example: IRGC report (2013).

viii. Who should care about glocal (emerging) risks?

Even international organizations like OECD, UN, ISO or WEF (all contacted in one or the other way during the iNTeg-Risk project), all dealing with global risks, can hardly claim more than a coordinating role in the "global risks business" – their nature of organization and work, precludes their presence and actions on local level. As the consequence, simultaneous coordination of global and local ("glocal") aspects of emerging risks is still a very open issue, making the effective management of emerging risks more complex and difficult.

Example: Volcanic ashes.

ix. Are tools needed/useful, even when imperfect?

iNTeg-Risk has developed a large number of tools, many of which still needing the real use cases and real users in industry and/or institutions (this is a natural consequence of the fact that research in the EU projects like iNTeg-Risk is targeting "pre-commercial" use). But iNTeg-Risk tools have clearly shown that most considerations related to emerging risks in the future will necessarily face the issue of "big data" and that one, in return, cannot be faced in without modern tools. Taking the results from the OCED FGS project as the starting point, further research in the direction of "risk radars-like" tools seems inevitable.

Example: iNTeg-Risk 1StopShop.

x. Is investment in resilience paying more than in, e.g. prevention?

If the consequences/impacts are uncertain, the likelihoods unknown, the emergence difficult to grasp and describe, and the main question is not "will it happen (at all)?", but "when will it happen?", it can be better to invest into the option "how to improve the system response, once when the risk does materialize?".

Example: Solar storms.

Not all of the above directions are "originated in iNTeg-Risk", but they have all been confirmed in the project.

In addition, iNTeg-Risk project has explored the business effects of emerging risks (e.g. on company rating) and shown that these can be modelled (see examples in Table 4 and Figure 32), cf. iNTeg-Risk deliverable D2.8.1. "Solvency II" of Emerging Risks - Rating of emerging risks.

Table 4: Small industrial goods company: Due to problems with a new technology the rating of the company in year 2 is lowered (probability of default increases)

	Without emerging risk				With emerging risk			
Year	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
EBIT/ Interest	BBB	BBB	A	A	BBB	BBB	BBB	A
LTD/ EBITDA	B	BB	BB	BB	B	B	B	B
LTD/ NW	BB	BB	BB	BB	BB	BB	BB	BB

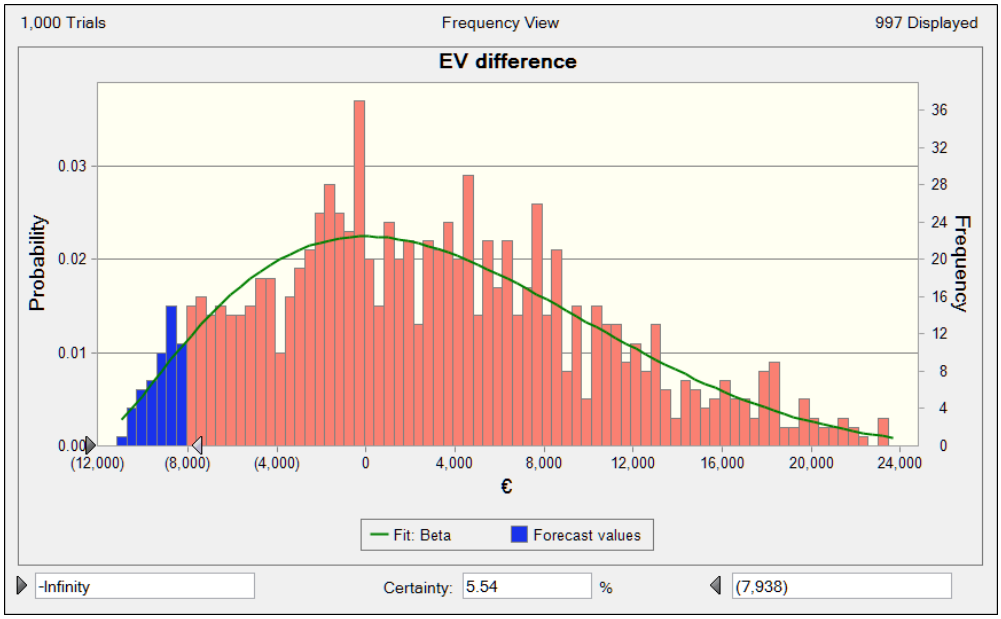


Figure 32: Different scenarios yielding different results and different probabilities of "loosing" or "gaining" due to an emerging risks, due to an emerging threat or a emerging opportunity (e.g. related to the entry into a "green technology")

7 Sustainability of iNTeg-Risk results

7.1 From iNTeg-Risk to E2R2: The European Emerging Risk Radar (E2R2) Initiative

As mentioned above, iNTeg-Risk is a large-scale integrating project aiming at improving management of emerging risks related to "new technologies" in European industry and has proposed a new management paradigm for emerging risks as a set of principles supported by agreed tools and methods all integrated into a single framework. Its goal is to reduce time-to-market for the new technologies "made in EU" and promote safety, security, environmental friendliness and social responsibility as a competitive advantage and a trademark of the EU technologies. The project involves leading EU industries and renowned R&D institutions and it is coordinated by the European Virtual Institute for Integrated Risk Management, the company founded with the goal to ensure sustainable use and exploitation of project results after the project end in May 2013. The E2R2 initiative is one of the ways of achieving this goal.

The European Emerging Risk Radar (E2R2) Initiative is envisaged as a platform enabling to recognize, monitor and manage emerging risks at the European level. Avoiding and mitigating such risks will be a strategic global advantage of the EU (cf. WEF 2011/12/13 Global Risk Reports weforum.org).

The multi-channel inputs for E2R2 are planned to come from (a) experts, (b) research projects, scientific publications, (c) web publications, social/professional networks and (d) general public. Privacy and strict control/protection of data must be ensured. The outputs are also expected to be multi-channel, containing items like monitoring risks in time, delivering alarms and alerts, providing timely and on-the-fly short info about emerging risks (the RiskSpark "2 pager"), statistics, scientific opinions, priority lists (e.g. the "Top 5" lists, e.g. largest risks, largest risks in an application area, fastest growing risks… largest risks for the region…). The Radar should also feed the on-line dynamic newsletters looking at issues like "Risks of the month", "Just appeared" and similar. The Web 2.0 and 3.0 solutions are envisaged for supporting the participative character of E2R2 and an open set of dedicated tools included/linked to it.

The European Emerging Risk Radar Initiative is also envisioned as one of the potential ways to ensure sustainability of the iNTeg-Risk results. The Radar is foreseen to start its operation at the end of iNTeg-Risk project (May 2013). The Initiative will seek endorsement/interaction with stakeholders such as, on the public side, SCENIHR (EU Scientific Committee on Emerging and Newly Identified Health Risks and important players, e.g. Insurer's Chief Risk Officer (CRO) Forum, on the industry side.

7.2 Who should / could be involved?

The E2R2 Initiative is envisaged to be

- open for different types of inputs and stakeholders and, at the same time,
- able to guarantee the right handling of safety relevant information.

The preliminary and very tentative list of possible stakeholders includes the following groups:

- Governmental and EU organizations (e.g. OECD, OSHA, EU Parliament/STOA, EU Scientific Committees like those dealing with health risks, environmental risks or consumer safety, and DGs Health, Enterprise, Energy, Environment, Research, etc.)
- Professional Groups and national and international organizations (e.g. CRO Forum for insurance industry, BBK, RIVM, IRGC, SRA, ESRA, etc.)
- Single industries (e.g. space and aerospace, energy sector, materials, insurance, automotive, etc.) or companies (e.g. EDF, GDF-Suez, ENI, Iberdrola, Swiss Re, AXA, Allianz and others already partners in iNTeg-Risk)
- R&D and academia (e.g. institutions like BfR, KIT, ZIRIUS, BAM, INERIS, CONPRICI, MIT, Harvard, Wharton, etc.)

7.3 Main goal: "Participative / Inclusive Risk Governance" and ...a "recognized reference source of information" about emerging risks

Safety and security are among the sectors so far the least affected by the globalization. There are no real reasons for that. General public will likely require more information about the issues of concerns (e.g. natural hazards, industrial safety, possibly harmful products, etc.), and will also require more ways to take a more active role in establishment and implementation of the safety-related policies in a risk-informed society. In addition, in the "global information jungle", systems like the European Emerging Risks Radar can provide a source of credible and reliable information for the scientific community, industry, SMEs and the general public.

The European Emerging Risk Radar (E2R2) is a framework to serve policy makers and industry as a robust mechanism for proper assessment of emerging risks. Its baseline is to develop a modern, web-based system that will process inputs from different sources and deliver tailored outputs for example a 2-D map of risks on a radar that can be customized or like GIS-Maps that point out to specific risk and their probability as well as their consequences. A prototype model of E2R2 is developed by taking models from iNTeg-Risk project like RiskEars, RiskAtlas and others. Emerging risks are also continuously updated in the list of ERIs and ERRAs and a CEN workshop agreement has been created proposing the process of emerging risk management for new technologies and supporting the principles of a European Risk Radar. E2R2 is accessible for all project participants, but the use is limited only for non-commercial purposes.

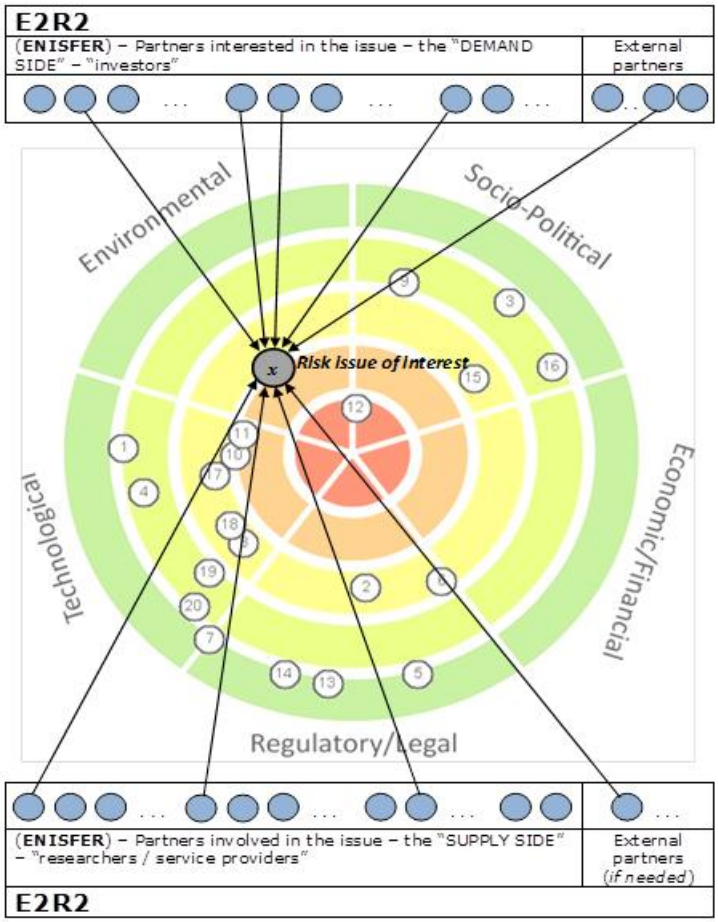


Figure 33: Providing aligned service to collated needs of the market

7.4 iNTeg-Risk "road-show" 2012-2013

In the period 2012-2013 the project results were presented and discussed or are planned to be presented and discussed, to a number of institutions, among them:

- World Economic Forum (Geneva, Switzerland)
- EFG – European Forum Gas (Dresden, Germany)
- EU European Commission, DG ENTER, DG CLIMA, DG ENTER, DG ECHO, DG MARKT, ESO, (Brussels, Belgium) / JRC (Ispra, Italy)
- EU European Parliament, STOA – Science and Technology Options Assessment (Strasbourg/Brussels, France/Belgium), STOA Workshop dedicated to E2R2 Initiative
- EPSC – European Process Safety Center (Warwick, UK)
- CRO Forum – Chief Risk Officers Forum (Hannover, Germany)
- IRGC Workshop – International Risk Governance Council (Geneva, Switzerland)
- World Economic Forum (Geneva, Switzerland)
- ISO – International Standardization Organization (Dublin/Sydney, Ireland/Australia)
- DIN – German national standardization body (Berlin, Germany)
- LUBW – State Institute for Environment, Measurements and Nature Conservation Baden-Württemberg, Germany (Karlsruhe, Germany)
- HSE – Health and Safety Executive, United Kingdom (Buxton, UK)
- KAN – German Commission for Occupational Health and Safety and Standardization (Sankt Augustin, Germany)
- EFSA – European Food Safety Authority (Bologna, Italy)

- UNECE – United Nations Economic Commission for Europe (Geneva, Switzerland)
- BJAST – Beijing Academy of Science and Technology (Beijing, China)
- OECD – High Level Risks Forum (Paris, France)
- DGUV – German accident insurance (Dresden, Germany)

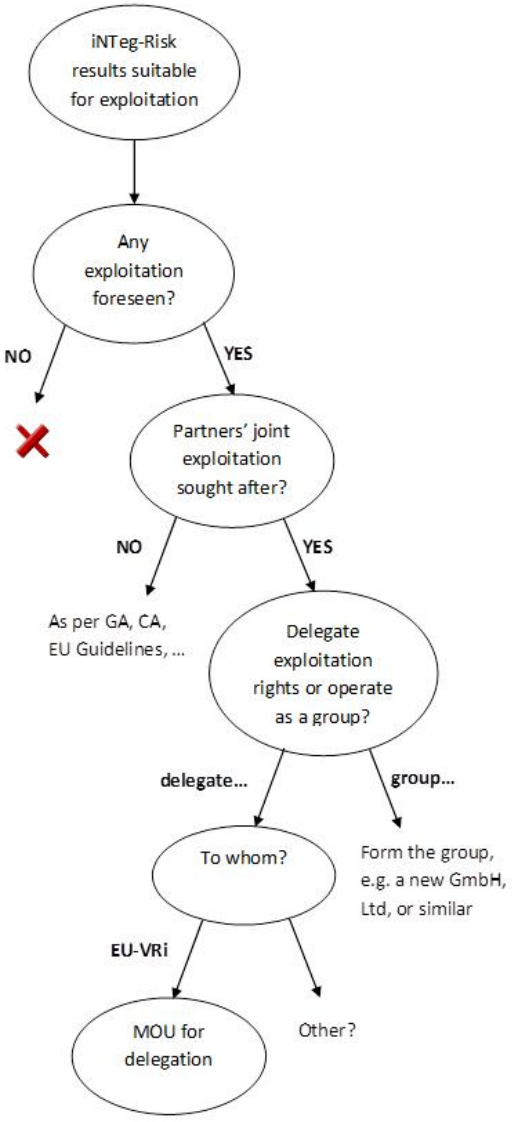


Figure 34: Process of achieving the iNTeg-Risk Memorandum of Understanding

7.5 Exploitation and business plan

The practical exploitation of the iNTeg-Risk results is envisaged to follow the pattern depicted in Figure 33, showing that the core of the service should be a need expressed in the network of partners to look at a given risk issue of interest and, then, the service, e.g. in the sense of further investigation of that risk, would be offered by a group of partners. EU-VRi has been foreseen as the focal point of this process, collating the interest and aligning the parties interested in providing the service.

Achievement of this goal is covered by a Memorandum of Understanding (MoU) among the partners following the process shown in Figure 34.

Use of iNTeg-Risk results is foreseen along the following main lines:

1. Use for future risk radar initiatives (primarily governmental/institutional and insurance applications)
2. Use of single tools for specific problems, such as risk monitoring, e.g. by analyzing social media

3. Use in future research projects

8 Conclusions
Improving resilience of societies and communities exposed to risks emerging from new technologies

8.1 iNTeg-Risk ERMF as the basis for future work

In summary, the considerations related to emerging risks, captured in iNTeg-Risk Emerging Risk Management Framework (ERMF), are based on the following general assumptions:

- The issue of emerging risk has to be made a compulsory part of innovation policies dealing with risk. Innovation risk governance, if done in a systematic and agreed way, does not have to slow down innovation.
- The issue of emerging risks is a very open one – we have neither well established and accepted the culture of discussing emerging risks, nor established overreaching mechanisms to do so.
- The issue of emerging risks is not likely to be closed soon – it will evolve further along with societal developments.

In the perspective of long-term iNTeg-Risk goals, the project contributed a lot in terms of being able to take into account factors like

- specific aspects of emerging risks (i.e. the differences in comparison with conventional risks)
- assessment of the likelihood of the emerging risks in the absence of experience and historical data
- agreed indicators in order to be able to compare the risks dynamically and as they change.

8.2 Resilience – increasing necessity for successful management of emerging risks in the future

The work on the project has clearly shown that the issue emerging risks, i.e. their early recognition, warning and monitoring, will remain the focus of the society for the time to come. The risks characterized by

- a high uncertainty and a lack of knowledge about potential impacts and interactions with risk absorbing systems (targets);
- complexity, emerging interactions and systemic dependencies with the potential to lead to non-linear impacts and surprises;
- dynamic changes in context (societal/behavioral, regulation, environment) that may alter the nature, probability and magnitude of expected impacts,
- and a high degree of ambiguity of what the often fragmented and disconnected insights from the research mean for policy making and risk management,

will be more numerous and more important for the society of the future. But, being aware that all the actions on the ambitious plans of early warning, monitoring and management may still not be enough to prevent the materialization (or simply, the prevention would not pay), in the future one will have to look at the situation "when the emerging risks materialize", i.e. look at the chances to recover, if they materialize.

Therefore, the research in continuation of iNTeg-Risk should look at providing answers to the questions like:

- What are the early warnings indicators/precursors and how can the data stemming from these early warning exercises be included in the policy and risk management processes?
- How can we prepare a prudent response to risks with uncertain impacts while burdened by the uncertainty resulting from new products, services, behaviors or regulation (as a result of social dynamics, including advancing science and technological innovation)?

- How can we dynamically adapt the assignment of responsibilities in the response system to cope with the equally dynamic emergence of threats and changing contexts?
- How can we do the above in particular cases of "poorer countries"?

Even when governance system for emerging risks may seem well established upfront, it may still show to be inadequate and not adaptive enough to external context changes. In particular, traditional risk management systems lack the capability to be adaptive to new insights and new developments, which is crucial for improving the resilience of systems and infrastructures. This has been the case in many crises experienced in last years (volcanic ashes, financial crisis, possible pandemics, Fukushima…).

In the particular case of systems for early recognition, warning and monitoring of emerging risks related to new technologies, the issue could be even more significant. Resilience can be challenged both in terms of the extreme character of the event and by the fact that disasters may come unexpectedly. Current approaches to early recognition, warning and monitoring of emerging risks, however, generally look at anticipated ("imaginable") events and scenarios. As shown by iNTeg-Risk project, even the dedicated methodologies[2] for "unanticipated scenarios" can hardly go much beyond the well-known boundaries and/or anticipated time or spatial frames. For instance, a risk governance/management agency in charge for, say, nanotechnology, may be directed towards monitoring potential health impacts, but may neglect other crucial factors such as public perception or malpractice in some countries which will backfire to the entire industry.

Thus, early recognition, warning and monitoring of emerging risk beyond the boundaries of a sector (e.g. health, food, …) or a country, become a serious challenge. Depending on national risk management styles and sectorial risk policies, one can observe typical silo-effects. Even agencies or organizations developing similar approaches will hardly be able to re-align them once when the approaches are implemented.

All of the above, already a problem in the developed countries, is an even bigger problem in poorer parts of the world, usually lacking the competences and resources needed to deal with emerging risk related to, e.g. imported technologies, be it

- a new application for a "used technology" (e.g. imported new technology for different consumption purposes),
- a new "production technology" (e.g. production site for new products, outsourced to that country), or
- new "infrastructures" based on new or a combination of established technologies (e.g. storage sites for waste, electricity grits, water supply systems).

8.3 Future research priorities

Post iNTeg-Risk research should, therefore, focus onto the development of the foundations for a new risk governance program (processes and structures) that promises to improve the resilience of societies and communities exposed to risks emerging from new technologies, based on the following main elements:

1. Extracting, analyzing and integrating the experience from the projects listed above (iNTeg-Risk, OECD, HLRF, national projects…) and integrating these results into the large body of insights in crisis management and resilience analysis;
2. Integration of technology-related/oriented approaches with the results of social science studies on risk perception and behavior and the insights from cognitive science;
3. Consolidation of well-established and proven principles for information sharing, indicator selection for early warning systems, geographic risk mapping, surveillance and adaptive management;
4. Improved risk communication procedures and protocols;
5. Focus on "proportionate response" that allows the dynamics of innovation to proceed and, at the same time, ensure a cautionary approach to emerging and still fuzzy risks;

[2] *Paltrinieri, N., et al. (2011). Lessons Learned from Toulouse and Buncefield Disasters: From Risk Analysis Failures to the Identification of Atypical Scenarios Through a Better Knowledge Management, Risk Analysis. doi: 10.1111/j.1539-6924.2011.01749.x*

6. Taking advantage of the opportunities linked to "swarm intelligence" by a systematic inclusion of social media for the purpose of early detection, risk mapping and risk evaluation as well as communication and perception.
7. By using these new sources of information and evaluation, addressing the challenges of:
    - multiple players and communication channels;
    - transparency and reliability of social media
    - inclusion of populations segment not covered by social media
    - information hyper-overload
    - Privacy and confidentiality, liability, security issues in a globalized context
    - Managing expectations, defining and avoiding misuse
    - Assessing impact

The new approaches will have to go beyond conventional wisdom of stakeholder inclusion: It is not enough that stakeholders' perception of risks and uncertainties are considered in risk analysis and management (as a means of getting societal acceptance for risk management measures), but that they are a crucial link in the process of adaptive risk assessment and management. Stakeholders act in this approach as observers, witnesses, reporters and responsible partners in detecting, locating and evaluating emerging risks. This is underlined by the use of social media as an important source of information, clustering and evaluation of complex and interconnected phenomena. This is characterized by a typical transdisciplinary, inclusive research approach: Empirical analysis is triangulated with theoretical deductions from previous studies, computer simulation and inclusion of stakeholders and individuals as data mining and interpreting agents.

The two corner stones of the proposed future solutions could be:

1. the results of the investigations in the framework of the "European Emerging Risk Radar (E2R2)" in iNTeg-Risk project, including all the elements of social media use developed there, and
2. new research about the "extractive vs. inclusive solutions" [16] offered by current risk governance systems and their ability to enhance *"…discoveries on key emerging risks in the civil society and foster the confrontation of ideas necessary to advance both research and public debate…"*,

We are convinced that the research will identify and improve many of the "extractive" elements in current emerging risk governance systems and correspondingly improve current practice. "Extractive" in the context of [16] means that the system may hardly take into account the informative and evaluative capacity of stakeholders as one major condition to ensure sustainable solutions and resilience.

8.4 Future tools for managing emerging risks

Most of the current risk detection systems, including the ones developed in iNTeg-Risk project, start with a key signal of a new risk (usually identified by experts, or simple change in parameters monitored in a given system). Once they "know" what they should follow on the radar, they concentrate on the monitoring of the signal trends, intensity or frequency. That means, they can easily miss any "lonely wolf", "black swan" and "tipping point" [17]. Black swans have the property that they are usually not shown in early radar warning systems. That is why we pursue a different strategy that is closely linked to the idea of swarm intelligence. We use the social media with its millions of "intelligent" observers to screen their (familiar) environment for unfamiliar phenomena, distorting developments or strange occurrences. Research on unexpected surprises has clearly demonstrated that each of these surprises was preceded by unusual events or precursors but these signals had not been systematically collected or linked to the risk in question. New semantic data mining programs that automatically scan and order these incoming information and link it to a simulation model that helps us to select the significant signals and distinguish them from noise, are needed. These should be made more reliable and robust insights by using swarm intelligence in a practical context.

The next future innovation in the methodology should be the system-of-system approach. One of the major characteristics of modern technology is the interconnection and interdependence of one technology on other technologies and surrounding context conditions (organizations, behavior, external events). The computer model, developed as part of the iNTeg-Risk activities is organized as a nested risk mapping structure in which each risk source is embedded in a net of connected

geographic (i.e. other risk sources in the neighborhood) and functional factors (i.e. service into and from the risk source into other domains) that can have an impact on the risk. As a result, we have developed an architecture for a system of systems approach in which domino effects and other interrelations between systems can be modeled. At this point, the computer model is still in its early stages, but tests that we made on known risk connections have shown its capability to serve this function.

The third innovation is the inclusion of a "risk communication clearing house" (e.g. on a broader, trans-sectorial level, e.g. health, food, occupational safety… or national/regional levels), in which organized stakeholders and interested individuals can contribute to the evaluation and interpretation of risk signals. In spite of the progresses expected with semantic data mining systems we still believe that, in the end, we need human "brains" to digest the signals and draw from the options available. For these reasons, we have developed a global platform for risk evaluation and interpretation as a means to insert stakeholder values and skills to assist in sense-making of data. Again this process is facilitated by computer models but the essential tasks of interpretation, i.e. assigning meaning to data, are performed in web-based Group Delphi processes. The interplay of computer simulation and direct input from structured group processes promise more reliable and valid results compared to purely computerized agent-based models or interactive group processes alone.

The iNTeg-Risk results provide an excellent basis for the above described future developments. And the development of a system of solutions that will further help risk managers from private and public sectors to scan for potential threats linked with new technologies and to anticipate problems before they become manifest. The proposed concept should be, therefore, included into strategic projects and activities such as those of Horizon 2020, OECD HLRF, EU PPPs, E2R2, SafeFuture and European Technology Platform on Industrial Safety (ETPIS). It will add a convincing solution to the complexity and multi-faceted risk landscape of today and will be more responsive to the fact that in complex systems overall safety cannot be achieved by only adding the "sum of single safeties".

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Annex 1 Deliverables of iNTeg-Risk (until May 2013)

Deliverable Number	Title	Contribution to Big 7
D1.1.2.1	ERD for the Common Template - ERRA Database, for storing intermediate and final results. Includes ERD, database, XML schema for import/export of data	Catalogue of Emerging Risks
D1.1.3.1	Report, meeting protocol including the comments formulated on the proposed template. Validated version of the ERRA template.	Catalogue of Emerging Risks
D1.1.4.1	Report defining different types of users, access authority to data, data categories. Authentication schema will be embedded in ERD.	Risk Radar & 1StopShop
D1.2.1.1	Methodology and models for assessing the emerging risk related with the CO2 capture and storage technology	Catalogue of Emerging Risks
D1.2.2.1	Package of: Solution containing documents, methods and tools, for which the guiding principle is the precautionary principle and preoccupation with failure.	Catalogue of Emerging Risks
D1.2.3.1	Package of: Reference solutions for A3 containing documents, methods and tools - Emerging risks related to the industrial use of automated and un-manned surveillance of industrial infrastructure	Catalogue of Emerging Risks
D1.2.4.1	Package of: Reference solution containing documents, methods and tools, for the assessment and management of emerging risks related to new and intensified technologies available for LNG regasification terminals	Catalogue of Emerging Risks
D1.2.5.1	Package of: Reference solution (A5), containing documents, methods and tools for Safety and Security of underground hubs with interconnected transportation services and shopping centers	Catalogue of Emerging Risks
D1.2.6.1	Package of: Integrated solution for A ERRAs, containing documents, methods and tools.	Risk Radar & 1StopShop
D1.3.1.1	Package of: Reference solutions for B1, containing documents, methods and tools for risk assessment of nano-materials, protection concept, implementation guidelines and a complete worksheet.	Catalogue of Emerging Risks
D1.3.2.1	Package of: Reference solutions for risks related to extreme storage of hazardous materials	Catalogue of Emerging Risks
D1.3.3.1	Package of: Reference solution containing documents, methods and tools for a consistent approach to management of the emerging risks connected with the introduction of new materials into new generation of products and technologies.	Catalogue of Emerging Risks
D1.3.4.1	Integrated reference solutions, Coordination of common input from Topic B for 1st integration - Workshop and Report.	Risk Radar & 1StopShop
D1.4.1.1	Reference solutions for emerging safety risks are related to heterogeneous safety cultures, distributed lines of responsibility, unclear ownership of safety responsibility.	Catalogue of Emerging Risks
D1.4.2.1	C2: Reference solutions to provide confidence that oil and gas can be explored and produced in sensitive areas in a defendable manner by way of integrated operations managed by virtual organizations.	Catalogue of Emerging Risks

Deliverable Number	Title	Contribution to Big 7
D1.4.3.1	Package of: Reference solutions for C3 On-line risk-monitoring and assessment of emerging risks in conventional industrial plants – monitoring of risks beyond the design/regulatory basis	Catalogue of Emerging Risks
D1.4.4.1	Package of: Reference solutions for Atypical, one-of-the-kind major hazards/scenarios (post-Buncefield implications) and their inclusion in the normal HSSE practice	Catalogue of Emerging Risks
D1.4.5.1	Package of: Reference solutions for C5, Security of energy supply and related emerging risks	Catalogue of Emerging Risks
D1.4.6.1	Integrated reference solutions, Coordination of common input from Topic C for 1st integration - Workshop and Report	Risk Radar & 1StopShop
D1.5.1.1	Package of: Reference solutions for D1: Definition of KPIs for emerging risks for selected industry case studies, including CSR aspects of emerging risks	Catalogue of Emerging Risks
D1.5.2.1	Package of: Reference solutions for D2, Four safety visions, Integrated approach on emerging risks related to the implementation of European safety legislation on SME´s and its application on companies working in Distributed Energy Resources (DER)	Catalogue of Emerging Risks
D1.5.3.1	Handbook of Good Practices for the Mitigation of NATECH risks	Catalogue of Emerging Risks
D1.5.4.1	Package of: Reference solutions for Emerging risks related to hazardous substances, impact on public health and relations with REACH and GHS	Catalogue of Emerging Risks
D1.5.5.1	Integrated reference solutions for D ERRAs, Coordination of common input from Topic D for 1st integration - Workshop and Report	Risk Radar & 1StopShop
D1.6.1.1	Report including the following volumes: - develop a questionnaire to ask for the state of the art of emerging risk in the for ERRAS and the needs to regulate them in the future	Risk Radar & 1StopShop
D1.6.2.1	Review report of the reports from ERRAs Topics A, B, C and D, Review procedure, List of reviewers, Comment-sheets of the reviewed reports	Catalogue of Emerging Risks
D1.6.3.1	Final report - extracting a set of reference tools and models from the ERRAs concerned with emerging risk related to technology.	Methods, Handbooks and Guidelines
D1.6.4.1	Topic B report - Common set (IT and paper) of reference solutions, documents, methods and tools	Methods, Handbooks and Guidelines
D1.6.5.1	Topic C Report - Common set (IT and paper) of reference solutions, document, methods and tools	Methods, Handbooks and Guidelines
D1.6.6.1	Report for topic D - Common set (IT and paper) of reference solutions, documents, methods and tools	Methods, Handbooks and Guidelines
D1.6.7.1	Report - Delphi Workshops for Topics A, B, C and D or an alternative method	Methods, Handbooks and Guidelines
D1.6.8.1	Delphi web - Tool for the iNTeg-Risk project	Risk Radar & 1StopShop
D1.6.9.1	Verification procedure report - Integration, scientific coordination and quality assurance in SP1	
D1.7.1.1	Report - ERRA : 1st verification	
D1.7.2.1	Integration with SP2 - liaisoning SP1-SP2	Methods, Handbooks and Guidelines

Deliverable Number	Title	Contribution to Big 7
D1.7.3.1	Integration with SP2 - 1 day workshop #1 (month 3) - together with Delphi Workshop	
D1.7.4.1	Integration with SP2 - 1 day workshop #2 (month 12)	Methods, Handbooks and Guidelines
D1.7.5.1	Integration with SP2 - 1 day workshop #3 (month 24)	Methods, Handbooks and Guidelines
D1.7.6.1	Report - Preliminary catalogue of ERRA facilities candidate for ENISFER (SP3)	Risk Radar & 1StopShop
D2.1.1.1	Definition of the new iNTeg-Risk paradigm: description of the different risks, emerging risks and the way of dealing with emerging risks including the interaction with relevant stakeholders (T-H-C-R)	Framework (ERMF)
D2.1.2.1	iNTeg-Risk ERMF: The Emerging Risk Management Framework	Framework (ERMF)
D2.1.3.1	Report on additional needs	
D2.1.4.1	Common vocabulary for iNTeg-Risk (glossary updated 3 times during the project)	Methods, Handbooks and Guidelines
D2.2.1.1	Common template for preparing the iNTeg-Risk guidelines	
D2.2.2.1	Integration report: Workshop for validating and approving the Guideline Template	
D2.2.3.1	GAP Analysis Report: of collected reference procedures for risk assessment perform gap analysis for the different topics of ERRAs	
D2.2.4.1	Report and model for presenting UML of Emerging Risks Management and domain language	
D2.2.6.1	Report and prototype: Development of an harmonised platform for exchange of info between accident databases originally designed for different purposes	
D2.2.7.1	Integration, scientific coordination and quality assurance in SP2	
D2.3.1.1	Report: iNTeg-Risk Framework Gap analysis to identify missing models and methods	Methods, Handbooks and Guidelines
D2.3.2.1	Best available Models and Methods for integrated risk management (for process developers and engineers)	Methods, Handbooks and Guidelines
D2.3.3.1	Best available Models and Methods for integrated risk management (for plant operators and maintenance staff)	Methods, Handbooks and Guidelines
D2.3.4.1	Guide for using relevant decision methods for integrated management of uncertain risks	Methods, Handbooks and Guidelines
D2.3.5.1	Applied guide for uncertainty treatment in integrated risk management of emerging risks	Methods, Handbooks and Guidelines
D2.3.6.1	Best available Models and Methods for governance and communication of emerging risks	Methods, Handbooks and Guidelines
D2.3.7.1	Model for the perception of Emerging Risks	Methods, Handbooks and Guidelines
D2.3.8.1	Models of Emerging Risks process based on bio-inspired models	Methods, Handbooks and Guidelines
D2.3.9.1	Guidelines for Life-Cycle Methods and Tools for Emerging Risks	Methods, Handbooks and Guidelines

Deliverable Number	Title	Contribution to Big 7
D2.3.10.1	CMMI-adapted approach for Emerging Risks with the set of criteria for assessment and guideline for application	Methods, Handbooks and Guidelines
D2.4.1	iNTeg-Risk ERMF: Active catalogue of KPIs for Emerging Risks and methods on how to build iNTeg-Risk KPIs	Emerging Risks Key Indicators
D2.4.1.1	Set of Key Performance Indicators related to technological issues	Emerging Risks Key Indicators
D2.4.2.1	Set of Key Performance Indicators for risk governance and communication	Emerging Risks Key Indicators
D2.4.3.1	Set of Key Performance Indicators for human aspects and management	Emerging Risks Key Indicators
D2.4.4.1	Set of Key Performance Indicators related to policies, regulation and standardization	Emerging Risks Key Indicators
D2.4.5.1	Guideline to build alternative Key Performance Indicators	Emerging Risks Key Indicators
D2.4.6.1	Report: Good Practice Guideline for Structuring KPIs at different levels of aggregation	Emerging Risks Key Indicators
D2.4.7.1	Report: Guideline for collecting/inquiring data for KPIs	Emerging Risks Key Indicators
D2.4.8.1	IT Tool: Decision Support System based on KPIs	Emerging Risks Key Indicators
D2.5.1.1	Main chapter of the Handbook for Emerging Risks (Recommended Practices) and Recommended Practices IT	Methods, Handbooks and Guidelines
D2.5.2.1	Recommended Practices to identify and evaluate uncertainties in the assessment of emerging risks	Methods, Handbooks and Guidelines
D2.5.3.1	Tools: Part of the Handbook- Perform data mining for emerging risks assessment	Methods, Handbooks and Guidelines
D2.5.4.1	Report: Part of the Handbook- NaTech, common and systemic factors (including external hazard factors)	❸ Methods, Handbooks and Guidelines
D2.5.5.1	Recommended Practices to assess human factor performance taken in its organisational context	Methods, Handbooks and Guidelines
D2.5.6.1	Report: Part of the Handbook- Environmental impact assessment and sustainability assessment	Methods, Handbooks and Guidelines
D2.5.7.1	Verification and Report: Stating the paradigm-coordination and integration of Recommended Practices	
D2.6.1.1	Guidelines for Emerging Risk Pre-Assessment	Methods, Handbooks and Guidelines
D2.6.2.1	Guidance for Emerging Risk Appraisal	Methods, Handbooks and Guidelines
D2.6.3.1	Guidance for Emerging Risk Management	Methods, Handbooks and Guidelines
D2.6.5.1	Guideline on Environment Issues of Emerging Risks (early consideration of environmental aspects in planning process for new technologies / new production systems)	Methods, Handbooks and Guidelines
D2.7.1	iNTeg-Risk - Data assessment and consolidation	Risk Radar & 1StopShop
D2.7.1.1	Catalogue of verified data sources for emerging risks	Risk Radar & 1StopShop

Deliverable Number	Title	Contribution to Big 7
D2.7.2.1	Report / Method: Criteria for producing data / missing data	Risk Radar & 1StopShop
D2.7.3.1	Report: Guideline for use of alternative data for emerging risks	Risk Radar & 1StopShop
D2.7.4.1	Web-database for data produced in the ERRAs and other tasks in iNTeg-Risk	Risk Radar & 1StopShop
D2.7.5.1	Creation of a web-based documentation of data sources used/verified in iNTeg-Risk	Risk Radar & 1StopShop
D2.8.1	"Solvency II" of Emerging Risks - Rating of emerging risks	Risk Radar & 1StopShop
D2.8.1.1	Report: Definition of principles of rating and benchmarking - basic document	Risk Radar & 1StopShop
D2.8.2.1	Report on Pillar I: Minimal quantitative requirements - legal, standard, Safety, protection layers, tech. maturity mismatches, Internal/external responsibility and hedging (owner of emerging risks)	Risk Radar & 1StopShop
D2.8.3.1	Report: on Pillar II, supervision and review process for the application of ERR	Risk Radar & 1StopShop
D2.8.4.1	Report: on Pillar III- giving the basic definition and ground for disclosure and transparency requirements	Risk Radar & 1StopShop
D3.1.1.1	Report on automatic report generation and its external validation	Catalogue of Emerging Risks
D3.1.2.1	Demonstrator: Extended A3: Verification example for automated aerial surveillance on 10 km and 50 km energy transmission pipelines	Catalogue of Emerging Risks
D3.1.3.1	Validation example: practical solutions in using ERMF and iNTeg-Risk approach and tools for LNG regasification plant	Catalogue of Emerging Risks
D3.1.5.1	C1: Validation example : Results of the implementation of guidance for human performance assessment in an organisational context.	Catalogue of Emerging Risks
D3.1.6.1	Demonstration of (C3) practical, On-line risk-monitoring and assessment of emerging risks in conventional industrial plants - monitoring of risks beyond the design/regulatory basis	Catalogue of Emerging Risks
D3.1.7.1	Demonstrator report: Validation examples of implementation of the Guideline of Integrated Risk Management Framework in several SMEs.	Risk Radar & 1StopShop
D3.1.8.1	Validated example set of Material Safety Data Sheets (MSDS) for Nano-Materials with special focus on emerging risk character of nano-enhanced material	
D3.1.9.1	Demonstrator report: Best implementation competition for NEW ERRAs; competition will be launched for the most attractive implementation	
D3.1.11.1	Reports/Notes on Biogas safety and regulation	Catalogue of Emerging Risks
D3.1.12.1	Space based technologies and potential global shocks/threats	Catalogue of Emerging Risks
D3.1.13.1	Robust infrastructures, based on nanotechnology	Catalogue of Emerging Risks
D3.1.14.1	Reports on occupational Risk in electricity producing systems	Catalogue of Emerging Risks

Deliverable Number	Title	Contribution to Big 7
D3.2.1.1	Verification / validation, report and results using the integrative ERRA #1	Catalogue of Emerging Risks
D3.2.2.1	Case study report: Application of ERMF and iNTeg-Risk approach and tools	Catalogue of Emerging Risks
D3.2.3.1	Application of the ARIPAR - like tools for land - use planning	Catalogue of Emerging Risks
D3.2.4.1	Decision making aiding tool - content to work flow policy. Transfer into concrete decision – making tools and regulations of the results	Catalogue of Emerging Risks
D3.2.5.1	Issuing the WP report on the integrative ERRA in the Emilia Romagna Region	Catalogue of Emerging Risks
D3.3.1.1	Selection of representative plants and data acquisition to demonstrate concepts developed in iNTeg-Risk	Catalogue of Emerging Risks
D3.3.2.1	Application of ERMF and iNTeg-Risk approach and tools for plant #1	Catalogue of Emerging Risks
D3.3.3.1	Application of ERMF and iNTeg-Risk approach and tools for plant #2	Catalogue of Emerging Risks
D3.3.4.1	Application implementation of ERMF and iNTeg-Risk approach and tools for Plant # 3:	Catalogue of Emerging Risks
D3.3.5.1	Application of ERMF and iNTeg-Risk approach and tools for Plant # 4:	Catalogue of Emerging Risks
D3.3.6.1	Integration of selected risk sources by using ARIPAR	Catalogue of Emerging Risks
D3.4.1.1	Data necessary for tasks realization.	Catalogue of Emerging Risks
D3.4.2.1	Assessment report on ERMF application	Catalogue of Emerging Risks
D3.4.3.1	Document summing up the ERMF management system applied on chemical plant HIP-Azotara.	Catalogue of Emerging Risks
D3.4.4.1	Demonstrate: Application of the ARIPAR - like tools for land - use planning	Catalogue of Emerging Risks
D3.4.5.1	Final Report - Integrative ERRA #3	Catalogue of Emerging Risks
D3.5.1.1	ERRA database for including ENISFER database	
D3.5.2.1	Report on public health aspects of Emerging Risks related to long-term effects	
D3.6.1.1	Report: Verification of nano - storage/explosion models on experimental facilities	
D3.6.2.1	Case study: ERMF in - silica applications to large underground coal - storage	
D3.6.3.1	Benchmarking results	
D3.7.3.1	ERRA A3 RTD extension: Evaluation of prototype threat detection system for automated pipeline monitoring based on object recognition and related emerging risk aspects	Catalogue of Emerging Risks
D3.7.5.1	Software and pilot system for advanced on-line risk monitoring for petrochemical plant	Catalogue of Emerging Risks
D3.7.8.1	Consolidated iNTeg-Risk Vocabulary	Risk Radar & 1StopShop
D4.1	Report on 1StopShop and related activities	Risk Radar & 1StopShop
D4.1.1.1	E-Document, case study of New Technology (T) which is seamlessly integrated to the One Stop Shop.	

Deliverable Number	Title	Contribution to Big 7
D4.1.2.1	E-Document, case study of Governance & Communication (C) which is seamlessly integrated to the One Stop Shop.	
D4.1.4.1	E-Document, case study of Policies, Regulation, Standardization (R) which is seamlessly integrated to the One Stop Shop.	
D4.1.5.1	Integrate and demonstrate all 4 dimensions (T-C-H-R) cases in the One-Stop Shop section over the web.	Risk Radar & 1StopShop
D4.1.6.1	Sustainability policy for cases within the One-Stop Shop	Risk Radar & 1StopShop
D4.2.1.1	IT structure - Operational Safetypedia, Tool for Import/Export mechanism form common database, XML schema for data exchange, E-Document template	
D4.2.3.1	Report - access policy on different levels (public to experts), to ensure sustainability of project and continues content management	Risk Radar & 1StopShop
D4.3.1.1	Report on suitability of KPIs models, recommendations for integrating of risks and factors, recommendations for emerging risks Input from Risk Observatory to other work packages	
D4.3.2.1	Demonstrate the Network Infrastructure for the Emerging Risks Monitoring Network System	Risk Radar & 1StopShop
D4.4.1.1	Review of decision-making methods recommendations, specification for the implementation of a DSS-KPI.	Risk Radar & 1StopShop
D4.4.2.1	Report: KPIs as criteria in decision making	Risk Radar & 1StopShop
D4.4.3.1	Report: Approved/revised set of (benchmarking) KPIs as input for software specification.	Risk Radar & 1StopShop
D4.4.4.1	Report: Software specification and min. requirements of DSS-KPI	Risk Radar & 1StopShop
D4.4.5.1	DSS-KPI (Decision-support-system based on KPIs) software tool as part of the iNTeg-Risk tools	Risk Radar & 1StopShop
D4.4.6.1	Report: DSS-KPI beta field testing and feedback	Risk Radar & 1StopShop
D4.4.7.1	Report: DSS-KPI set of benchmarking cases	Risk Radar & 1StopShop
D4.4.8.1	Report: Assuring technical sustainability of DSS-KPI	Risk Radar & 1StopShop
D4.5.1.1	iNTeg-Risk Virtual library	Risk Radar & 1StopShop
D4.5.2.1	Report and demonstration of text mining tool	Risk Radar & 1StopShop
D4.5.3.1	Exploitation and management agreement to use the results of the project	Risk Radar & 1StopShop
D4.6.1.1	The web on-line implemented IT tools in aspect of the New Technology (T) of Emerging Risk	Risk Radar & 1StopShop
D4.6.6.1	Demonstrate the Emerging Risk Tools on-line web site for risk assessment of 4 dimensions, operational understanding and impact analysis. Link with Safetypedia, Risk Atlas and external tools	Risk Radar & 1StopShop
D4.6.9.1	Set of IT infrastructure tools for the benefit of Content Management of the 4 dimensions	Risk Radar & 1StopShop
D4.7.2.1	Demonstrate Risk Atlas based on GIS engine and visualize Emerging Risks by defined categories with their assesment data.	Risk Radar & 1StopShop

Deliverable Number	Title	Contribution to Big 7
D4.7.5.1	Report on the application of a case study on the Risk Atlas	Risk Radar & 1StopShop
D4.8.1.1	Define portal structure of all aggregated One-Stop Shop and related external tools.	Risk Radar & 1StopShop
D4.8.2.1	ERD for the One-stop Shop of iNTeg-Risk - the main deliverable repository structure of the project- providing the communication basis for integration	Risk Radar & 1StopShop
D4.8.3.1	Provisioning report of the One-Stop Shop including internal sources and external data sources.	Risk Radar & 1StopShop
D4.8.4.1	Report on One-Stop Shop - Business model case - Business plan	Risk Radar & 1StopShop
D4.9.1	CEN Workshop Agreement "Managing emerging technology-related Risks"	iNTeg-Risk CWA
D4.9.1.1	Business Plans and operating agents for identified CEN WA	iNTeg-Risk CWA
D4.9.2.1	CEN WA #1 General ERMF Guideline	iNTeg-Risk CWA
D4.9.3.1	CEN WA #2 Emerging Risks in New Technologies	iNTeg-Risk CWA
D4.9.4.1	CEN WA #3 Emerging Risks in New Materials and Products	iNTeg-Risk CWA
D4.9.5.1	CEN WA #4 Emerging Risks in New Production and Production Networks	iNTeg-Risk CWA
D4.9.6.1	CEN WA #5 Emerging Risk Policies	iNTeg-Risk CWA
D4.9.7.1	CEN WA #6 Emerging risks due to uncertainties in testing procedures	iNTeg-Risk CWA
D4.9.8.1	Report on liaisoning activities with relevant Technical Committees at ISO & CEN	iNTeg-Risk CWA
D4.10.7.1	Demonstrate Nano Technology example on the cases web site - Operational NANOMATERIAL RISK TRAINING WEB SITE	
D5.1.1.1	Annual management report (starting from year 1)	
D5.1.2.1	Annual reports on specific transversal management (promoting integration) by senior managers for industry, SMEs, communication and standardization (from year 1)	
D5.1.3.1	Annual management and periodic reports to the EU (Month 12, 24, 36, 48, 54), including if the minutes of the Exc. Board and IAB meetings and Final project report	
D5.1.4.1	IT, Quality assurance, Secretariat	
D5.1.5.1	Annual report of the meetings of the International Advisory Board (once a year, M9, M21, M33, M45 and M52)	
D5.1.6.1	Executive Board meetings (as needed) and General Assembly (annual)	
D5.1.7.1	Annual report on Pre-existing know-how and IPR management	
D5.1.8.1	Annual report on measures related to the Consortium Agreement (starting from year 1)	
D5.1.9.1	Project Risk management reports (annual report starting from year 1)	
D5.1.10.1	Financial statements (annual reporting starting from year 1)	

Deliverable Number	Title	Contribution to Big 7
D5.1.11.1	Mandatory deliverable (every 12 months), comprising of Updated audited financial documents, Explanation on the use of resources during the period concerned and Explanation of the work carried out during the period concerned	
D5.2.1.1	Common IT infrastructure: Web - based project management tool	
D5.2.2.1	Common IT infrastructure: Web - based collaborative tools including blogs and forum to share information, data, ideas among the partners	
D5.2.3.1	Common IT infrastructure: Web - based conferencing	
D5.2.4.1	Common IT Infrastructure: Web - based Quality Management System	
D5.2.5.1	IT structure available for project management and project execution	
D5.3.1.1	Publication activities report iNTeg-Risk newsletter, journals, leaflets, magazines, web (annual report starting from year 2)	
D5.3.2.1	Liasoning reports (annual report starting from year 2)	
D5.3.3.1	Organization of specific education activities based on iNTeg-Risk results: summer schools, workshops, seminars dedicated to the use of training tools developed within the project (annual report starting from year 2)	
D5.3.4.1	1st iNTeg-Risk International Conference	
D5.3.5.1	2nd iNTeg-Risk International Conference	
D5.3.6.1	3rd iNTeg-Risk International Conference	
D5.3.8.1	Liasoning reports (annual report starting from year 2)	
D5.3.9.1	Liasoning reports (annual report starting from year 2)	
D5.3.10.1	Report of the Workshops for the dissemination of iNTeg-Risk project among the National Technical Platforms on Industrial Safety (annual report starting from year 2)	
D5.3.11.1	Liasoning reports (annual report starting from year 2)	

Annex 2 Emerging risk scenarios tackled within the project

A.2.1 ERIs (detailed analysis)

Acronym	Short name	ERI name
a1.01	CO2 release - installations	Potential release of large quantities/flow rates of CO2 from surface CCS installations
a1.02	CO2 release- underground storage	Potential release of large quantities of CO2 from underground storage
a1.03	CCS and Climate change	Failure to establish the new emerging technology of CCS would contribute to climate change and global warming
a2.01	Smart grids	Potential to change the risk landscape for re/insurers by introducing a new information technology component to the electric grid
a2.02	Privacy theft of personal data	Privacy/theft of personal data in companies
a2.03	Counterfeit parts	Counterfeit (bogus/falsified) parts in the aviation industry and other luxury goods leading to potential impact on insurance
a2.04	Cyber vulnerability	Potential huge impact due to cyber vulnerability (Critical Information Infrastructure breakdown)
a2.05	Emerging infectious diseases	Emerging infectious diseases in new regions and population segment drivers
a2.06	Space debris	Operational risks to spacecraft and satellites due to debris in orbit
a2.07	Hydrogen technology	Life cycle of the new hydrogen fuel cell infrastructure (filling stations, pipelines) includes a range of emerging risks from utilizing nanotubes for hydrogen storage to composites storage
a2.08	Misuse of / resistance to antibiotics	Misuse of antibiotics in the medical sector as well as in the animal production industry has supported the growth of microbes that are resistant to one or many antibiotics.
a2.09	Malicious effects - Nano-technology	Nanotechnology have produced products with smaller than the usual structures that are interacting both with the environment and humans in an unpredictable manner potentially causing malicious effects
a2.10	Gradual bodily injury	Gradual bodily injury
a2.11	Polluter held liable	Polluter held liable
a2.12	Private robots	"Private robots" can replace a huge number of human workers.
a2.13	Pervasive computing side effects	Potential side effects on human health, social behavior and the environment due to Pervasive computing
a2.14	Rapid manufacturing	Rapid manufacturing
a2.15	Terahertz Technology	Usage of terahertz technology risks to leave travelers frustrated and to have a negative impact on air flight business
a2.16	Complex working practices	Complex working practices
a2.17	Flexible working patterns	Flexible working patterns
a2.18	Gene therapy side effects	Gene therapy can cause risks like Immune response, viral spread, possibility of tumor induction.
a2.19	Human performance enhancement technologies	Technologies for human performance enhancements (human brain may be able to include cyborg implants in its representation of the body)
a2.20	Hydrogen economy	Hydrogen economy - General

Acronym	Short name	ERI name
a2.21	Geomagnetic storms impact to energy systems	Geomagnetic storms can impose a change as high as 7 Volts per kilometer, this electrical energy gradient if it is accompanied by electrically resistant ground can cause geo-magnetically induced currents (GIC).
a2.22	Deepwater Drilling	Deepwater Drilling linked to the Deepwater Horizon Incident
a3.01	Failure/loss of control of UAVs	Critical Drone Failure and loss of control of UAVs
a3.02	Image collection & pre-processing issues	Image collection by UAV and pre-processing issues
a3.03	Image processing inefficiency	Automated image processing inefficiency
a3.04	Regulatory acceptance of UAVs	Acceptance by Civil aviation authorities of operational drone flights
a3.05	Societal acceptance of UAVs	Societal acceptance issues related to the use of UAVs (Unmanned Aerial Vehicle)
a3.06	UAV surveillance	Automated industrial surveillance improves pipeline risk management
a4.01	Unknown scenarios for LNG terminals	Lack of understanding of typical risk scenarios for LNG terminals
a4.02	Major hazards caused by external factors	Assessment of credible scenarios and damage areas related to major events caused by external factors
a4.03	Lack of common risk criteria	Lack of common criteria across the countries and ensuring consistency in the assessment and trust of the local stakeholders in the correctness and completeness of the decisions
a5.01	Volatility of volume of passengers (hubs)	Passenger volume heavily influence the results and extent of damage in hubs
a5.02	Errors in escape route design (hubs)	Escape route design for hubs
a5.03	Underground ventilation (hubs)	Ventilation systems for underground hubs
a5.04	Orientation in underground hubs	Orientation in underground hubs covers all different aspects of localization and communication of locations
a5.05	Communication in underground hubs	Communication is critical in complex infrastructures with growing complexity and the increasing number of stakeholders in underground hubs
b1.01	Nano-technology based industry	Rapidly developing 'nano-technology' based industry
b1.02	Nano-materials release during life-cycle	Nano-materials could be released during life-cycle
b1.03	Unknown Hazards/risks - Nanotechnology	Objective knowledge of hazards/risks due to nano-technology
b2.01	Large emissions of smoke (storage)	Risks caused due to large emissions of smoke
b2.02	Large masses of CO2 (storage)	Risks related to Large masses of highly concentrated CO2
b2.03	H2 underground storage	Large scale storage H2 underground, keeping the cost of such operation as low as possible and to avoid leaks of hydrogen
b2.04	Excessive Underground fires (storage)	Perfectly sealed storage of hazardous wastes underground thus preventing emissions of potentially harmful material
b3.01	Complexity & toxicity-advanced materials	Complexity and toxicity of advanced materials – composite materials

Acronym	Short name	ERI name
b3.02	Lack of material performance	Lack of relevant composite materials' performance information hinders the specification of composite materials
b3.03	Lack of product performance	Standards for composite products should be more appropriate to ensure product performance
b3.04	Side effects – use of advanced materials	Lack of sufficient database of mechanical/material behavior (unknown / side reactions) of advanced materials during exploitation phase.
b3.05	Unknown use cases of advanced materials	Use of Advanced material which has new physical and chemical properties may cause undesired results
b3.06	Car breaks fine dust	Lack of investigation and monitoring of car breaks dust in urban air pollution
b3.07	Nano-based advanced materials	Effect of size, shape and surface area of nano-materials on human health
b3.08	Nanomaterial induced DNA damage	Mechanisms of nanomaterial induced DNA damage
b3.09	Lack of data - nano materials & products	Lack of data on environmental impacts of nano-materials and nano-products might cause serious problems.
b3.10	Alignment of techniques & standards	Difference in the measurements techniques and identification standards may lead to different material properties description/values
b3.11	Lack of investment in facilities	Manufacture of composites requires investment by suppliers in new manufacturing facilities
b3.12	Lack of investment in R&D	Relatively high costs of advanced materials applications can limit amount of investment made in R&D compared to other industrial sectors
b3.13	Lack of measurement techniques	Advanced materials produced using new vacuum coatings processes including side products with a strong face on materials with dimensions in the nanometer scale
b3.14	Lack of regulation for advanced materials	Lack in current legal/regulatory systems may involve increasing of emerging environmental, social and technological risks.
b3.15	Composites - environmental risks	Environmental Risks of using composites - recycling consideration
b3.16	Lack of reference data	The data-base or reference values for the basic design composites properties introduces complexity
b3.17	Negative risk perception	Lack of communication and understanding about advanced materials science among all stakeholders has negative risk perception
b3.18	New manufacturing methods	Changing of geographical distribution of industry due to new manufacturing methods
c1.01	Outsourcing/subcontracting	Challenges to safety posed by outsourcing or subcontracting of critical tasks.
c2.01	Oil spill in sensitive areas	Oil spill in sensitive areas can cause environmental destruction
c3.01	Unpredictable change in the technology	Unexpected/unpredictable change in the technology
c3.02	Abnormal operational situations	Abnormal operational situations
c3.03	Change in the quality of crude oil	Change in the quality of crude oil
c3.04	Change of the production volume	Change of the production volume

Acronym	Short name	ERI name
c3.05	Change in the management &human aspects	Change in the management and human aspects which may affect the level of risk
c3.06	Increasing degradation/failure rate	Increasing degradation/failure rate and/or unexpected degradation/failure of equipment
c4.01	Major atypical accident scenarios	Description and analysis of events leading to major atypical accidents
c4.02	Atypical VCE type events	Atypical VCE type events that cause risks
c4.03	HAZID techniques & assessment of unknown risks	Review of HAZID techniques and defining a new methodology of support for the atypical scenarios identification
c5.01	Rising energy prices	Rising energy prices due to known or unknown origin
c5.02	Blackouts in unknown/unexpected origin	Electricity disruptions caused due to unknown or unexpected origin
d2.01	OSH risks in DER deployment	Occupational risks for companies working in electric power generation and distribution
d3.01	Development of areas exposed to natural hazards	Industry development in areas exposed to natural hazards or disasters
d3.02	Complexity of industrial system	Growing complexity of the industrial system
d3.03	Climate change induced natural disasters	Climate change induce more severe/intense natural disasters with subsequently growing impacts on growing industrial facilities
d4.01	New chemicals - risk assessment practices	Identification and evaluation of developments in risk assessment practices and guidelines
d4.02	New chemicals - emergency management	Needs assessment of chemical emergency management to prevent risks from chemical incidents.
d4.03	New chemicals - emergency guidelines	Lack of consistent emergency guidelines may lead to risk scenarios

A.2.2 Excerpt of other emerging risks (notions) considered in the project – at the "risk horizon" of iNTeg-Risk (out of 1041 submitted by May 2013)

Notion ID	Title
7	The deadly world of fake drugs
8	High losses in China's refineries
9	Super-Virulent tuberculosis
10	Auto Loan Default- The next crisis?
11	Electrical infrastructure: potentially increased instability risk through ever larger inputs of renewable energies (esp. wind power)
12	Pet food contamination in US (Update)
13	Product liability / recall claims on the rise
14	(a2.18) Gene therapy can cause risks like Immune response, viral spread, possibility of tumor induction
15	China's low quality standards and non-sustainable growth
16	Risk management and public knowledge
17	Respiratory diseases from wood/dung fired stoves in developing countries
18	Vicious bloggers
19	Brown cloud

Notion ID	Title
20	Wireless security vulnerabilities
21	Inadequate sprinkler systems
22	13 seconds time difference may affect flight safety
23	Changes in accounting rules: feasibility of financial products
24	(a2.05) Emerging infectious diseases in new regions and population segment drivers
25	Stem cells - blood banks
26	Fast train (ICE) - near miss
27	Space weather impact on aviation
29	Invalid patents
30	Airlines can't afford risk reducing software to reduce runway incursions
31	Software manufacturer advertising with "addictive" Games
32	Trans-Atlantic rifts and the future of global business
33	Online drugstores selling prescription drugs
34	Glutamate
35	Aluminum in drugs
36	Xenotransplants
37	Trans fatty acids
38	Prevalence of Alzheimer
39	Glycidamid - new carcinogen detected in food
40	Data decomposition
41	Genetically modified seeds
42	(a2.02) Privacy theft of personal data in companies
43	Shipping traffic not increasing energy efficiency
44	Robot safety
45	Changes in life style cause clear-out in households
46	Diesel-filter increases toxic exposure
47	Hormesis - Low doses can have opposite effect of high doses
48	Increasing wildfire risk
49	Vitamins can have negative impact
50	Oil industry skill shortages
51	Graphite bombs
52	Obesity
53	Changing to a renewable energy production getting more costly over time
54	Discharge and waste of hospitals
55	Tin Whiskers: the next "Big Ten Year Problem"!
56	Hybrid cars pose hazard to blind people
57	(a2.09) Nanotechnology have produced products with smaller than the usual structures that are interacting both with the environment and humans in an unpredictable manner potentially causing malicious effects
58	MMT (Methylcyclopentadienyl manganese tricarbonyl)
59	Aluminum and citric acid may cause Alzheimer's
60	Being in deeper Soft Market than realized
61	Space debris
62	Lithium-ion batteries pose fire hazard
63	Agriculture mass production
64	PCB polluted land for sale in US

Notion ID	Title
65	Bypass approval process for pharmaceutical
66	Artificial insemination and offspring
67	Traffic pollution causes asthma attacks
68	Ethanol from cellulose using engineered microbes
69	Banks sued for asset fraud
70	Mercury emissions: potential liability for power and utility clients
71	Depopulation of Europe
72	Fama industry (Pheme [greek], Fama [roman] = personification of fame and renown)
73	Declining Biodiversity of Agricultural Crops
75	Surgery for eye sight
76	Herbal remedies
77	Cosmetic delivery systems use nanotechnology
78	Climate change could trigger more allergies.
79	Dams
80	Umbilical cord blood - liability exposure
81	Internet traffic reaching its limits on the last mile
83	Implants
84	Aroma substances
85	UK law makes employees liable if they fail to report grievances that lead to damages
86	Food poisoning
87	Splenda
88	Clever software increases surveillance options
89	Colony Collapse Disorder (Update)
90	Fire fighters are highly exposed from solar panels based power during a fire.
91	Catholic church sued for sexual harassment/abuse
92	(A1) CO2 capture and sequestration, both technical risks and governance risk
93	Bisphenol A
94	Oil age turning point
95	State-controlled capitalism gaining control over industries which are strategic for market-based western economies
96	Germany investigates Second Life child pornography
97	(C1) Challenges to safety posed by outsourcing of critical tasks – in oil, gas, petrochemical and construction industries
98	Unstable bombs in a sunken ship endanger Sheerness (UK)
99	Glycidamid in Chips and french fries
100	Madoff
101	Damage done by non-indigenous vermins
102	Extractive Transparency Compliance Initiative (EITI)
103	Crop failure due to decreasing genetic versatility and reliance on monocultures
104	North/South divide (tangentially related to "e-literacy")
105	Water shortage resulting in migration
106	Cloning
107	Experimental gene therapy treatement could be linked to the death of a participant
108	E-discovery requirements very costly for companies
109	Fire-fighters occupational diseases
110	Stolen body parts

Notion ID	Title
111	Less plankton in a warmer world
112	New risks for food retailers
115	Composites
116	Manganese welding fumes associated with Parkinson's disease
117	Allergy to hair dye increasing
118	Soft drinks cause obesity/Fast food class action
119	Iceland volcano activity with subsequent catastrophic flood
120	Stress-related illness / death could be recognized as occupational disease in France
121	Critical software
122	Property business interruption costs can increase due to CO2 certificates
123	Volcanic eruption Vesuv
124	New environmental liability directive EU
125	EMF could be one of the causes for Colony Collapse Disorder
126	Deteriorating Asian governement safety standards
127	Faster approval of drugs in Germany
128	Diesel and gasoline exhaust fumes
129	Reuse of single-use medical devices
130	Growing number of automobile in Asia
131	Class Action & Contingency Fee Regime
132	Data centers running out of space and power
133	Beryllium
134	Strange matter (Strangelets)
135	Nearly two-thirds of U.S. workers don't care about their work
136	Therapeutic drug imitations on market increase
137	Artificial Intelligence attacking human
138	Hazardous chemicals in textile products
139	Antibiotic Resistance
140	Designer baby
141	Stress at work
144	Nanoworms Target Tumors
145	"Enronizing"
146	Possible connection of genetically modified corn and susceptibility for toxic mould.
147	Ground zero aftermath
148	Kopfhörer können Herzschrittmacher stören + Realtime illusion
149	Second Life
150	Accumulation problem due to widespread use of lithium-ion batteries
151	Failure of fire extinguisher
152	Toxic mould
153	Mixture effects of chemicals
154	Single kid policy in China
156	Ageing of technical infrastructure
157	ATC staff shortage
158	Privacy violation of iPod running shoes
159	Golf war syndrome
160	Near-Earth objects (NEO)

Notion ID	Title
161	Ethnicity
162	Used tools are being taken back, repaired and sold again as new products
163	10b5-1 trading rule outperforms the market
164	California Consumers File Class Action Over Health Risks Associated With Popcorn
165	Rifle industry negligence
166	Carbon Black in toner cartridges
167	Arctic sea ice melts fast
168	No claims information available at SR
169	Impaired internet
171	Pilotless aircrafts permitted to share route of passenger planes
172	Grain dust exposure
173	Number of premature births increased
174	Geopolymer out of toxic waste
176	Genomics, customized drugs
177	Deep vein thrombosis
178	Food contaminants (Acrylamid)
179	Supplier crunch "forces contractors to work backwards"
180	Wireless Power Transfer
181	Shampoo may affect nervous system
182	US attempts to reduce possibility of class actions
183	Vermiculite insulation contains asbestos
184	Invasive species
185	Skype outage
186	Information about health effects of nanotechnology is lacking
187	Concrete additives polluting drinking water
188	Mega Tsunami
190	Red rain over India
191	Disturbed masculinisation due to endocrine disrupters
192	Unbalanced ratio between men and women in Asia
193	Privatization of public entities
194	Supporting Gangsta rappers could lead to liability
195	Tar sands/oil sands
196	Forum shopping
197	EMF in cars
198	Builders sunburn
199	Labor market failure
200	Ultrasound diagnostics influences development of brain

Annex 3 iNTeg-Risk courses

Curriculum

I-R01 INTRO: Introduction to Risk Management

The course covers the main topics of industrial safety, starting with different aspects of risks and terminology used in the field. The main part of the course is dedicated to the related EU directives. The course outlines goals, scope and required measures / obligations considering acute (accidents) and chronic (pollution) risks. Special focus is given to major accident prevention and related process safety risk assessment methodology.

I-R02 PETRO: Risk Analysis in Petrochemical Industry

The petroleum industry is changing rapidly, challenging many organizations and individuals to keep pace and distinguish opportunity from risk. This course will present current global and regional issues in petrochemical industries. Topics include risk aspects and methods for hazard identification applied in petrochemical industries, probability and consequences analysis, risk assessment and safety and environment issues related to petrochemical industries.

II-R04a RBI-PETRO: Risk Based Inspection - Petro

The course elaborates risk issues in petrochemical industries and explains principles of risk based inspection. It deals with existing risk-based approaches and gives links to applied codes and standards. The focus of the course is given to the main reference documents of American Petroleum Institute: Recommended Practice for Risk-Based Inspection (API RP 580) and Base Resource Document on RBI (API Publication 581) API 581.

II-R04b RBI-POWER: Risk Based Inspection - Power

The state-of-the art knowledge of risk based approaches currently applied in power generation industries to the wide range of professionals involved in different activities in conventional power generation.

IIIA-R06 HSSE: Health, Safety, Security and Environment

The course gives an overview of EU regulation in the field of HSSE (Health, Safety, Security and Environment), explains the objectives and requirements, as well as the state-of-the art in the implementation including constraints and advantages. Special focus is on the Integrated Pollution Prevention and Control (IPPC) and Industrial Emission Directive (IED) and on the prevention of major accidents (Seveso).

IIIB-R08 FIRE: Fire Protection

The course starts with the theory of fire and extinguishment, and thoroughly explains fire protection principles. Further, the course gives details related to the fire protection concepts including legal background and requirements with special focus on industrial fires and risk analysis. The course introduces basic principles and application of fire modeling, explains the phenomenon of a fire and gives an overview of the fire models and their hierarchy and discusses particular models, including numerical. The theoretical part is complemented with number of examples, including calculations, that illustrate the use of different fire models.

IVC-R32 ISO31000: ISO 31000 Principles and Management

Credit Points: 1

The course covers the International Standard of ISO 31000:2009 elaborating the relationship between the risk management principles, framework and process as described in this International Standard. The course also highlights issues related to the applicability of the standard in industry and in general.

VC-R21 S&RA: Safety and Reliability Analysis

Credit Points: 3

This course presents the basic theory for safety and reliability analysis. The starting point is definition and discussion of basic concepts related to reliability and risk analysis. Then qualitative techniques like functional analysis, FMECA and identification and evaluation of faults and hazards are introduced. The next step is to introduce familiar quantification techniques like reliability block diagrams, fault- and event tree analysis, and Markov methods. Special attention is paid to safety-critical systems (IEC 61508) where analysis of systems with common cause failures is important. The course ends with methods for estimation of failure rates and a survey of reliability data sources.

VC-R34 RP&C: Risk Perception and Risk Communication

Credit Points: 3

This course presents theoretical backgrounds and state-of-the-art research issues on perception and communication of risk. It aims to provide a solid basis for further developments of such work tasks by including theoretical achievements in the related fields, various examples from field work, and an internal training exercise. The understanding of communication processes and the improving of information and communication techniques related to risk and hazards are central themes of the course. The course will also provide insight into selected historical aspects as well as current topics and literature. Lecturing is complemented with exercises based on experience of focus group work.

VD-R26 QRA&A: Quantitative Risk Assessment and Advanced Applications

Credit Points: 3

The course presents an introduction to Quantitative Risk Analysis, thus illustrating the necessary steps for the calculation of risk indexes.

Practical approach to frequency calculation and consequence assessment, including vulnerability models, will be discussed. A specific focus on domino effect and accidents triggered by Natural-Technological (Na-Tech) events will be presented.

VD-R35 TRA: Transportation Risk Assessment

Credit Points: 3

The aim of the course is the introduction to transportation risk analysis. The risk assessment of road, rail and pipeline transportation of hazardous substances will be illustrated. The approaches to frequency calculation, consequence assessment and risk assessment will be discussed. Case-studies will be analyzed to illustrate the calculation and the use of individual, societal and other advanced risk indexes.

VE-R38 IRP: Industrial Risk Psychology

Industrial Risk Psychology is the scientific study of employees, workplaces, and organizational **risks. Industrial Risk Psychology (IRP)** contributes to an organization's success by improving the performance and well-being of its people and technological process. An IRP psychologist researches and identifies how risks can improve behaviors and attitudes by using risks through hiring practices, training programs, and feedback systems. IRP psychologists also help organizations' transition among periods of change and development.

VF-R39 DAA: Decision Aid Approaches for Risk Management

Decision making is a process where multiple factors interact to shape the final outcome. Those factors can be technical, informational, emotional/psychological, cultural... Nevertheless, the limited rationality of economic operators makes the decision exercise more and more difficult in a more and more complex world. Safety management requires short, mid and long term decisions that may highly influence the ability of the organization to cope with its risks.

VF-R40 KPI: Concepts and Applications of Key Performance Indicators for New Technologies

Credit Points: 1

The course addresses the issue of Key Performance Indicators (KPIs) as used in the safety and risk assessment, in particular for assessing and managing emerging risks linked to New Technologies. Main concepts developed by organizations like OECD, API, HSE/HSL, CCPS or VCI are presented in detail. Application of these and other concepts, as well as the corresponding guidelines, are discussed in the second part of the course, where also the practical aspects of these applications, including tools and practical views from industry on the use of indicators are presented and discussed.

VI-R41 Data entry

Participants will master methods of large amount of data entry of components, such as handwritten documents, information on spreadsheets, sequences of numbers, computer codes and other types of data. The goal is to learn how to minimize data entry errors and to enter data while performing other tasks.

VI-R42 Use of iNTeg-Risk tools

Training about the iNTeg-Risk tools developed within the scope of the project, such as the One-Stop-Shop, including RiskEars, RiskAtlas, RiskRadar, RiskTweet, RiskTicker, etc.