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# A monitoring-based management approach for Natech-related risks: reflection from a case study

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## Abstract

*Natech risk management is an example of the difficulty of understanding and dynamically monitoring several physical phenomena in order to prepare a decision to adapt an industrial tool. On the one hand, the models on which to base the decision are very contextual and complex, integrating several hypotheses to be controlled. On the other hand, there are choices to be made concerning the parameters to be followed. Finally, there is a management of modifications, the analysis and monitoring processes being iterative. The monitoring must allow to trigger the eventual decision, and/or to lead to the evolution of the models and/or the choice of new monitoring parameters. We will present this difficulty from the case of an installation located at the seaside, confronted with a risk of submersion/flooding due to the recession of the coastline, to the erosion of the dunes, to the possible bypassing of the dunes during storms, to the rise of the water table during storms. This problem is obviously linked to global warming, but not only. It is also a contextual situation, aggravated by developments carried out over the last forty years by a municipality close to the site to avoid a coastal risk, and by the operating choices of several other industrialists nearby. How can we monitor the evolution of these phenomena and their potential impact on the integrity of installations? How to define selection criteria? How can global models and contextual factors be articulated? How to put this work in perspective with regulatory requirements? How can we bring together in a simple process the many actors who will participate in these analyses, follow-up actions and decisions? Our purpose is to discuss the mode of organization of expertise and knowledge that we envisage, which consists in using digital technology to co-construct: 1/ the models adapted to the case study and to the characteristics of the decision to be served, 2/ the analyses and choice of parameters to be monitored, 3/ the monitoring systems, 4/ the principles of the decision, 5/ the management of changes at all levels (model, parameter, monitoring, decision). All this with the concern of giving the actors to follow a scientific method where uncertainty management plays a central role.*

## 1 Introduction

As stated in the JRC Risk Management Technical Report for Natech (2022), Natech risk assessment requires a significant amount of input data, such as information on the natural hazard, the vulnerable equipment, damage models and data linking damage to releases, consequence analysis models for human health and the environment / ecosystem, likelihood estimates and information on the risk receptors. And the authors add that there are a number of uncertainties in Natech' s data and risk models. (especially for very rare events). The key finding is the following. Natech risk analysis usually contains a larger number of uncertainties compared to the analysis of other types of technological risks:

- missing and fragile data for specific natural hazards and for certain types of vulnerable equipment.

- the absence of consolidated models for Natech risk analysis (including damage or consequence analysis models for human health and the environment / ecosystem[1]). The analyst may resort to using expert judgement that is - by nature - subjective to complete the missing information, adding further uncertainty to the analysis.
- the increase and transformation of Natech phenomena in the future; disaster scenarios that seemed too improbable to be really taken into consideration seem to be more and more possible and appear to us as new; in a context favourable to territorial mutation (galloping urbanization, rapid industrialization, deforestation, soil artificialisation).
- the randomness of certain phenomena which constitute natural sources of uncertainty (some appear to us -and are perhaps- intrinsically indeterminate).
- the major nature of the risks (which is a decisive subjective dimension): the more we want to control risks, because their consequences are considered more and more unacceptable, the more precise we have to be in managing the realities of dangerous phenomena, installations, and practices, the more precise the data and the risk control models have to be... the more we encounter shortcomings and uncertainties.

When these uncertainties concerns major accident scenarios[2] there is a major problem:

- it is therefore not possible to regulate prevention on the basis of feedback from accidents, because these accidents, being by definition major, it is unacceptable to accept its occurrence.
- there are too many uncertainties to know exactly what risk control measures to implement.

How to manage major Natech risks in an acceptable way? It seems necessary to turn to a management approach centered on the acquisition of new data as sources of a dynamic design and re-interrogation of the assumptions that form the basis of the acceptability of risk control models on which risks taken are based. In simpler terms, we can say that it would be a management approach based on periodic “active” monitoring (vs a passive follow-up that does not try to question the realism of the model, and vs a more traditional and bureaucratic management focused on the implementation of procedures -paperwork approach).

This article attempts to reflect on this management logic, that would take note of these uncertainties (Leva, M.C., 2015). The challenge would be to lay the foundation for a duplicable and scalable approach to better manage Natech risks, including site and territory levels. However, because it is easier to ask questions based on an example, this article will begin by presenting a case study.

## 2 Case study: the need for a specific monitoring system

The case study X presented here describes a perfectly realistic and typical problem. The case study focuses on a Natech risk associated with the operation of a dangerous substance depot. This depot is located near the Sea, about 1km from the coastline. In the 50's, the site of this depot is built in a completely natural environment. Fifty years later, a seaside town has been built nearby. The area where the site is built is extremely low. Almost the entire area is less than 2 meters above sea level. Only a few dune strips exceed this altitude.

There is an increasing risk of marine flooding due to storms surges and wave setup that can easily raise the water level by 3 meters, or even 4 meters in the most extreme cases. Developments related to climate change tend to amplify this risk by playing on the rise in sea level and the increased probability of stronger storms. But this is just one of the factors. The main problem comes from the retreat of the coastline for several years, due to the developments made near the depot which have on the one hand cut the supply of sand (industrial

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([1]) Let us insist on the fact that consequence analysis models must take into account human health and the environment (ecosystems), in accordance with the orientation of the EU Seveso-III Directive - 2012/18/UE, even if in the national translations of this regulation the part concerning the environment is poorly - or not at all - treated. It should also be noted that natech scenarios affect both the probability of pollution events *and* their intensity or geography. For example, a flood may increase the likelihood of a pipeline rupture but also transport large quantities of pollutants away from the site.

([2]) In The EU Seveso-III Directive - 2012/18/UE ‘major accident’ means an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive, and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances.

developments on a nearby location), and on the other hand created currents that remove the sand at the location of the depot. The coastline has retreated about 500 meters since the creation of the depot (and the phenomenon will continue), the slope of the beach steepens, risking the discovery of a pipe, and storm waves lead to the erosion of the dune line. In addition, it is possible that during storms the water table in the land near the repository may rise due to the temporary increase of the sea level. This point is still to be studied.

The consequences of saltwater flooding on the integrity of the site must also be studied. Among them, there will certainly be an increase in the risk of corrosion on the steel plates that make up the tank walls. This risk in particular is currently the subject of numerous and complicated discussions with the inspectorate, because several regulatory texts apply concerning major risks, the ageing of installations, and the implementation of good practices included in the legislation. This risk is also the subject of an in-depth study, with the participation of several type of experts, on the whole network of depots managed by the operator across several countries with different legislations. These tanks have been designed in such a way that the external walls of the steel are not accessible. The analysis of a possible corrosion must be done when the tanks are empty and cleaned, from the inside.

To ensure the control of the risks of "small leaks" (accidental but chronic leaks that are difficult to detect with traditional operating means) that a possible corrosion could cause, the operator has implemented:

- a periodic osculation program, which proceeds by sampling on the basis of a study which concerns the 150 tanks, revisable according to the results (modification of the sampling and/or of the periodicity...)
- a monitoring system, implemented on all its plants, based on the transfer time of hydrocarbons which conditions the detection of possible small leaks, on a very sophisticated and precise level control device, on detectors in the drains, and on a network of piezometers whose positioning has been defined on the basis of hydrogeological studies (not all sites are equipped).

The whole system is monitored by an international level steering committee every 6 months. This entire organization can be re-examined for our case study site, as the criticality of the risk of a small leak could be modified by the flooding problem.

The following points should be noted from this case study:

- The contextual nature of the problem, and the interweaving of global phenomena such as sea level rise and the increased probability of strong storms with local land use issues around industrial sites. If the site had been built 500 meters further along the coast, where currents (largely related to land use) deposit sand, there would be no risk of flooding but a reinforcement of the dunes against storms.
- The abundance of regulations to take into account and the complexity of discussions with the administration in charge of operating permits, and with local stakeholders.
- The diversity of monitoring actions to be nested:
    i. On the side of natural risks: Monitoring of coastline retreat by satellite image; Monitoring of dune erosion during each storm; Monitoring of flooding near the site to see if there is possible bypassing of dune ridges during storms; Analysis of water table variation during sea level rise during storms; and if there is a correlation; analysis of flooding risk; Geolocation of marine pipeline and analysis of sand height above it; Consider modeling/projection incorporating flooding and rising water table.
    ii. On the side of technological risks: Study of cascading effects integrating flooding risks, review of criticalities, quantification of the severity of environmental consequences of a possible pollution (not required by law but particularly critical in this case study); Monitoring of the possibilities of access to the site, according to the needs related to the various scenarios of crisis management; In-depth study of the integrity of the safety devices (barriers), in particular of the possible common failure modes by operating phase, analysis of the criticality of the possible impacts, and possible revision of the exclusions; In-depth study of the impact of Natech scenarios on the risk of corrosion; Study of the impact of Natech scenarios on the safety of the

workstation; Assessment and identification of modifications to be considered in the safety management system.

- The necessarily dialectical character of the assessment and monitoring approach, characterized by a possible questioning of the risk control model according to the analysis of the monitoring results. For example, in order to know whether the water table evolves with the rise in water levels during storms, specific monitoring work needs to be put in place? Similarly, the periodicity and sampling of the evolution of possible corrosion points on the external walls of the tanks concerned will have to take into account the occurrence of such and such a type of flood, to be determined and monitored in the field. Perhaps this will change the criticality, and therefore the need to revise the leakage risk prevention strategy; but it will be necessary to optimize the ad hoc prevention strategy to be implemented at the problematic site with the national and international strategy to harmonize them, and to guarantee both a reduction in their costs and in the effectiveness of their management (scale effect), Etc.

We assume that these are in fact typical aspects of Natech problems (Rey-Valette H, Balouin Y, 2016). This would mean that Natech risk monitoring must be based on a specific logic that is flexible enough to cope with the complexity of contextual problems, regulatory issues, a wide variety of monitoring actions, and a continuous dialectic with risk assessments that incorporates multi-scale requirements, both at the level of disciplines to be mobilized to deal with natural and technological hazards, at the level of territories, sites and networks of sites, and at the temporal level (Pilone, E., Demichela, M, 2019).

# 3 Typical issues

How can Natech' s risk monitoring be flexible enough to deal with the complexity illustrated by this case study? Monitoring is clearly a part of the ISO-31000 risk management process proposed as the basis for risk management by the JRC Risk Management Technical Report for Natech (2022). However, good monitoring practices able to cope with the complexity never seem to be explained in detail. In the 55-page JRC report (2022), there are no more than 10 lines on risk monitoring.

Since 2014, facing monitoring problems of the type that need to be tackled for our case study, INERIS and SNOI with Interactive have been thinking about and developing a flexible risk monitoring approach and tool[3]. The difficulties encountered could be classified into 5 categories. These difficulties are all related to the problem of the dialectic between monitoring and risk assessment. The fifth is by far the most important, because it characterizes the difficulty to have an approach which allows to deal frontally the problem of the complexity of the specific, diverse, and multi-scale problems, therefore of the uncertainties which justify the dialectical approach. It should be noted that this fifth category of difficulties requires the resolution of the first four.

The first category of problems concerns the fact that the monitoring of a major accidental risk is based on a risk control model (singular) that crosses several studies (plural). In our case study, we see, for example: the study of major risks, the study of aging, the derogatory study (demonstration booklet of a double envelope alternative), and the studies of natural risks. This means that the scope of risk monitoring is not the same as that of risk studies. It is not a question of having a monitoring logic specific to each study, but an overall logic that is fed by the diversity of the studies. This means that the management of monitoring is independent of, or even transversal to, that of the risk studies, in order to allow cross-referencing. In concrete terms, this means that the risk studies must be carried out in relation to each other in order to feed the same risk control model from which the monitoring work will be carried out. This point obviously poses significant difficulties, as experts generally work independently of each other, and risk studies are generally closed in on themselves (in the sense that they are not co-constructed around a reference framework shared with others). It is up to the operator to reconstitute his risk model in a unified way... a difficult task when it has not been anticipated from the beginning of the risk studies. Let's add that it is a very difficult task without a computer tool, and that a database will be much more convenient than an excel file, when the systems considered are complicated (and they all are when the studies must be precise because the stakes are of major importance), as it is the case in our example.

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([3]) This research started within the framework of the European project TOSCA and gave birth to the CBMS approach (Computerized Barrier Management System) renamed, by 2020, in MIRA (Monitoring Integré des Risques Actualisés).

The second category of problems concerns the fact that risk assessment often takes a generic approach, whereas risk monitoring is necessarily specific. Risk assessors will always seek to treat facilities or practices as coherent whole. To speed up and facilitate the analysis, their approach will seek to be as abstract as possible. So, for example, in our case, the risk studies consider a "tank system" that is valid for several tanks that are deemed identical for the purposes of the study, grouping together some of the piping and all the safety devices. However, the monitoring will have to be done by tank... which are never totally identical, if only because they are not always equipped with the same safety systems of the same technology, or simply because they are not located in the same place. A tremendous amount of work will need to be done to ensure that risk assessments and facilities match actual operational practices. This work is partly carried out by maintenance in particular, which must take charge of the specifications considered in the risk studies, for example with regard to safety barriers (response time of safety chains, independence from the installation's operating system, etc.). But, on the one hand, this work is not systematically carried out. On many sites, it is common to observe a disconnect between risk assessments and the reality of the installations: assessments can be significantly modified without any change in practices or installations in the field, or vice versa. On the other hand, maintenance does not consider exactly the same elements as monitoring. For example, monitoring must reconstruct the systems considered abstractly by the evaluators, by tank, to have the means to update the calculations; this is not a requirement of maintenance, as this type of system is an abstraction only useful for risk assessment or monitoring.

The third category of problems concerns the fact that risk assessment are not always consistent. The complex and voluminous studies are carried out with Excel and Word, without the support of a database, and it is difficult for the writers to verify their integrity, especially when, at the time of writing, the assumptions are changed, the names evolve, the calculations are redone, the descriptions are modified, etc. This poses problems of consistency within a study, but also between studies, and even more so at the level of a multi-site network that would like to have harmonized management of its facilities and operating practices. All of this usually goes unnoticed because the reader has no way to verify their integrity. Not to mention that the readers are rarely the same, that each study has its specialists, and that they are rarely responsible for correcting all the studies of an entire network (at least if they are, they rarely have the means). Moreover, these studies are composed of numerous annexes, not always up to date, provided by different services, which the authors of the studies do not have the time, the means or the mission to control. The most astonishing example is that of the analysis tables (preliminary analysis, Hazop, etc.), made in Excel, where the means of risk control are not managed in a single list and therefore change name from one line to another, or from one tab to another... and this does not bother the analyst when he does not have to anticipate the management of these means. This poses a problem for monitoring, which must have clear and consolidated lists of what to monitor.

The fourth category of problems concerns the difficulty of identifying, in risk assessments, the parameters and computational elements that will constitute the conceptual infrastructure for monitoring. All the elements needed for monitoring are (or could be, or should be) in the risk studies, but these studies are not done to help with the monitoring work. The risk studies seem most of the time (we know of no counterexample) to be focused on the steps of the methodological reasoning, so that the critical components and tasks are presented in different parts of the reports, in an unsystematic and non-explicit way, from several angles, with several levels of abstraction, and sometimes (often) with different names (the same equipment can be named differently in the same study). Moreover, the analyses are not systematically conducted with the same level of depth. For example, the means of controlling risks identified as "MMR" (i.e., as barriers that must meet the requirements of the French regulations) will be analyzed in greater detail than the safety measures that do not fall into this category. It is up to the operator to voluntarily make the effort to systematically analyze with the same level of depth all his means of risk control as if they were "MMR". But, for control purposes, an equal and systematic level of analysis is needed, clearly describing all parameters (technical components and tasks) and all calculation elements.

Let's take stock. The monitoring of a major accidental risk is based on a risk control model, whose constitution and updating must be an objective in itself of the management, and which implies working on the basis of risk studies on the problems of correspondence with the realities of the installations and practices, of coherence, and of systematic identification of all the parameters and all the elements of calculations which constitute this model. But that's not all.

There is a fifth category of problems: monitoring data should not only be used to say whether, given the model, risk control is satisfactory or not, they should also lead to questioning the model itself, helping to improve it. Monitoring is understood here as a key element of scientific reasoning on risk control modeling. It is about

being able to dynamically manage a model, a monitoring system and modifications of the whole. This is what we see in our case study, and it is all the interest of the Natech problematic whose uncertainties will perhaps obliterate in a certain way to enter in this follow-up logic. Since the problems are contextual, as our case study perfectly shows, with an imbrication of natural risks, technological risks, land use choices and uncertainties at all levels that cannot be solved by existing regulations or good practices, it seems necessary to adopt an interactive management approach based on a dialectic between the elaboration of an action model and the modification of this model in order to reorient the action on the basis of the results produced by the monitoring. Indeed, it is a matter of putting at the heart of risk management a scientific reasoning approach that is precisely designed to tackle uncertainties head on, by accepting to proceed by hypotheses. Here, the boundary between scientific research and the industrialization of management practices (Taylorian tendency) is blurred in favour of an integration of science into the very dynamics of the management life cycle which cannot be done without a comprehensive review of risk management (see the discussion section of this article).

## 4 Proposal for a digital approach

How to deal with the five categories of difficulties we have just listed, in order to deal with the complexity of Natech risk as seen in our case study? There appears to be a need to organize the management of a "major risk control model", which would be what is questioned by the monitoring in the risk studies to demonstrate that the risks remain acceptable over time. This model would be unique and continuously evolving/ constant change, while risk studies and monitoring are plural and discontinuous/ periodically redone.

A/ The major risk control model of a plant would be exclusively made of calculation elements and risk calculation parameters.

1. Parameters. These would be:
    (a) Critical components. We propose to name in this way all the physical components that enter as parameters in the risk calculations. These components are:
        i. the facilities, buildings, equipment, safety devices, etc.
        ii. the substances
        iii. the elements of land use planning: housing, critical infrastructure,
        iv. the natural environment: ecosystems, water, etc.
    (b) Critical tasks. We propose to name in this way all the tasks that are performed on or with these critical components in normal or degraded situation, and that enter as parameter in the risk calculations. For example, the task of an operator who has to press an emergency stop button within x minutes if an alarm appears. Or the task of maintaining this alarm. In our opinion, these tasks are systematically (or should be systematically) described in the safety measures/barriers, and explained in the associated procedures.
2. Calculation elements. These would be the elements of the risk calculations, which aim, at the end, at estimating the acceptability of the risks. They take as parameters the critical components and tasks (some calculations are also based on other elements like weather data). These elements of the risk calculations are:
    (a) The events (initiating events, central feared events, consequences), for the calculation of the probability, the intensity, the distance of effect and the gravity of the dangerous phenomena.
    (b) Measures/ barriers, for calculating the performance of risk control measures.

    Note that events are possibilities, that means abstractions, associated with components, and that measures/ barriers are also abstractions generally grouping several components and tasks. We consider them as elements of computations because they carry the computations, while the parameters (components and tasks) are exclusively variables representing current realities whose changes of state can impact the result of the computations.

    Example. The corrosion of a steel plate is a change of state of a parameter. The corrosion of this type of plate at a frequency x is an event whose possibility enters a probability calculation.

B/ The risk studies would design the model:

- Establish the lists of critical components and tasks with detailed specifications, and establish how these parameters are used for calculations.
- Establish the calculation algorithms.

C/ The monitoring work would use and question the model:

- Monitoring would be done by checking the status of the parameters (critical components and tasks) that are used in the risk calculations. The monitoring would consist in having the means to periodically update calculations on the basis of the update of their parameters, and in verifying that observed deviations do not affect the acceptability of the risks.
- Monitoring would ensure that the correspondence of actual installations to the specifications of these components and that the correspondence of actual operating practices to the specifications of these tasks is effective and correctly check; because the monitoring is based on the establishment of correct lists of:
    - all critical components, with: labelling in the field; codes in operating tools (CMMS, ERP, control panels, etc.); location on a ground plan; location on PIDs; location on a GIS; their specifications, which validate the demonstrations of an acceptable risk level
    - all critical tasks: whose specifications are described in the human barrier analysis or in the associated procedures; which form the basis of the organization of the control of major risks (support and management processes)

The studies and monitoring of risks would be part of a virtuous improvement dialectic. Monitoring would be based on risk studies, and it would lead to rereading, to checking the consistency of the studies, to verifying the correspondence of the studies with the realities of the installations and practices.

A database should be used to support at the same time the management of the model, of the risk assessment processes, and of the monitoring works, in order to:

- Improve the back and forth between all the stages of the studies until the monitoring stages, and in particular, to carry out directly, the constitution and the verifications of the lists of specifications of the parameters and the calculation algorithms, as the risk studies are carried out through monitoring actions.
- Strengthen collaborative work and review cycles for studies and monitoring by stakeholders
- Promote consistency and data sharing between sites, territories, and inspectors
- Manage the multiple and extensive data processed by monitoring.

The central idea is that, basically, risk studies and monitoring work would constitute one and the same action: the design, control and updating of the risk control model. Conducting a risk study would automatically and implicitly prepare the monitoring work from the start. And conversely, doing the monitoring work would automatically and implicitly be doing a review and possible update of the studies. All this would be controlled by the major risk control model, which would guarantee a continuous internal consistency check between the studies and the operational tools (EPR, CMMS, etc.) that feed the monitoring.

From a knowledge management point of view, the only requirement, and it is a big one, is to try to stop using Word or Excel, because they are not databases and they do not allow to manage the integrity of the model. To ensure this integrity, you need an application that allows you to manage each critical component and each critical task in a single copy, and that allows their integration into the calculations (which are also managed in a single copy), via screens and operations adapted to each stage of the studies and monitoring. It is important to note that these parameters should not be ordered in relation to each other, classified beyond what is necessary for the calculations. They are only parameters, that is, they only have meaning from the perspective of these calculations. It is the way in which they are used by the calculations, in the different steps of the risk analyses, that allows them to be classified.

Managing each element (component, task, calculation) in a single copy is crucial. This allows to:

- Ensure that it is the same element, this element with its properties, that plays this or that role in the risk control model
- List all the elements that must be managed, monitored and maintained over time
- Measure the consequences of a failure of a particular element
- Better control its errors (having mischaracterized the properties of the concepts/knowledge and their dynamics) by giving the stakeholders the means of criticism
- Better identify the principles and limitations of a model, ... in order to better question and improve it if necessary

# 5 Project and tools

This approach need to be specified, improved, and tested. IT difficulties are obviously numerous[4]. It would be necessary to have the means to manage:

- all the stages of risk studies and monitoring work
- the parameters resulting from studies on natural and technological risks, with the actors who are able to identify, design, build, modify and control them
- the complex and diverse computational methods, especially when it is necessary to integrate the spatial and temporal problems characteristic of Natech problems
- a platform approach rather than a closed software, in order to keep the necessary flexibility to respond to the diversity of needs of operators, territories and inspectors, and to accompany the evolution of these needs over time. You have to be able to design and maintain not one application but as many applications as there are particular cases.

This will be the next challenge of BRGM and INERIS, with SNOI and other operators interested in this approach, through the coupling of two already existing and operational IT tools[5]:

- VIGIRISK for Natural risk analysis and for analysis of cascading effect analysis and system resilience (from BRGM).
- MIRA-InOV for Physical & technological risk analysis, for resilience option selection, and for decision support & monitoring (from INERIS, SNOI and Interactive).

VIGIRISK is a tool for incorporating expert-users, methods, data and tools to deal with natural risks in a territory. It is a web platform allowing the execution of risk assessment workflows and the production of valued data sets useful to the natural hazard communities. This platform ensures reproducibility, allowing transparency but also improving efficiency by easing collaborative work and sharing results and practices to different end users or to scientists working on related topics. The scientific scope is risk assessment in the domain of natural hazard (e.g. seismic, landslide, submersion) from the phenomenon modelling to the impact evaluation on exposed elements such as buildings and networks. It is intended to have a wide range of methods for calculating hazard and susceptibility and relations between risk and vulnerability for calculating damages on identified assets. The platform supports workflow for data analysis, preparation and transformation. This platform will allow the use of scientifically validated methods, but it will also serve as an innovation tool allowing scientists to propose new methods of risk assessment and to proceed their validation more easily on several datasets covering different study areas. Currently several workflows are implemented for damage and risk calculation for different combinations between several hazards and different levels of description of the exposed elements (landslides, earthquakes, tsunami).

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(4) In the literature several authors have highlighted the steps required in the development of an expert system or a decision-making support system as part of a complex of intelligent technological management of the reliability and efficiency of oil and gas systems (Zemenkova et al. 2020), and many of those steps are in common with the one followed when developing IT solution for Natech risk assessment and monitoring.

(5) This is one of the objectives of the IRIMA project (a French research project planned over eight years, starting in 2023). We come back to this project in conclusion.

MIRA-InOV (Integrated Monitoring of Updated major Risks – Monitoring Intégré des Risques majeurs Actualisés)[6] was initially developed within the EU funded project TOSCA with the contribution of: INERIS, Interactive, TU Dublin, and POLITO. Then, it has been continuously improved through research partnerships with industrialists, and particularly with the SNOI. MIRA is an integrated web-based risk management tool, for major hazards (which, by definition, cannot be regulated by trial and error, but by driving a model). It is an IT solution based on a continuous updating of risk control models and, consequently, of all the knowledge supporting the modeling of risks and their uncertainties. MIRA monitors the criticality of the technological risks (and of all the items allowing its calculation), the internal consistency of the models and their correspondences with actual facilities and practices. It numerically integrates thousands of pages of risk studies, operational procedures and recording. MIRA allows direct entry and dynamic management of all descriptive data, on processes, products, equipment, potential hazards, dangerous phenomena, exclusions and their justifications, internal/ external sources of aggression, safety measures/ barriers and their linked operational procedures for managing major risks. MIRA makes risk studies operational by integrating procedures, operating modes and field operator records into a single model of real activities. It also provides the means for data manipulation, risk assessment (Preliminary Risk Analysis, Hazop, Bow-tie, Barrier analysis, etc.), and periodic recalculation of the probability propagation based on daily reporting of operating data. MIRA has been developed and is used with the InOV technology (from Interactive company), which is a flexible platform based on a user-oriented programming logic, and a set of IT packages (such as task management, notification and e-mailing system, GIS, DMS, document editor, interoperability management through the provision of web services and an API, integrated screen and workflow management systems for the design and display of operations and rights) for designing ontologies, running web applications but also for designing and prototyping without coding by the systematic reuse of proven components, in order to ensure bug-free developments within the reach of super users.

Vigirisk and MIRA will be hosted and secured by BRGM, which will promote the use of territorial data (urbanization, critical infrastructures, ecosystems, etc.) to which BRGM, as an operator of the French State, has access via a reliable datacenter.

# 6 Discussion

It would be a profound change to organize the licensing process on the basis of the monitoring process described below (Fraccascia, L., 2018). Currently, this authorization is based on the instruction of risk studies and then on field inspections. But the five categories of difficulties we have listed above are not addressed together. In other words, inspections are carried out on a spot-check basis, not in a systematic way. In short, the administration seems to rely mainly on paperwork. And yet, in several in-depth audit or field survey we have conducted, we have found significant discrepancies between the studies and reality. Why is it that, if the studies always match reality, the law requires that they be reviewed every five years? Why do many risk experts consider that the new French regulations concerning this revision (we are thinking here of the procedures for re-examining hazard studies) are too light and should systematically involve new in-depth risk analyses? Why do operators still experience (let's say the vast majority of them) the performance of these studies as an administrative cost and not as the basis of their risk management? One could imagine better safety monitoring by asking operators to produce periodic reports (once or twice a year, with validation by a steering committee) on their risk management model (combining study and monitoring). Is this not the spirit of the Seveso III directive? But wouldn't putting it into practice be a revolution, as it would clash with well-established organizational practices?

When the question of the correspondence between studies and the reality of installations and practices does not arise, operators do not have to invest in monitoring. And their documentation system can be satisfied with being formally correct, administratively compliant. And many organizational biases can be put in place without being discovered. What about risk assessment workgroups where one participant systematically takes the floor without leaving room for the expertise of others? What about groups that focus on details when time is limited because the number of working days has been contracted in advance? What about groups where process engineers are absent? Or when field operators are absent or muzzled because they are afraid to reveal their true practices? In most cases, it is consulting firms that are in charge of carrying out the studies... but they do not know the realities of the field. Reorganizing the work of risk assessment around the verification of the

(6) The development of MIRA is based on a preliminary analysis of the problem of managing major accidental industrial risks which was the subject of a publication: Plot, E., 2007.

correspondence between studies and the reality of facilities and practices would be a profound change that would help to counter many of the organizational shortcomings of operators that affect the quality of risk studies.

From the point of view of the consulting firms, working on paper is perhaps preferable in that it is much easier to organize. An expert can take charge of a whole study, alone, with the support of other skills, in an essentially analytical approach that he will carry out in his office, from the documents that he will have requested and that will have been provided to him (even if these documents are not up to date). His first concern may be to respect the costs and deadlines of his company, because he will undoubtedly be judged first on this criterion... insofar as no one will be able to question the correspondence between the study carried out and the reality of the practices and the installations.

At the end of the day, shouldn't we simply organize the stakeholders around the spirit of the Seveso III Directive where the safety management system is central and which we interpret as being centered on the monitoring work (annex III element vi) “for the ongoing assessment of compliance with the objectives set by the operator’s MAPP and safety management system”? … provided that the five categories of difficulty discussed in this article are met.

Many seem to read this directive by overvaluing the requirement of procedures, as opposed to the requirement of demonstration, tending to consider, as is undoubtedly too often the case in France, that the existence of procedures is a sufficient demonstration. Procedures seem to play a central role in a bureaucratic approach, insofar as they can be distanced from reality and self-validated by records that are managed only by formalism. It is obviously easier to comply with the Seveso 3 directive by interpreting it as requiring procedures than as requiring primarily demonstrations based on a monitoring process fed by risk assessments.

This situation is not too problematic when it comes to managing facilities and practices that are well known to operators in the field who have long experience, and informal practices that are well established within the collectives to correct the shortcomings of the formalism of procedures. But when dealing with evolving Natech risks, which are new to everyone and truly complex, isn't it important to give ourselves the means to rethink risk management approaches around a demonstration and monitoring logic? The issue seems too serious to be treated lightly. It would therefore be important to rethink risk management practices in light of the challenges posed by the Natech problem, for example around the organizational mode envisaged in this article.

# 7 Conclusion

The main idea is that:

- from a risk management perspective, the focus should not be on risk assessment but on monitoring (a simple idea with consequences we believe to be decisive);
- this could lead to an organizational "revolution" in risk governance (at the level of inspectors, operators, consulting firms, and territories);
- it is probably difficult to do otherwise when the phenomena to be managed are complex and relatively unknown, as are the Natech scenarios.

It is therefore necessary to specify the modalities of this “new” management principle and to build the ad hoc supporting IT platform, by connecting the Vigirisk and the MIRA-InOV IT tool. This work is already planned as a part of the IRiMa project (an exploratory French PEPR project) which we present below in order to explain the framework in which this research will be conducted.

IRIMA project (eight-year project starting in 2023) aims to produce a new "risk science" to contribute to the development of a new strategy for managing risks and disasters and their impacts in the context of global, anthropogenic and climatic changes. To do this, it implements a series of research and expertise (observation, analysis or decision support) to accelerate the transition to a society capable of facing a set of hazards (hydroclimatic, telluric, technological, health-related, mixed), to adapt and to be more resilient and more sustainable.

Over the period 1998-2017, France was the 10th most affected country in the world by disasters with an overall cost of more than 40 billion dollars. To face this challenge, increasing with ongoing warming, it seems necessary to stimulate and coordinate the national effort. The chosen approach in IRIMA, holistic and integrative of knowledge, aims to largely federate geosciences, climate sciences, engineering, data and digital

sciences, as well as human and social sciences (in particular geography, history, economic and financial sciences, behavioral sciences). These different disciplines are now heavily involved in these issues, but still work too much in silos and / or, sometimes, without direct interaction with society.

By capitalizing on available knowledge and developing inter and transdisciplinary methodological approaches, it will be a matter of jointly developing and constructing new knowledge so as to better detect, quantify and anticipate risks, understanding their complexity (extreme events, multiple risks), and unsteady, coupling and cascading effects, multi-scale dynamics, taking better account of human and socio-economic issues, etc.) It will also be a question of making better use of data and citizen knowledge, and of better valuing new technologies, particularly those of information, by consolidating data acquisition and assimilation / modeling / decision support / policy implementation for crisis management and anticipation of future risks related to climate change and anthropization.

The IRIMA project is built around a national consortium largely federating major research universities, key universities in the field of risks (natural, technological and environmental), and organizations or establishments of national reference. To promote transdisciplinary dynamics, research stimulation and coordination mechanisms will be put in place, in particular calls for innovative projects, instruments for structuring regional centers, attracting talents and encouraging young scientists, partnerships international (European in particular), a renewed policy of training through research and life-long training, as well as an infrastructure of research platforms. The latter will strongly contribute to bringing together teams around the study of risk dynamics, crisis scenarios, as well as the evaluation of decision support tools, in vivo and in vitro experimentation with the different social actors. It will rely on collaborations between observatories, data and high-performance computing national infrastructures, creating synergies and novel convergences.

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