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The Development of a holistic IT platform for major risk assessment and management: the MIRA tool

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There are natural human cognitive biases that affect many aspects of our activities, including major risk management. Some of these have a common characteristic, namely the reification process related to our tendency to selectively seek or interpret information in a way that confirms our representations of reality, and which can lead to forgetting that our representations are in some way abstractions, or hypotheses, and as such, must be continually questioned, analysed and checked against reality. The moment we forget that the correspondence between our representations and reality is only a conditional truth and requires constant verification, is the moment when most human and organizational errors in major risk management can occur. How to fight against this? This is the question that preoccupied us during ten years of research, starting within the European Tosca project (see Leva et al. 2019, Anzirsi et al. 2019), and that still haunts us today. This article presents the problem to be solved and the envisaged solution, based on an IT tool allowing to organize the dialogue between the risk assessment and management stakeholders. This solution has been designed with the SNOI, which is responsible for the French part of the NATO pipeline network in Central Europe.

Keywords: complexity, cognitive bias, risk assessment, risk management, dialogue, digitization.

1. Introduction

Language is not transparent, we must always question the words we use and our linked representations, even those that seem obvious, especially within organizations in charge of major risk management, where a managerial error is likely to have catastrophic consequences. It is not “just” a problem of interpersonal communication. It is, at a deeper level, an issue related to the construction of our thought, the way we elaborate and rationally accept our knowledge and models, in the face of complexity, in order to make effective choices, i.e. choices that are sufficiently in touch with objective reality so that our actions produce the desired results.

This incessant questioning, necessary for the proper functioning of our rationality, is at the heart of our problematic: why and how to organize it? Our thesis can be summarized by the following sequence of arguments which constitutes the plan of this article:

1/ Several technical factors contribute to the complexity of risk assessment and management.

2/ This complexity is reinforced by the characteristics and limitations of our cognition.

3/ These factors of complexity can only be mastered by the development of prudent strategies based on cognitive trade-offs, integrated into scenarios for action (procedural schemes).

4/ These strategies are dependent on our beliefs, in the sense of interpretive frameworks, that work a priori.

5/ One of the mechanisms common to the functioning of these beliefs is the fact that they tend to be hidden from us, because of a tendency to selectively search for or interpret information in a way that confirms one's representation of reality and because we spontaneously reify our representations by believing that they designate things that exist as we think them, forgetting that they are constructions, abstractions, hypothesis.

6/ Digital technology opens new opportunities to solve this issue. In the literature other authors have also 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 MIRA. However, in this paper we will try to describe the main step underpinning the rationale, derived from human science research (Plot, 2007), that ended up shaping the envisaged software solution. The key scientific contribution of this software solution was an attempt to develop and test in practice a method and a web tool (MIRA) dedicated to the combined management and assessment of major risk, where the data from daily monitoring and periodic inspections, alongside the requirements from the regulations, can be integrated with the risk assessment. This foster the advantage of updating a risk assessment that is often static and unable to provide un up to date assessment of the situation as to support daily decisions.

2. Technological complexity factors

This paragraph offers a quick overview of the events that had to be monitored and managed in the holistic platform developed in this case study. The list is only indicative but non exhaustive.

a) Events resulting from the physical environment: the most characteristic is the interruption of the energy supply for example during a storm. Even if a backup power supply is provided, its activation in an extremely short time (a few fractions of a second) is never certain. In any case, the passage on a secondary network modifies the values of the parameters as well as the nature of the physicochemical reactions. These rare events can be a factor of complexity.

b) The sudden and accidental failure of a part of the installation or of a mechanism. Its essential characteristic is that it is not recoverable. As a general rule, safety devices are provided for this circumstance and aim to put all or part of the installations out of service: this is the emergency stop. When a pipe suddenly opens under the effect of internal pressure, the automatic safety devices are activated, provided that the state of the installation allows it. An emergency shutdown may concern a part of the installations. However, the whole process is disturbed.

c) Control system faults: their main characteristic is that they are not immediately visible. A sensor can indicate an erroneous position of a valve: operators can act on the displayed information and elaborate actions that are relevant from the point of view of the erroneous information presented but not relevant for the safety of the process. This is a problem of instrumentation reliability, which is the cause of many disasters. Anticipating this problem with cross-checking systems makes the daily activity more complex.

d) Interfaces can generate quantity and quality problems in the feedback, including control directionality problems, feedback delays, and response delays... which require operators to work on a relatively sophisticated representation of the process.

e) Fluctuations in the manufacturing process on the side of the incoming products or the industrial process. These fluctuations are signaled by alarms or pre-alarms indicating that a given parameter is outside the tolerated limits; nevertheless, their signaling leaves unanswered the question of their origin and the factors that cause them. The origin may be in another area than the one reported.

f) Interference between tasks: conflicting activities (the team may be busy with other tasks when an incident requires the availability of each team member), or, on the contrary, areas left unattended and to a dilution of associated responsibilities, all of which are conducive to the genesis of the unexpected.

g) The hierarchical structure of an organization, which can lead to uncontrolled decision-making processes. The information flow may be too slow, or may not provide the necessary information to the relevant managers, etc.

h) The time pressure which is defined by the time available for the operator to make his decision and act on the system by obtaining a response in accordance with his objectives (the pressure includes the response time of the system). Many slow processes are characterized by fast transients and action windows. Hesitation or neglect on the part of the operator reduces the time available to act, and by simple consequence, mechanically increases the time pressure on the decision to be taken.

i) The degree of reversibility of actions. Reversibility describes the possibility for the actor to cancel an action on the system. This reversibility is a guarantee for safety (the error is without consequence if it is seen). It allows testable simplifications of the representation. However, it is never possible to obtain a total reversibility in processes in constant evolution.

j) The under-specification of the objectives to be achieved. As a result, the actors cannot clearly imagine their objectives, the types of knowledge they need to have to be successful, the level of performance they want to achieve.

3. Cognitive properties that reinforce this complexity

Operators facilitate the implementation of processes. They are generally a factor of efficiency and performance, insofar as they manage to implement strategies that fill in the gaps resulting from the unthinking of technical and organizational systems.

So, as a major element of the system, they must be given special attention. The articulation of human activities and facilities is a problem in itself that cannot be omitted. From this point of view, human factors must be added to the purely technical considerations, and we can say that they constitute an additional level of complexity.

Thus, our list of complexity factors is growing for instance with human errors mechanisms. See also problems such as the feeling of difficulty, defined as an emerging feeling, during the execution of an action, of the risk of losing control of the situation. See also cognitive operations that the actor must put into play to guarantee the best validity for his representation throughout the execution of the work without risking saturating his cognitive system (Amalberti, 1996).

Beyond these factors, the important point is to recognize that the problem of complexity is necessarily linked to the management of major risks. The real is only simple within the framework of abstractions that man constructs to facilitate his action. The real is always complex, when it has to been managed with a high level of reliability.

Let us take a banal example. The control of walking is apparently simple. However, we sometimes fall, because the ground is slippery, because we did not see a stone, because we were pushed, etc. We accept these losses of control in our daily lives. We accept these losses of control to the extent that further control of walking would be more costly than beneficial. But we no longer accept them when these losses of control can put our life or health in danger, as is the case in the mountains. The control of the same action is different according to the level of success desired. To ensure total success, we must take into account the finer points of reality, everything that can prevent success.

Experience shows that this "everything" is never totally predictable, if only because reality is much richer than what our understanding can grasp. Therefore, in order not to fall, prudent mountaineers make great efforts to pay attention and advance roped up. This is the principle of safety barriers, which presupposes that despite all the precautions taken, control of an activity is never assured and that several independent means of avoiding the consequences of its failure must be provided.

4. Strategies of prudence to counteract this complexity

Faced with the complexity of reality, we must recognize the limits of our knowledge, we must know that our assumptions and decision can only be considered provisionally true. We must accept that we can only regulate systems through cycles of trial and error. And when these errors can lead to catastrophic consequences, deemed unacceptable, we must ensure that their probability is extremely low.

This approach is a source of efficiency and reliability. It is the approach of prudence, which consists in judging the errors to be acceptable.

In this perspective, the fundamental problem is not that of complexity or errors, but that of the strategy allowing to master reality in spite of it, with an acceptable risk taking. The principle of the solution consists in constructing in advance a minimal representation of the situation to be mastered, which provides a maximum of comprehension, anticipation and guidance capacities (a representation of effective and safe scenarios/possible solutions), and in carrying out the action by seeking to remain within the envisaged scenarios so as not to find oneself in situations not envisaged. The principle of the solution is therefore to give oneself the means to guide the process and not to be guided by it (Amalberti, 1996). The generic solution consists in progressively structuring the knowledge in a form compatible with its subsequent highly automated use. This learning allows the passage from the state of rules or declarative schemes to the state of procedural schemes that the operator will be able to activate and then unfold with a minimum of attentional control. Only the practice of the profession allows this almost infinite transformation.

Actors create room for manoeuvre to ensure that they will be able to solve the problems encountered in the course of the action. The quality of this strategy, the quality of the cognitive compromise, is based on defences in depth that make it possible to control that the accepted risk does not degenerate into a loss of control and above all to accept the risk in the first place.

The adjustment of the cognitive compromise is established on the basis of confidence. Prudence consists in defining measures according to what we judge to be known (the reliability that we attribute to our knowledge), and in accepting the risks of an error in this judgment. There is no prudence in those who do not recognize their limitations.

The adjustment of the cognitive compromise is also established according to other criteria such as workload (feeling of overload), stress (feeling of loss of control over the immediate or future situation) or fatigue (emergence of the feeling that intellectual performance is less effective than it could be in an optimal situation).

The emergence of these feelings is uncontrollable by the subject but will seriously modulate the adjustment of the cognitive compromise. These strategic elements underlying prudence are the subject of numerous studies in cognitive psychology.

5. Dependence of these strategies on our beliefs

These strategies are dependent on a priori interpretive frameworks that have been the subject of sociological studies. These include the "Simmel effects" or "Simmel model" widely analysed by Boudon (2003). We consider here a sociology very much focused on epistemological questions and, conversely, an epistemology concerned with the social conditions of production mechanisms and sorting of knowledge.

The central idea is that our beliefs can be dubious or false because within a perfectly valid argumentation, there slip a priori or implicit propositions that the subject treats as self-evident, and that, for this reason, he perceives in a meta- conscious way, and that these implicit a priori take the form of logical frameworks that calibrate the other propositions.

A parallel could be drawn with the Kantian categories of a priori. It seems that this "Simmel model" can also be compared to schema theory which provides a cognitive model in psychotherapy. Beck, for example, proposed a model as early as 1967, based on the idea that schemas represent personal and automatic interpretations of reality that process information unconsciously and influence individual coping strategies. Many authors have focused on analysing these mechanisms. We can cite, also, for example, the works of Morel (2004, 2018), Bronner (2007, 2021), or even Pinker (2022).

6. The reification process as a common failure mode

A common thread in these analyses is our tendency to miss these implicit facts and to be mistaken about truth. Basically, this difficulty is a preoccupation from the earliest philosophical texts to the more contemporary one. As far as we are concerned, it is with Auguste Comte that we have found the simplest and most enlightening analyses of the problem and especially of the principle of the solution to be considered (Comte, 1842).

The cornerstone idea is that starting from observation the observer may immediately and spontaneously form abstractions. We only observe what we can abstract. And conversely, we can only abstract correctly by observing. There is therefore no leap between experience and its conceptualization. We understand then that any abstraction, tends to be reduced to an observation, that is to say to the enunciation of a fact, more or less specific, particular, or general.

This expresses the horizon of the search for true propositions, knowing that the starting point is the hypothesis which is characterized precisely by a freedom with regard to the existing knowledge/ observation, and that there always seems to remain a kind of gap, of hollow, of falsity, between clear representations and observed facts. It is that reason must try to bend to observation at every moment of its constitution, so that the principles it employs should try to be as real facts, only more general and more abstract than those they must link, and it is always from their direct or indirect conformity with the observed phenomena that their objective effectiveness results exclusively.

This imperative of submission to what is observed provides the means of distinguishing between justified and unjustified propositions. In this approach a theory is superior when it allows to foresee the phenomena, discovering their modifiability and the way to modify them, it is relatively to its effectiveness that the value of a theory is defined.

If we must confine our research to the domain of the observable, the less the proposals are based on accurate and objective observations, the less they are justified. …knowing that the quality of our abstractions is in the narrow dependence of our cultural heritage, and thus, evolves in time, progresses.

Thus, it is not so much the complexity factors, or the "classical" cognitive bias that constitute our starting points, but rather those implicit frameworks of validity of our truths that are not questioned when we forget (it is the process of reification) that our representations are abstractions of abstractions that must submit to observation, and that the observed facts are from the outset an encounter of a subjectivity with the truth of the world, and thus that Truth is made of Our truths. Let us note in passing the very enlightening reading of the phenomenon of reification, proposed by Bergson and his numerous successors. For Bergson, it is a mechanism proper to the functioning of our intelligence which spatializes in order to think a reality whose framework is duration, which plays as well in our daily life as in sciences.

In this perspective, the fundamental error is to forget that representations, like those proposed by risk assessors or risk managers, are as fictions, of course useful fictions but always partially disconnected from reality, and that the proper of these abstractions is to freeze and to reduce, for the needs of the analysis and the action, a complex reality which exceeds what we can seize alone.

Only objectivism will pretend to substitute this abstract vision to reality. Or, better yet, only an overly bureaucratic or a too legalistic approach will make this substitution. This reification attitude is concluded by the substitution of the idea to the real and opens the field to postures where the document presenting a facility will be held as truer than the facility itself!

However, not falling into the trap of objectivism is only possible if cognitive strategies incorporate the need to provide and collectively process quality incidental feedback.

Alone, an individual will necessarily succumb to objectivism. In this perspective, the organization of dialogues, the continuous confrontation of points of view, on the robustness of major risk control models would be the key to their performance.

This approach leads us at the same time to trust our representations (and therefore to accept the risks), and to distrust our representations in order to enter into a continuous process of improving our knowledge, with methods adapted to the nature of the problems, through the necessary dialogues with the stakeholders.

7. Digital technology opens new opportunities

Why is it so important when managing major risks?

Because when we deal with major risks, we must consolidate the models without being able to rely on a trial and error process up to accidents, since by definition they are major and therefore unacceptable. It is mandatory to monitor the acceptability of models and to update them based on an incidental feedback.

It should be noted that our problem is centered on knowledge management. In this area, everyone knows that digital technology offers revolutionary opportunities. Starting in 2014, within the European project Tosca, we have done research to develop a knowledge management IT tool to support together risk assessment and risk management. We call it MIRA (Integrated Monitoring of Updated major Risks – Monitoring Intégré des Risques majeurs Actualisés).

The MIRA project is to assist in the management of the acceptability and updating of major risk control models, by fighting the risk of reification.

MIRA is a web platform dedicated to technological risk assessment and management, for resilience option selection, and for decision support & monitoring. Today, MIRA offers 5 basic modules: Risk assessment, Document management, Question/ answer and rules, Data management, Monitoring.

These modules offers the possibility to decompose and recompose models in order to have both an overall view and partial views down to the smallest elements on which they rely, to compare the analyses between them, to change scale when it is possible, to control the coherence within the models, to control the correspondence of the elements of the model (equipment, substances, tasks, ...) with the reality of the installations and the practices, thus to give a maximum of intelligibility to the multiple experts who will participate in this work. The objective is to multiply the points of view on the models and the elements of feedback, in order to optimize the possibilities of answers to this imperative of submission to what is observed, to rely on the truths of the stakeholders to progress towards a more robust modeling, until the dialogues dry up because a common operational picture seems to have been deemed acceptable by all. This is also why MIRA goes so far as to monitor the criticality of the risks (and of all the items allowing its calculation and periodic recalculation). It numerically integrates thousands of pages of risk studies, operational procedures and recording into a database logic. For it is always a question of re-examining the models without losing sight of what is really important and what is less important: by giving oneself the means to prioritize the problems. In this case, the whole process of doubt, regret and curiosity, to use the emotions that can be put forward to encourage this positive dynamic (Houdé, 2019), must not lose sight of the fact that the final issue is the overall level of risk acceptability. Is it obvious? Without a doubt. But it is clear that current risk management approaches, practices and tools do not address this issue. To our knowledge, no IT solution has this objective, so they generally focus on the communication aspects around the bow ties for example, but without the concern to re- interrogate the models by going as far as recalculating the risks from the feedback. Similarly, government inspectors will tend to rely on probabilistic analyses to identify safety barriers, take them out of context, and prescribe obligations of means (rather than obligations of objectives) requiring operators to achieve 100% success when the risk assessment has estimated a level of confidence, i.e., designed an acceptable possibility of failure.

The key here would be to keep the connection between risk assessment and risk management so that there is a way to update the estimated statuses for the equipment in the risk assessment and guide the choices made to manage priorities.

Any break at this level between risk assessment and risk management seems inevitably to ruin the construction of a positive dynamic of dialogues around a common operational picture.

To give a maximum of intelligibility to the stakeholders, by taking into account the points of view of each one, in order to build a dynamic of dialogues around the acceptability of the models, by keeping in the heart of the risk management the principles and the methods of the risks assessment... this is the challenge of the MIRA project, this is where we hope to take advantage of the new possibilities offered by digitization.

A lot of progress has been made in this perspective, notably the development of adapted web based tool. However, much remains to be done, in particular through the multiplication of industrial case studies.

8. An example of application: MIRA

The current application developed was for a case study with Service National des Oléoducs Interalliés (SNOI) to develop a system at three levels:

Level 1/ A risk assessment IT solution able to support decisions regarding risk management and provide the rationale to justify SNOI choices also if questioned by the regulator and its own management. This rationale informed the very foundation of the way the system was designed and realized. Above all SNOI wanted the risk assessment to be the foundation of a live picture shared across all levels to provide transparency on the risk faced and the impact that the unavailability or the unreliability of tasks or equipment can have on the accident scenarios the SNOI is exposed to. The computer system tends to become the support tool for the drafting of risk studies. It can manage the hundreds of thousands of pages of these studies and extracting lists of measures (safety barriers) and its critical equipment or tasks linked to exclusions, estimates of hazard potentials, calculations of frequencies of initiating events, and assumptions for modeling the intensity of hazardous phenomena.

Level 2/ An IT monitoring processes to:

- Support the improvement of the risk assessment,
- Demonstrate the congruence between the risk control means considered in the analyses and the resources efficiently managed on the sites,

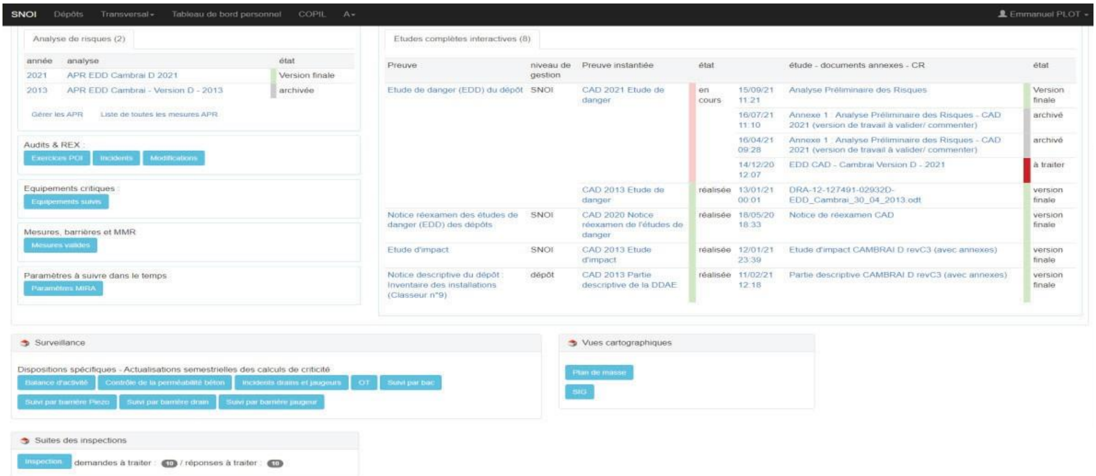

Figure 1: the pop out window in this screenshot shows the risk studies associated to an installation

o Monitor that the evolution of the criticality of the hazardous phenomena remains acceptable over time. This is a system for reporting real-time updates of risk monitoring data from facility operating systems (maintenance, production, incident management system). The system manages records and monitoring data associated with critical equipment or tasks from which risk acceptability update calculations are periodically performed for an entire installation (see Figure 1). A critical asset is any equipment or key task involved in the realization of a safety measure (cf. the criteria used for the detailed barrier analysis: independence, response time, etc.) that plays a role in the risk assessment (whether it is at the level of exclusion choices, estimates of hazard potentials, calculations of frequencies of initiating events, or even at the level of assumptions for modeling the intensity of the hazardous phenomena). The system can also offer an interactive ground plan of the safety critical assets linked to the database. Once selected the item identified on the ground plan, the risk studies and safety management procedures/ document connected to the items can be displayed. In the GIS mapping other relevant items and related Isorisk curves are made accessible that can be relevant for topological risk mapping related to releases etc. The tool also offers dashboards for monitoring changes in the performance of critical items. This point is crucial as it provides a complete feedback loop between prospective risk assessments and the updated picture of actual equipment and industrial process status and how they impact the SNOI risk profile for the relevant scenarios. This link is visible and simplified in a way that it provides transparency for the outcome of unavailability of critical tasks or equipment connected with relevant safety measures. This knowledge is not available just to the risk expert or the process engineer but shared across all levels of the organizations, easy to understand also for operational personnel. In this sense it can also allow those consideration to update HAZOP and HAZID studies that would otherwise become stale picture of a status quo no longer valid (see Figure 2).

Level 3/ An IT rules and proofs management system capable to include:

- o All the type of requests and demands received from different inspectors (including updates to risk studies), with a classification according to how clear and easy or not to do they are to realize,
- o How to best address them so that recurrent similar request can be dealt in a consistent standardized way
- o The lists of evidence that answer daily to mandatory requests.

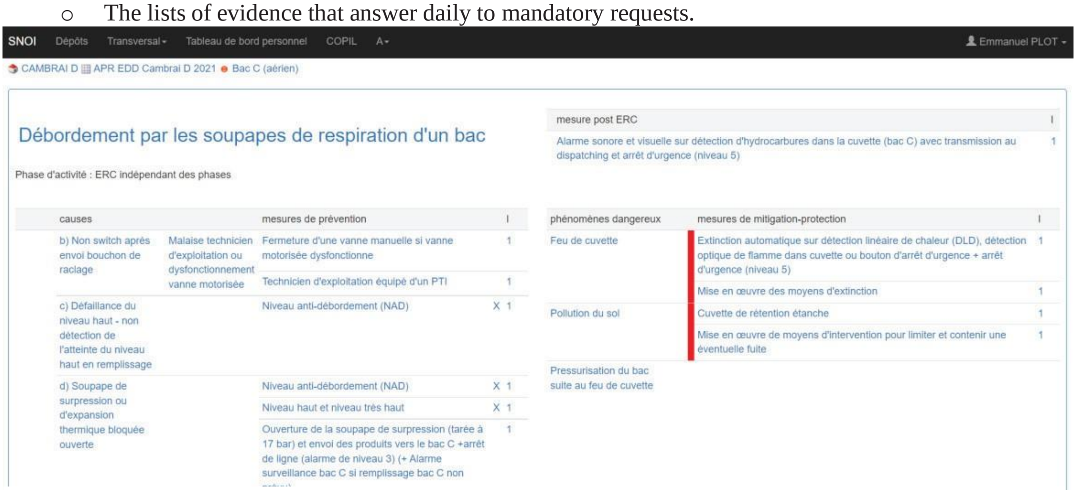

Figure 2: Interactive worksheet available in MIRA to edit and populate HAZID or HAZOP

The system allows organizing and storing the internal requirements connected to the external regulatory requirements the plant must comply with. For each internal requirements the plant can store evidence or proof that the requirements have been applied and is being followed on site. Some evidence is also to be found in the risk studies and how they are updated in the system considering the actual reliability data with status updated from the field. Each piece of evidence is also attached to the regulation they refer to. The regulations are stored in the system by uploading the official PDF and each article is translated as an item on the list of requirements. However, these requirements which can be many and varied (approx. 1300 items on the current system database) can be linked and aggregated in company guidelines/procedures (named "doctrines" in French in the system), following which the organization can safely align themselves to the regulations. They can provide a much more synthetic set of rules/ procedures for the system to safeguards the alignment with regulatory obligations.

9. Conclusions

There is a need for digital applications able to support the management of technical complexity factors, promoting the methodical development of conservative strategies within cognitive trade-offs that integrate in the form of action scenarios the implementation of identified safety barriers for the control of accident scenarios, despite cognitive biases that enhance complexity and/or hinder the development of these strategies.

The developed digital MIRA platform attempts to achieve this goal by supporting the organization of dialogues between stakeholders, around a database that is comprehensive of risk assessment, regulatory requirements and up to date info on monitoring and inspection data. The system needs to process information in a dynamic way to support proposals regarding the acceptable level of major risks, and explicitly lay out the basis of decisions and assumptions for each stakeholder involved.

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