Convergence in risk assessment for SEVESO sites from assurance results to ARAMIS method

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CONVERGENCE IN RISK ASSESSMENT FOR SEVESO SITES

FROM ASSURANCE RESULTS TO ARAMIS METHOD

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1. INTRODUCTION

In the SEVESO II Directive, the objectives in terms of risk management are very clear, but the remaining question is: How to reach them ?
For example, there is no harmonised definition of the scenarios that have to be considered for risk assessment. Typically, the chosen scenarios (BLEVE, total loss of containment, fire in the largest tank, explosion of the largest mass of explosive, etc.) can be different according to the specific risk analysts and according to the deterministic or risk-based approach of the country applying the Directive.

In this presentation, I will share with you the main results of the ASSURANCE project, in which 7 European organisations performed a benchmark exercise for the risk analysis of a specific plant. ASSURANCE pointed out the need for further development that were achieved in the ARAMIS project. For this latter project, I will present the main results and the perspectives and how the ARAMIS results constitute a major step forward in the convergence of practices in risk assessment.

2. ASSURANCE PROJECT

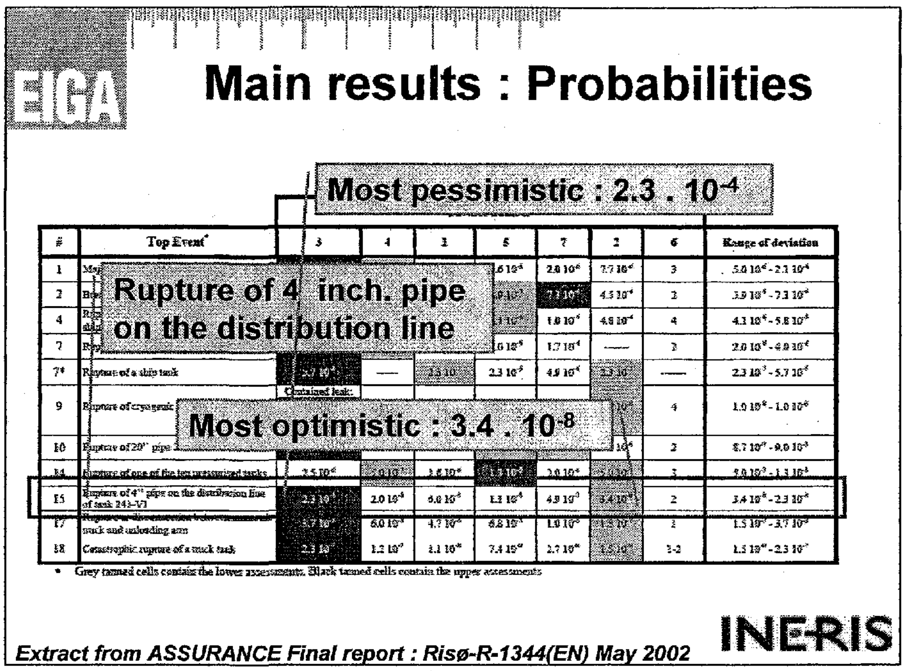
2.1 Project description

ASSURANCE means ASSessment of Uncertainties in Risk Analysis of Chemical Establishments. This project was a benchmark exercise on risk analysis of chemical installations to understand discrepancies between experts. The project consisted in the comparison of the selection of scenarios, the comparison of the estimation of the consequences and finally the comparison of the estimation of the probabilities. The project lasted 3 years from 1998 to 2001. The 9 partners from 7 different countries, representatives of the risk assessment approaches implemented in Europe.

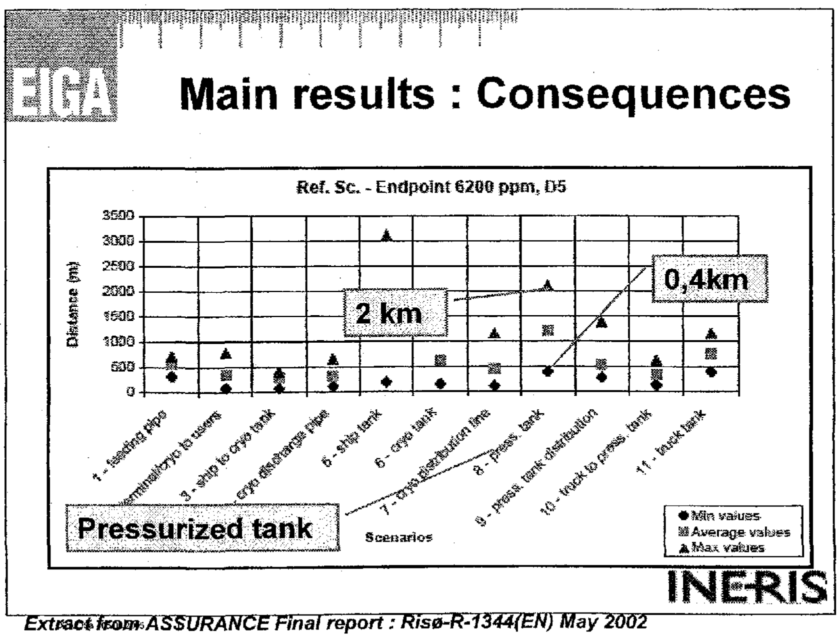
2.2 Main results

The partners used various risk analysis techniques and arrived at quite different conclusions with respect to the selection of the scenarios, the estimation of their probabilities and the estimation of their consequences.

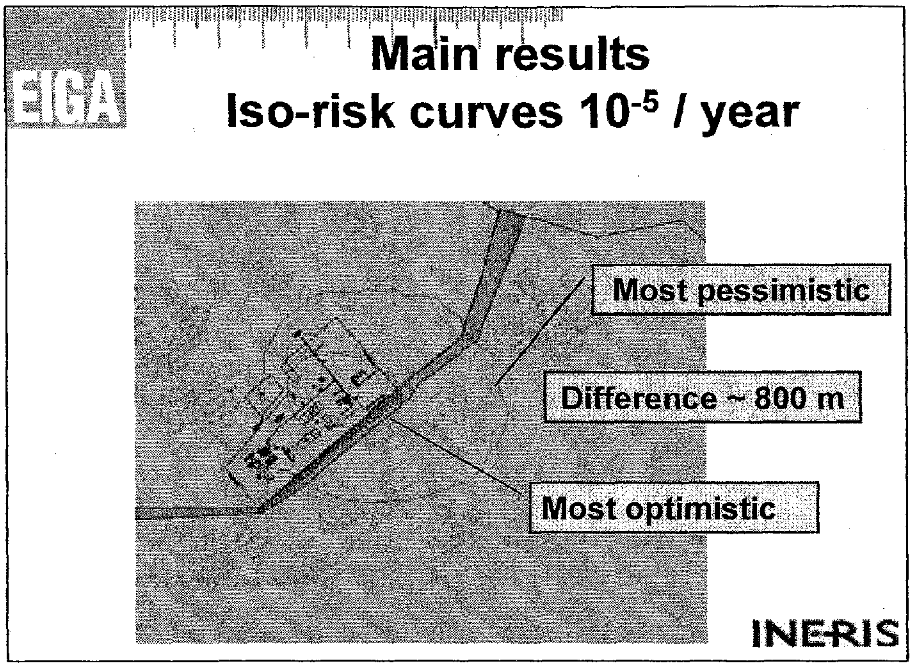
For example, in terms of probabilities, for a classical event which is the "Rupture of 4 inch. pipe on a distribution line", the most optimistic partner estimated a probability of occurrence at $3.4 \cdot 10^{-8}$ per year, and the most pessimistic partner at $2.3 \cdot 10^{-4}$ per year.



Concerning the consequences of the scenario, for a rupture in a pressurized tank, the distance to reach the end point 6200 ppm in a normal atmospheric condition, was estimated by the most optimistic partner at 0,4 km and by the most pessimistic partner at 2 km.



The last comparison concerned the iso-curves for 10-5 / year that a person dies in the vicinity of the plant because of an accident. There is a difference of about 800 m between the most optimistic and the most pessimistic partners.



2.3 Lessons learnt from ASSURANCE

The ASSURANCE project has shown that there are discrepancies between the experts in the definition of scenarios considered for risk assessment. Some assumptions are different and these have a strong impact on consequence calculations.
There are also discrepancies in the estimation of the probabilities of some events because there is a lack of reliable and contextual data (on failure rates, reliability...)
Moreover, the project pointed out that risk curves mapping is not meaningful for local authorities and the public (consequence-based approach countries).

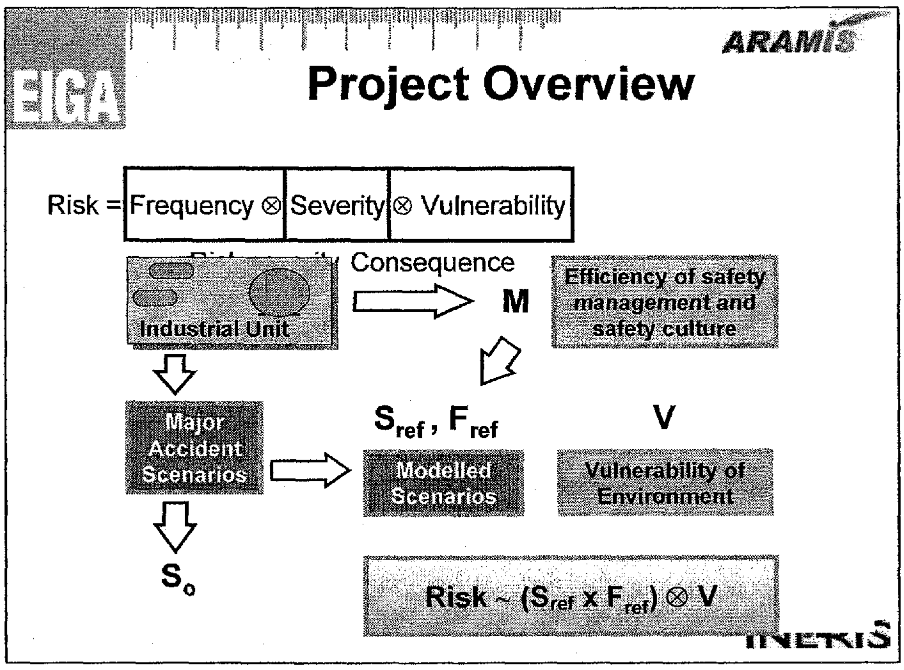
3. ARAMIS PROJECT

3.1 Project description

The ARAMIS project built further on the conclusions of the ASSURANCE project and proposed a structured approach that reduces the discrepancies in risk assessment.
The main objective is to build a methodology that will improve the effectiveness of the safety reports required by the Seveso 2 directive.
This method combines the benefits from risk- and consequence-based approaches.
It will help operator to better demonstrate that hazards are identified and risks are controlled.

Finally, it will provide appropriate information to base risk-related decisions like the deliverance of permit, lands use planning and emergency planning.

The project, which lasted from 2002 to 2004, consisted in the elaboration of a methodology giving consistent rules for the identification of scenarios that take into account mitigation devices and safety management, and being recognised by a large number of risk experts from Competent Authorities and from Industry, gathered in a Review Team.



In ARAMIS, the risk level of an establishment is characterised with an integrated approach where 3 independent parameters are quantified:

- the Frequency of the scenarios
- their Severity
- and the vulnerability of the environment

From the risk analysis, Major Accident Scenarios are identified and then Reference Accident Scenarios that take into account the preventive measures implemented by the operator. The severity Sref and the frequency Fref of these reference scenarios are estimated.
The selection of the Reference Accident Scenarios is made possible thanks to the evaluation of the efficiency of the safety management system: both the formal aspect and the safety culture within the plant.
The environment vulnerability estimation describes the sensitivity of the potential targets located in the vicinity of the SEVESO II establishments
The outputs of the ARAMIS method are mainly represented on maps.

3.2 Main results

ARAMIS method is well structured and contents 6 major steps that are described more extensively in the main chapters of a user guide.

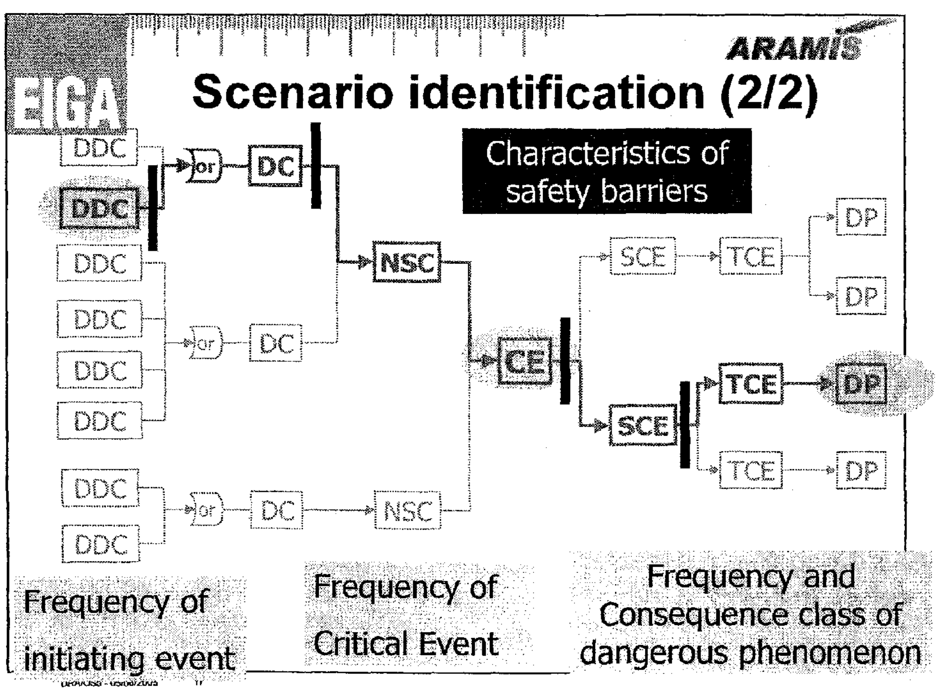
- Identification of major accident hazards (MIMAH)
- Identification of the safety barriers and assessment of their performances
- Evaluation of safety management efficiency to barrier reliability
- Identification of Reference Accident Scenarios (MIRAS)
- Assessment and mapping of the risk severity of reference scenarios
- Evaluation and mapping of the vulnerability of the plant surroundings

I will present some key part of the method to give an overview of its content.

The scenario identification

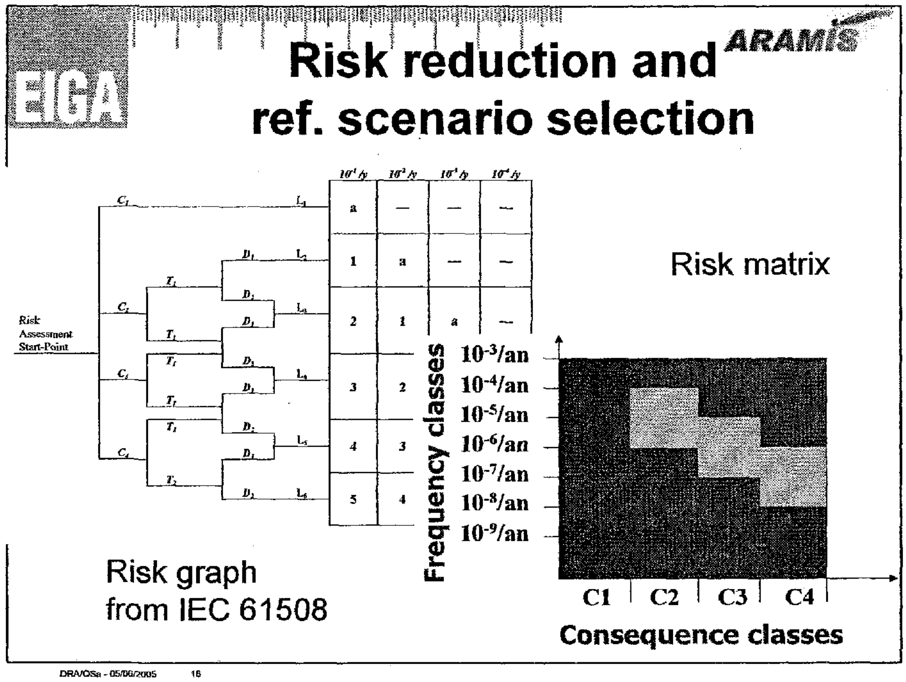
One of the crucial step is the scenario identification. It is based on the bow-tie approach where fault trees and event trees are connected through the critical events. The identification of the scenarios consists in the identification of typical and generic events: direct causes (DDC and DC), necessary and sufficient conditions (NSC), the critical events (CE), the secondary and tertiary critical events (SCE and TCE), the dangerous phenomena (DP).

This representation enables then to identify the safety functions and the safety barriers.



The influence of safety barriers is determined in assessing their performances (level of confidence, efficiency and time response in accordance with the scenario).

The reference accident scenario identification
Then, a risk reduction goal, defined in terms of aggregated level of confidence, is assigned to each scenario in order to reach an acceptable level of risk during risk analysis. This phase use the principles described in the standard IEC 61508 on the evaluation of the functional safety of safety instrumented systems.



At this stage, the scenarios taking into account the safety barriers are ranked in a matrix. Those scenarios that are in the yellow zone are considered as Reference Accident Scenarios while the scenarios in the red zone have to be further worked out to reduce their consequences or their frequence by implementing appropriate risk reducing measures.

The barrier management performance
The barrier management performance combines a generic and a specific approach. The method allows the use of databases with generic levels of confidence. But 2 tools have been developed to assess the specificity of the studied plant:
- an audit protocol to assess the barrier-related management activities
- and a questionnaire to assess safety culture/climate onsite

The barrier management performance reflects the level of control of the activities relating to safety barrier life cycle.

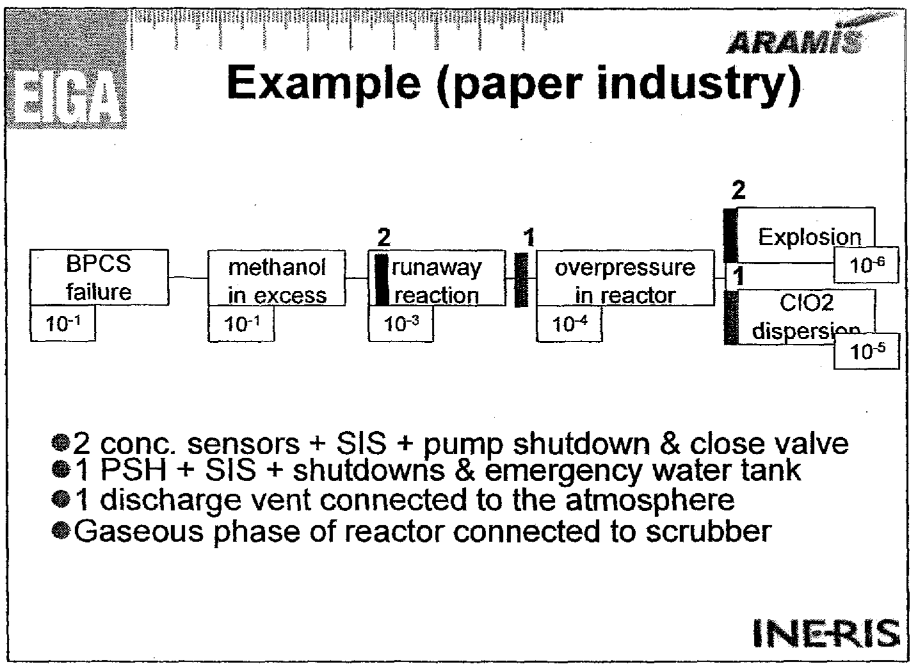
Example

It is proposed to consider an example from the paper industry taken from the test cases of ARAMIS.

The critical event is a runaway reaction that can be caused by the introduction of an excess of methanol in the reaction, because of the failure of a BPCS pump.

This runaway reaction will lead to an overpressure with an explosion and the release of chlorine dioxide, which is toxic.

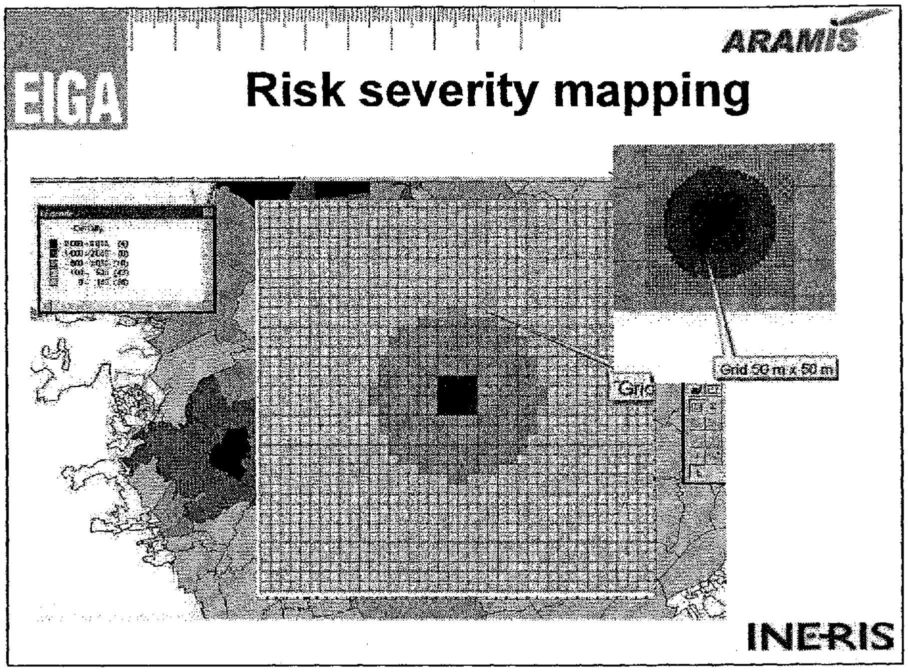
In this example, we can estimate the probability of the dangerous phenomena if we know the frequency of the initiating event and the level of confidence of the safety barriers.



The severity calculation and mapping

The severity $S_{CEi}(d)$ is estimated in every point in the surrounding of the plant for each dangerous phenomena associated to all critical events. Then, the multiplication of the frequency by the severity of each critical event is summed up to calculate the severity $S(d)$ at a given distance.

$$S(d) = \sum_{i=1}^{n} \left(F_{CEi} \cdot S_{CE_i}(d) \right)$$



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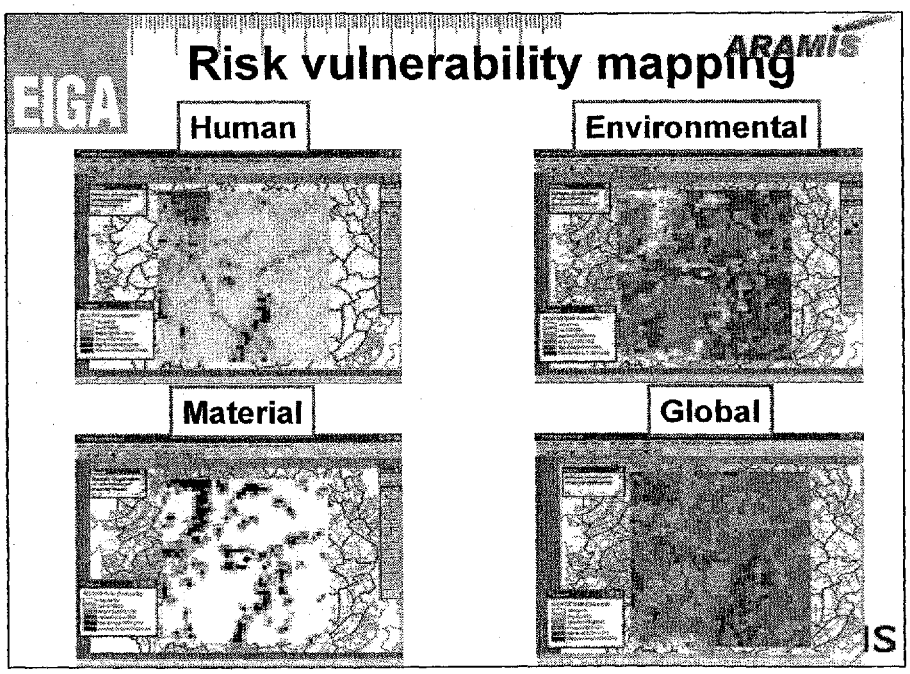
The vulnerability

The estimation of the vulnerability of the environment consists in an inventory and a quantification of the possible targets by using a Geographical Information System. Three types of targets are considered:

- environmental targets
- human targets
- material targets



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The importance and sensitivity of the targets was achieved by implementing a multi-criteria decision-aiding method where the ranking factors were elicited through questionnaires distributed to a large number of experts.

4. CONCLUSIONS AND PERSPECTIVES

The ARAMIS method has answered some of the difficulties related to risk assessment pointed out by the ASSURANCE project.

Three project main conclusions can be drawn up.
ARAMIS method is based on the safety barrier approach. This constitutes an alternative to the probabilistic/consequence based approaches which is well understandable by the industry as well as by the competent authorities. It is didactic and pedagogic.
The safety barrier approach is also compatible with Layer Of Protection Analysis (LOPA) method and the IEC 61508 standard, which is largely implemented in the industry.
This approach leads to constructive discussions on the level of performance of safety barriers within the plant and with the authorities.

ARAMIS is a method that takes into account the specificity of the plant, its safety management system performance and its safety culture, when other methods consider only generic data.

Beside the development of an integrated risk assessment method, ARAMIS project has achieved a tremendous exchange of practices between practitioners from more than 15 EU Member States if we consider the consortium and the review panel.
This has led to a certain convergence among countries (partners and reviewers) in the way of implementing risk assessment in the framework of the Seveso 2 directive.
The project has brought elements to fulfil the need to establish a method that is capable to assess the risk level of an installation by integrating the preventive measures implemented by the operators. Such a method is a prerequisite in order to reach the goals of the SEVESO II Directive, that are to improve the prevention linked in particular with the safety management. The application of this method results in a more consistent risk evaluation and safety management strategy in all European Countries

This reflection has continued in the European Working Group on Land Use Planning (EWGLUP) which aims at exchanging experience in risk assessment and land use planning in all Member States.

Acknowledgement

The work presented in this paper has been elaborated in the frame of the EU project ARAMIS "Accidental Risk Assessment Methodology for IndustrieS", co-ordinated by INERIS (F) and including EC-JRC-IPSC-MAHB (I), Faculté Polytechnique de Mons (B), Universitat Politècnica de Catalunya (E), ARMINES (F), Risø National Laboratory (D), Universita di Roma (I), Central Mining Institute (PL), Delft University of Technology (NL), European Process Safety Centre (UK), École des Mines de Paris (F), École des Mines de Saint Etienne (F), École des Mines d'Alès (F), Technical University of Ostrava (CZ) and Jozef Stefan Institute (Si).
The project is co-funded under the Energy, Environment and Sustainable Development Programme in the 5th Framework Programme for Science Research and Technological Development of the European Commission.