Risk assessment and decision making related to land-use planning in France

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1. INTRODUCTION

The *Third Assessment* [1] from the European Environment Agency (2003) indicated that Major technological accidents continue to occur, even with advances in the safety management of hazards and the efforts to control major accident hazards with Seveso I and Seveso II directives. Recent accidents (Enschede in 2000, Toulouse in 2001) have shown that disasters continue to occur throughout the EU. Moreover, a recent communication from the Commission [2] indicates that the frequency of major accidents is estimated at about 3.10^{-3} per year if we consider the number of accidents reported in the MARS accident database of the European Commission (Major Accident Reporting System, http://mahbsrv.jrc.it/) versus the number of hazardous installations in the EU.

So, controlling major accident hazards by reducing the risk at the source is not sufficient to promote a sustainable development for both industry and urban areas in the next decades. It is necessary to organise the settlement of industrial and urban areas with an appropriate land-use planning (LUP).

This paper describes and discusses suggestions that will be implemented in the French risk management system according to the new law on the control of technological and natural risks [3]. In particular, the paper will focus on propositions to improve the efficiency of the land-use planning procedure.

2. CONTEXT AND ISSUE ADDRESSED

2.1 Seveso II requires land-use planning around hazardous installations

The article 12 of the Seveso II directive requires that: "Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest, and, in the case of existing establishments, of the need for additional technical measures in accordance with Article 5 so as not to increase the risks to people."

Even if the directive is the same within the European Union, the history of the legal systems in the different Member States shows that LUP can be implemented in several ways, using a deterministic approach, a probabilistic approach or tables of appropriate distances [4].

2.2 LUP, a decision making process involving multidisciplinary expertise

The risk management decisions have to be made for the interest of the Civil Society since the main goal of risk based decision making is to protect people and the environment.

As described in the IEC/ISO Guide 73 [5] on risk management, it is fundamental to distinguish the risk assessment and the decision making steps. The guide explains that risk assessment is a part of the risk management process, ended up with the decision. Risk assessment is a tool used to estimate the risk, characterised by the likelihood and severity of specific events. Risk based decision making process is naturally based on risk assessment criteria, but must also integrate other criteria that can be economical, cultural, ethical… Having said that, the ISO Guide 73 should apply to the LUP procedure.

Moreover, recent major accidents, in particular in Europe, have shown that politicians and risk-decision makers are facing difficulties to manage technological risk. This situation is probably due to, on one hand, the complexity of the issue, and on the other hand, citizen's loss of trust in politics, since in a knowledge-based society, citizens ask for more and more access to information and require transparent decision-making processes. In fact, there seems to be a lack of balance between the

citizen's expectations and the decision-maker's behaviour on risk-related problems, mainly due to the uncertainties of the risk assessment and to the complexity of the context.
The increasing complexity of industrial systems and the conscience that the role of humans and organisations is a key issue to control major accident hazards have strongly emphasised the need for better methods and tools to manage industrial risks. Such approaches are based on models that integrate a holistic vision of the industrial system. It implies that trans-disciplinary approaches are currently developed by integrating the concepts, models and tools from various sciences : engineering, psychology, sociology, management etc.
Therefore, LUP appears as a decision making process involving **multidisciplinary** expertise.

2.3 Public involvement in risk management

The awareness of the general public about technological risks has recently increased and as well the demand for effective, consistent and adequate risk management. Moreover, by nature technological risks are required to be treated at both national and local levels. The national level should define general rules, and the local level should apply the rules and reach agreements according to the local socio-economic, political and cultural context. It has long been recognised that increasing public participation
is an essential element in improving environmental and risk-related legislation. It has led to the adoption on 25 June 1998 of the Aarhus convention on access to information, public participation in decision-making and access to justice in environmental matters.
When the various stakeholders are aware of risk issues, and involved in decision-making, the solutions inevitably become more sensible and legitimate. The quality of stakeholders participation in risk decision-making is often determined by how well informed they are about the nature of risk issues, and how responsible institutions deal with them.
According to the discussion presented here, the key issues seem to be both scientific and societal.

3. THE SITUATION IN FRANCE

3.1 Risk management policy in France

In France, land-use planning is a major part of the risk management policy implemented by the Competent Authorities in charge of Seveso plants. In the regulation related to the control of hazardous establishments, the deliverance of the license to operate can be subordinated to a sufficient distance between the establishment and people located around.
To apply the Seveso II directive requirements and to develop a system on the control of major-accident hazards involving dangerous substances, the Member States need to built a risk management policy combining several tools. The risk management policy implemented in France is based on the accident model constituted by the following system:

- hazardous source: it is constituted by the hazardous installations, products, equipment, processes,
- hazard flux: it corresponds to the dangerous phenomenon like dispersion, fire or explosion,
- receptors: they are the elements located in the vicinity of the hazardous installation that could be affected by the hazard flux.

This model and the four components of the risk management policy are presented in Figure 1 [6]:

- risk reduction on-site: to reduce the hazard potential (amount of hazardous substances, process pressures and temperature...) and to implement risk control measures during plant operation,
- land-use planning: to maintain appropriate distances between the hazardous installation and the sensitive receptors,
- emergency plans: to prepare the public and the rescue services to behave efficiently in case of a major accident,
- information to the public: to inform the public about the possible consequences of a major accident and the behaviour they need to have in such a situation, but also to explain about the risk reduction at the source and the land-use planning objectives.

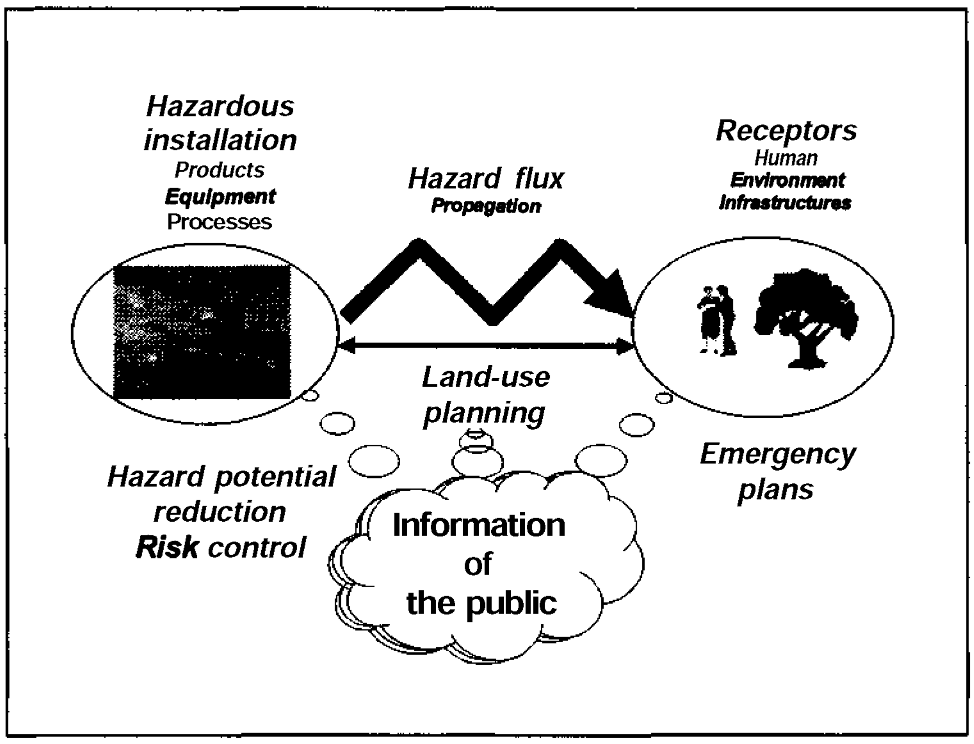

Figure 1: Risk management policy in France [6]

Using the model of Figure 1, it is clear that **LUP** is a complementary tool to the on-site risk reduction and to the emergency plans. The philosophy behind LUP is to maintain a distance between the hazardous source and the receptors in case of a major accident, in particular if the accident can occur so quickly that the emergencies plans cannot be activated, or so that the number of people to evacuate is too high.

3.2 Development of the French deterministic approach for risk assessment

To enhance a harmonised implementation of the philosophy presented above, the French Ministry of Environment published in 1990 a guide [7] that defined reference accident scenarios to be considered for determination of safety distances for land-use planning. Then, in a circular letter published in June 1992, it was explained that the safety distances should be determined using the safety reports written for the licensing procedure. Consequently, to write the safety reports that aim at characterising the hazard of their plants, the operators have been asked to focus on the examination of the reference scenarios described in the guide. This approach is known as the consequence-based approach or as the French deterministic approach.
The term deterministic means that the scenarios are pre-defined and considered independently of their likelihood, which is not assessed. The underlying philosophy is based on the idea that if sufficient measures exist to protect the population from the worst accidents, sufficient protection will also be available for any less serious incident.
The risk acceptance of hazardous establishments is a very complex decision process based on several criteria difficult to evaluate. In France, the only explicit criteria are those related to the possible consequences of accidents that are used to define the safety distances around hazardous establishments. They are linked to the LUP process.

4. ANALYSE AND RECOMMENDATIONS TO IMPROVE THE SITUATION

4.1 Methods to analyse the situation in France

In 2000, the French Ministry in charge of the Environment and Spatial planning asked **INERIS** to take stock of the situation regarding risk assessment and land-use planning in France. Then, a 3-years study was launched to analyse in particular, the procedure to write the safety reports required by the Seveso directive, and the relation with land-use decisions and zoning according to major accident hazards.
In this study, INERIS has brought the experience gained from, on one hand, a project entitled "Risk analysis and major accident prevention", and on the other hand, from the critical analyses of the safety reports asked by the authorities. Indeed, the French legal system allows the Authorities to ask a third

party expert to make a critical analysis of a safety report provided by an operator of a Seveso plant. The critical analysis is paid by the operator and is delivered to both him and the Authorities.
Besides, in order to collect the relevant information and identify the possible changes to improve the situation, several working groups were initiated both at local level and national level, involving inspectors and industry representatives. Both the thoughts of the INERIS team and of the working groups enable to identify the strength but also the weaknesses of the French approach.
Then, the Toulouse accident occurred in September 2001, at the mid term of the study. Its dramatic consequences has reinforced the interest of the study, but has changed both the context of the study and the expectation of the Ministry. Moreover, the regional debates and national debate launched by the French parliament provided substantial information to enrich the study from a technical point of view and also from a societal one.
Thanks to this work, lessons have been learnt about the implementation of LUP and the risk assessment used for the LUP purposes. They are presented hereafter as guiding principles that could be used to improve the LUP procedure in France. However, some of them are so general, that they could be applied in other Member States of the European Union.

4.2 Distinguish risk assessment for giving the permit to operate and for LUP

In the safety report required by the Seveso II directive, the risk assessment should enable the operator to conduct a deep analysis on the hazards of a plant and on the way to control the associated risks. The analysis should start with a systematic hazard identification and a risk analysis. Then, after the assessment of a set of scenarios, the adequacy of the risk control measures should be discussed. This requires the identification of worst case scenarios and of scenarios that take into account the safety barriers implemented by the operator. The comparison of these two types of scenarios shows the risk reduction and the gain provided by the safety control system. In other words, the demonstration required by article 9 of the Seveso II directive, in particular that "major-accident hazards have been identified and that the necessary measures have been taken to prevent such accidents and to limit their consequences for man and the environment" need a detailed risk assessment. Based on this risk assessment, the authority can verify that the operator has "taken all measures necessary to prevent major accidents and to limit their consequences for man and the environment", as required by the Article 5 of the Seveso II directive.

The purpose of LUP is, as explain in Article 12 of the directive to "maintain appropriate distances between establishments [...] and residential areas, areas of public use and areas of particular natural sensitivity or interest". This objective can be interpreted as the need to estimate the consequences of major accidents in order to determine the zones in which the number of people should be minimised.
Clearly, the objective of risk assessment to deliver the permit to operate and the objective for LUP are different. The later has often a great economical impact outside the plant, the former has the main impact inside the plant. In particular, to do risk assessment, scenarios must be defined. Since an accident scenario is the combination and the conjunction of several events, the assumptions related to the conditions of occurrence of the events including the functioning or not of some safety devices have a great importance on the final results.
The risk assessment for LUP purpose should therefore be defined by the authorities in a public guide.

4.3 Defining certain assumptions related to the safety barriers and to the consequence assessment

The scenarios that can lead to the most serious consequences are usually used to determine the emergency plans. The scenarios considering that the safety barriers in place can prevent the occurrence of some events or reduce their consequences can also be identified. They are usually used to judge the adequacy of the safety control system which includes naturally the safety equipment and operations, and the organisational measures, both defined and maintained by the safety management system.
For land-use planning purpose, intermediate scenarios are needed. Such scenarios should take into account some safety barriers, for example, those prescribed by standards and regulations. In particular, the safety barriers that are the most reliable should be considered as in good operation.

Since there is still a great uncertainty on the performance of safety barriers and the reliability data, the safety barriers should be identified, reviewed and accepted with a consensus by the authorities and the other stakeholders of the LUP process. The scenarios taking into account these barriers can therefore be considered as conventionally defined.

Looking at several risk assessments of similar hazardous installations, strong discrepancies have appeared on the estimation of the distances related to the apparition of the lethal effects and first injuries. This statement was the same in the ASSURANCE project [8]. This benchmark exercise allows to measure the size of the uncertainties in risk assessment and to propose some explanations. The results indicated discrepancies of about 4 orders of magnitude (variation of 1.5 10^{-7} to 2.1 10^{-3}) in the probability estimation of some events. There is a factor 6 for the estimation of the consequences of a liquefied ammonia release in unfavorable atmospheric conditions (variation from 1510 m to 9700 m for first injuries, and from 570 m to 3800 m for the first deaths).
These results are due to the great variety of possible assumptions related to the parameters describing the conditions of occurrence of the scenarios and the hazardous phenomena. The choice of these assumptions generates uncertainties on the estimated safety distances.

However, the decision making process constituted by the LUP should be homogeneous and consistent at the national level, and further at the European level.
Therefore, defining certain assumptions could reduce the discrepancy in the decision process, and should make it more transparent. It is no more tolerable that the results of the risk assessment step depends
on the experience, the feeling of a risk evaluator, neither the pressures related to the implication of the results. It is essential that the rules are the same for all, should they be discussed and determined after a debate involving all stakeholders: industry, authorities, mayors, communities and risk appraisers.
In order to make it explicit that the scenarios used to estimate the danger zones in LUP are based on predefined assumptions, it was proposed to call them "conventional" scenarios. On the basis of the conventional scenarios, then the LUP decisions can be adopted as a function of the local context.

4.4 LUP, local concerns
LUP is implemented at the local level and should take account of local specificity. The LUP ACS project [9] proposed a methodology for LUP involving chemical sites for making decision in local and regional administration. This European project expressed that LUP is a complex decision process involving actors at different levels with different interests.
In that context, the estimation of the consequences of the proposed conventional scenarios should be one of the criteria used to define the danger zones for the use of land. But the problem has other dimensions than the risk level, and decision makers should take into account the economical, social, cultural dimensions of the problem.
The danger zones based on the conventional scenarios enable to identify the residential areas and other sensitive areas capable to be affected by the accident. They identify also the stakeholders who should be involved in the discussions and negotiation that will lead to find a consensus on the most adequate alternatives between: a) keeping large zones around the plant and disable the development of the city and b) reducing the zones by implementing technical measures to enable the development of the city.
For both new installations or existing ones, the danger zones should not be directly transposed from the risk assessment step. The implication of land-use by taking into account the hazard potential of a plant should be discussed at the local level, and should be analysed regarding all the aspects of the decision.

4.5 Recommendation of a two-step approach for a risk-informed land-use planning
Using the lessons learnt for more than 10 years, INERIS formalized a two-step approach described in Figure 2 [10]. This two-step approach allows:

- To assess the hazard and estimate the danger zones in a homogeneous manner, following a common procedure defined at the national level,

- To develop and assess alternatives that can be negotiated at the local level, according to criteria defined at the national level, that should be made explicit.

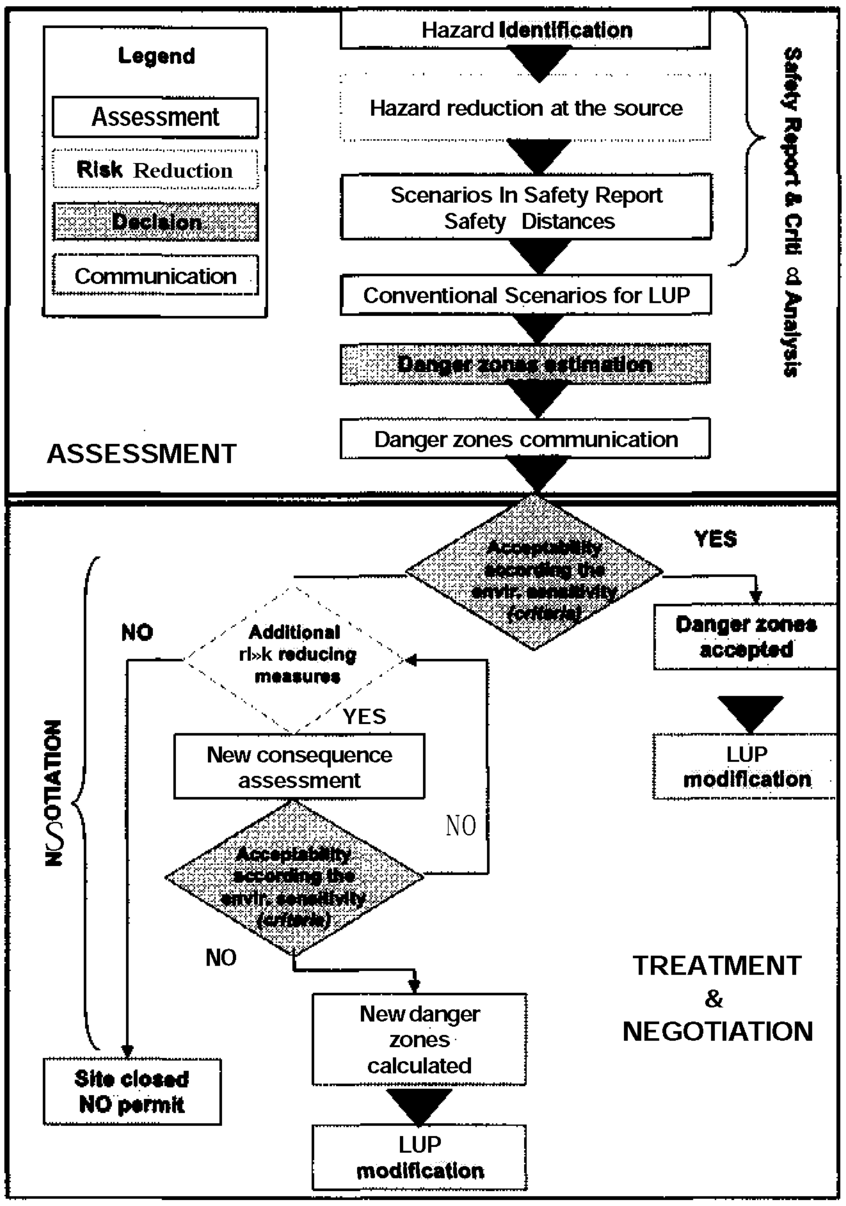

Figure 2: Two-step approach for land-use planning as suggested by INERIS [10]

The first part of the approach is the risk assessment that leads to the estimation of the danger zones and their communication to the public, in order the public and the stakeholders know about the extension of the possible damages in case of a severe accident. This step is based on the examination of a set of scenarios, covering the different hazardous phenomena associated to accidents involving toxic, explosive and flammable substances. The conventional scenarios used to determine the danger zones should be defined in a guide, which is currently under development.

The second part is the treatment of the risk and the negotiation of the alternatives for the land-use planning, according to the local constraints like the composition of the environment in the vicinity of the hazardous installations, and socio-economical context. At this second stage, the discussions and the negotiation should associate the various stakeholders identified within the danger zones determined in the first stage. This phase of the procedure can be iterative if the local constraints need the implementation of several risk reducing measures to reduce the extension of the zones. However, attention should be paid in order to avoid that the final danger zones become too small, because then the principles of LUP (maintain a appropriate distance between the hazardous installations and the receptors in case of a major accident) would not be respected.

This two-step approach bring consistency in the risk assessment and the risk management. It offers transparency in the negotiation as well as flexibility to take into account the local context.

5. CONCLUSION AND PERSPECTIVES

This paper presents the evolution of the situation in France regarding LUP, in particular after the Toulouse accident. The driving idea to make both risk assessment and LUP procedures evolving was to reduce the uncertainty and discrepancy of the evaluations that are used for public decisions.

Concerning the risk assessment procedure used to get the permit to operate a Seveso plant, INERIS recommended an approach based on the definition of reference accident scenarios using the bow-tie model and on the evaluation of the safety barriers implemented to prevent or mitigate the possible accidents. This approach helps to fulfil the requirements of the article 9 of the Seveso II directive such as to "demonstrate that major-accident hazards have been identified and that the necessary measures have been taken to prevent such accidents and to limit their consequences for man and the environment".

For the LUP procedure which ends with a zoning where constructions can be restricted, INERIS elaborated a two-step approach that allows: 1) To assess the hazard and estimate the danger zones in a homogeneous manner, following a common procedure at the national level, and 2) To assess various alternatives of reducing measures that can be negotiated at the local level by the stakeholders, according to criteria that have to be made explicit.

The two-step approach described in this paper results from the experience of more than 10 years of application of LUP in France. It is based on an assessment of the consequences of accident scenarios and on transparent and traceable negotiation of the risk reducing measures to determine the final danger zones that are inscribed in the urbanism documents. The suggested approach brings some responses to the Presidency conclusions of the European Council meeting in Barcelona (15 and 16 March 2002), that expressed the invitation "to develop a strategic approach on the management of technological risks, while considering the social, economic and environmental challenges in relation with the issue of sustainable urban development."

The recommendations suggested by INERIS may be used to implement the new law on technological risks and natural hazards that was elaborated as a follow up of the Toulouse accident and adopted on 30 July 2003. The focus will be now on the implementation in concrete of the recommendations.

As written by the European Environment Agency, major accidents continue to occur despite of the efforts of the industry and of the authorities. "Zero risk doesn't exist" is a reality. This motto should reinforce the conviction that all stakeholders, in particular, the industry, the authorities and also the civil society should optimise the control of the risk in a best way, as a function of the resources of each, and of the benefits associated to the industrial activity. It is also important to underline that the choice of accident scenarios for LUP purposes doesn't mean that more catastrophic accidents will not happen. The choice of scenarios and the estimation of their consequences is a tool to make a risk management decision.

From the research point of view, new developments must focus on trans-disciplinary approaches, integration of social sciences, engineering and management sciences for both risk assessment and risk management. This topic is strongly addressed in the development of the ARAMIS methodology [11], which is a shared-cost RTD project of the 5th Framework programme of the EC. Results from the ARAMIS project will certainly bring knowledge to improve the risk management and LUP processes.

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