RAPPORT

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

# PRIME Project

Description of the technical proposition accepted by the French Ministry of Environment in the framework of the research call RDT 2006

DIRECTION DE L'ENVIRONNEMENT
ET DE L'INTERVENTION
Service d'Etude et de Surveillance de la Radioactivité dans l'Environnement

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

DIRECTION DE L'ENVIRONNEMENT
ET DE L'INTERVENTION

Service d'Etude et de Surveillance de la Radioactivité dans l'Environnement

| | |
|---|---|
| Demandeur | |
| Référence de la demande | |
| Numéro de la fiche programme | Affaire 15 000 001 / 0010 |

# PRIME project

## Laboratoire d'Etudes Radioécologiques en milieux Continental et Marin (LERCM)

Rapport DEI/SESURE n°2007-68

| | Réservé à l'unité | | Visas pour diffusion | | |
|---|---|---|---|---|---|
| | Auteur(s) | Vérificateur* | Chef du SESURE | Directeur DEI | Directeur Général de l'IRSN |
| Noms | C. Mercat et coll. | P. Renaud | JM. Pérès | D. Champion | J. Repussard |
| Dates | 11/10/07 | 15/10/2007 | 24/10/07 | 30/10/07 | |
| Signatures | | | | P.i. Denis BOULAUD | |

* rapport sous assurance de la qualité

Adjoint au Directeur de l'Environnement et de l'Intervention

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

**LISTE DES PARTICIPANTS**

| Nom | Organisme |
|---|---|
| Geneviève BAUMONT | IRSN/DSDRE/DOS |
| Eric CHOJNACKI | IRSN/DPAM/SEMIC/LIMSI |
| Catherine MERCAT-ROMMENS | IRSN/DEI/SESURE/LERCM |
| Jean-Michel METIVIER | IRSN/DEI/SECRE/LME |
| Philippe RENAUD | IRSN/DEI/SESURE/LERCM |
| Sylvie ROUSSEL-DEBET | IRSN/DEI/SESURE/LERCM |

**SOMMAIRE**

# 1 CONTEXT

The risk related to radiological and nuclear activities in France concerns 48 nuclear power reactors located on 19 geographic sites, 10 fuel cycle installations located on 6 sites, 61 research centers located on 4 sites, 10 installations which are dismantled on 7 sites, 2 waste storage sites, industrial irradiators, and gamma radiography inspection equipment. In addition, this risk concerns 50 000 local medical and research units located throughout France as well as transportations of radioactive material by road (300 000 transportations in 2004). The scope of French nuclear and radiological activities shows that the incorporation of territory characteristics is a potentially important component in the management of risks and especially accidental risk management.
The nuclear activities are effectively carried out to prevent accidents, but as it is not possible to guarantee zero risk, it is also necessary to limit the consequences of potential accidents. Two intervention phases are generally differentiated in case of an accident involving radioactive substances: an emergency phase involving a quick and organized response within the framework of intervention plans and a deferred phase, post-accident, which must be implemented on the medium or even long term in order to return to a situation considered acceptable by the various stakeholders involved. Even if the post-accident phase has to be implemented in continuity with the previous phase, the PRIME project is mainly focused on the development of methodological tools useful in this second phase.
The objective of the PRIME project is to develop, conjointly with the experts, the decision makers and representatives of the territory, a multi-criteria analysis method to characterize the contaminated territory that is useful for the managers of the risk related to industrial accidents involving radioactive substances. The method will be based on the ranking of the radio-ecological sensitivity factors of a territory with regard to radioactive pollution.
Is a 50km radius territory around a nuclear site only sensitive to accidental nuclear pollution depending on its distance from the source, or are there criteria varying its sensitivity according to the nature and use of the land? What criteria are important for the people living in the territory and how are the criteria weighted one against the other? What criteria can be used for decision-making? Can a multi-criteria method be a good tool to publish and make this data visible and accessible?

## 1.1 STATE OF THE ART ON PREPARATION FOR POST-ACCIDENT SITUATIONS

Thoughts on the management of post-accident situations started in France in 1986, initiated by the general secretary of the Nuclear Safety Inter-ministerial Council (CISN) and the Civil Safety Director. Within this context, a guide specially dedicated to decentralized services of the State (Coulon et al., 1994) was produced by the IPSN (now the IRSN) conjointly with the National Federation of Farming Operator Unions (FNSEA) and the Milk Economy Inter-professional Center (CNIEL). This strong inter-ministerial demand at the end of the 1980s in particular initiated by the Chernobyl accident was then strongly reduced in the 1990s. Thoughts on post-accident management was most of all supported in the 1990s by the works produced by expert institutes. On this theme, the IPSN and the Institute of Nuclear Energy Safety (IBRAE, Russia) carried out common exercises (Saint-Petersburg in 1993, Kola in 1995 (Enerpresse, 1995)). The main aspect treated by the exercise scenarios concerned the management of contaminated territories.
Since the middle of the 90s, thoughts on post-accident management have evolved to integrate social aspects more fully, as the feedback from the Chernobyl accident showed that the reduction of the radiological impact is only part of the problem raised and it can be tackled efficiently and durably only when the population is involved in decision. The ETHOS

program (Schneider, 2000) is carried out conjointly by the Protection Assessment Studies Center in the Nuclear Domain (CEPN), MUTADIS Consultants, the Technological University of Compiègne and the National Institute of Agronomy of Paris Grignon. ETHOS covers a concrete situation in Byelorussia. ETHOS was one of the first examples of this change towards partial retrieval of post-accident management by the population and local communities (Dubreuil et al. 1999). The ETHOS project was founded on strong participation of the local population in the rehabilitation processes. Its main goal was to associate the inhabitants of contaminated territories in the reconstruction of an "acceptable" quality of life, especially in relation to radiological safety. This project was applied in Byelorussia from 1996 to 2002. The CORE program in which the IRSN participated succeeded it in 2003. By taking the inhabitants as partners in improving living conditions in the contaminated territories, this program targets the introduction of concerted actions by local, national and international players in the environmental, agricultural, health, education and memory assessment domains.

In France in 1996, the Becquerel exercise (Badie et al., 2000) simulated a severe accident on an experimental reactor of the Saclay research center (Essonne). An area of approximately 16 $km^2$ contaminated with $^{131}I$, $^{137}Cs$ and $^{134}Cs$ was studied. The objective of the exercise was to assess the management capacity of the operational structures both with regard to decision-making and with regard to intervention, and to study the communication of the information related to the accident. Using indicators (dose affecting populations, levels of contamination in soils and in food), a comparison of the different rehabilitation strategies, including countermeasures, was carried out. The conclusions demonstrated: i) the significance of external radiation, ii) the radiological efficiency of the rehabilitation actions carried out in a built-up area and iii) the difficulties inherent to the management of waste generated by urban or agricultural rehabilitation actions.
Since then, several exercises have been carried out for post-accident evaluation. In particular, the *Cattenom* and *Pierrelatte* exercises in 2004 and the *Belleville sur Loire* exercise in 2005 covered this problem. In January 2002, a commission was set up by the Prefecture of the Aube to analyze the different components in post-accident situation management. Five working groups were made up on the following themes: administration and economic organization; environmental measures; health follow-up of the population; decontamination, rehabilitation of surfaces and contamination of the food chain; circulation in the contaminated territory.
The INEX 3 exercise, organized in 2005 by the OECD at international level concerning the cereal chain showed the need for protocols and procedures, especially with regard to harvest management.
In the chemical risk domain, the AZF accident in Toulouse on September 21, 2001 also highlighted the social demand for greater transparency in decision making with regard to industrial risk management. Between 2001 and 2004, within the context of the 5$^{th}$ PCRD, the ARAMIS project (Accidental Risk Assessment Methodology for Industries in the framework of SEVESO II directive) conducted by INERIS proved the advantages of multi-criteria methods to develop decision making help tools (Hourtolou et al., 2004). Based on 5 case studies corresponding to 5 European industrial sites, the ARAMIS project also revealed the significant zonal variability of decision-making modes and the need to continue the development of tools making it possible to combine the vulnerability of different natures (human, environmental and equipment vulnerability). The European multi-disciplinary TRUSTNET network, created in 1996 and financed by the European Commission, has the main role of analyzing the social negotiation process of risks. It is monitored by the TRUSTNET-IN-ACTION (TIA, 6$^{th}$ PCRD, 2004-2006) the purpose of which is to federate the different independent national initiatives concerning the analysis of current risk management schemes. The European TRUSTNET-CLIC project (supported by the INERIS) is focused on accompanying the setting up of several CLICs (Local Information and Consultation Committees) to define methodological recommendations targeted at improving communication and consultation practices between the different players involved in industrial risk management. The first stage is dedicated to the observation of pilot CLICs. The second stage will be a global analysis of risk management practices in France and in terms of perspectives at European level.

Today in France, considerable inter-ministerial work has been undertaken under the authority of the General Secretary for National Defense (SGDN) as the inter-ministerial directives setting down the operational organization modes in case of an emergency radiological situation essentially originated from the end of the 1980s and must be updated. This work led to the publishing of an inter-ministerial directive in April 2005, concerning the organization of the public authorities in case of an emergency radiological situation. This directive specifies the roles and responsibilities, intervention in emergency radiological situations (excluding those covered by an emergency or intervention plan) and especially the role of advisers and experts in of the Nuclear Safety Authority (ASN) in relation to the competent policing authority (mayor, Prefect). In particular, one of the major current methodological undertakings of the ASN (the ASN 2005-2007 strategic plan) is to orient crisis organizations and to participate in the preparation of a doctrine, then an organization for the post-accident phase. In June 2005, the Steering Committee was created within this framework to manage the post-accident phase of a nuclear accident or an emergency radiological situation (CODIR-PA), as well as six work groups. In addition, the first directive related to "intervention principles in case of an event likely to entail an emergency radiological situation outside situations covered by interventions or emergency plans" has been published (Circular DGSNR/DHOS/DDSC No. 2005/1390 dated December 23, 2005). The demand of French decision makers on the operational organization in case of an emergency radiological situation is therefore very strong.

## 1.2 STATE OF THE ART ON MULTI-CRITERIA ANALYSIS

Multi-criteria analysis came into being in the 1980s following a stalemate situation in the use of the cost-benefit analysis in environmental problems (Maystre *et al.*, 1994). In fact, how is it possible to convert the impact of environmental phenomena as varied as noise, water pollution of degradation of the countryside into a common monetary value?
Multi-criteria methods were then developed to answer this question by developing the following two dimensions:

- complexity reduction enabling an analysis minimizing the potentially interesting variants,
- conflict reduction by providing a base acceptable to all players.

Practical examples for the application of these methods are still relatively rare, as historically the classical single criterion decision-making tools have been preferred. This is also the case in the nuclear domain where the dosimetric approach is generalized largely. In fact, the single criterion approach has the advantage of resulting in simplified mathematical problems, but they are not necessarily representative of reality as the comparison of several situations can rarely be made on a single criterion, and the preferences on a single criterion are in many cases difficult to model (ICRP, 1989). There is a previous example of use of these methods for post-accident management. This concerns action 2 of the Joint Study Projects (JSP-2), coordinated by the CEPN and implemented between 1991 and 1995, within the framework of a vast research problem set up by the European Commission to assess and manage the consequences of the Chernobyl accident. The idea of JSP-2 was to develop a multi-criteria decision-making tool to integrate all available data (dosimetric aspects as well as economical social and psychological aspects) to assess the consequences of the Chernobyl accident and to help in the search for optimal solutions in terms of countermeasures. However, this work was only carried out in an institutional context (24 European organizations) and if the "multi-criteria" dimension of post-accident management was explored, the "multi-players" characteristics of this type of management were not taken into account. In fact, use of several criteria (for example a dosimetric criterion, an economic criterion, a socially acceptable criterion) boils down to admitting that a decision will unavoidably be the result of a compromise between several objectives and several representatives with sometimes conflicting interests. The development of a multi-criteria method will then be based on the finding and the acceptance that the preference of those involved are often conflicting, poorly

structured, destined to evolve during the decision process or even be influenced by the implementation of a decision making process (Maystre *et al.*, 1994).

# 2 POSITIONING AND OBJECTIVES OF THE PRIME[1] PROJECT

The successive works carried out in France on post-accident situation management show that it is mandatory that this management is based on an anticipated characterization of the radiological status of the environment discussed globally and according to a strategy taking into account the inhabitants and their living conditions. The objective is to provide the managers and the civil society with a simple tool enabling a methodic choice of actions to undertake and the comprehension of such actions by all when health, economic, ecological and even social criteria are simultaneously involved.

The findings in the field on the radiological consequences of radioactive releases, especially in the case of experience feedback from the Chernobyl accident, shows that the consequences for man and the environment of such pollution depends on the importance and the nature of the pollution as well as the territory polluted and its human and environmental context. This is also true for all industrial pollution. These consequences will be penalizing to different levels, whether expressed in economic, territorial image, toxicity or health risk terms, depending on the characteristics of the affected medium (environmental parameters) and according to the use made of it by man (anthropologic parameters). The different media: urban, agriculture, forest, rivers, lakes, oceans or at altitude, in particular incorporate appreciable sensitivities with regard to pollution and within these major environmental components themselves, which are the media, different natural or anthropologic factors specific to the ecosystem involved determine the response of the environment to pollution at a given moment. In an agricultural area, for example, the type of culture and the vegetative cycle time constitute a major sensitivity factors. Wheat and dairy products on a surface affected by the same pollution will also have very different respective levels of contamination. The remnants from this contamination in successive cultures will greatly depend on the soil characteristics. In addition, generally speaking, all characteristics intrinsic to an ecosystem and affecting transfer of pollutants invest a territory with a specific sensitivity with regard to pollution. The same applies to anthropologic factors such as cultural practices, use of fertilizer, irrigation, sowing period or animal production (animal feeding, presence outside). All these factors, later on called the sensitivity factors (meaning radiological sensitivity). The radiological sensitivity of a territory is therefore defined by two components: environmental and anthropologic. The relative weighting of these components may change over time.

If a territory is sensitive to pollution proper to this territory, it is currently difficult to compare the global sensitivity of different territories: is it more serious to have a major stock of pollutants in a natural space with little human presence or to have a low concentration of the same pollutants in a watercourse used extensively for irrigation? The radiological sensitivity is a concept making it possible to represent the intensity of the response of a territory to pollution. The perspectives of use of this concept have been explored at the IRSN since 2003 as part of the SENSIB project financed by IRSN and ADEME. The concepts studied in SENSIB show interesting perspectives for application in the different stages in the life of a nuclear installation (chronic discharge, accidental context, dismantling). The objective of the PRIME project is to propose an application of the radiological sensitivity concept at the scale of a territory in the post-accidental context.

The workability of this application will be examined by exploring several focuses invoked in call for proposals RDT 2006:

[1] PRIME: Research Project on radioecological sensitivity indicators and multi-criteria methods applied to an industrial territory environment.

- focus 2 (knowledge of vulnerabilities): by identifying the sensitivity factors of a territory with the stakeholders involved and by explaining the relationship between the sensitivity factors of a territory and the sensitivity indicators of territorys to accidental radioactive pollution (mass activity surface activity, radioactivity flow…),
- focus 3 (evaluation and ranking of risks): by developing a multi-criteria method to rank these indicators and provide managers with guidelines,
- focus 6 (emergency plans): by proposing a method of anticipated characterization of the sensitivity of the territory as a basis for the intervention preparation plans,
- focus 9 (analysis of the modes of implication of civil society in risk management): by participation of local information commissions on nuclear sites (Marcoule, Tricastin-Pierrelatte and Cruas) in the PRIME project.

From an IRSN/DEI standpoint, the PRIME objectives are three-fold:

- Provide scientific elements to rationalize decision making within the framework of post-accident management. In fact, the territory characterization method to be developed in PRIME makes it possible to assess and later justify the amplitude of interventions to schedule and/or measurement strategies/follow-up in the post-accident context. For example, the project will make it possible to answer the following questions: What are the most exposed environmental matrices? Where to measure? What compartments of the environment must be monitored (active networks or dormant radioactivity surveillance networks)?
- Simplify the representation of territory consequences from an accidental radioactive contamination situation and create a management tool common to the different people involved, who a priori speak different "languages".
- Identify the study themes found important to estimate the radiological sensitivity of a territory and which are currently incorrectly completed or otherwise in a form not practical to use. (For example, it is possible to see that a database is necessary concerning the agricultural characteristics or a database on the drinking water collection with the river transit time's indication). Conversely, research themes may be considered secondary or even useless within the framework of post-accident studies.

Nevertheless, the PRIME project is designed as a partnership between scientific laboratories (IRSN and other risk expert institutes, LAMSADE, etc…), representing the public authorities (ASN/DSNR-Rhône Alpes, Prefecture, town hall) and also representatives for the civil society (Local Information Commissions). Therefore, this project is a "complex" project according to Le Cardinal et al. (1997), being "a system in which different players build representations; use rationalities; undergo constraints; are based on assessment criterion and elaborate their own objectives". Therefore, there are multiple objectives of the PRIME project and at this point of the project elaboration, certain objectives proper to people involved called in to cooperate with the IRSN have probably not yet been expressed.

Therefore, one of the initial actions of PRIME will be identifying with partners their own objectives for a common re-appropriation in order to verify that there are no contradictions between the objectives followed by the different representatives and to decide on common evaluation criteria to reach these objectives. This action will be the first step in exploring the forms of innovative cooperation as part of the "consultation" aspect of the PRIME project. In addition, the PRIME project will benefit from the experience acquired by the IRSN from opening of the scientific expertise to stakeholders involved, especially as part of the framework of the Nord-Cotentin Radiological Group works (Rommens *et al.*, 2004).

This project must in the end provide territory characterization usable within the framework of risk management and evaluation for man and for the environment.
The multi-criteria analysis will be used here in its original manner as it will be used to explain the environmental assessment criteria (sensitivity indicator) supporting partnership decisions with the stakeholders involved. The exhaustive list of sensitivity factors proposed by the

stakeholders involved and their systematic examination should eliminate certain use limits of these methods observed in the past when the factors were listed unilaterally by the experts and quickly questioned by the other players.

# 3 METHODOLOGY AND STUDY CASE

The PRIME project shall be structured according to the following steps (refer to figure 1):

1. choice of the study territory, timescale and indicators of the territory sensitivity,
2. identification, in relation with local stakeholders involved, of the sensitivity factors to take into account to assess the sensitivity indicators,
3. characterization of the range of indicator values for the study territory (use of radio-ecological models),
4. preparation of a table of indicators weighted according to the range of values discussed with the stakeholders involved,
5. discussion with the local stakeholders involved of the results obtained, with a view to answering their concerns and facilitate decisions.

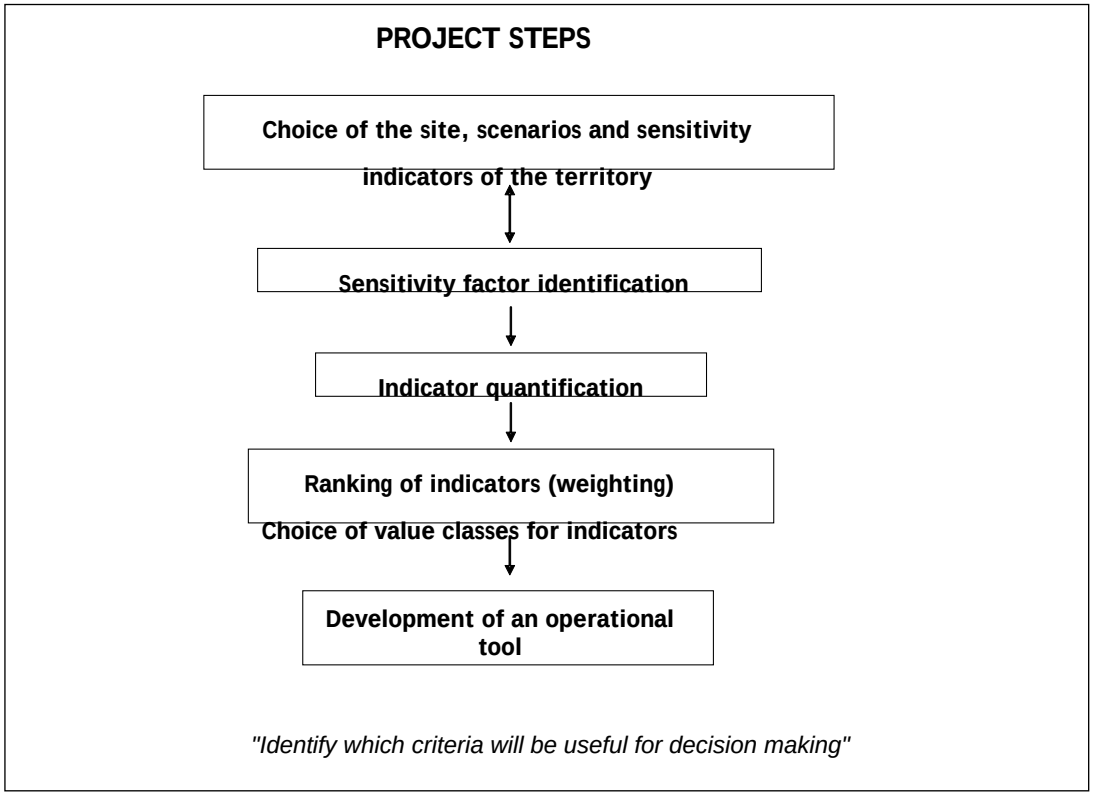



Figure 1: Steps of the PRIME project

The territory notion selected for the PRIME project is the notion of a territory affected by the accident according to the meaning of "risk territory" invoked in call for proposals RDT 2006. Therefore, the territory involved is not necessarily an administrative unit nor a territory in which human activities are homogeneous. The management of the border differences between the "risk territory", the "administrative territory" and the "social territory" will be one of the challenges of the PRIME project as the availability of data does not necessarily cover the same scales as the territories and the decision coverage territory will probably not be the same. The territory envisaged to carry out the PRIME project is located in the Southeast of France, in the Basse Vallée du Rhône (figure 2). The accidental pollution source

will be a virtual point located on the nuclear site of Tricastin. However, the project will also cover accidental nuclear pollution that could be from the Cruas and Marcoule sites. The participants shall define the type of discharge (atmospheric/liquid) and its characteristics (in particular, discharged radionuclide spectrum) in a consensual manner.

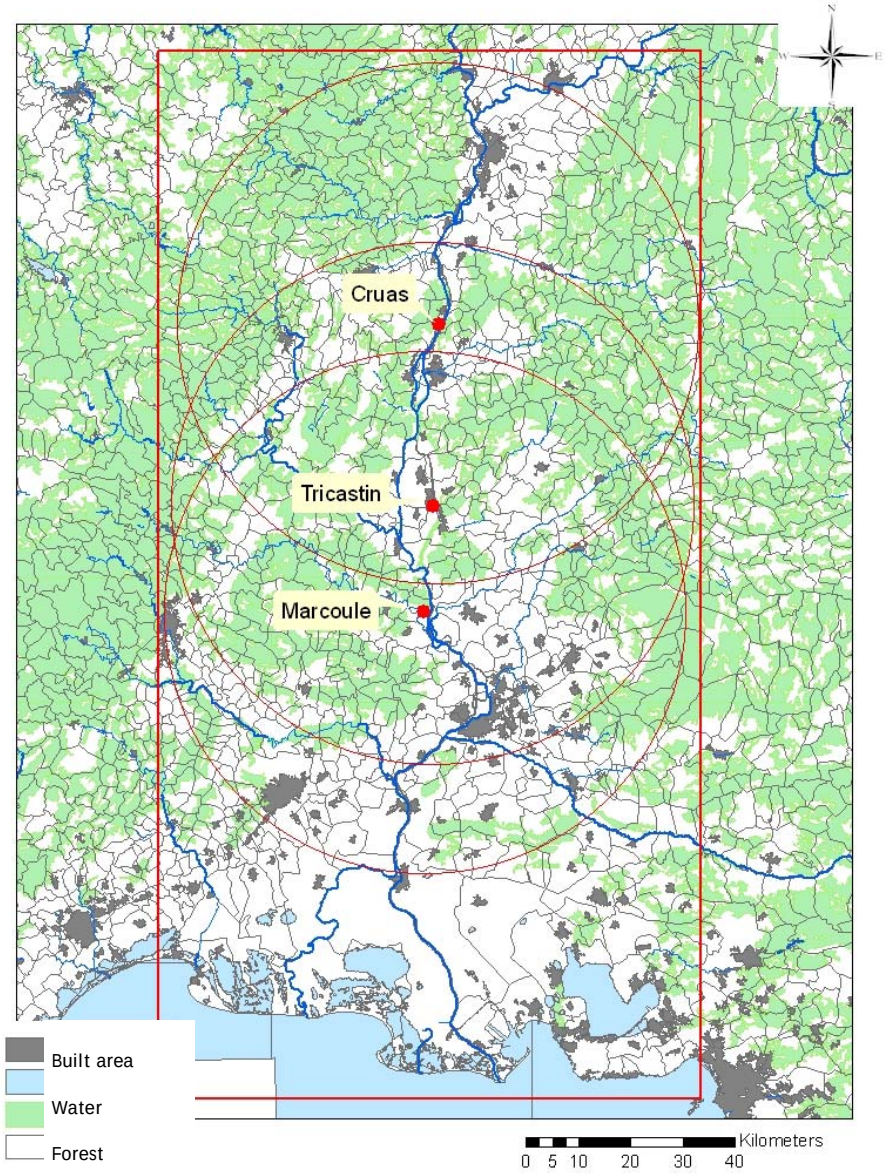
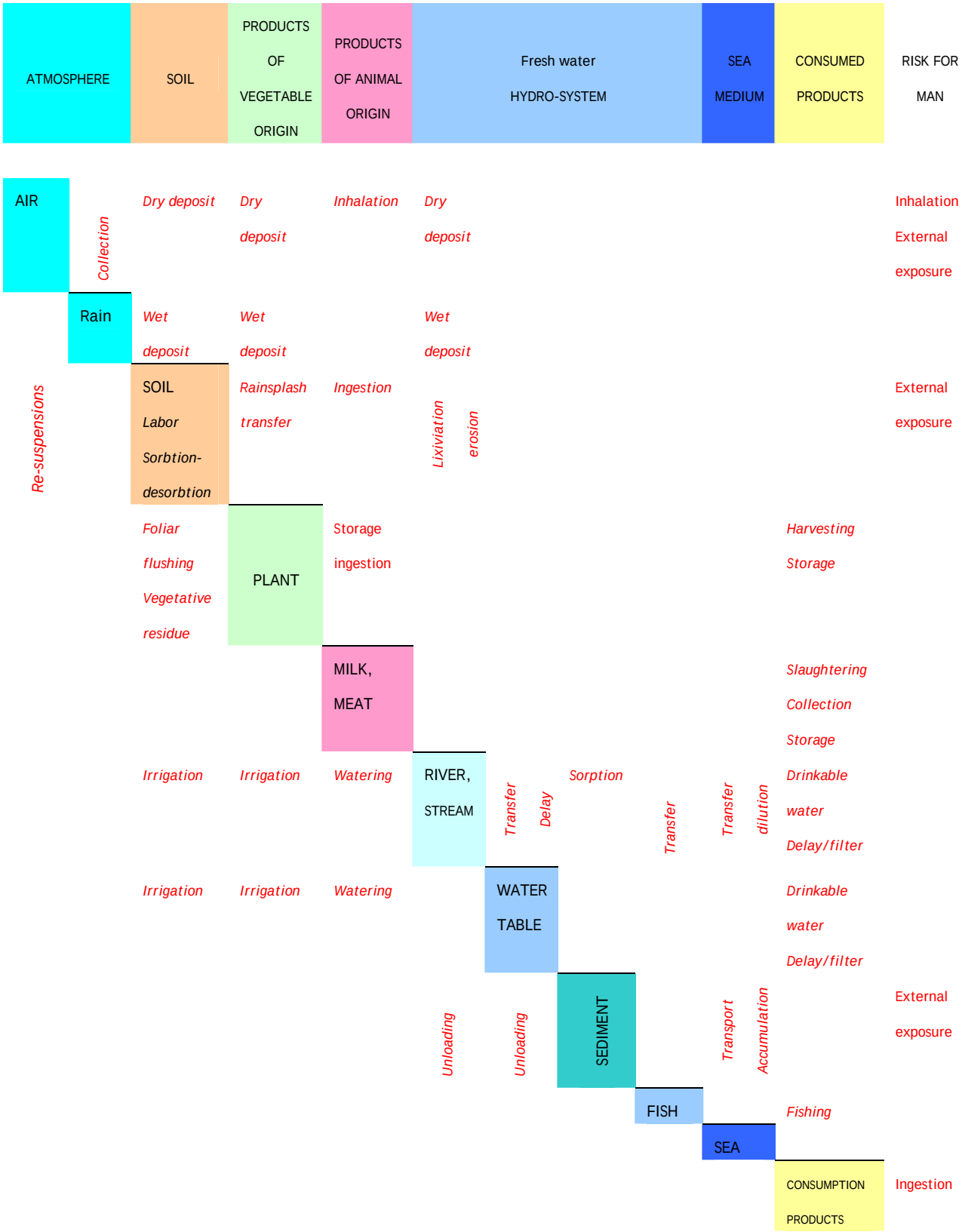



Figure 2: Study territory.

In terms of the affected territory, the study territory will be located globally in a fifty kilometer, approx. radius around the three nuclear sites for pollution by the atmosphere. With regard to transfer by liquid discharged into the Rhône, the study territory will cover the river downstream from Marcoule and the coastal territories from Sète to Toulon. In fact, the radioecological data acquired within the framework of the OPERA network (Thébaut, 2003; Eyrolle et al., 2005; Rolland, 2006) show that the artificial radioactive discharge in the tributary basin, including the Marcoule site, due to operation of the Marcoule site or other sources of radioactive discharge in the environment are likely to generate a measurable impact on the entire Mediterranean coastal territory.
The media treated are the atmosphere, the soil, agricultural production, the river domain, water tables and coastal territorys. Interfaces between these media will be processed (refer

to figure 3, interaction table). The different ensuing anthropologic actions will be taken into account: foodstuff transformation, sales chains related to agricultural products from the contaminated territory, water uses. The PRIME project will therefore in particular call upon skills in the following disciplines: meteorology, agronomy, geography, hydrogeology, pedology, cartography… This project will benefit, amongst others, from the skills federated by the IRSN in the framework of the CAROL project (Camargue-Rhône-Languedoc) carried out over the 1998-2004 period and of which the objective was to study and quantify the distribution of artificial radio nuclides in the low valley of the Rhône (IRSN, 2004).




This table explains the COMPONENTS (diagonal elements, colored boxes) and the *radionuclide transfer process* (red italic elements, outside diagonal) between compartments. The document is read in clockwise direction.

Figure 3: Table of interactions to assess the radioecological impact

Performance of the PRIME project steps requires federation of available radio-ecological data (field data, modeling, experimental results), as well as territory data and then the processing of these with a common approach defined by the project. The space constraint will strongly affect the PRIME project as the granularity of available space data is not necessarily the same between the different media or between the different spaces of the study territory. The non-homogeneous data management problem at the different quality and space scale will be at the heart of the concerns of the PRIME project.
The assessment method of the radiological sensitivity indicators will invoke classic impact calculation models for radionuclides used at the IRSN: CASTEAUR code for river discharges (Duchene et al., 2003), ASTRAL code for forest ecosystem and food chain contamination following accidental radioactive pollution (Renaud et al., 1999; Calmon and Mourlon, 2005 ), integrating the regionalizable parameters. Studies carried out in environmental sciences generally differentiate the atmospheric, terrestrial, continental aquatic and marine media. Special care will be paid to the interfacing between these media and their inter-dependence. For example, one of the components of this analysis will concern the incorporation of contaminated soils following a radioactive deposit as the source of the contamination contribution to rivers and the marine medium. In this case, one speaks about the sensitivity of tributary basins as their potential to transfer part of the contamination received towards the receiving aquatic medium.
Assessment of the radiological sensitivity will unavoidably lead to the calculation of the different sensitivity indicators. In the radio-ecological domain this concerns, for example, the volume activities in the water table, surface activities on soils intended for different uses, total activities "produced" on agricultural lands, radionuclide flows in running streams. In addition, territory sensitivity indicators of different natures will complete the radiological sensitivity indicators: demographic indicators (temporary or resident population, urbanization, etc...), "ecological" indicators (presence of spaces or protected species), socio-economic indicators (value of agricultural production, storage/distribution costs, countermeasure costs, indirect costs for abandonment of tourist territorys, degradation of the territory image …).

The PRIME project will study the methods available to rank the radiological sensitivity of a territory and to find a means of comparing them one against the other. The data processing methods explored in the PRIME project will be those of the multi-criteria analysis (AHP, MAUT, ELECTRE, PROMETHE…).
Recourse to a multi-criteria analysis method makes it possible in particular to model and formalize decision preparation. In this line of thought, recourse to multi-criteria methods increases the chance of improving the transparency of the decision process and the traceability of this process. This time, the opinion of involved stakeholders will be requested in particular to guarantee the acceptability of future use of the tool.

Three main steps are consecutive in the development of a multi-criteria analysis method, being:

- the development of the assessment table for which the radiological sensitivity of the components of a territory are assessed using specific sensitivity indicators of each medium. Each sensitivity indicator may be weighted with the approval of the stakeholders involved.
- the performance of the aggregation procedure which makes it possible to obtain the global preferences from the over-classing relations, deduced from the assessment table. During this step, it is necessary to choose the type of multi-criteria analysis method (sort method, classification method, etc...) that will be used. This step introduces the discordance or concordance threshold notion. The setting of a single concordance threshold makes it possible to determine the value under which the over-classing hypothesis of an action in relation to another action is to be rejected. The discordance threshold makes it possible to determine the maximum tolerance so that an over-classification hypothesis will not be rejected. These thresholds also make it possible to discuss what opposition and compromise levels are acceptable between the

different players and may make it possible to take diverging positions between players into account.

- the ruggedness analysis of the result, which then makes it possible to test whether the results are not modified significantly when the parameters vary around their initial value and therefore to know whether the recommendation is rugged. The parameters that may be varied are the range of radiological sensitivity indicators values (or the notation if they are quality criteria), the indicator weight, the discordance and/or concordance threshold. An in-depth analysis of the ruggedness will in particular make it possible to compensate for the subjective nature of certain parameters.

The PRIME project will perform the first of the three steps and prepare the tools necessary to perform the two following steps. The definition of the assessment table terminals will be a key step in the method. The total number of sensitivity indicators to consider and how they are chosen will be based on proposals from research teams, arbitrated by the stakeholders involved. With regard to the possible allocation of a weight for each indicator and the concordance/discordance thresholds, the opinion of the stakeholders involved will significantly affect the approach and may entail different resolutions according to the levels of agreement or disagreement expressed (a common aggregation procedure or several aggregation proposals supported by different points of view).

The stakeholders involved in PRIME are of two types:

1. the partners of the work group (PRIME WG) consisting of:
    a. representatives of the risk experts (IRSN, INERIS and university consultants[2]),
    b. decision player representatives: representatives of the Nuclear Safety Authority (DSNR Rhône-Alpes) or the local authority (Prefecture of the Drôme and associated government services),
    c. representatives of the territory: CLI of the Gard.
2. the other stakeholders involved in the management of the environmental consequences from a potential nuclear accident at study territory level, who cannot all be included or represented in the PRIME work group for questions related to project sizing.

The implication of the two types of stakeholders involved will not be the same. In the framework of the regular meetings of the PRIME WG (refer to the figure 4), the multi-criteria analysis method will be elaborated and targeted at taking advantage of the listing of territory sensitivity factors (anthropologic use and environmental use), prepared with type 1 stakeholders involved and their common examination. SIMOS technical type elicitation procedures (called "pack of cards", Simos 1990**)** or comparison technique by pairs (Mousseau 1995) can only be implemented within the framework of a limited work group. These techniques will then be explored with the type 1 stakeholders involved and make it possible to size the assessment table (number and nature of sensitivity factors as criteria for the multi-criteria analysis) and to model the preferences amongst the criteria. Type 2 stakeholders involved shall be consulted at different key moments in the progress and building of the multi-criteria table. For example, they will be consulted for the validation of all criteria selected by the PRIME WG (interview type survey amongst a sample of type 2 stakeholders involved) and for the validation of the ranking of these criteria (via postal

[2] On January 31, 2007, the academics consulted and that accepted to participate in the PRIME project either as experts (type 1 stakeholders involved) or as type 2 are from: the University of Paris-Dauphine (LAMSADE), the University of Grenoble (UMR PACTE), the Ecole des Mines, Saint-Etienne (SITE Center, Information and Technological Science for the Environment), the Ecole des Mines, Alès (Industrial and natural risks team) Royal Kings College of London, the Technological University of Compiègne, the University of Caen (LASAR, Socio-anthropologic risk analysis laboratory), the University of Aix-en-Provence/Marseille (UMR Space).

questionnaires which may be prepared using an adaptation of the SIMOS technique (Molines 2003)).

Several criteria aggregation methods will be explored in order to test the ruggedness of the territory classification obtained by the different methods. For example, it is planned to implement a constructive European school method (Roy 1985) such as ELECTRE TRI and an American normative school method such as the MAUT method (Keeney and Raiffa 1976). The definitive methodology can only be chosen after evaluation of

- representation formats of the knowledge shared by the stakeholders involved for the different criteria (digital values, categories, quantitative scheduling …),
- the acceptability by type 1 stakeholders involved of the criteria aggregation rules specific to each method (complete transitive aggregation between criteria, partial aggregation making it possible to take into account, in particular, the potential incomparability between two criteria, local and iterative aggregation).

The application of multi-criteria analysis methods to the PRIME study territory also comprises a strong space analysis component and pairing of decisional analysis tools with GIS tools (geographical information systems) shall be the object of special analysis within the framework of the PRIME project (Chakhar 2006).

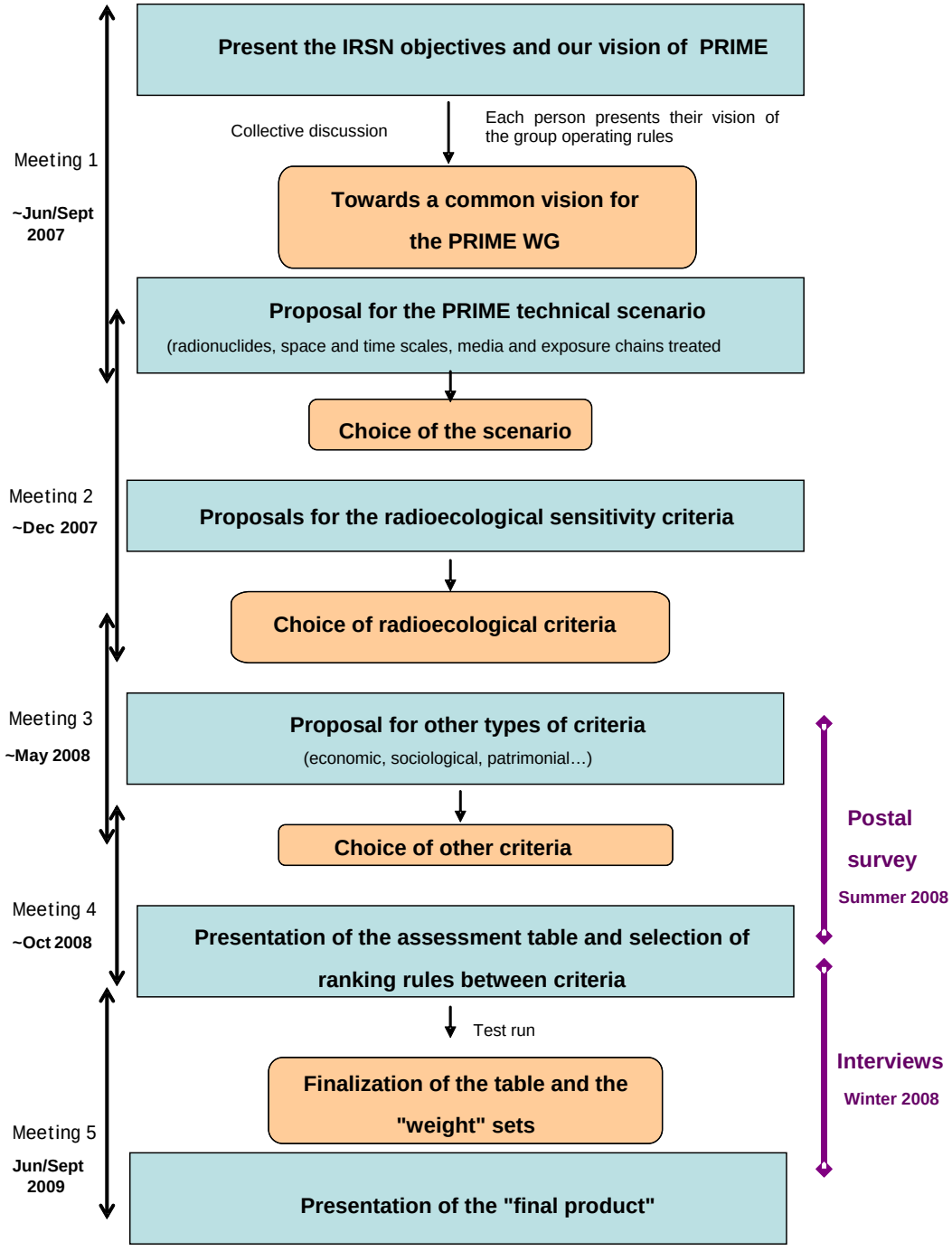



Figure 4: Running of the multi-criteria analysis and contribution of type 2 stakeholders involved at the same time as PRIME WG

The restitution of PRIME project results may be in different formats: assessment guide for the radiological sensitivity, mapping of iso-sensitivity territories, sensitivity scale. The format of the scale shall be discussed with partners and especially with the representatives of decision-makers: number of levels, threshold values, choice of aggregation in a single index (international INES scale for damage related to nuclear accidents), or aggregation around several indexes (French BARPI scale for damage related to industrial accidents). The scale obtained will be coupled with a tool making it possible to make a cross reference between a

given situation and a scale level. This tool may be a table of cross references levels with the values of the sensitivity factors, a hardcopy or computerized guide, a hardcopy or computerized decision tree, depending on the requirements expressed, especially by the decision-makers.

# 4 EXPECTED RESULTS

At local level, PRIME will provide a main contribution in the following fields:

- knowledge of environmental factors, identified by local stakeholders which may also be used for other non-nuclear accidental pollution,
- provide appropriate responses to the local context of the low valley of the Rhône for management of nuclear related industrial risks,
- analysis of the appropriation modes by means of a consultation process with the local stakeholders involved, scientific knowledge associated with the nuclear industrial risk and its integration in decision making, especially in terms of decision criteria traceability,
- preparation of methods adapted to the requirements of stakeholders in charge of management of the nuclear industrial risk and creation of a local network of exchanges and discussions on this theme,
- development, conjointly with the local stakeholders involved, of computerized and mapping media (database and multi-criteria analysis tool) to transfer the scientific knowledge available on assessment of the nuclear industrial risk.

Transfer to national scale will mainly be methodological: a critical analysis of the multi-criteria method as an interaction tool with the stakeholders involved shall be carried out, the traps and difficulties shall be the subject of specific experience feedback, a methodological guide may describe the method for other potential players.

At international level, PRIME may contribute to the concerted FUTURAE action controlled by the IRSN (Commission of the European Communities within the framework of the Euratom Call 2005). The objective of FUTURAE is to assess the feasibility of excellence networks to maintain and improve skills and develop durable collaboration in the assessment and management field of the impact of radioactivity on man and the environment. To achieve this objective, FUTURAE proposes in particular a specific investigation on interactions between the stakeholders involved (authorities, industrialists, decision makers, scientists, etc...) to assess present and future requirements in radioecology (FUTURAE-WP2). The PRIME project may contribute to WP2 by presenting a local example of network construction for collaboration targeted at decision-making.

# 5 PROPOSED VALUATION

- Scientific

  At least one publication in a French review such as *Radioprotection* and at least one publication in an English language journal such as *Health and Environmental Risk Analysis*.

- Transfer to users - Training

  An operational tool making it possible to use the multi-criteria analysis method prepared in common will be made available to project partners (software or hardcopy tool depending on partners' specifications). A restitution will be proposed during the

"transfer" days of the IRSN, ASN and CLI personnel with a view of transferring know-how to operational personnel

- Opening/Generalization
  This project will be the subject of a local request to the "Risk" competition pole of the PACA region.

# 6 SCHEDULED COORDINATION MODE

A three-part steering committee (representative of scientific experts, representative of decision players and representative of territorys) will coordinate the entire project and will take the main decisions (Figure 5). Experts will be represented by the Nuclear Safety and Radioprotection Institute (IRSN) and more precisely, the Radio-ecological Study Laboratory in Continental and Marine Media (LERCM). The decision players will be represented by the Nuclear Safety Authority of the Rhône-Alpes region. Territory players will be represented by the Local Information Commission of the Gard (CLI-Gard).
The three partners will be assisted by a peripheral organization proper to each one of them, making it possible to collect all information (territory data, method and opinions) required for the implementation of this project (Figure 6). Nonetheless, the peripheral organizations proper to each partner may interact together and with all partners of the project by means of an internet space dedicated to the PRIME project proposed by the MEDD within the framework of the RDT 2006 program.

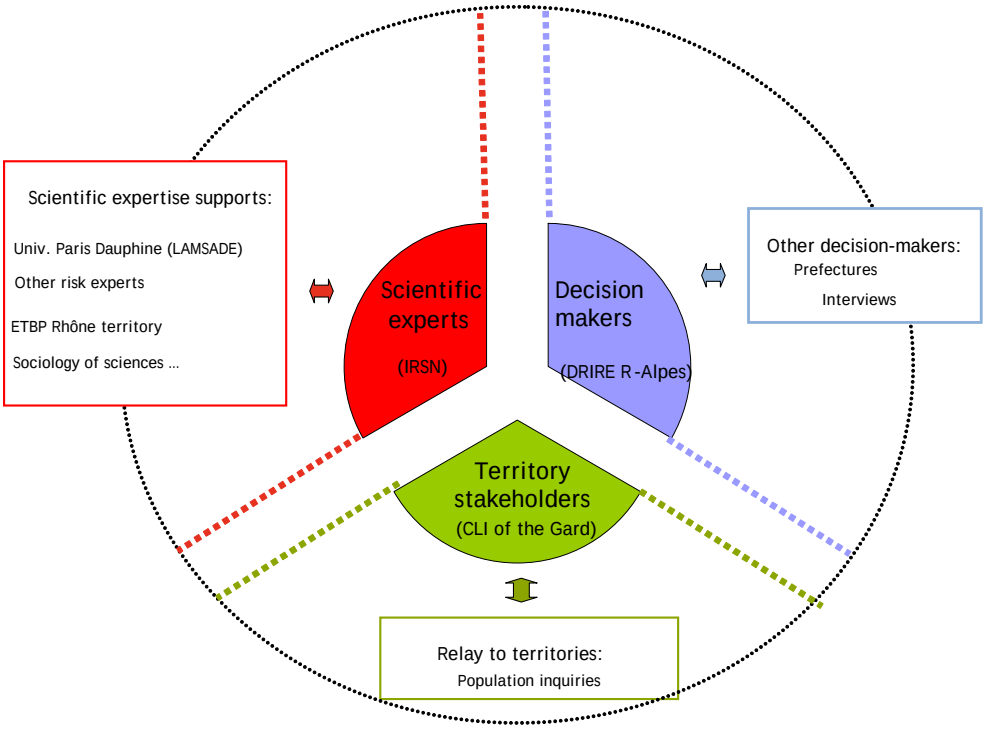



Figure 5: Organization of the PRIME project work

| | Who? | t0 | t0+3 month | t0+6 month | t0+12 month | t0+18 month | t0+24 month |
|---|---|---|---|---|---|---|---|
| **Choice of a scenario** | **All partners** | **xx D1** | | | | | |
| **Choice of indicators** | **All partners** | **xx** | **x D2** | | | | |
| **Quantification of sensitivity factors** | **All partners** | | **xxx** | **xx** | | | |
| **Quantification of indicators** | **Experts** | | | **xxx** | **xxx** | | |
| **Ranking of value ranges for indicators** | **All partners** | | | | | **x xxx** | |
| **Choice of multi-criteria analysis method** | **All partners** | | | | | **D3 xxxxxx** | |
| **Development of the operational tool** | **Experts** | | | | | | **D4 xxxxxx** |

x = 1 month

Figure 6: PRIME project time chart (estimation)

# 7 BIBLIOGRAPHY


Badie OM, Brun-Yaba Ch, Cessac B, Peres JM (2000). Méthodologie d'aide à l'évaluation des stratégies de réhabilitation après un accident: mise en oeuvre et résultats. *Radioprotection*, 35(4): 487-503.

Calmon P, Mourlon C (2005). ASTRAL V2.2: A new version to better assess post-accidental situations. *Radioprotection*, 40(Sup. 1) : S839-S844.

Chakhar S (2006). Cartographie décisionnelle multicritère: formalisation et implémentation informatique. Thèse de doctorat de l'Université Paris-Dauphine.

Coulon R, Delmas J, Guetat P, Madelmont C, Maximilien R, Loyau R, Griperay G, Rottereau JC (1994). *Agriculture, environnement et nucléaire : comment réagir en cas d'accident*. EDP Sciences, Paris, 105 p.

Coopération franco - russe en matière de sûreté nucléaire : la participation française à l'exercice KOLA (1995). *Enerpresse*, 6348 -19 juin.

Duchesne S, Boyer P et Beaugelin-Seiller K (2003). Sensitivity and uncertainty analysis of a model computing radionuclides transfers in fluvial ecosystems (CASTEAUR): application to $^{137}Cs$ accumulation in chubs. *Ecological Modelling*, 166(3): 257-276.

Dubreuil GH, Lochard J, Girard P, Guyonnet JF, Le Cardinal G, Lepicard S (1999). Chernobyl Post-Accident Management: The Ethos Project. *Health Physics*, 77(4) : 361-372.

Eyrolle F, Louvat D, Métivier JM and Rolland B (2005) Origins and levels of artificial radionuclides within the Rhône river waters (France) for the last forty years: Towards an evaluation of the radioecological sensitivity of river systems, Radioprotection. Vol.40(4), pp.435-446.

Hourtolou D, Debray B, Salvi O (2004) ARAMIS Project : Achievement of the integrated methodology and discussion about its usability from the case studies carried out on real test Seveso II sites, Contract number : EVG1-CT-2001-00036. INERIS, Verneuil-en-Halatte, May 2004.

International Commission on Radiological Protection (1989) Optimization and decision-making in radiological protection. ICRP Publication 55. Volume 20 n°1.

IRSN (2004) Rapport final du projet CAROL. Rapport DEI/SESURE 2004-22. Fontenay-aux-Roses. 42 p.

Keeney GA, Raiffa H (1976). Decisions with multiple objectives : preferences and value trade-offs. Wiley, New-York.

Le Cardinal G, Guyonnet JF, Pouzoullic B (1997) La dynamique de la confiance : construire la coopération dans les projets complexes. Dunod 246 p.

Maystre LY, Pictet J et Simos J (1994). Méthodes multicritères ELECTRE. Presses Polytechniques et Universitaires Romandes. Collection Gérer l'environnement. 323 p.

Molines N (2003). Méthodes et outils pour la planification des grandes infrastructures linéaires et leur évaluation environnementale. Thèse de doctorat de l'Université de Saint-Etienne.

Mousseau V (1995). Eliciting information concerning the relative importance of criteria. In Pardalos, Y et al (Eds), Advances in Multicriteria analysis. Kluwer Academic Publishers, pp. 17-43.

Renaud P, Stapel R, Maubert H, Bleher M., Wirth E (1999). Comparative study of the PARK and ASTRAL post-accidental decision support software. *Health Physics*, 76(5):502-9.

Rolland B (2006). Transfert des radionucléides artificiels par voie fluviale : conséquences sur les stocks sédimentaires rhodaniens et les exports vers la Méditerranée. Thèse de doctorat géosciences de l'environnement de l'Université Paul Cézanne Aix-Marseille soutenue le 10 février 2006, 243 p.

Roy B (1985). Méthodologie multicritère d'aide à la décision. Economica. Paris. 423p.

Schneider T (2000). *Rehabilitation of Living Conditions in Contaminated Territories: The ETHOS Approach*. Eye-Opener 11 IRPA 10 - May, 18, 2000. Hiroshima – Japan.

Simos J (1990). Evaluer l'impact sur l'environnement. Presses Polytechniques et Universitaires Romandes, Lausanne.

Thébaut H (2003). Bilan des résultats du volet littoral méditerranéen de l'Observatoire Permanent de la Radioactivité (OPERA) de 1992 à 2001, rapport DEI/SERNAT 2003-09