GLOBAL

A decision aid approach for risk assessment of dangerous goods logistics

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GLOBAL
la maîtrise des risques "produits dangereux" sur l'ensemble de la chaîne logistique

INERIS
maîtriser le risque pour un développement durable

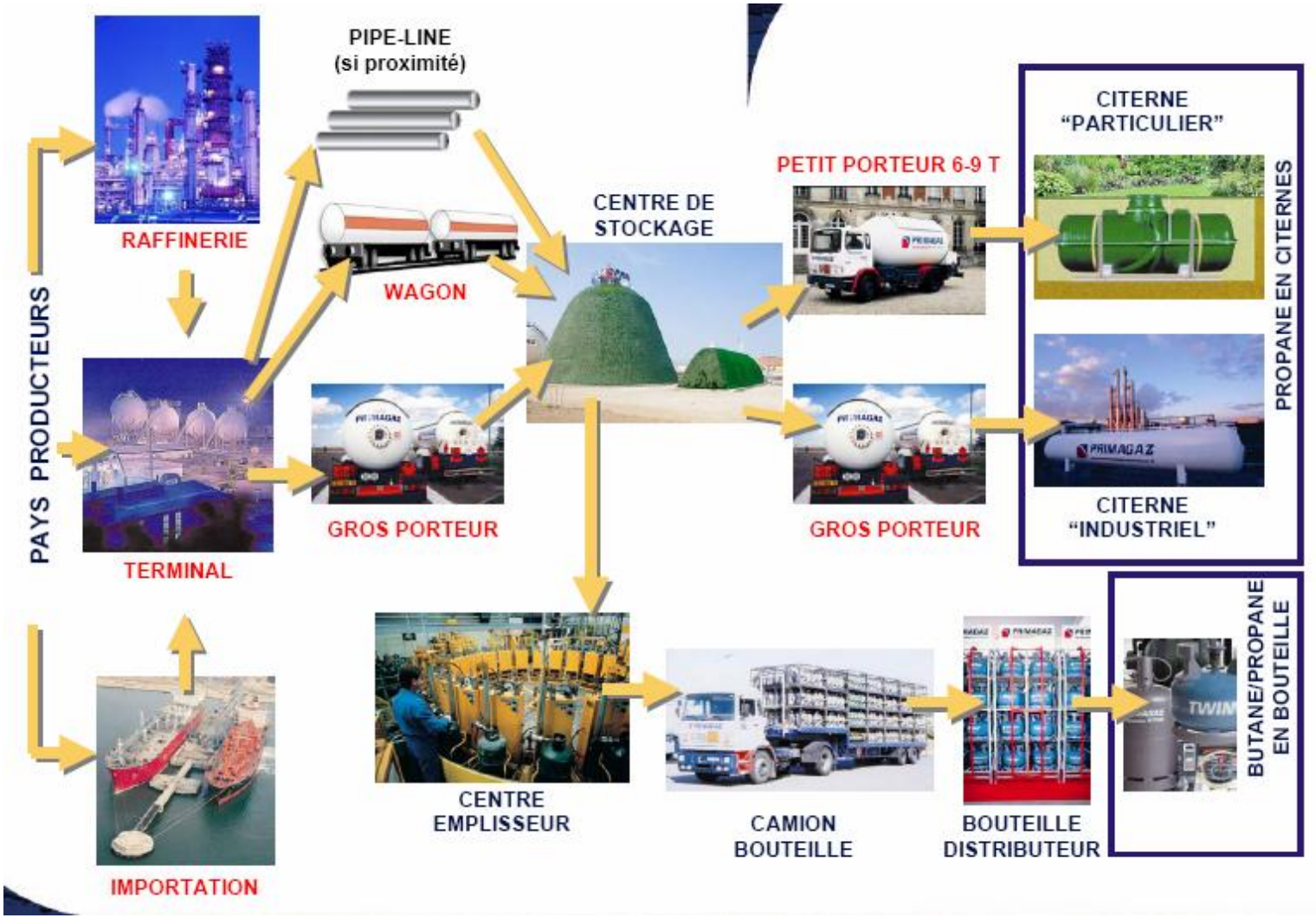
Summary

1. Dangerous goods logistics: the problem.
2. Definitions and concepts.
3. GLOBAL : objectives and challenges
4. GLOBAL : Proposal of a decision aid approach.
5. Conclusions and perspectives

1. Dangerous goods logistics : the problem

- Dangerous products remain necessary for our everyday lives...
  - § Energy
    - Liquefied Gas and Petrol (LGP),
    - Inflammable liquids (IL).
    - Nuclear energy,
    - Hydrogen.
  - § Food processing industry
    - Ammoniac, HCL...
  - § Chemical processes
    - plastics, pharmaceutical processes, detergents...

1. Dangerous goods logistics : the problem



BUTAGAZ presentation, October 2007

1. Dangerous goods logistics : the problem

- A fragmentary juridical framework
  - § Hazardous sites (storage and manufacturing) legislation is completely disconnected from transportation legislation.
    - Land use planning considered for hazardous sites but not for transportation.

      → Reduction of storage capacities and increasing of transportation flows...and risks.

    - Logistics activities are frequently externalised.

      → Great varieties of practices and approaches for risk assessment.

1. Dangerous goods logistics : the problem

- Multiple stakeholders to be considered:
  - § industrialists.
  - § providers of logistics services.
  - § public authorities (national and local)...
  - § citizens potentially impacted by risks.

. Lack of a global vision of the whole supply chain of dangerous products.

. Need for a participative approach that enhances collective decision making.

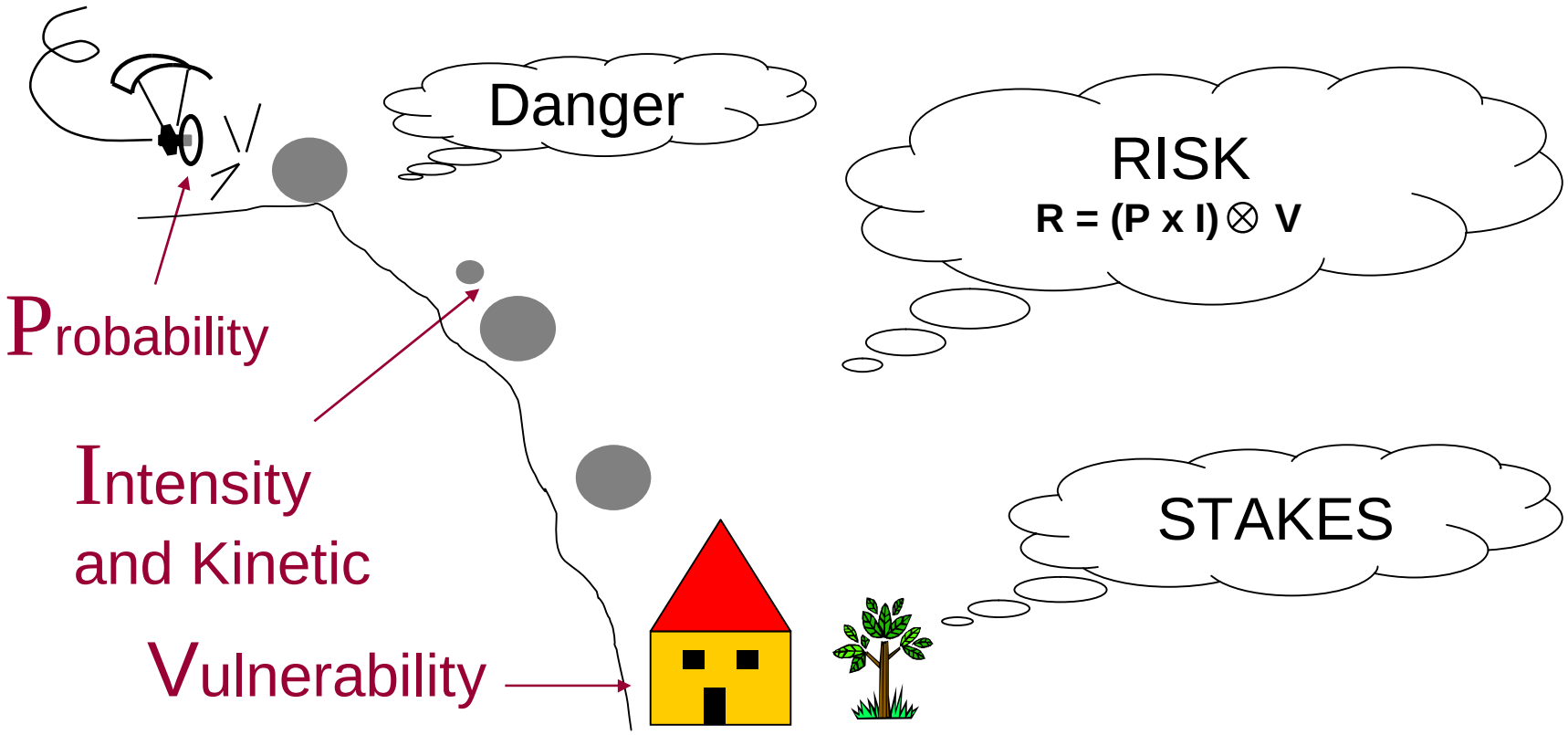
Need for an approach providing a global vision of the whole supply chain of dangerous goods.

Summary

2. Definitions and concepts

RISK :

The combination of a hazard and a vulnerability



2. Definitions and concepts

Risk assessment

Identification of risk sources and evaluation of their potential consequences.

- Inputs :
  - § Technical system analysis : reliability evaluations, what-if approaches, scenario analysis...
  - § Human and organisational factors : ergonomics, evaluation of competencies, psychological and social interactions in an organisation...
- Outputs:
  - § Identification and classification of risk scenarios.
  - § Geographical representation of potential consequences.

Summary

3. GLOBAL : Objectives and challenges

- Objectives
  - § Assess, using a unique and coherent framework, all the risks related to supply chain steps (transportation, storage and manufacturing).
  - § Compare different supply chain alternatives in order to identify the best one(s) regarding the risks generated.
  - § Enhance participative decision making for decisions related to dangerous products logistics.
- Challenges
  - § Uncertainties related to quantitative data.
  - § Need to combine qualitative and quantitative data.
  - § Different stakeholders = different uses.

Summary

4. GLOBAL: Proposal of a risk assessment approach

- The GLOBAL approach relies on a classical structure of a decision aid process.
- Consideration of the risk dimension during all the steps of the decision process.

Step 1: Problem formulation
Formulation of the decision problem to be considered.

↓

Step 2: Conception of alternatives
Identify a reasonable set of alternatives and stakeholders

↓

Step 3: Risk assessment of the logistic alternatives
- Formulation of the risk criteria.
- Evaluation of the identified alternatives.

↓

Step 4: Aggregation model and validation of the conclusions
- aggregation operators.
- sensitivity and robustness analysis.
- Validation of conclusions.

4. GLOBAL: Proposal of a risk assessment approach

Step 1: Problem Formulation.

- 3 “standard” problem formulations have been identified:

Problem formulation 1

An industrialist wants to carry a dangerous product from point A to point B. He wants to identify the best logistic alternative in regard to potential risks.

Problem formulation 2

A local authority needs to regulate (time slots, allowed and forbidden routes) the flows of dangerous products on its territory. The best routes and time slots in regard of risks have to be identified

Problem formulation 3

A local authority wants to consider logistics risks when elaborating its land use planning planning ploicy. A geographical representation of logistics risks need to be elaborated

Risk indicator 1: the Integral Risk

The Risk associated with a logistic option is calculated by considering the accident probability and all the stakes (human, environmental and material) potentially exposed to.

$$IR^S = \sum_{i=0}^{i=n} P_i * N_{S_i}{}^a \qquad a \geq 1; S \in \{H, E, M\}$$

Risk indicator 2: the Territorial risk

Every point of the territory will be characterised by the levels of risks impacting him.

4. GLOBAL: Proposal of a risk assessment approach

Step 2: Conception of alternatives.

- An alternative is:
  - a combination of industrial installations (fixed) and transportation modes (train, road, pipeline and boat) that carries a dangerous product from a point A to a point B

    +

  - a supply policy : which quantity and which frequency for deliveries?

- The conception of potential alternatives needs to:
  - list the existing installations and transportation modes;
  - study potential investments to be considered;
  - elaborate all realisable combinations;
  - for each combination, study the potential supply policies to consider.

4. GLOBAL: Proposal of a risk assessment approach

Step 3: Risk assessment of the alternatives.

- The first criteria to be considered are Integral Risk (IR^H, IR^E, IR^M)
  - § quantitative;
  - § obvious preference function: $IR_1^S \leq IR_2^S \Rightarrow Alt_1\ S_S\ Alt_2$
  - § can be used with generic data.
  - § easily understandable by all the stakeholders.

BUT…

  - § does not consider human and organisational factors.
  - § does not consider risk reduction efforts accomplished by stakeholders (industrialists and logistic services providers)
  - § is not incentive for risk reduction.

4. GLOBAL: Proposal of a risk assessment approach

- The second criterion : Risk Reduction Factors (Q)
  - § aims to consider human and organisational dimensions of risk reduction;
  - § human and organisational factors influence strongly the probability and/or the intensity of a risk;
  - § No model to quantify this influence....qualitative criterion.
  - § 4 factors have been identified for each type of industrial installation and transportation vector.

Risk audit	Evaluation
No risk reduction factors have been implemented within the industrial installation / transportation vector.	1
1 or 2 risk reduction factors have been correctly implemented within the industrial installation / transportation vector	2
3 or 4 risk reduction factors have been correctly implemented within the industrial installation / transportation vector	3

4. GLOBAL: Proposal of a risk assessment approach

- At this moment of the project, we consider only two criteria : IR^H and Q.
- Axiomatic validation;
- Every industrial installation / transportation vector will be characterised by the 2-uplet (IR_j^H, Q_j).
- For every alternative:

$$IR_{Alt}^{H} = \sum_{j=1}^{j=n} IR_j^H \qquad Q_{Alt} = \sum_{j=1}^{j=n} \frac{IR_j^H}{IR_{Alt}^H} * Q_j$$

	IR^H	Q
Alternative 1 (Pipeline)	**0.54**	**1.5**
Alternative 2 (Boat + truck)	**0.79**	**2**
Alternative 3 (Truck)	**2.44**	**2**
Alternative 4 (Train + truck)	**1.24**	**3**

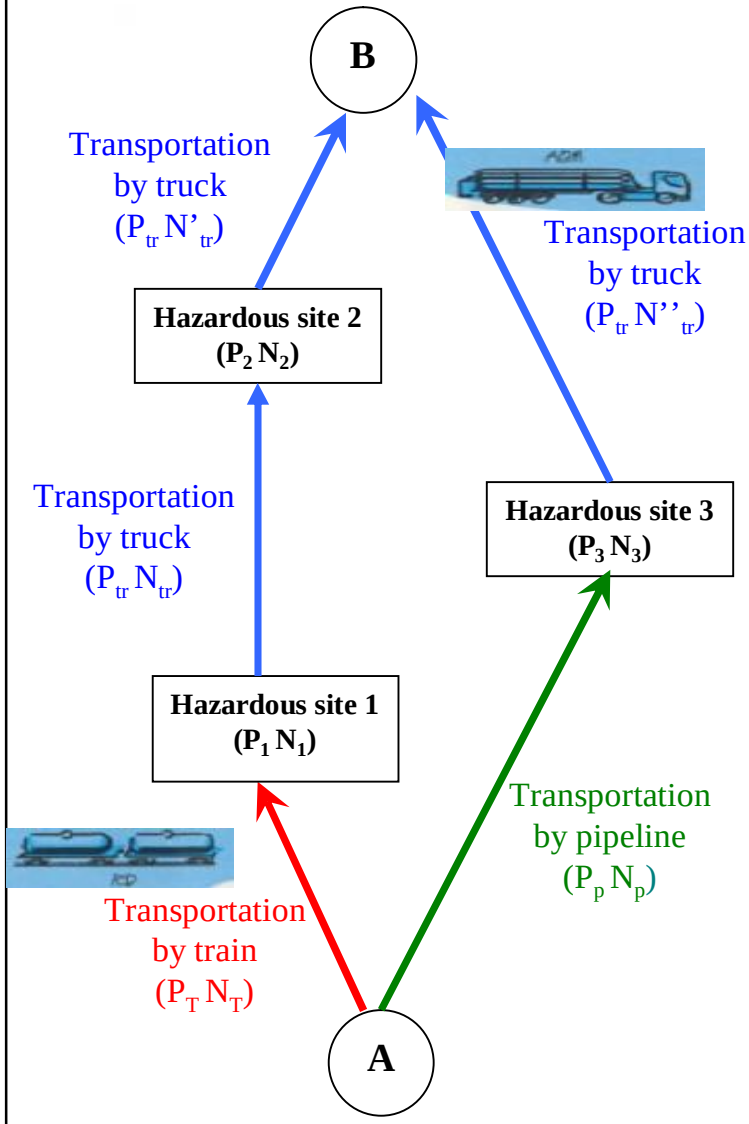
4. GLOBAL: Proposal of a risk assessment approach

- Two different aggregation approaches are still considered at this level:
  - § ELECTRE III approach.
    - Adapted for qualitative and quantitative evaluations.
    - Incommensurable evaluations.
    - Software availability.
    - Experimentation:
      - Proposal of criteria weights and preferences thresholds.
      - Sensitivity analysis.
      - Conclusions validated by decision makers.
      - Stakeholders reactions and objections have been collected.
  - § Choquet Integral.
    - Captures interactions between criteria.
    - Could be very useful when considering all the four criteria IR^H, IR^E, IR^M and Q.

5. Conclusions and perspectives

- 2 major innovations in the GLOBAL approach:
  - § risk assessment of a whole supply chain of dangerous products.
  - § combination of technical system analysis with human and organisational factors.
- More than risk assessment, GLOBAL aims to help stakeholders considering the risk dimension in all steps of the decision process.
- A first aggregation approach has been proposed when considering exclusively human stakes (2 criteria : IR^H, Q).
  - § Validation of results with decision makers
- Need to select an adequate aggregation operator when considering all the varieties of stakes (Human, Material and Environmental).

4. GLOBAL: Proposal of a risk assessment approach



Alternative 1

Train + site 1+Truck +site 2 + truck

Alternative 2

Pipeline + site 3 + truck.

$$IR_1^H = P_T * N_{H_T}{}^a + P_1 * N_{H_1}{}^a + P_{tr} * N_{H_{tr}}{}^a + P_2 * N_{H_2}{}^a + P_{tr} * N'_{H_{tr}}{}^a$$

$$IR_2^H = P_p * N_{H_p}{}^a + P_3 * N_{H_3}{}^a + P_{tr} * N''_{H_{tr}}{}^a$$

4. GLOBAL: Proposal of a risk assessment approach

TERRITORIAL RISK

Carte d'aléas possibles des effets thermiques

Sources:

Rédaction/Edition: INERIS - 19/02/2008 - MAPINFO® V 8.5 - SIGALEA® V 2.0.3

SIGALEA

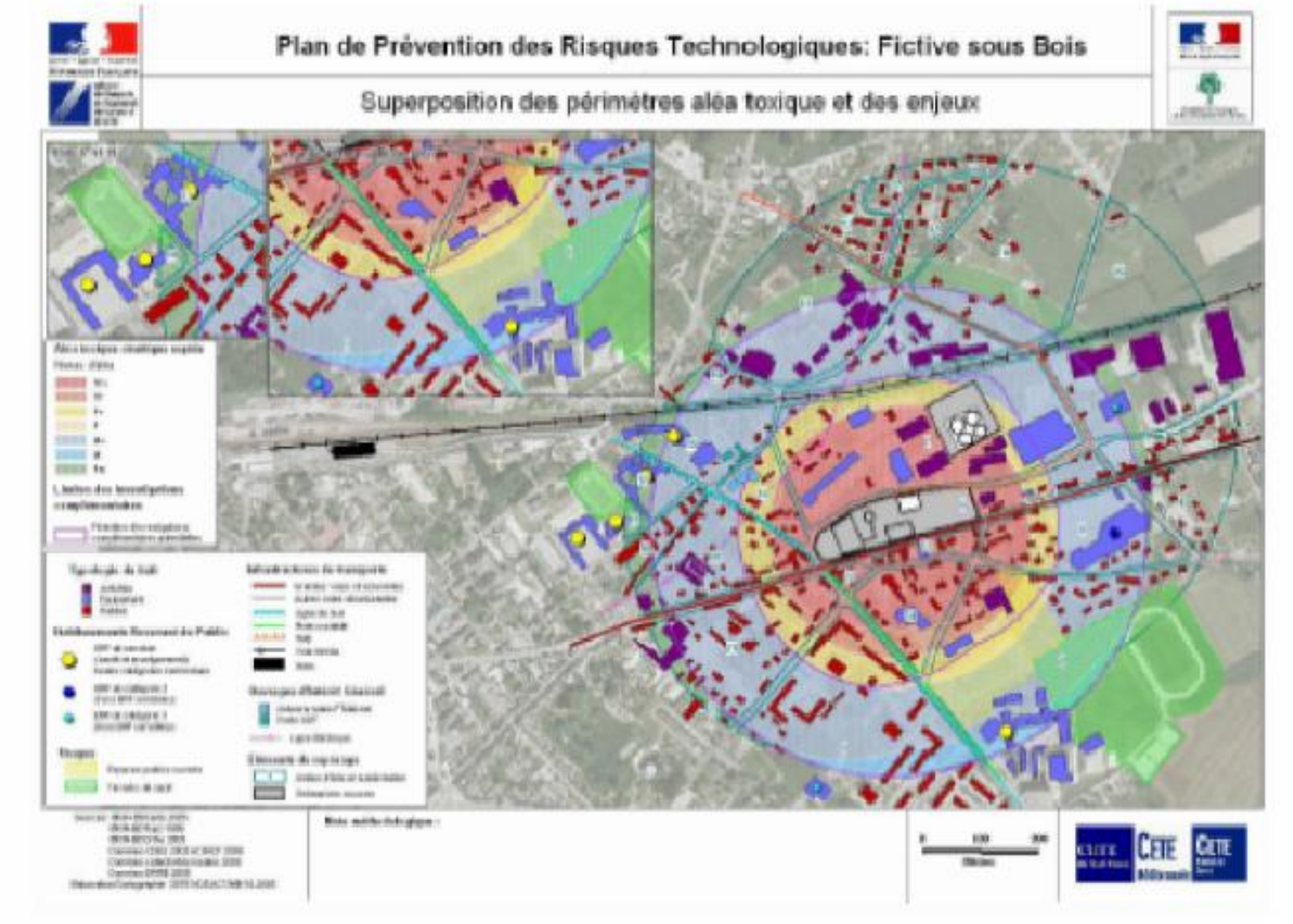


Fig.1 Geographical representation of an identified risk