# Validation and optimization of an integrated information system for industrial risk management at the regional-subregional level

**Dusserre G.[1], Franco C.[2], Tuffery C.[3], Venturini E.[4], , Casal J.[5] and Morari F[6],**

1 EMA, 6 Avenue de Clavières 30100 Alès France ,

2 SOGESCA, Padova, Italy 3 BRL, Nïmes, France 4 TRR, Bergamo, Italy 6 UPC Spain, 6 Veneto Progetti, Conegliamo, Italy

Research carried out in the framework of the 1991-94 Environmental EC R&D programme

Scientific Officer , *Dr Giovanni Giannandrea*

With the financial participation of the European Commission

(Research Contract N°EV5V-CT92-0474)

Environmental Project EV5V CT 94098 - Projet Européen (DG XII)

**Abstract:**

A decisionnal support system for territorial planning, denominated SIGRI (Geographical Information System for Industrial Risk Management), was developed for the evaluation of the consequences and the risk associated to accidents of industrial origins on regional/subregoinal scale. Both dangerous industrial plants and the transportation of dangerous substances were considered as potential sources of risk.

The innovative character of SIGRI is to be found in the risk analysis and description performed in relation to all environmental components: Human beings, ecosystems and anthropic structures. Thematic maps are built up by SIGRI on the basis of the themes included in the territorial databank

The indices adopted to assess the risk are the individual and the social risk. The individual risk is the probability that a certain target in a of the territorial area may suffer a damage given by any of the accident scenario is represented by isopleths. The social risk is the frequency F° associated to accident scenarios of a given severity C over the whole territorial area and is represented by F-C curves.

SIGRI is able to upgrade the outputs produced (Thematic maps, isopleths, F-C curves) when there is a variation in the targets and risk sources characteristics. The interpretation of the isopleths, thematic maps and F-C curves should help the planners in making decisions for the territorial planning. Potential customers of SIGRI are local governments (regions, departements, etc...) and technical administrative organisms, such as DRIRE, DIREN, DDE and Fire Brigades in France. SIGRI relies on a Geographic Information System (ArcInfo and ArcView for final users) associated to external tools as databanks, mathematical models (BLEVE, Unconfined Vapour Cloud Explosion, Dispersion of hazardous gases) and expert systems (dispersion in soil of pollutants)

A first phase of the project dealing with the feasibility of SIGRI began in early 1992. Now the second phase is in progress to develop a pilot application on the area of Marghera-Venezia (Italy) and Thau lagoon (France)

## Introduction

A decisionnal support system for territorial planning, denominated SIGRI (Geographical Information System for Industrial Risk Management), was developed for the evaluation of the consequences and the risk associated to accidents of industrial origins on regional/subregoinal scale. Both dangerous industrial plants and the transportation of dangerous substances were considered as potential sources of risk.

These information are contained in different databases, controlled by a database management system which may either be internal or external to the GIS software.

The database management system chosen will be capable of handling the following actions:

*consultation,
*keying in data,
*modifications,
*import/export of data.

## Architecture of SIGRI

The architecture of SIGRI enables the integration of all the alphanumerical data on:

*Dangerous substances,
*Dangerous plants
*Sensitive area and sensitivity ratings.

**Dangerous substance database**

This database contains all the information on the physico-chemical characteristics of each dangerous substance present per territory.

**Dangerous plant database**

This database contains two types of information. The first part of it centralises general information on the equipment managed by SIGRI: Administrative informations, details on types of danger, types of incident, the coefficients which characterise the pollution source area etc...The second part of the database will cover information on the equipment actually installed in the plant, i.e. the diameter (in metrers) and the length of the equipment (in meters).

**Sensitivity rating database**

The sensitivity rating is defined as the amount of damage done to a given target (population, environment and economic structure) by a given physical effect (excess pressure, toxic levels etc...) according to a pre-defined scenario (Explosion, BLEVE, atmospheric dispersion of toxic gases etc...).

This set of data is used to describe:

*the entire pre-defined territory and more particularly the types of target identified,

*the group of dangerous plants present on the territory,

*the set of information on the transport of hazardous material (THM) for the territory,

The operational functions related to the management of geo-referenced data are as follows:

*Basic data capture functions, data integration and structuring functions (the capture of vectorial and raster data (arcs and polygons),

It can be achieved in several different ways:

*importing existing numerical data according to pre-defined format compatibility (BD CARTO and BD TOPO of IGN),

*vector mode digitising (industrial plant)

*keying in data manually (bitmap scanning)

The updating functions will enable the following procedures to be carried out:

*adding, moving, modifying and effacing simple or complex entities,

*the combination and shaping of arcs and polygons,

*the attachment or modification of associated data.

The database administration functions mainly concern easy access to data, whatever its location and the management of rights of access.

The following functions will be available to the operator during consultation and query of SIGRI:

*display functions: scale changes (specification of scale or choice in a menu-list, geographic movement, zoom, etc...

*Classification of associated data,

*Statistical analysis of associated data,

*Selection according to multi-criteria requests in the appropriate database management system language integrated in the GIS, in SQL for alphanumerical databases,

*Selection according to spatial requests,

*Identification of entities by interactive graphic specification on-screen.

In addition to GIS specific analysis functions, SIGRI will provide its users with:

* mathematical models to assess the consequences of a accidents,

* an expert system to assess the consequences of pollution on the environment.

* a set of rules for probability assessment enabling damage assessments (in progress),

The resulting feedback will be of three kinds:

*Data-list printouts (associated data),

*Reports (associated data in table form with possibilities of obtaining graphs),

*Maps.

**Risk management functions**

Individual risks are calculated for the entire area defined by the operator and for a given target.

The hazards can be fixed (plants) or mobile (transport of hazardous materials).

The individual risk is only evaluated for the following pairs of scenarios and targets:

The measuring units adopted under SIGRI are in table 1:

| Scenario | Variable factor | Measuring unit |
|---|---|---|
| Explosion | Overpressure | Bars |
| Fire | Heat generated | kW/m2 |
| Toxic substance released in the atmosphere | Concentration | ppm |

Table 1: Measuring units

For each source of danger, the affected area is calculated and then an individual risk calculated with the following formula:

$R_i = F_s \times P_c \times P_{occ}$

where:

$F_s$ is the probability of the scenario taking place

$P_c$ is the probability that the target will undergo the damage defined and

$P_{occ}$ is the probability that the target will be present at the time when the accident occurs

After combining the surface area data, the polygons resulting from the intersection are given a new individual risk value calculated by adding together the individual risk of each of the initial polygons.

The individual risk for the study area will be fed back in map form showing the following:

*reference information used to draw the territory (roads, hydrological network, toponymy, etc.),

*information on the target (population given in density: number of inhabitants per km2),

*the initial conditions will be inscribed in the legend (meteorological factors, duration of exposure, lethal quantities),

*the danger source will be shown by symbols (symbols will represent dangerous substances),

## Conclusion

This Geographical Information System for the management of Idustrial Risks is still in progresss. At this phase of the project, a pilot application runs in Languedoc Roussillon DRIRE (administrative industrial and environmental planner). A phase of validation of the product itself and the several models (e.g. atmospheric gaussian model) will be held during 1996.

## References


- DUSSERRE G. J.M. GUILLOT, P.LE CLOIREC
"Global methodology of risk assessment in industrial toxicology - case of atmospheric dispersion of xenobiotics after an accident of transportation of hazardous materials"
*Toxicology Letters*, 1/78, Août 1995

- DUSSERRE G., CITEAU J.M., TOURAUD E., LE CLOIREC P.
"Geographic Information System for the management of Industrial risks at the subregional level" The International Emergency and Engineering.Conference TIEMEC, Nice Mai 1995

- EIDSVICK, K.J
On the prediction of hazard area resulting from a gas release. Rapport interne au Norvegian Institute for Air Research, Norvege, 1980

- FEDERATION NATIONALE DES SAPEURS POMPIERS FRANCAIS "Guide d'intervention face au risque chimique". Paris, 1992

- GRANDAMAS. O.
"Aide à l'organisation de l'intervention en cas d'accident de transport de produits toxiques liquides ou gazeux".
Thèse pour obtenir le grade de Docteur de l'Université de Savoie. 1992

- HANNA S.R., STIMAITIS D.G., CHANG J.C.
Evaluation of fourteen hazardous gaz models with ammonia and hydrogen fluoride field data, *Journal of hazardous materials*, 26, 1991, 127-158.

- MINISTERE DE L'ENVIRONNEMENT
"Accidents survenus dans le département de l'Hérault". DPPR / SEI / BARPI, 1995