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Through ARIPAR-GIS the quantified area risk analysis supports land-use planning activities

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Abstract

The paper first summarises the main aspects of the ARIPAR methodology whose steps can be applied to quantify the impact on a territory of major accident risks due to processing, storing and transporting dangerous substances. Then the capabilities of the new decision support tool ARIPAR-GIS, implementing the mentioned procedure, are described, together with its main features and types of results. These are clearly shown through a short description of the updated ARIPAR study (reference year 1994), in which the impact of changes due to industrial and transportation dynamics on the Ravenna territory in Italy were evaluated. The brief explanation of how results have been used by local administrations offers the opportunity to discuss about advantages of the quantitative area risk analysis tool in supporting activities of risk management, risk control and land-use planning. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Since many years, some significant quantified area risk studies have been carried out in Europe with different purposes: e.g. establishing the acceptability of the industrial installations and evaluating risks resulting from fixed installations and harbour activities of Canvey Island [1]; examining methods and models for risk assessment applied to the control of industrial hazards in the quantification of risk involving six fixed installations

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in the Rijnmond area [2]. In Italy, the Ravenna area was the territory of the first area risk project [3]. It started in 1989 and, gaining experience from the two pioneer studies cited above, the investigation field was enlarged by including all transportation activities (by roads, railways, pipelines and ships) as risk sources. A detailed procedure was defined to assess the risk of each source and to reassemble them to obtain the total risk for the area of interest. Several and different were the purposes of the project; among them to gain help in decisions for land-use planning and to control future industrial and commercial developments in the area. The central theme of art. 12 of the Community Directive 96/82/EC was anticipated recognising, as it happened in other European countries [4], that the objectives of preventing major accidents and limiting their consequences should also be performed with a suitable land-use policy oriented to minimise risks for population and the environment.

The opportunities offered by both the methodology used to develop the project and the informatic structure created for reassembling risks on the area, have persuaded the Region Emilia-Romagna and the Italian Department for Civil Protection to further the implementation of a decision support tool. In this paper, the ARIPAR methodology is shortly examined mainly to introduce the new software, its main features and types of results. The capabilities of the tool are described by presenting the updated ARIPAR study (reference year 1994), in which the impact on the territory of changes due to industrial and transportation dynamics were evaluated. The brief explanation of how results have been used by local officers offers the opportunity to discuss about advantages of the quantitative area risk analysis tool in supporting activities of risk management, risk control and land-use planning.

2. The ARIPAR methodology

Focusing the attention on the methodology, in other words on the set of procedures leading to evaluate some risk measures, four steps can be identified.

2.1. The identification of accident risk sources and impact area

Storage, process plants and transportation of dangerous substances define the set of *risk sources* which are located on a territory, called impact area, where residents, workers and tourists live and could be wounded by accidents. At the beginning of the study, the identification of the impact area could only be tentatively made because the true extension is defined by the results; but the initial choice, governed by locations of near towns and vulnerability centres, leads often to take into consideration a wider area which will be only partially influenced by risk sources. The impact area must be characterised through territorial data: *geographic information* on locations of plants, transport networks, vulnerability centres (hospitals, schools, . . .), *quantitative information* on population distribution (residents, tourists, workers, students and so on), *meteorological information* on prevailing conditions of atmospheric turbulence (Pasquill stability class and wind distribution).

2.2. The inventory of accident risk sources

Data on stored, processed and transported dangerous substances are collected by using specific forms whose contents already address the following risk analysis phase. Transportation activities by road, railway, pipeline and ship, are examined in order to gain a detailed knowledge of annual flows and of preferential courses when road transport is considered, in this way giving also basic inputs to accidental frequencies calculation.

2.3. The risk analysis of the single accident risk sources

The risk analysis includes identification and evaluation of likely accidental scenarios (releases, fire and explosion events, their probabilities and consequences) for each fixed installation and each type of transport. Generally, this is the most time-consuming phase of the project, since industrial complexes must be analysed and accident typologies and frequencies in transportation characterised (a Systematic Identification of Release Points method can be profitably used). Safety reports of establishments constitute the natural support of requested quantified risk analyses, but an experts team should examine the whole documentation in order to control and/or introduce the use of both the same work methodologies, in identifying accidents and evaluating their frequencies, and the same physical–mathematical models, in performing consequences calculations. This defines a condition necessary to guarantee a right ranking of the different risk sources with respect to their contributions to the overall risk, whatever the absolute values of the evaluated final risk figures are.

2.4. The area risk evaluation

The measures of *local and individual risk*, *F/N curves* and *I/N histograms* are used as indicators of the area risk resulting from merging of point risk sources (plants) and linear risk sources (different ways of transportation). Owing to the extensive use in similar studies of such figures, their complete definitions are surely redundant and only some remarks are here introduced with the aim to point out their meaning and importance in the ARIPAR context. *Local and individual risks* are *area point values* whose differences are introduced by calculations of human being vulnerability distribution due to each accidental scenario. In the first risk measure, no likely protection (for instance by staying indoor) is considered and the probability of presence of a person in a specific location is always equal to one, whatever the category he belongs to is; consequently, the same value is obtained if a desert land or a densely populated town surrounds the industrial site. The second risk measure takes into account protections and differences in the probability of presence of population categories so that different values can be associated to different destinations of the territory (residential houses, agricultural land, schools, stadia and so on). The corresponding contour lines on impact area represent very useful information to land-use planning decisions. The *societal risk* is represented not only by drawing the well-known *F/N curve*, but also adopting the so called *I/N histogram*, which reports the numbers of persons included in specific ranges

of individual risk (10^{-6} – 10^{-7} , 10^{-7} – 10^{-8} , ...): new information are added and the potential for comparisons among different risk sources is considerably increased.

The *reassembling procedure* requests a powerful numerical algorithm (see Ref. [3] for a short description) able to overcome computational difficulties arising from:

- the non-symmetric distribution of local and individual risks around sources when scenarios depending on wind rose must be simulated;
- the need to manage a large number of accident scenarios;
- the presence of linear risk sources, caused by accidents travelling with vehicles (trucks, trains, ships) or with mass flows (in pipelines), which should be represented by many point sources (segments of fixed lengths).

Values of local and individual risks are calculated for the centres of the meshes in which the impact area is subdivided. In the same points the distributed population is clustered for societal risk evaluation purposes, so that an accurate choice of mesh dimensions must be done to assure a good compromise between accuracy of results and short computational time. Time-saving is also the aim of *interpolation functions* through which *accident consequences* are modelled. The physical variables, which are the results of each single accident scenario, are often available from numerical codes for discrete points only; then they are substituted by continuous functions representing the time and/or spatial distribution of concentrations, overpressures and thermal radiation. Moreover, such functions facilitate the drawing of damage areas.

The reassembling procedure also considers, although in a simplified manner, the domino effects between different risk sources. Indeed, when physical effects of an

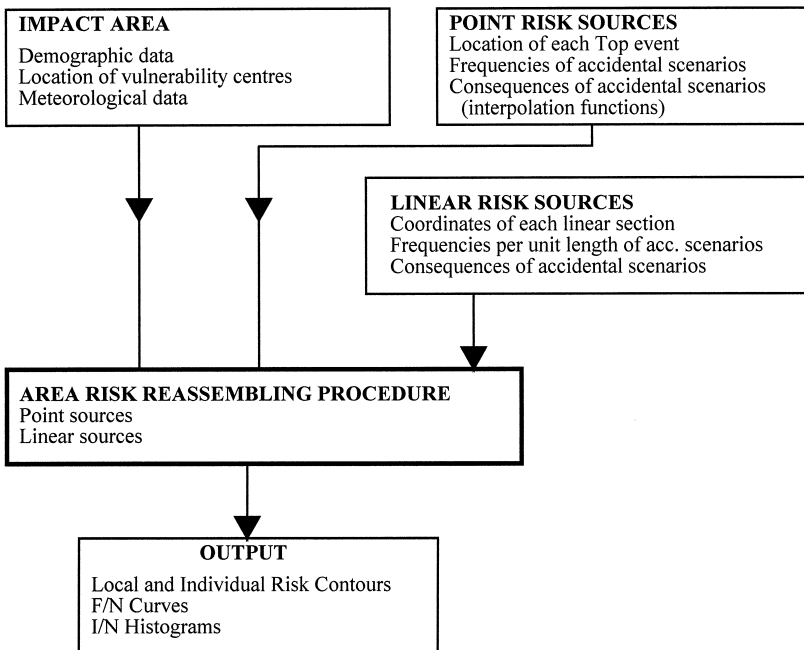


Fig. 1. Block diagram of the area risk assessment procedure.

accident are found to give rise to a thermal radiation or to an overpressure greater than threshold values at a vulnerable location, the consequences of the new scenario identified are added to the former scenario.

In Fig. 1, the main modules of the numerical code developed during the ARIPAR project are presented. The figure represent the phases of the procedure that can profitably be implemented into a software tool to perform the quantification of the area risk figures.

3. The software package: technical solutions adopted

The new version of the software, based on the ARIPAR methodology, is composed of three main parts: the databases, the risk calculation modules and the geographical user interface based on the Arc-View GIS environment from ESRI. The GIS technology offers the possibility to simplify enormously the input phase, as a lot of data are geographically referenced, and to allow a clear representation of the risk indices for decision-making purposes.

Therefore, the new tool has significant advantages:

- it simplifies and speeds-up the analyses of the experts team,
- it performs quickly a detailed calculation of risk measures,
- it represents the results on proper cartographic maps.

Fig. 2 shows a simple scheme of the software organisation; its description follows the different phases, through which the area risk analysis is performed, i.e., from the input data to the display of final results.

Referring to Fig. 1, the first step is the definition of both the risk source area and the impact area. Digital or cartographic maps of the impact area can easily be imported: typical scales used range from 1:25,000 to 1:100,000 depending on the extension of the impact area. Maps at different scale can be used for the same area. Satellite maps are particularly useful for areas where the up to date cartography is not available. Maps are then geographically referenced by means of one of the available commercial tools, e.g. Erdas Imagine.

The raster maps, besides giving a clear picture of the area, help in generating the set of vector maps (layers) representing the elements of the area of interest for risk analysis. These layers concern:

- the set of grids;
- the vulnerability centres;
- the risk sources.

3.1. Generation of grids

After importing the maps of the impact area, a grid has to be defined for risk quantification and representation. The grid can be composed of several sub-grids of different dimensions (length, width and cell size), depending on the requested accuracy in risk calculation which, in turn, depends from the land use (industrial, residential, agricultural, sea, and so on). The smaller the cell size, the more accurate is the risk

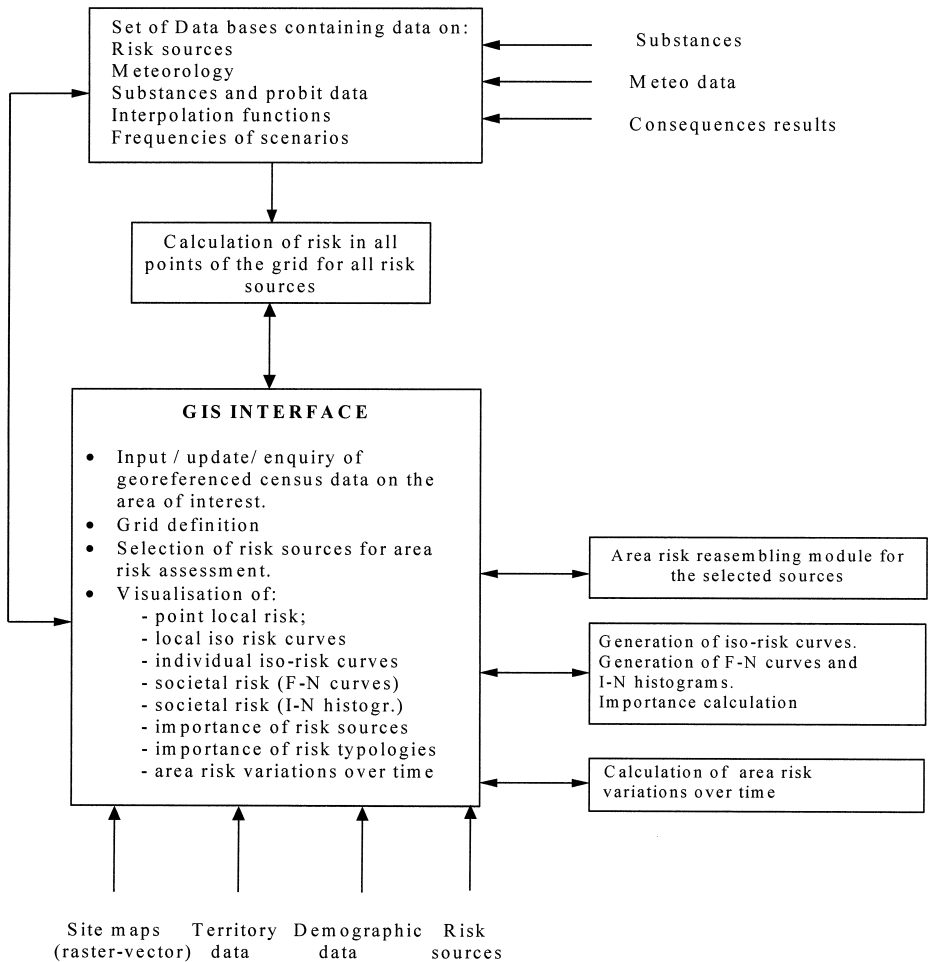


Fig. 2. Simplified block diagram of the GIS version of the ARIPAR software.

representation. Furthermore, the intersection of two sub-grids of different dimensions is automatically considered by the program for the generation of the final unique grid of the area. The risk is calculated in the centre of each cell, where data on the population distribution are concentrated.

The population distribution in the area, needed for assessing the individual and the societal risk, can be classified (see Section 2.4). For each class, both the spatial and temporal distributions can be associated with the centres of the grid cells (probability of presence in the area as a function of the season, during day/night, indoor and outdoor).

3.2. Vulnerability centres

The risk is also calculated on those points of the area representing the location of vulnerability centres, e.g. hospitals, churches, commercial centres, and so on, i.e. where

a significant concentration of people can occasionally be present. The graphical description of vulnerability centres requires a simple click of the mouse in the point where the centre is located; attributes (name, use, distribution of presence of people) is then associated.

3.3. Risk sources

With the raster map displayed on the screen, vector layers describing the different risk categories can easily be generated by simple “click and drag” operations of the mouse. Fixed installations are represented by polygons, inside which the plant layout, if considered useful, can also be inserted. Attributes describing the industry, such as name, address, industrial category, and so on, are associated to the corresponding polygon. Risk sources (i.e. points where accidents may occur) can be described by a simple click of the mouse (the symbol used is the cross).

The road network, needed for determining the risk from road transport, can rapidly be produced using the mouse only. Associated attributes are the roads name and type. The same considerations apply to the other transport categories: rail, pipelines, inland channels and harbours.

Since these layers are generated over the geo-referenced map, all co-ordinates of the graphical objects are automatically loaded into the corresponding databases.

3.4. Meteorological conditions

To complete the description of the area, the meteorological conditions must be defined. The user can define N_p pairs of values “wind velocity–stability class” to describe conditions of the atmospheric turbulence in the impact area. Their occurrence probabilities are then evaluated from raw data, for each of the 16 sectors of the assumed wind rose and for each season of the year.

3.5. Area risk calculation

Data on accident scenarios, together with their occurrence frequency, are *directly entered* from the database interface. Accident frequencies from road transport can also be automatically calculated by the programme; based on the mean accident frequency per road type, length of the road, traffic flow for each transported substance and type of scenario, the accident frequency can be calculated and automatically stored into the databases. Consequence models which evaluate overpressures, heat radiation and concentrations due to accidents involving flammable and toxic substances are run for each N_p meteorological conditions; the results are then used to determine the parameters of interpolation functions that are directly stored into the databases.

At the end of the input phase, modules for calculating the risk of a generic source on all points of the grid and on vulnerability centres can be run. The consequences on all points of the impact area are calculated by means of the interpolation functions. For a given scenario, the number of times each interpolation function is run to determine the

effects on a given cell is given by: 16 (number of sectors) $\times N_p \times 4$ (seasons). Physical effects of accidents, on each grid cell, are then translated into the vulnerability, i.e. the probability of death; then, coupling with scenario frequency, the risk is calculated.

Furthermore, by clicking with the mouse on a given risk source, the user can select a scenario and get the representation of the effects on the geo-referenced map. Three different curves can be plotted corresponding to threshold values defined by the user. Default values are those proposed by the Italian Department of Civil Protection for emergency planning.

The user can also select the *risk sources to analyse* from a pull down menu. This command is useful when new sources are added and must be analysed separately. All results of the analysis are stored on files for subsequent calculations. From this point on, the user can select the risk sources for which he/she wants to calculate the area risk. The procedure for reassembling the risk of a set of sources is very fast, thus allowing the user to work interactively.

The *local and individual risk figures* can be rapidly obtained for the whole area. The calculation of iso-risk curves, and their representation on the geo-referenced map, can be done either using the Spatial Analyst tool from ESRI or a proprietary module developed in C language. Furthermore, the user can, by clicking on a given point of the map, obtain the *point risk value* and a *histogram of risk sources* showing their contribution in decreasing order of importance. Measures of societal risk can also rapidly be obtained, i.e. *F/N curves and I/N histograms*. Both can be obtained for each risk category, i.e. fixed installations and different transport means.

Other results given by the program concern:

- the relative contribution (frequency percentage) of risk sources for a given number N of deaths;
- the importance of each risk typology vs. N .

All these results can be obtained for all risk sources or for a subset of them. The selection can be done from the GIS interface. For instance, the recombination of risk from different sources can be made for a certain chemical substance or for a class of substances, for a certain type of installation, or for a specific plant, and so on, depending on the user needs. On the result of the selection, the area risk-reassembling module is run, giving the total risk in each point of the grid. The iso-risk curves are then generated and displayed on the geo-referenced map of the impact area. All other risk figures are displayed in graphical form (curves and histograms).

Based on the risk analysis results, the user can easily identify the causes of major accident risk in the area. It is possible to rapidly simulate the consequences of different decisions, e.g. relocation of a marshalling yard, construction of a new road for the transport of dangerous goods, construction of a new plant, and so on. Finally, the software allows the user to compare two different risk maps, say M1 and M2. The comparison is done cell by cell and the resulting map shows the areas where the risk difference is positive, negative or nil. Since the two maps may be covered by different grids, a common grid is generated before proceeding to the risk comparison. Thus, for a generic point (e.g. vulnerability centre) a graph of the risk vs. time can rapidly be calculated. Furthermore, the user can easily manage an archive of risk maps showing the risk modification vs. time in the impact area.

4. Some results of the ARIPAR updating

As an example of how the summarised methodology and the related software can help decision makers, some results of risk analyses of the updating project, extracted from the large amount produced, are here reported comparing the new (reference year 1994) and the old (reference year 1987) risk measures. Like the first project, the updating has also been led by a *technical-scientific committee* including members of local administrations and of regional civil protection service as well as experts in risk analysis. The same members of the committee have spent many hours to collect basic data, while risk analyses and calculations have been performed taking advantage of the scientific support of a university team.

Before going on, it is again necessary to observe that, being aware of the uncertainties which may affect the absolute values of the final risk figures, a great effort has been made to keep consistency among the results from the evaluations performed. This effort can give sufficient guarantees that the comparison of risk measures among different risk sources in different time steps can be consistent and consequently useful.

4.1. Inventory of risk sources

From the comprehensive inventory of stored, processed and transported dangerous substances, resulting from collaboration of all institutions and industries involved, it is possible to gain a *detailed mass balance of dangerous substances* which are present and pass through the impact area. This last one has a surface of about 205 km² and includes the city of Ravenna (with about 90,000 inhabitants), the proximate coast and the developments around the principal roads departing from the town; industrial installations are located around the Candiano port canal in the middle of the area.

Of particular interest are the results referred to *transportation of dangerous goods*, because they put in evidence the differences in used transport ways and could suggest where modifications, if confirmed by performed risk analysis, should be addressed. Global quantities in the two reference years are compared in Table 1, where some important substance classes are detailed. In the specific case, the data show that while the global transport of dangerous substances has undergone a small decrease, some

Table 1
Transportation of dangerous substances by road, rail and ship (in brackets are data of 1987). Quantities in t

| Class | Substance | Road | Ship | Railway |
|--|-----------|-----------------------|-----------------------|-------------------|
| Liquified toxic gases | Ammonia | 589 (19,408) | 4399 (180,000) | – (15,248) |
| | Chlorine | – (74) | – (–) | 252 (290) |
| Liquified flammable gases | LPG | 123,468 (187,000) | 110,307 (292,000) | 29,058 (24,907) |
| Flammable liquid | gasoline | 978,593 (740,000) | 381,473 (560,000) | – (–) |
| | gas oil | 1,186,721 (1,450,000) | 422,586 (800,000) | – (–) |
| | fuel oil | 85,600 (104,000) | 2,799,058 (3,116,000) | – (17,200) |
| Global transport of dangerous substances | | 2,964,000 (3,001,000) | 5,578,537 (6,436,000) | 128,670 (183,393) |

significant differences resulted in the used transport means (e.g. for ammonia (transport by pipeline has been introduced) and LPG).

4.2. Risk analysis of risk sources

In an updating phase, the work effort is smaller because only the new installations and the revamped ones must be analysed. The risk analysis of transportation by rail, road and ship, performed through a SIRP method, only requests new calculations of frequencies of accidental events, in those cases when the conveyed substances, the transport means and, consequently, the accidental hypotheses concerning the single transport unit are the same. From new accidental frequencies, some interesting comparisons can be made showing the consequences of modifications in traffic distribution. As an example, Fig. 3 depicts changes in distribution of *gasoline trucks on road network* in the impact area: different road courses and increased conveyed quantities explain the behaviour.

4.3. Area risk measures evaluation

Figs. 4 and 5 show respectively the overall local and individual risk contours (from all sources) on the whole area of study (reference year 1994). A local risk contour line characterised by a frequency of about 10^{-4} lethal events per year is found on the industrial area near to the harbour channel. In this area, there was a high concentration of fixed installations, which is almost unchanged so that the new line overlaps the previous one. A significant decrease in local risk contours, compared with previous results, characterises the town of Ravenna, where values are less than or equal to 10^{-7} e/y, while the contour lines are nearly the same in the proximity of the road network. As it could be seen from maps representing the risk due to each hazard source category,

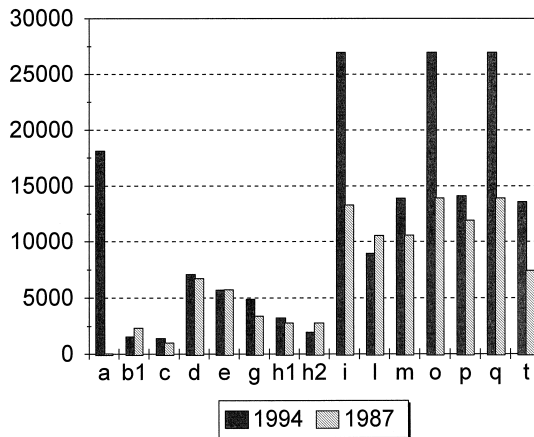


Fig. 3. Number of gasoline trucks on sections of road network.

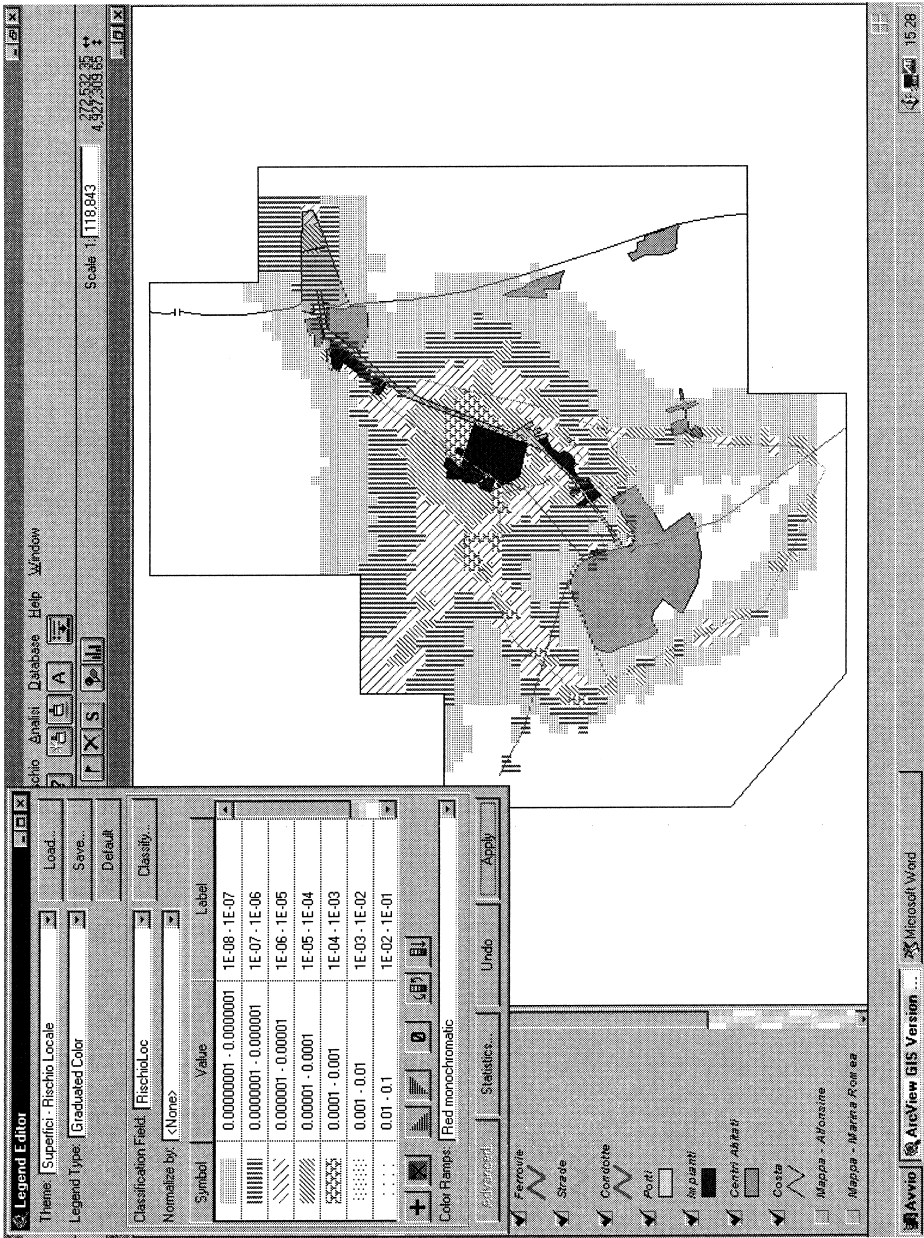


Fig. 4. Map with local risk surfaces.

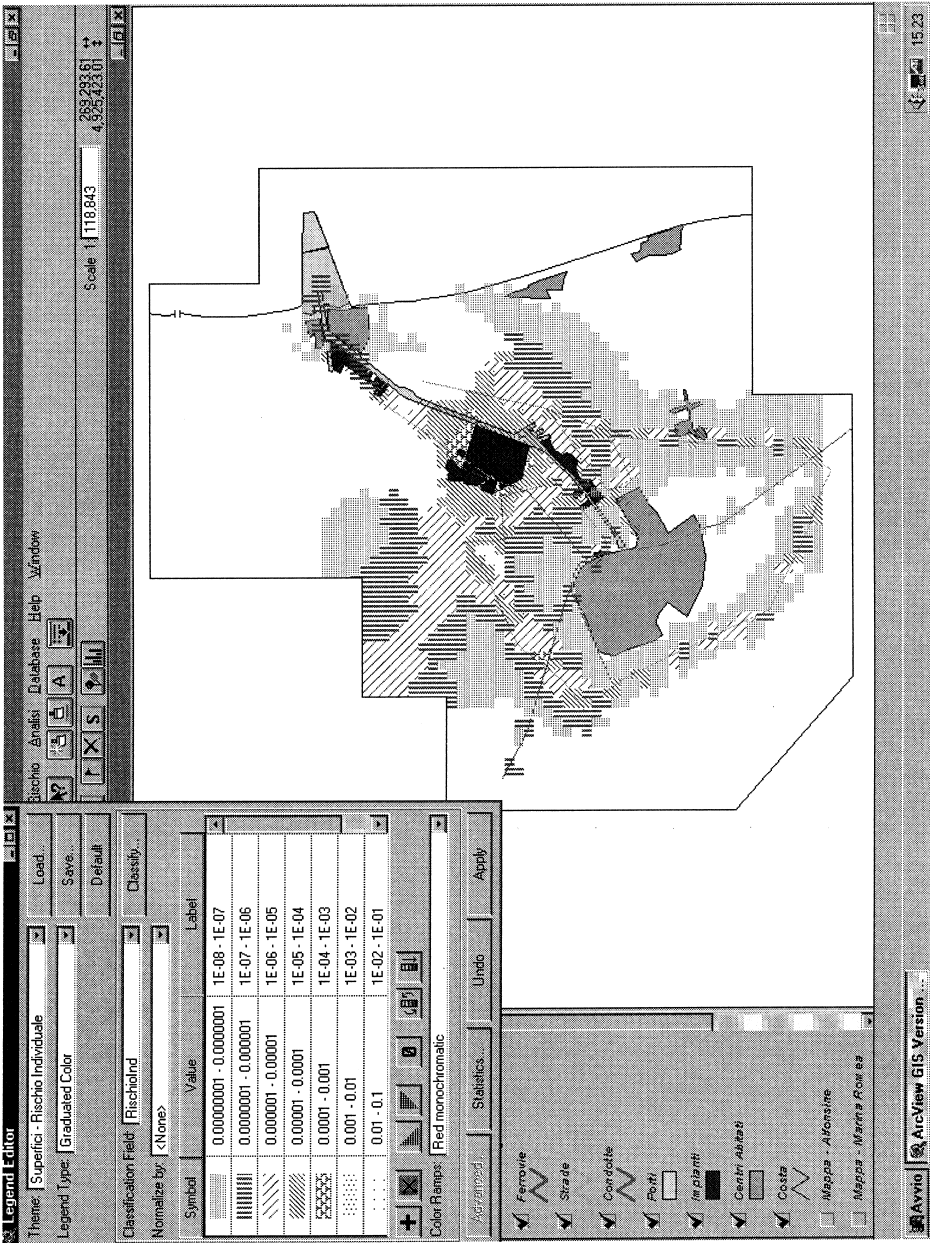


Fig. 5. Map with individual risk surfaces.

the major contribution to local risk in the town derives from road transportation. The results clearly show the positive effect of the extensive reduction of ammonia road transport. Greater local risk results just at the entrance of the port canal, owing to the increase of the global traffic by ship. At the location of new sporting centre of great capacity, the local risk assumes a value of 5×10^{-7} e/y: it could satisfy criteria set up by some countries for their land-use planning policy.

The I/N histogram confirms the risk reduction for the population: about 96% of the population is exposed to an overall individual risk less than 10^{-6} e/y, of this one almost 90% is exposed to an individual risk less than 10^{-7} e/y (Table 2).

Focusing the attention on the analysis of societal risk curves, split in order to put in evidence contributions of different risk sources, interesting considerations result. This data representation clearly show which risk source gives the maximum contribution at fixed N and, if changes occurred in industrial installations give significant modifications of the social impact. The comparative analysis of societal risk curves could show a significant decrease in cumulative frequencies of scenarios characterised by $N > 800$, while substantially unchanged is the behaviour for smaller N . Curves can be better explained comparing the contributions of each single hazard source category with respect to societal risk at fixed N . In particular, the comparing analysis of Table 3 leads to observe that:

- fixed installations give contributions to the societal risk up to $N = 100$;
- up to $N = 500$, the major contribution to the risk arises from dangerous substances transported by road;
- for $N = 1000$, the major contributions arise from the marshalling yard located inside the town and partially from the transportation by ship;
- for $N > 1000$, the contribution from the marshalling yard dominates.

The comparison of such results with the previous ones indicates that: (a) there is a decrease in contribution of fixed installations, owing to shutting down of some activities; (b) the transportation by road continues giving a significant contribution to area risk but accident scenarios are characterised by a reduced magnitude; these effects derive from modifications in traffic distribution of flammable substances and from the significant decrease of ammonia transport; (c) accidental scenarios with greatest values of N are still caused by transportation by rail, as the marshalling yard is located near to inhabited areas. The temporary decrease in transportation of dangerous substances, put in evidence

Table 2
Number of people exposed at given values of individual risk

| Individual risk | Number of people (1994) | Number of people (1987) |
|------------------------|-------------------------|-------------------------|
| $\geq 10^{-3}$ | 0 | 0 |
| $10^{-4} \div 10^{-3}$ | 285 | 148 |
| $10^{-5} \div 10^{-4}$ | 2795 | 1182 |
| $10^{-6} \div 10^{-5}$ | 3803 | 9814 |
| $10^{-7} \div 10^{-6}$ | 5833 | 75,430 |
| $10^{-8} \div 10^{-7}$ | 55,240 | 71,588 |
| $< 10^{-8}$ | 91,685 | 5510 |

Table 3

Contributions of the different risk sources to the societal risk (in brackets are the values of the year 1987)

| $N \geq$ | $F (1/y)$ | Fixed installations | Transport by road | Transport by rail | Transport by ship | Transport by pipeline |
|----------|--|---------------------|-------------------|-------------------|-------------------|-----------------------|
| 10 | 1.56×10^{-3} (1.67×10^{-3}) | 28.7 (26.8) | 66.7 (68.3) | 1.6 (1.4) | 0.5 (2.0) | 1.8 (1.5) |
| 100 | 1.21×10^{-4} (1.25×10^{-4}) | 7.4 (14.2) | 85.9 (75.9) | 5.5 (7.7) | 1.1 (2.2) | 0.0 (0.0) |
| 500 | 2.10×10^{-5} (1.39×10^{-5}) | 0.3 (34.5) | 97.1 (35.0) | 1.8 (28.1) | 0.9 (2.4) | 0.0 (0.0) |
| 1000 | 2.80×10^{-7} (5.45×10^{-6}) | 0.0 (38.0) | 0.0 (20.8) | 91.8 (40.7) | 8.1 (0.5) | 0.0 (0.0) |
| 2000 | 1.52×10^{-7} (1.25×10^{-6}) | 0.0 (7.8) | 0.0 (7.5) | 100.0 (84.7) | 0.0 (0.0) | 0.0 (0.0) |
| 4000 | 3.66×10^{-8} (9.77×10^{-8}) | 0.0 (20.7) | 0.0 (9.7) | 100.0 (69.6) | 0.0 (0.0) | 0.0 (0.0) |
| 8000 | 0.0 (2.46×10^{-8}) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (100.0) | 0.0 (0.0) | 0.0 (0.0) |

by the inventory, reduces the cumulative frequencies of scenarios; (d) the transportation by ship seems to be more important, especially for $N \geq 1000$: this effect is caused by both the increase of traffic and loading/unloading of dangerous substances and the decrease of the contribution of fixed installations and road transport; and (e) pipelines do not give a relevant contribution to the societal risk owing to location on uninhabited land.

5. Some conclusions

The description of the ARIPAR methodology and of the new related software package has put in evidence that the comprehensive tool adopts, as it happens in other European countries [4], a risk-oriented approach to quantify risk from industrial sites and completes the risk analysis examining also transportation activities. In addition, as the scenarios concurring to the complete evaluation can be examined one by one, the consequence-oriented approach could also be supported, even with a partial or reduced use of the tool. Owing to its capability to calculate different risk measures in a defined impact area and to rank risk sources in order of their importance, it surely represents a tool of great support in land-use planning activities, once tolerability criteria are defined and well-structured procedures are established for taking major hazards into account in the decision process.

However, also in lack of tolerability criteria, the ARIPAR updating has shown that results could be used, and actually are used, to address and support decisions of local authorities (in this case the Emilia-Romagna Region).

In particular, the above-reported updating of the quantitative assessment of the major accident risks in the Ravenna area has allowed the evaluation of the impact on the territory of changes due to industrial and transportation dynamics, verifying priorities of

interventions suggested by the previous project and finally quantifying variations in risk measures due to choices both in the public sector and in the private one. From the results, it might be inferred that: (a) fixed installations do not contribute significantly to the risk in the town, as they are located sufficiently far from the city; (b) the contribution to the overall risk from road transportation of toxic substances has been decreased due to the almost exclusive use of pipeline for transporting ammonia to plants; (c) road transport still has a relevant importance, particularly in some sections of the road network; an improvement of the existing regulation on transportation of dangerous substances, and mainly new roads constructions, could reduce risks; (d) the marshalling yard continues to give a significant contribution to societal risk owing to its location near populated areas; (e) the contribution of ship transport within the harbour channel to the overall risk did not undergo a relevant increase owing to the very stringent traffic regulations adopted.

These conclusions have supported the Region in assuming decisions on:

- controlling future industrial and commercial developments in the area (the consultation of the technical scientific committee is requested in case of new developments);
- making proposals for a better risk control (an electronic control system of the Port (PAC), recently built, verifies that the very stringent traffic regulations are applied);
- territorial planning (risk prevention through displacement of the marshalling yard whose location near the town originates a great societal impact).

Even in lack of specific legislation addressing control of residential developments near major accident risk installations, the area risk study clearly proves that it can help local authorities in making decisions about possible plant modifications, new plants installation, new infrastructures and new residential areas still maintaining the risk under control.

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