RISK AND TERRITORY, A PENDING MATTER?

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1. Presentation of the article

The present article pretends to provide a global idea of the current situation on Land Use Planning by describing major accidents in this regard and European methodologies to tackle this issue. This paper, was used to introduce the ISPC (Institute of Public Safety of Catalonia) magazine (issue 23) which focused on the relation between risk and territory, i.e. how to merge the values of the various risks that are present in the territory with the land usage government regulatory authorization agencies. Therefore, this paper includes a summary of the publications included in the journal which analyze LUP from different points of view.

Considering the risk factor as another element to take into account in land use planning, has legally just begun, but is not yet implemented in a stable and sustainable way in the real world.
Local economical interests are beyond the aim of EU and Member States to regulate the territory usage according to existing risks, and consequently the efficiency of legal and regulatory mechanisms which have been launched to achieve these goals.

The present article only aims to contribute with some reflections taken from scientific and technical points of view, with no other aim but to inform interested parties and regulatory bodies with a neutral view of this matter, raised from different perspectives.

For land long-term planning in according to risk it requires a social, anthropological, geographical and probabilistic vision of the matter. It would normally be recommended, when evaluating the cost/benefit of the new development, that the general interest of our society must benefit.

We can not play Russian roulette, neither a zero tolerance game. As almost always, in the eclecticism, we can find a balanced solution. It includes a small compilation of recent major accidents, as a reminder of what has happened, and that can happen again.

Also supplied there is a summary of the different approaches used by the EU institutions and some short reviews of the articles that different authors give us with their opinions and perspectives.

Finally, we also include a conclusion and a basic bibliography, which we hope will help to create interest and new ideas in order to manage the problems we expose.

2. Compilation of cases

There are several industrial accidents which have occurred in history. These accidents vary from a simple incident due to the negligence of a worker to the Bhopal accident which was a tragic industrial accident. In this article, the four following industrial accidents will be reviewed:

1) Bhopal, India
2) Bouncefield, United Kingdom
3) Enschede, Netherlands
4) Toulouse AZF, France

2.1 Bhopal

At 12:45 on 3 December 1984, a Union Carbide India Limited (UCIL) pesticide plant in Bhopal, India, leaked 41 tons of the deadly gas methylisocyanate (MIC) which is considered as the worst industrial accident in history. None of the six safety systems designed to contain such a leak were operational, allowing the gas to spread throughout the city of Bhopal. Half a million people were exposed to the gas that night and 8-10,000 are believed to have died within 72 hours. Up to 25,000 people are now estimated to have died as a result of their exposure to MIC. Today, more than 120,000 people still suffer from ailments caused directly by exposure to MIC or by the subsequent pollution caused by the UCIL plant site. Although pesticide production in the plant had stopped after the disaster in 1984, the plant was never dismantled and the site has never been properly cleaned up. [1],[2],[3],[4].

In the UCIL company, MIC used to be stored in steel tanks for the manufacture of the carbamate pesticide carbaryl. The disaster was caused by the entry of water into the MIC containing tank No. 610. The exothermic reaction between water and MIC converted liquid MIC into vapour, generating enough heat and pressure to burst open the vent. MIC vapour was discharged in the atmosphere, and because it was heavier than air it descended on the densely populated areas; people were awakened by a choking sensation and eye irritation. Unfortunately most of the pictures of this disaster are too graphic to be published. Figure 1 shows the victims who lost their sight in the Bhopal poison gas tragedy as they sit outside the Union Carbide factory. [1]

At the UCC Bhopal plant, there had been numerous accidents before the 1984 tragedy. These were warning signs that were ignored. At least six serious accidents had occurred in the 4 years preceding 1984, including one in 1982 that had resulted in the death of a worker. The other staff were agitated, and a series of articles were published in the local press warning of the impending disaster. However, neither the management nor the civic authorities took action to analyse the situation to prevent any future accidents. [6]


Fig 1. Victims who lost their sight as they sit outside the Union Carbide factory. [5]

The legacy of Bhopal left its impact not only on the policy framework, but also on aspects such as recommended practices and operation guidelines developed by industry associations and trade organizations. In the years following Bhopal, a flurry of legal and regulatory activity began to put into place a nationwide system to prevent the recurrence of such an incident. The first step was the Environment Protection Act of 1986, which sought to protect the environment by preventing major incidents. The Act holds the management of the facility responsible for any violations of the Act. In 1980, the program now adopted worldwide and known as Responsible Care was developed in Canada by the Canadian Chemical Producers' Association (CCPA). The United States started its implementation through the American Chemistry Council (ACC) eight years later, after the Bhopal incident raised public awareness about the possible impact of the chemical industry on the environment and neighbouring communities. [7]

2.2 Buncefield

At around 06.00 on Sunday 11 December 2005, a number of explosions occurred at Buncefield Oil Storage Depot, Hemel Hempstead, Hertfordshire, United Kingdom. At least one of the initial explosions was of massive proportions and there was a large fire, which engulfed over 20 large fuel storage tanks over a high proportion of the site. There were 43 people injured in the incident, none seriously. There were no fatalities. Significant damage occurred to both commercial and residential properties in the vicinity and a large area around the site was evacuated on emergency service advice. About 2000 people were evacuated. Total damages were of the order of $1.5 billion. Figure 2 shows the Buncefield site on the first day of the fire and the Figure 3 shows the damaged site.


Fig 2. The buncefield site on the first day of the fire. [8]


Fig 3. Damaged buncefield site. [8]

The fire burned for several days, destroying most of the site and emitting large clouds of black smoke into the atmosphere, dispersing over southern England and beyond. Large quantities of foam and water were used to control the fire, with risks of contaminating water courses and ground. The emergency services (primarily the Fire and Rescue Service and the police) led the initial response to the incident and its immediate aftermath. The incident also damaged nearby housing. Some houses closest to the site suffered significant structural damage; several families were living in temporary accommodation while their houses were repaired. At least 300 houses suffered lesser damage. [8]

An explosion can be produced when a gas cloud is ignited within a confined volume such as a building. As the flame propagates through the gas cloud it produces hot combustion products. The confinement prevents expansion of these combustion products and as a consequence, the pressure increases. In general, this continues until the confining structure fails, in some cases catastrophically. This mechanism does not explain the type of explosion that occurred at Buncefield as the majority of the cloud was not confined. It is recognised that two 'confined explosions' did occur, but these events alone could not explain the severity of the overall explosion.

There are two known mechanisms for generating an explosion in a relatively unconfined vapour cloud. One is a deflagration, where the flame accelerates to high speed, which requires a mechanism for generating the flame acceleration. It has been shown in large-scale experiments that this can be provided by turbulence generated as the explosion propagates through pipework congestion typical of process plant. In the case of Buncefield, this pipework congestion was not present to any significant degree and not at all in some areas where high pressures were produced. Trees and undergrowth were, however, present along both sides of Buncefield Lane. It is possible that these acted as a means of accelerating the flame in a manner similar to congested pipework areas on process sites.

The second mechanism is a detonation, which if sustained, can be much more damaging. It may arise from the coalescence of a strong shock wave and a fast-moving chemically reacting front. Together, this can undergo a transition to propagation faster than the speed of sound and produce over-pressures at the front in excess of 10 bar. It can also arise from the high temperatures and pressure generated by a shock wave in a confined, high flame speed deflagration or directly from strongly focused shock waves in a very reactive mixture. One possibility considered was the initiation of a detonation as a result of an explosion venting from either of two confined explosions. However, at Buncefield there was no clear evidence of even localized detonations. [9]

2.3 Enschede

On Saturday afternoon, May 13th 2000 a severe accident at a fireworks factory took place in the Dutch town of Enschede (150,000 inhabitants) destroying an entire neighbourhood. The disaster generally referred to as the Enschede SE-Fireworks-Disaster, after the fireworks firm 'SE Fireworks'. It changed the lives of more than two thousand people living in the disaster area, roughly encompassing two square kilometres of the city.

The incident began with a small fire at the site of the SE-Fireworks Company that resulted in a series of explosions ending in a devastating mass explosion. The first fireworks explosions attracted a large audience onto the streets of the city. This was later to cause some additional deaths among the most curious people standing close to the site of the fire, but at the same time it saved the lives of people who otherwise would have been crushed by the demolished buildings of the final explosion. In total 22 people died, more than 960 were injured and more than 600 houses, 40 shops and 60 small-scale-factories were demolished: burned out or simply blown away by the great explosion. The cost of the damage was estimated to be more than half-a-billion euros.

Soon after the disaster the national government, together with the Province of Overijssel and the municipality of Enschede, undertook to set up an independent investigation. The final report of this committee published in February 2001 showed that the company, the local government of Enschede and the national government were all responsible and that in particular, disaster mitigation failed. Figure 4 shows the disaster and its effects.

Fig 4. View of the Enschede disaster. [10]

The committee did notice that more fireworks were stored on the site of SE Fireworks than it had obtained permits for. Moreover, the majority of these fireworks were of a much heavier class than was allowed by the environmental permits in force. The committee also criticized the municipal administration for its inadequate urban planning and for its absent monitoring of new developments. The company enlarged without building permits. The 1986 local land use plan, and afterwards also the 1996 Enschede North land use plan did not allow the company to expand.

The Enschede disaster stimulated a public debate on disaster prevention and the need for the effective enforcement of fire and safety regulations. Many municipalities and provinces began to centrally register sites holding hazardous substances and announced initiatives to intensify the inspection of hazardous sites. The need for municipal disaster control plans was expressed and discussions started with regard to the position of fireworks depots and other potentially dangerous sites near living areas. There has also been a review of the roles and responsibilities of the various competent authorities and advisory bodies involved in issuing environmental permits.

Local governments announced after the Enschede disaster that companies, particularly those operating from industrial sites and handling hazardous substances, can expect more inspections and stricter enforcement by the competent authorities. The national government moreover also decided upon a new Decree covering new rules on the import, storage, production and trading of fireworks. This Decree also stipulates that the distance between residential and recreational areas on the one hand, and fireworks depots on the other, should be at least 800 metres. Such a safety zone should provide considerable protection. In July 2002 the preliminary decision was made to concentrate fireworks storage at only two remote sites – one in the North and one in the South of the country. [11]

2.4 Toulouse AZF explosion

At 10:15 am on 21 September 2001, a huge explosion occurred at the AZF (Azote de France) fertiliser factory of Grande Paroisse firm, located about 3 km outside the city of Toulouse in France. The explosion was measured 3.4 on the Richter scale and let a crater of 65m x 54m x 8m. 31 people were killed (21 people killed onsite and 10 people killed offsite) and about 3000 were injured. The explosion shattered shops, car windows, and tore doors from their hinges in the city centre. Over 500 houses became uninhabitable. The overall damages were estimated to be 3 billion dollars. Figure 5 shows the AZF chemical plant after the explosion and Figure 6 shows the AZF plant and the nearby Toulouse city. [12]

Fig 5. View of the AZF chemical plant after the explosion [12]

Fig 6. Effects of the AZF plant and nearby Toulouse city [13]

Several inquiries have been carried out by different authorities. However, there is still a controversy on the direct causes of the explosion between the Justice, the company and the media. Investigations on Toulouse's explosion showed its origin was neither a fire nor a first explosion followed by the mass explosion. Studies have therefore focused on reviewing the role of contamination in AN decomposition, and in particular the chemical incompatibility. Dangerous reactions may occur between AN and products such: halogenated (specially chlorinated) compounds; combustible/organic materials; divided metals, especially in contact with molten AN. [13]

This accident highlighted some deficiencies in land-use planning (proximity of dwellings, lack of communication with inhabitants) and risk control (accidental scenario not taken into account in safety report, inefficient management of subcontractors). In the aftermath of this disaster, the approaches of land-use planning and risk analysis in safety reports were entirely revised. Before 2003, only worst-case scenarios were examined without quantified probability assessment. A new law was adopted on 30 July 2003 (French Parliament, 2003), asking for the investigation of all representative scenarios, and the assessment of the probability of the resulting dangerous phenomena, to demonstrate an acceptable level of safety. So any accident is now examined from a global perspective, according to its gravity and its probability. [12]

In the following days of 21st September, 1570 firemen and militaries, 950 policemen were involved in the emergency response and housing monitoring. The problem was that they arrived themselves without any plan and any discussion by phone as the classical phone lines were partly destroyed and the mobile phone network was saturated. In those kind of situations, the experience on forest fires should help to organise the arrival of little groups of vehicles. The internal and external emergency plans were not prepared for this scenario and its gravity. Previous training helped firemen and others to behave adequately. However, the first firemen were not protected with adequate equipment for any toxic cloud and with devices to detect those toxic gases.

The trend of major accidents recorded in the MARS (Major Accident Reporting System) database of the EC is approximately 30–40 major accidents per year throughout the EU. So, one of the conclusion is that controlling major accident hazards by reducing the risk on-site is not sufficient to promote a sustainable development for both industry and urban areas without LUP in the next decades. Another conclusion is that the Seveso I and II Directives have their limits which was a shocking surprise for part of the public opinion that lived in the “zero risk” belief. Several statements were made by the European Parliament (EP) 2 weeks after the Toulouse disaster. They asked, in a context of sustainable development (safety, employment and environment), for a new risk management.

AN-based products were classified in Europe, according to the Seveso II Directive (96/82/EC) in two different categories depending on the explosion hazards it presents (fertiliser and technical grades). The update of the Seveso II Directive was adopted in view of classifying two new categories: “off-spec” materials (unclassified AN), taking into account one of the lesson of Toulouse’s explosion and AN-based composite fertiliser because of other accidents in EU with self-sustaining decomposition.

The accident also showed that public was not efficiently informed (were surprised) and the public opinion in Toulouse surveys confirm this lack of transparency on the accident. Besides, a kind of climate against chemical plants spread and tried to push for radical decisions. [13]

3. State of the art in the UE

In the European environment, any attempt to establish guidelines on Land-Use Planning should certainly take into consideration the significantly different national legislation that exists in the various Member States and the practices used. [14]

In the last ten years, due to the independence of Member States with regard to the implementation of Art 12, most MS have developed their own methodological and procedural approach without any reference to common guiding principles. The matter of “risk in land-use planning” has therefore a strictly national character. [15]

3.1 Methods of Hazard/risk assessment and scenario selection

As already mentioned, each country has it's own guidelines on LUP in vicinity of hazardous industrial developments. However, in the recent years, different methods and tolerability thresholds have been developed in European countries, fulfilling the SEVESO II requirements regarding LUP. In general, two risk assessment methodologies are applied to risk-informed land-use planning: a consequence-based and a risk-based approach. A number of other methods have also been developed, which are mainly a combination or a derivative of these two main methodologies. [16]

Generally speaking, the 'consequence based' approach focuses on the assessment of consequences of a number of conceivable event scenarios, and the 'risk based' approach focuses on the assessment of both consequences and probabilities of occurrence of the possible event scenarios. For a given installation, the 'consequence based' approach will characteristically show the consequence area for lethal effects and serious injuries resulting from the scenarios assessed, while the 'risk based' approach will show an area within which there is a given probability of a specified level of harm resulting from the large number of possible accident scenarios. [14]

There is also another common method that may be considered as sub-category of Consequence oriented method [15] or it can be distinguished as third approach which consists on the determination and use of 'generic' distances depending on the type of the activity rather than a detailed analysis of the specific site. These safety distances usually derive from expert judgement and are mainly based on historical reasons, the experience from operating similar establishments, or the environmental impact of the plant. [14]

3.1.1 Risk-oriented (or risk-based) / Quantitative approach

Various other names have been used for characterizing the risk assessment method implied by this approach, such as Probabilistic Risk Assessment (PRA), Probabilistic Safety Analysis (PSA), and Quantified Risk Assessment (QRA). The purpose here is not only to evaluate the severity of the potential accidents, but also to estimate the likelihood of their occurrence. In general, the methods use sophisticated tools and consequently more time-consuming and more expensive. Criticism has also been expressed on the uncertainties associated, such as those related to the frequencies of occurrence assigned to some initiating events.

In risk-oriented approach two measures of risk are usually calculated: (1) the individual risk, defined as the probability of fatality due to an accident in the installation for an individual being at a specific point, and (2) the societal risk, defined for different groups of people, which is the probability of occurrence of any accident resulting at fatalities greater than or equal to a specific figure. Individual risk is usually presented by the isorisk curves, while F–N curves provide a visualisation of the societal risk. [14]

In some classifications, there is also another method which is called semi-quantitative approach which splits the main elements (likelihood of occurrence, consequences) into two different options of description, qualitative or quantitative. [15]

3.1.2 Consequence-oriented / Effects based approach

The 'consequence based' approach (for which sometimes the term 'deterministic approach' is used) is based on the assessment of the consequences from the conceivable accidents. this method evaluates only the extent of the accident, and not the likelihood of its occurrence. The criticism of the method underlines the difficulty in selecting the basic accidents.

As it already mentioned, there is also Generic safety distance approach which may be distinguished as sub-category of Consequence based method which is based on the principle that uses of land which are not 'compatible' with each other should be separated with separation distances. The extent of this separation zone is assumed to depend only on the type of industrial activity or on the quantity and type of the hazardous substances present. In order to assist the implementation of the approach, a number of tables have been elaborated which classify the industries into categories. [14]

3.1.3 Scenario selection and major accidents

In the LUP Principles Guidance a "scenario" to be used for LUP risk analysis is defined by:

Scenario = "Top Event" (usually/mostly Loss of Containment) & Dangerous Phenomenon (fire, explosion, toxic cloud) [15]

Major accidents are associated with the occurrence of fires, explosions or atmospheric dispersions of hazardous materials. An accident can also involve more than one of these phenomena: an explosion can be followed by a fire, a fire can cause the explosion of a vessel, and an explosion can cause the dispersion of a toxic cloud. 47% of major accidents in process plants and in the transportation of hazardous materials are due to fires, 40% because of explosions and 13% due to gas clouds.

Fire accidents can be classified into the following general categories: 1) Pool fires, 2)Tank fires, 3)Jet fires, 4)Flash fires and 5)Fireballs. Explosions are associated with major accidents involving mechanical phenomena.

Explosions occur when there is a rapid increase in volume due to the expansion of a pressurized gas or vapour, the sudden vaporization of a liquid (physical explosions), or a fast chemical reaction (often combustion). Explosions can be classified into the following categories: 1)Vapour cloud explosions, 2)Vessel explosions and BLEVEs (Boiling Liquid Expanding Vapour Explosions) and 3)Dust explosions.

The release of a toxic material can produce a toxic cloud. Depending on the density of the cloud (heavier than air or with a density that is equal to or less than that of air) and on the meteorological conditions, the cloud is either dispersed quickly into the atmosphere or evolves close to the ground and moves at wind speed.

The major accidents which can occur in industrial installations or during the transportation of hazardous materials are usually related to a loss of containment. The loss of containment can be caused by an impact, by the failure of a piece of equipment (a pipe or tank) due to the effects of corrosion, by human error during a loading or unloading operation, or by various other factors. The loss of containment can also be a consequence of the accident itself, for example in the case of the explosion of a pressurized tank. [17]

3.2 State of the art in EU

The SEVESO directive already implemented in many European member states. obliges a significant number of process industries (including refineries, chemical production sites and LPG storages) to perform safety studies and the competent authorities to organize emergency plans and land use policies based on the results of these studies, in order to protect the public and the environment. For historical, geographical, economical, social and political reasons, there are big differences in the way the various countries approach the sitting of hazardous facilities and the development of areas in the vicinity of existing installations. Different methods and tolerability thresholds have been developed in European countries, fulfilling the SEVESO II requirements regarding LUP. In this part, the state of the art of LUP in EU will be explained briefly. This overview includes the following countries: France, Germany, Italy, Netherlands and United Kingdom. [18]

3.2.1 France

France has a 200 years history in risk prevention regulations related to dangerous facilities. [15] During the last fifteen years, in France, three aspects where classically considered to prevent the occurrence of industrial accidents: reducing risk at its source; limiting the effect of an accident (mitigation), and protecting from its consequences (now reducing vulnerability). At present, two era are distinguished in French risk management: the before and the after Toulouse AZF explosion. [19]

The French Ministry of the Environment produced guidelines to implement the new approach of risk analysis, described in a document entitled “General Principles for the Elaboration of safety Reports”. After a description of the environment of the site, a description of the process and the equipments, safety reports have to deal with the following stages:

1) Identification hazards
2) Characterisation of main hazards
3) Reduction of the main hazards
4) Learning from accidents
5) Preliminary risk analysis
6) Detailed risk analysis

7) Evaluation of the intensity of dangerous phenomena
8) Assessment of the probability of dangerous phenomena
9) Determination of the potential consequence for people
10) Classification of the scenarios in the national matrix.

There are also some terms which are used by the French ministry of the environment's guidelines:

- ✓ *Gravity:* Combination of two parameters 1) Intensity of the effects and 2) Number of people in each dangerous area outside the facility.
- ✓ *Probability:* The frequency with which an accident may occur during the lifetime a facility and it can be assessed qualitatively and quantitatively.
- ✓ *Bow-ties:* Combination of failure tree on the left and an events tree on the right.
- ✓ *Acceptability of the risk:* The French Ministry of the Environment has also defined a national matrix of acceptability of the risk for high-risk facilities.
- ✓ *PRPT (Technological risk prevention plans):* The aim of PRPT is to protect the population, through reducing the risk at its root source or adopting measures such as protective measures, construction and land-use planning measures, restriction on use of land, etc.

It seems nowadays the French ministry of the environment generally uses risk-oriented methods which are Quantitative probabilistic assessment method and also Semi-quantitative probabilistic assessment method. It seems there is still more work to do to harmonize probabilistic assessment methods, mainly because of the lack of accurate data. [12]

Until recently, France has been considered as a typical example of the consequence-based approach. However, French legislation on land-use planning was revised after the accident of Toulouse. In general, France adopted a hybrid approach that combines a consequence-based approach for the determination of zones that correspond to damage thresholds and a risk-based approach for the determination of the considered accident scenarios. [16]

3.2.2 Germany

Germany is a federal country consisting of 16 States. Land use planning in Germany is regulated within a number of statutes at federal and state level. Federal law determines the rules for granting licenses for potentially polluting or hazardous installations or activities. In 2005 the Guidance "SFK/TAA-GS-1" was published which gives recommendations for separation distances between establishments under the German Major accidents Ordinance and areas requiring protection within the framework of Land-Use Planning.

Probabilistic risk assessment as carried out in the Netherlands and the UK does not have an equivalent use in Germany and the method generally used is of the "consequence-based" type. In exceptional cases different tools are applied, e g. probabilistic assessment or a case by case approach. The general used “consequence based” approach refers to pre-selected “worst credible” or “representative” scenarios. [15]

3.2.3 Italy

In Italy, the Land Use Planning (LUP) is based on 4 different stages, regulated by the National Urban Law, that sets guiding principles and establishes different roles of regional, provincial and municipal authorities. Due to the three-levels structure of Italian governance (Regions, Provinces & Municipalities), licensing procedures are carried out by regional authorities (responsible for lower-tier establishments) and the Regional Technical Committee (responsible for upper-tier establishments). [15]

Italy has adopted a hybrid criterion that takes into account the frequencies, as a mitigation factor for the damage zones, identified using a consequence-oriented approach. The frequency values calculated for each scenario are considered as mitigating factors for LUP restrictions and are not used to express the individual and the societal risk. [16]

3.2.4 Netherlands

The Seveso II Directive is implemented in the Dutch legislation by the Dutch Major Hazards Decree (BRZO) and the Dutch Public Safety Decree (BEVI). The BRZO focuses on the management of hazardous installations. The BEVI instead regards the regulation of land-uses around hazardous installations, i.e. the external safety regulation. [20]

In the Netherlands, a full QRA is required in the phase of permit application for the installation of new establishments, as well as for modifications of existing situations. The coordination role for external safety matters has been assigned to the VROM (Spatial Planning, Housing & Environment Ministry) who decided to establish the External Safety Directorate as specific implementation body.

Concerning the risk assessment methodology, the Dutch approach is based on three guiding principles:

- the quantification of the risk through an analytical approach accounting probabilities;
- the evaluation of the individual risk and the definition of thresholds of acceptability;
- the evaluation of the societal risk.

The last step involves the calculation and the representation of location-based risk contours and of a societal-risk diagram. [15]

In addition, safety distances are applicable for the situation around an establishment. These safety distances are based for the majority of situations on a generic risk modelling of the type of installation, in combination with the risk acceptability criteria. For large chemical establishments, this approach would not work, as the complexity of the site does not enable the determining of a generic safety distance. In these cases, the risk parameters for the establishment are being calculated specifically. The calculated risks then form the basis for licensing of the establishment and physical planning around the establishment.

The Dutch external safety policy is based on the risk management approach, involving quantitative assessment of risks and evaluation against quantitative tolerability criteria. The experience in harmonizing the policies for the various activities involving dangerous substances, is very positive from a viewpoint of efficiency and transparency. To facilitate the application of risk-based safety policy for medium-size installations like, e.g., tank filling stations and ammonia cooling units, practical instruments like standard safety measures and safety distance tables can be effectively applied. Similar instruments developed for the management of risks from the transport of dangerous substances are being applied very effectively as well. [21]

The 'Purple Book' outlines the method to carry out a QRA calculation in compliance with the regulations in the Netherlands and overviews the various starting-points and basic data. The Guideline comprises a method to select installations to be included in the QRA, a set of default loss of containment events, default values to be used in the dispersion and effect calculations, and provides guidance on presentation of the results. [22]

3.2.5 United Kingdom

In the UK, the Health and Safety Executive (HSE) advises Local Planning Authorities about the location of major hazard facilities and pipelines and the control of housing and other developments nearby. HSE uses quantified risk assessment (QRA) to set a consultation distance around each of the major hazards and advises on possible risks to people within this distance so these risks can be considered in reaching planning decisions. [23]

In the UK arrangements have existed since 1972 for local planning authorities (PAs) to obtain advice from the HSE about the safety implications for developments from risks associated with chemical major hazards.

The HSE advises PAs on applications for development in the vicinity of major hazard sites and major accident hazard pipelines. HSE also advises PAs on applications for Hazardous Substances Consent to create a new major hazard site, or for Consent to modify an existing major hazard site. HSE is also consulted on the routing of new major accident hazard pipelines.

The previous scheme has been replaced with a new scheme known as PADHI (Planning Advice for Developments near Hazardous Installations). This has now been provided to PAs as a computer programme which they can use themselves to obtain advice. The codified scheme does not represent the true situation of a gradual change in risk with distance but is a pragmatic way to generate timely advice: it is intended to give broadly similar decisions to the previous system that are consistent across the UK and allows a more effective use of the HSE resources. Thus the scheme may be seen as a development of the previous system rather than a replacement.

HSE's advice is based on an assessment of the residual risks to people presented by the major hazard site. Residual risk is the risk that remains after the site operator has done all that they need to do to comply with the law (noting that the law does not require the risks to be zero). The residual risk concept also recognises that a lapse in vigilance at a site that normally complies with the law can lead to an accident. For the purposes of delivering land use planning advice, HSE defines a Consultation Distance, within which are usually three zones (Inner, Middle and Outer) around the major hazard. [24]

LUP evaluations in the surroundings of plants are carried out by means of the risk analysis developed by the HSE. Different methods are used, depending on the specific scenario and substances. Generally, advices related to toxic releases refer to the "risk oriented" approach, while in the case of thermal radiation and explosions the consequence-oriented approach is adopted. In the first case, safety distances are assessed against the probability to receive at least a dangerous dose; in the second one, safety distances are assessed against the receipt of prescribed thermal dose units. The criteria used to determine the likelihood of incurring these effects are both the individual and the societal risk. [15]

3.2.6 Overview of State of the art in EU

Table 1 shows a brief overview of the LUP practices in the European Union in 1999 [14] and Table 2 is the most recent overview in 2010. Comparison of these two tables clarifies the changes and developments in last decade in European Union. Table 3 also shows the comparison of LUP regulations in different European countries, including Catalonia. There is also recently published book "llibre blanc sobre investigació d'incendis i explosions (Sans, J. Coordinator)" about major fire accidents and investigations on them recommended for those who want to survey more in this area.

Country	'Generic' safety distances	'Consequence based' approach	'Risk based' approach	Land-use planning criteria	Arrangements still being developed
Austria					X
Belgium		X (Walloon)	X (Flemish)		X
Denmark					X
Finland		X			
France		X		X	
Germany	X	X		X	
Greece					X
Ireland					X
Italy					X
Luxembourg		X		X	
The Netherlands			X	X	
Portugal					X
Spain		X			X
Sweden	X	X			X
The United Kingdom			X	X	

Table 1. Brief overview of the land-use planning practices in the European Union in 1999 [14]

Country	Risk Based Approach	Consequence Based Approach
Austria		X
Belgium		X
Finland		X
France	X	X
Germany		X
Italy	X	X
Luxembourg		X
Netherlands	X	
Spain		X
Sweden		X
United Kingdom	X	

Table 2. Brief overview of the land-use planning practices in the European Union in 2010

PAÍS	METODOLOGIA	HIPÒTESIS D'ACCIDENTS	VALORS LLINDARS DE REFERÈNCIA	CRITERIS D'ACCEPTACIÓ	ELEMENTS VULNERABLES	TRACTAMENT DE SITUACIONS EXISTENTS NO ACCEPTABLES/ TERMINIS PREVISTOS	TRACTAMENT ESTABLIMENT AG NIVELL BAIX
FRANÇA	Mixta (determinística/ probabilística)	Extracte de les de *l'Étude de Surêté*[1]	Dosis letals (5 % i 1 %) Efectes irreversibles (SEI)	Zones d'expropiació forçosa, dret d'abandó i preempció[2].	NO	SI. S'estima en una generació (30 anys) el termini necessari per "regularitzar" les situacions existents no adients.	NO
REGNE UNIT	AQR	Extracte de les del *Safety Report*[1]	Dosis letals.	Risc individual: 10^{-6}, 10^{-5} i $3\ 10^{-7}$/any.	SI	NO	NO
HOLANDA	AQR	Purple Book[3]	Dosis letals.	Risc individual: 10^{-6} i 10^{-5}/any	SI	SI. Es disposava de tres anys (fins a setembre 2004) per reduir el risc dels elements vulnerables existents per sota de 10^{-5}/any i fins a 2010 per reduir-lo per sota de 10^{-6}/any.	SI (ídem nivell alt)
ITÀLIA	Aproximació AQR	Les del *Safety Report*[1]	Diferents nivells de danys.	Matriu compatibilitat freqüència dels accidents, nivell de danys i elements vulnerables.	SI	NO	NO
ÀUSTRIA	Determínistica	Relació d'hipòtesis tipus	Danys no letals.	No.	NO	NO	NO
BÈLGICA[4]	AQR	Les de *l'Étude de Surêté*[1]	Danys no letals	Cas a cas en l'estudi d'impacte ambiental.	NO	NO	NO
ALEMANYA	Mixta (determinística/ distàncies fixes)	Trencaments de línies diferents diàmetres	Dosis no letals.	Zonificació. Distàncies fixes/ anàlisi cas per cas.	SI	NO	SI (ídem nivell alt)
CATALUNYA	AQR + Franja de seguretat	Purple Book [3]	Dosis letals.	Risc individual: 10^{-6} i 10^{-5}/any[5]	SI	SI[6] Previst un període transitori d'adaptació als llindars de risc acceptable fins a 2010.	SI (ídem nivell alt)[7]

1 Document equivalent a l'Anàlisi de Risc segons RD 1196/2003 de 19 de setembre.

2 La llei de 30 de juliol de 2003 defineix els PPRT (Plans de Prevenció de Riscos Tecnològics) per a gestionar, un cop reduït el risc en origen, les situacions existents no desitjables i evitar desenvolupaments futurs no adients. Els PPRT per establiments AG de nivell alt delimiten tres zones en els voltants dels establiments i a l'interior de l'àmbit del PEE: a) un sector on l'Estat pot declarar d'utilitat pública l'expropiació; b) un sector on es pot instaurar el dret d'abandó als propietaris (els municipis han de comprar els seus terrenys si els propietaris desitgen allunyar-se del risc) i c) un sector on el municipi té dret de "preempció" (preferència en la compra de terrenys).

3 COMMITTEE FOR THE PREVENTION OF DISASTERS. *Guidelines for quantitative risk assessment*. CPR 18 E. "Purple Book". Primera edició. 1999.

4 La directiva Seveso II va entrar en vigor a Bèlgica al juny de 2001 mitjançant un acord de cooperació entre l'Estat federal i les regions. S'han fet adaptacions en el decret relatiu a permisos mediambientals per a incorporar els requeriments d'aquesta directiva. Assigna a les regions (Bruxelles capital, Valònia i Flandes) la competència per la planificació del territori (article 12). Les dades indicades corresponen a la regió de Bruxelles on el COBAT (*Code Bruxellois pour l'Aménagement du Territoire*) va ser aprovat el 9 d'abril de 2004 després d'una modificació que inclou, entre altres, l'article 12 de la directiva Seveso II.

5 Aquest llindar està previst en el procés de regularització dels establiments existents AG existents.

6 Està en projecte una instrucció de requeriment de l'AQR a tots el establiments AG de Catalunya.

7 L'AQR, per establiments nous i canvis substancials en els existents, es actualment requerit en virtut de l'article 12 del decret 174/2001 de 26 de juny que desenvolupa el RD de transposició de la directiva. Està en projecte una instrucció que dona caràcter preceptiu a la presentació d'aquesta anàlisi per establiments de nivell baix.

Table 3. COMPARATIVA PER LA PLANIFICACIÓ URBANÍSTICA ALS VOLTANTS DELS ESTABLIMENTS AG A DIFERENTS PAÏSOS EUROPEUS [25]

4. Review of the articles

As mentioned at the beginning of the paper, this article also introduces the ISPC (Institute of Public Safety of Catalonia) magazine (issue 23) which included several articles written by the LUP workgroup members analyzing the situation from different points of view. Next you will find the abstracts and reflex ions of the articles [26].

4.1 Forest risk and territory

Human action has conditioned the current structure of forests in Catalonia. Before mankind lived from the woods, now we look at them and complain because they are dirty and get burnt down. Numerous invasive plant species do not help solving the problem either.

Jose Arola brings us up to date, in a realistic way, on the problem of interaction between rural environment and urban culture.

It is perhaps a partial vision of the analysis between human and rural necessities. A micro-planning helps to assess the problem of forest fires and land usage.

His vision of the Catalan area of "el Bages" can serve us as an example that can be extrapolated to the rest of the country.

The author analyzes some representative forest fires in recent years, with an anthropological and slightly traditional view leading us to believe that what worked years ago is not working now and nor will it do so in the near future.

We can not return to the past, new ideas are needed to build the future.

4.2 Risk governance for sustainable territories: the French case and some challenges.

In France, industrial security was firstly regulated in the times of Napoleon (1810). The document presented by Myriam Merad describes in the first part how France manages the risk and the territory after the experience of the major accident in Tolouse (2001). These practices are still under scientific debate that includes the proposal to create an independent LUP (Land Use Planning) and risk governance work group in order to advise public institutions because they make the final decision.

In the second part, different improvement and research lines are proposed in order to achieve a more sustainable and efficient LUP.

She also introduces the necessity to tackle the uncomfortable matter of retroactivity in the governmental management of risk. Legal safety of the administrated organisms "versus" public safety or general interest may be a legal debate.

She also explains in detail how to manage technological risks in France, whether they are large or small. It is particularly interesting the management of "micro-risks" which provide high frequency, but low severity.

4.3 Chemical risk and territory

Casal and Vilchez expose from a technical, academic, rigorous and classical perspective the typical problems generated by dangerous substances (hazardous materials) naming them, in a colloquial and widespread concession "chemical hazard".

They analyze various aspects of risk associated with the facilities of the chemical industry: concepts and types of risk, evolution of major accidents depending on the time and the main types of accidents which can occur in this type of facilities.

It talks about the importance of the chemical sector in Catalonia and in the Spanish state framework, and exposes the main sections of the specific legislation on this issue at three levels, European Spanish and Catalan.

They also demonstrate with an analysis how to carry out the risk assessment associated to a particular facility and how it is measured and represented over the affected zone; this methodology is applied, as an example, in a particular case: a flammable product storage.

Finally, a relatively frequent situation is analyzed, when there is an overlap between the area subject to certain risks and the population. It discusses the threshold values used to define danger and intervention zones as well as the possible actions.

The article ends up with a series of final reflections, which propose to streamline the protection zones, driving away from drastic resolutions and using instead quantitative risk values as main parameters to follow.

4.4 Relation between urban regulation and recent legislation on technological risks

Fortunately we live in a democratic state where state based laws mean that the rules of the game are marked by the legal powers in force, although often the legislative framework is complex and sometimes not easy to apply.

An example of a case like this would be the juridical laws that frame and legalize complex technical rules that give no simple solutions to problems that aren't simple at all.

Joann Amenós analyses the legislation in force today, focusing on Catalonia and chemical risk.
The juridical vision, it is absolutely indispensable for legitimating any adopted solution and it is also indispensable to avoid long and expensive lawsuits that may occur given the economical value involved.

No scientific or technical approach will be valid and enforceable, no matter how consistent it may be, if it doesn't fit within the present juridical frame.

4.5 Development patterns and vulnerability

This article offers a holistic vision of the territory capable of holding any type of activity and therefore tackles the territory risk management as a particular case in a broad and social vision of the problem.

Analyses the vulnerability of the public amenities available in the territory and makes evident the weakness of certain supplies such as electricity which has become a critical element, and when not available it threatens our whole system of life.

It is not a coincidence that critical infrastructures are called critical. Bernis also raises the classic discussion between compact or disseminated city analyzing the pros and cons. He makes an analysis using a "cocktail" of various social and technical disciplines, where energy and efficiency have a prominent role.

Risk, understood as a global parameter, is another element to consider in the design of modern cities.

4.6 The UK Approach to Land Use Planning in the Vicinity of Chemical Major Hazard Installations

In a highly technical article, Tom Maddison analyses from his experience the vision of how technological risks and territory are managed in Great Britain. In the UK arrangements have existed since 1972.

The PADHI system provides quality advice to the competent authorities in planning, it is a centralized methodology from the standpoint of technical knowledge but at the same time it is a decentralized methodology attending the real decision-making capacity that local authorities have, which is widely described in the article.

It is a point of view to be taken into account in any new sustainable public safety initiative in the long troubled relationship between territory, risks, general interest and economic interests of the involved parties.

In Europe, the management of technological risks is well developed. Industrial and storage facilities regulated by the Seveso directive across Europe are a very technical and scientifically studied field and highly regulated.

Never the less, always from the perspective of major accidents with deterministic methods, probabilistic methods or a mixture of both.

Basically we aim to assess the risk from an accident occurrence probability, from which we can calculate the consequences (physical and chemical values) which are the requests received by the vulnerable component, and the result this calculation is the damage that can be expected.
This is a matter that clearly belongs to safety and is controlled by the technical bodies of all kinds, public and private.

We mustn't forget that the facilities that handle hazardous substances, whether they are classified as Seveso or not, are critical infrastructures that could be the objective of terrorist attacks.

In a safety methodology the worst accident possible (credible) is defined by occurrence probability value and not by the impossibility of that happening.

In the event of an attack, the parameters vary and often what is practically impossible can occur if it is provoked.

Therefore in a security study we will logically have different safety scenarios plus others probably worse.

The calculation methodology is the same; we just have to consider additional initiating events.

It would be advisable to define an S & S (Safety & Security) methodology to assess the real, accidental or provoked risks in facilities where the presence of hazardous substances can cause a major damage.

To do serious LUP studies, we must therefore consider delivered attacks as initiating events; taking them into account will make the results vary considerably and in some cases even provide information on scenarios not often considered by the police.

5. Conclusions

Land management incorporating risk criteria is still a pending issue. Despite the studies and scientific technical engineering methodologies related to security that provide us with tools to asses what is likely to happen and by which probability, despite the multiple legal tools available at European, national, regional and also local level, despite all the accidents that remind us that this problem continues, the real solution is not yet defined.

It is also pending to integrate in a single methodology, which we could call S & S (Safety & Security) the prevention management and its consequences which are the same regardless of the cause whether it is an illegal act (Security) or an accidental act (Safety) to head towards an integral security.

In Europe many applicable solutions have been proposed, local creativity in this case may end up being an industrial policy tool, and therefore, economic, which can be positive or negative, controlled or not, it all depends.

Although some governments may not have realized how important this issue is, it must be studied because it is certainly a major subject.

6. Bibliography

[1] Sambhavna Trust Clinic. The Bhopal medical appeal (UK registered charity No. 1117526). Analysis of chemical contaminants in groundwater of communities surrounding UCIL plant site in Bhopal. 2009.
[2] Willey, R., Crowl, D., Lepkowski, W. The Bhopal tragedy: its influence on process and community safety as practiced in the United States. Journal of Loss Prevention in the Process Industries. Vol.18, 2005, p.365-374.
[3] Bisarya, R., Puri, S. The Bhopal gas tragedy-A perspective. Journal of Loss Prevention in the Process Industries. Vol.18, 2005, p.209-212.
[4] The Bhopal Medical Appeal. Brighton, United kingdom, 2010. [http://bhopal.org/index.php?id=22&L=nkqibdjuigpqzcl, 15.8.2010].
[5] The Boston Globe. Boston, MA, United States, 2009. [http://www.boston.com/bigpicture/2009/11/25th_anniversary_of_the_bhopal.html, 15.8.2010].
[6] Gupta, J. The The Bhopal gas tragedy: could it have happened in a developed country?. Journal of Loss Prevention in the Process Industries. Vol.15, 2002, p.1-4.
[7] Sam Mannan, M., West, H., Krishna, K., Aldeeb, A., Keren, N., Saraf, S., Liu, Y., Gentile, M. The legacy of Bhopal: The impact over the last 20 years and future direction. Journal of Loss Prevention in the Process Industries. Vol.18, 2005, p.218-224.
[8] Buncefield Major Incident Investigation Board. The Buncefield Incident, 11 December 2005, The final report of the Major Incident Investigation Board. Vol.2, 2009.
[9] Johnson, M. The potential for vapour cloud explosions-Lessons from the Buncefield accident. Journal of Loss Prevention in the Process Industries. 2010, p.1-7.
[10] Enschede: Stedenbouw & Architectuur. Enschede, Netherlands, 2010. [http://www.enschede-stad.nl/~Fotos/Luchtfotos/14.jpg, 15.8.2010].
[11] Voogd, H. Disaster Prevention in Urban Environments. European Journal of Spatial Development. Vol.12, 2004.
[12] Taveau, J. Risk assessment and land-use planning regulations in France following the AZF disaster. Journal of Loss Prevention in the Process Industries. 2010, p. 1-11.

[13] Dechy, N., Bourdeaux, T., Ayrault, N., Kordek, M., Le Coze, J. First lessons of the Toulouse ammonium nitrate disaster, 21st September 2001, AZF plant, France. Journal of Hazardous Materials. Vol.111, 2004, p.131-138.
[14] Christou, M., Amendola, A., Smeder, M. The control of major accident hazards: The Land-use planning issue. Journal of Hazardous Materials. Vol.65, 1999, p.151-178.
[15] Basta, C., Struckl, M., Christou, M. Overview of roadmaps for land-use planning in selected member states . JRC scientific and technical reports. EUR 23519 EN, 2008.
[16] Sebos, I., Progiou, A., Symeonidis, P., Ziomas, I. Land-use planning in the vicinity of major accident hazard installations in Greece. Journal of Hazardous Materials. Vol.179, 2010, p.901-910.
[17] Casal, J. Evaluation of the effects and consequences of major accidents in industrial plants. ISBN: 978-0-444-53081-3, First edition, 2008, Elsevier.
[18] Papazoglou, I., Nivolianitou, Z., Bonanos, G. Land use planning policies stemming from the implementation of the SEVESO-II Directive in the EU. Journal of Hazardous Materials. Vol.61, 1998, p.345-353.
[19] Merad, M., Dechy, N. Risk governence for sustainable territories: the French case and some challenges. Revista Catalana de Seguretat Pública. To be published, 2010.
[20] Basta, C., Neuvel, J., Zlatanova, S., Ale, B. Risk-maps informing land-use planning processes A survey on the Netherlands and the United Kingdom recent developments. Journal of Hazardous Materials. Vol.145, 2007, p.241-249.
[21] Bottelberghs, P.H. Risk analysis and safety policy developments in the Netherlands. Journal of Hazardous Materials. Vol.71, 2000, p.59-84.
[22] Uijt de Haag, P., Ale, B., Post, J. The "Purple book": Guideline for Quantitative Risk Assessment in the Netherlands.
[23] Brazier, A.M., Greenwood, R.L. Geographic information systems: a consistent approach to land use planning decisions around hazardous installations. Journal of Hazardous Materials. Vol.61, 1998, p.355-361.
[24] Madisson, T. The UK approach to Land Use Planning in the vicinity of chemical major hazard installations. Revista Catalana de Seguretat Pública. To be published, 2010.
[25] Tost Pardell, S. Panorma de la seguretat industrial a Catalunya. El cas de la Planificacio del territori als voltants dels establiments amb risc d'Accident greu. Revista Catalana de Seguretat Pública. Vol.19, 2010, p. 103-131.
[26] Several authors. Revista Catalana de Seguretat Pública. n23, 2010.