EUROPEAN COMMISSION
JOINT RESEARCH CENTRE
Institute for the Protection and Security of the Citizen
Hazard Assessment Unit

MAJOR ACCIDENT HAZARDS BUREAU

LAND USE PLANNING GUIDELINES IN THE CONTEXT OF ARTICLE 12 OF THE SEVESO II DIRECTIVE 96/82/EC AS AMENDED BY DIRECTIVE 105/2003/EC,

ALSO DEFINING A TECHNICAL DATABASE WITH RISK DATA AND RISK SCENARIOS, TO BE USED FOR ASSESSING THE COMPATIBILITY BETWEEN SEVESO ESTABLISHMENTS AND RESIDENTIAL AND OTHER SENSITIVE AREAS LISTED IN ARTICLE 12.

Edited by
M. D. CHRISTOU, M. STRUCKL and T. BIERMANN
September 2006

ACKNOWLEDGEMENTS

This guidance document has been developed by Michalis Christou (Chairman of the Group), Michael Struckl (Detached National Expert) and Tobias Biermann (DG ENV) in close collaboration with the members of the Technical Working Group 5 on Land Use Planning appointed by the Committee of Competent Authorities for the Seveso II Directive. The editors would like to thank all the members of TWG 5 (see composition below) for their constructive comments and suggestions throughout the process of preparing this guidance. In particular the editors want the thank the following group members for their specific input for the contents of the guidance: Ms. Roberta Gagliardi, and Messrs. David Bosworth, Sebe Buitenkamp, Bruno Cahen, Stuart Duffield, Thomas Hackbusch, David Hourtolou, Gerald Lommers, John Murray and Olivier Salvi.

Composition of the Technical Working Group 5 (Plenary Group and Subgroup on Objective 2)

Lena Ahonen
Finn-Juel Andersen
Fabrice Arki
Volker Arndt
Dominique Asselin
Herlinde Beerens
Emmanuel Bernuchon
David Bosworth
Emmanuel Bravo
Peter Buckley
Sebe Buitenkamp
Jim Burns
Bruno Cahen
Gianfranco Capponi
Henri Chapotot
Alain Chetrit
Bruno Chevallier
Patrick Conneely
Gabor Cseh
Veronika Cygalova
Maria Laura D'Anna
Pavel Danihelka
Paola De Nictolis
Valerie DeDianous
Fausta Delli Quadri
Henri DeSchouwer
Gareth Doran
Stuart Duffield
Nijs Jan Duijm
Janet Edwards
Christophe Erhel
Cecile Fievez
Carmo Figueira
Elena Floridi
Roberta Gagliardi
Antonia Garces de Marcilla
Martin Henry Goose
Richard Gowland
Zsusanna Gyenes
Thomas Hackbusch
Armin Heidler
Caroline Henry
David Hourtolou
Pauline Anne Hughes
John Irwin
Pavel Janik
Mikael Jardbrink
Jasmina Karba
Lajos Katai-Urban
Thomas Klein
Igor Kozine
Birgit Kristiansen
Jean Paul Lacoursiere
Nathalie Larbanois
Kurt Lauridsen
Mark Lawton
Gerald Lommers
Harriet Lonka
GiancarloLudovisi
Katarina Malcikova
Jean Michel Meslem
Riita Molarius
Joelle Mousel
Georgios Mouzakis
John Murray
Rodrigues Nelson
Alain Papon
Klaus-Dietrich Paul
Alain Pierrat
Jos Post
Paivi Rantakoski
Michel Raymond
Stuart Reston
Sonia Roman
Olivier Salvi
Peter Georg Schmeltzer
Philippe Sebbane
Ernst Simon
Maria Stangl
Stellan Svedstroem
Lars Synnerhom
Jyrkii Tiihonen
Sophie Tost
Nicoletta Trotta
Georges Van Malder
Ghislaine Verrhiest
Sara Vieira
Jeffrey Watson
Anton Wilson

INTRODUCTION

This document represents existing best practice drawn from the cumulative knowledge of experts in this field. Its use is not mandatory, but it can be used by Member States to achieve compliance with the legislation. This is a developing area of knowledge so there is a need to remain alert to progress.

The document is intended to give guidance for risk assessment in Land Use Planning (LUP) in general as far as the major accident potential of industrial establishments is concerned. The main aim in this respect was to combine the understanding of the land use planners and the risk assessment experts in a coherent view. In this respect it may offer especially land use planners not familiar with industrial risk assessment considerations a quick and comprehensive information resource.
It will also assist with the use of the risk/hazard assessment database which the Major Accident Hazards Bureau (MAHB) was assigned to develop and which shall provide proposals for key factors in this respect. By defining best practice of risk assessment in Land Use Planning the underlying principles of the risk/hazard assessment database are described.

The overall aid provided to the Member States for dealing with Article 12 of the Seveso II Directive (Land-Use Planning), as amended by Directive 105/2003/EC, consists of three parts: (i) The present Guidance document, defining principles for dealing with the requirements of Art.12 in operational terms; (ii) the "Roadmaps" document, which provides supplementary information material describing in detail "good LUP practices" available within selected Member States; and (iii) the technical database of common scenarios, failure frequencies and data to be used in the underlying hazard/risk assessments supporting LUP decisions. The applicability and continuous update of the Guidelines and the update of the database will be continuously monitored and steered by an electronic Community-of-Interest, constituted by experts from the Member States and MAHB. It is believed that the above-mentioned set of guidance instruments will constitute a complete and sufficient aid for the Seveso Competent and planning authorities of the Member States in dealing with the requirements of Article 12.

The present Guidance document is divided in three parts: Part A discusses general aspects of LUP and Article 12 and describes the obligations of Article 12 through a number of main and supporting principles, which represents best LUP practice. Part B presents technical and methodological aspects of the evaluation of major accident hazards and the structure of the technical database. Finally, Part C focuses on Environmental aspects, summarizing the corresponding EU legislation and making reference to tools and methodologies aiming at addressing the environmental risk of major accidents.

TABLE OF CONTENTS

Part A - General Aspects

1. Land-Use Planning in the Seveso II Directive

Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances (Seveso II Directive) aims at the prevention of major accidents and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner.

The requirements for land-use planning were introduced into by Article 12 into the Seveso II – Directive 96/82/EC; Seveso I did not contain such requirements. The provisions reflected the request by the Council of Ministers that following the incidents in Bhopal (1984) and Mexico City (1984) the lessons learnt should be taken into account and that land use restrictions could limit the consequences of such incidents. Article 12 explicitly refers to the overall objectives of the Directive as laid down in Article 1 (= man and environment).

Land-Use Planning is only one element in the multi-level safety concept of the Directive, the other elements for accident prevention and response and the obligations for operators and Member States authorities are not dealt with in this document.

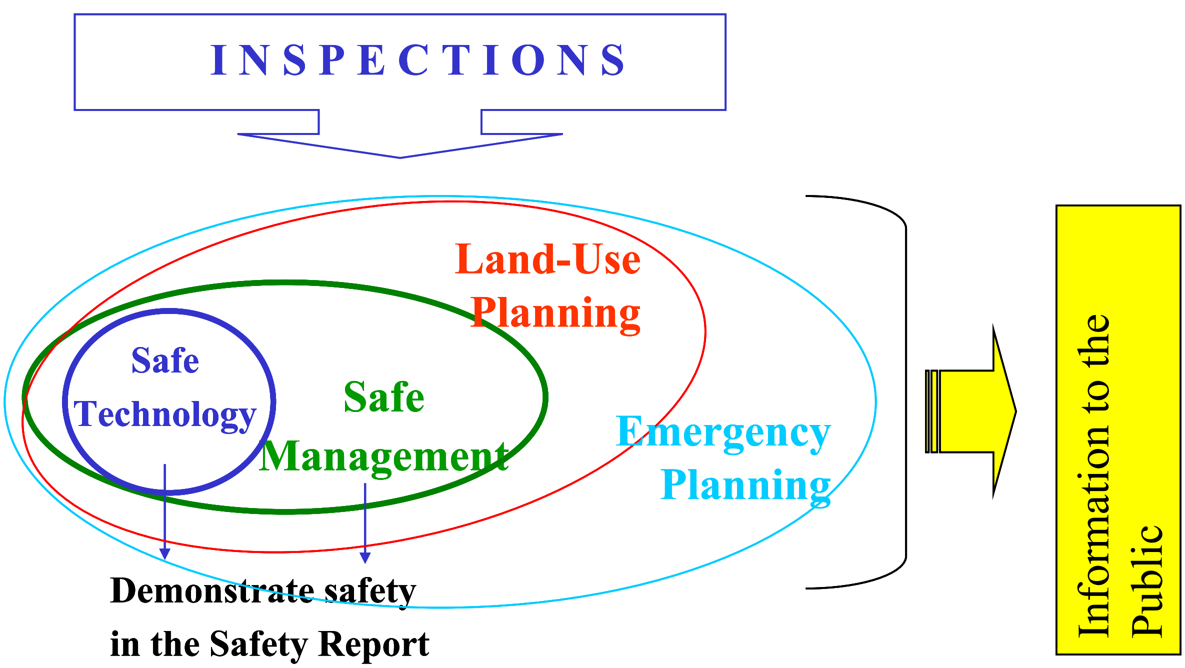

Figure 1. Schematic representation of the philosophy of Seveso II Directive

Major accident hazards (fires, explosions, toxic releases) are a relatively new element in Land-Use Planning. Other threats like natural disasters (floods, avalanches, earthquakes etc.) or long-term or permanent impacts (industrial or municipal emissions etc.) are better known and its consideration in Land Use Planning is sometimes already State-of-the-Art.

To assist Member States in carrying out the specific tasks connected with Article 12 MAHB issued a Guidance Document in 1999[1].

Following the accidents in Enschede and Toulouse, the Amendment Directive 2003/105/EC gave in Art.1, paragraph 7b a mandate to the Commission to draw up by 31 December 2006 in close collaboration with the Member States these *"guidelines defining a technical database with risk data and risk scenarios, to be used for assessing the compatibility between Seveso establishments and residential and other sensitive areas listed in Art.12".*

1. 1. "Land Use Planning" as defined by Article 12

Article 12 of the amended Seveso II Directive reads as follows:

1. Member States shall ensure that the objectives of preventing major accidents and limiting the consequences of such accidents are taken into account in their land use policies and/or other relevant policies. They shall pursue those objectives through controls on:

(a) the siting of new establishments,

(b) modifications to existing establishments covered by Article 10,

(c) new developments such as transport links, locations frequented by the public and residential areas in the vicinity of existing establishments, where the siting or developments are such as to increase the risk or consequences of a major accident.

Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, buildings and areas of public use, major transport routes as far as possible, recreational areas and areas of particular natural sensitivity or interest, and, in the case of existing establishments, of the need for additional technical measures in accordance with Article 5 so as not to increase the risks to people.

2. Member States shall ensure that all competent authorities and planning authorities responsible for decisions in this area set up appropriate consultation procedures to facilitate implementation of the policies established under paragraph 1. The procedures shall be designed to ensure that technical advice on the risks arising from the establishment is available, either on a case-by-case or on a generic basis, when decisions are taken.

From the text of the Directives the following conclusions may be drawn with regards to the overall land use (or spatial) planning system:

- The requirement of Article 12 is a specific one within the general objectives of planning.
- The requirement may be fulfilled by means of planning and/or technical solutions.
- It is a mandatory requirement, which means it cannot be "overruled" by other factors of consideration.
- It applies only for cases of future development (new sites, modifications or new developments in the vicinity) → Article 12 therefore does not apply retrospectively.

[1] Christou/Porter: *Guidance on Land Use Planning as required by Council Directive 96/82/EC – JRC 1999*

2. Land Use Planning Aspects

2.1. The Term "Land Use Planning"

The title of Article 12 in the various language versions reflects the various differences described in the previous chapter:

- Land Use Planning
- Maitrise de l'Urbanisation
- Überwachung der Ansiedlung
- Control de la Urbanizacion
- Controllo dell'urbanzzazione
- Etc.

"Land Use Planning" can be defined[2] *as "a systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection and implementation of measures most likely to encourage such land uses…"*

A "plan" is an intellectual anticipation of a desirable situation in the future, or in more simple words: a plan describes how a situation in the future will exist. "Planning" therefore is the procedure to elaborate a plan. Actually this term covers a range of activities, from procedures of a purely technical type to administrative or governmental arrangements.

Land Use Planning has to be understood as an aspect of "spatial planning", a term that refers to the "space" as a multidimensional concept that describes and reflects the synthesis of the physical environment and its use by humans, whereas traditional "land use planning" deals only with the efficient use of land ("land" as a synonym for the surface of the earth).

The EC provides a definition of "spatial planning" in its 1997 Compendium of Spatial Planning Systems and Policies[3]:

"Spatial planning refers to the methods used by the public sector to influence the future distribution of activities in a space or spaces. It is undertaken with the aim of creating more rational territorial organisation of land uses and linkages between them to balance demands for development with the need to protect the environment and to achieve social and economic objectives. Spatial planning embraces measures to co-ordinate the spatial impacts of other sectoral policies to achieve more even distribution of economic development between regions than would otherwise be created by market forces and to regulate the conversion of land and property uses"

Spatial planning is a process of decision making thus weighing between social, ecologic and economic demands. It is a steering instrument and also a regulatory procedure that

- supports the economic development of the society
- safeguards environmental sustainability including the safety of people
- achieves a reduction of regional disparities and
- supports the development and stability of resources.

Spatial planning has also the character of a common generic term for the national *physical/land use/territorial planning* systems of European countries. The terms "physical planning", "land use

---

[2] FAO, Rome (Italy),Guidelines for land-use planning (FAO Development Series No. 1)

[3] European Commission/Regional Development Studies: EU compendium on spatial planning systems and policies

planning", "urban planning" or "territorial planning" all have broadly the same meaning. They describe government action to regulate development and land uses in pursuit of agreed objectives. This form of planning is one policy sector within government, alongside policy sectors such as transport, agriculture, environmental protection and regional policy, although it may incorporate mechanisms to coordinate other sector policies**.**

Although ***spatial planning*** is now widely used as a generic term for all systems, in fact the systems have considerable differences. Each country has a specific name for its system of planning, for example, *urbanisme et aménagement du territoire (France, Belgium, Luxembourg)*, *town and country planning (United Kingdom)*, *Raumplanung (Germany)*, *ruimtelijke ordening* (the Netherlands), *fysisk planering* (= physical planning, in Swedish), *land use planning* (Ireland). The meaning of these terms has evolved in the particular legal, socio-economic, political and cultural conditions of the country or region in question. Strictly speaking, the terms are not transferable to other countries, except in the most general sense. This applies even if the same words are used; e. g. *aménagement du territoire* has a different meaning in Belgium, France and Luxembourg.
Spatial planning is currently not a formal responsibility of the Community, but many EU policies have important territorial effects as recognized in the European Spatial Development Perspective (ESDP). The ESDP reviews EU policies with spatial impact, and puts forward its proposals to take into account the spatial dimension in Community and Member State decision-making.

2. 2 Land Use (Spatial) Planning Objectives

Spatial policies which are targeted at a balanced development in principle are influenced by three elements:

- Society
- Economy
- Environment

Within these main categories relevant objectives are defined; the following list names the most common ones:

- Seek to achieve as equal as possible living conditions for the population
- Try to improve these living conditions by creating a balanced structure of economy and the social system
- Protect the population and the environment against harm caused by natural or man-made extraordinary incidents
- Protect the natural resources, in particular ecosystems (plants, animals and landscape), soil, water and climate
- Ensure that supply of the public with housing, infrastructure, recreation possibilities and facilities for social and educational needs
- Secure the agricultural resources in order to ensure the supply of the public with aliments and related raw products
- Develop the land use in balance with the ecological and economic capacities
- Private interest has to give precedence to public interest.

2.3 Land Use Planning Protection Issues

In the list of objectives in the previous chapter there is explicitly one on the protection of the population and the environment which may be understood as the basis for further considerations on the role of land-use planning in the context of the Seveso II Directive.

As can be seen in the Figure below, Land-Use planning is only one tool amongst others:

Figure 2. General overview of tools designated for the protection of mankind and the environment from various stressors

2.3.1 Human Health

The protection of residential and other populated areas liable to be affected by a major accident is a key objective of the Directive. Therefore, risk considerations have to be incorporated in the spatial planning process. The assessment of major accident impacts requires the existence of clearly established hazard/risk assessment methods and criteria. For a given installation, a "consequence based" approach will characteristically show the consequence area for lethal effects and serious injuries resulting from the scenarios assessed, while a "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. Detailed information on the most common methods currently used for risk assessment is given in part B of this document.

2.3.2 Vulnerable environmental receptors

Whereas the identification of areas for the protection of the public is often based on consideration of quantitative effect values (at least at some extent), a similar approach is usually more difficult to be carried out for environmental issues. As for any project with potential environmental effects, a first step in the planning process is to collect and generate environmental data of the surrounding area at project level. Thereby it is recommended to identify vulnerable receptors and to assess qualitatively the environmental impact on these receptors. The following is a non-exhaustive list of aspects defining areas of particular natural sensitivity and interest on community level, that should be assessed:

Nature: Special areas of conservation defined in the Habitats Directive (92/43/EEC). The assessment under the Habitats Directive is a test to certify that a plan does not adversely affect the integrity of the site concerned; the competent national authorities must not adopt a plan which has adverse effects impairing the site unless the conditions and criteria in Article 6(4) of the Habitats Directive are fulfilled. Another Directive is the "Birds Directive" 79/409/EEC which lists specifically protected species.

Water: The Water Framework Directive 2000/60/EC (WFD) introduces a concept of ecological protection for surface water and groundwater. Amongst other targets it introduces a system of preventive action against pollution and controlling pollution at the source which would also include short-term accidental releases. For the WFD, a Common Implementation Strategy has been developed and numerous informal guidance documents have been produced which give more detailed advice on approaches to implementing the Directive.

Furthermore, the precautionary approach for example based on preventing soil degradation and soil contamination should be considered.

3. The Element of Risk in Land Use Planning

3. 1. Key Definitions[4]

Risk:

The Seveso II Directive defines "risk" as follows:

Risk: the likelihood of a specific effect occurring within a specified period or in specified circumstances

The definition according to ISO/IEC 51 reads:

Risk: the combination of the frequency or probability of occurrence and the consequence of a specified hazardous event.

Risk Assessment:

Risk Assessment: the overall process comprising a risk analysis (the systematic use of available information to identify hazards and to estimate the risk) and risk evaluation (procedure whether the desirable[56] level of risk has been achieved)

Risk Management:

Risk Management: Systematic application of management policies, procedures and practices to the tasks of analysing, evaluating and controlling risks

3. 2. LUP – related considerations for the definition of "risk"

In principle "risk" is a term of universal significance implying the elements of uncertainty and consequences; a "risk" is created by a "hazard" – a disposition (properties, potential) to cause adverse effects. Also in Spatial Planning the term "risk" characterizes possible unwanted consequences that the public perceive to be undesirable or worse but are accepted because the benefits accruing from the activity outweigh the risks. This leads either to decisions or non-decisions and may result in adverse consequences or the loss of possible advantages. The "space" in this respect therefore is a reference system where the public collectively is exposed to risks and reacts to this exposure by means of assessing and controlling the risks.

Whereas spatial-relevant risks may include risks like financial or political decisions, the typical Land Use Planning (LUP)-relevant risks are considered entirely those of man-made technical or natural origin. Land Use Planning in itself is one element of the overall system of (governmental, administrative) risk management in this respect.

[4] For a comprehensive list of definitions please refer to the "Glossary of terms" developed within the work of the Working Group.

[5] "Desirable" stands for a broad qualitative target definition. It does not indicate a safe/unsafe boundary value.

[6] "Desirable" or "tolerable" refer to the level of risk which is accepted in a given context based on the current values of society (see also ISO/IEC 73). In the industrial safety management context and based on other considerations (social, economic, etc.) a risk higher than this desirable level may not necessarily cause binding measures against the continuation of the relevant activity immediately or in the future (contrary to the usual strict linguistic meaning of the term "intolerable").

The role of Land Use (or Spatial) Planning in risk management depends on its scope according to national legislation. In the traditional form of land use planning, LUP mainly would be a mitigation tool to reduce the extent of consequences, but in connection with a permit scheme and the possible imposing of technical conditions it is also a prevention tool.
"Risk" or "risk management" in the context of LUP in general appears by different forms of threat:

- natural disasters (floods, avalanches, earthquakes etc.)
- long-term or permanent impacts (industrial or municipal emissions etc.)
- man-made disasters (short-term accidental releases).

The first type of threat is well-known and significant experience has been accumulated with its consideration in Land Use Planning that can already allow State-of-the-Art in the relevant risk-informed decision-making. The second type of threat is taken into account more recently by legislative tools like EIA and – more combined with Land Use Planning – SEA. Threats caused by man-made accidental releases and subsequent phenomena (fires, explosions, toxic clouds) are a relatively new element in Land Use Planning.
In particular, LUP-activities as part of such a risk management in the context of Article 12 of Seveso II are

– planning measures (land allocation, zoning, spacing safeguards etc.)
– technical measures (prevention or mitigation measures imposed in permit procedure etc.).

4. Best Practice

4. 1 Best Practice in Land Use Planning

Land Use Planning is in essence a decision making process including preparatory steps.
As such, a proper LUP policy shall provide[7]:

- clear definition and assignment of roles and responsibilities including appropriate institutional framework and administrative structures
- availability and accessibility of data and information
- participation of all stakeholders
- simplicity and clarity
- realistic concepts in terms of scope and implementation
- assessment of impacts

To comply with these targets, an important LUP principle is that of robustness; robustness means that limiting conditions and real impacts may undergo changes to a certain extent without altering the previous decision.

A robust LUP in the context of risk management exists if it follows these elements:

Consistency: Outcomes from broadly similar situations are broadly the same under similar conditions.

Proportionality: The constraint should be proportional to level of risk

Transparency: Clear understanding of the decision-making process

4. 2. Best Practice in Risk Assessment

In principle all risk assessment methods without regard to individual applications have the same relevant elements; these are[8]:

- Definition of scope, objectives and risk criteria
- Description of the object or area of concern
- Identification of hazards
- Identification of vulnerable targets
- Assumption of source terms or hazardous incidents
- Development of escalation scenarios
- Estimation of consequences
- Estimation of likelihood
- Presentation of resulting risk and comparison with established tolerability criteria
- Identification of mitigation measures
- Acceptance of result, modification or abandoning

Besides these elements a proper risk assessment should furthermore ensure

- a level of detail proportional to the severity of consequences;
- the use of acknowledged methods (or it must be demonstrated that these are equivalent);
- reliability of data and relevant information and
- transparency of the process.

---

[7] *"UN-HABITAT – Guidelines for Good Urban Policies and Enabling Legislation"*,
[8] Taken from *Mannan/Lees* "Loss Prevention in the Process Industry", 2005

4. 3 The Obligations of Article 12 in Operational Terms

4. 3. 1 General Principles

To comply with the legal requirement, the following general principles with respect to Best Practice of Land Use Planning and Risk Assessment are defined:

General Principles	Explanations	Outcomes & Comments
Consistency		
Hazard/Risk Assessment methods should exist	Can be based on hazard and/or risk; generic adoptions may be used	A systematic[9] approach to LUP advice will be used
Inputs should include a representative set of major accident scenarios	A credible and/or evaluated range of scenarios should be defined to provide information on the potential extent of consequences	Distances or zones are determined within which LUP controls should apply
Planning decisions should be broadly similar	In similar situations for similar hazard or risk conditions the planning decisions reached should be broadly similar	Avoidance of undesirable development and promotion of activity which meets socio-economic requirements
Proportionality (also: reasonableness)		
Criteria exist for desirable limits or boundaries of the level of harm and risk control requirements	Support decision making on land use development by providing comparative measures, analysing them and justifying	Subjectivity in decision making is reduced
Development types are characterised	Types of land use in the vicinity of MA establishments and their population to be established	Optimisation of land use.
Judgment frameworks are described	A set of benchmarks is provided within which decision makers can exercise their discretion	Land Use Planning is determined having regard to public safety as well as socio-economic considerations
Transparency		
An understandable, clear and well-described system exists	A coherent explanation of the LUP system is possible/assured for all interested people/persons	The LUP system is practicable in all parts of the MS
Responsibilities for key actors are described	All key actors know their role and the limits within which they exercise their responsibilities	Everybody within the system knows what to do and the limits of his or her discretion
Mechanisms for independent control exist	Land use decisions must be coherent with regional and national policies	Potential undesirable land use decisions are subject to review and may be prevented
Decisions can be understood at the time they are made and later.	Decision factors are laid down and the decision-making process can be retraced and decisions are recorded	Decision flow is made transparent and can be reproduced

[9] "systematic" means in general that the limiting conditions of an analysis, a survey etc. are identical and pre-defined for all steps or all single parts of the process

4. 3. 2. Supporting Principles of Article 12 - Obligations

With respect to the specific requirements of Article 12, the supporting principles below are defined as complementary clarifications of the legal text:

Supporting Principle	Explanation	Outcomes & Comments
LUP process has a role in the prevention and mitigation[10] of major accident hazards over time.	Can be up to 30 years to achieve its impact (50 years in cases of large scale strategic planning)	Not always immediate effect of LUP for the consequences of a major accident (MA)
Risks to public should not increase significantly and over time be maintained or reduced where necessary	MS need to develop approaches to define what is "significant" (baseline)	Risk communication may be necessary
The residual risks arising from a Major Hazard (MH) establishment to individuals and to society should not exceed a maximum desirable level.	- Residual risk is the risk that remains after having relevant safety measures in place. - MS need to establish approaches to define desirable levels	There must be LUP-related policies that mitigate the risk. . These LUP policies should be such that can be implemented and able to reduce off-site risk at all times
Manage population/community development over long term	Long term strategic planning of the use of land in the vicinity of a MH establishment	- Authorities must define the area around Seveso establishments where safety issues have to be considered; - balance land use to control public risk where necessary
Equity balance should be achieved between major hazard establishment operators and community	Operators and community should share the constraints, benefits, opportunities, etc.	Possible need for further proportionate measures on-site or off-site (includes design and lay-out of the planned development)
Mitigation can be achieved through LUP in combination with emergency planning	LUP should have a stronger influence in mitigation near to the establishment compared to emergency plans (e.g. in case of risks from explosions)	- Necessary cooperation of LUP and emergency planning and mutual consideration - Possibly different scenarios for LUP and emergency planning.
Public safety and socio-economic considerations are both significant factors, the balance of which may change with distance	- Risks do not have a zero value but usually diminish with distance - Some development should be allowed near to MA establishments provided the risks are at a desirably low level.	- Proper proportionality will be achieved - Different patterns of land use are possible

[10] The terms "prevention" and "mitigation" in the context of Article 12 Seveso II may be understood partly as synonyms. "Prevention" – without any broadly accepted definition - refers to any action taken reduce a potential risk or hazard, "mitigation" is defined by ISO/IEC 73 as the "limitation of any negative consequence of a particular event". Whereas the distinction is more evident for measures, LUP may serve in both roles: a "major accident" has this qualification because of the potential consequences (number of victims etc.), so LUP can avoid an accident to become a "major" one because it reduces the potential extent pro-actively or – when the accident has already happened – it limits the consequences; here LUP acts only in mitigation.

Supporting Principle (cont.)	Explanation	Outcomes
LUP considerations that prevent or mitigate the con-sequences of MA should be given more weight in choosing the location of a new MH establishment.	"New" means "greenfield" or new[11] because of change of operation to bring into the Seveso II Directive. New MH installations should be considered undesirable where there already exist developments which would be considered incompatible if the MH establishment were constructed.	MS authorities should seek to achieve appropriate distances from those areas listed in Article 12 (= seek not to replace them by additional technical measures)

4. 3. 3. Timeframe

To manage, regulate and coordinate the use of land, LUP policies must consider various economic factors, like:

- regional disparities,
- excessive costs for infrastructure,
- waste of resources,
- need for growth or
- need of economy for long term sound and predictable conditions

Because of this the protection of the consequences of major accidents provided by LUP in most cases will not come into effect immediately or on short term but within a typically longer LUP timeframe.
There are no clear definitions for the figures that describe "long-term" or "short-term", but there are Europe-wide coherent examples which can be summarized in the indicative table below:

Short term planning	< 1 year
Medium term planning	1 – 5 years
Long term planning	5 – 10 years
Long term strategic planning	Up to 30 years (up to 50 years for large scale cases)

From this overview it may be concluded that it depends on the actual type of development which figure applies for the timeframe of the application of Article 12 but typically *"…in the long term…"* means a time horizon of not less than 5 – 10 years.

[11] Existing sites are also establishments that use dangerous substances brought into the scope of the Directive later by either a change of classification of the substances they use or an amendment to the Directive. An existing site remains an existing site following a change of name or ownership – see also chapter 5.

5. Existing Situations

"Existing" in the context of Seveso II means

- Establishments that had a legal right for operation prior to February 3rd 1999 (when the Seveso II Directive came into force[12]), or
- establishments that did not exceed substance thresholds of Seveso II at that date and fell into the scope later because of subsequent threshold amendments or changes of substance classification. Article 12 of the Seveso II Directive applies only if any change of a given situation takes place, either a new siting, a modification (Art 10) of an existing establishment or a new development around an existing establishment. If none of those factors is applicable, Article 12 does not require any retrospective action. Nevertheless appropriate monitoring should take place around existing establishments in order to manage future developments or modifications.

In the table below supporting principles for existing situations of Seveso II sites are listed:

Supporting Principle	Explanations	Outcomes & Comments
Information on the location of the site	The LUP-deciding authority has to know the location of the Seveso II establishments and the details of the risk/hazard potential	Provides basis for risk assessment
Identification of the land use around the site	The LUP-deciding authority has to identify the land use patterns of concern and rank them according to risk levels	Provides basis for risk/consequence assessment
Pro-active provision of distances or zones	Calculate/assess the area which requires Land Use Planning	Facilitates consideration when new developments are planned/proposed
Socio-economic aspect consideration	The LUP policy should consider the socio-economic consequences for the limitation of future developments, the viability of industry and the community	Potential need for specific processes
Definition of compatibility indices	The LUP policy has to take account of and evaluate existing situations of concern indices	Need for continuously updated information (population density etc.)
3 way approach to deal with existing situations: - prevention and mitigation on -site - LUP - off-site (emergency planning)	Optimization of level of safety + (qualitative) cost-benefit considerations	Combination of approaches may vary over time, balance of measures may have regard to existing permitted operator rights
Give consideration to the technical standard when the plant was set up[13]	New plants must follow more rigorous standards	For existing plants off-site measures may have more relevance

It becomes evident from the above supporting principles that issues of land-use planning in the vicinity of existing Seveso plants should be addressed within the Strategic planning and/or SEA of the community/region.

---

[12] The Seveso I – provisions and the legal right of operation that derives from this Directive are of no relevance in this respect, because Seveso I did not have a LUP requirement

[13] However, in certain legal obligations a continuous adaptation according to latest standards is required, e.g. in the IPPC Directive

6. Additional Technical Measures – Principles

6. 1. Definition

The following definition of additional technical measures in the context of Article 12 of Seveso II is given hereby:

"Additional technical measures (ATM)" in the context of Article 12 of the Seveso II – Directive are measures that reduce the likelihood and/or mitigate the consequences of a major accident as effective as the establishing of a distance to the relevant vulnerable recipient. This involves consideration of whether there are measures at or outside the establishment in addition to those already in place.

6. 2. Supporting Principles

The supporting principles for the selection of ATM are listed below:

Supporting Principle	Explanations	Outcomes & Comments
ATM must provide a solid and over-time effective basis for LUP-related decisions	ATMs must have an auditable basis that can be measured and verified over a time period consistent with LUP methods	ATMS shall provide means of reducing risk in a verifiable manner
ATM must be proportionate to the aspired level of risk	A significant and relevant increase of risk justifies ATM	"Over –designing" of ATM is avoided
ATM must be enforceable	Certain types of measures e.g. such that rely entirely on a behavioural basis are not enforceable	ATM must be demonstrated
The design of ATM must allow assessment of their effectiveness	Conclusions on the assessment must be reached within a reasonable time	The effectiveness of many ATMs may be evident, e.g. firewalls
Preconditions for the assessment of the effectiveness and reliability of ATM are good basic standards and efficient inspection systems	ATM are not intended to address substandard levels of risk control. Therefore before considering any ATM relevant standards must be achieved	Member State authorities must have a clear perception on what is the basic standard
Necessity and appropriateness of ATM shall be decided by national approaches	Need for a scaling of ATM, see also the supporting principles in chapter 4.1	National criteria like individual/societal risk level or severity of consequences are required
ATM may be on-site and/or off-site decision	Link with the overall principle that states a sharing of advantages and constraints	The most cost-effective risk-reduction is achieved
There are boundaries for the role of ATM on-site[14]	Some MH establishments may have already the best standard of technology and operation and the risk is still not at a desirable level	In such cases only measures off-site (technical [15] or land use management) are possible

[14] However, certain evident measures like the reduction of the quantities present may always be taken
[15] "Technical" with the meaning of design of constructions or physical barriers outside the establishment

PART B - TECHNICAL ASPECTS

The purpose of this part is to provide information on technical aspects with regard to the Guidance topic. There is a range of hazard and risk assessment (RA) techniques which may be used in isolation or combination to achieve broadly consistent outcomes. These techniques can produce the best possible results possible given the state of technical knowledge and can indicate the scale of uncertainty that exists.
Further, more detailed information may be taken from the LUP database[16].

7. Technical advice related to major accident potential: Hazard and Risk Assessment Methodologies and Criteria

The target of this guidance is to enhance consistency of RA in LUP in the Member States. Together with the database it shall enable benchmarking of RA results for LUP by MS. This consistency of outcomes may be achieved by various approaches and methods.

As described in Part A, the way by which risk concerns are expressed and hazard/risk situation is assessed, constitutes probably one of the most important elements of the Member States' LUP policies. In fact, the existence of a risk or hazard assessment method is the basic requirement for fulfilling the *Consistency principle* (paragraph 4.3.1), while the establishment of criteria for hazard, risk or "the boundaries of the level of harm and risk control requirements" are the basic requirements for the *principle of proportionality.*

Typically, Land-Use Planning is based on the principle that incompatible uses of land should be separated by adequate distances. It then requires the establishment and application of constraints defining which uses of land are allowed at the various zones around the plant. Obviously, these zones depend on the risk profile and the relevant constraints should be proportional to the level of risk. This is the reason why hazard/risk assessment methods and criteria are so important for risk-informed LUP. Moreover, assessment methods and criteria should be compatible with the overall risk management culture and philosophy of each Member State or region. Evidently, more than one method is in use, depending not only on historical and cultural reasons, but also on the conditions of the particular case. In the following, selected categories of hazard/risk assessment methods are presented together with the relevant criteria, with the aim to assist the Member States in selecting an adequate and consistent system.

In addition to traditional "constraint-based" LUP, more "dynamic" approaches may also be adopted. These approaches aim at medium- or long-term improvement of the risk situation, by incorporating risk considerations in the spatial planning process. Such "target-oriented" approaches may also successfully address the "legacy of the past", existing situations of concern that cannot be resolved with short-term constraints. The application of these LUP policies also requires the existence of clearly established hazard/risk assessment methods and criteria (for example, in order to assess the success of selected measures).

7.1. Uncertainty Constraints

Risk assessment in LUP takes place under the influence of uncertainty. Ideally all relevant data of effects of spatial developments should be available; practically this will never be feasible. To tackle this factor the estimate must be simplified. Therefore, when data is not available or of a quality which cannot be verified, expert judgment and/or scenarios that generalize the underlying situation can be

---

[16] Refer to annex ... and…(not yet present in the document).

used. Consequently, the decision-making process in LUP usually does not take into account uncertainties within a range or variation of results and is normally based on a single number or a qualitative classification of the risk acceptability which prompts the cautious best estimate of the risk level (the "conservative but not pessimistic approach")[17].
The risk level reliability should be secured as much as possible by the use of validated methods; the most important existing ones are described in the following chapter.

7.2. Overview of Existing Methodologies

Risk assessment methods were developed for a wide range of applications. The existing RA methods for LUP may be considered as a specific subdivision of those RA methods in use for risk analysis in the context of the safety of industrial establishments; some examples show a more distinct difference, in other cases an integrated approach can be found that links RA for the safety of the establishment directly with the RA for LUP purposes.
RA methods in principle may consist of the following four elements, in various combinations:

Qualitative	**Quantitative**	**Deterministic**	**Probabilistic**
Non - Numerical Assessment	Numerical Assessment	Safety defined as a discrete value	Safety defined as a distribution function

Regarding the way the likelihood of the accident scenarios is taken into account, two main categories of approaches can be distinguished: the first focuses on the assessment of consequences of a number of conceivable event scenarios and can be typically called "consequence based" approach, and the second on the assessment of both consequences and probabilities of occurrence of the possible event scenarios and can be called "risk based" approach. For a given installation, a "consequence based" approach will characteristically show the consequence area for lethal effects and serious injuries resulting from the scenarios assessed, while a "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.
Besides the two main categories also other methods are in use which are in principle combinations of the two main ones or are derived from them.

In the following sections these most common methods currently used for RA in LUP are described. .

7.2.1 The "consequence-based" Methods

The "consequence based" approach is based on the assessment of consequences of credible (or conceivable) accidents, without explicitly quantifying the likelihood of these accidents. This way the approach circumvents having to quantify the frequencies of occurrence of the potential accidents and the related uncertainties.
A basic concept is the existence of one or more "worst credible scenario(s)", which are defined using expert judgment, historical data and qualitative information obtained from hazard identification. The underlying philosophy is based on the idea that if measures exist sufficient to protect the population from the worst accident, sufficient protection will also be given for any less serious incident. Therefore, this method evaluates only the extent of the accidents' consequences, and not their likelihood, which is taken into account only implicitly: Extremely unlikely scenarios may not be considered as "credible" or "conceivable" and may be excluded from further analysis.

[17] Additionally, the available data mostly do not take into account certain Domino-effects or natural hazard causes (they are derived from plant-own events but do not consider natural causes that are more likely e.g. earthquakes)

The pre-selected "reference scenarios" can be chosen in various ways, either by a numerical or non-numerical consideration of the likelihood of occurrence or by simple expert judgement. Then, the more conceivable of these reference scenarios (by consideration of specific limiting conditions, such as barriers or initiating events) are identified and taken into account for LUP purposes. Other, more serious scenarios may not be considered for land use planning purposes, but perhaps may be considered for emergency planning.
In this approach the efficiency of measures (or barriers) is estimated qualitatively, also judging on the character of representing an "independent layer of protection". The qualification "State-of-the-Art" for these measures, defined by norms, standards, national legislation, testing etc. is usually taken as sufficient proof in this respect.
The consequences of the accidents mostly are taken into consideration by calculating the distance in which the physical and/or human health - relevant magnitude describing the effects (e.g. toxic concentration) reaches, for a given exposure period, a threshold value corresponding to the beginning of the undesired effect (e.g. irreversible health effect/harm or fatality). The weather conditions for modelling the consequences may represent again the "worst conceivable case" or a "neutral" average one. Zones are thus defined for which LUP restrictions are applied.

This approach corresponds to the deterministic principle where safety and thus undesirable consequences are defined by a discrete value. The situation which is subject to planning restrictions is uniform (in terms of likelihood and severity) for the whole area within the calculated distance.

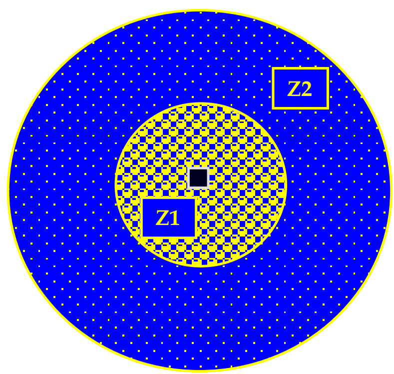

Figure 4. The land-use restriction zones according to the consequence-based approach. The zones correspond to pre-defined health effect thresholds

7.2.2 The "risk-based" Methods

The second main category of approaches used in Land Use Planning is the "risk based" approach *(also known as the "probabilistic" approach*). The purpose is to evaluate the severity of the potential accidents, and to estimate the likelihood of their occurring. For estimating the likelihood of scenarios various methods are in use, ranging from simple selection of scenarios and frequencies from the relevant databases to the application of sophisticated tools.

In general, the "risk based" approaches define the risk as a combination of the consequences derived from the range of possible accidents, and the likelihood of these accidents. The degree of quantification may vary.

Typically a risk-based approach consists of five phases:

• Identification of hazards (usually a deterministic step including the selection of realistic scenarios);
• Estimation of the probability of occurrence of the potential accidents;
• Estimation of the extent of consequences of the accidents and their probability;

• Integration into overall risk indices that may include both individual and societal risk;
• Comparison of the calculated risk with acceptance criteria.

Two measures of risk can in principle be calculated: (i) the *individual risk*, defined as the probability of the reference damage (e.g. fatality, or "receiving a dangerous dose or worse") due to an accident in the installation for an individual located at a specific point near the installation, and (ii) the *societal risk*, defined for different groups of people, which is the probability of occurrence of any single accident resulting at reference damage (e.g. 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. Another risk concept, *area risk*, is not actually a different measure of risk, but rather a combination of the risk imposed by several sources, and it is therefore expressed by individual and societal risk measures. Area risk is a very meaningful and useful concept, especially when a number of plants or hazardous activities affecting the same area are considered

For the calculation of individual and societal risk not only the evaluation of the consequences (which is performed by applying similar models and tools as in the "consequence-based" approach) is necessary, but also the assessment of the probability under which the accidents are likely to occur. The likelihood of factors completely defining the scenario, such as weather conditions, wind direction, etc., is also taken into account in the calculation of risk. The individual risk criterion is applied for the protection of each individual against hazards involving the dangerous chemicals and it does not depend on the population around the plant, or on the number of victims of the potential accidents. It expresses a pre-set level of risk, above which no individual is permitted to be exposed. The societal risk criterion concerns the protection of the society against the occurrence of "large scale" accidents. For its calculation, not only the population density around the installation is taken into account, but also the population's temporal variation along the day, as well as the possibilities for emergency measures (distinction between indoors and outdoors). Usually the application of societal risk criterion is supplementary to the use of individual risk criterion. The underlying philosophy beyond its application is the fact that even when the individual risk criterion is met, if a population centre is located close to a "safety distance" it is possible that a major accident causes a large number of victims. With this criterion the *society's aversion against increased number of fatalities* is expressed.

The general idea of establishing country-wide individual and societal risk criteria is given below. Usually there are three regions; an acceptable (or "tolerable", or "desirable") risk region, a non-acceptable risk one, and a region where the risk can be considered as affordable, however its reduction is strongly desired (according to the national policy for the status of the "acceptability" criteria, such as the ALARA principle – As Low As Reasonably Achievable, or the ALARP principle – As Low As Reasonably Practicable).

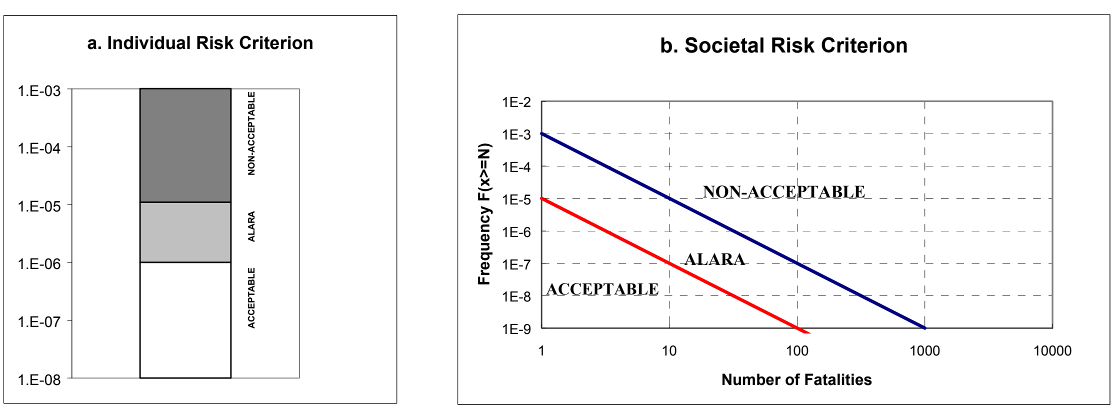

Figure 5. Theoretical examples of Criteria for (a) Individual and (b) Societal Risk

7. 2. 3. "State-of-the-Art" – Approach: Deterministic approach with implicit judgment of risk.

The State-of-the-Art – Approach is not a RA method for LUP in the strict sense. The underlying philosophy is also based on the idea that sufficient measures must exist to protect the population from an accident considered to be the "worst conceivable". For that purpose it is assumed that the consideration of the consequences of the worst conceivable accident (including a "precautionary element") has been carried out during the identification of a specific State-of-the-Art.

The approach is based on the target to operate without imposing any "conceivable" risk to the population outside the fence of the installation ("zero-risk principle"). To comply with this target State-of-the-art technology is applied and additional safety measures are taken on the source in order to restrict the consequences of potential accidents within the fence. Risk is taken implicitly into account in the definition of the "state-of-the-art". However, it is recognised that this is not possible in all cases and therefore additional mitigation is appropriate through LUP zones derived from the consequences of representative scenarios. Therefore, the method is complemented with the consideration and assessment of consequences of typical scenarios and the definition of zones where development restrictions are applied.

7.2.4. Hybrid Methods

- **Semi-Quantitative Methods:**

The semi-quantitative methods can be regarded as a specific subcategory of the risk-based or the consequence-based methods. Here explicitly a quantitative element (e. g. likelihood analysis) is accompanied by a qualitative one (e. g. the consequence assessment).

In general, the level of risk imposed by the operation of a Seveso plant in the vicinity of residential and other sensitive areas depends on:

- the relevant scenarios,
- their frequency,
- the kinetics of each scenario (how fast do the dangerous phenomena deploy and how easy it is for the emergency teams to intervene),
- the intensity of the dangerous phenomena,
- the vulnerability of the area, and
- the population affected.

Each of the above parameters can be assessed either quantitatively (i.e. assessing the exact value together or not with the relevant uncertainty measure), semi-quantitatively (i.e. assessing the range of the parameter instead of giving the exact value), or qualitatively (i.e. giving a description of the magnitude of the parameter). Typically, in semi-quantitative methods some of the parameters of risk are assessed in a quantitative way, while others are assessed qualitatively. Acceptability is then assessed by analysing the level of each element and applying certain combination rules. For example, if the frequency of a scenario is high and the intensity of the dangerous phenomena exceeds defined thresholds (e.g. $LC_{10\%}$), then restrictions in the land-uses may apply in order to keep the number of affected people low. Moreover, restrictions may apply in order to keep the vulnerability of the area low (and therefore advise against uses such as schools or hospitals).

- **Tables of generic safety distances:**

Tables of fixed distances may be considered as a simplified form of the consequence-based method, most common as a rough consequence estimate based on selected scenarios, or in their most simple form they may have been derived from expert judgment, including consideration of historical data or the experience from operating similar plants and are developed on a rather conservative basis.
Tables of appropriate distances are often used because of the limited relevance of the case. The distance extent depends mainly on the type of industrial activity or on the quantity and type of the hazardous substances present; design characteristics, safety measures and particular features of the establishment under question are not explicitly taken into account.

“Look-up” tables of generic distances can be very useful for standardised installations, used especially for screening purposes. However, their conservative nature should always be taken into consideration and wherever practicable a detailed analysis should be preferred.

8. Database of LUP Scenarios and risk assessment data: Purpose, content and structure

Paragraph 1a of Article 12 reads as follows:

> *The Commission is invited by 31 December 2006, in close cooperation with the Member States, to draw up guidelines defining a technical database including risk data and risk scenarios, to be used for assessing the compatibility between the establishments covered by this Directive and the areas described in paragraph 1. The definition of this database shall as far as possible take account of the evaluations made by the competent authorities, the information obtained from operators and all other relevant information such as the socioeconomic benefits of development and the mitigating effects of emergency plans.*

It is clear from the above text of Directive 2003/105/EC that the overall objective of the database is not the EU–wide harmonization of the calculation of “appropriate distances” but the promotion of a systematic selection of reference scenarios and assistance for important steps of the selection process. In that respect the database is not a Computational Tool or a model to perform evaluations or even a black-box that “decides” Uses of Land / Acceptability of plans.

Therefore, the database of LUP Scenarios and risk assessment data is a source of consistent data to be used in the Risk Assessments and Hazard Assessments supporting LUP decisions.

An important question needing to be addressed in the development of the database is the following: “Given the variability of risk/hazard assessment methods applicable in the Member States, what should be the content of the database in order for it to provide substantial aid and be a reference point of useful scientific information *independent* of the risk/hazard assessment method?” In other words, is it possible for the database to contain and provide data useful to all methods? In fact, it should be noted that common elements are present in all RA methods and these elements should be included in the database. As most important common best practice elements of risk assessment in LUP the following may be listed:

- Scenarios: they are used either directly in different numbers, pre-selected (“reference”) or implicitly e. g. for generic distance tables ► <u>scenario selection</u>
- Event Frequencies: the event frequency is either a factor directly necessary for the assessment method or it appears implicitly in other form, e. g. as limiting condition for the scenario definition ► <u>likelihood data</u>
- Endpoint Values: they are applied either for individual consequence calculations or are considered implicitly in a generic form ► <u>underlying basics for risk/consequence evaluation</u>

- Technical Measures: they influence the event frequency consideration (the acknowledged level of confidence may vary) or are proposed as "additional measures" to reduce the likelihood of an undesired event or limit the consequences (with different ways to impose them) ► influence of measures/barriers on scenario likelihood.

The database assisting this guidance document must therefore include:

- clear reference to the scope of annex I of the Seveso II Directive (substance, substance categories)
- a systematic framework for the description of relevant units
- a tool for the systematic choice of reference scenarios
- data on the quantitative frequency or qualitative likelihood of relevant data ("loss of containment" + propagating factors e.g. ignition; initiating event categories)
- typical technical conditions with influence on the accident likelihood
- proposals for additional technical measures and their effect on the scenario likelihood
- if possible, indications on costs
- lists of typical mitigation measures
- recommendations for endpoint values for the effect calculation

The following Figure provides a schematic representation of the procedure for using the Database. The user enters the database by selecting the *substance* of interest and the type of installation (e.g. atmospheric storage tank, pressurised vessel, pipeline, etc.). He/she then gets a list of "generic" *scenarios* which are in principle applicable in this type of installation and dangerous substance, which they should evaluate according to the selected method and criteria (deterministic or probabilistic, qualitative or quantitative). If there is *incompatibility* between the land uses and the risks from particular scenarios, then the user needs to refer to the *causes* of those scenarios that give raise to incompatibility issues. The potential causes (or initiating events) of the scenarios are also included in the Database, together with information for their quantitative or qualitative evaluation, i.e. their *frequency* and the *conditions* under which these causes can initiate an accident in the particular establishment. Following this evaluation, the user can decide upon which *additional technical measures* should be applied in the establishment in order to prevent/mitigate the "remaining" accident scenarios (i.e. the ones which are still possible and likely for the particular establishment, and whose risks are incompatible with the uses of land in the surrounding area). In this selection the user is assisted by the Database, which contains structured information about possible technical measures for the particular installation, together with indications about their costs and efficiency. Finally, the revised list of scenarios needs to be evaluated with regards to the compatibility of the relevant risks (after application of the technical measures) with the uses of land in the vicinity of the establishment.

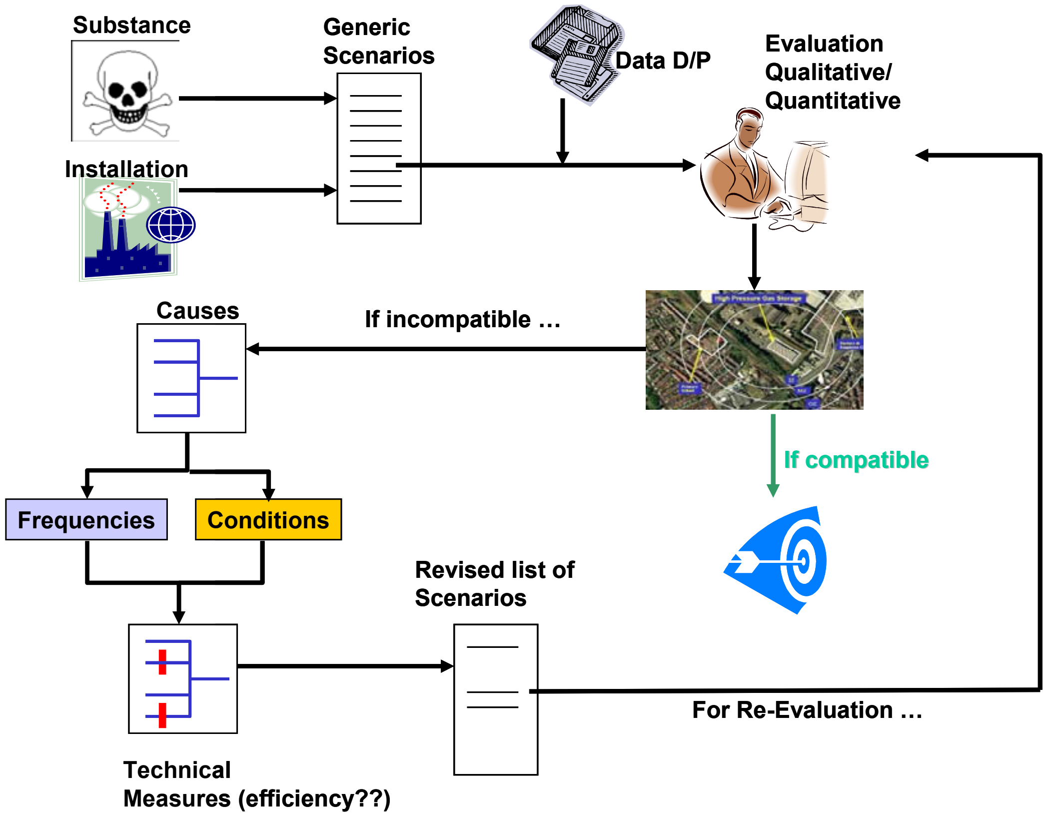

Figure 6. Schematic representation of the structure of the LUP Scenarios Database

The procedure therefore consists of the following steps:

Step 1: Select a Substance[18]

Step 2: Select the Type of installation

Step 3: Get List of scenarios from the Database

Step 4: For each scenario, evaluate the LUP case, according to the selected assessment method and the selected criteria (note: decided by the Seveso and planning authorities of the MS – not included in the database)

Step 5: If the risks associated with the particular scenario are incompatible with the land-uses, refer to the causes of that scenario.

Step 6: Evaluate each cause, with regards to its frequency or conditions, according to the accepted methods and criteria of the MS.

Step 7: If the cause is likely or the conditions make it possible for the particular installation, consider applying additional technical measures. Get a list of relevant technical measures from the database, together with indications on their efficiency and cost.

Step 8: Re-evaluate the scenario taking into consideration the additional technical measures. Repeat from Step 4.

[18] This step implicitly assumes the initial selection of a relevant establishment unit

In addition to the above data (scenarios, causes, frequencies, conditions and technical measures), the database should contain information on *models* (e.g. type of models applicable in particular situations, range of parameters, etc.) and *human health endpoints*. Especially concerning endpoints, distinction should be made between human health endpoints (viewed as thresholds for human health effects) and decision endpoints (viewed as decision or action thresholds). Suggesting decision endpoints is outside the scope of the database and the present guidance.

In the following, the contents of the database – in particular, scenarios, frequencies, models and endpoints – are analysed.

9. Scenarios

Scenario methods describe a hypothetical future situation (= an assumption, what – if - relationship) under certain limiting conditions and compare this with a desired situation (the "planned" or "good" outcome).
As shown in chapter 8, a common element for risk assessment in LUP is the use of scenarios (in the following text named "reference scenarios") to define an area of concern and to compare the consequences with a situation with desirably low risk. This chapter outlines the framework of this guidance on best practice how to select proper reference scenarios in the context of Article 12 of the Seveso II Directive

9.1. Scenario Definition

As concerns LUP in the context of Seveso II, scenarios describe the conditions that might lead to a major accident and the potential consequences. In more operational terms a major accident scenario describes usually the loss of containment (LOC) of a hazardous substance (or the change of state of a solid substance) and the conditions that lead to the realization of an undesirable consequence (fire, explosion, toxic cloud = the dangerous phenomenon). This can be shown in the so-called bow-tie diagram:

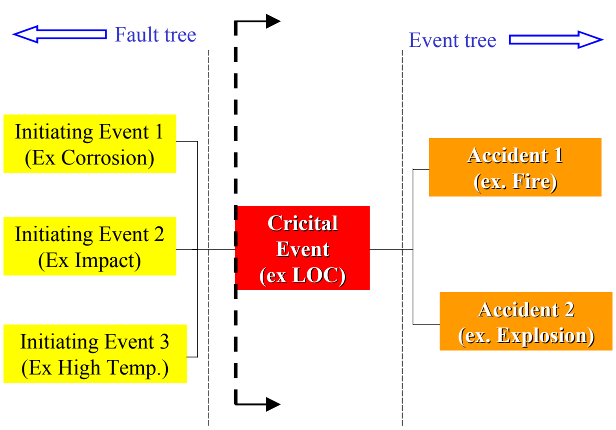

Figure 7. Definition of scenarios and representation as a bow-tie

To achieve a robust decision, the scenario must be well defined. Additionally all relevant scenarios need to be addressed. Taking into consideration the practice of the Member States, the following definition for a reference scenario to be used for risk assessment in Land Use Planning may be given:

REFERENCE SCENARIO = (CRITICAL EVENT (loc) + DANGEROUS PHENOMENON)

(= right side of the bow-tie; simplified part of the event tree)

Typical reference scenarios:

- catastrophic vessel failure & BLEVE
- hole in vessel wall & poolfire
- pipe leak & toxic release etc.

For further assessment steps the chosen accident scenarios then may be linked to different categories of initiating events in form of a standard set of assumptions:

Examples: External impact leads to hole in vessel wall, vessel empties in pool, and substance ignites (= external impact is the initiating event) or
Corrosion leads to small pipe leak (10% section) and toxic release during 10 minutes (initiating event is corrosion)

9.2 Selection Principles for Scenarios

Selection Principle 1
Reference scenarios to be used for risk assessment in Land Use Planning may be selected by the frequency of their occurrence and the severity of their consequences.

Besides the question of the degree of occurrence frequency and severity (which lies in the decision of each individual LUP authority) the selection should be based on these two key factors.

Selection Principle 2

"Worst Case" scenarios are not necessarily the basis for LUP, but may rather be considered for a matter of Emergency Planning, further to the requirement to implement Best Practice or Standards to reduce Worst Case events to a "negligible" frequency.

There is good consensus for not necessarily selecting **worst-case scenarios** in risk assessment, for Land-Use Planning purposes, even though they must be examined under the requirements of Seveso II in general, in particular for the preparation of external emergency plans.
The selected set of scenarios, so-called "reference accident scenarios" should therefore be composed of scenarios chosen according to a given (pre – defined) level of likelihood to occur; the on-site risk analysis carried out may be used as a source of information. MS should develop criteria under which conditions "worst case" - scenarios are not the basis for LUP.

Selection Principle 3

The time scale of the consequences of a specific scenario to come into effect shall be considered for the selection.

The selection of accident scenarios either for LUP or for emergency planning is mainly based on the appropriateness between the estimated delay for a realistic rescue / emergency response and the time scale for an accident scenario to develop fully.
This means that all scenarios dealing with (mechanical or chemical) explosion should be considered as a priority for Land-use planning, due to the lack of time to take proper emergency action off-site.

Time scale of consequence development for fires (in particular solid fires) is worth examining thoroughly since it allows most of the time to consider generalised fire scenarios for emergency planning provided that alarm / evacuation / sheltering of offsite population is correctly set up.

Example: a Boilover phenomenon requires up to several hours to develop over an atmospheric tank fire. It could be considered as a typical scenario for setting emergency plans.

However, time scale of consequence development for toxic airborne dispersion (speed of toxic cloud & target exposure time) can hardly be considered from a generic point of view and should be examined for each case.

<u>*Selection Principle 4*</u> *According to the chosen level of likelihood for the occurrence of a reference scenario the effectiveness of barriers may be taken into account for the selection.*

An overall typology of safety barriers could distinguish between barriers being (functioning) permanent, independent of the state of the process (all passive barriers are permanent), and those being activated by the state of the process. The latter barriers can either interrupt a sequence of events (e.g. interlock systems, emergency shut down trips) or initiate one or more actions (e.g. opening of a relief valve or a process quench).

Activated barriers always require a sequence of detection – diagnosis – action. Using hardware, software and human action as building blocks alone or in combination can perform this sequence.

Behavioural barriers refer to required human action; passive behavioural barriers in this respect necessitate staying away from a given area, active behavioural barriers consist of acting in certain defined ways.

There is no common approach in the MS approaches concerning which type of barriers are taken into account for the selection of scenarios; a majority of MS take into account passive barriers for the definition of scenarios. Some MS also take account of active hardware or mixed barriers, when demonstration is made through the safety report (for upper-tier establishments) of good feedback on effectiveness and reliability. This may relate to the legal framework of the individual MS which barriers are already mandatory or to the established approach.

<u>*Selection Principle 5*</u> *Land-use planning is both a prevention and mitigation measure offsite, which requires as a minimum that relevant good practice as published in standards has been implemented onsite.*

According to the safety principle of defence in-depth, LUP constitutes with emergency planning additional lines of defence that consist of protecting targets (human, environment…) from the major effects, either by delimiting buffer zones around the hazardous sites (LUP) or by implementing effective evacuation / sheltering measures. Thus an incident may not develop to a major accident because of the lack of vulnerable recipients or the consequences of a major accident may be limited. As a common principle it should be assumed <u>that a certain standard of technology</u> is in place.

10. Critical Event Frequencies

For the use in risk/hazard assessment in LUP, critical event frequencies are by definition of the reference scenario as given in chapter 10.1 occurrence frequencies of these scenarios. According to the principles listed in chapter 10.2, these values may be taken as criteria for the selection of reference scenarios.
Frequencies of critical events (= reference scenarios) can be obtained

- from literature in the form of generic values or
- on the basis of frequencies of causes in a fault tree analysis or

- from the establishment operator's validated records.

Notwithstanding the fact that specific data gained for the individual case are the more favourable options of those listed above, generic data are widely used in order to avoid extensive investigation and with regard to the feasible accuracy of the result. Therefore the matter of generic frequencies is explained in more detail in the following two subchapters.

10.1. Available Data Sources for Generic Frequencies

a) The Dutch Purple Book (1999)[19]
Data values given in this report are set by consensus following discussions between representatives from the industry, the competent authorities and the government. The frequencies are often based on the rare (old) data available at that time, and this in combination with expert judgment. It concerns default values, which means that an approximation is made for any specific plant.

b) FRED (Failure Rate and Event Database) from the HSE (1999)[20]
Similar situation as stated for the Purple Book; some failure rates are given as an upper, median and lower value. The authors state that the failure data are a good starting point for the derivation of failure frequencies for other applications. In many cases, reference is made to expert judgment.

c) Study on failure frequencies performed by *R. Taylor* under the authority of the RIVM[21]
The key issue of this study is the definition of baseline failure frequencies (refined for the more susceptible equipment items) that include failure causes which can not be avoided, and can be expected in any type of equipment. These baseline frequencies are combined with modification factors, according to the standards of design, construction, operations, and maintenance and to the actual operating conditions. The study contains more recent and varied data, some of them on a confidential basis. However, additional work including validation of failure frequency values and development of reliable modification factors is necessary in order to make the findings of the study readily usable.

d) Data sources in other EU Member States
Besides the sources listed above, in most countries no common failure frequency databases are available. The AMINAL study[22] from Belgium is mainly based on the failure frequency data of the Dutch Purple Book.

In all current datasets the failure frequencies are independent of technical and organizational provisions. For example, for a vessel the failure frequency is fixed, irrespective of the quality of the safety management systems**,** the number of safety devices and their reliability, the corrosive, reactive and flammable properties of the compound and the design specifications of the vessel. In other words all the measures taken with a view to a better safety and integrity of the installation are not taken into account.

10.2. Evaluation of the Available Generic Data

---

[19] Committee for the Prevention Disasters (CPR), 1999, "*Guideline for Quantitative Risk Assessment-"Purple Book*" CPR18E, SDU, The Hague

[20] HSE, "*Failure rate and event data for use in risk assessment (FRED)"* , issue 1, Nov 99 (RAS/99/20) – HSE, "New failure rates for land use planning QRA Update" RAS/00/22 - HSE, "*Chapter 6K: Failure rate and event data for use within risk assessments"* 2/09/2003

[21] Taylor, J.R. *"Hazardous materials release and accident frequencies for process plants"*- draft version 2003.

[22] Handboek Kanscijfers voor het opstellen van een Veiligheidsrapport, 1/10/2004, AMINAL – Afdeling Algemeen Milieu- en Natuurbeleid

Combining the different data sources would require an agreement on definitions, vocabulary, and terminology in order to make a fair comparison and is complicated due to discrepancies in:

a) Scenario definitions: discrepancies for e.g. diameter of pipes, size of leaks, range of leak sizes

b) Specification level of the equipment: differences may concern e.g. pumps with additional provisions (centrifugal pump, reciprocating pump…,) or atmospheric tanks with division that conform the type of the roof or depending on the protection level displacement

c) Failure causes considered: The information in the data sets is often limited and does not give indication of the kind of failure causes that are included. In case it is known there is not enough specification or performance or testing data available in order to eliminate or add a particular failure cause.

d) There is no fine distinction of the boundary of the equipment, e.g. if flanges are included in pipeline failure data.

Furthermore also the frequencies for component failures given in the literature have a generic character; however the number and nature of the safety barriers included in these failures is not known. The frequencies are given for a "standard" safety level, though the exact definition of standard safety level is not specified.

As a consequence, the existing data must be used with proper precaution and it must be clear that they have only "order-of-magnitude character". At the same time it becomes necessary for the industrial safety community to undertake an effort to further evaluate the data and to develop modification factors.

11. Modelling and Endpoints

11.1. Modelling

The modelling of potential consequences is a complex task that must take into account many site-specific parameters such as ambient weather conditions or components of the establishment of concern that may have an influence on the calculation. Therefore this guidance will not go into detail in this respect, but will only address some basic elements.
Modelling of consequences of major accidents has three main input factors:

- the physical and hazard properties of the material considered
- the emissive properties
- the release characteristics and
- the weather conditions,

all being subject to many agreements based on convention
Emissive properties concern values for specific accident scenarios like thermal radiation or overpressure and depend on physical properties of the substances involved. The values are listed in the literature and sometimes measured values recorded or estimated in an actual accident event and published later. There is fairly good correlation for these values. For heat transmission the values are derived from test cases because the emissive load is influenced by fire conditions like smoke production. For overpressure the calculations are based on the thermodynamic and reactivity properties of the substances.
Typical release characteristics are:

- amount released
- release duration (dependent on actual properties, calculated in detail or generic)
- limiting conditions, for example friction factor
- in case of 2-phase outflow the distribution gas/vapour – liquid and the evaporation of the pool formed from the liquid outflow
- characteristics of the area where release takes place, etc.

The relevance of certain meteorological conditions is also subject to the method chosen. Some methods seek to include the weather factors as accurately as possible taking into account available likelihood data of wind speed, wind direction, Pasquill classes etc. Other methods are based on generic assumptions that relate to the conditions most likely to apply (calculation done for one or two wind speed values, prevailing wind direction and stable and neutral Pasquill classes).

The modelling methods vary according to the national approaches and the accuracy demanded by the individual case.

11.2. Endpoints

The so-called "endpoint values" of consequence assessment of major accidents are of particular importance for the process in general (as described in chapter 7). As previously described, the various approaches of the final decision of acceptability depend on these values. They may mark

- human vulnerability, e.g. fatal consequences
- major obstacles for emergency response or
- severity in terms of loss of material or equipment.

Two main concepts to define endpoint values may broadly be distinguished:

- the dose/probit concept and
- the concept of fixed thresholds

The dose/probit - concept considers the impact on the recipient over time and relates this impact to a probability of a certain damage (physiological or material). The concept of fixed thresholds sets limits due to an expected impact without any damage percentage. The border between these two concepts is not totally strict, depending on the type of impact (e.g. the thresholds for airborne substances always relate to a time of possible intake).

A set of endpoint values with regard to LUP should comprise the following types:

- Accidental release of airborne substances leading to dangerous concentrations
- Overpressure
- Thermal radiation (static)
- Thermal radiation (dynamic)

12. Additional Technical Measures - Technical Considerations

The actual choice of Additional technical Measures (ATM) relates – as already explained above – to various individual factors. One or more of the following generic options might be considered:

- The replacement of a dangerous substance by a less dangerous one
- The reduction of the quantity of dangerous substances to a minimum
- The avoidance or minimizing of the release of a dangerous substance
- The control of the release of a dangerous substance at source
- The prevention of the formation of an explosive atmosphere
- The removing of any release of a dangerous substance to a safe place
- The avoidance of ignition sources
- The avoidance of adverse conditions
- The segregation of incompatible dangerous substances
- The containment of a spill
- The confinement of the consequences of effects

According to the principles on scenario selection described in chapter 9, ATM may be placed either "upstream" of the reference scenario bow-tie and thus have a link to an initiating cause or "downstream" and act by creating a barrier between the critical (LOC) event and the dangerous phenomenon. ATM in the context of LUP may have one of the following functions:

- "to avoid": the reference scenario will not occur (example: burying of a vessel)
- "to prevent": the frequency of occurrence of the reference scenario is reduced (example: automated system to prevent overfilling)
- "to control": the extent of the dangerous phenomenon is reduced (example: gas detection avoids ignition)
- "to mitigate": the extent of the consequences is reduced (source term or effects are limited, e .g. by a firewall or similar)

PART C ENVIRONMENTAL ASPECTS

Within the EU environmental framework there are specific Directives addressing environmental issues where the impact of such large projects and programmes has to be assessed before their realization. These will be described below, as some methods in the context of these Directives could give additional information for Land Use Planning purposes in the context of Seveso II.
For these requirements various manuals and specific recommendations exist and may be of use for the procedures followed for Article 12 of Seveso II also.

13. Environmental Risk Assessment Methods

This chapter gives guidance on existing tools for the assessment of the effects on the environment of certain activities (including projects, plans and programmes) which may be relevant to the consideration of risk of environmental damage at the planning level.

13.1 Corresponding EU legislation

As this guidance should advise on good practice which could be applied, it is important to present the two main pieces of European legislation on Environmental Impact, the Directive on Strategic Environmental Assessment (SEA - Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment) and that on the Environmental Impact Assessment (Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment and its amendments). One of the criteria for triggering the application of the SEA Directive is whether a plan or a programme sets the framework for future development consent of projects listed in the annexes to the EIA Directive. As the EIA normally takes place at a later stage when options for significant changes are often limited, the SEA plugs this gap by requiring the environmental effects of a broad range of plans and programmes to be assessed at an earlier stage. This will normally enable them to be taken into account in the preparation or revision of land-use plans.

SEA: An environmental assessment is mandatory for one class of plans or programmes defined in the Directive (essentially those described above which set the framework for future development consent of projects listed in the EIA Directive).To decide whether other plans or programmes to which the Directive refers are likely to have significant environmental effects, Annex II of the SEA Directive identifies significance criteria relating to the characteristics of the plan or programme and of the effects and the area likely to be affected. In the list with characteristics of the effects and of the area likely to be affected, the SEA Directive mentions in particular
— the probability, duration, frequency and reversibility of the effects,
— the risks to human health or the environment (e.g. due to accidents), and
— the magnitude and spatial extent of the effects (geographical area and size of the population likely to be affected).
Annex I f of the SEA Directive describes 'receptors' of these effects that should be considered, i.e. *biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between these factors* (Annex I (f)*)*. The characteristics noted in the footnote to Annex I(f) should also be taken into account (i.e. whether the effects are *secondary, cumulative, synergistic, short, medium and long-term permanent and temporary, positive and negative).* The use of Annex I together with Annex II in this way enables cross-media effects to be considered in a multidisciplinary way.

EIA: The EIA Directive outlines which project categories shall be made subject to an EIA, which procedure shall be followed and the content of the assessment. Annex I and II of the EIA Directive describe the projects that are covered by the Directive and that cover several establishments that fall under the Seveso II Directive, mainly for the energy and chemical industry.

Apart from the EIA and SEA, several ideas and methodologies are under discussion and development on how to assess not only the general "continuous" impact, but especially the short-term accidental impact on environmental receptors. Due to the few number of major accidents occurred in Seveso-like sites with environmental effects, no scenarios or methodologies have been drawn up reverting to experience gained or lessons learned from these accidents. But to consider appropriately areas of natural concern, it is recommended to identify vulnerable receptors and to assess qualitatively the environmental impact on these receptors.

The issue of environmental vulnerability may concern a broad scope of issues and related acceptability criteria together with vulnerability indices that do not yet exist at the same level of acknowledgement as in the area of human health. Nevertheless the issue needs to be addressed in the LUP risk assessment procedure if it is carried out in the context of Article 12 of Seveso II. In this context, it will be always a challenge to distinguish if a possible impact on environmental targets/recipients should be restricted to consequences caused by dangerous substances defined by the annex of the Seveso Directive, or if other impacts that are not within the scope must be considered, too.

13.2 Specific tools and methodologies already used in various countries

There are models that can predict the size of the polluted area (e.g. in groundwater, surface water, etc.) given a certain pollution source. These are used in order to assess one particular scenario and usually the authorities analyse then what measures exist in order to protect from this scenario. In the following, methods applied in various Member States are presented.

A simplified hazard index, which has been developed by the Swedish FOI[23], is also used in *SPIRS (Seveso Plants Information Retrieval System).* This index takes into account the quantity and the properties of the substances:
- Amount
- Toxicity
- Consistency
- Solubility
- Volatility
- Biodegradation, and
- Bioaccumulation

An attempt to quantify all consequences to the environment[24], i.e. surface/ground water, soil, flora and fauna (e.g. how many casualties may occur to the livestock, etc.) and to define acceptability criteria showed that such a process is very difficult in application, especially due to lack of data.
A similar method is the H&V – Index[25] which is based on the parallel evaluation of danger of the released quantity of the substance of concern and the vulnerability of the environmental receptors.
Another method to address environmental consequences is the PROTEUS[26] method and tool, which systematically considers and analyses the transport routes to particularly vulnerable receptors. It works by considering: What are sources of accidental pollution? – what are the vulnerable receptors (ecological environment)? – what routes can the pollution follow to reach them? – what measures can be implemented to avoid this?.

As far as acceptability is concerned, the restoration time has been applied as a criterion for considering contamination of the environment as unacceptable: if environment cannot be restored within 2 years, then the contamination is considered as unacceptable. However, it should be defined to what

[23] FOI – Swedish Defence Research Institute
[24] Bundesamt für Umwelt, Wald und Landschaft, "Beurteilungskriterien zur Störfallverordnung StFV", Entwurf vom Juni 1995, Switzerland, 1995.
[25] Issued by the Czech Ministry of Environment in 2002
[26] PROTEUS method, the Netherlands

conditions shall the restoration aim (a site might be already heavily polluted at the time of the accident, so is the restoration meant to bring the environment to the initial conditions or to the conditions at the time of the accident). Also the means of this restoration may be defined (extremely costly measures may contribute to fast restoration of the environment).

A respective guideline has recently been developed[27] which describes a semi-quantitative rapid assessment methodology for environmental consequences of liquid hydrocarbon releases; it is based on two indices:

- **R**elease **T**endency **I**ndex which takes into account plant equipment characteristics, critical activities management (SMS) as well as substance toxicity, persistence and mobility in sub-soil environment and
- **P**ropagation **T**endency **I**ndex based on the rapid evaluation on ground water filtration velocity and the comparison between estimated time for the arrival of pollutants to the vulnerable environment (groundwater) and the emergency response ability.

Both indices are combined in a "criticality matrix" and define a safety distance to vulnerable receptors (grouped into categories).

Guidelines[28] have recently been developed for the assessment of environmental risk, based on indices. There is an index for the amount and the properties of the substance (based on the Swedish index), the transport route (how easy it is to reach the vulnerable receptor points), the likelihood of the scenario (how easy it is for the scenario to be realized, again in qualitative or semi-quantitative terms) and the existence of vulnerable points (ecosystems, environmentally sensitive areas). All these indices are then combined to provide an overall index, which expresses the environmental risk.

Other Guidelines[29] on dealing with environmental risk are based on hazards related to three components: source, pathway and receptor. The Guidance includes description of techniques for hazard identification, frequency and consequence assessment, as well as for risk management. Checklists are also proposed of aspects to be included in the Seveso safety reports.

Summarizing, it should be concluded that a uniform and comprehensive method for Environmental Risk Assessment is presently not available because of:

- advanced complexity of modelling and lack of agreement on basic assumptions;
- lack of data, with regards to response of environmental receptors to toxic loads;
- lack of understanding and difficulty of modelling of the reactions within the components of the ecosystem.

For that reason, emphasis is usually put on the prevention phase, control of the potential routes of pollution and response measures, rather than to the development of a quantitative risk assessment approach and introduction of risk-based criteria.

Nevertheless, systematic (qualitative, semi-quantitative or quantitative) approaches to assess the environmental risk may address the following issues, some of those may also be addressed performing an Environmental Impact Assessment :

- Are there any environmentally sensitive areas in the vicinity of the establishment?
- Are there any endangered species?
- Are there protected water resources/biospheres

[27] APAT-ARPA-CNVVF, "Rapporto conclusivo dei lavori svolti dal gruppo misto APAT/ARPA/CNVVF per l'individuazione di una metodologia speditiva per la valutazione del rischio per l'ambiente da incidenti rilevanti in depositi di idrocarburi liquidi", Rapporto 57 /2005, Italy, 2005.
[28] Spanish Civil Protection DG (Ministry of the Interior), Spain, 2004
[29] UK Department of Environment and the Regions, 1999

- How can the environment around the establishment be contaminated and the ecosystem be destroyed? What environmental compartments are in risk? What types of accident can cause this environmental damage (e.g. fire fighting water)?
- Which are the possible routes of contamination (e.g. water courses)?
- What measures are in place in order to protect the environment? Are they sufficient?
- If release and contamination occurs, what measures are in place in order to contain it? What emergency actions are foreseen and have they been included in the internal and external emergency plan (e.g. collection of fire fighting water)?
- What is the estimated recovery period (even qualitatively) with and without interventions?
- If the environmental risk is assessed in quantitative or semi-quantitative terms (even as an index), is the assessed risk "desirable"?

13.3 Endpoints

The so-called "endpoint values" of consequence assessment of major accidents are described in chapter 11.2. As concerns endpoints for environmental consequences, this area in principle has to be considered with reference to the explicit requirement to include also *areas of particular natural sensitivity*. While ecological impact assessment is aimed more at the ecological context at stake as a whole, Article 12 explicitly entails "appropriate distances" as a result of a systematic process. Therefore numerical values for the calculation are needed. For substances dangerous for the aquatic environment thresholds for short term exposure exist. For the intake of substances into groundwater an assessment on the basis of ambient conditions and thresholds for the use of the water for consumption may be feasible. For over ground short term exposure the situation is less comprehensive. Whereas the effects of toxic substances on mammals are well-known indirectly by thresholds relevant for humans, not much is known concerning the effects on other animals and plants; the same applies for physical damage. The following effects are likely to be of concern:

- Acute toxicity of chemicals for animals
- Acute phytotoxicity of chemicals for plants
- Acute physical effects for animals
- Acute physical effects for plants
- Soil sedimentation of chemicals