The introduction of Safety Integrated Urban Design

Shahid Suddle[a,b*]
[a]Delft University of Technology, Delft, The Netherlands
[b]SSCM – Suddle Safety Consultancy & Management, Schiedam, The Netherlands

Abstract: In the Netherlands no standards or design criteria are formulated by the government or the legislator for the realization of buildings adjacent to the infrastructure with transport of hazardous materials or chemical installations. In regard to external safety there is even also no judicial base for example the functional design of land-use planning for such locations. This paper presents a framework of design parameters for realizing projects in the neighbour of hazardous locations. The framework is set-up from an urban planning point of view, in which the effect related safety measures and design parameters for urban planning are extensively analyzed on the macro (city), meso (urban plan) and micro (building) scale level. Subsequently, design parameters are derived from the characteristics of relevant scenarios which may take place with hazardous materials. Also design parameters are investigated in relation to the safety chain enabling to integrate the measures of emergency response. Finally, the analysis is combined with each other, resulting in the framework of safety integrated urban design on different scale levels of land use. The main advantage of such a framework is that different disciplines and design parameters can be integrated at an early possible design stage in urban development, e.g. fire safety engineering, relief, loss prevention and risk analysis, through which external safety becomes communicable particularly for urban planners.

Keywords: Land Use Planning, Urban planning, Safety integrated design.

1. INTRODUCTION

A shortage of land across the Netherlands has led to the development of design and construction techniques that enables intensive use of the limited space. In the last decade, the space available adjacent to the transport infrastructure and chemical installations has been used at a growing rate in city centres. In addition, as a part of the economic foundation, the number of hazardous activities is growing as well. In most cases hazardous activities take place near densely populated urban areas. One may expect that realizing buildings adjacent to hazardous materials will both increase in the future. The interface between urban planning and hazardous activities is called external safety. The survey of Poort [1] showed that the probability of occurrence of a hazardous event will increase rapidly if the use of rail infrastructure is intensified. Hence, external safety is one of the critical issues in intensive-use-of-space projects, especially in the exploitation stage, against which measures can be taken during the planning and design stage of such a project.

In the Netherlands, regulations for land-use planning in the vicinity of major industrial hazards or transport routes of hazardous materials are explicitly risk-based, in which the societal risk must be motivated by local authorities. Economic aspects as well as repressive measures are widely considered in such a motivation. The problem is however no standards or design criteria are formulated by the government or the legislator for the realization of safety measures for buildings adjacent to the infrastructure with transport of hazardous materials or chemical installations. These standards or design criteria are significant for the motivation of the societal risk. This is exactly one of the major issues through which the land-use planners practice the motivation of the societal risk as non-contagious constraint. As a consequence, safety measures in such projects are taken on ad hoc basis. Whereas a proper structure for taking safety measures to an urban plan or a building realised in the vicinity of hazardous locations are strongly required by the land-use planners.

In a quest for more physical safety for areas in the vicinity of transport routes of hazardous materials, the Dutch Ministry of Transport, Public Works and Water Management anticipates on this matter and is developing a so-called Basic Network for urban planning near transport routes of hazardous materials (water, rail and roads). The Basic Network categorizes the total amount of transport of hazardous materials by a transport route, measured in tank wagons, for the current and future transport routes in the Netherlands. In this regard, a first elaboration on the basic network is given by the Mobility Policy Document ('Nota Mobiliteit', [2]). The Mobility Policy Document states that the government is to create a basic network which consists of three types of routes with different importance to either spatial development or transport. Also, along the Basic Network a safety zone (e.g. 30 meters) will be created within which limitations to certain activities will be set. A distinction is made between three main categories for transport of hazardous materials, with a different value of importance to either transport of hazardous materials or spatial development.

1. Primary routes with unlimited transport of hazardous materials. Urban development has large limitations due to safety zoning;
2. Secondary routes where transport of hazardous materials as well as urban development have their limitations;
3. Tertiary routes on which transport of hazardous materials is limited and next to which urban development should not be hindered at all.

One of the main problems and challenges of applying the Basic Network is that the concept does not provide proper solutions to the urban developers. The concept propagates that no spatial functions are allowed (population density is thus 0) in the safety zoning area [3], whereas the design according to a project developer is usually to achieve a large population density in the safety zoning (see figure 1). It is desired to integrate the safety measures in the functional and structural design in (the buildings in) the vicinity, in order to save costs and to make both activities - transport of hazardous materials and urban development adjacent to these transport routes - possible [4,5]. Especially safety measures to buildings adjacent to transport routes with hazardous materials can be integrated in the safety zone, enabling a safety integrated design. However, in the Netherlands there are no standards or design criteria formulated by the government or the legislator for the realization of buildings adjacent to the infrastructure with transport of hazardous materials or chemical installations. In regard to external safety there is even also no judicial base for example the functional design of land-use planning for such locations. Besides, there is less knowledge in literature on the safety integrated design topic, except some basic empirical studies, see e.g. [4,5,6,7,8,9]. One should be aware that urban development is frequently and necessarily shifted further to risk full locations, simply due to the shortage of space. Besides, from an urban development point of view, standards and design criteria are strongly desired on different scale levels of land use, enabling:

- Safety integrated design on a city level (MACRO), also called safety integrated development;
- Safety integrated design within an urban plan (MESO), also called safety integrated planning;
- Safety integrated design on a building level (MICRO), also called safety integrated design.

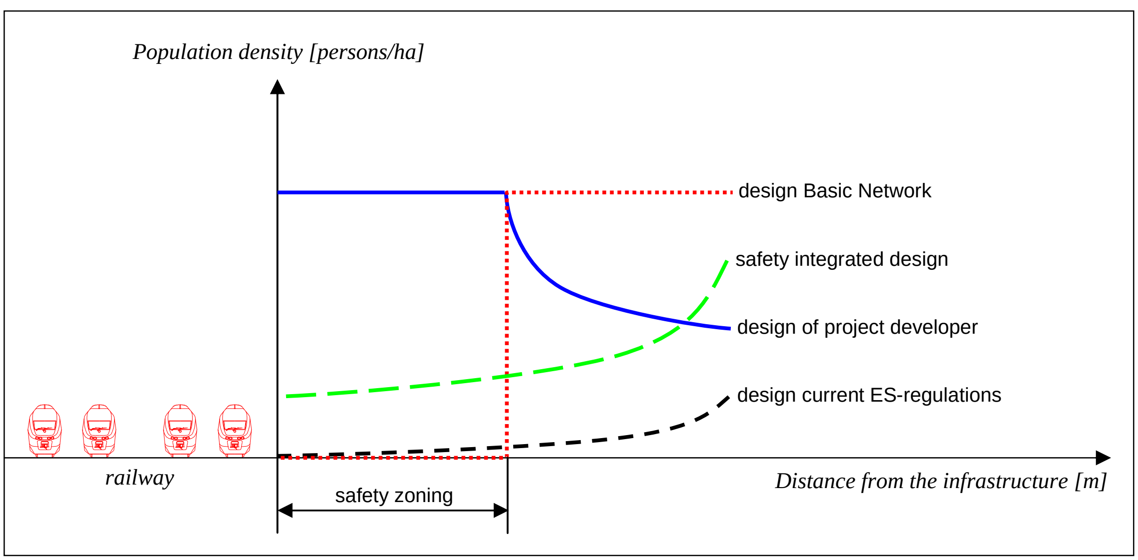

Figure 1: Urban Development versus External Safety / Safety zoning [4,5].

This paper presents a framework of design parameters for realizing projects in the neighbour of hazardous locations. The framework was designed for the Ministry of Spatial Planning and Environmental Issues [9]. The framework is set-up from an urban planning point of view, in which the effect related safety measures and design parameters for urban planning are extensively analyzed on the macro (city), meso (urban plan) and micro (building) scale level. Subsequently, design parameters are derived from the characteristics of relevant scenarios which may take place with hazardous materials. Also design parameters are investigated in relation to the safety chain enabling to integrate the measures regarding emergency response. Finally, the analysis is combined with each other, resulting in the framework of safety integrated urban design on different scale levels of land use. The main advantage of such a framework is that different disciplines and design parameters can be integrated at an early possible design stage in urban development, e.g. fire safety engineering, relief, loss prevention, safety chain, risk analysis, cost-effectiveness through which the concept becomes communicable particularly for urban planners (see figure 2). Moreover, this concept transforms safety as a design parameter in stead of a test objective, supporting the motivation of the societal risk.

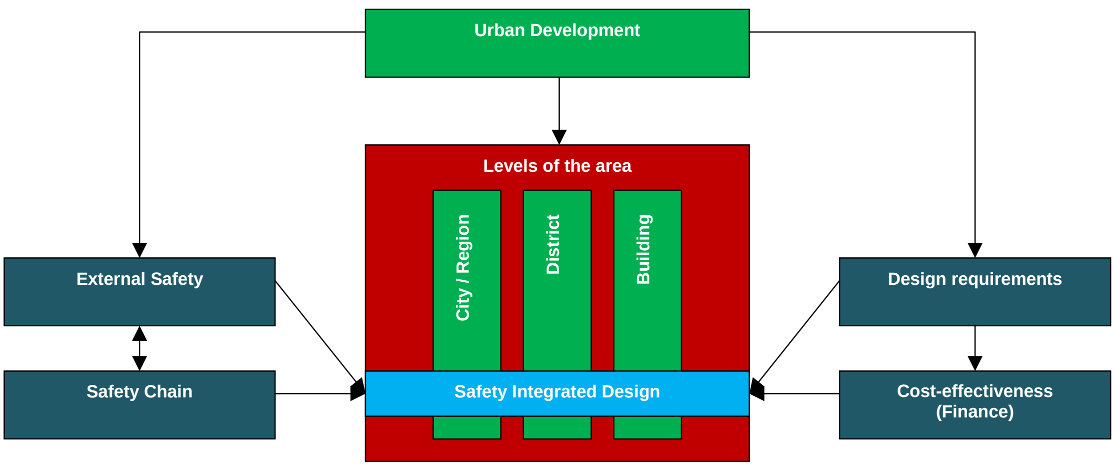

Figure 2: Relation between safety integrated design at different scale levels of the area for different policy fields [9].

2. THE SAFETY INTEGRATED DESIGN PARAMETERS PER LEVEL OF THE AREA

2.1 Introduction

Safety integrated design is up until now a relatively new and an unprompted issue for project developers and municipalities, while these are currently confronted with the continuous changing demands of the users. It is therefore rather interesting to develop another type of working strategy, in which a few standards (prescriptions) are worked out, including an integral approach towards safety on different scale levels. In order to associate design parameters to different scale levels of urban development: city level (MACRO), district level (MESO) and building level (MIRCO), an insight to these levels is indispensable. The relation between these levels is presented in figure 3.

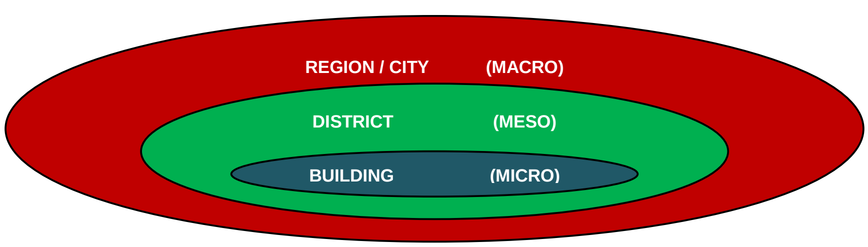

Figure 3: The relation between the scale levels of urban development.

The three scale levels inextricably bound up with each other. A building plan is a part of a zoning plan, which is itself a part of a regional or a city policy. Let's discuss the safety design parameters per scale level.

2.2 Safety Integrated Design parameters on the level of region or city

During the outline process of the spatial policy on a national, provincial, regional or an urban level, the conceptual framework of the spatial development and thus the division is outlined. Building areas and different functions (such as infrastructure, business centres, residential areas, offices) to these areas are configured and assigned in such a policy. Regarding the design parameters on the level of region or city for safety integrated development, three parameters can be enumerated into three categories:

1. Separating functions:
    - No (vulnarable) buildings in the vicinity of transport routes of hazardous materials;
    - transport routes of hazardous materials skirting a residential area by rerouting;
    - Less urban developments adjacent to transport routes of hazardous materials;
    - Separate the transport of passengers and the transport of hazardous materials.
2. Clustering functions:
    - Bundle different types of infrastructure, such as a railway track along with a highway;
    - Intensify the use of space in residential area on a large distance from transport routes of hazardous materials, e.g. by using high rise buildings;
    - Production and processing of a toxic gas on one single location;
    - Cluster the risk generating objects with an attractive effect on transport of hazardous materials on such areas;
    - Establishment of risk generating areas adjacent to transport routes of hazardous materials;
3. Combining functions:
    - Realising building in the vicinity of transport routes of hazardous materials, such as inner city stations and highways;
    - Realising buildings above a chemical installations
    - Buildings spanning a road.

Measures of these three categories can be laid down in master plans, urban plans or policy documents. The dilemma is however, that combining functions per definition results in (local) external safety problems through which a motivation of the urban plan in the vicinity of a hazardous activity is required. This means that design parameters are required on the level of a district and an urban plan, since measures on a city level can hardly be changed.

2.3 Safety Integrated Design parameters on the level of a district (urban plan)

The analysis of design parameters on the level of a district or an urban plan particularly requires elements for a safety integrated planning, i.e. how the different functions within an urban plan can be functionally arranged. Attention should be paid on the configuration and positions of functions like residential area, offices, recreation and infrastructure. The enumeration of the design parameters on the level of a district or an urban plan is as follow:

- The location of buildings;
- Functional division and lay-out of the public space (functions within the zoning plan);
- The level of protection of people;
- Population density (the number of people in the risk effect area);
- Building density (the number of buildings in the risk effect area);
- FSI (Floor Space Index);
- GSI (Ground Space Index);
- OSR (Open Space Ratio);
- Gross floor area of buildings in the zoning plan;
- Nett floor area of buildings in the zoning plan;

- The (average) presence (duration) of number of people in the risk effect area;
- The distribution of presence of the number of people inside and outside the buildings;
- The distribution of presence of the number of people during the day and night;
- The height of buildings;
- The distance between the buildings and the infrastructure;
- The extent of self rescue of people inside and outside buildings.

Let’s give a small example: A low population density means that the societal risk will be lower than in case of a high population density. This means that population density is a strong design parameter for the urban planner. The urban planner can vary the societal risk. If the urban planner has gone through these design parameters, he will go more deeply into the next level: design parameters on the level of a single building plan.

2.4 Safety Integrated Design parameters on the level of a single building plan

Design parameters on the level of a single building plan focus particularly on the single building within the urban / zoning plan, through which safety integrated design becomes possible. The major question on this level is of course: how can the building designed against the scenarios taking place due to transport of hazardous materials. The enumeration of the design parameters on the level of an individual building is as follow:

- Type of the building;
- Robustness of the structure of the building;
- Fire-resistance of the building;
- Type of the structure of the building;
- Second main bearing structure in order to prevent progressive collapse;
- Shape of the building;
- Material of which the building is made;
- Façade of the building;
- Ventilation system of the building;
- Air volume flow of the building;
- The design of installations of the building;
- Building physical design;
- Emergency stay rooms;
- The presence of hazardous materials inside a building;
- The functional design of the space between the buildings and the infrastructure;
- Emergency plan of the building;

3. THE DESIGN PARAMETERS AND THE EFFECT DISTANCE OF HAZARDS

Hazardous materials transported on the infrastructure roughly consist of four major classes: flammable liquids, flammable gassed, toxic liquids and toxic gasses. During the exploitation stage the risk for people in the vicinity of the infrastructure largely depends on the hazards taking place on the infrastructure. Both the effect distance and the physical loads of the scenarios with hazardous materials are important variables for safety integrated design, rather than the scenarios them self. The hazard scenarios that may occur on the infrastructure are collisions, fires, explosions, and leaks of toxic substances (consecutively decreasing in probability of occurrence and increasing in consequences; see figure 4). These accidents can also be the starting points of others. A fire for instance can cause an explosion and vice versa. The release of toxic gasses hardly initiates other events. Figure 4 shows qualitatively the frequencies and consequences for the four hazard scenarios that may occur on the covered infrastructure. For instance, the probability that an explosion will occur in the (covered) infrastructure is quite small, but the consequences of that scenario could be quite large in the number of people killed or injured and in the amount of economic damage. In contrast, the probability of a traffic accident is relatively high and resulting in few fatalities.

It is important to notice that the effect distance of scenarios can be related to the scale level of the area. This means that a mechanical accident mostly takes place local scale, through which the effect distance of such a scenario is relatively small, let say 0 - 30 meters (MICRO). Likewise, such an explanation can argued for small (pool) fires and release of toxic liquids. In such cases the effect distance is also round about 0 - 30 meters (MICRO). The transport of LPG (Liquefied Petroleum Gas) may cause an explosion, resulting in a fireball with an effect diameter of 300 metres. This effects of this explosion ranges a district scale (MESO). The release of toxic gasses results in a large number of people killed because the effect distance of this hazard is large (e.g. 0 - 3000 meters). The range of this scale is rather on the city level (MACRO). This matter is shown in figure 4.

Figure 4 also shows that if safety measures are taken, they should be taken at the right area level! Measures against mechanical impacts or pool fires can be taken on the level of the building, whereas measures against heat radiation or toxic loads should be taken on the level of district and city respectively. Measures taken on a not appropriate level are hardly cost-effectiveness.

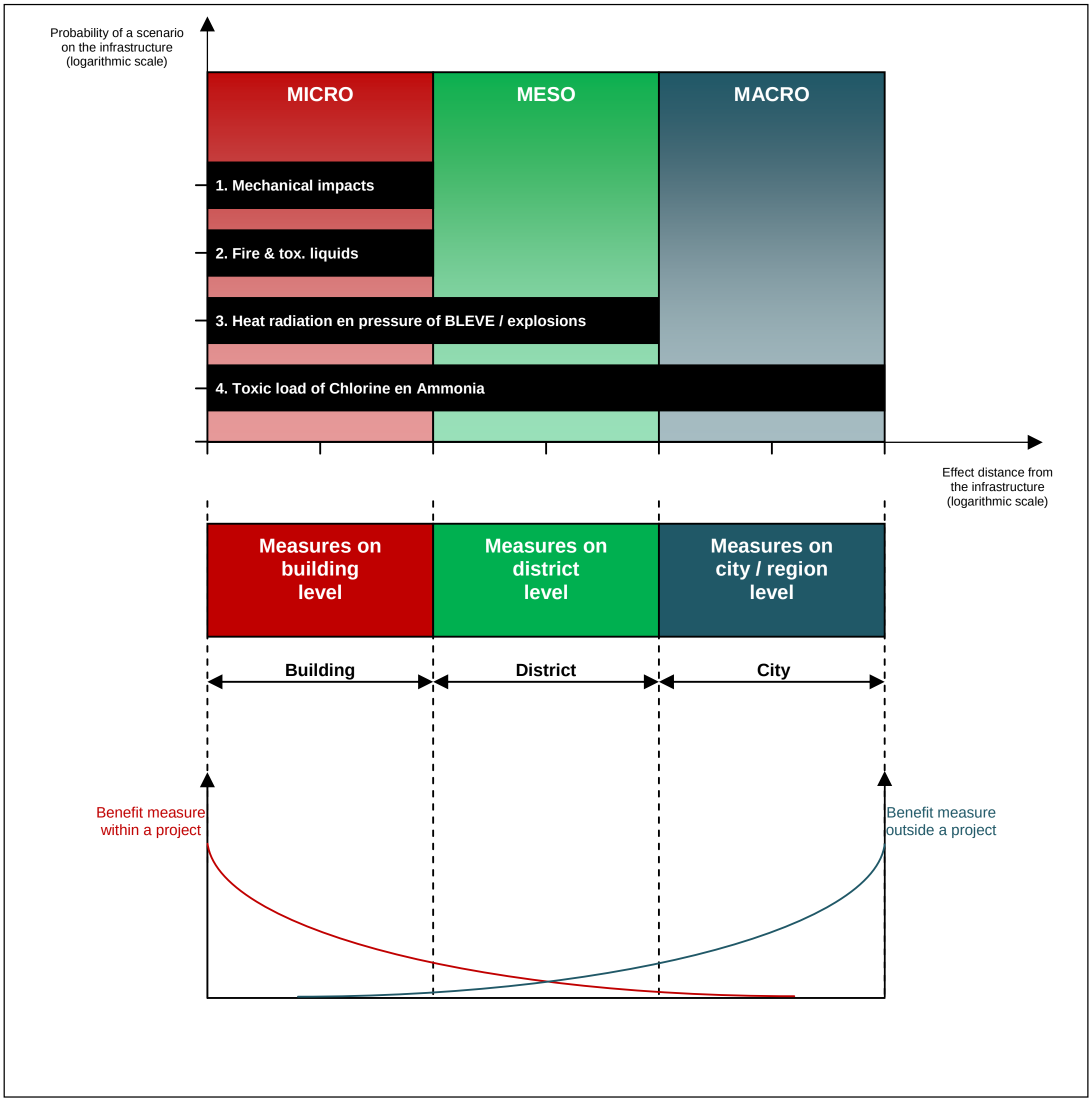

Figure 4: The effect distance of scenarios of hazardous materials related with the area level.

4. THE DESIGN PARAMETERS IN RELATION WITH THE SAFETY CHAIN

4.1 Introduction

In a densely populated country such as the Netherlands, disasters and serious accidents can have far-reaching consequences. However, accidents and disasters can never be prevented altogether. It is therefore necessary to prepare for the worst. Crisis management is part of the safety policy. The basis of the safety policy is the so-called safety chain, the most used classifications of safety measures. The safety chain is particularly drawn up in order to classify the moment of action of the safety measures. Sometimes the safety chain is combined with a Bow-tie model. This makes it possible to present the moment of implementing measures on particular events before, during, or after an accident. The safety chain distinguishes between five links or phases of risk and crisis management: pro-action, prevention, preparation, response and recovery:

- The Pro-action phase involves making enough effort in reducing risks. This is applied in the design and manufacture of roads, viaducts, buildings, planes, ports, etc.
- The Prevention phase, involves reducing risks by granting licenses and rule making. This can include, for instance, granting a license for a new type of building which allows it to become fire resistant or the rules system for buildings.
- The Preparation phase is all about the preparation of remaining risks. Preparation is generally linked to making calamity plans, disaster prevention plans and numerous amounts of training and safety drills for employees in the event of an actual disaster.
- The Response phase starts when a disaster has actually happened and the concentration is on reducing the consequences. Limiting the consequences of a disaster is worked on, on an operational as well as tactical and strategic level.
- The Recovery phase concentrates on getting the situation back to before the incident occurred. Reconstructions and evaluations will also be done in this phase of the operation to formulate improvements so that this kind of incident can be prevented in the future.

Both the chains pro-action and prevention are related to risk management, whereas preparation and response are particularly related to crisis management. In order to determine the design parameters for a safety integrated design, one should derive the relation of each chain of the safety chain between the scale levels of the area, as globally schematized in figure 5.

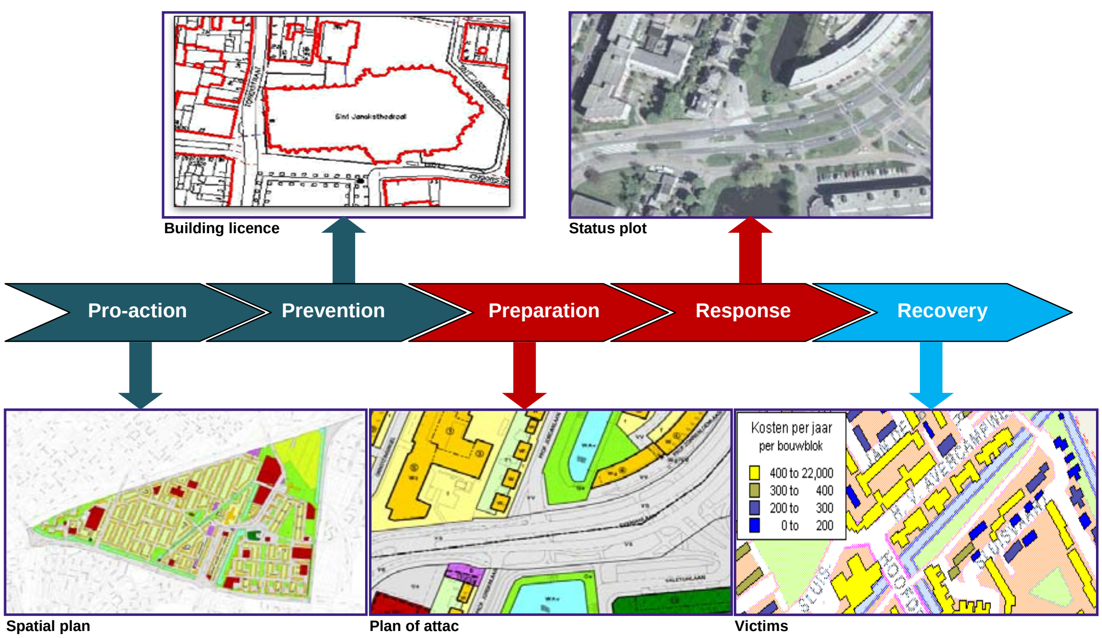

Figure 5: The relation between the safety chain and the levels of the area.

Figure 5 shows that the level of area per chain varies. If we focus on pro-action and the prevention chain, than the scale level of city and district are relevant, whereas the preparation and repression takes place on the level of district and single buildings. In this paper we will focus on the first four chains of the safety chain, since these chains are significant for design safety integrated parameters.

4.2 Design parameters and scale level of Pro-action

The goal of pro-action is, in the earliest stage of planning, the prevention or avoidance of dangers. The Pro-action consists of the following issues:

- Guidance and coordination of fire fighting processes in objects;
- Scenario analysis for e.g. (tunnel) infra-incident combat and associated planning from the sides both of users and fire fighting;
- Risk analysis for fire fighting actions for infrastructure or building projects;
- Fire fighting affairs for major infrastructure projects.

If we link the area level on the elements of pro-action, the following design parameters can be enumerated, which are roughly the same as the parameters for the city and district level.

Table 1: The safety integrated design parameters for pro-action for the city and district level.

Region / City level	**District level**
• Separating functions; • Clustering functions; • Combining functions.	• The location of buildings; • Functional division and lay-out of the public space (functions within the zoning plan); • The level of protection of people; • Population density (the number of people in the risk effect area); • Building density (the number of buildings in the risk effect area); • FSI (Floor Space Index); • GSI (Ground Space Index); • OSR (Open Space Ratio); • Gross floor area of buildings in the zoning plan; • Nett floor area of buildings in the zoning plan; • The (average) presence (duration) of number of people in the risk effect area; • The distribution of presence of the number of people inside and outside the buildings; • The distribution of presence of the number of people during the day and night; • The height of buildings; • The distance between the buildings and the infrastructure; • The extent of self rescue of people inside and outside buildings.

4.3 Design parameters and scale level of Prevention

Prevention is aimed at preventing and limiting fires. The prevention chain offers:

- Advice and guidance in the issuance of use permits;
- Assessment of building plans;
- Guidance of new construction projects in the area of fire prevention and maintenance;
- Fire safety advisory services for complex construction;
- Fire safety maintenance projects;
- Calculation of fire load capacity.

The effort of prevention on both the level of district and building are vital. The basis of prevention chain is to obtain a building permit in which all the relevant elements of the prevention chain are described. A building permit is provided by the municipality or sometimes local authorities, allowing the project developer to realize the building under the conditions of the permit. Within the framework of safety integrated design, some design parameters can be listed, which are related to the environmental issues. It should be noticed that not all these parameters are yet a part of the required building permit. If these parameters are included however, than the safety integrated design becomes an automatic design aspect in stead of a test element. The following design parameters can be listed:

Table 2: The safety integrated design parameters for prevention for the district and building level.

District level	Building level
• Setting of buildings; • Accessibility of rescue workers (access roads); • The restriction of fire spread to nearly located buildings; • Direction of escape routes; • The level of height of buildings (high-rise and underground buildings); • Fighting the fire.	• Availability of lightening in a building; • The restriction of fire spread (by means of a sprinkler system); • The number of escape possibilities; • The indication of escape routes; • The number of emergency rooms; • The number of smokeless escape routes; • The level of height of buildings (high-rise and underground buildings); • The indication (automatic) fire indicators in buildings; • Installations for evacuation.

4.4 Design parameters and scale level of preparation

The preparation phase of the safety chain deals with proper preparation in the broadest meaning of the word for incidents so that these can be combated effectively. The preparation chain consists of the training of van personnel, development of plans, fire extinguishing water tests, recommendations for acquisition of equipment, assessment of newly built fire stations, filling officer or staff functions, management plans, maintaining and advising on BRZO and BEVI tracks, research into coverage data and turn out procedures, support in the construction or renovation of fire stations, emergency plans, attack plans, and custom disaster response plans, developing of specific plans for major infrastructural projects and major chemical companies. The major issue preparation is also the equipment and the training of fire fighters. These elements results in the following safety integrated design parameters:
Safety integrated design parameters on the level of a district (organizational):

- Accessibility of rescue workers (access roads);
- The number of access routes;
- The number of strategic fire fight possibilities;
- The accessibility of building for traffic and fire extinguish provisions;
- Accessibility plans and maps;
- Fire extinguish and attack plans;
- Emergency and rescue plans;
- The number of fire fighting locations (open water) c.q. extinguish pumps;
- The presence of open water;
- Drilled water recourses.

Materiel (en organisonal) parameters

- The number of (fire) hydrant;
- The number of fire brigade companions;
- The number if fire fighting vehicles and tanks;
- The number of fire fighters;
- The number of divers;
- The number of gas packs;
- A regional management plan;
- A calamity plan;
- Exercise material for fire fighters;
- The frequency of exercising;
- Gas measurement apparatus;
- Materials for maintenance;
- The number of rescue operations for wounded people.

4.5 Design parameters and scale level of Response

Response chain is focused on the actual combat of fires, accidents, or disaster, offering:

- Design and guidance of new fire station construction projects;
- Design and guidance of new equipment stations;
- Advice and guidance on closure of equipment stations;
- Design or reorganisation of industrial fire fighting organisations;
- Supply of an industrial fire brigade organisation.

The response chain anticipates particularly on a district and building level. The response has several task, which can be categorized in four classes:

1. Extinguish fires;
2. Rescue operations;
3. Fighting disasters;
4. Help during heavy accidents.

In the past, the fire brigade responded to fires and other emergencies and prevented fires from causing harm or damage to people and property, which was done by providing the following services:

- Community safety;
- Emergency response;
- Emergency planning;
- Resilience;
- Regulatory safety.

Nowadays, the fire brigade faces a range of new threats and hazards, and is constantly developing plans to ensure that the fire brigade is always prepared and resourced to provide whatever response is required. In recent years, the fire brigade has made substantial investment, supported by the government, in additional vehicles, equipment and training for our fire fighters to manage major incidents. The fire brigade has improved our capacity to deal with the consequences of terrorist attacks, extreme weather conditions and other large scale emergencies. The fire fighters are trained to quickly identify and deal with hazardous materials, or carry out complex rescues involving people, fire, wreckage or debris. A wide range of new vehicles and equipment has already been introduced with more coming into service. These have included specialist urban search and rescue teams, scientific support units, major lighting units, and high volume pumping units to remove large quantities of water. If necessary, the fire brigade can undertake the mass decontamination of people who have been exposed to chemical, biological, radiological or nuclear (CBRN) substances. Planning their response to new threats and hazards, and giving necessary specialist training to our staff has been and will continue to be a priority [10].

Regarding the design parameters for safety integrated design, one should be aware of the following parameters, which should be used during the urban design:

- The location of the rescue team;
- The total area of treatment of patients;
- The maximum allowed load of roads;
- Stempellasten van wegen;
- The free height of roads;
- The number of bridges;
- Grade (railroad) crossing.

Finally, it should be noticed that all these parameters of the response are narrowly associated with the parameters of the preparation chain, i.e. if the preparation is not well “prepared”, the response will also not well response.

5. SAFETY INTEGRATED DESIGN MATRIX IN THE EXTERNAL SAFETY

All parameters regarding safety integrated design are related to the level of the area, the effect of the hazardous materials and the safety chain. Subsequently these parameters can now be combined in an overall conceptual model presenting the so-called safety integrated (urban) design matrix. This matrix enables urban developers to understand the external safety and the measures needed to ensure a thorough motivation of the group risk, as described in chapter 1. The uniqueness of this concept is that if the measures of the matrix are taken into account, these measures can be integrated by urban developers in their design of their urban plan, whereas till now these measures are taken after the urban design is finished. This will lead in the reduction of costs.

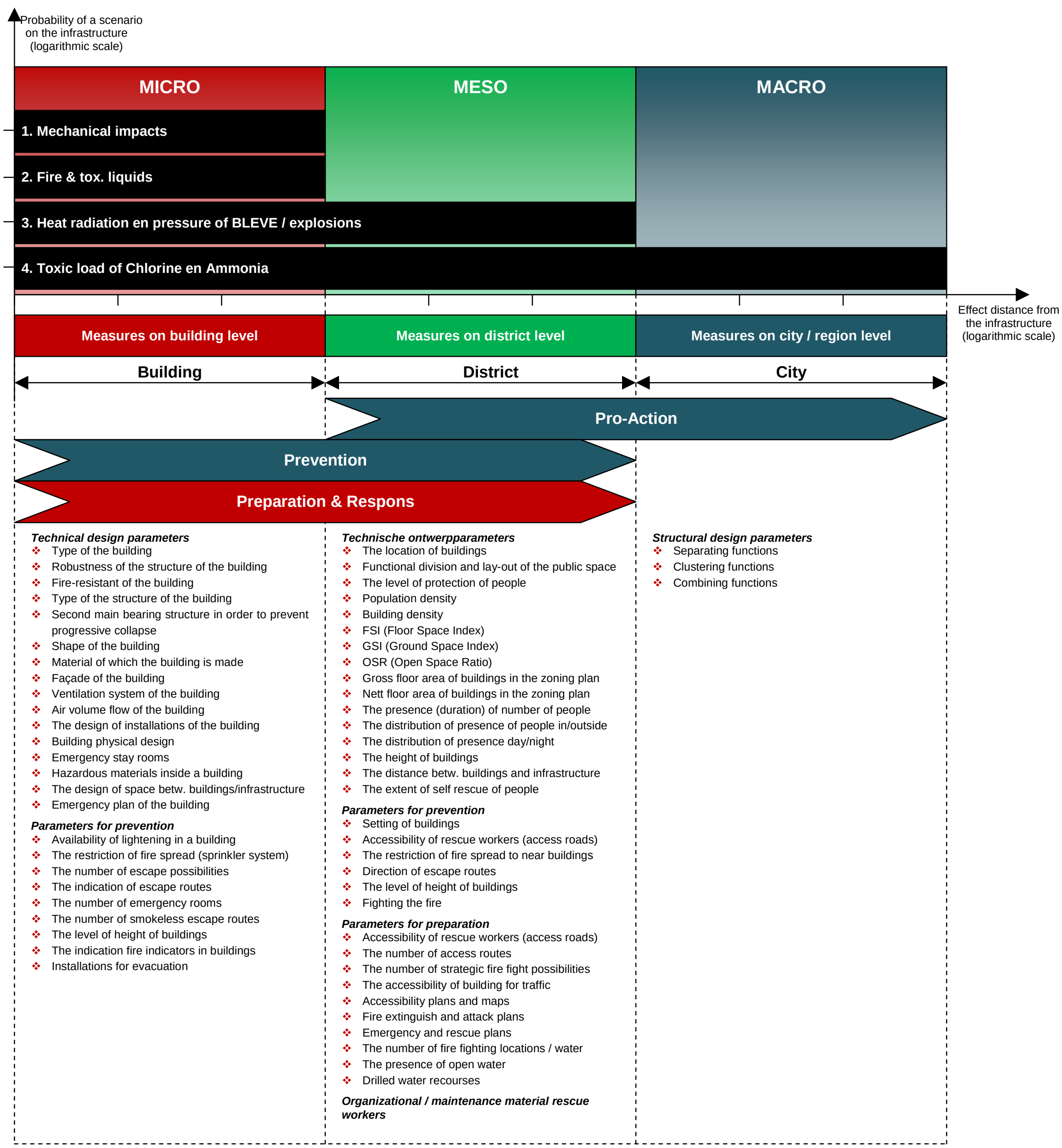

Figure 6: The safety integrated design matrix [9].

6. CONCLUSIONS

The objective of this paper was to present a framework of design parameters for realizing projects in the neighbour of hazardous locations. The framework is set-up from an urban planning point of view, in which the effect related safety measures and design parameters for urban planning are extensively analyzed on the macro (city), meso (urban / district plan) and micro (building) scale level. In this regard it was obvious to derive the design parameters from the characteristics of relevant scenarios due to hazardous materials. The safety chain also provided design parameters, especially for the measures of emergency response. This resulted in the conceptual framework of safety integrated urban design matrix on different scale levels of land use, making possible that different disciplines and design parameters can be integrated at an early possible design stage in urban development, e.g. fire safety engineering, relief, loss prevention and risk analysis, through which external safety becomes communicable particularly for urban planners. In order to take cost-effective safety measures, it is important to integrate these measures at an early possible stage as well, in which the safety measures should be fine tuned during the urban development process:

- Safety integrated development should take place on a city level (MACRO);
- Safety integrated planning should take place within an urban (district) plan (MESO);
- Safety integrated design should take place on a building level (MICRO).

This approach requires a preference order through which safety measures can be taken (i.e. safety ladder):

1. First of all, safety measures against the transport of toxic gasses should be taken on a national level. It is less convincingly that cost-effective safety measures can be taken at low scale level, since the effect distance of such scenarios is high and the probability of occurrence hereof is low.
2. Second, considering the characteristics of the scenarios with transport of hazardous materials, it should be investigated on a city level whether the transport of hazardous materials should be separated from new urban development, since these developments are vulnerable.
3. Third, the lay-out of an urban plan on a district level should be well planned, e.g. a low density should be realised adjacent to transport routes of hazardous materials, in which the measures for emergency response are integrated into that urban plan.
4. Finally, one should implement safety integrated design on the building level, by means of technical specifications and requirements for the emergency response, self rescue during incidents.

References

[1] Poort, J.P. *Grenzen aan benutting*, NYFER, Breukelen, mei 2002, 75 pp.

[2] Ministerie van Verkeer en Waterstaat, 2004: 'Nota mobiliteit: naar een betrouwbare en voorspelbare bereikbaarheid'. Den Haag

[3] Suddle, S.I., *Veiligheidsgeintegreerd Ontwikkelen, Ordenen en Ontwerpen*, SSCM rapport, 20 December 2007, 29 pp

[4] Suddle, S., Het Basisnet als instrument voor veiligheidsgeintegreerd ontwerpen?, *Externe Veiligheid*, Volume 3, no. 4/2007, december, pp. 39-42.

[5] Suddle, S.I. & V. van der Vlies, Wettelijke verankering van veiligheidsgeïntegreerd ontwerpen, *Rooilijn*, Volume 41, no. 5/2008, oktober, pp. 354-359

[6] Suddle, S., Ridder, H. de, Ghauharali, T. and Stoop, J., The Living Building Concept as design tool for safe buildings, *Innovations for Building and Construction*, Europia Productions, In: Dado, E., Beheshti, R. and Zreik, K., Paris, France, ISBN 978-2-909285-56-1, March 2009, pp. 351-371.

[7] Suddle, S.I. (2004), *Physical Safety in Multiple land use*, Ph.D. Dissertation, Delft University of Technology, Delft. Also downloadable from URL: http://repository.tudelft.nl/file/354674/203416

[8] Wiersma, T., M. Molag & J.W. Ekelenkamp, *Toetsing Externe Veiligheid Spoorzone Dordrecht / Zwijndrecht*, TNO rapport TNO-MEP-R2004/105, Apeldoorn, The Netherlands, 2004, 26 pp.

[9] Suddle, S.I., *Veiligheidsgeintegreerd Ontwikkelen, Ordenen en Ontwerpen*, SSCM rapport, 20 December 2007, 29 pp.

[10] http://www.london-fire.gov.uk/index.asp