Eesti Maaülikool
Estonian University of Life Sciences

EMERGENCY RISK ASSESSMENT IN ESTONIA

HÄDAOLUKORRA RISKIANALÜÜS EESTIS

ANTS TAMMEPUU

A Thesis
for applying for the degree of Doctor of Philosophy
in Environmental Protection

Väitekiri
Filosoofiadoktori kraadi taotlemiseks keskkonnakaitse erialal

Tartu 2014

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Institute of Agricultural and Environmental Sciences,
Eesti Maaülikool, Estonian University of Life Sciences

According to verdict No 169 of March 25, 2014, the Doctoral Commitee of the Agricultural and Natural Sciences of the Eesti Maaülikool has accepted the thesis for the defence of the degree of Doctor of Philosophy in Environmental Protection.

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Defence of the thesis:
Eesti Maaülikool, room 1A5, Kreutzwaldi 5, Tartu,
on May 26, 2014, at 10:00 am.

The English language was edited by Elsevier's English Language Editing Service and Tia Ruutopõld and the Estonian language by Karin Liivaleht.

Publication of this dissertation is supported by the Eesti Maaülikool and granted by the Doctoral School of Earth Sciences and Ecology created under the auspices of European Social Fund.

ISBN 978-9949-536-29-0 (trükis)
ISBN 978-9949-536-30-6 (pdf)

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following papers, references to which in the text are by their Roman numerals.

I **Tammepuu, A**., Sepp, K. 2013. Emergency risk assessment: the Estonian approach. Journal of Risk Research, 16(2): 169–193.

II **Tammepuu, A.**, Sepp, K., Uiga, E. 2007. Aspects of risk assessment in land use planning: the case study of Tartu. Safety and Security Engineering II. Guarascio, M., Brebbia C. A., Garzia, F. (eds.). WIT Transactions on the Built Environment, Volume 94. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 345–357.

III **Tammepuu, A.,** Sepp, K. 2012. National emergency risk assessments: comparative study of Estonia and the UK. Brebbia C.A., Zubir, S.S. (eds.). Management of Natural Resources, Sustainable Development and Ecological Hazards III. WIT Transactions on Ecology and the Environment, Volume 148. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 633–644.

IV **Tammepuu, A.,** Sepp, K., Paasoja, R., Kuusemets, V. 2008. Risk assessment of the cities of Estonia and UK: comparative study. Gospodini, A., Brebbia, C.A., Tiezzi, E. (eds.). The Sustainable City V: Urban Regeneration and Sustainability. WIT Transactions on Ecology and the Environment, Volume 117. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 591–604.

V Möldri, M., **Tammepuu, A.**, Tint, P., Paas, Õ., Laaniste, P. 2012. Integration of the SMS to IMS in Estonian Seveso II establishments: selected case studies. Brebbia, C.A. (ed.). Risk Analysis VIII. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 227–236.

VI **Tammepuu, A.**, Tammepuu, O., Sepp, K. 2009. Emergency preparedness in integrated management systems: case study of the Port of Tallinn. Disaster Management and Human Health Risk: Reducing Risk, Improving Outcomes. Duncan, K., Brebbia C.A.

(eds.). WIT Transactions on the Built Environment, Volume 110. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 65–76.

VII **Tammepuu, A.,** Sepp, K., Kaart, T. 2014. Emergency preparedness in the ISO 14001 enterprises: Estonian case study. International Journal of Emergency Management. Manuscript (in press).

The contributions of the authors to the papers were as follows:

	I	II	III	IV	V	VI	VII
Original idea	**AT**	**AT**	**AT**	**AT**	**AT**, MM	**AT**, OT	**AT**
Study design	**AT**, KS	**AT** EU KS	**AT**, KS	**AT,** KS	**AT**, PT, ÕP	**AT**, KS OT	**AT**, KS
Data collection	**AT**	**AT,** EU	**AT**,	**AT,** RP	**AT**, ÕP PL	**AT**, OT	**AT**
Data analysis	**AT**	**AT**	**AT**	**AT**, VK RP	**AT**, MM PL	**AT**, OT	**AT**, TK KS
Manuscript preparation	**AT**, KS	**AT** KS	**AT**, KS	**AT**, KS VK	**AT**, MM PT	**AT**, KS	**AT**, KS TK

AT – Ants Tammepuu; KS – Kalev Sepp; EU – Evelin Uiga; RP – Raivo Paasoja; VK – Valdo Kuusemets; OT – Orm Tammepuu; MM – Margus Möldri; PT – Piia Tint; ÕP – Õnnela Paas; PL – Priit Laaniste; TK – Tanel Kaart

ABBREVIATIONS

APELL	awareness and preparedness for emergencies at local level
ARAMIS	Accidental Risk Assessment Methodology for Industries in the framework of SEVESO II directive
DaGoB	Safe and Reliable Transport Chains of Dangerous Goods on the Baltic Sea Region
DG	Dangerous Goods
EC	European Commission
ECI	European critical infrastructure
EIA	environmetal impact assessment
EmRA	emergency risk assessment
EMS	environmental management system
EU	European Union
FRA	functional risk assessment
IMS	Integrated Management System
ISO	International Standard Organisation
LPG	liquefied propane gas
MAHB	Major Accident Hazards Bureau
MAPP	Major Accident Prevention Policy
NRA	National Risk Assessment
NRR	National Risk Register
OECD	Organisation for Economic Co-operation and Development
OHSAS	Occupational Health and Safety Assessment Series
PDCA	plan-do-check-act
PSFRA	potential significant flood risk areas
QUARTER	TERritorial QUAlity, territorial risk management systems of municipality
SEA	strategic environmental assessment
SMS	safety management system
TRA	territorial risk assessment
UK	United Kingdom
UNEP	United Nations Environmental Programme
UN ISDR	The United Nations Office for Disaster Risk Reduction

1. INTRODUCTION

The existence and survival of life in the world, including the incipience and development of humanity, has been accompanied by emergencies, disasters and catastrophes. Humans have always been exposed to different hazards (Tammepuu et al., 2009). Emergencies have occurred in the past, occur at present and will occur in the future, and, in hazardous environments, as Flynn and Theodore (2001, 80) argue, accidents will happen again – it is only a question of time. Major accidents and hazards are results of destabilising factors, which can cause serious setbacks and breakdowns in the continuous developmental process (Tammepuu et al., 2008). Currently, the outbreaks of unwanted accidental events are mostly uncertain and are thus usually handled in relation to risk concept. Risks, hazards and threats can be hidden and kept out of the public eye until something serious happens (Tammepuu et al., 2008, 2009). Therefore, it is important for communities to be aware of these risks (Tammepuu et al., 2008). For this purpose, risk assessment is an essential part of civil protection (Tammepuu et al., 2007). Currently, the requirements concerning emergency preparedness, which include accident risk identification and assessment, can be found in several international/national legal documents and also in various standards.

The emergency risk assessment in Estonia began in the early 1990s, and since then, it has continued to produce remarkable achievements in methodological developments and practical applications. Although risk assessment is currently an essential component of Estonian crisis management, many gaps, contradictions and ambiguities concerning the legal and methodological requirements, classifications of emergencies, indicators, etc. have remained.

The scope of this dissertation embraces the development and current state of emergency risk assessment in Estonia as one of the 'new' members of the EU. This dissertation is composed of the national, regional-local and organisational levels. The comparison with the UK as an 'old' member of the EU has an important place in the entire thesis. The objective and aims are expressed more precisely in Chapter 3. The overview of the studies for finding solutions to the proposed aims is combined in seven papers. The following is a brief review of these papers:

Paper **I** generically summarises the problems of emergency risk assessment in Estonia. The development of the emergency risk assessment is discussed in retrospective, current and comparative contexts. The survey shifts its attention to the impact of national and international acts on this development of the emergency risk assessment and discusses the application of emergency risk assessment outcomes.

Paper **II** is composed of the problems that are connected with the risk assessment of emergency situations in Estonia and their relations with land use planning, in view of the risk assessment of the city of Tartu. The scenarios of the development of emergency situations are grouped into five groups in relation to land use and spatial planning, which are described and analysed separately.

Paper **III** is composed of the Estonian and the British national risk assessments. The selected indicators include a comparison of legislative requirements, provisions and performance, methodologies, types of analysed risks, large-scale risk assessment outcomes, and risk assessment results, as well as the usage of risk.

Paper **IV** presents a comparative study of city risk assessment in Estonia, which is a so-called 'new member', and in the UK, which is an 'old member' of the EU. The comparison of the outcomes used four strategically selected risk assessments of Estonian cities and the same number of British cities.

Paper **V** concerns the integration of Safety Management Systems of the Estonian Seveso II establishments into ISO-based Integrated Management Systems (IMS). The results demonstrated that, in spite of different approaches, many common factors exist, which enabled general recommendations to be determined.

Paper **VI** discusses the problem of the integration of emergency preparedness and safety management into the ISO-based integrated management system (IMS). The problem was observed in the context of a case study of the Port of Tallinn, which has implemented the integrated quality and environmental management system.

Paper **VII** observes the application of emergency preparedness and response in environmental management systems. In this context of ambi-

guity, we studied Estonian enterprises to analyse a variety of approaches to emergency preparedness and response. A comprehensive study engaged the identification and assessment of accidents and emergency situations, as well as the response to these situations by organisations that had implemented the requirements of the ISO 14001.

2. REVIEW OF THE LITERATURE

2.1. Meaning of emergency risk

The term 'risk' is widely used both in the scientific world and in everyday life (Christou, 1998). Risk is an integral part of life (Smith, 2001) that has become one of the most powerful concepts in modern society (Leiss and Chociolko, 1994), to the extent that today's world has even been called a 'risk society' (Beck, 2000). Wlodarczyk and Tennyson (2003) contend that risk is both the product of the harmful consequence of an activity or event and the probability of its occurrence. Safety literature most commonly defines risk as the probability of an adverse future event multiplied by its magnitude (Adams, 2001). Although contemporary society is greatly concerned with many aspects of risk, the concept of risk and its assessment and management have not yet been sufficiently developed to provide a holistic approach (Aven and Kristensen, 2005).

The EU Civil Protection Financial Instrument (EC, 2007a) defines an emergency as any situation that has or may have an adverse impact on people, and preparedness is defined as a state of readiness in which the capacity of human and material means enables protection against such emergencies (EC, 2007a, 2007b, Article 3). The UN ISDR terminology considers the terms 'crisis' and 'emergency' as effectively the same, with both being 'a threatening condition that requires urgent action' (UN ISDR, 2009, 12). The glossary of the European Environment Agency (EEA, 2010) defines collocations containing 'emergency', such as 'emergency law' and 'emergency plan', but unfortunately not the word 'emergency' itself.

The Estonian Emergency Preparedness Act (Parliament of Estonia, 2000), which was valid until 23 July 2009, designated an emergency as 'an event or a chain of events, which endangers national security, the life and health of persons, causes significant damages to the environment or extensive economic damage' (Parliament of Estonia, 2000: Section 2 of General Provisions). Responding to any of these events requires 'the co-ordinated action of the Government of the Republic, government agencies and local governments' (Parliament of Estonia, 2000: Section 2 of General Provisions). This definition is comparable to Smith's definition of disaster as: 'an event, concentrated in time and space, in which a community experiences severe danger and disruption of its essential

functions, accompanied by widespread human, material or environmental losses, which often exceed the ability of the community to cope without external assistance (Smith, 2001, 7).

2.2. Emergency risk assessment in the context of civil protection

Today a wide range of professions and academic subjects use the technique of risk assessment (Fairman et al., 1998). Risk assessment is an essential component of the overall management of risks within society, and specifically risks to human health and/or the environment (OECD, 1997). It is the first step in explaining the problems and evaluating the significance of risk either quantitatively or qualitatively (Smith, 2001). Although today's society is greatly concerned with many aspects of risk, the concept of risk and its assessment and management have not yet been sufficiently developed to meet many challenges (Aven and Kristensen, 2005).

Lonka (1999) conducted a comparative study of risk assessment in the field of civil protection in Europe and concluded that in many European countries the usefulness of the further development of risk assessment in the field of civil protection and emergency preparedness was clearly recognized. The European research project QUARTER concentrated on the development of a territorial management system for territorial risk reduction and environmental quality improvement (Treu et al., 2004). In the frames of the previously mentioned research project, a methodological framework for territorial vulnerability analysis and assessment was worked out (Treu et al., 2005). In the context of territorial vulnerability analysis the Environmental Risk Management System procedure was proposed by the research group (Baldi et al., 2004).

Risk assessments on a national level are recognized to be a determinant for improving disaster prevention and preparedness activities (EC, 2010a). Recently the European Commission issued risk assessment guidelines with the main goals being to improve coherence among the national risk assessments and to make these risk assessments more comparable between member states (EC, 2010a). Nowadays many countries are undertaking national risk assessments (EC, 2010a), including the UK (Cabinet Office, 2010a) and Estonia (Ministry of the Interior, 2011).

2.3. Emergency risks regulated by EU directives

2.3.1. Major chemical accident risks and safety

The essential principles and requirements concerning the EU risk assessment of industrial institutions designated as major accident hazards are formulated in the Seveso II Directive (EC, 1997). This document belongs to the most remarkable EU Directives, supporting the protection of people and the environment from major accidental hazards (Salvi and Gaston, 2004). The requirements for risk assessment are specified in the accompanying guidance on the preparation of a safety report (see MAHB, 2005) and in land use planning guidelines (see MAHB, 2006). The accidental risk assessment methodology for industries (ARAMIS) developed by the ARAMIS project had as one objective the creation of a harmonised EU-wide methodology based on the specific requirements of the Seveso II directive, combining the strengths of both deterministic and probabilistic approaches (Salvi and Debray, 2006).

The Seveso II Directive requires the compilation of a "Major Accident Prevention Policy" (MAPP) and "Safety Management System" (SMS) from all establishments with a major accident hazard (EC, 1997; Duijm and Goossens, 2006) on the basis of a summarized qualifying quantity by Annex I of the Directive. In accordance with Annex III of the Directive the SMS must embrace the following issues (EC, 1997; Basso et al., 2004):

1. Organisation and personnel
2. Identification and evaluation of major hazards
3. Operational control
4. Management of change
5. Planning for emergencies
6. Monitoring performance
7. Audit and review

The Safety Management System can be briefly defined as the system for implementing safety management (Mitchison and Papadakis, 1999). SMS substantially means multiple activities, initiatives, programs, etc., consolidated by organisational, human and technical aspects (Harms-Ringdahl, 2004). SMS in a formal sense is a framework, holding a large package of documents, containing different procedures, manuals, charts, reports, records, emergency plans, etc. (Bragatto et al., 2010). The safety management system is considered to be a basic component of the organisations'

safety culture (Fernandez-Muniz et al., 2007; Sales et al., 2007). The size and orientation of SMS procedures are deeply dependent on identification and evaluation of major accident hazards and selection of risk analysis method(s) (Demichela et al., 2004). The integration of the principles of inherent safety and land use planning into the plant safety management system permits the reduction of possible consequences (Vierendeels et al., 2011). The SMS of neighbouring Seveso establishments may be organized in clusters, which enables observing common risks and possible counteractions as well as knowledge exchange and coordinated planning of pro-active and re-active measures (Reniers et al., 2009).

2.3.2. Flood risks

The main requirements for the risk assessments of floods are presented in the EU's new Flood Directive (EC, 2007b), which includes the preparation of flood hazard maps and flood risk maps. De Moel et al. (2009) suggest that the Directive refers to the mapping of flood hazards and risks as essential components of flood risk assessment and are consequently the basis of flood risk management plans.

2.3.3. Critical infrastructure risks

The requirements for the identification and designation of European critical infrastructures (ECIs) and the assessment of the need to improve their protection were enacted in the Council Directive 2008/114/EC of 8 December 2008 (EC, 2008).Vrijling et al. (2004) characterise critical infrastructures as complex societal systems, and Pursiainen, Lindblom and Franke (2007) argue that they play an essential role in the maintenance of vital societal functions such as the supply chain, health, safety, security and the economic and social well-being of the population. Although the Directive (EC, 2008) focuses on ECIs, the disruption or destruction of which would have a significant impact on at least two Member States, the Directive's main principles have broader applicability.

2.4. Application of emergency risk assessment outcomes

2.4.1. Environmental assessment and management

The term 'risk' is not defined in the main texts of the Environmental Impact Assessment (EIA) Directive (EC, 1985), the Strategic Environmental

Assessment (SEA) Directive (EC, 2001), Estonia's Environmental Impact Assessment and Environmental Management System Act (Parliament of Estonia, 2005), ISO 14001 (2004) or the EU's Eco-Management and Audit Scheme regulation (EC, 2009). Although risk is not defined and is strictly exteriorised in the above documents, the practical requirement to consider the probability of its consequences creates an unavoidable necessity for the practical usage of risk assessment as a tool for explaining environmental aspects and impacts (Tammepuu and Sepp, 2013).

2.4.2. Mapping and spatial planning

The ESPON Hazards Project 1.3.1 has worked out spatial patterns of natural and technological hazards in Europe in the shape of an overview on all NUTS3 areas (Schmidt-Thome et al., 2006). The European research project QUARTER concentrated on the development of a territorial management system for territorial risk reduction and environmental quality improvement (Treu et al., 2004). The report of the project EUROBALTIC I presents different examples of methodologies of risk assessment, management and mapping in the Baltic Sea Region, developed and applied in the countries of the region (Hedin et al., 2006).

2.5. Emergency risk in the context of ISO 14001 and IMS

Today several organisations over the world have implemented and certified integrated management systems (IMS), based on corresponding ISO standards, relying on the universal management cycle of plan-do-check-act (PDCA) and containing quality (ISO 9001, 2008), environment (ISO 14001, 2004) and often also occupational health and safety requirements (BS OHSAS 18001, 2007). The latter is not based on ISO standards, but on a document of the British Standard Institute, which has generically adopted the structure of ISO 14001 and has been recognized in many countries. The ISO 14001 and OHSAS 18001 both contain requirements concerning emergency and safety management.

The International Organization for Standardization's (ISO) standard for Environmental Management Systems (EMS), ISO 14001, is a globally recognized standard containing direct requirements for emergency preparedness and response (ISO 14001, 2004). The global context is reflected in the 129,199 organizations in 140 countries that were certified, in 2006, as observing the ISO 14001 EMS standard (ISO/Survey, 2006;

Balzarova and Castka, 2008). Emergency preparedness and response is one of the key elements of ISO 14001, for which all certified organisations have taken responsibility (ISO 14001, 2004).

The ISO 14001 standard provides a practical and workable framework for controlling environmental risk to prevent accidents and environmental regulation violations (Kwon et al., 2002). The avoidance of environmental risks arising from the activities of the organisation and mitigation of the impact deriving from accidents and emergencies is one of the goals of implementing the environmental management system (EMS) (Belmane et al., 2002). At the same time the meanings of emergency or emergency preparedness are not defined in the ISO 14001 (ISO 14001, 2004). Martin (1998) for instance brings out that emergencies include releases of all types to the environment, including natural disasters that might lead to releases, and process hazards that might become emergencies.

Risk in the different issues of ISO 14001 (Jones and Mason, 2002; Martin and Edgley, 1998; Voorhees and Woellner, 1998) is observed in a broader context than that of merely emergencies and accidents, covering additional uncertain and undesirable environmental impacts. The ISO 14001 sets that environmental aspects should not be limited only to normal operational conditions; abnormal and emergency situations must also be considered (ISO 14001, 2004; Põder, 2006). Voorhees And Woellner (1998) point out, that for understanding the degree of risk, ISO 14001 requires that the following environmental concerns need to be addressed: the scale of the impact, the severity of the impact, the probability of occurrence, and the duration of impact. Organizations, in addition to first-string ones, often engage risk management specialists to assist in the identification of potential emergency or accident situations that could lead to human injury, environmental damage, or economic loss (Schaarsmith, 2005).

The ISO 14001 (2004) does not specify that the accidents and emergency situations, covered by the procedure(s), descend only from the elements of an organisation's activities, products and services, (e.g. environmental aspects – on-site hazards). Conversely, the responding guidance of ISO 14004 (ISO 14004, 2004) mentions that in establishing its procedure(s), the organization should include consideration of the potential for (an) emergency situation(s) or accident(s) at a nearby facility (e.g. plant, road, railway line).

A number of studies have been carried out, concerning emergency preparedness in ISO 14001 certified enterprises, some of which focus on major chemical hazards and relationships with ISO 14001 (Rosenthal and Theiler, 1998; Gerbec and Kontic, 2009). Rosenthal and Theiler (1998) discuss, for example, the ISO 14000 option of implementing the United States Environmental Protection Agency's rule on Risk Management Programs for Chemical Accidental Release Prevention. Gerbec and Kontic (2009) conducted a survey of the implementation of the Seveso II Directive enterprises in Slovenia, in which they found the majority of the 'Seveso enterprises' were combining the Safety Management System, as required by the directive, with voluntary management systems, including the ISO 14001. Other studies, while focusing on any of a broad range of ISO 14001 topics will include emergency preparedness and response (Savely et al., 2007; Sambasivan and Yun Fei, 2008; Marazza et al., 2010; Saengsupavanich et al., 2009). Savely and others (2007) in a survey of the implementation status of EMS in U.S. colleges and universities demonstrate that environmental emergency preparedness and response procedures were present in 88% of the studied cases. Sambasivan and Yun Fei (2008) argued organizational preparedness to emergency situations is a component and a key factor of organisational change. Marazza et al. (2010) studied the environmental aspects of local authorities, bringing out that direct environmental aspects could also include the risks of environmental accidents. Saengsupavanich et al. (2009), during an environmental performance evaluation of a Thai port and adjoining industrial estate, included a study of emergency preparedness and plans. They determined emergency plan availability as one of the environmental performance indicators (Saengsupavanich et al., 2009).

3. OBJECTIVE AND AIMS OF THIS STUDY

The objective of this dissertation was a survey of the development of Estonian emergency risk assessment since the restitution of Estonia as an independent state, which examined the impact of legislation and guidelines from other states and international institutions.

The particular aims of the present doctoral thesis were as follows:

1. To identify and determine the key events and agents of the development of emergency risk assessment of Estonia.

2. To observe the development and application of the emergency risk assessment and its outcomes in Estonia on national, regional-local and organisational levels.

3. To compare the national and local level emergency risk assessments of Estonia and the UK.

4. To study the emergency risk assessment in the context of Estonian case organisations with certified ISO 14001 environmental management systems.

4. MATERIALS AND METHODS

4.1. Study area and sites

This dissertation consists of a series of relatively independent studies, whose essential intersection is the theme of emergency risk assessment in Estonia and, partly, in the UK in a comparative context. Thus, the materials and methods are observed separately by concrete survey directions.

The generalised study area predominantly embraces the entire territory and concrete sites of Estonia and part of the UK.

4.2. Development and organisation of EmRA in Estonia

4.2.1. The Estonian approach to emergency risk assessment

The emergency risk assessment generic study (**I**) in Estonia, which embraced both the development and current arrangement, was, to a large extent, of a reference quality, in that there was no direct disparity between the reference sources and research documents. The main research documents, in addition to literary resources, were legislative acts and regulations, methodologies and different reports of risk assessments, environmental assessments, etc. The prevailing methodological approach was a textual analysis, which was based on the selection of key topics and determining limiting features for the systematic determination and description of the developmental process of emergency risk assessment on Estonian state, regional, local and organisational levels, while revealing the impacts of legal documents and methodologies of other countries and international organisations. Some descriptive statistics were applied only in a subsequently described case study.

The case study, which performed risk assessments of the hazardous enterprises of the South-Estonian region, was performed using a corresponding questionnaire. There were 147 hazardous enterprises, which included enterprises with major chemical accident hazards, in the six counties of the South-Estonian region. The results of the questionnaire were processed in the Microsoft Excel program.

4.2.2. Case study of Tartu

The risk assessment of the city of Tartu **(II)** was based on the document "Methodology of Risk Assessment of County, City and Community", which was enacted by a regulation of the Minister of the Interior (2001). The risks were assessed by a risk matrix approach, which uses a 5-step ranking system for the assessment of probability (1-5, where 1 was the lowest and 5 was the highest) and the consequences (A-E, where A was the least serious and E was the most serious) were united into the matrix, which was based on principles that were analogous to the APELL/UNEP methodology (UNEP IE/PAC, 1992).

The probabilities of the accidents occurring were assessed indirectly, considering the existing statistics of accidental events, as well as the possible internal and external causes and initial events that could activate accident scenarios. The consequences of each selected accident scenario were first assessed separately using the following four tasks: human life and health, essential sectors, environment and property, with each task given a five-point ranking. Then, a general appraisal was given.

The methodology of complementary analysis consisted of determining appropriate criteria for a systematic approach to hazard zoning and to the application of risk assessment results for land use planning. This analysis embraced the attempt to find and describe characteristic features by which the accident types and concrete emergency scenarios could be distinguished and analytically described concerning their relation to the rural and urban environment and to group these events using these characteristic features for further practical application. The benchmarks in this approach were the type and distribution of the risk sources, as well as impacts of these sources.

4.3. Comparative studies of Estonia and the UK

Comparative studies of the national **(III)** and local **(IV)** risk assessments of Estonia and the UK were performed as textual analyses of certain cases: the public outcome documents of the national risk assessments and the selected cities or conurbations of the two countries.

4.3.1. Comparative study of the national risk assessments

The main research materials of study **III** were the most recent publicly available output documents of the national risk assessments of the two countries: the 2008 National Summary of Risk Assessments for Emergencies (Ministry of the Interior, 2009) of Estonia and the National Risk Register of Civil Emergencies (2010 edition, Cabinet Office, 2010a) of the United Kingdom. The observed and compared subjects were the requirements, methodologies, output document compositions, risk assessment processes, risk assessment performers, risk types, risk categories, and risk assessment outcomes.

4.3.2. Comparative study of the Estonian and the UK city risk assessments

Comparative study **IV** of the emergency risk assessments in Estonia and the UK was drafted using the comparison of the selected documents by specific criteria. The research materials were legislative acts and regulations, guides, risk assessment reports of Estonian cities and community risk registers with supplementary materials from British cities (including the boroughs in London) and conurbations. The Estonian sample risk assessment reports were of the largest cities of Estonia's four rescue regions: Tallinn (North-Estonia), Tartu (South-Estonia), Narva (together with the Vaivara municipality, East-Estonia) and Pärnu (West-Estonia). The British analogues were the community risk registers of the boroughs of London, Greater Manchester, West Midlands conurbation (Birmingham with surrounding urban areas), and Belfast. The last community was chosen because differences exist in the requirements and methodologies for Scotland and Northern Ireland. The compared and discussed criteria were the following: steps of risk assessment; risk types and categories; assessment of likelihood and consequences; risk assessment performance; public availability; outcomes and outputs.

4.4. Emergency risk assessment in ISO 14001 certified organisations

4.4.1. EmRA in IMS: case studies of three Estonian establishments with major chemical accident hazards

At present, as previously stated, approximately 1/3 of Seveso II establishments in Estonia have implemented the integrated management system.

Three of these establishments, which each belong to different economic activities, were selected for case studies in the scope of study **V**. One principle of the selection was finding organisations that were not competitors with each other. This principle allowed for pleasant conditions for possible further cooperation between the specialists of the organisations in IMS and SMS development.

The common characteristics of the selected case organisations were the following: first, all three organisations belonged to international corporations; second, all the establishments had implemented and certified at least the ISO 9001 and ISO 14001 as IMS; and third, all three had the additional duty to follow the internal standards of their international corporations. One of the three case study establishments belonged to the upper tier and the two others belonged to the lower tier, according to the threshold quantity of dangerous substances, which was presented in Annex I of the Seveso II Directive (EC, 1997).

The dominating method was the textual analysis of the following: safety reports or descriptions of SMS-s, handbooks of IMS-s, procedures and guides of IMS-s and also emergency plans. During the case studies, relatively more attention was focused on SMS-specific components: the identification and evaluation of major hazards (risk assessments), as well as planning for emergencies.

4.4.2. Case study of the Port of Tallinn

The methodology of case study **VI** of the emergency preparedness in the IMS of the Port of Tallinn was principally textual analysis, which was in the form of an audit of the safety system of the ports. This methodology essentially embraced the revision of sample documents. The sample documents were primarily the components of the integrated quality (ISO 9001, 2008) and environmental (ISO 14001, 2004) management systems of the port. These sample documents included the handbook, the procedures, the additional documents derived from the procedures as guidance, plans, filled forms and reports. The assessment criteria were legal requirements and the requirements of the standard ISO 14001.

The document analysis was complemented by interviews with key persons and by observations of the sites. The interviews with selected responsible persons of the ports embraced the practical operations for

espousing the requirements. The aim of observations on the sites was primarily the comparison of the contents of the documents with real situations and finding possible nonconformities.

4.4.3. EmRA in Estonian organisations: a multiple case study

Study **VII** was conducted by sending a survey questionnaire to selected Estonian ISO 14001 certified organisations. The questionnaire consisted of 16 questions, including 7 open questions, 6 questions with selected answers and 3 closed questions, which were designed to elicit data and information concerning the enterprises' structures, and their compliance, aspirations and problems with ISO 14001 certification in the specific context of emergency preparedness and response. The questions embraced the following topics:

- Identification of possible emergencies and accidents
- Types of identified accidents and emergencies
- Emergency preparedness, response procedures and emergency plans;
- Training and testing
- Proposals for continual improvement
- Information sources.

Initially, 84 companies with the longest experience in having certified environmental management systems were selected. This selection indicates that only organisations that had certified environmental management systems before the publication of the new version of the ISO 14001 standard in 2004, were chosen. The questionnaire was sent to these 84 companies. In total, 45 of these organisations returned completed or partially completed questionnaires. The data regarding these 45 organisations are displayed in Table 1, which were adapted from paper **VII**.

The sizes of the workforces were rounded to complete 'tens' and ranged from 40–4600, which, for the 44 enterprises that supplied this data, meant an average workforce of 350 and a median of 150. In the context of chemical hazards, almost 23% (10 of 44) were enterprises with 'major chemical accident hazards' according to the criteria of the Seveso II Directive (1997) or 'hazardous enterprises' according to the criteria of Estonia's Chemicals Act 1998 (Parliament of Estonia, 1998).

The descriptive statistics were based on either or both the percentages and number of responses. The percentages were rounded into integers,

Table 1. Activities of the Estonian ISO 14001 Certified Businesses that were Surveyed (N=45)

Frequency	Business Activity Category	Size of Workforce and Chemical Accident Hazard (+)
6	Electronics and electrical equipment	70,110,110,130,490,520
5	Construction	90,220,270,290,330
4	Chemical industry	60+,60+,110+,210+
4	Energy Production and distribution	140,160+,300,990
3	Petroleum products	50+,110+,150+
3	Printing	40,50,180
2	Building materials	80,130
2	Design	70,100
2	Furniture industry	130,200
2	Metalworking	70,650
2	Waste management	210,350+
1	Animal husbandry	180
1	Aviation	Data Not Available
1	Automobile components production	800+
1	Forestry	1300
1	Medical equipment production	90
1	Oil shale production	4600
1	Port services	740
1	Textile industry	150
1	Transport and logistics	60
1	Wood industry	250

and when the number of responses, due to incomplete questionnaires, fell short of the total (45), the shortened total is indicated, e.g., 30% of 43. In addition to simple descriptive statistics, factor analysis using the SAS software (SAS Institute Inc., Cary, NC, USA) to uncover the main patterns and structures in emergency preparedness and response was used.

5. RESULTS AND DISCUSSION

5.1. Development of EmRA legislation and methodologies in Estonia

Similar to Sweden, Finland and Norway (Lonka, 1999), emergency risks are also assessed nationwide in Estonia. The development of EmRA has been essentially dependent on the formation and adoption of pertinent legislation, which was initially independent of EU legislation.

5.1.1. Period I: Transition from the Soviet republic to a re-established independent state

The emergency risk assessment topic in Estonia was recognised in 1992, when the Civil Protection Act (Parliament of Estonia, 1992) was adopted, which initially defined and established the goals of civil protection in a national context. This Act did not contain the word 'risk' or define its meaning; however, risk was the principal catalyst for conducting EmRAs. The primary aim of civil protection of those times was to identify the possible extraordinary situations, their possible causes, locations and consequences. Simultaneously, concrete requirements and legally acknowledged methodologies for risk assessments were absent at that time. The translation of the UNEP/APELL guidebook Hazard Identification and Evaluation in a Local Community (UNEP IE/PAC, 1992) into Estonian was an important developmental factor. The guidebook was based on the handbook of the Swedish Rescue Services Agency (1989). The translated text, which was prepared through the cooperation of the Estonian and Swedish Rescue Boards, led to the adoption of an approach known in Estonia as the 'Swedish methodology'. During the years from 1993 to 1999, only occasional pilot risk assessments were conducted using modifications of the Swedish methodology, most of which concerned chemically hazardous enterprises. A more intensive application of practical EmRAs was undertaken when the government passed the Estonian Chemicals Act (1998) and the corresponding regulations of the Minister of the Interior (1999) into law. These documents already considered the principles and selected criteria of EU legislation.

5.1.2. Period II: EU acceptance through 2008

An important feature of this period was the adoption the Estonian Emergency Preparedness Act (Parliament of Estonia, 2000), which clearly at-

tempted to conform to the EU legislative framework. The Act defined risk assessment as an important task of crisis management from which all following measures of crisis management should be organised. This Act also specified two types of risk assessment, territorial risk assessment (TRA) and functional risk assessment (FRA). The TRA concerned the counties, the largest cities and communities, whereas the FRA involved the Ministries and their areas of government. Pertinent risk assessment methodologies were integral to the Act. Both the TRA and the FRA methodologies are essentially variants of the aforementioned Swedish methodology (UNEP/APELL), and they were developed and adjusted to Estonian conditions by work groups, with the organisational and/or financial support of the Ministry of the Interior. The risk assessment that is conducted by these two methodologies is basically a risk matrix approach, which uses a 5-step ranking system for both the assessment of probability (1–5, with 1 as the lowest and 5 as the highest) and the assessment of consequences (A–E, with A as the least serious and E as the most serious).

The methodology of TRA was established by a special regulation in 'Methodology of risk assessment of the county, the community and the city' (Minister of the Interior, 2001). The objective of risk assessment in the context of this regulation was to determine and to assess certain types of possible accidents in the territory of counties, communities or cities, as well as the probabilities of their occurrences. The methodology required the assessment of multi-hazard risks of 16 main types of possible accidents or hazards. These types, in alphabetical order, were as follows: building collapses, communal systems, communication systems, dangerous chemicals, drinking water pollution, electricity supply, epidemics, epizootics, explosions, extreme environmental conditions, forest fires, floods, gas, social hazards, transport and water bodies. The Emergency Preparedness Act of 2000 included the requirement that the outcomes of risk assessments formed the basis for composing crisis management plans and spatial (or land use) planning in the contexts of county plans, comprehensive plans, detailed plans and specific building projects. This important requirement expressed the requirement for further research and the development of a more effective link between risk assessment and land use planning.

The methodology of FRA was presented in the guidance document 'The Schedule and Methodology of Ministerial Risk Assessment' (Ministry of the Interior, 2003), which conformed to the decisions of the Crisis Com-

mission of the Government of the Republic of Estonia and was amended until 2007. The aims of FRA were to assess possible emergencies and their corresponding hazards in the fields and relevant institutions for which each Government Ministry was responsible. The FRAs were performed by work groups of the Ministries. The methodology of FRA did not require the Ministries to detail these emergencies because the risks that were classified as being highly probable and/or of the most serious consequence could be analysed at a later date. All Ministries (except for the Ministry of Defence, which was exempted from the requirement) conducted FRAs, and the counties and most of the largest cities in Estonia conducted TRAs in the frames of the requirements of those times.

The Estonian risk matrices, which were recommended in the TRA and FRA methodologies, did not originally contain the risk ranking divisions, which enabled a creative approach to the problem on the one hand but complicated the comparison of risk assessments on the other. The following examples of the risk matrices from the risk assessments of the cities of Estonia (Figure 1 to Figure 4, adopted from paper **IV**) demonstrate the variability of the approaches of that period.

The risk matrix form for the methodology is displayed in Figure 1, using the example of the city Narva, where risk ranking was not determined on

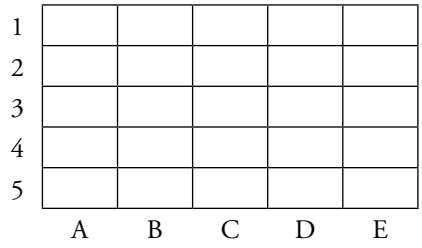

Figure 1. Risk matrix of Narva.

	A	B	C	D	E
1	II	III	IV	V	VI
2	II	III	IV	V	VI
3	I	III	IV	V	VI
4	I	I	I	V	VI
5	I	I	I	I	I

Figure 2. Risk matrix of Tallinn.

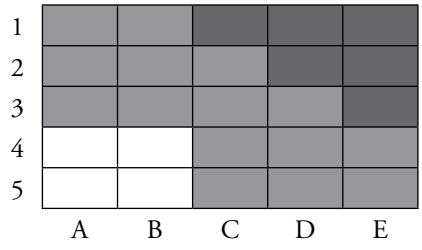

Figure 4. Risk matrix of Tartu.

	A	B	C	D	E
1	II	V	V	VII	VII
2	II	V	V	VII	VII
3	II	IV	IV	VI	VI
4	I	IV	IV	VI	VI
5	I	I	III	III	III

Figure 5. Risk matrix of Pärnu.

the matrix. The blank risk matrix of Narva represents the original "pure" one from the TRA methodology, without determined risk ranking zones. The blank risk matrix of Tallinn (Figure 2) is divided into 6 (I-VI) risk ranking zones. Analogous with the British risk matrix, the relative importance of the consequences is accentuated, but, most likely, with too high a degree of contrast. For example, in the case of catastrophic consequences, the events with a small likelihood belong to the VI zone, which is the highest, and the events with an extremely small likelihood to zone I, which is the lowest. The blank risk matrix of Tartu (Figure 3) uses the three risk ranking zones on the matrix (originally red, yellow and green), where likelihood and consequences have proportional weights. The blank risk matrix (Figure 4) of Pärnu uses seven (I-VII) risk-ranking zones. The last two zones had noticeable aberrances from the general logics of a risk matrix, where the risk increases "diagonally" towards the matrix, following the increasing values of likelihood and consequences (or impacts).

5.1.3. Period III: Current development as a member of the EU

The adoption of the Emergency Act (Parliament of Estonia, 2009) into law designated the onset of Period III. The Act defines risk assessment as a document that identifies the risk coupled with a report of the risk assessment outcomes. The risk assessment should include all relevant data pertaining to the emergency: a description, hazards causing the event, the probability and the consequences of the event, related information, references to applied models and to the sources and other relevant information on which the risk assessment is based. With this Act, risk assessment becomes more emergency-based; delineated distinction between the FRA and the TRA disappears. This substantial difference means that work groups, which consist of representatives of various National Boards, now assess the risks of concrete emergencies. These work groups can be amended with additional competence from civil service, research and development institutions, as well as from the private sector. This new approach enables Estonia the versatile opportunity to follow the contemporary principles of risk governance: communication, inclusion, integration and reflection, as determined by van Asselt and Renn (2011).

According to the Emergency Act of 2009, the Government had to establish a list of emergencies, which define 26 types of events, all of which must be assessed for risk at the national level (Government of the Republic, 2010). The Act also requires the compilation of interdisciplinary

work groups for each type of emergency, which are formed by an authorised competent agency that is responsible for conducting the particular risk assessment. The quantity of emergency risks, which the Act requires at the regional level, is slightly smaller, consisting of 19 different types of events. The Emergency Act of 2009, with a fundamental difference from the previous Acts, assumes risk assessments for the continuous operation and provision of vital services. The arrangement of the continuous operation of vital services is delegated to particular Ministries, the Bank of Estonia and the municipalities. Simultaneously, the obligation of preparing the risk assessments for the continuous operation of vital services is placed on the direct providers of these services. The guidelines for the risk assessment of the continuous operation of vital services were established by the regulation of the Minister of the Interior, which principally means that a separate methodology was compiled for this specific sector.

The noticeable change in the methodological development of EmRA is the new orientation to the example of the British methodology in addition to the Swedish methodology (UNEP IE/PAC, 1992). The example methodology was developed in the UK and published as a chapter of the Emergency Preparedness Guidance (HM Government, 2005), which was, in turn, based on Australian methodology (Emergency Management Australia, 2004). The transition was blended because of the relative similarity between Estonia's thus far Swedish-based methodology and the UK's methodology for local communities (**IV**). The causes for this change of orientation in methodology were mostly practical, and an explanation is subsequently outlined. First, the British methodology was more recently developed and was novel. Second, the entire methodological concept and its particular steps of risk assessment were presented in a systematic and straightforward manner; these steps were also widely accepted and proven in solid practical applications (Ministry of the Interior, 2008a). Third, the system enabled the design of better solutions for several problematic characteristics of the previous methodology, e.g., risk rating (or ranking) into certain categories on the risk matrix. Fourth, as a purely practical advantage, the public version of the British methodology was easily available via the Internet and was composed in English. Before the Minister of the Interior (2010a) enacted the current Estonian EmRA methodology as a legal document, the Government's Crisis Management Committee (Ministry of the Interior, 2008a) compiled and made public a guide to the EmRA, which was available in both Estonian and English. This guide can be considered the Estonian version of the UK's methodology.

The new perspectives that were espoused from the UK's methodology were the principle of likelihood scoring and the risk rating (or ranking) on the risk matrix. Formerly, distinct and occasionally paradoxical scales for risk rating had been suggested by risk assessors, but a uniform methodological approach was missing. The likelihood scale of previous Estonian risk assessment methodologies (TRA and FRA) employed 5 steps, which were defined by the probability of a particular event occurring in n years; for example, probability (3) defined an event as occurring at least once in five years. The currently valid EmRA methodology also presents the likelihood scoring scales in 5 steps, which are defined periods of five years in percentages, and simultaneously, in the number of emergencies per certain background events. The last is observed more precisely in subdivision 5.4.3 of the current dissertation.

5.2. Performing Emergency Risk Assessments in Estonia

The following subjects in study **I** embrace three categories of emergency risk assessment: national risk assessment summaries on the state level, flood risk assessments and chemical accident risks assessments in establishment with fixed sites. The last two categories are covered with the requirements of corresponding EU directives.

5.2.1. National emergency risk assessment summaries

The publicly available issues of Estonian national risk assessment reports are attainable via the Internet for the period 2005-2011 (Ministry of the Interior, 2006, 2007a, 2008b, 2009, 2011). The annual national level risk assessments of 2005–2007 were compiled using the 'old' methodology (Ministry of the Interior, 2003), which was amended until 2007 (Ministry of the Interior, 2007b). By 2008, the first version of the current methodology was applied (Ministry of the Interior, 2008a), which was then amended to become the currently valid methodology (Minister of the Interior, 2010a). The summary of the emergency risk assessments of 2011 was completely based on the most recent methodology.

The summary reports of the national risk assessments from the four-year period from 2005–2008 exhibited a lack of continuity in the identification, definition and classification of emergencies. The comparison of assessed risks over this brief period was complicated because the quantity and the formulations of identified emergencies varied from year to year.

The main disparities concerned the number of identified emergencies, which ranged from 10 in 2005 to 26 in 2008, and the number of groups of emergencies, which ranged from 2 in 2005 to 5 in 2007. The key difference that occurred in 2008 was the application of Roman numeral codes I–XXVI to each of the 26 identified types of emergencies. This same technique was also applied to the summary of 2011. Subsequently the last two Estonian national risk assessment summary reports of 2008 (Ministry of the Interior, 2009) and 2011 (Ministry of the Interior, 2011) are observed in particular detail.

The summary report of 2008 was composed of 26 types of emergencies, as was required by the current EmRA methodology (Ministry of the Interior, 2008a). This system finally determined certain obligations for the assessment of emergency types. The emergencies were coded with Roman numerals from I to XXVI, and the evaluated risks were marked on the corresponding division of the risk matrix. The list of the emergencies was composed of several definitions, which included quantitative pre-assessment components concerned the estimated consequences, such as an aircraft accident or its dissipation with many victims or extensive marine pollution. We still hold that the definition of an emergency should not initially consist of the determined criteria of its consequences, which are essentially the components evaluated during the risk assessment. Emergency risks were assigned into 4 risk rating groups, which are described below, with reference to the previously described risk rating principles.

- Very high risk – extensive marine pollution (IV)
- High risk – extensive forest and brush fire (I)
- Medium risk – road accident with many casualties (VIII)
- Low risk – extraordinarily cold (XIV) or hot (XV) weather

The summary report of 2011 observed the same principles in dividing the emergencies (or emergency risks) into 26 types (or more precisely into 25 types, as the risk assessment of one of the new categories, the hostage crisis, was confidential and not contained in the publicly available summary). Simultaneously, the typology and the numbers of the emergencies were changed. This conversion denotes that, in most cases, the same Roman numerals have different meanings in the matrices of 2008 and 2011, which complicates any simple one-to-one comparisons. A more circumstantial comparative analysis demonstrated that most of the assessed emergency risk types were fundamentally the same or similar. However, the formulations of many emergency definitions were

changed, and two new types of emergencies were included and the same number removed. This change generally led to better continuity in typology than that observed in the years from 2005 to 2008.

5.2.2. Chemical accident risk assessment

In Estonian legislation, the requirements for the assessment of chemical accident risks in dangerous enterprises and in enterprises that are likely to be affected by a major accident are based on the Chemicals Act (1998). Estonian legislation determines which establishments are dangerous and divides them into three categories, depending on the inherent hazardous characteristics of the substances these establishments process and the quantities stored. The threshold quantities of Estonia's two most stringent categories are outlined in the Seveso II Directive's Annex 1, by which enterprises (hereafter 'Seveso establishments') are deemed to be likely to be affected by a major accident. The number of Estonian Seveso establishments has increased from 53 in 2011 (Estonian Rescue Board, 2011) to 58 in 2013 (Estonian Rescue Board, 2013). The threshold quantities for the third category, which comprises 'dangerous enterprises', are substantially lower than those threshold quantities that were prescribed in the Seveso criteria. For instance, the threshold quantity for petrol (petroleum spirits) was previously 10 tonnes; consequently, the majority of Estonia's petrol stations belonged to this category. Since the 1st of October 2011, however, the threshold quantities for the 'dangerous enterprises' were increased, and the threshold for petrol (petroleum spirits) was raised to 100 tonnes. Due to this increase, the number of designated 'dangerous enterprises' dramatically decreased after that date. Originating from the corresponding regulation of the Estonian Government (Government of the Republic, 2011), 'dangerous enterprises' have a duty to perform risk assessments and to compose emergency plans.

The previous (Minister of the Interior, 1999; Minister of the Interior, 2003) and the current (Government of the Republic, 2011) regulations provided only generic requirements for risk assessments, which gave risk assessors a broad scope to select their methodologies and approaches. For example, researchers at the Tallinn University of Technology, acting as risk assessors (Paas et al., 2009), have used the risk matrix-based methodology of the University of Melbourne (2003).

Two mini-studies were performed in the frames of study **I** to observe the conformity of selected cases of chemical accident risk assessments with the current legislation for the time at which these assessments were conducted. Subsequently, the results of two mini-studies are presented.

First, in 2005, the 147 category three 'dangerous enterprises' of the South Estonian region were studied, which found that only 66% of the risk assessments complied with the generic requirements of 'The Procedures' regulations (Minister of the Interior 2003), which were valid during the period of the study.

Later, in 2010, the publicly available safety documents of five Estonian category one and two 'Seveso establishments' (Ministry of the Environment, 2010) were observed. These establishments utilised the following dangerous chemicals or groups of chemicals: Establishment 1 (oil products); Establishment 2 (ammonium nitrate); Establishment 3 (oil shale products); Establishment 4 (liquefied petroleum gas); and Establishment 5 (chlorine). Establishments (1), (4) and (5) based their risk assessments on a risk matrix. Establishment (1) used an elementary risk matrix with 3-step probability and consequence scales, similar to the risk matrix that was used in occupational risk assessment. Establishments (4) and (5) used risk matrices with 5-step scales, which were contingently compatible with those risk matrices used in TRAs. Establishments (4) and (5) also used simplified combinations of fault and event trees (bow-ties) for accident scenario identification and layer of protection analysis (EN 61511-3, 2005) in a qualitative form, without the probabilities of the safety barrier operations. Establishments (2) and (3) only emphasised the qualitative descriptions of risks. Establishments (2) and (5) calculated the consequences, based on safety distances according to certain criteria, whereas Establishments (1) and (4) used generic safety distances.

In compliance with the valid emergency risk assessment methodology (Minister of the Interior, 2010a) and the Emergency Act (Parliament of Estonia, 2009), major chemical accidents are also the responsibility of regional and national risk assessments. In spite of the absence of a 'major chemical accident' in the classifications of emergencies, which are required for regional or the national risk assessments, this type of event is linked to other types of classified emergencies. The following examples are selected from the 2011 National Summary of Risk Assessments for Emergencies (Ministry of the Interior, 2011):

- Extensive and/or complicated fire/explosion in industrial or warehouse buildings (production enterprises and warehouses with a risk of major accident, including explosive depots)
- Extensive pollution on coast/shore
- Mass poisoning
- Extensive contamination of ground, body of water or groundwater

Chemical accident risk assessments of dangerous establishments are an important source of data for regional and national risk assessments, and therefore, methodological compatibility is presumed by default. Because of this presumption, the assessors of dangerous enterprises have to consider that their results should be easily formatted to meet the input requirements of regional and national risk assessments. Problems may arise from the usage of quantitative and probabilistic methods, in which the probable consequences (fatalities) usually reflect individual and societal risks in concrete conditions. Quantitative methods are certainly more precise and informative; however, their outcomes are not directly adoptable as inputs to regional or national risk assessments. This issue could be solved by the development of a method that enables the comparison of risk assessment outcomes, with the aim of interpreting and converting their results into a suitable format. A similar solution already exists in the UK, where compatible criteria for risk-based and consequence-based approaches have been established for the definition of zones around a dangerous enterprise (Christou et al., 1999).

5.2.3. Flood risk assessments

Flood risk assessments, in the Estonian conditions, have two conclusive moments, which were observed and discussed in study **I**. First, the risk assessments must obey the special requirements of the EU's Flood Directive, particularly the compilation of flood risk or hazard maps; and second, the flood risk assessment must be performed by regional and national assessors.

The Estonian Ministry of the Environment is coordinating the performance of the directive requirements. Therefore, the ministry has commissioned research studies for the specification of the application conditions of the Flood Directive. Mugra and Sults (2006) studied flood mapping and concluded that the majority of existing maps were hazard maps. De Moel et al. (2009) found that the existing flood maps, which covered

the entire Estonian territory, were produced by the central government and were inherently historical. Kupits and Osjamets (2010) conducted a preliminary assessment of flood risks, using a framework in which they detailed the actual types of floods, their probability of occurrence and potential significant flood risk areas (PSFRA). In the same study, Kupits and Osjamets (2010) also observed many longstanding trends of water flow, which can affect the occurrence of floods. The Estonian Land Board recently created the flood hazard map layer on the digital map of Estonia for four cities: Tallinn, Pärnu, Haapaslu and Tartu (Estonian Land Board, 2012). The mapping was based on the water level rise height. The Kronstadt zero was taken as the initial height for Tallinn, Pärnu and Haapsalu, which are situated on the coasts of the Baltic Sea, and a compromise zero height was established for Tartu, which is situated inland on the banks of the River Emajõgi. The contour lines were counted with a range of 0.25 meters, starting from 0.5 meters above the zero levels.

Flood types are determined as either coastal or river floods in the public versions of the last two national EmRA summaries (Ministry of the Interior, 2009, 2011). Irrespective of the location and mechanism, the summaries infer that there is one unified emergency for flooding, which is defined as a flood in a high-density population area. The flood risk was assessed as high in both summary reports; however, the flood hazard or flood risk maps were not amended. Achieving a better conformance with the EU's Flood Directive assumes the disclosing of both types of maps to future versions of the national and regional EmRA summaries.

5.3. Applicability of emergency risk assessment outcomes

5.3.1. Environmental Assessment and Management

According to the Estonian experience thus far, risk assessment has been a part of many EIAs and SEAs, where the consideration of the probability of adverse outcomes was important, including engineered objects, in which abnormal and emergency situations were expected, such as (chemically) dangerous enterprises. While observing selected reports of EIAs and SEAs during study **I**, which were connected with the planning and projecting of new sites for 'Seveso establishments', preliminary evidence was found that the elements of qualitative, semi-quantitative and quantitative risk assessment approaches were used in different combinations. Simultaneously, the requirements for concrete methodological ap-

proaches were absent. Therefore, this subject may be a worthy direction for future studies.

The implementation of voluntary EMSs from ISO 14001 and from EMAS (EC, 2009) requires the applying organisations to prepare measures for emergency preparedness and response. These requirements include the identification of potential emergency situations, as well as potential accidents, which is equivalent to an assessment of the risks of these accidental events. Simultaneously, the risk sources can be identified with significant environmental aspects. Risk assessment, in the context of ISO 14001 and, more generically, in ISO-certified integrated management systems, is more thoroughly observed in subdivision 5.5 of the current dissertation, which is based on studies **V**, **VI** and **VII**.

5.3.2. Spatial planning and mapping

The currently valid version of the Estonian Planning Act (Parliament of Estonia, 2002) compels the consideration of the results of EmRAs at all determined levels of planning: national, county, comprehensive and detailed. The pertinent maps were previously, and are currently, required as appendices to both regional and national EmRAs. Simultaneously, there is much doubtfulness concerning the criteria of hazard or risk mapping, which are applicable in Estonian conditions. This ambiguity has caused assessors to employ a broad variety of approaches. To provide a solution to the problem of multiple approaches, we established the simple principles that are necessary for evaluating and mapping the hazards of local conditions during the study **II** from emergency risk assessment risk assessment outcomes of the Tartu municipality (Tammepuu et al., 2007). The circumstantial objective of the study was to select, group and analyse the scenarios of the rise of emergency situations in relation with land use and spatial planning in Tartu and to develop measures to mitigate environmental risk. The applied approach divided the emergencies, which originated from the characteristic of connectivity of the risk source or hazard with the surrounding space, into five clusters:

(1) Events that are characterised by the existence of a specific and localised risk source, for example, accidents at hazardous installations handling dangerous goods;
(2) Events with mobile sources of risk and logistics chains, for example, accidents with dangerous goods on traffic routes, rail routes and pipelines;

(3) Events where the risk source does not have a specific localisation but could be found in a limited area, for example, wildfires and fires in districts with a high proportion of old timber houses, where the level of fire protection is low;
(4) Events in which the main problem is not a surplus but a shortage of material or energy, mainly the coverage areas of certain supply networks, for example, electricity, water, gas supplies and communication system;
(5) Events that are 'hardly localisable,' where the exact or even indirect identification of a particular hazard area during risk assessment and its consideration in spatial planning procedures at the urban level is almost impossible, for example, natural disasters: thunder, snow and hailstorms, extreme snow conditions, unusually high and low temperatures, etc., but also some technological emergencies, such as nuclear accidents in a neighbouring country, also fall into this category.

Although the proposal dividing emergencies into these clusters can be only a preliminary solution, this proposal does enable a simple form of coverage for the problem of multi-hazard mapping for land use planning needs. Therefore, a good solution at the EU level requires the development of unified risk mapping tools that are suitable for multi-hazard or multi-risk mapping at the local level. Currently, the generic or consequence–based hazard zones of most of the 'Seveso enterprises' and 'hazardous enterprises' have been mapped by, and are available from, the Estonian Land Board (2012).

5.4. Comparative study of emergency risk assessments in Estonia and the UK

5.4.1. Generic remarks

The current dissertation embraces two comparative studies of emergency risk assessments of Estonia and the UK. Study **III** compares the public outcomes of the national risk assessments, whereas study **IV** discusses the risk assessment of selected cities of the two countries. The results of the mentioned studies are also partly summarised in study **I**. The main attention in the current dissertation focuses on national risk assessments and relies on publicly accessible information for both countries. Estonia and the UK began to arrange and undertake local, regional and national risk assessments in the middle of the last decade. The development

and implementation of Estonian emergency risk assessments has been reviewed and discussed in subdivisions 5.1.1 and 5.2.1 of the current dissertation. Subsequently, the organisation of the British risk assessment of public emergencies is briefly described below.

5.4.2. Arrangement of EmRa in the UK

The Government of the UK has performed emergency risk assessments since 2005 (Cabinet Office, 2010a). The Civil Contingencies Act of 2004 (Parliament of the UK, 2004) actuated the reorganisation of the emergency management system, which included risk assessment. The Act, as well as the Civil Contingencies Act of 2004 (Contingency Planning) and Regulations of 2005, puts the risk assessment duty on Category 1 responders and local resilience forums. The Category 1 responders are, briefly: emergency services, local authorities, health bodies and environment agencies (HM Government, 2005b). From these documents, it is clear that the crucial responsibility for emergency risk assessment lies on a local level.

The British risk assessment processes that are used at regional and national levels are not completely identical with the process on the local level, but have many characteristics in common and are generally consistent (HM Government, 2005a). The brief summary of the British national risk assessment process can be recognised in the NRR edition of 2010. Allegedly, the methodology of the British National Risk Assessment (NRA) is described more thoroughly in some other document, which is not available for public use because the NRA-s are stated as secret, and the NRR-s are only the public outputs of these assessments (Cabinet Office, 2010b).

The UK National Risk Register (NRR) is a public document from NRA National Risk Assessment, and the first NRR was published in August 2008 (Cabinet Office, 2010a, 2010b). The NRR 2010 Edition (Cabinet Office, 2010a), which is at the centre of attention in the current paper, is the second updated version, which is based on the 2009 iteration of the NRA (Cabinet Office, 2010b). The main changes to the 2010 Edition and the original NRR embrace the update of risk types and risks on the risk matrix and in the text, as well as in expansions of the last chapters of advisory and informative characteristics (Cabinet Office, 2010b). At the time of the composition of the current dissertation, the latest version of NRR is the 2013 edition (Cabinet Office, 2013).

5.4.3. Risk assessment processes in the two countries

The Estonian emergency risk assessment process, which is described in the methodologies (Ministry of the Interior, 2008a; Minister of the Interior, 2010a) is generically uniform for national, regional and local levels. The process consists of 6 steps, which are nearly one-to-one comparable with the steps of the British emergency risk assessment methodology for local responders because the latter has served as an example for the Estonian approach (HM Government, 2005a; Ministry of the Interior 2008a).

The Estonian national EmRAs were performed in working groups, which each included the representatives of different bureaus, and were conducted by a lead institution (Government of the Republic, 2010). Later, these initially independent assessments were collected into a summary by the Ministry of the Interior (2009, 2011). The British National Risk Assessment drew on expertise from a wide range of government departments and agencies (Cabinet Office, 2010a).

The consequences or impacts of the emergencies were presented with four categories in the national risk assessments outcomes of both countries. The categories were not completely one-to-one in conformance, but were postured in a comparative context, emanating from the definitions of these attributes (Cabinet Office, 2010a; Ministry of the Interior, 2009; Ministry of the Interior, 2008a) as follows in Table 2, which was adapted from paper **III**.

Table 2. The consequence (impact) categories

Estonia	**United Kingdom**
Categories of consequences	**Categories of impact**
Human life and health	The number of fatalities Human illness or injury
Vital service	Social disruption
Natural Environment	Economic damage
Assets	

The British approach takes a certain period of 5 years and sets the percentage and/or ratio of the accidental event. The Estonian EmRA methodology, which is currently in force, also presents the likelihood scoring scales in 5 steps, as defined periods of five years in percentages, and con-

currently, in the number of emergencies per certain background events. For instance, 1 chance in 20,000 that an emergency will take place during 5 years equates to 0.005% per 5-year period. The meaning of the entirety (100%) allows for various interpretations in the frames of this system, such as many ordinary events, many near misses, etc. The likelihood scoring criteria were not adopted like-for-like from the UK methodology, as brought out in Table 3, which was adapted from paper **I**.

Table 3. Probability criteria in Estonian and British risk assessment methodologies

Level	Estonian		British	
	Descriptor	Probability over 5 years	Descriptor	Probability over 5 years
1	Very small	<0.005% up to 0.05%	Negligible	>0.005%
2	Small	>0.05% up to 0.5%	Rare	>0.05%
3	Average	>0.5% up to 5%	Unlikely	>0.5%
4	Large	>5% up to 50%	Possible	>5%
5	Very large	>50%	Probable	>50%

The Estonian risk matrix (Minister of the Interior, 2010a) has the following position of the scales: likelihood on the vertical axis and consequences on the horizontal axis. In contrast, the scales on the British (local) risk matrix (HM Government, 2005a) are reversed. The Estonian risk matrix (see Figure 6) presents the likelihood levels by numbers (1-5) and the consequence levels by letters (A-E), whereas the UK risk matrix imposes numbers for both scales (see Figure 1), which is similar to the Finnish risk matrix (Allinniemi, 1994; Seppälä, 1994; Lonka, 1999).

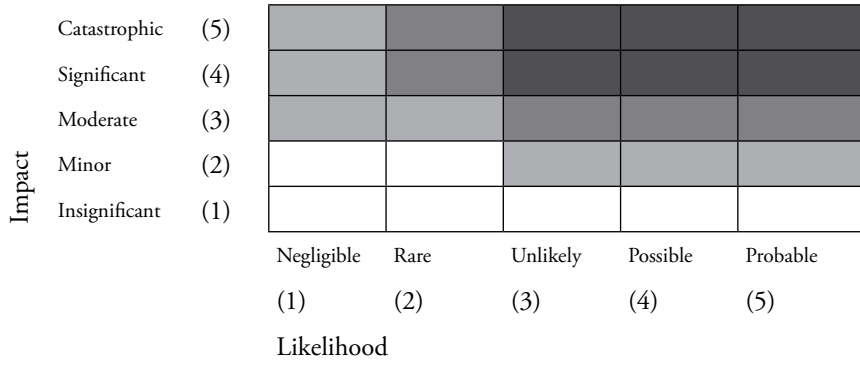

Figure 5. British local risk matrix (HM Government, 2005a)

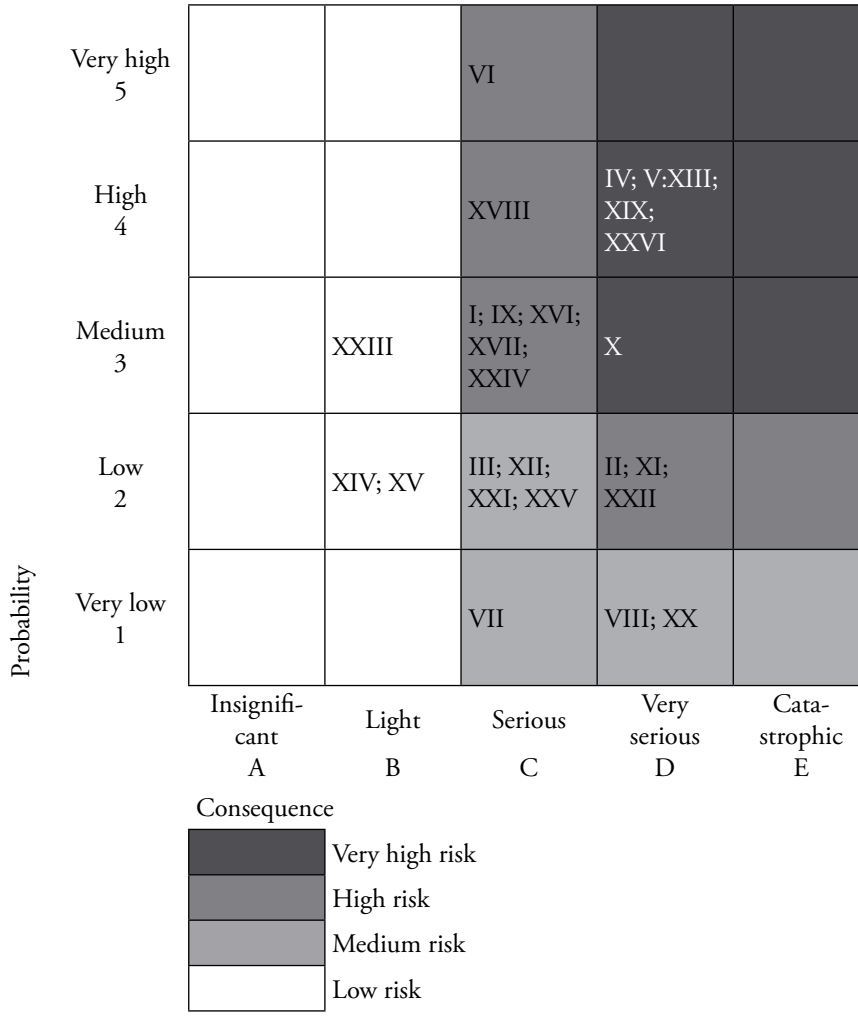

Figure 6. Estonian Risk Matrix 2008 (Ministry of the Interior, 2009)

The Roman numerals, which are displayed in the Estonian risk matrix of 2008 are the codes of the 26 assessed emergencies that were previously observed in subdivision 5.2.1 of the current dissertation.

The British local level risk matrix includes categories of risk rating with explanatory keys, which the Estonian methodology has espoused on an almost like-for-like basis. The main difference is that, whereas the Estonian risk matrix defines the level of likelihood of occurrence of 3B, 4B and 5B as 'low risk', the British risk matrix defines their equivalents, 2–3, 2–4 and 2-5, as 'medium risk'. The former Estonian risk matrix, which is analogous with the Swedish matrix (Swedish Rescue Services Agency,

1989; UNEP IE/PAC, 1992; Davidsson et al., 2003), did not initially contain the risk rating categories. This ambiguity caused the plural interpretations of the risk-rating problem, which were previously mentioned in subdivision 5.1.2. The risk rating categories, in both Figures 1 and 2, flow from 'very high' in the right upper corner through 'high' and 'medium' to 'low' in the left lower corner.

In spite of the widespread use of the risk matrix method, which also belongs to the European standardised risk assessment techniques (EN 31010, 2010) and is recommended by the Risk Assessment and Mapping Guidelines for Disaster Management (EC, 2010a), this method is not free of substantial imperfections. For example, Cox (2008) demonstrated that risk matrices have only a limited ability to reproduce the risk ratings correctly, and therefore, careful attention is necessary for using these ratings as risk assessment tools. Levine (2011), who considered previous critical studies, recommended that, in cases where quantitative methods are not available or a reasonable choice, the most defensible risk matrices are those matrices employing logarithmic scales and a logical progression of risk rating categories on the matrix horizontally, vertically and diagonally.

The Swedish, British and Estonian risk matrices that are used for emergency risk assessment have logarithmic scales in principle. This quality occurs more observably in the Probability (or Likelihood) scales and less detectably in the Consequence (Impact) scales, although the latter are defined by the combination of both quantitative and qualitative criteria. The division of risk rating categories in the British and Estonian matrices is not proportional and tends more in the direction of Impact (Consequence). The British matrix has a more coherent succession of risk rating categories; however, this matrix still contains paradoxical sections from 2–2 to 3–3 and 3–2 to 4–3, in which the risk rating is diagonally "jumping" from 'low' to 'high' and from 'medium' to 'very high', respectively. The Estonian matrix contains more paradoxes of a similar nature and is additionally divided into two areas, depending on Consequences: 'conventional accidents and operating problems' covering from 1A to 5B (white area) and 'emergency situations' including from 1C to 5E (grey areas). This division refers to the possible impact of the example of Irish emergency risk assessment methodology (A Framework for Major Emergency Management, 2006), where the division into the previously mentioned

two areas and their positions on the risk matrix, although formulated slightly differently, were identical.

The British NRR 2010 edition brings only relative scales for impact and likelihood assessment because these scales cannot be compared with the Estonian 5-point scales (basically similar with British local level). The last editions of NRR (Cabinet Office, 2012, 2013), which are not included in studies **I** and **III** of the current dissertation, have again distributed 5-point scales in use on the risk matrices.

5.4.4. Risk types and assessment outcomes

The EU Vademecum of Civil Protection (EC, 2010b) generically recommends the division of the typology of emergencies into two broad categories: natural and man-made disasters.

The public output documents of the national risk assessments of both of the observed countries (Ministry of the Interior, 2009; Cabinet Office, 2010a) presented the risks on risk matrixes.

The methodology, on which the 2008 Estonian national risk assessment was based, determined 26 emergency types in a one-step list, which indicates that the emergencies (or emergency risks) were not grouped into broader categories by certain features (see also subdivisions 5.1.3 and 5.2.1 of the current dissertation).

The British NRR 2010 edition divides emergency types into three broad categories, the first of which essentially includes natural events, and the last two categories include man-made events. The main risk types, in turn, contained sub-categories, which were described in the text of the NRR 2010 edition. The number of non-divided risk types and subtypes of the divided main types altogether included 23 events. In contrast with the risk matrix, which was recommended for UK local communities (see Figure 5, adapted from paper **III**), both scales of the British NRR 2010 matrix reflected correspondingly relative likelihood and impact without distributions. The British NRR 2010 matrix, as shown on Figure 7, displays 14 high consequence risks (**III**).

The implicit comparison of the assessed risks of the two countries, from the public outputs of Estonian 2008 and the British 2010 national risk

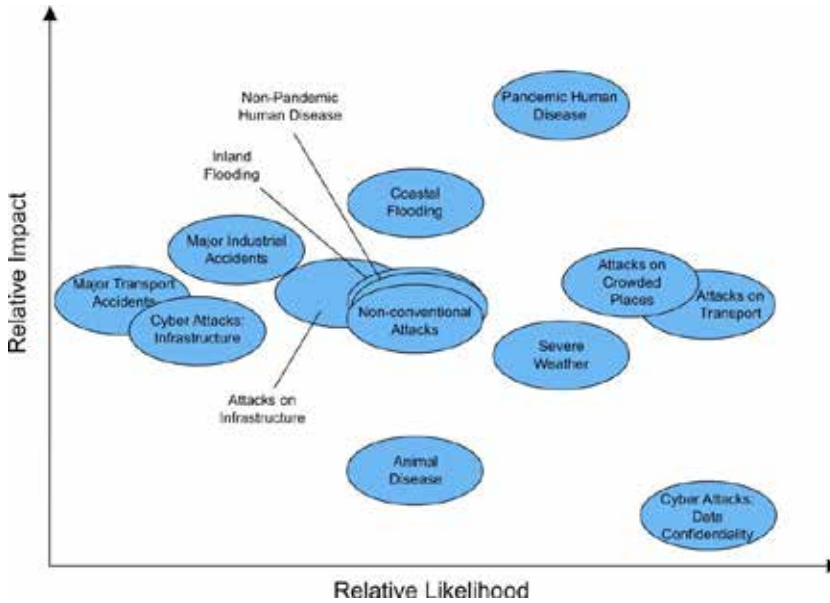

Figure 7. British National Risk Matrix 2010 (Cabinet Office, 2010a)

assessments, demonstrated the following: The risks of pandemic human disease were indicated in both countries as very high. The Estonian approach also determined the risks of extensive oil spills as very high; however, the British viewpoint did not observe these risks as independent accidental events because these events can be taken, in principle, as the results of transportation or industrial accidents. Flood risks were also assessed as remarkably high in the both countries, although, in the UK, coastal and inland floods were handled separately, and, in Estonia, the limiting criteria for flood risk assessment was localised in high-density areas. The risks arising from severe weather conditions were acknowledged as remarkably high in the both countries. Major industrial accident risks were assessed as relatively high in the both countries, whereas the risks of major transport accidents were more emphasised in the Estonian output document. The risk of cyber attacks was observed as higher in Estonia. Simultaneously, the British NRR 2010 accentuated the risks of different types of malicious attacks, which was even included as one of the broad categories of risks. In the Estonian approach, the corresponding events were not qualified as separate risk types, but simultaneous, for instance the risk of mass unrest, which could result from malicious attacks, which was estimated as high.

5.4.5. EmRA output documents

The plain comparison of the output documents (Ministry of the Interior, 2009; Cabinet Office, 2010a) demonstrated remarkable differences in composition and points of view.

The 2008 National Summary of Risk Assessments for Emergencies (Ministry of the Interior, 2009) of Estonia consisted of 2 generic and 26 specific chapters, as well as 9 appendixes. The specific chapters were the short summaries of risk assessments of concrete emergency types. Each specific chapter included the subdivisions as follows: a description of the emergency, historical facts and previous (similar) events, an overview of the hazards causing the emergency, assessment of risks, existing resources and actions for emergency prevention and consequences mitigation, as well as required additional resources and actions for emergency prevention and consequences mitigation. Appendix 1 was a risk matrix (Figure 1), and the remaining 8 appendixes contained informational materials in the forms of tables, maps or texts.

The British NRR 2010 edition (Cabinet Office, 2010a) consisted of five main chapters. The Chapter 1 introduction provided a summarising, which included, among other things, the national risk register matrix. Chapter 2 was a discussion of assessed risks according to the previously discussed three broad categories. For each category, features were observed, such as risk, background, and planning measures by the Government, the Devoted Administrations and the emergency responders. Chapters 3 and 4 provided orientations to risk communication, which addressed businesses and civilians, respectively. Chapter 5 was a brief overview of the risk assessment process on the national level. Each chapter contained many appropriate Internet references.

Generally, the British NRR 2010 edition was a more advising, guiding and directing document, whereas the Estonian national risk assessment output document of 2008 was primarily a summary of different emergency risk assessments.

5.5. Emergency risk assessment in Estonian ISO 14001 organisations

This chapter collocates the results of studies **V, VI** and **VII**, which all include different aspects of emergency preparedness and response in the ISO 14001, which certified organisations based on Estonian case studies.

5.5.1. Identification of possible emergencies and accidents in selected Estonian ISO 14001 certified organisations

The results indicated that 96% of the enterprises that were included in study **VII** identified any possible accidents and emergencies (the risks of these) in the frames of their assessments of environmental aspects. The causes of possible accidents, which were not environmental aspects of the organisations, were taken into account by 73% of these enterprises. Organisations exerted an occupational risk assessment in 82% of the cases for the identification of possible accidents, and 40% of the respondents, primarily those respondents with a chemical hazard, conducted additional environmental risk assessments. Other methodological approaches towards conducting assessments were additionally used by 13% of the organisations. The last method was composed of: qualitative assessment based on expert knowledge; methods originating from object-specific requirements; identification during environmental impact assessment; and specific methods of risk assessment, for example the risk assessments of raw materials and products. The personnel of each enterprises own personnel committed the identification of possible accidents and emergencies in 45% of 44 of the cases, and the identification was conducted by external consultants in only 32% of 44 or by a combination of both in 23% of 44 cases.

The types of accidents and emergencies that were identified by the organisations covered a range from the traditional (fire and vandalism) to the modern (bomb threats and IT security). The enterprises ranked fire (100%) as the most common type of possible accident with a logical outcome. Four-fifths of the enterprises (80%) defined possible accidents with dangerous chemical substances as a serious hazard, although only 23% of the enterprises were considered hazardous under the Estonian Chemicals Act or belonged to the establishments with major chemical accident hazard by the Seveso II Directive. The case organisations identified accidental pollution of soil and/or water (62%) as more probable than air pollution (31%). A remarkable hazard was explosions (58%); one reason for this result may be the identification of bomb threats as a potential cause of explosive events. Other accidents that were included were vandalism, technical break-downs, occupational accidents, natural gas accidents, slips, electrical accidents, animal epidemics, bomb threats, transportation accidents, security and IT risks and off-site events, such as major accidents at neighbouring enterprises, extreme natural conditions,

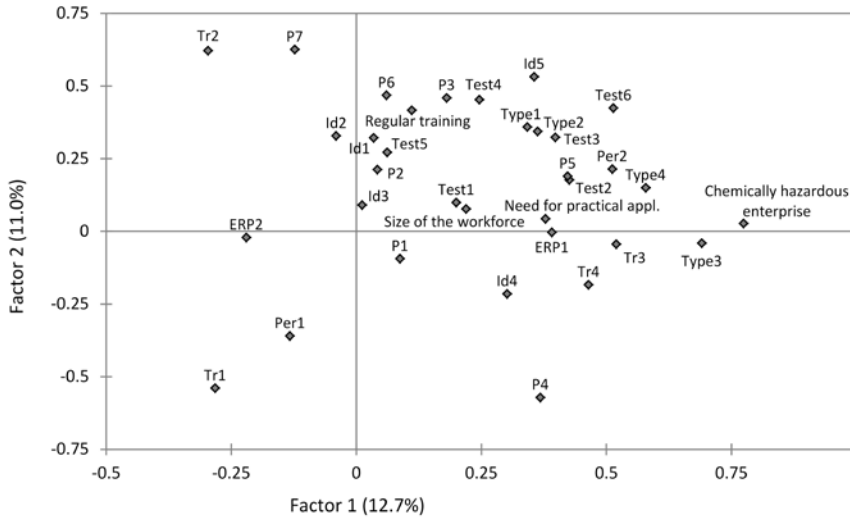

Figure 8. Results of the factor analysis of selected questions. Abbreviations that were used in the figure: Id – identification of possible emergencies and accidents (Id1: assessment of environmental aspects, Id2: assessment of off-site hazards, Id3: occupational risk assessment, Id4: additional environmental risk assessments, Id5: other methodological approaches), Per – persons identifying possible accidents and emergencies (Per1: enterprises' own personnel, Per2: external consultants), Type – types of identified accidents and emergencies (Type1: explosion, Type2: dangerous chemical substances, Type3: accidental air pollution, Type4: accidental pollution of soil and water), P – emergency preparedness and response procedures (P1: supplementary documents of preventive measures, P2: collection of safety guidelines, P3: fire safety document, P4: operational control manual, P5: occupational health and safety document, P6: emergency plans, P7: chemical safety document), ERP – general emergency response procedures (ERP1: common plan, ERP2: specific procedures not originating from the common plan), Tr – route to deliver a training procedure (Tr1: in-house personnel required to manage on their own, Tr2: foreign consultants employed to manage the entire procedure, Tr3: foreign consultants employed to support their in-house personnel, Tr4: selected categories of workers dispatched to thematic external courses), Test – testing of the emergency preparedness and response procedures (Test1: theoretical training with role-playing, Test2: practical training with selected employees, Test3: practical exercises for most of the employees, Test4: training exercises supervised by external instructors, Test5: practical exercises in cooperation with neighbouring enterprises, Test6: practical exercises in cooperation with emergency services (police, fire, ambulance) and other local or governmental offices.

epidemics, disruptions to the power supply and other networks, as well as radioactive pollution of the surroundings.

The factor analysis permitted the following conclusions concerning emergency risk assessment. The organisations with more hazard(s) more

often used the services of external consultants, as well as specific methods for the identification of possible emergencies and accidents. The organisations with low levels of hazards, but with well-developed safety measures, primarily used foreign consultants to manage their entire emergency preparedness and response procedure, including the organisation and execution of training. The results of the factor analysis are presented in Figure 8.

5.5.2. Emergency risk assessment in the Port of Tallinn

The safety audit in the frames of study **VI** enabled the observation of several paradoxical moments, which included the following: The identification of emergencies was conducted by groups of competent port employees. The lists of emergencies were composed independently of the assessment of environmental aspects and other similar procedures. The emergencies were primarily described qualitatively and relied on experiences and expert decisions. Despite the fact that the group members were aware of the environmental aspect assessments, as well as the risk assessments of the operators of 'Seveso enterprises' on the port areas, municipalities, etc., the outcomes of these assessments were only indirectly considered. The assessed (indirect) environmental aspects (of the terminals) included the release of hazardous chemicals and fire; however, the assessment methodology in use classified these aspects as non-significant. Therefore, the relevant environmental objectives and targets were presumably missing in the programmes of IMS. The procedure of EMS for emergency preparedness and response enacted the duty of coordinating the risk assessments of the operators, utilising dangerous goods, to the safety personnel of the ports. Simultaneously, the safety personnel did not actually have copies of the risk assessment outcomes or safety reports. Further, it became evident that one security company, who was a partner of the Port of Tallinn, had performed the general emergency risk assessment; however, the outcomes were somehow disremembered or shunned by the interested parties. Therefore, the composition of a systematic overview of the existing outcomes of different risk assessments and further application of additional assessment methodologies for accident and emergency risks, as well as for risk-related environmental aspects and impacts, was suggested based on the study.

5.5.3. Emergency risk assessment in Estonian ISO 14001 certified 'Seveso establishments': three case studies

The first case study in paper **V** was the process industry. The main risk sources were highly flammable gases that are analogous with LPG. The industry belongs to the lower tier according to the Seveso II Directive. The identification and evaluation of major hazards, and as well as planning for emergencies, were both enacted by the emergency preparedness procedure of the IMS, which had references to the procedures of environmental aspect assessments and the assessment of occupational hazards and risks. The internal standards of the corporation were also considered. The identification of hazards was accomplished by the well-known HAZOP (BS IEC 61882, 2001; EN 31010, 2010) methodology, in combination with the risk matrix for the assessment of risks. The establishment used a rather ordinary risk matrix: 5*5 – with five-point scales for both likelihood and consequences. The risk assessment outcome documents were compiled as appendixes of the IMS emergency preparedness procedure. The environmental aspects and occupational risks were assessed separately from emergency risks; however, the principles were quite similar to the major hazard risk assessment.

The second case study in paper **V** was an oil terminal. The limiting risk sources were crude oil and heavy and light naphtha products. The terminal belongs to the upper tier by the Seveso II Directive. The terminal had a uniform management policy, which also contained the essential elements of MAPP. The special procedure of emergency preparedness in the IMS was absent. Instead of this procedure, the elements of SMS, such as a safety report, risk assessment and an emergency plan are integrated into IMS to cover the provisions of subdivision 4.4.7 "Emergency preparedness and response" of the ISO 14001, i.e., replacing the missing special procedure. Until now, the risk identification of major hazards was primarily performed using a deterministic approach, which relied on the competences of attracted specialists, experts and consultants. The risks were assessed by a 5*5 risk matrix. The establishment has an orientation to apply HAZOP to improve of the identification of hazards.

The third case study in paper **V** was a water treatment plant. The decisive risk source, which was chlorine, was only used in one of several sites, specifically, where the owner company operated. Therefore, the IMS, which covered the entire company, and the SMS, which was obligatory

only for a certain site, were developed quite independently until the final times. The water treatment plant belongs to the lower tier according to the Seveso II Directive. The application of SMS already occurred under the conditions of a previously implemented and certified IMS, which included the ISO 9001 and ISO 14001 management systems. The IMS of quality and environmental management included the procedure of crisis management, which covered the provisions of 4.4.7 "Emergency preparedness and response" of the ISO 14001. The procedure was aimed to arrange preparedness and response against various types of possible emergencies beyond the entire company, and one of the guides, which originated from the procedure, was specifically a chlorine accident. Concurrently, for better compliance of SMS requirements, special documents, such as a chlorine accident risk assessment and emergency plan, were compiled for the water treatment plant, with the help of a consultation company. The risks were assessed by a 5*5 risk matrix. Afterwards, in the frames of the implementation of OHSAS 18001 and its integration into the IMS, the entire subject of risk was thoroughly revised, and a special procedure of risk management was compiled. The objective was to design a uniform approach to different types of risks, as well as environmental aspects. The company actuated the HAZOP methodology, covering all the production units, including the water treatment unit. The successive direction for a major accident risk from chlorine is the adjustment of the possible major accident scenarios, with the help of HAZOP, and bonding the risk assessment step-by-step with the methodological approach, which was derived from the risk management procedure of the IMS. During study **V**, there were good opportunities for this adjustment because the outputs of general (of the entire company), and chlorine emergency-specific, risk assessment resulted in 5*5 risk matrices, regardless of the diversely defined scales, levels and other criteria.

6. CONCLUSIONS

1. The development of the Estonian emergency risk assessment can be distributed into three periods, with certain limiting features. These divisions are the periods after transition, while joining the EU and the current state in the EU (**I**).

2. The factors causing the most intensive impact on the development of emergency risk assessment have been the Swedish and British methodologies, as well as the legislation concerning emergencies and chemicals. Those factors with the lease impact have been substantially influenced by the corresponding requirements of EU legislative acts. The main tools of emergency risk assessment were partially adopted from Swedish methodology, which were later improved by the example of the British methodology, with facilities for risk rating (or ranking) and a more flexible assessment of the likelihood (**I**).

3. The Estonian typology and classification of emergencies until now have demonstrated only slight continuity. During the period from 2005 to 2011, the numbers, names and the identification codes were the serial numbers in the list that was enforced by the provision of the Government of the Republic. This classification complicates the comparison of emergency risks by the crosscut of the years (**I**).

4. The regulation emanating from the Chemicals Act enacts the generic requirements for establishments with major chemical accident hazards and hazardous establishments, but simultaneously enables the application of different methodologies and criteria. Therefore, it will be relevant that the outcomes of chemical accident risk assessments were compatible with the validated requirements and criteria for emergency risk assessments (**I**).

5. In relation to the changeover to the emergency-centric and interdisciplinary emergency risk assessment, as well as the resignation of territorial risk assessment, less attention has been given to the concurrence of multiple risks. Emanating from the needs of spatial planning, this situation requires a solution that includes, among other things, the mapping of the hazard zones of different emergencies. One opportunity for this mapping is an approach of five clusters, which depend on the type and localisation of the risk sources (**I**, **II**).

6. The risk ranking on the risk matrix of the British example enabled the substantial renovation and unification of the risk rating in comparison with the previous method. Simultaneously, both Estonian and British (local level) risk matrices have many paradoxical moments, with the generic logics of risk matrix, which counts on an equable increase of risk by the diagonal of the (logarithmic) matrix (**I**, **III**, **IV**).

7. The renovation of the likelihood assessment by the British example permitted a more flexible approach; however, it remains unclear how exactly to consider a case per event or a percent (e.g., 1/2000 or 0.05%) in the five-year observation period (**I**, **IV**).

8. During the comparison of the public outputs of Estonian and British national risk assessments, similar risks were assessed as high or very high, such as epidemics or pandemics and severe weather conditions or floods. Additionally, one particular disparity was that, in Estonia, the risk of cyber attack was assessed as very high, whereas in the UK, different types of malicious attacks were emphasised. In these cases, the assessment results may be influenced by the risk perception of the assessors, which, to a certain extent, depends on actual events in the recent past (**III**).

9. The comparison of the public output documents of Estonian and British national risk assessments demonstrated that Estonian output documents were basically the compendiums of the summaries of the emergency risk assessments and that the British output documents provided broader objectives of risk communication, which contained specific guidelines for private and legal persons (**I**, **III**).

10. The studies of selected Estonian case organisations, which had implemented and certified the ISO 14001 standard, demonstrated that the identification of possible accidents and emergencies is performed in association with the identification of environmental aspects, also considering external factors, which are not environmental aspects of particular organisations (**V**, **VI**, **VII)**.

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SUMMARY IN ESTONIAN

Inimkond on kogu oma eksistentsi vältel olnud erinevate ohtude meelevallas, millest paljudega on kaasnenud tõsised õnnetused või katastroofid, mis on viinud hävinguliste sündmusteni. Suurõnnetused ja katastroofid on destabiliseerivateks teguriteks, mis võivad anda ühiskonna arengule tõsiseid tagasilööke, ohustades jätkusuutlikku arengut. Õnnetuste toimumine on enamasti etteaimamatu, olles seetõttu tihedalt seotud riski kontseptsiooniga. Ootamatute õnnetusjuhtumite ja hädaolukordade riskid ja ohud on sageli varjatud ning äratavad avalikkuse tähelepanu alles siis, kui midagi tõsist on juba juhtunud või juhtumas. Seetõttu on parema valmisoleku huvides oluline olla nendest riskidest ja ohtudest teadlik. Eeltoodu on ka põhjuseks, miks riskianalüüs on elanikkonnakaitse oluline komponent. Tänapäeval on hädaolukorraks valmisoleku ja sealhulgas ka riskide kindlaksmääramise ning nende hindamise nõuded leitavad paljudest rahvusvahelistest ja rahvuslikest õigusaktidest ning erinevatest standarditest.

Hädaolukorra riskianalüüsi valdkonnas Eesti Vabariigis tehti esimesed sammud eelmise sajandi viimasel kümnendil ja sellest ajast kuni tänaseni on riskianalüüsialane töö teinud läbi olulise arengu nii metodoloogilise lähenemise kui praktilise rakenduse osas. Vaatamata asjaolule, et riskianalüüs on praeguses Eestis kriisireguleerimise elulise tähtsusega koostisosa, esineb sellega seoses jätkuvalt mitmeid vastuolusid ja küsitavusi. Need hõlmavad nii õiguslikku käsitlust ja metodoloogilist lähenemist kui ka hädaolukordade klassifikatsiooni, määratlemist jm asjasse puutuvat.

Käesoleva dissertatsiooni käsitlusala hõlmab Eesti kui Euroopa Liidu n-ö uusliikme hädaolukorra riskianalüüsi arengu kulgu ja praegust olukorda. Dissertatsioonis käsitletakse riskianalüüsi korraldamise ja teostamisega seonduvat riiklikul, regionaalsel, kohalikul ja organisatsiooni tasandil. Olulist rolli dissertatsiooniga haaratud uuringutes etendab Eestis praktiseeritava riskianaüüsi võrdlus Suurbritannia ja Põhja-Iirimaa Ühendkuningriigi kui Euroopa Liidu n-ö vana liikmesmaa vastavasisulise tööga.

Dissertatsiooni põhieesmärgiks oli uurida hädaolukorra riskianalüüsi arengut Eestis alates taasiseseisvumisest kuni tänaseni, selgitades ühtlasi teiste riikide ja rahvusvaheliste institutsioonide õigusaktide, standardite ja juhendmaterjalide mõju.

Doktoritöö konkreetsemad eesmärgid olid järgmised:

1. Selgitada välja ja määrata kindlaks Eesti hädaolukorra riskianalüüsi arengu võtmesündmused ja mõjutegurid.

2. Uurida Eesti hädaolukorra riskianalüüsi ja selle tulemuste rakendamist riiklikul, regionaalsel, lokaalsel ja organisatsiooni tasandil.

3. Võrrelda Eesti ja Ühendkuningriigi riikliku ja kohaliku tasandi hädaolukorra riskianalüüse.

4. Uurida hädaolukorra riskianalüüsi ISO 14001 keskkonnajuhtimissüsteemi sertifikaati omavate valitud Eesti organisatsioonide kontekstis.

Uurimismaterjalideks olid Eesti ja teiste riikide ning rahvusvahelised õigusaktid, juhendamterjalid ja standardid, kus olid sätestatud või kajastusid hädaolukorra riskianalüüsialased nõudmised, metodoloogiad ning muud asjakohased teabeallikad. Võrdlevuuringutes (**I, III, IV**) kasutati Eesti ja Ühendkuningriigi riiklike riskianalüüside ning samuti valitud suuremate linnade ja linnastute riskianalüüside avalikke väljunddokumente.

Valdavaks uurimismeetodiks oli kvalitatiivsete meetodite hulka kuuluv tekstianalüüs (**I, II, III, IV, V, VI, VII**). Kvantitatiivsetest uurimismeetoditest kasutati kirjeldavat statistikat (**I, VII**) ja faktoranalüüsi (**VII**).

Uuringute tulemusete alusel tehti järgmised olulisemad järeldused:

1. Hädaolukorra riskianalüüsi arengut Eestis saab kindlate tegurite alusel jaotada kolme perioodi. Nendeks on taasiseseisvumisjärgne periood, Euroopa Liiduga liitumisprotsessi-aegne periood ja Euroopa Liidus liikmesriigina tegutsemise aegne periood (**I**).

2. Hädaolukorra riskianalüüsi arengut enim mõjutavateks teguriteks on olnud Rootsi Kuningriigi ja Ühendkuningriigi hädaolukorra riskianalüüside metoodikad ning hädaolukordi (sh üleujutusi) ja kemikaalikäitlust sätestavad seadused. Viimastele on avaldanud olulist mõju Euroopa Liidu õigusaktide vastavad nõuded. Rootsi metoodikast võeti üle põhilised riskianalüüsi töövahendid, mida täiendati hiljem Ühendkuningriigi metoodika alusel riskitaseme määramise ja tõenäosuse paindlikuma hindamise vahenditega (**I**).

3. Eestis on hädaolukordade tüpoloogia ja klassifikatsiooni määratlemise osas olnud seni järjekindlusetust. Aastate jooksul ajavahemikus 2005 kuni 2011 on korduvalt muutunud nii analüüsitavate hädaolukordade arv, nimetus kui ka kood, milleks on olnud järjekorranumber Vabariigi Valitsuse korraldusega jõustatud nimekirjas. See komplitseerib hädaolukorra riskide võrdlust aastate lõikes (**I**).

4. Kemikaaliseadusest tulenev määrus sätestab küll üldised nõuded suurõnnetuse ohuga ja ohtlikele objektidele, kuid samas võimaldab rakendada riskianalüüsi teostamisel erinevaid metoodikaid ja kriteeriumeid. Sellest tulenevalt oleks otstarbekas, et kemikaaliõnnetuste riskianalüüside väljundid oleksid ühildatavad hädaolukorra riskianalüüsi jaoks õiguslikult kehtestatud nõuete ja kriteeriumitega (**I**).

5. Seoses üleminekuga hädaolukorra riskide olukorrakesksele interdistsiplinaarsele hindamisele ja territoriaalse riskianalüüsi kaotamisele on vähenenud tähelepanu erinevate riskide koosmõju arvestamisele. Ruumilise planeerimise vajadustest lähtuvalt on vajalik leida olukorrale lahendus, mis eeldab muuhulgas ka erinevate hädaolukordade ohualade koos kaardistamist. Ühe võimaliku metoodilise võttena on käesolevas dissertatsioonis pakutud viiest klastrist koosnevat rühmitust sõltuvalt riskiallika iseloomust ja paiknemisest (**I, II**).

6. Riskimaatriksi liigendamine riskitasemeteks Ühendkuningriigi riskimaatriksi eeskujul võimaldas riskide tasemehindamise olulist korrastamist ja ühtlustamist võrreldes varasemaga. Samas ilmnevad nii Eesti kui ka Ühendkuningriigi (lokaalse tasandi) hädaolukorra riskimaatriksites vastuolud ristkimaatriksi üldise loogikaga, mis eeldab astmelist lähenemist, mis arvestab riski ühtlast suurenemist piki (logaritmskaaladega) maatriksi diagonaali (**I, III, IV**).

7. Tõenäosuste hindamise ümberkujundamine Ühendkuningriigi metoodika eeskujul võimaldab paindlikumat lähenemist, kuid samas jätab selgusetuks, mida konkreetselt peaks arvestama juhtumina sündmuste kohta või protsendina (näiteks 1/2000 ehk 0,05%) viieaastase vaatlusperioodi kohta (**I, IV**).

8. Eesti ja Ühendkuningriigi riiklike hädaolukorra riskianalüüside avalike väljundite võrdlusel ilmnes, et mõlemas riigis hinnati väga kõrgeks või kõrgeks järgmisi riske: epideemiad või pandeemiad, tõsi-

sed ilmastikutingimused ja üleujutused. Ühe erinevusena võib välja tuua, et Eestis hinnati väga kõrgeks küberrünnaku riski, samas kui Ühendkuningriigis olid fookuses erinevad kuritegelikud füüsilised rünnakud. Viimati mainitud juhtudel võivad hinnangud olla mõjutatud hindajate riskitajust, mis teatud määral sõltub lähiminevikus reaalselt aset leidnud sündmustest (**III**).

9. Eesti ja Ühendkuningriigi riiklike hädaolukordade riskianalüüside avalike väljunddokumentide võrdlus näitas, et kui Eesti väljunddokumendid olid peamiselt hädaolukordade riskianalüüside kokkuvõtete kogumikud, siis Ühendkuningriigi omad täitsid riskikommunikatsiooni laialdasemaid eesmärke, sisaldades konkreetseid suuniseid era- ja juriidilistele isikutele (**I, III**).

10. Uuringud ISO 14001 standardi juurutanud ja sertifitseerida lasknud valitud Eesti Vabariigi organisatsioonides näitasid, et enamasti teostatakse võimalike õnnetuste ja hädaolukordade identifitseerimine seostatult keskkonnaaspektide kindlaksmääramisega ning seejuures arvestatakse ka väliseid tegureid, mis ei ole konkreetse organisatsiooni keskkonnaaspektid (**V, VI, VII**).

ACKNOWLEDGEMENTS

Foremost I should like to render thanks to the University of Life Sciences, and the Institute of Agricultural and Environmental Sciences for the pleasant opportunity to carry out my doctoral studies.

I am especially grateful to my supervisor professor Kalev Sepp for his versatile advise, support and encouragement during all these years.

My best thanks to the complaisant personnel of all these organisations who were patient enough to answer the questionnaires, concerning emergency preparedness in environmental management systems.

I should like to thank the personnel of the Port of Tallinn, the City Council of Tartu and the City Council of Narva for their cooperation.

My special thanks to Evelin Uiga from Risk Management OÜ company and to Tõnu Paasoja from Estonian Aviation Academy for help with the expert advise.

I am thankful to my family for their patience, understanding and support.

These studies were granted by the Doctoral School of Earth Sciences and Ecology created under the auspices of European Social Fund.

These studies were supported by European Social Fund's Doctoral Studies and Internationalisation Programme DoRa. Programme DoRa is carried out by Archimedes Foundation.

These studies were also supported by the Target Funding Project No. 1090050s07 of the Ministry of Education and Science, Estonia; by the research group of risk management and civil protection of Estonian Academy of Security Sciences – domestic arrangement 6.1-5/182 and by the Interreg IIIB programme DaGoB.

I

ORIGINAL PUBLICATIONS

Tammepuu, A., Sepp, K. 2013.

EMERGENCY RISK ASSESSMENT:
THE ESTONIAN APPROACH

Journal of Risk Research, 16(2): 169–193.

Journal of Risk Research
2012, 1–25, iFirst Article

Routledge
Taylor & Francis Group

Emergency risk assessment: the Estonian approach

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(*Received 8 July 2011; final version received 16 July 2012*)

Although risk assessment in the field of civil protection is a vital element of emergency and disaster prevention, EU policy directives do not promote a common methodological approach for evaluating the performance of emergency risk assessments (EmRAs). Consequently, new member states have based the development of their national risk assessment systems on examples from the EU-15 member states and elsewhere. The latest important trend in the EU is the construction of unified guidelines on risk assessment and mapping for disaster management. This paper explores the developments in and problems of the risk assessment of emergency situations in post-Soviet Estonia. In the 1990s, the requirements for EmRA in Estonia were vague; only since 1998 has the Chemicals Act established more concrete requirements for hazardous industrial plants. Entry into the EU required Estonia to abide by and implement EU regulations. The primary aim of the current study was to conduct a survey on the development of Estonian EmRA since the restitution of Estonia as an independent state (1991). A secondary aim was to examine the impact of guidelines from other states and international institutions on the process of developing Estonia's regulations. Although this study emphasises the success of the key stages in the developmental process of Estonia's EmRA system, it also demonstrates the need for further improvement of the system's legal and methodological basis, as well as the practical arrangement of EmRA. The problems and solutions of EmRA in Estonia have common features with those in other EU member states, and therefore more cooperation inside the Union is recommended.

Keywords: assessment; civil protection; crisis management; emergency; hazard; legislation; risk; standards

Introduction

Hazards and risks, and their consequent emergencies, disasters and catastrophes, have always accompanied human development. Emergencies have occurred in the past, occur at present and will occur in the future (Tammepuu, Tammepuu, and Sepp 2009), and as Flynn and Theodore (2001, 80) argue, accident will happen in any given hazardous environment. Major hazards and accidents are examples of destabilising factors, which can cause serious setbacks to a continuous development process (Tammepuu et al. 2008). Disasters of both natural and human agencies pose

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ISSN 1366-9877 print/ISSN 1466-4461 online

http://dx.doi.org/10.1080/13669877.2012.726237
http://www.tandfonline.com

remarkable challenges to sustainable development in twenty-first century Europe (EC 2008a).

The unplanned and unforeseen nature of accidents means that they are usually handled in relation to risk. Institutions in all sectors of society can (and do) conceal the variables of the risks, hazards and threats of their operations from public attention until a serious accident occurs; therefore, society should be aware of all three of these variables (Tammepuu et al. 2008). Risk assessment is thus an essential part of civil protection (Tammepuu, Sepp, and Uiga 2007), and many European countries clearly recognise the usefulness of developing risk assessment standards in the field of civil protection and emergency preparedness (Lonka 1999). Requirements concerning accident risk identification and assessment for emergency preparedness currently exist in various international and Estonian national legal documents, as well as in international standards. For example, ISO 14001 refers to a set of requirements for emergency preparedness and response, focusing on the identification of possible accidents and emergencies (ISO 14001 2004).

Several recent studies concerning risk assessment in civil protection have focused on concrete accident types, e.g. major chemical accidents, according to the 'SEVESO II' Directive (EC 1997; Salvi and Gaston 2004; Salvi and Debray 2006). Fewer studies, either national or comparative, are available concerning the integrated approach of multi-hazard territorial risk assessment (TRA) and management. Lonka (1999) conducted a comparative study of risk assessment in the field of civil protection across several European countries. The European research project QUARTER focused on the development of a territorial management system for territorial risk reduction and environmental quality improvement (Treu, Colucci, and Lodrini 2004). In the context of this research project, Treu, Colucci, and Samakovlija (2005) developed a methodological framework for territorial vulnerability analysis and assessment, for which QUARTER's research group (Baldi, Martelli, and Treu 2004) proposed the Environmental Risk Management System procedure. Other research projects in the EU sphere are discussed later in the paper. Unfortunately, an inclusive overview of the risks that the EU faces does not exist. This lack is due to the diversity of methodological approaches employed in previous studies, which has reduced the comparability of information and caused difficulties in data consolidation at the EU level (Commission of the European Communities 2009).

A report from the EUROBALTIC I project, which was conducted in the Baltic Sea region, has introduced several methodologies for the risk assessment, management and mapping that were developed and applied in the countries of that region (Hedin, Hellenberg, and Pursiainen 2006). In Estonia, Tint et al. (2003) and Paas, Tint, and Järvis (2009) have discussed the problems of major accident hazards on the basis of Tallinn's risk assessments. Tammepuu, Sepp, and Uiga (2007) studied the aspects of risk assessment in land use planning, based on Tartu's risk assessment, engaging a number of different types of emergency risk. Tammepuu et al. (2008) conducted a comparative study on the risk assessment strategies of cities in Estonia and the UK and Tammepuu, Tammepuu, and Sepp (2009) examined emergency risk assessment (EmRA) in a Port of Tallinn facility. Although risk assessment is currently an essential component of Estonian crisis management, many gaps, contradictions and ambiguities remain concerning its legal and methodological requirements, classifications, indicators, etc. Therefore, the current study had three overarching aims in the context of EmRA: (1) to perform an overview survey on the development of Estonian EmRA; (2) to research the impact of international and

national regulations and methodologies on the development of Estonian EmRA; and (3) to discuss the applicability of EmRA and its outcomes in the context of environmental assessment and management as well as spatial planning and mapping. Throughout the current study, analogous materials from the UK were chosen for the purposes of comparison, as the Estonian Ministry of the Interior (2008) has recently adopted the UK approach for Estonian methodological development of EmRA.

Emergency risk in a context of civil protection

The term 'risk' is widely used both in the scientific world and in the everyday life (Christou 1998). Risk is an integral part of life (Smith 2001) that has become one of the most powerful concepts in modern society (Leiss and Chociolko 1994), to the extent that today's world has even been called a 'risk society' (Beck 2000). A great many 'risk' researchers and practitioners are involved in research studies, and risk appears to be a crucial component of many important societal decisions. Wlodarczyk and Tennyson (2003) contend that risk is both the product of the harmful consequence of an activity or event and the probability of its occurrence. Safety literature most commonly defines risk as the probability of an adverse future event multiplied by its magnitude (Adams 2001). Although contemporary society is greatly concerned with many aspects of risk, the concept of risk and its assessment and management have not yet been sufficiently developed to provide a holistic approach (Aven and Kristensen 2005). The EU Civil Protection Financial Instrument (EC 2007a) defines an emergency as any situation that has or may have an adverse impact on people, and preparedness is defined as a state of readiness in which the capacity of human and material means enables protection against such emergencies (EC 2007a, 2007b, Article 3). The UN ISDR terminology considers the terms 'crisis' and 'emergency' as effectively the same, with both being 'a threatening condition that requires urgent action' (UN ISDR 2009, 12). The glossary of the European Environment Agency (EEA 2010) defines collocations containing 'emergency', such as 'emergency law' and 'emergency plan', but unfortunately not the word 'emergency' itself. The Estonian Emergency Preparedness Act (Parliament of Estonia 2000), which was valid until 23 July 2009, designated an emergency as 'an event or a chain of events, which endangers national security, the life and health of persons, causes significant damages to the environment or extensive economic damage' (Parliament of Estonia 2000: Section 2 of General Provisions). Responding to any of these events requires 'the co-ordinated action of the Government of the Republic, government agencies and local governments' (Parliament of Estonia 2000: Section 2 of General Provisions). This definition is comparable to Smith's definition of disaster as:

> [A]n event, concentrated in time and space, in which a community experiences severe danger and disruption of its essential functions, accompanied by widespread human, material, or environmental losses, which often exceed the ability of the community to cope without external assistance. (Smith 2001, 7)

The new Estonian Emergency Act (Parliament of Estonia 2009) defines an emergency as:

> … an event or a chain of events, which endangers the life or health of many people or causes significant proprietary damage or significant environmental damage or severe and extensive disruptions in the continuous operation of vital services and responding to which requires the prompt co-ordinated activities of several agencies or the persons engaged by them. (Parliament of Estonia 2009: Section 2 of General Provisions)

In our opinion, an emergency can be defined as an accident for which external aid is required to provide an adequate response. We recognise a minimum of four levels of additional aid: (1) institutions need to call emergency services such as the fire brigade, ambulance, police, etc.; (2) local community councils ask for help from the regional level; (3) regions ask for national government help; and (4) the national government asks for international aid. We consider emergencies as the risk of undesired events in a number of levels of severity, starting from everyday incidents and proceeding through accidents to disasters and, finally, catastrophes. Simultaneously, we propose that the majority of emergency risks be classified essentially as specific 'environmental risks' on the basis that the EEA Glossary (EEA 2010) defines environmental risk as the 'likelihood, or probability, of injury, disease, or death resulting from exposure to a potential environmental hazard'.

Estonian background

Estonia is one of the post-2004 'new' members of the EU, each of which has a different twentieth century background, in contrast with the 'old' EU-15 members. Estonia's experiences in the previous century have undoubtedly influenced the societal and scientific development of risk assessment and associated concepts in the country. Both geographically and geologically, Estonia is a safe environment that is unaffected by plate tectonic activities (volcanoes, earthquakes and tsunamis) or any major environmental hazards except for its low-lying west coast, which is prone to flooding by the Baltic Sea. The legacy of human activity in northern Estonia during the latter half of the twentieth century does, however, cause a high degree of concern for the environment; the excavation of oil shale in the Kohtla-Järve and Kiviõli area, the storage of nuclear waste at Saku from the Soviet training reactor at Paldiski and the Soviet processing of uranium at Sillamäe all provide possible threats to environmental safety. During the Soviet period 1944–1991, EmRA research into these activities, in the context of the contemporary definition of 'risk assessment', did not occur.

On regaining independence in 1991, Estonia began to develop its regulative framework, and on admission to the EU, this framework was transformed to adopt the EU legislation requirements. Consequently, the need to elaborate new regulations drove Estonia's implementation of risk assessment. Between 1991 and 2004, Estonia was a society in transition, and in moving from an authoritarian planned economy under the Soviet sphere of influence to a democratic free market economy within the EU, the country experienced rapid socio-economic and environmental changes. The process of change brought about the wider societal perception and recognition of risk-related issues and the necessity for corresponding research into those issues. Since regaining its independence, Estonia has gradually transformed the previous Soviet-based, military-style civil defence system into a comprehensive civil protection system (Stern et al. 2002). The organisational structure of this system is centralised, i.e. coordinated and mostly organised by the central national civil protection authority (Elomaa and Halonen 2007).

Development of EmRA legislation and methodologies

General characteristics

As in Finland, Sweden and Norway (Lonka 1999), a nationwide system of risk assessment exists in Estonia. The development of EmRA has been substantially dependent on the formation and adoption of pertinent legislation, which was initially independent of EU legislation.

Period I: Transition from Soviet republic to re-established independent state

Risk assessment in the field of civil protection in Estonia began in 1992, when the Civil Protection Act (Parliament of Estonia 1992) was adopted; this law initially defined the meaning and established the goals of civil protection in a national context. The Act neither contains nor defines the word 'risk', but it essentially was the catalyst for conducting EmRAs. The primary aim of civil protection was to identify all the possible extraordinary situations in particular locations, their causes and the areas endangered by their consequences. Although this aim, in principle, presumes an assessment of the risk of those events, concrete requirements and legally acknowledged methodologies for such assessments were absent at the time. One important development was the Estonian translation of the UNEP/APELL guidebook Hazard Identification and Evaluation in a Local Community (UNEP IE/PAC 1992), which was based on the handbook of the Swedish Rescue Services Agency (1989). The translated text was prepared through the cooperation of the Estonian and Swedish Rescue Boards, and it led to the adoption of an approach known in Estonia as the 'Swedish methodology'. Several courses were held with the participation of Swedish specialists who introduced the theoretical basis and practical applications of this particular methodology. Between 1993 and 1999, only occasional pilot risk assessments were conducted using modifications of the Swedish methodology, most of which concerned chemically hazardous enterprises. A more intensive programme of practical EmRAs was undertaken when the government passed the Estonian Chemicals Act (1998) and the corresponding regulations of the Minister of the Interior (1999) into law. These documents partly adopted the principles and selected criteria of EU legislation. The risks of chemical emergencies will be covered in greater detail in a dedicated section of the paper.

Period II: EU acceptance to 2008

The key characteristic of this period was the adoption of a new legal act, the Estonian Emergency Preparedness Act (Parliament of Estonia 2000), which clearly attempted to conform to the EU legislative framework. This Act established risk assessment as an important task of crisis management on the basis of which all following measures of crisis management should be planned and implemented. The Act specified two types of risk assessment, TRA and functional risk assessment (FRA). The TRA involved the Ministries and their areas of government, whereas the FRA concerned the counties and the largest cities and communities. Pertinent risk assessment methodologies were integral to the Act. Both the TRA and the FRA methodologies are essentially variants of the aforementioned Swedish methodology (UNEP/APELL), and they were developed and adjusted to Estonian conditions by work groups with the organisational and/or financial support of the

Ministry of the Interior. Any risk assessment conducted via these two methodologies can be characterised as a risk matrix approach, which uses a 5-step ranking for both the assessment of probability (1–5, with 1 as the lowest and 5 as the highest) and the assessment of consequences (A–E, with A as the least serious and E as the most serious).

The methodological basis for TRA was established by special regulation in 'Methodology of risk assessment of the county, the community and the city' (Minister of the Interior 2001). The goal of risk assessment in the context of this regulation was to determine and assess certain types of possible accidents in the territory of counties, communities or cities, as well as the probabilities of their occurrences. Such a risk assessment would obtain an overview of the potential hazards for state security, human life and health, the environment and critical infrastructures. The methodology required the assessment of multi-hazard risks, 16 + *n* different types of possible accidents or hazards. The 16 types, in alphabetical order, were as follows: building collapses, communal systems, communication systems, dangerous chemicals, drinking water pollution, electricity supply, epidemics, epizootics, explosions, extreme environmental conditions, forest fires, floods, gas, social hazards, transport and water bodies.

The Emergency Preparedness Act of 2000 included the requirement that the outcomes of risk assessments had to be established as the basis for composing crisis management plans and spatial planning (land use) in the contexts of county plans, comprehensive plans, detailed plans and specific building projects. This was an important requirement as it expressed the need for further research and the development of a more effective link between risk assessment and land use planning.

The methodological basis for FRA was the guidance document 'The Schedule and Methodology of Ministerial Risk Assessment' (Ministry of the Interior 2003), which conformed to the decisions of the Crisis Commission of the Government of the Republic of Estonia and was amended until 2007. The primary and secondary aims of FRA were to assess possible emergencies and their corresponding hazards in the fields and relevant institutions for which each Government Ministry was responsible. The methodology of FRA did not require the Ministries to detail these emergencies, as any risks classified as being highly probable and/or of the most serious consequence could be analysed at a later date. Work groups of the Ministries were mainly responsible for conducting the FRAs. To date, all Ministries (except for the Ministry of Defence, which was exempted from the requirement) have conducted FRAs and the counties and most of the largest cities in Estonia have conducted TRAs.

Period III: Current development as a member of the EU

The adoption into law of the Emergency Act (Parliament of Estonia 2009) marked the beginning of Period III. The Emergency Act combined the requirements of the previous Emergency Preparedness Act of 2000 and the Emergency Situation Act of 1996 (amended in 2002), while simultaneously superseding both Acts. The Emergency Act defines risk assessment as a document that identifies the risk coupled with a report of the risk assessment outcomes. The risk assessment should contain all relevant data pertaining to the emergency: a description, hazards causing the event, the probability and the consequences of the event, related information,

references to applied models and the sources and other relevant information on which the risk assessment is based.

The Emergency Act no longer makes a distinction between the FRA and the TRA of the Emergency Preparedness Act of 2000, but instead makes risk assessment more emergency-based. This key difference means that work groups, consisting of representatives of various National Boards, now assess the risks of concrete emergencies. These work groups can be amended with additional competent persons from civil service, research and development institutions, and from the private sector. Such an approach flexibly and conveniently enables Estonia to follow the contemporary principles of risk governance: communication and inclusion, integration and reflection, as determined by van Asselt and Renn (2011). The Emergency Act of 2009 required the Government to establish a list of emergencies, which defines 26 types of events, all of which must be assessed for risk at the state level (Government of the Republic 2010). The Act also requires the appointment, for each risk type, of a competent agency, which is responsible for forming a work group to conduct the risk assessment. The quantity of emergency risks, which the Act requires to be assessed at the regional level, is slightly smaller and includes 19 different types of events.

The Emergency Act of 2009, in a fundamental difference from the previous Acts, requires risk assessments for the continuous operation and provision of vital services. The organising of the continuous operation of vital services is delegated to particular Ministries, the Bank of Estonia and the municipalities, whereas the obligation of preparing the risk assessments of the continuous operation of vital services is placed on the direct providers of these services. The guidelines for the risk assessment of the continuous operation of vital services were established by the regulation of the Minister of the Interior, which essentially means that a separate methodological approach was employed for this specific sector. The paper further discusses the topic of continuous operation of vital services in a special dedicated section.

The most notable change in the methodological development of EmRA is the re-orientation away from the Swedish methodology (UNEP IE/PAC 1992) in favour of the methodology developed in the UK and published as a chapter of Emergency Preparedness Guidance (HM Government 2005), which was in turn based on Australian methodology (Emergency Management Australia 2004). The transition was smooth, as Estonia's Swedish-based methodology and the UK's methodology consist of similar steps of action and are consequently comparable (Tammepuu et al. 2008). The reasons for this change of orientation in methodology were mostly practical, and an explanation is outlined as follows. Firstly, the British methodology was recently developed and was novel. Secondly, the entire methodological concept and its particular steps of risk assessment were presented in a systematic and straightforward manner; they were also widely accepted and proven in solid practical applications (Ministry of the Interior 2008a). Thirdly, the system enabled the design of better solutions for several problematic characteristics of the previous methodology, e.g. risk rating (or ranking) into certain categories on the risk matrix. Fourthly, as a purely practical advantage, the public version of the British methodology was easily available via the Internet and was written in English. Prior to the Minister of the Interior (2010a) enacting the current Estonian EmRA methodology as a legal document, the Government's Crisis Management Committee (Ministry of the Interior 2008a) compiled and made public a guide to the system,

which was available in both Estonian and English. This guide can be considered as the generic Estonian modification of the UK's methodology.

The new aspects adopted from the UK's methodology were the principle of likelihood scoring and the risk rating (or ranking) on the risk matrix. Previously, variable and occasionally paradoxical scales for risk rating had been proposed by risk assessors, but a unified methodological approach was missing. The likelihood scale of earlier Estonian risk assessment methodologies (TRA and FRA) employed five steps, which were defined by the probability of a single event occurring in n years; for example: probability (3) defined an event occurring at least once in five years. The current EmRA methodology also presents the likelihood scoring scales in five steps, as defined periods of five years in percentages, and concurrently in the number of emergencies per certain background events. For example, one chance in 20,000 that an emergency will take place during 5 years equates to 0.005% per five-year period. The meaning of the entirety (100%) allows for various interpretations (Tammepuu et al. 2008) under this system, for example a number of ordinary events, a number of near misses, etc. The likelihood scoring criteria were not adopted like-for-like from the UK methodology (see Table 1).

The risk matrix of Estonian methodology (Minister of the Interior 2010a, 2010b) has the scale of likelihood on the vertical axis and the scale of consequences on the horizontal axis, whereas the scales on the British risk matrix (HM Government 2005) are reversed. The Estonian risk matrix (see Figure 2) displays the likelihood levels by numbers (1–5) and the consequence levels by letters (A–E), whereas the UK risk matrix, similar to the Finnish risk matrix (Allinniemi 1994; Seppälä 1994; Lonka 1999), uses numbers for both scales (see Figure 1).

The British risk matrix displays the five ranked categories of risk rating with explanatory keys, which the Estonian methodology has adopted on an almost like-for-like basis. The key difference is that, whereas the Estonian risk matrix defines the level of likelihood of occurrence of 3B, 4B and 5B as 'low risk', the British risk matrix defines their counterparts, 2–3, 2–4 and 2–5, as 'medium risk'. The previous Estonian risk matrix, like the Swedish matrix (Swedish Rescue Services Agency 1989; UNEP IE/PAC 1992; Davidsson et al. 2003), did not originally contain the risk rating categories; this ambiguity gave rise to the previously mentioned plural interpretations of the risk rating problem. The risk rating categories, in both Figures 1 and 2, run from 'very high' in the right upper corner through 'high' and 'medium' to 'low' in the left lower corner.

Despite the widespread use of risk matrix method, which belongs to the European standardised risk assessment techniques (EN 31010 2010) and is also

Table 1. Probability criteria in Estonian and British risk assessment methodologies.

	Estonian		British	
Level	Descriptor	Probability over five years (%)	Descriptor	Probability over five years (%)
1	Very small	< 0.005 up to 0.05	Negligible	>0.005
2	Small	>0.05 up to 0.5	Rare	>0.05
3	Average	>0.5 up to 5	Unlikely	>0.5
4	Large	>5 up to 50	Possible	>5
5	Very large	>50	Probable	>50

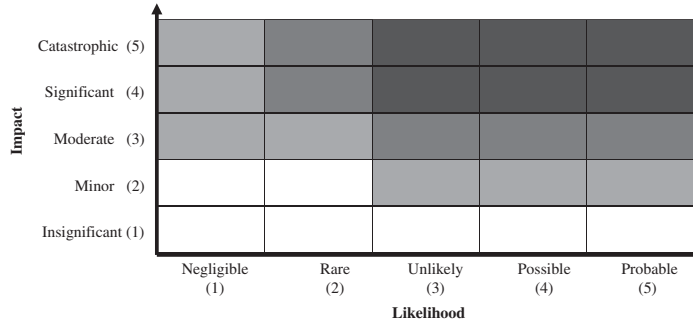

Figure 1. British risk matrix.

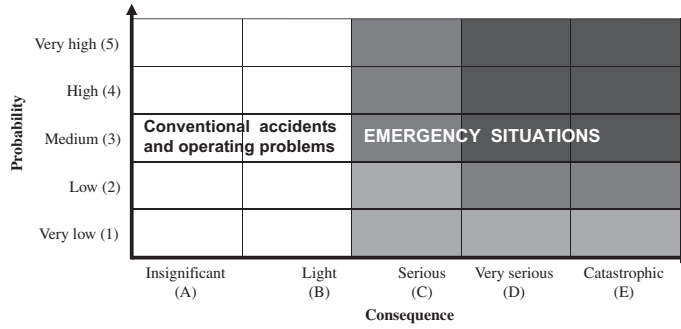

Figure 2. Estonian risk matrix.

recommended by Risk Assessment and Mapping Guidelines for Disaster Management (EC 2010a), it is not free of substantial imperfections. For example, Cox (2008) demonstrates by thorough theoretical analysis that risk matrices have only a limited ability to reproduce the risk ratings correctly; thus, caution is needed in using these ratings as risk assessment tools. Levine (2011), taking into account previous critical studies, suggests that in cases where quantitative methods are not available or a reasonable choice, the most defensible risk matrices are those employing logarithmic scales and a logical progression of risk rating categories on the matrix horizontally, vertically and diagonally. The Swedish, British and Estonian risk matrices used for EmRA have logarithmic scales in principle. This property is more clearly expressed in the probability (likelihood) scales and less detectable in the consequence (impact) scales, as the latter are defined by the combination of both quantitative and qualitative criteria. The division of risk rating categories in the British and Estonian matrices is not proportional, inclining more to the direction of impact (consequence). The British matrix generally has a more graceful succession of risk rating categories, but contains paradoxical sections from 2–2 to 3–3 and 3–2 to 4–3, in which the risk rating is diagonally 'jumping' from 'low' to 'high' and from 'medium' to 'very high', respectively. The Estonian version

contains more paradoxes of this nature, and the risk matrix is additionally divided into the areas of 'conventional accidents and operating problems' and 'emergency situations', depending on consequences. This division refers to the possible example of Irish EmRA methodology (A Framework for Major Emergency Management 2006), where the division into the previously mentioned two areas and their positions on the risk matrix, although formulated slightly differently, were identical.

Conducting EmRA

Brief overview

In recent years, regular summary reports of EmRAs at the national (nationwide) and local levels (counties, the largest cities and selected municipalities) have been produced. The new regulation (Minister of the Interior 2010a, 2010b) does not specifically concern local level EmRAs but emphasises the regional level, which consists of four rescue regions: North, South, East and West. The EmRAs of these regions are still being prepared and are not yet publicly available.

Two years ago, we conducted a comparative study of the EmRAs of four Estonian cities and four cities or conurbations of the UK (Tammepuu et al. 2008). We selected the administrative centres of each of the four rescue regions: Tallinn (North), Tartu (South), Narva (East) and Pärnu (West). In the UK, we selected London, Greater Manchester, the West Midlands conurbation (Birmingham and its surrounding urban areas) and Belfast. The survey demonstrated several conformities between the risk assessments of the two countries' cities, as was expected based on the similarity of their respective methodological bases. The UK cities' risk assessments were generally more homogenous as they have a more voluminous and detailed methodological basis. Estonian cities' risk assessments demonstrated more variability in individual comparisons, for example, in the previously mentioned risk rating categories, which were not determined by the previous methodology.

Subsequently, we examined the Estonian national level risk assessment summaries and compared them with the National Risk Register of the UK. During this survey, we focused on the definition and typology of emergencies (or emergency risks) on the basis of publicly available versions (Tammepuu and Sepp 2012).

State level EmRA summaries

The public versions of national risk assessment summaries are available via Internet for the period 2005–2011 (Ministry of the Interior 2006, 2007a, 2008b, 2009, 2011). The Ministry of the Interior composed the summaries of the annual national level risk assessments of 2005–2007 using the 'old' methodology (Ministry of the Interior 2003), which was amended until 2007 (Ministry of the Interior 2007b). By 2008, the Ministry of the Interior was using the first version of the current methodology (Ministry of the Interior 2008a), which was then amended to become the currently valid methodology (Minister of the Interior 2010a). The summary of the EmRAs of 2011 was completely based on the most recent methodology.

The summaries of the national risk assessments demonstrated a lack of continuity during the four-year period of 2005–2008 in the identification, definition and classification of emergencies. The quantity and the formulations of identified emergencies varied from year to year, which complicated the comparison of assessed risks over this brief period.

Baseline differences involved the number of identified emergencies, which ranged from 10 in 2005 to 26 in 2008, the number of Groups of Emergencies, which ranged from 2 in 2005 to 5 in 2007, and the removal of the time-scale for the probability aspect from 2007 onwards. The key difference that occurred in 2008 was the appendage of Roman numeral codes I–XXVI to each of the 26 identified types of emergencies. This same technique was also applied in the summary of 2011.

The summary of 2005 itemised 10 types of emergencies into two risk groups. The first consisted of emergencies characterised by a probability of occurrence of once in one to 10 years and serious or very serious consequences, such as epidemics and pandemics. The second consisted of emergencies characterised by lower probabilities of occurrence, once in more than 10 years, with very serious or catastrophic consequences, such as an emergency caused by radioactive substances.

The summary of 2006 itemised 18 types of risks into four groups and made recommendations for the management of these risks. The first group included those events assessed to have a high level of probability (once in 1–10 years) and very serious or serious consequences, such as pandemics and epidemics. The second group consisted of moderately probable emergencies (once in 10–25 years; in the case of radiation accidents, once in 25–50 years) with very serious or catastrophic consequences, such as an emergency caused by radioactive substances. The third group contained high or moderate probability emergencies with very serious or serious environmental and/or economic consequences, which in turn would affect the function of vital societal spheres and endanger human life and health, such as extensive marine pollution. The fourth group comprised low or very low probability events with catastrophic or very serious primarily economic consequences, which in turn would affect the function of vital societal spheres and endanger human life and health, such as a long-term breakdown of electronic communication.

The summary of 2007 presented 17 types of emergency risks, which were divided into the following five groups:

- Emergencies with high probability and very serious consequences (such as extensive marine pollution, epidemics and murrain).
- Emergencies with high probability and serious consequences (such as emergency caused by a large fire or explosion, massive intoxication and extensive environmental pollution).
- Emergencies with medium probability and very serious consequences (such as terrorism or a long-term and massive blackout).
- Emergencies with medium probability and serious consequences (such as a massive influx of refugees).
- Emergencies with low probability and serious consequences (such as an emergency caused by radioactive substances).

The summary of 2008 handled 26 types of emergencies, as was required by the current EmRA methodology (Ministry of the Interior 2008a); this system finally determined certain obligations for assessment emergency types. The emergencies were coded with Roman numerals from I to XXVI, and the evaluated risks were marked on the corresponding division of the risk matrix. The list of the emergencies comprised several definitions, which included quantitative pre-assessment components, concerning the estimated consequences, such as an aircraft accident or its dissipation with many victims or extensive marine pollution. We still hold that

the definition of an emergency should not initially consist of the determined criteria of its consequences, which are essentially the components evaluated during the risk assessment. Emergency risks were assigned into four risk rating groups, which are described below, on the basis of the previously described risk rating principles:

- Very high risk – extensive marine pollution (IV).
- High risk – extensive forest and brush fire (I).
- Medium risk – road accident with many casualties (VIII).
- Low risk – extraordinarily cold (XIV) or hot (XV) weather.

The recently published summary of 2011 followed the same principles in dividing the emergencies (or emergency risks) into 26 types (or more precisely into 25 types, as the risk assessment of one of the new categories, the hostage crisis, was confidential and not contained in the publicly available summary). At the same time, the typology and the numbers of the emergencies have changed. This alteration means that in most cases the same Roman numerals have different meanings in the matrices of 2008 and 2011, which complicates any simple one-to-one comparisons. A more detailed comparative analysis demonstrated that most of the assessed emergency risk types were basically the same or similar; only the formulations of a number of emergency definitions were changed and two new types of emergencies were included and the same number was removed. This generally led to better continuity in typology than that observed during the period from 2005 to 2008.

We conducted a parallel study using comparative material from another EU state, the UK's National Risk Register (Cabinet Office 2010). The Register delineates 14 high consequence risks (see the matrix on page 5, Cabinet Office 2010) split into three groups: natural events, major accidents and malicious attacks. Each of the 14 high consequence risks is placed in the matrix according to the variables of relative impact and relative likelihood. The matrix does not mention either the three groups or the risk rating categories. Furthermore, the Register succinctly explains, in a section titled 'Risks in Context', the reason for omitting time as a variable in rating the likelihood of emergencies occurring:

> In setting out the risks, their likelihood, and their impact, the National Risk Register is not predicting that any particular type of emergency will happen in the next five years or that, if it were to do so, it would happen on a specific scale. Events have a habit of confounding predictions; prudent emergency planning is based on consideration of a wide range of risks rather than on a forecast that any particular risk will occur in a time-schedule. (Cabinet Office 2010, 5)

On the basis of our comparison, the UK's National Risk Register of the UK was definitive, whereas the Estonian EmRA summaries contained condensed information (Tammepuu and Sepp 2012).

The various approaches employed across nations for identifying, defining and categorising emergencies (or disasters) make it difficult to ensure the continuity of comparative data and statistics domestically, inside the EU or worldwide. One reason why we propose this remarkable variability of emergency definitions and classifications is the absence of a globally acceptable paradigm for each type of event; if such paradigms existed, they would enable states to compile lists of emergencies

based on a unified foundation. In the context of the EU, a disaster typology designed to suit all member states, the EU's Vademecum of Civil Protection (EC 2010b), does exist, but this system is inherently open to criticism and is neither sufficiently universal nor flexible to serve as an acceptable foundation for risk assessment. For example, the Vademecum of Civil Protection classifies forest fire as a natural hazard, despite the most common direct cause of these fires (the ignition source) being anthropogenic. The developers of the European spatial planning observation network (ESPON) Hazards project (Philipp Schmidt-Thomé et al. 2006) developed a typology specifically for spatially relevant hazards, which involved 15 risk categories with corresponding indicators divided between two groupings: natural hazards (11) and technological hazards (4). We conclude that although a great deal of work has been done to develop emergency typologies, further development is still required. The results of a recent study (De Vries, Verhoeven, and Boeckhout 2011) accentuate that the taxonomy (classification or typology) of risks has a number of problematic aspects, not only from the relatively narrow viewpoint of emergency and disaster risks, but also in the generic context of risk governance in contemporary society.

Risk assessments of selected types of emergencies – (i) major accidents involving chemicals and (ii) flooding

The following section investigates the compliance of certain EmRAs in the context of EU directives and Estonian legislation.

Chemical accident risks (in establishments with fixed sites)

The essential principles and requirements concerning the EU risk assessment of industrial institutions designated as major accident hazards are formulated in Seveso II Directive (EC 1997). This is arguably the most significant EU Directive as it supports the protection of people and the environment from major accidental hazards (Salvi and Gaston 2004). The requirements for risk assessment are specified in the accompanying guidance on the preparation of a safety report (see MAHB 2005) and in land use planning guidelines (see MAHB 2006). These guidance materials introduce the general methodological principles, approaches and best practices of risk assessment, explaining important concepts such as the arguments for and against employing qualitative or quantitative methods and deterministic or probabilistic relations, etc. However, the guidelines do not prescribe a concrete default, or recommended, methodological scheme. The accidental risk assessment methodology for industries (ARAMIS) developed by the ARAMIS project had as one objective, the creation of a harmonised EU-wide methodology based on the specific requirements of the Seveso II directive, combining the strengths of both deterministic and probabilistic approaches (Salvi and Debray 2006).

In Estonia, the requirements for the assessment of chemical accident risks in dangerous enterprises and enterprises liable to be affected by a major accident were initially enacted by a government document titled 'The Procedures' (Minister of the Interior 2003), but since 17 February 2011 they have been superseded by the regulations outlined in 'The Requirements' (Government of the Republic 2011), which are based on Estonia's Chemicals Act of 1998 (Parliament of Estonia 1998). Estonian legislation determines which enterprises are dangerous and divides them into three categories, depending on the inherent hazardous characteristics of the

substances they process and the quantities stored. The threshold quantities of Estonia's two most stringent categories are outlined in the Seveso II Directive's Annex 1, by which enterprises (hereafter 'Seveso enterprises') are deemed to be liable to be affected by a major accident. There are 53 Seveso enterprises in Estonia (Estonian Rescue Board 2011). The threshold quantities for the third category, comprising 'dangerous enterprises', are substantially lower than those prescribed in the Seveso criteria. For example, the threshold quantity for petrol (petroleum spirits) was previously 10 tonnes; consequently, the majority of Estonia's petrol stations belonged to this category. Since the 1st of October 2011, however, the threshold quantities for the 'dangerous enterprises' were increased and the threshold for petrol (petroleum spirits) was raised to 100 tonnes. Therefore, the quantity of designated 'dangerous enterprises' dramatically decreased after that date. All the remaining Estonian category three 'dangerous enterprises' are obliged to conduct risk assessments and prepare emergency plans.

Both the 2003 (Minister of the Interior 2003) and the 2011 (Government of the Republic 2011) regulations provided only generic requirements for risk assessments, which gave risk assessors broad scope to select their methodologies and approaches. Risk assessors for Estonia's three categories of dangerous enterprises consist of three types: (i) the enterprises themselves acting independently or with expert help and advice; (ii) private companies specialising, partially or totally, in risk assessments; and (iii) universities and colleges acting on the basis of research contracts with the 'dangerous enterprises'. This typology of assessors is quite similar to that observed in the Nordic countries (Magnusson et al. 1999), but determination of the precise proportions of the each category requires additional study. We (the authors) have participated in risk assessments, resulting in risk matrixes analogous to the previously mentioned TRA; researchers at the Tallinn University of Technology acting as risk assessors (Paas, Tint, and Järvis 2009) have used the risk matrix-based methodology of the University of Melbourne (2003).

We conducted two mini-studies to evaluate whether the conducted risk assessments complied with the legislation of the time at which they were conducted. First, we surveyed the 147 category three 'dangerous enterprises' of the South Estonian region, finding that only 66% of the risk assessments complied with the generic requirements of 'The Procedures' regulations (Minister of the Interior 2003). Second, we examined the publicly available safety documents of five Estonian categories one and two 'Seveso enterprises' (Ministry of the Environment 2010). These enterprises handled the following dangerous chemicals or groups of chemicals: Enterprise (1) (oil products); Enterprise (2) (ammonium nitrate); Enterprise (3) (oil shale products); Enterprise (4) (liquefied petroleum gas); and Enterprise (5) (chlorine).

Enterprises (1), (4) and (5) based their risk assessments on a risk matrix. Enterprise (1) used a simple risk matrix with three-step probability and consequence scales, similar to that used in occupational risk assessment. Enterprises (4) and (5) used risk matrices with five-step scales, contingently compatible with those used in TRAs. Enterprises (4) and (5) also used simplified combinations of fault and event trees (bow ties) for accident scenario identification and layer of protection analysis (EN 61511-3:2005 2005) in a qualitative form, without the probabilities of the safety barrier operations. Enterprises (2) and (3) only emphasised the qualitative description of risk. Enterprises (2) and (5) calculated the consequences, based on safety distances according to certain criteria, whereas Enterprises (1) and (4) used generic safety distances.

According to the current risk assessment methodology (Minister of the Interior 2010a) and the Emergency Act (Parliament of Estonia 2009), major chemical accidents are also the responsibility of regional and national risk assessments. Although neither the regional nor the national risk assessments have a classification for a 'major chemical accident', this type of event is linked to other types of classified emergencies, as indicated by the following selection from the 2008 National Summary of Risk Assessments for Emergencies (Ministry of the Interior 2009):

- extensive and/or complicated fire/explosion in industrial or warehouse buildings (production enterprises and warehouses with a risk of major accident, including explosive depots),
- (oil) spill on coast/shore,
- mass poisoning and
- extensive environmental contamination.

As risk assessments of dangerous enterprises are an important source of data for regional and national risk assessments, methodological compatibility is presumed by default. The assessors of dangerous enterprises must therefore consider that their results should be easily formatted to meet the input requirements of regional and national risk assessments. Problems arise from the widespread usage of probabilistic and quantitative methods, in which the probable consequences (fatalities) usually reflect individual and societal risks in concrete conditions. Although quantitative methods are undoubtedly more precise and informative, their outcomes are not directly adoptable as inputs to regional or national risk assessments. A solution to this issue could be the development of a method that enables the comparison of risk assessments' outcomes, with the aim of interpreting and converting their results into a suitable format. This solution is similar to approaches that are already in use in the UK, where comparable criteria for risk-based and consequence-based approaches have been established for the definition of zones around a dangerous enterprise (Christou, Amendola, and Smeder 1999). The lack of published research on similar problems in the EU might otherwise suggest that this issue is specific to Estonia.

Flood risks

The main requirements for the risk assessments of floods are presented in the EU's new Flood Directive (EC 2007b), which includes the preparation of flood hazard maps and flood risk maps. De Moel, van Alphen, and Aerts (2009) suggest that the Directive refers to the mapping of flood hazards and risks as essential components of flood risk assessment and are consequently the basis of flood risk management plans. A flood hazard map presents, where relevant, variables that affect flood probabilities, such as water depth or level and flow velocity, whereas a flood risk map presents the potential adverse consequences associated with flood scenarios. The criterion that differentiates flood hazard and risk maps is the analysis of the consequences of a flood rather than the probability of a flood.

Flood risk assessments, in the Estonian context, have two crucial and necessarily complementary aspects. Firstly, the risk assessments must follow and implement the special requirements of the EU's Flood Directive, particularly the preparation of

maps and secondly, the assessment of the flood risks must be conducted by regional and national assessors.

The Ministry of the Environment commissioned research studies for the specification of the application conditions of the Flood Directive. Mugra and Sults (2006) analysed flood mapping and concluded that the majority of existing maps were hazard maps. De Moel, van Alphen, and Aerts (2009) found that the existing flood maps, which covered the entire Estonian territory, were produced by the central government and were inherently historical. Kupits and Osjamets (2010) conducted a preliminary assessment of flood risks, using a framework in which they detailed the actual types of floods, their probability of occurrence and potential significant flood risk areas (PSFRA). Kupits and Osjamets (2010) also observed many long-standing trends of water flow, which can affect the occurrence of floods.

The last two publicly available national EmRA summaries (Ministry of the Interior 2009, 2011) analytically discuss flood types as being either coastal or river floods. The summaries conclude that there is one unified emergency for flooding, defined as a flood in a high-density population area. Both summaries assess the risk of this emergency as high, but they do not include either the flood hazard or the flood risk maps. We assume that both types of maps will accompany future versions of both the national and the regional EmRA summaries to better conform with the EU's Flood Directive. We also express the necessity of maintaining the compatibility of the risk assessment criteria for use in flood hazard or risk mapping. The Estonian Land Board recently compiled the flood hazard map layer on the digital map of Estonia for four cities: Tallinn, Pärnu, Haapaslu and Tartu (Estonian Land Board 2012). The mapping principle here was based on the water level rise height criteria. The Kronstadt zero was taken as initial height for Tallinn, Pärnu and Haapsalu, which are situated on the coasts of the Baltic Sea and a compromise zero height was established for Tartu, which is situated inland, on the banks of the River Emajõgi. The contour lines were counted with a range of 0.25 m, starting from 0.5 m above the zero levels.

Risk assessment of the continuous operation of vital services

Vrijling et al. (2004) characterise critical infrastructures as complex societal systems and Pursiainen, Lindblom and Franke (2007) argue that they play an essential role in the maintenance of vital societal functions such as the supply chain, health, safety, security and the economic and social well-being of the population. The requirements for the identification and designation of European critical infrastructures (ECIs) and the assessment of the need to improve their protection were enacted in the Council Directive 2008/114/EC of 8 December 2008 (EC 2008b). Although the Directive focuses on ECIs, the disruption or destruction of which would have a significant impact on at least two Member States, the Directive's main principles have broader applicability.

Estonian legislation does not include the definition of a critical infrastructure but does require the risk assessment of continuous operation of vital services, which have much in common with critical infrastructures. The Emergency Act (Parliament of Estonia 2009) defines the continuous operation of vital services as the capability of the consistent functioning of vital services and the ability to restore this consistent functioning after a disruption. The Act designates over 40 different types of vital services, the responsibility for the continuous operations of

which falls to six component Ministries, as well as The Bank of Estonia and local governments.

During the validation period of the Emergency Preparedness Act of 2000, the risks of several types of disruptions or disturbances of vital services were analysed in the context of both TRAs and FRAs, together with other types of emergencies, on the basis of corresponding (and, in principle, compatible) methodologies (Minister of the Interior 2001; Ministry of the Interior 2007b).

Since the adoption of the Emergency Act (Parliament of Estonia 2009), dual approaches are now required for risk assessments. Firstly, there is the special regulation enacting the guidelines for risk assessment of the continuous operation of vital services (COVS), henceforth COVS, (Minister of the Interior 2010b). Unlike EmRA compilation under the previous guidelines (Minister of the Interior 2010a), the Emergency Act and its guidelines for risk assessments of COVS require the providers of vital services to prepare and submit risk assessments of the continuous operation of these vital services. The criteria of risk assessment and risk rating on the COVS matrix differ significantly from those of the EmRA compilation guidelines (Minister of the Interior 2010a). Furthermore, the impact of a disruption on COVS is a component of the EmRA of each emergency type, as outlined by the Minister of the Interior (2010a). In our opinion, the cooperation between these separated approaches is necessary for complex and comprehensive solutions. Nevertheless, the methodological differences of the approaches could cause problems. Practical feedback is not yet available, as these regulations are new and currently in the implementation phase. Therefore, we emphasise the need for convergence of these methodological approaches or additional tools to assure their comparability.

Applicability of EmRA outcomes

The EmRAs, their results and outcomes can form both a portion and a basis for a range of formats (e.g. studies, reports and work documents) concerning various types of applications (planning, environmental protection measures and management systems of the organisations). The following section will discuss the aspects of environmental assessment and management as well as spatial planning and mapping.

Environmental Assessment and Management

The term ‘risk’ is not defined in the main texts of the environmental impact assessment (EIA) Directive (EC 1985), the strategic environmental assessment (SEA) Directive (EC 2001), Estonia’s EIA and Environmental Management System Act (Parliament of Estonia 2005), ISO 14001 (2004) or the EU’s *Eco-Management and Audit Scheme* regulation (EC 2009). Although risk is not defined and is strictly exteriorised in the above documents, the practical requirement to consider the probability of its consequences creates an unavoidable necessity for the practical usage of risk assessment as a tool for explaining environmental aspects and impacts. This concerns the EIA of projects, the SEA of planned activities and the implementation of environmental management systems (EMS) in existing organisations.

In Estonian practice, risk assessment has been a part of a number of EIAs and SEAs where the consideration of the probability of adverse outcomes was important, e.g. engineered objects, in which abnormal and emergency situations were

expected, such as (chemically) dangerous enterprises. Browsing through randomly selected reports of EIAs and SEAs connected with the planning and projecting of new sites for 'Seveso establishments', we found preliminary evidence that the elements of qualitative, semi-quantitative and quantitative risk assessment approaches were used in different combinations. At the same time, the requirements for concrete methodological approaches were absent. We conclude that this subject may be a worthy direction for future studies.

Voluntarily implemented EMS according to ISO 14001 and EMAS require organisations to prepare measures for emergency preparedness and response. These requirements include the identification of potential emergency situations as well as potential accidents, which is equivalent to an assessment of the risks of these accidental events. The risk sources can, at the same time, be significant environmental aspects. We have previously studied emergency preparedness and response in 44 Estonian enterprises that, according to ISO 14001 requirements, have implemented an EMS. We subsequently conducted an in-depth investigation of emergency preparedness and response at the Port of Tallinn (Tammepuu, Tammepuu, and Sepp 2009). The key concern at the Port of Tallinn was the identification of environmental aspects and their impacts. We discovered that some aspects that could be the causes of accidents and emergencies had been assessed as insignificant, primarily due to their low probability of occurrence compared with non-accidental events. Our default recommendation was to apply a unified approach to the problem; indeed, we generally advise many organisations to improve their tools for identification and assessment of environmental aspects, enabling them to consider the specific features of accidental events.

Spatial planning and mapping

Risk mapping has a key role in planning and preparing for accident scenarios, enabling institutions to reduce the impacts of hazards (EC 2008a, 66). The consequences of unwanted events are spatially distributed and depend on multiple hazard and safety factors: the character of the risk source, the pathways of hazard factors, the vulnerability of specific objects and systems, protective barriers, etc. (Tammepuu, Sepp, and Uiga 2007). In this context, the ESPON hazards project 1.3.1 has calculated the spatial patterns of natural and technological hazards in Europe in the form of an overview of all *Nomenclature d'Unités Territoriales Statistiques level 3* areas (Schmidt-Thomé et al. 2006). The tools that ESPON developed enable a comprehensive overview of the hazards at EU level, but they are too generic for localised needs, i.e. spatial planning at the local level. The EU member states have developed various initiatives relating to hazard and risk mapping, and this diversity of methodological approaches has complicated the comparability and consolidation of appropriate information at the European level (Commission of the European Communities 2009, 5). For example, Carpignano et al. (2009) recommend the use of an aggregated risk index for multi-risk mapping at the regional level.

In Estonian legislation, the Planning Act (Parliament of Estonia 2002) requires the consideration of the results of EmRAs at all determined levels of planning: national, county, comprehensive and detailed. The appropriate maps were previously and are currently required as appendices to both regional and national EmRAs. However, Estonian legislation has yet to determine whether these maps should be hazard maps or risk maps, and the criteria that should be applied for the

compilation of the maps also remain uncertain. This ambiguity has caused assessors to employ a broad variety of approaches. To provide a solution to the problem of multiple approaches, we established the simple principles necessary for evaluating and mapping the hazards of local conditions during a risk assessment of Tartu municipality (Tammepuu, Sepp, and Uiga 2007). Our approach divided the emergencies, which originated from the character of connectivity of the risk source or hazard with the surrounding space, into five clusters:

(1) Events that are characterised by the existence of a specific and localised risk source.
(2) Events with mobile sources of risk and logistics chains.
(3) Events where the risk source does not have a specific localisation but could be found in a limited area.
(4) Events in which the main problem is not a surplus but a shortage of material or energy (mainly the coverage areas of certain supply networks).
(5) Events that are 'hardly localisable', where the exact or even indirect identification of a hazard area during risk assessment and its consideration in spatial planning procedures at the urban level is almost impossible.

We are convinced that dividing emergencies into these clusters is only a preliminary solution; however, it does enable a simple form of coverage for the problem of multi-hazard mapping for land use planning needs. Therefore, we find that a good solution at the EU level requires the development of unified risk mapping tools that are suitable for multi-hazard or multi-risk mapping at the local level. Currently, the generic or consequence-based hazard zones of most of the 'Seveso enterprises' and 'hazardous enterprises' have been mapped by, and are available from, the Estonian Land Board (2012).

Conclusions

The development of Estonian EmRA can be divided into three periods.

The first period can be characterised by both the absence of strict requirements for risk assessment and the endeavours to implement the Swedish risk assessment methodology. The practical usage of risk assessment methodology began in the mid-1990s, when the first risk assessments of chemically hazardous enterprises were performed, and intensified following the adoption of the Chemicals Act in 1998.

The main feature of the second period was the adoption of the Emergency Preparedness Act in 2000, which established risk assessment requirements and methodologies for TRA and FRA, respectively, that were largely based on Swedish methodology. This Act resulted in the systematic risk assessment of the counties, largest cities and the Ministries, as well as the first versions of Estonian national risk assessment summaries.

The third period began with the adoption of the Emergency Act in 2009, which legalised an emergency-based interdisciplinary methodological approach on the basis of British methodology and a special methodology for the risk assessment of the continuous operation of vital services. Risk assessments at the national and regional levels are defined as essential and those at the local level are performed when necessary.

The requirements for emergency risk analyses and the legalised methodological approaches are based on risk assessment methodologies from Sweden and the UK. The key impacts of these foreign systems on Estonia's methodology were that Sweden's system enabled the application and distribution of EmRA and the UK's system enabled the unification and arrangement of approaches to risk ranking.

EIA and SEA have used the outcomes of risk assessments as inputs or performed special risk assessments. Organisations implementing EMS employ various approaches for risk assessment. Spatial planners at all levels must consider these risk assessment results. Although Estonia's legislation requires risk maps to be appendices to risk assessments, there is no legal definition of the concrete requirements for these risk maps. Therefore, on the basis of implementing the European Commission's proposals concerning 'A Community approach ons the prevention of natural and manmade disasters' (Commission of the European Communities 2009, 5), the present need is to concentrate on formulating multi-hazard and multi-risk mapping solutions applicable for regional and local level planning purposes.

Acknowledgements

This study was partially supported by Target Funding Project No. 1090050s07 of the Ministry of Education and Science, Estonia. The authors would like to thank all the institutions and people who rendered help in the preparation of the materials used in this paper.

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II

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ASPECTS OF RISK ASSESSMENT IN LAND USE PLANNING: THE CASE STUDY OF TARTU. SAFETY AND SECURITY ENGINEERING II

Guarascio, M., Brebbia C. A., Garzia, F. (eds.). WIT Transactions on the Built Environment, Volume 94. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 345–357.

Aspects of risk assessment in land use planning: the case study of Tartu

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Abstract

The purpose of this work was to analyse the problems connected with the risk assessment of emergency situations in Estonia and their relations with land use planning. The research was carried out on the basis of a case study: the preliminary risk assessment of Tartu, the second largest city of Estonia, conducted by the specialists of the Estonian University of Life Sciences.

The Estonian Emergency Preparedness Act designates risk assessment as an important task of crisis management, on the basis of which all of the following measures should be planned and implemented. The act specifies two types of risk assessment, functional and territorial. The first involves the ministries and their areas of government, whereas the second concerns the counties and the largest cities and communities. The methodical basis of territorial risk assessment is established by special regulation of the Minister of the Interior. The regulation requires the determination and risk assessment of 15 (or more) different types of possible emergency situations. The outcomes of the risk assessments will serve as the basis for composing crisis management plans and spatial (land use) planning, concerning county plans, comprehensive plans, detailed plans, and also specific building projects.

At present, the risk assessments of all of the counties and most of the largest cities in Estonia have been performed, but the possibilities for the application of the outcomes for spatial planning remain uncertain. Our intention was to select and group the scenarios of development of emergency situation in relation with land use and spatial planning, and to draw up proposals for specific planning activities. On the basis of their relations to city area, the 15 types of possible emergency hazards were divided into five groups, which were described and analysed separately. The conclusions concerned the opportunities for taking into consideration the results of risk assessment in planning and design procedures.
Keywords: risk assessment, land use planning, public safety.

WIT Transactions on The Built Environment, Vol 94, © 2007 WIT Press
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/SAFE070091

1 Introduction

The whole existence of mankind and its activities are entirely concerned with the use of land. All human activities, as well as all natural conditions pose hazards for human beings and/or the environment, and therefore involve certain elements of risk [1]. The consequences of unwanted events are spatially distributed, depending on multiple hazard and safety factors: the character of the risk source, the pathways of hazard factors, the vulnerability of specific objects and systems, protective barriers etc. Population growth has made land scarcer, especially in urban areas, which leads to ever more intensive use of available space [2] and an increasing likelihood of adverse interactions and impacts.

Today a wide range of professions and academic subjects use the technique of risk assessment [3]. Risk assessment is an essential component of the overall management of risks within society, and specifically risks to human health and/or the environment [4]. It is the first step in explaining the problems and evaluating the significance of risk either quantitatively or qualitatively [5]. Although today's society is greatly concerned with many aspects of risk, the concept of risk and its assessment and management have not yet been sufficiently developed to meet many challenges [6]. Risk assessment is an essential part of civil protection. In many European countries the usefulness of the further development of risk assessment in the field of civil protection and emergency preparedness is clearly recognized [7].

An important landmark in the development of risk assessment and land use planning (LUP) in the context of major hazards involving dangerous substances is Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances (the "SEVESO II" Directive) [8,9]. The consequences of major industrial accidents can cause remarkable damage in surrounding areas. Article 12 of the Seveso II-Directive requires that the objectives of preventing major accidents and limiting their consequences be taken into account by the Member States in their land use policies and/or other relevant policies [8–10]. Risk assessments are increasingly used in land use planning with the purpose of minimizing the undesirable effects of accidents at hazardous installations. An emerging and important aspect of risk-based land use planning concerns the aspect of integrated risk assessment and management. [11]. For the siting of new establishments, the hazards of accidents and the environmental impact from continuous emissions could be considered together in order to have an integrated assessment of the environmental compatibility of the proposed activity [12].

At present, after the recent enlargement of the European Community, only a limited number of European countries have developed specific criteria for LUP with respect to major accident hazards [13]. From the methodological point of view, two approaches adopted in support to land use planning decisions can be distinguished in the countries of the European Union: the first, called a "consequence-based" approach, focuses on the assessment of the consequences of a number of conceivable event scenarios, and the second, called a "risk based" approach, focuses on the assessment of both the consequences and probabilities

of possible event scenarios occurring [9,14]. A third methodological approach that could also be considered consists of the determination and use of "generic" distances that depend on the type of activity rather than on a detailed analysis of the specific site [9,14].

Although the term land use planning is mostly discussed in the context of major hazards in fixed installations, these are not the only hazards for which LUP is necessary [12]. For example, the risks arising from the transportation of dangerous chemicals are often of the same magnitude as those that are due to fixed installations, and thus need to be taken into account with the same attention in order to keep them under control and to reduce them [15]. Smith discusses the problems of the land use planning of several environmental hazards on the basis of the experiences of different countries [5].

The goals of this study were first to give an analytical description of risk assessment in the field of emergency preparedness in Estonia as a whole and in the city of Tartu. Second, to develop further the methodology of using risk assessment results for land use and spatial planning in the case study of Tartu.

2 Emergency risk assessment and spatial planning in Estonia

2.1 Risk assessment

In Estonian legislation, risk assessment is defined as the systematic determination and evaluation of possible accidents and risk sources and the planning of measures for their prevention [16]. The requirements for risk assessment in the field of emergency preparedness and crisis regulation are enacted in the Emergency Preparedness Act [17]. Risk assessment in the field of civil protection in Estonia took its first steps in the middle of the last decade. One important development was the translation of the UNEP/APELL guidebook: Hazard Identification and Evaluation in a Local Community [18] into Estonian in cooperation with the Estonian Rescue Board and Swedish Rescue Board. Several courses and information seminars were held [19], and thus specialists from all over the country were able to receive elementary knowledge in the field of contemporary risk assessment. Since the middle of the 90s, basic courses of risk assessment were taught at Estonian universities.

As in Finland, Sweden and Norway [7], a nation-wide system of risk assessment is also applied in Estonia. The Estonian Emergency Preparedness Act establishes risk assessment as an important task of crisis management, on the basis of which all the following measures should be planned and implemented [17]. The act specifies two types of risk assessment: functional and territorial. The first involves the ministries and their areas of government, whereas the second concerns the counties and the largest cities and communities. Both types of risk assessments use methods of preliminary assessment. The result of such preliminary assessment is the ascertainment of hazards that have the potential to develop into emergencies, and the general description of the probabilities and consequences of these hazards.

The methodological basis for ministries' risk assessment (the functional approach) is the guidance document "The Schedule and Methodology of Ministerial Risk Assessment" [20] conformed with the decision of the Crisis Commission of the Government of the Republic of Estonia. The goal of the risk assessment of ministries is to ascertain possible emergencies in the fields of government of ministries. An important task of the risk assessment of ministries is risk assessment in the institutions in the field of government of ministries. In determining emergency situations, institutions shall proceed from the duties enacted in their charter, which means determining the emergencies in its fields of government and assessing hazards. These risk assessments are event-based, i.e. the probabilities and consequences of events and the hazards causing them are analysed. It is not necessary to go into detail. Risks classified as high ones, could later be analysed in greater detail.

The methodological basis for territorial risk assessment is established by special regulation of the Minister of the Interior [16]. The goal of risk assessment in the context of the regulation is to determine and assess certain types of possible accidents in the territory of counties, communities or cities and the probabilities of their occurrence, thereby obtaining an overview of the potential hazards for state security, human life and health, environment and critical infrastructures. Factually, the methodology requires preliminary assessment of multi-hazard risks, the primary types of which are prescribed. The outcomes of risk assessments are established as the basis for composing crisis management plans and spatial (land use) planning, concerning county plans, comprehensive plans, detailed plans and also specific building projects. This is an important fact, which expresses the need for the further development of a more effective linkage between risk assessment and land use planning.

The risk assessments of hazardous installations are important source data for territorial risk assessment. The Chemicals Act establishes the requirements for chemically hazardous enterprises [21], in which hazardous installations are determined and divided into three categories. The thresholds of the two more strict categories are these of the Seveso II Directive, and these are plants with major accident hazards. For the third category, so-called (simply) 'hazardous enterprises', the threshold quantities are remarkably lower than prescribed in the Seveso criteria. For example, the threshold quantity for gasoline is 10 tonnes, and thus most petrol stations belong to that group. These hazardous installations are also obliged to carry out risk assessments and prepare emergency plans.

At present the risk assessments of all of the ministries (except for the Ministry of Defence, which is not required to do so), counties and most of the largest cities in Estonia have been performed. The Ministry of the Interior has composed a summary of risk assessments of ministries and counties [22]. The aim of the summary was to offer a brief introduction to the principles of risk assessment applied in the system of emergency preparedness and crisis regulation. The summary points out the ten types of risk that have been assessed as the highest, and makes recommendations for the management of these risks.

2.2 Spatial planning

The purpose of planning in Estonia is to ensure conditions that take into account the needs and interests of the widest possible range of members of society for balanced and sustainable spatial development, spatial planning, land use and building [23]. Spatial planning is democratic and functional long-term planning for spatial development that co-ordinates and integrates the development plans of various fields and in a balanced manner takes into account the long-term directions in and needs for the development of the economic, social, cultural and natural environment.

The Planning Act defines four levels of planning – national, county, comprehensive and detailed. The latter two are relevant in the urban context. A comprehensive plan is prepared for the whole territory of a rural municipality or city or parts thereof.

The comprehensive plan defines the main directions and conditions for the development of the territory of a town or community, to prepare the basis for composing the detailed plan for areas and cases where detailed planning is mandatory, and to prepare the basis for adjusting the land use and building criteria for areas where detailed planning is not mandatory. Several tasks of comprehensive plans should also consider aspects of environmental risk: to establish conditions for sustainable and balanced spatial development; determine general use and building provisions for land and water areas; define the location of roads, streets, railways, ports and airports and the general principles of traffic management; define the location of principal utility network routes and technical infrastructure, take account of general national defence needs and, where necessary, to designate national defence areas and specify the boundaries of national defence areas designated by the county plan and address in the plan land use provisions and building provisions arising from Acts and other legislation.

A detailed plan is prepared for a part of the territory of a rural municipality or city, and it serves as the basis for building activities and land use in the short term. The purpose is to guide the land use and construction criteria in towns and small towns and in other areas and cases where detailed planning is mandatory [24].

3 Materials and methods

The methodological basis of risk assessment in the city of Tartu was the document “Methodology of Risk Assessment of County, City and Community”, enacted by regulation of the Minister of the Interior [16]. The risk assessment can be characterised as semi-quantitative: a risk matrix approach which uses a 5-step ranking for the assessment of probability (1-5, where 1 was the lowest and 5 the highest) and the consequences (A-E, where A was the least serious and E the most serious) united into the matrix, based on the principles analogical to the APELL/UNEP methodology [18].

The initial information was collected in cooperation with Tartu City Government. The risk sources in the town were identified through the

classification of the methodology: local risk sources, moving risk sources, risk sources without definite location (for example extreme environmental conditions) and risk sources that threaten public safety (disturbance of the supply of some essential resource). The following analysis and assessment of risks was conducted on the basis of corresponding accident types:

1) fires
2) explosions
3) transport accidents
4) accidents with dangerous chemicals
5) drinking water pollution
6) accidents on water bodies
7) accidents involving communal systems
8) breakdowns of electricity supply
9) breakdowns of communication systems
10) gas accidents
11) floods
12) collapses (buildings)
13) extreme environmental conditions
14) epidemics
15) epizootics.

The probabilities of the accidents occurring were assessed indirectly, taking into account the existing statistics of accidental events and also the possible internal and external reasons and initial events that could activate accident scenarios. The consequences of each selected accident scenario were first assessed separately using the following four tasks: human life and health, essential sectors, environment and property, each task in a five-point ranking and after that, secondly, a general appraisal was given. The risks were collated by magnitude, and the proposals for mitigation measures were developed.

This embraced our attempt to find and describe characteristic features by which the accident types and concrete emergency scenarios could be distinguished and analytically described as concerns their relation to the rural and urban environment, and to group these events on the basis of the characteristic features for further practical application.

4 Tartu case study

4.1 Risk assessment in Tartu

Tartu is Estonia's second largest city, with 98,313 inhabitants [25]. The area of the city is 38.8 km^2, which means that the city's territory is quite densely inhabited. The average population density is ca 2600 inhabitants per square kilometre.

The City Government of Tartu has ordered several studies of environmental risk. In 2002, for example, the Tallinn University of Technology carried out a risk assessment in Tartu [26] which mostly focused on critical infrastructures. In 2003 Tammepuu, who compiled an expert opinion about the study, stated that

the work profoundly treated the selected tasks in depth but only partially corresponded to the established requirements [27]. In 2004 the working group on spatial planning of the Department of Human Geography of the University of Tartu carried out a study concerning the linkage between risk assessment and urban space [28], based on the results of the risk assessment of Tallinn University of Technology. The authors recognized that present-day city planning did not consider hazard zones, and these aspects need to receive more attention in future. In 2005 the workgroup of the Department of Human Geography performed a study on flood risks in Tartu [29]. In addition to the above-mentioned studies, the risk assessments of hazardous enterprises were performed by several persons, using different methodical approaches. Thus the previous risk assessments could be divided into two groups: risk assessments and expert opinions ordered by the city government and risk assessments of hazardous installations.

The preliminary risk assessment of Tartu in 2005 was carried out by specialists of the Estonian University of Life Sciences [30]. The general conclusion of the study was that in Tartu the occurrence of emergencies of different types was of low or moderate probability. The preliminary risk assessment showed clearly that the situations considered to be probable causes of emergencies were the following: accidents with ammonia, LPG and fuel containers and carriages, the pollution of water supply and long-lasting interruptions of water, electricity and gas supply, comprehensive disturbances in communication systems and extreme meteorological conditions.

The assessed probability of serious accidents was estimated to be higher in the parts of the town that contained a greater number of hazardous enterprises, and through which the railway passes. An accident with a railway carriage containing ammonia was expected to be the worst case of a chemical accident. Several important and vulnerable objects remain in the hazard zone, including Tartu University Hospital. In addition to the railway transport of ammonia only one enterprise, which uses ammonia in refrigeration technology, has remained in place of about ten in the last decade, which means that in this sense the situation has improved remarkably.

Liquid fuels transported both by railway and by road are also an important component in the context of considerable accidents with chemicals. The most serious fires were expected in the occasion of accidents with flammable chemicals. Possible accidents with truck carriages of petrol were assessed as being most problematic in filling stations, especially for those stations situated in densely inhabited areas. The accident with the fuel truck was supposed to be the most serious situation in petrol stations which formed the majority of the hazardous installations in Tartu. The possibility of explosion was also evaluated as being the highest in the case of an accident with chemicals.

In addition to chemically hazardous plants and the transport of dangerous goods, serious fires are possible in enterprises that store large quantities of flammable materials. This primarily concerns the timber industries. Another type of object where fires were estimated to have serious results were buildings where the presence of large number of people was expected (department stores,

theatres, concert and sports halls etc.). There are also relatively large areas on the city's territory where wildfires can take place, and districts in which old timber houses are situated problematically close to each other, increasing the hazard of extensive fires involving a group of buildings.

Critical infrastructures play an important role in the rise of the emergencies from one side and in mitigation and reacting activities from the other. The insufficiency of water supply was observed to be the most serious type of accident in communal systems and networks, the most expected reason for which was the long-term interruption of electricity supply. The hazard of drinking water pollution was assessed to be highest at one of the water intakes, which covers about 40% of the water supply of Tartu and therefore can independently cause an emergency. Extensive and long-lasting interruptions of electricity supply are possible due to both external causes (not dependent on installations in city areas) and internal causes. Tartu is vulnerable because of the lack of reserve electricity generators, a limited number of which can be found at some important objects. Large-scale disturbances in the work of communications systems can firstly independently cause emergencies or secondly have an impact on various kinds of emergencies.

The influenza and other similar viral infections were considered to be the most probable causes for the outbreak of large-scale epidemics.

4.2 Results of complementary analysis

The goal of the study was to select, group and analyse the scenarios of the rise of emergency situations in relation with land use and spatial planning in Tartu and to develop measures to mitigate environmental risk. The 15 types of possible emergency hazards were divided into 5 groups that were described and analysed separately.

The first group comprises events that are characterised by the existence of a specific and localised risk source. Accidents at hazardous installations could be the typical example of that group. There are no enterprises with a major accident hazard corresponding to the Seveso II criteria in Tartu, but there are 27 objects that the Estonian Chemicals Act treats as hazardous installations; most of these are petrol stations. These events can be characterised by definite hazard (or safety) distances and/or zones, on the basis of certain criteria. In addition, industrial plants using large quantities of flammable materials (not chemicals), for example timber, could be classified into this group.

The second group involves events with moving sources of risk and logistics chains. This primarily involves possible accidents on railways and roads/streets but also water traffic on the Suur-Emajõgi River and also to a certain extent accidents on gas pipelines and high-voltage electricity lines, as the latter can be characterised as the carriers of (moving) substance or energy, uncontrollable emissions of which could cause adverse outcomes. In the case of the transportation of dangerous chemicals, the hazard zone is principally ribbon-shaped, in the centre of which is the observed route or in other words: the hazard (or safety) zone, which is circular for a localised object, moves together with the

risk source. It is important to mention that the probabilities of accidents occurring are not the same in all places on the routes, and also influenced by traffic density, which is time-dependent.

These two groups can be treated similarly in relation to possible chemical accidents. The methods used for risk assessments in the hazardous installations of Tartu for the identification of safety distances were mostly "generic" and/or "consequence-based" (drawing an analogy with the Seveso II terms). Various criteria were used by different experts for the determination of safety distances (or identifying hazard or safety zones) during the performance of risk assessments of concrete hazardous objects. The data from norms, standards, handbooks and practical experiences has been applied in these assessments for the determining of "generic" distances. The "consequence-based" approaches have used the criteria from different sources, including some of those applied for Seveso II enterprises in other European Union countries [31,32]. The main solutions for the near future could be the determination and harmonization of recognized (and preferably legalized) methodological approaches and criteria for modelling and assessing the consequences throughout Estonia. There could be a gradually shift towards the use of more detailed and quantitative methods. We suggest that the usage of "generic", "consequence-based" and perhaps "risk-based" approaches could initially exist simultaneously in Estonian practice. At the same time, this requires the preparation of a methodology for the comparison and /or combination of the results obtained by different approaches. Another important task for risk assessors, managers and planners, real estate developers etc. is the specification of the limitations of planning and building in hazard zones.

The third group contains events where the risk source does not have a specific localisation, but could be found on a limited area. These areas of distributed risk source can be marked on a map. Typical events of this group are, for example, wildfires and fires in districts with a high proportion of old timber houses, where the level of fire protection is low. The fire protection level should be increased via measures proposed in spatial planning and projecting (for example the selection of construction materials, the installation of centralised fire alarm systems, the reconstruction of the fire-fighting water supply, the observance of fire safety distances and the planning of protective barriers etc.). Floods were also classified in this group, as the limiting factor is the increase of the water level, and the accidentally flooded area is dependent on the height, which limits the areas of the flood with observable probability. These areas are mapped, and conditions for the land use are established through comprehensive or thematic planning.

The fourth group can be characterised by the keywords 'networks' and 'deficiency'. This means, that probable emergency situations with certain critical infrastructures can be characterised as events in which the main problem is not the surplus of matter or energy but the shortage thereof. This concerns electricity, water, gas supplies and communication systems. Thus the hazards depend on the normal functioning of the chain of supply from the reservoir or generator of the required resource to the intermediate distributors and final consumers. The initial

event causing the absence or lack of the resource can take place in each part of the chain or network. In connection with such events, the mapping and planning of networks could be examined from the point of view of reliability and risk. Factors that should definitely be considered are: the technological state of the network elements and the presence and/or possibility of alternative supply. Spatial planning should consider the opportunities for modernizing the specific network sectors and the application of alternative sources and channels of feeding or supply.

The fifth group covers events that are 'hardly localizable', where the exact or even indirect identification of a hazard area during risk assessment and taking it into account in spatial planning procedures on the city level is almost impossible. This group contains such accidental events as natural disasters: thunder, snow and hailstorms, extreme snow conditions, unusually high and low temperatures etc. A technological emergency like a nuclear accident in a neighbouring country also falls into this category in the context of municipal risk assessment and planning. Although this kind of event has a certain localized risk source, the impact depends on meteorological conditions. These kinds of possible events do not enable one to map the specific risk or hazard or safety zones in the risk assessment of the city, but allow one to identify more vulnerable objects and take these into account in comprehensive planning, and certainly plan measures in the city's crisis management plan.

5 Conclusions

The preliminary risk assessment of the town of Tartu and the opportunities for applying risk assessment outcomes in spatial planning were studied in the context of multiple hazards and emergency scenarios. Whereas previous studies [26,28,29] focused on a limited number of events and proposed specific solutions, we tried to explore the risk aspects more broadly, and certain characteristics of systematisation and grouping the accident types were identified in relation to land use and planning. On the basis of the selected criteria, the main accident types were grouped into 5 clusters that could be applied in mapping, planning and projecting/management procedures.

The study shows clearly that the experiences of other EU member states (which are in that sense more developed) could only partially be adopted. There are remarkable differences between the EU countries in the implementation of risk assessment and land use planning. We emphasize the urgent need for further improvement of risk assessment and crisis management in Tartu. One important task in this area is to consider the risk assessment outcomes in spatial planning, which helps to mitigate risk and increase environmental and public safety.

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III

Tammepuu, A., Sepp, K. 2012

NATIONAL EMERGENCY RISK ASSESSMENTS:
COMPARATIVE STUDY OF ESTONIA AND THE UK

Brebbia C.A., Zubir, S.S. (eds.). Management of Natural Resources, Sustainable Development and Ecological Hazards III. WIT Transactions on Ecology and the Environment, Volume 148. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 633–644.

National emergency risk assessments: comparative study of Estonia and the UK

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Abstract

This paper presents a comparative study of the national risk assessment outcomes of two different countries of the European Union: Estonia, as a so-called 'new member' and the UK as an 'old member'. The comparative survey was carried out on the basis of the National Summary of Emergency Risk Assessments of Estonia and the National Risk Register of Civil Emergencies of the UK. The features compared were requirements, methodologies, risk assessment process and performers, risk types and categories together with risk assessment outcomes as well as output documents' composition. Simultaneously parallels were drawn with local level emergency risk assessments. Although the risk types were defined diversely in the two countries, an indirect comparison was still accomplishable. For instance, the risk of pandemic human disease was assessed as one of the highest in both countries. On the grounds of our observations, the National Risk Register of the UK was comparatively more, an advising, guiding and directing document while the Estonian emergency risk assessment summaries were in a greater part of a summarizing character.
Keywords: emergency preparedness, risk assessment, civil protection.

1 Introduction

The existence and survival of mankind and the whole of life in the world has been accompanied by the impacts of unexpected and hazardous events. Disasters and emergencies are samples of the destabilising factors, which can cause serious setbacks and breakdowns in the environment and society [1]. The last decades have demonstrated a significant increase of technological and natural disasters worldwide and in Europe [2]. The risks of emergencies can be out of the eye of

WIT Transactions on Ecology and The Environment, Vol 148, © 2011 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/RAV110581

public attention, as disasters are uncertain events, which happen relatively rarely. Disasters do not respect borders [3]. Therefore it is important to assess and communicate corresponding risks on local and regional as well as national and international levels.

Today risk assessment has become an essential part of civil protection and disaster management [4]. Several studies, and also comparative studies, are available concerning the integrated approach of multi-hazard territorial risk assessment and management. Lonka has conducted a comparative study of risk assessment in the field of civil protection of European countries [5]. The European research project QUARTER concentrated on the development of a territorial management system for territorial risk reduction and environmental quality improvement [6]. The report of the project EUROBALTIC I present different examples of methodologies of risk assessment, management and mapping in the Baltic Sea Region, developed and applied in the countries of the region [7]. The ESPON Hazards Project 1.3.1 has worked out spatial patterns of natural and technological hazards in Europe in the shape of an overview on all NUTS3 areas [8].

In different EU countries the usefulness of the further development of risk assessment in the field of civil protection and emergency preparedness is clearly recognized [5]. Risk assessments on a national level are recognized to be a determinant for improving disaster prevention and preparedness activities [9]. Recently the European Commission issued risk assessment guidelines with the main goals being to improve coherence among the national risk assessments and to make these risk assessments more comparable between member states [9, 10]. Nowadays many countries are undertaking national risk assessments, including the UK [10, 11] and Estonia [12].

Three years earlier we carried out a comparative study of the local level emergency risk assessments of four Estonian cities (Tallinn, Tartu, Narva and Pärnu) and four cities or conurbations of the UK (London, Greater Manchester, West Midlands conurbation and Belfast) [1]. Our previous positive experience as well as the latest developments in the EU brought us to the decision to perform a comparative study of the public outcome documents of the national emergency risk assessments of the same two EU countries. Whilst Estonia is approximately 5.4 times smaller by territory and 45 times by population than the UK, the countries still have enough similar features, favouring the comparison. This comprises their relatively northern positions in Europe, a long coastal line, a low proportion of seismic and an absence of volcanic hazards, etc.

The main research materials were the latest publicly available output documents of the national risk assessments of the two countries, correspondingly: the 2008 National Summary of Risk Assessments for Emergencies [12] of Estonia and the National Risk Register of Civil Emergencies (2010 edition) [11] of the United Kingdom. The essential goal of the current study was a comparison of the publicly available outcomes and outputs of the national risk assessments of the two EU countries for bringing out and discussing the parallels and dissimilarities. The observed and compared subjects were requirements, methodologies, output documents' composition, risk

assessment process and performers, risk types and categories as well as risk assessment outcomes. The results of the study can serve as useful information in moving towards the 2012 overview of the major risks the EU may face in the future [9].

2 Comparison

2.1 General remarks

As much as publicly available sources enable to conclude, both countries: Estonia and the UK started to organise and undertake national level risk assessments somewhere in the middle of the last decade.

In Estonia the public versions of national risk assessment summaries have been available since 2005. During that period remarkable changes have taken place, concerning the legislative requirements and methodological approaches. The currently valid Emergency Act [13] replaced the previous Emergency Preparedness Act [14], which was valid until 23 July 2009. While the previous methodology, used in the years up to 2007, was essentially based mostly on the Swedish or UNEP/APELL methodology [15], then the later methodology, used since 2008, was generically built on the example of the British methodological approach [16]. Due to this the principles and criteria of risk assessment have also remarkably transmuted during the last years. Thus the 2008 National Summary of Risk Assessments for Emergencies [12] differs considerably from the previous analogical documents.

In the UK the Government has carried out a classified assessment of the risks facing the country, since 2005 [11]. The Civil Contingencies Act 2004 [17], which is currently valid, embarked on a thorough reorganisation of the emergency management system, including risk assessment. The Government performs the National Risk Assessment (further also NRA), which is secret by nature and not directly available for public use [11, 18]. The National Risk Register (further also NRR) is a public document on the basis of National Risk Assessment and the first NRR was published in August 2008 [11, 18]. The NRR 2010 Edition, which is at the centre of attention in the current paper, is the second, updated, version, based on the 2009 iteration of the NRA [18]. The main changes to the 2010 Edition and the original NRR embrace the update of risk types and risks on the risk matrix and in the text, as well as expansions of the last chapters of advisory and informative character [18].

2.2 Requirements and methodologies

The Estonian Emergency Act designates risk assessment as a document which describes the following on a national and, if necessary, regional and local government level: the emergency; the threats and hazards causing the emergency; the probability of the emergency; the consequences of the emergency; other important information related to the emergency; references to models, source materials and other such information, on the basis of which the

risk assessment is prepared. This definition emphasises clearly, that the national level approach is recognized as principal in Estonian emergency risk assessment. Emanating from the Emergency Act, the Minister of the Interior enacted an emergency risk assessment compilation guidance, which contains currently valid methodological requirements [19]. Earlier, in 2008, the more voluminous methodological guidance, approved by the Government's Crisis Management Committee was compiled (in Estonian and English) and made publicly available [20]. The 2008 National Summary of Risk Assessments for Emergencies [12] of Estonia was composed on this methodological basis.

The British Civil Contingencies Act 2004 as well as the Civil Contingencies Act 2004 (Contingency Planning) Regulations 2005 [21] principally set the risk assessment duty on Category 1 responders and Local Resilience Forums. The Category 1 responders are in brief the following institutions: emergency services, local authorities, health bodies and environment agencies [21]. This generically refers, that the essential requirements for emergency risk assessment lie on a local level. As a matter of fact the methodology of risk assessment for British local responders, brought in the emergency preparedness guidance [16] and was an essential example for working out the previously mentioned Estonian emergency risk assessment methodologies [19, 20]. The British risk assessment processes used at regional and national levels are not precisely the same as on the local level, but have many features in common and are generally consistent [16]. The laconic description of the British national risk assessment process can be recognized in the NRR edition 2010. We guess that the methodology of the British National Risk Assessment is described more thoroughly in some other document, not available for public use, as the NRA-s are mentioned to be secret and the NRR-s are only the public outputs of these [18].

2.3 Risk assessment processes and performers

The Estonian emergency risk assessment process, described in the methodologies [19, 20], generically uniform for national, regional and local levels, consists of 6 steps. The steps are almost one-for-one comparable with the steps of the British emergency risk assessment methodology for local responders, obviously for the previously described reasons and connections [16, 20]. The steps of emergency risk assessments in Estonia (national, regional, local) and in the UK (local) are presented in a comparative context in Table 1. The British national risk assessment process is described as consisting of the three main steps in the NRR 2010 edition [11], which are the following: identifying risks, assessing risks and comparison of risks. As much as the brief description of the risk assessment methodology allows proposing, the first two steps cover more or less the greater part of analogical or similar actions of the steps of the risk assessment on a local level. The third step is the comparison of risks, where priority is given to the risks that are both relatively likely and could have a serious impact, taking into account different types of planning assumptions. There is no precise analogy in Estonian national risk assessment(s), although higher risks certainly gather higher attention in emergency and spatial planning practices.

Table 1: The steps of Estonian national [12, 20] and British local [16] emergency risk assessments.

Step	Estonia	United Kingdom (local)
1	Conceptualization	Contextualisation
2	Description of the threats and consolidation for the purposes of assessing the likelihood of an emergency	Hazard review and allocation for assessment
3	The assessment of possible accident's probability	Risk analysis
4	Determining risk category and ranking the risks	Risk evaluation
5	Preventive and alleviatory measures for emergencies	Risk treatment
6	Entering results on risk form, and monitoring and audit of risks	Monitoring and reviewing

The British NRR 2010 edition brings only relative scales for impact and likelihood assessment, on account of which these cannot be compared with the Estonian 5-point scales (basically similar with British local level).

The consequences or impacts are exemplified with four characteristics in the national risk assessments outcomes of both countries. The categories were not completely one-to-one in conformance, but were postured in a comparative context, emanating from the definitions of these characteristics [11, 12, 20] as follows in Table 2.

Table 2: The consequence (impact) categories [11, 12, 20].

Estonia	United Kingdom
Categories of consequences	**Categories of impact**
Human life and health	The number of fatalities Human illness or injury
Vital service	Social disruption
Natural Environment	Economic damage
Assets	

The Estonian national risk assessments of different emergencies were carried out in corresponding working groups, each embracing the representatives of different bureaus and conducted by a lead ministry as was recently determined in the 2008 methodology [20]. Today the same principle is enacted by the Government of the Republic [22]. The lead ministries are shown in Table 3. Afterwards these separate assessments were collocated into a summary by the Ministry of the Interior [12]. According to the NRR 2010 edition, the British National Risk Assessment drew on expertise from a wide range of departments and agencies of government [11].

Table 3: Estonian national emergency risks [12, 20].

Number (Code)	Emergency	Lead ministry performing assessment
1	Extensive forest and brush fire	Ministry of the Interior
2	Extensive and/or complicated fire/explosion in industrial or warehouse buildings (production enterprises and warehouses with a risk of major accident, including explosives depots)	Ministry of the Interior
3	Extensive and/or complicated fire/explosion as a consequence of which very many people are injured and must be evacuated	Ministry of the Interior
4	Extensive, third-degree (oil) spill at sea	Ministry of the Interior
5	(Oil) spill on coast/shore	Ministry of the Environment
6	Mass unrest	Ministry of the Interior
7	Mass disorder in prison	Ministry of Justice
8	Road accident with many injured	Ministry of Economic Affairs and Communication
9	Accident involving passenger trains with many injured	Ministry of Economic Affairs and Communication
10	Accident involving a train carrying hazmats with many injured and/or major environmental damage	Ministry of Economic Affairs and Communication
11	Accident involving or sinking of passenger ship or ship with many casualties	Ministry of Economic Affairs and Communication
12	Air accident with many casualties	Ministry of Economic Affairs and Communication
13	Emergency situation caused by biological risks (including epidemic/pandemic, bioterrorism etc)	Ministry of Social Affairs
14	Extraordinarily hot weather	Ministry of Social Affairs
15	Extraordinarily cold weather	Ministry of Social Affairs
16	Storm	Ministry of the Interior
17	Flood in a high-density area (especially hazardous storm surge)	Ministry of the Interior
18	Mass poisoning	Ministry of Social Affairs
19	Epizootic (infectious animal disease)	Ministry of Agriculture
20	Nuclear accident with cross-border impact	Ministry of the Environment
21	Domestic incident involving source of radiation	Ministry of the Environment
22	Extensive environmental contamination	Ministry of the Environment
23	Massive immigration of refugees into the country	Ministry of Social Affairs
24	Hostage crisis	Ministry of the Interior
25	Extensive financial crisis (non-functioning of financial system)	Ministry of Finance
26	Extensive cyber attack	Ministry of Defence

2.4 Risk types and assessment outcomes

The methodology, which was the basis of the 2008 Estonian national risk assessment, determined 26 emergency types in a one-step list, which means that the emergencies (or emergency risks) were not grouped into broader categories by certain characteristics. The types of emergencies are shown together with the ministries, responsible for performing the concrete emergency risk assessment in Table 3. The serial numbers serve simultaneously as the codes of the emergencies.

The EU Vademecum of Civil Protection [23] generically recommends the division of the typology of emergencies into two broad categories: natural and man-made disasters. In the British NRR 2010 edition, the risks are divided into three broad categories, the first of which embraces essentially natural, and the last two man-made events. The main structure of 3 broad categories and 11 main types are shown in Table 4. The main risk types in turn contained sub-categories, which were described in the text of the NRR 2010 edition. The number of non-divided risk types and subtypes of the divided main types made altogether 23 events. These main risk types or subtypes, which are further brought out in the illustrative risk matrix (Figure 2), are marked with light-grey background.

Table 4: British national emergency risks [11].

Risk category	Risk type
Natural events	Human disease
	Pandemic human disease
	Non-pandemic human disease
	Flooding
	Coastal flooding
	Inland flooding
	Severe weather
	Animal disease
Major accidents	Major industrial accidents
	Major transport accidents
Malicious attacks	Attacks on crowded places
	Attacks on infrastructure
	Attacks on transport
	Non-conventional attacks
	Cyber security
	Cyber attacks: infrastructure
	Cyber attacks: data confidentiality

The public output documents of the national risk assessments of both of the observed countries [11, 12] presented the risks on risk matrixes. The Estonian risk matrix [12] has the scale of likelihood on the vertical axis and the scale of consequences on the horizontal axis. The allocation of the scales on the British national risk register matrix [11] is the opposite. The likelihood levels on the Estonian risk matrix are marked with numbers (1–5) and the consequence levels with letters (A-E). Both scales of the British national risk register matrix reflect correspondingly relative likelihood and impact – without distributions. The Estonian national risk matrix of 2008 is shown in Figure 1 and the British national risk register matrix 2010 in Figure 2. The 26 roman numerals on Estonian matrix coincide one-to-one with the Arabic numerals in Table 3, which means that the numbers of the emergencies in the list serve simultaneously as the codes on the matrix. The British matrix presents 14 high consequence risks, 8 of which are shown as main risk types and 6 as sub-types, as displayed in Table 4.

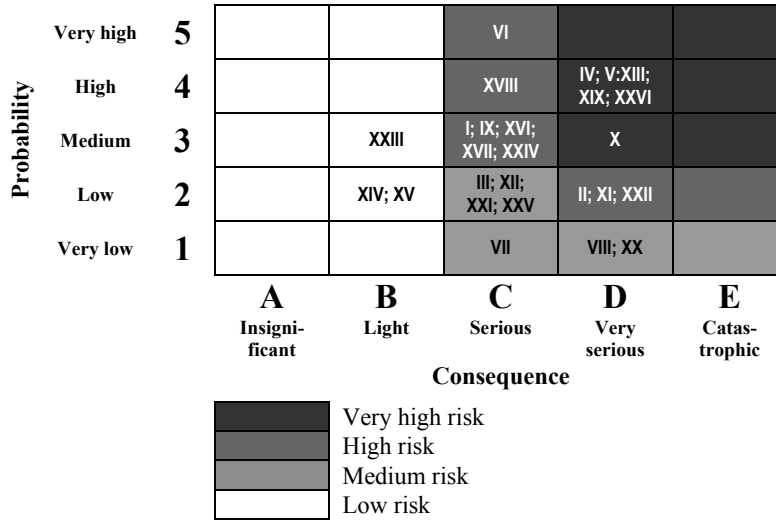

Figure 1: Estonian national risk matrix 2008 [12].

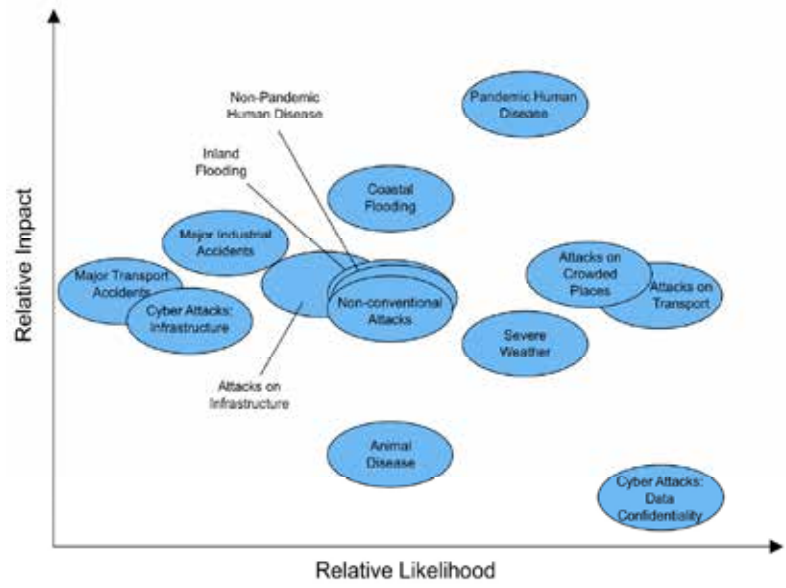

Figure 2: British national risk matrix 2010 [11].

The indirect comparison of the assessed risks of the observed countries demonstrated both: similarities and differences. The following is a set of selected examples. The risks of pandemic human disease were indicated in both countries as very high. The Estonian approach also deemed the risks of extensive oil spills as very high, but the British viewpoint did not handle these as autonomous events as these can be taken in principle as the results of industrial or transportation accidents. The risks accompanied with severe weather conditions were assessed as remarkably high in the both countries. Flood risks were also found remarkably high in the two countries, whereby in the UK coastal and inland floods were assessed separately but in Estonia the limiting criteria for flood risk assessment was localised in high-density areas. Major industrial accident risks were assessed as relatively high in the both countries, but the risks of major transport accidents were more accentuated in the Estonian approach. The assessed relative risk of cyber attacks was also observed higher in Estonia. The British NRR 2010 turned serious attention to the risks of several malicious attacks, which was even determined as one of the broad categories of risks. In the Estonian approach, these events were not handled as separate risk types, but simultaneously, for instance with the risk of mass unrest, which could bring along malicious attacks, which was assessed as high.

2.5 Composition of the output documents

The plain comparison of the output documents [11, 12] demonstrated remarkable differences in composition and points of view.

The 2008 National Summary of Risk Assessments for Emergencies [12] of Estonia consists of 2 generic and 26 specific Chapters and of 9 Appendixes. The specific chapters are the outputs of risk assessments of concrete emergency types. The content can be briefly displayed as follows:

- Introduction;
- Changes in comparison with the 2007 National Summary of Risk Assessments;
- Summaries of risk assessments of certain emergency types (I-XXVI);
- Appendixes (1-9).

Each specific chapter included the following sub-divisions: description of the emergency, historical facts and previous (similar) events, overview of the hazards causing the emergency, assessment of risks, existing resources and actions for emergency prevention and consequences mitigation, required additional resources and actions for emergency prevention and consequences mitigation.

Appendix 1 was a risk matrix (Figure 1), the remaining 8 appendixes contained informational materials in the forms of tables, maps or texts.

The British NRR 2010 edition consisted of the following main chapters:

1. Introduction;
2. Risks;
3. Considerations for business and organisations;
4. Preparing yourself, your family and your community for emergencies;
5. The risk assessment process.

The Chapter 1 Introduction in the NRR 2010 edition, among other things, was partly with a summarizing character, bringing out the national risk register matrix. The Chapter 2 Risks contained a discussion of assessed risks according to the previously discussed three broad categories. For each category features were observed such as risk, background, and planning measures by the Government, the Devoted Administrations and the emergency responders. Chapters 3 and 4 contained correspondingly the considerations for businesses and recommendations for civilians. Chapter 5 was a brief overview of the risk assessment process on the national level. Each chapter contained a number of apposite Internet references.

3 Conclusion

The public outputs of the risk assessments of the two EU countries had both: similarities and differences. The Estonian national emergency risk assessment was based on a similar methodology as the British local emergency risk assessments since the first was worked out greatly on the basis of the second. The typologies of emergency risks of the two countries were remarkably different, but still the majority of risk types were indirectly comparable. Both countries featured risks of emergencies such as pandemic or epidemic human disease, flooding, events connected with severe weather conditions and major industrial accidents. The Estonian approach unilaterally accentuated more comparable risks such as cyber attacks, major transport accidents and (infectious) animal disease, the British on the other hand different kinds of malicious attacks. Generically the British NRR 2010 edition was a more advising, guiding and directing document while the Estonian national risk assessment output document of 2008 was in a great part a summary of different emergency risk assessments.

Acknowledgements

This research was supported by European Social Fund's Doctoral Studies and Internationalisation Programme DoRa and also by the Target Funding Project No. 1090050s07 of the Ministry of Education and Science, Estonia. The authors would like to thank Tia Ruutopõld for linguistic advice and correction.

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IV

Tammepuu, A., Sepp, K., Paasoja, R., Kuusemets, V. 2008

RISK ASSESSMENT OF THE CITIES OF ESTONIA AND UK: COMPARATIVE STUDY

Gospodini, A., Brebbia, C.A., Tiezzi, E. (eds.). The Sustainable City V: Urban Regeneration and Sustainability. WIT Transactions on Ecology and the Environment, Volume 117. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 591–604.

Risk assessment of the cities of Estonia and the UK: comparative study

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Abstract

This paper presents a comparative study of city risk assessment in Estonia, as a so-called 'new member' and in the UK as an 'old member' of the EU. The comparison of the outcomes was carried out on the basis of four strategically selected risk assessments of Estonian cities and the same number of British cities. The selected indicators of comparison were legislative requirements, provision and performance, methodologies, types of analysed risks, risk assessment outcomes on a wide scale, risk assessment results, usage of risk matrixes and also publication and availability.

The risk assessments in both countries were required not only on a local community level, but on regional and state levels as well. In the UK the legal requirements and anchors in methodology were in general more clearly defined, which guarantees the similarity and better compatibility of the risk assessments of different cities and parishes. For example the division of risk matrix between risk rankings is precisely determined in British methodology, however in the Estonian, different interpretations are currently allowable. British legislation also sets concrete requirements for the publication of the community risk register, but in Estonia the availability of similar material depends on the decision and good will of the local government.

The final conclusion is that the territorial risk assessment methodologies of different European countries cannot be overtaken one-for-one or converted. At the same time, British risk assessment methodology and organisation can undoubtedly serve as one of the examples in the process of the further development of territorial risk assessment methodology in Estonia and maybe also for other 'new members' of the European Union, as was previously expected.

Keywords: risk assessment, civil protection, public safety.

WIT Transactions on Ecology and the Environment, Vol 117, © 2008 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/SC080561

1 Introduction

Sustainable development of cities and other urban units or urban settlements as complex systems depends on a large amount of characteristics and presumes relatively stabile conditions. Major accidents and hazards are samples of the destabilising factors, which can cause serious setbacks and breakdowns in the continuous development process. The risks, hazards and threats can be hidden and out of the eye of public attention until something serious happens. Therefore it is important for communities to be aware of these risks. For that purpose risk assessment is an essential part of civil protection [1]. In many European countries the usefulness of the further development of risk assessment in the field of civil protection and emergency preparedness is clearly recognized [2].

A lot of studies have been carried out concerning risk assessment in civil protection in the urban environment. Most of these concern concrete accident types, for example major chemical accidents, according to the "SEVESO II" Directive [3]. Fewer studies are available concerning the integrated approach of multi-hazard territorial risk assessment and management and also comparative studies. Lonka et al have conducted a comparative study of risk assessment in the field of civil protection of European countries [2]. The European research project QUARTER concentrated on the development of a territorial management system for territorial risk reduction and environmental quality improvement [4]. In the frames of the previously mentioned research project, a methodological framework for territorial vulnerability analysis and assessment was worked out [5]. In the context of territorial vulnerability analysis the Environmental Risk Management System procedure was proposed by the research group [6]. In Estonia Tint et al have discussed the problems of major accident hazards on the basis of Tallinn city risk assessments [7]. Tammepuu et al studied the aspects of risk assessment in land use planning, based on Tartu's city risk assessment and engaging different emergency risk types [1].

The authors of the current paper have been involved in the risk assessments of Estonian cities, communities and counties for several years. During our practical and research work we have noticed the remarkable differences between risk assessment outputs, based on the same methodology. Therefore we decided to study the problem more thoroughly, carrying out a comparative study of the largest cities of Estonia's four rescue regions: Tallinn (North –Estonia), Tartu (South-Estonia), Narva (together with Vaivara municipality, East- Estonia) and Pärnu (West-Estonia). After beginning the research we found it would be useful to compare the risk assessments in turn with the analogical work of another country, preferably 'an old' member of the EU.

After some casting about for a suitable country for comparison our eye stopped on the United Kingdom. Although the UK is very different from Estonia, being approximately 5.4 times larger by territory and 45 times by population, the countries still have enough similar features, favouring the comparison. Both countries are situated generically in the northern part of Europe, have a long coastal line, a low proportion of seismic and an absence of volcanic hazards, etc. In UK the performance of territorial risk assessment is

shared between local resilience areas. Therefore, in the context of the study, we had to look for cases where the local resilience areas coincided with the territories of the cities or conurbations, including also surrounding urban areas. The selected areas were: (the boroughs of) London, Greater Manchester, West Midlands conurbation (Birmingham with surrounding urban areas), and Belfast. The last was chosen as differences exist in the requirements and methodologies for Scotland and Northern Ireland.

The essential goal of the study was finding out, analysing and discussing the parallels and dissimilarities between the different risk assessments and assessed risks of the cities of two European countries and to look for new ideas for proposals for the improvement and development of Estonian territorial risk assessment methodology.

The research materials were legislative acts and regulations, guides, risk assessment reports of Estonian cities and community risk registers with supplementary materials from British cities (incl. the boroughs in London) and conurbations.

2 Legislative requirements for risk assessment

The requirements for risk assessment in the field of emergency preparedness and crisis regulation in Estonia are enacted in the Emergency Preparedness Act. The Estonian Emergency Preparedness Act designates risk assessment as an important task of crisis management, on the basis of which all of the following measures should be planned and implemented [8]. The act places the duty to conduct risk assessments of cities and rural municipalities on local governments. The rural municipality or city government has to perform risk assessments in order to identify the dangers, which may exist in the rural municipality or city, respectively. The outcomes of territorial risk assessment will serve as the basis for composing crisis management plans and spatial (land use) planning, concerning county plans, comprehensive plans, detailed plans, and also specific building projects. The act does not enact duties concerning the public availability of risk assessment issues in any form nor sets any restrictions.

The British Civil Contingencies Act 2004 [9] places a risk assessment duty on all Category 1 responders. The Category 1 responders are generically the following institutions: emergency services, local authorities, health bodies and environment agencies [10]. These Category 1 responders are obliged to assess risk from time to time, but as often as is necessary to ensure that they are in a reasonable position to maintain and update their emergency plans and to perform the civil protection duties under the Act, including the duty to maintain business continuity plans. The Category 1 responders also have an obligation to arrange for the publication of all or part of (risk) assessments made, simultaneously considering the security classification of the information and the restrictions on the disclosure of sensitive information. The requirements are detailed in The Civil Contingencies Act 2004 (Contingency Planning) Regulations 2005 [11].

3 Risk assessment methodologies

3.1 General overview

The methodological basis of territorial risk assessment in Estonia is established by a regulation of the Minister of the Interior. In the methodology legislation, risk assessment is defined as the systematic determination and evaluation of possible accidents and risk sources and the planning of measures for their prevention [12]. The methodology is largely based on the UNEP/APELL guidebook: Hazard Identification and Evaluation in a Local Community [13], of which the Estonian translation was organized in cooperation with the Estonian Rescue Board and Swedish Rescue Board.

The methodologies in the UK are presented in different issues. The methodologies for England and Wales can be found from the emergency preparedness guidance as a corresponding chapter [14] and the same for Scotland [16]. Northern Ireland has its own special (draft) guidance for risk assessment [15]. The methodologies have different elements, but in general the main principles are the same, partially adopted from the standard used in Australia and New Zealand. To facilitate our approach we dwell primarily on the English (and Welsh) version.

Our preliminary comparison demonstrated the existence of abundant similarities between the methodologies of the observed countries. Parallels can be drawn between the steps of assessment and the elements of risk evaluation. Both countries use five-point scales for likelihood and consequences assessment, which are combined into the five-times-five risk matrix. The following comparison is based on succeeding characteristics: steps, assessed risk types and categories, likelihood assessment, consequence assessment, the outcomes, output documents.

3.2 Steps of risk assessment

Estonian methodology requires the risk assessment as a 7-step process. British methodology consists of 6 defined steps. The first steps in the methodologies are expressed differently, but there is much in common between them as the Estonian information collecting (and exploitation) function is partially similar to British contextualisation – "describing the characteristics of the local area that will influence the likelihood and impact of an emergency in the community" [14]. The British 3rd step – risk analysis, covers both the 3rd and 4th steps of Estonian methodology. The Estonian 5-th and British 4-th, as well as the Estonian 6-th and British 5-th step are in conformance with each other. The 7-th step of Estonian methodology covers the actions, which are self-evidently conducted in the British approach, but not brought out as a step. The same could be mentioned about the 6-th step of British methodology from the viewpoint of the Estonian treatment. The steps of the risk assessments are brought comparatively in table 1.

Table 1: Comparison of the steps of risk assessments in Estonia and UK.

Step	Estonia	UK
1	Collecting information	Contextualisation
2	The clearing up of possible accidents	Hazard review and allocation for assessment
3	The assessment of possible accident's probability	Risk analysis
4	The assessment of possible accident's consequences	Risk evaluation
5	Risk evaluation	Risk treatment
6	The arrangement of prevention methods	Monitoring and reviewing
7	Forming of risk assessment outcomes and compilation of the report	-

3.3 Risk types and categories

The Estonian methodology requires the determination and risk assessment of 16+n different types of possible accidents (or hazards of those). These are the following: fires, explosions, transport accidents, accidents with dangerous chemicals, drinking water pollution, accidents on water bodies, accidents involving communal systems, breakdowns of electricity supply, breakdowns of communication systems, gas accidents, floods, collapses (buildings), extreme environmental conditions, epidemics, epizootics, social hazards, and the like, which means possible hazards that are actual but not in the main list.

The British methodology presumes the characterising of risk types with the risk identifier and risk category which responds to a certain numeric code. Risk identifiers have the following variants:

- H - hazards which will require a national as well as local response;
- HL - hazards which would not ordinarily prompt a national response, and would usually be dealt with locally;
- T - threats, which will require a national as well as local response.

The risk categories and codes are not defined in the methodology and its annexes (or more precisely in the publicly available version of it, used in our study). Browsing of concrete community risk registers brought out 10 main categories on which the concrete hazards are based. These are: industrial accidents and environmental pollution, transport accidents, severe weather, structural, human health, animal health, public protest, industrial action, international events and industrial technical failure.

3.4 Assessing the likelihood

The methodologies of both countries evaluate the likelihood with 5-level scales (Tables 2 and 3).

Table 2: Likelihood assessment criteria in Estonian risk assessment.

Level	Likelihood	Frequency
1	Improbable	Less than once during 25 years
2	Rare	At least once during 25 years
3	Probable	At least once during 5 years
4	Very probable	At least once a year
5	Frequent	At least once a month

Table 3: Likelihood assessment criteria in British risk assessment.

Level	Descriptor	Likelihood over 5 years	Likelihood over 5 years
1	Negligible	>0.005%	>1 in 20,000 chance
2	Rare	>0.05%	>1 in 2,000 chance
3	Unlikely	>0.5%	>1 in 200 chance
4	Possible	>5%	>1 in 20 chance
5	Probable	>50%	>1 in 2 chance

The Estonian approach uses the frequencies of the occurrence of accidental events. At the same time no additional conditions exist, which enables various interpretations. The reason being that the area where the possible accident (realized hazard) takes place can be chosen randomly: a city, a county, Estonia, EU, Europe, North America etc., and the frequency depends largely on the size of the surveyed territory. The British approach takes a certain time period of 5 years and sets the percentage and /or ratio of the accidental event. Simultaneously, originating directly from the public version of the methodology, the meaning of the entirety (100%) remains unclear, which could be understood for example as the number of accidents per some kinds of ordinary events.

3.5 Assessing the consequences

The methodologies of both countries under observation use a 5-level assessment of the consequences. The evaluation scales are comparatively shown in table 4.

Table 4: Consequences assessment criteria in risk assessment methodologies.

Estonia		United Kingdom	
Level	**Descriptor**	**Level**	**Descriptor**
A	Missing	1	Insignificant
B	Limited	2	Minor
C	Serious	3	Moderate
D	Hard	4	Significant
E	Very hard	5	Catastrophic

The comparison demonstrated the principal similarity, although the levels are defined and the descriptors named differently. The categories of consequences are also defined in different manners but a detailed comparison of the meanings and contents of the terms exhibited an almost direct conformance between the categories as displayed in table 5.

Table 5: The consequence (impact) categories.

Estonia	**United Kingdom**
Categories of consequences	**Categories of impact**
Life and health	Health
Vitally important sectors	Social
Environment	Environment
Property	Economic

3.6 Risk assessment outcomes and outputs

The Estonian methodology requires the compilation of an output document (summary or report) with the following statutory elements: area characterisation, maps and schemes of the area, accident statistics, environmental impacts, data of previously existing risk assessments (of concrete objects), risk assessment of accidents and appendixes (risk matrix, risk tables and risk map). The publication of the document is not mandatory.

The British legislation insists the Category 1 responders' creation and maintenance of a community risk register (CRR). The regulation [Regulation 2004] does not precisely define what the CRR is. Therefore we understand it (after having studied the concrete CRR-s) in two ways: firstly as a database with a predetermined structure in the form of table (the narrower sense) and secondly a document containing, in addition to the table, textual parts like introduction, purpose, context, explanation of assessment criteria etc. and usually the risk matrix, filled with risk evaluation outcomes (the broader sense).

The methodologies of both of the studied countries anticipate tables with a certain structure and risk matrixes for risk assessment and evaluation. The Estonian approach assumes the composition of a separate table for each risk, but does not require the compilation of a unified complex table like the CRR in the UK. At the same time British methodology affords an individual risk assessment example for documenting definite assessments and supporting the CRR. This example has comparable features with the Estonian risk table (for each assessed risk). The risk matrix in Estonian methodology has the scale of likelihood on the vertical axis and the scale of consequences on the horizontal axis. The allocation of the scales on the British risk matrix is the opposite. The likelihood levels are marked with numbers (1-5) and the consequence levels with letters (A-E) on the Estonian risk matrix and both scales are marked with numbers (1-5) on the British risk matrix. The British risk matrix (Figure 1) displays the four categories of risk ranking with explanatory keys. The current Estonian risk matrix does not originally contain the risk ranking divisions, which enables a creative approach to the problem on the one hand but complicates the comparison of risk

assessments on the other. The "pure" risk matrix form of the methodology is displayed in Figure 2 using the example of Narva, where risk ranking was not determined on the matrix.

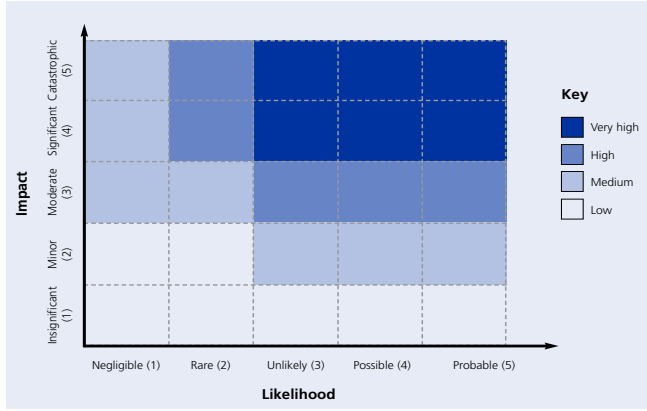

Figure 1: British risk matrix [14].

	A	B	C	D	E
5					
4					
3					
2					
1					

Figure 2: Risk matrix of Narva.

	A	B	C	D	E
5	II	III	IV	V	VI
4	II	III	IV	V	VI
3	I	III	IV	V	VI
2	I	I	I	V	VI
1	I	I	I	I	I

Figure 3: Risk matrix of Tallinn.

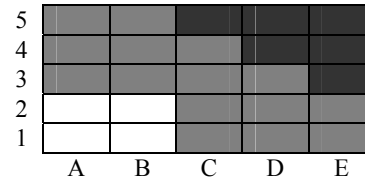

Figure 4: Risk matrix of Tartu.

	A	B	C	D	E
5	II	V	V	VII	VII
4	II	V	V	VII	VII
3	II	IV	IV	VI	VI
2	I	IV	IV	VI	VI
1	I	I	III	III	III

Figure 5: Risk matrix of Pärnu.

4 Comparison of city risk assessments

4.1 General remarks

The comparison of the risk assessments of the selected study areas: (cities, boroughs, conurbations) was performed mostly on the basis of publicly available materials via the Internet. The exceptions were the risk assessment outputs of the

Estonian cities Tartu and Narva (together with Vaivara municipality), which have no direct open access by web but are still easily accessible for research purposes. London has six different local resilience areas, divided by boroughs, of which each has its own CRR and so we studied all of these. During the comparison, the same characteristics as in the comparison of the methodologies were under observation.

4.2 Steps of risk assessment

The steps of risk assessments in all the case studies were in conformance with those required in the corresponding methodologies of the two countries as much as it could be concluded on the basis of available outputs.

4.3 Risk types and categories

During the observation of the treatment of accident (hazards) categories variations emerged in the risk assessments of Estonian cities. The types of risks and categories of hazards in the risk assessments of British cities originated directly from the methodologies. In the Estonian approaches, the main structure of the accidents list was transformed from the original of the methodologies (16+n) for the risk assessments of Tallinn [17,18] and Pärnu [19], and sub-categories were added to the modified main categories. The risk references responding to categories of accidents (hazards) were similarly to the British, marked with the combinations of letters and numbers in the risk assessment of Tallinn but in another way: the letter showed the accident main type and the number the concrete accident (R1, R2; M1, M2, M2.1 etc.). The sub-categories of the original main categories were appended in the risk assessments of Tartu [20] and Narva [21]. The main accident (hazard) categories and sub-categories were marked with numbers in the form of two-step classification (1: 1.1, 1.2; 2: 2.1, 2.2 etc.).

4.4 Likelihood assessment

The criteria for likelihood assessment in the methodologies were directly followed by all the studied British risk assessments. The risk assessments of Estonian cities again contained more variability or more precisely - Tallinn had developed its own modification of the methodology, where the frequency range was from: more than once a year up to rarer than once per 100 years. The risk assessments of other studied Estonian cities followed the likelihood scale of the original methodology.

4.5 Consequences (impact) assessment

The certain impact categories, as defined in the methodologies, were followed in risk assessments of the British cities. The same could be said about the three Estonian cities except Tallinn where modification of the methodology defined two additional components to the four, compared beforehand with British

analogues. These areas were the (need for) evacuation and (presence of or coverage with) rescue resources.

4.6 Risk assessments performance, availability, outcomes and outputs

Although the responsibility for the performance of risk assessment of a city or community in Estonia lies with the local governments, the real practical executors can be different persons, who have reciprocal agreements. For instance the risk assessment of Tallinn was carried out mainly by specialists of the crisis management service of the (previous) Tallinn Fire and Rescue Department (whose functions have been replaced by the crisis management bureau of the North-Estonian Rescue Centre). The risk assessment of Tartu was conducted by a research team from the Estonian University of Life Sciences with the participation of the authors of the current paper. The risk assessment of Pärnu was accomplished under the coordination of crisis management specialists of the rescue service, but different offices and persons were involved. The risk assessment of Narva was carried out mostly by private consultants. All the risk assessments of the four British cities or conurbations were performed by Local Resilience Forums, formed by Category 1 responders (or more precisely by working groups formed by previously mentioned institutions on the basis of Category 1 and Category 2 responders) as required by the Act [9]. The risk assessments were studied through publicly available community risk registers and therefore we had no detailed information about the exact staff of these working groups.

The risk assessment output documents (reports or summaries) of Tartu, Narva and Pärnu follow the formal structure enacted in the methodology. The risk assessment report of Tallinn is the most substantial with its two parts, but only partially complies with the previously mentioned structure. For instance there is no special chapter for emergencies statistics but at the same time there exists a special chapter for the (previously referred modification of) methodology. The British cities CRRs, in the narrower sense, originate comparatively accurately from the settings of the methodology and the examples of its annexes. The CRRs in a broader sense have more variations, considering the constitution and additional textual parts. For example the CRRs of (the boroughs of) London [22—27] include the contextualisation statement chapter, describing the social and environmental factors and economic and transport infrastructures. The included textual part of the Greater Manchester CRR [28] is on the contrary very laconic, but simultaneously there exists additional material: The Great Manchester Profile Document [29] which functionally belongs together with the CRR.

The risk assessment reports of Tallinn and Pärnu are available on the homepages these city governments. The risk assessment reports of Tartu and Narva are available upon request to the city governments, having currently no open access via Internet. The CRRs of the London (boroughs) and Greater Manchester can be downloaded from special sites of the homepages of the responding fire departments or brigades. The CRRs of West Midlands [30] and Belfast [31] can be found from special sites of the local resilience forums.

Hereby, it should be mentioned that West Midlands had no complete version of CRR, but only preliminary materials, covering partly the essential elements of the CRR. We began from these in our research.

As the risk matrices are core elements of the risk assessments, the ongoing comparative description is mainly based on these. The risk matrix is not only a risk evaluation tool, but also an output form, filled with risk evaluation and rating results. The risk assessments of Estonian cities in general use uniform risk matrices, but diversity is recognised in the approaches to risk ranking. The (blank) risk matrix of Narva (Figure 2) represents the original one from the methodology – without determined risk ranking zones. The (blank) risk matrix of Tallinn (Figure 3) is divided into 6 (I-VI) risk ranking zones. Analogically with the British risk matrix, the relative importance of the consequences is accentuated, but probably with too high a degree of contrast. For example in the case of catastrophic consequences, the events with a small likelihood belong to the VI zone (the highest) and the same with very small likelihood to the Ist zone (lowest). The (blank) risk matrix of Tartu (Figure 4) uses the 3 risk ranking zones on the matrix (originally red, yellow and green), where likelihood and consequences have proportional weights. The (blank) risk matrix (Figure 5) of Pärnu uses 7(I-VII) risk-ranking zones. In our mind the last has aberrances from the general logics of a risk matrix, where the risk increases "diagonally" towards the matrix, following the increase of the values of likelihood and consequences (or impacts). The risk assessments of the British cities followed the uniform risk ranking from the methodology.

The assessed risks were observed only cursorily in the current study, concentrating on (the comparison of) the highest assessed risks, because the results of the risks assessments of the two countries, as well as different regions of Estonia, were not comparable one-for-one. The highest risks in risk assessments of Estonian cities were in general: fire risks, chemical accidents risks in transport and fixed installations, failures of vitally important networks, extreme environmental conditions, and epidemics (except Tallinn, where the last was not assessed). Typical examples of very high risks in risk assessments of the British cities and conurbations, which were brought out in all or most studied cases (including the CRRs of London boroughs), were: influenza type disease with pandemic course, industrial technical failures of telecommunication infrastructure and/or electricity network, major local fluvial flooding.

5 Conclusions

The previous study demonstrated that the methodological approaches and the risk assessment outcomes and outputs of the two countries were readily comparable, as was proposed. The Estonian territorial risk assessment methodology was more laconic and less precise which enabled various interpretations and, as the cases showed, a creative approach. In general parallels can be drawn between the main steps of risk assessment in the methodologies of the studied countries. The positive side of the latter- is the generation of new ideas and viewpoints for the further development of the methodology. At the same time a drawback is the noticeable variability and difficult comparability of

the outcomes. The British risk assessment methodology was more voluminous and detailed and the work arrangement was firmly enacted. This ensured the principally uniform approach amongst the essential components of the risk assessments of the cities, as was noticed in the studied cases.

In our opinion the current Estonian territorial risk assessment methodology needs improvement. We believe that during the development and further specification of the Estonian territorial risk assessment methodology more attention has to be turned to the following components: the classification of hazards (and/or accidents caused by these), risk matrix from the aspects of risk ranking, and likelihood assessment. We find that the British methodology is suitable for serving as one indirect example for that purpose.

The optimal classification of categories of accidents (hazards) should be 2-step and the possible variants could be the combination of a letter and a number (A: A1, A2; B: B1, B2 etc) as in the case of Tallinn and alternatively the 2-step numeration (1: 1.1, 1.2; 2: 1.2, 2.2 etc) as in the cases of Tartu and Pärnu. The British system of codes and categories seems too complicated and specific to adopt directly.

The risk ranking as we visualize it, could be 3-level: low, medium, high or 5-level, involving two intermediate levels. Two variations could be conceivable: firstly, where the likelihood and consequences are in "balance" like in the case of Tartu (Figure 3) and secondly, where the weight of consequences is expressed more, like the British and Tallinn cases (Figures 1 and 3). The latter could be considered because of the fact that adequate response to single accident(s) with multiple victims is on average more complicated due to the lack of resources for simultaneous application rather than multiple accidents with few victims.

The likelihood assessment tools could be equipped with supplementary limiting criteria in addition to frequency, like commitment with certain territorial units (per n km^2), etc. The application of similar principles as the British use is also conceivable, but this presumes an adjustment of the circumstances beforehand.

Finally we emphasize, that the accurate determination of work arrangements, publication requirements and conditions, as well as information exchange and cooperation in the field of civil protection with other EU countries will be conducive to the perspectives of Estonian territorial risk assessment.

Acknowledgements

This study was supported by the Target Funding Project No. 1090050s07 of the Ministry of Education and Science, Estonia. The authors would like to thank Tõnu Paasoja from Tartu Aviation College and Evelin Uiga from Risk Management OÜ company for their help with the expert advise and city governments of Narva and Tartu for cooperativeness.

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Möldri, M., **Tammepuu, A.**, Tint, P., Paas, Õ., Laaniste, P. 2012

INTEGRATION OF THE SMS TO IMS IN ESTONIAN SEVESO II ESTABLISHMENTS: SELECTED CASE STUDIES

Brebbia, C.A. (ed.). Risk Analysis VIII. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 227–236.

Integration of the SMS to IMS in Estonian Seveso II establishments: selected case studies

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Abstract

This paper concerns the integration of Safety Management Systems of the Estonian Seveso II establishments into ISO-based Integrated Management Systems (IMS). Estonia has an obligation to follow the requirements of the EU Seveso II Directive since joining the EU in 2004. Today altogether 51 enterprises with major accident hazards are in the official register. According to the data available at the Estonian Association for Quality, seventeen of these establishments have certified quality (ISO 9001), environmental (ISO 14001) management integrated systems. Therefore it is useful and politically sound to integrate the SMS to the IMS. The essential goal of the current study is to explain the application of the unified management system and to find characteristic features for further recommendations. The results have demonstrated that, in spite of different approaches, a number of common factors exist, enabling general recommendations to be worked out.
Keywords: emergency preparedness, safety management systems, major chemical hazard.

1 Introduction

The existence of mankind has been filled with disastrous events: both natural and anthropogenic. Major accidents and hazards are destabilizing factors for continuous and sustainable development [1]. During the last decades there has been a significant increase in the number of technological and natural disasters in Europe and worldwide [2]. Therefore it is very important to work out different


WIT Transactions on Information and Communication Technologies, Vol 44, © 2012 WIT Press
www.witpress.com, ISSN 1743-3517 (on-line)
doi:10.2495/RISK120201

kinds of measures and requirements for keeping the hazards and risks under control and avoiding emergencies. Today the requirements concerning safety management are available in international and national legal documents and also in a variety of international standards. Different requirements cover single organisations and also broader social structures on regional, national and international levels.

Industrial installations using dangerous chemicals in quantities, which can cause major accidents, have been under heightened attention in Europe for about thirty years. Nowadays the Seveso II Directive [3] sets out basic principles and requirements for safety policies and management systems, suitable for the prevention, control and mitigation of major accident hazards. This document belongs to the most remarkable EU Directives, supporting the protection of people and the environment from major accidental hazards [4]. The Seveso II Directive also includes the settings for Safety Management Systems for ensuring the systematic measures and control mechanisms in the establishments with a major accident hazard. Safety management systems are obligatory for establishments with a major accident hazard as failures of the management system often cause accidents.

Since the 1990s the International Standard Organization (ISO) has worked out standards for different management fields in organisations, based on the universal management cycle of plan-do-check-act (PDCA). Today several organisations over the world have implemented and certified integrated management systems (IMS), based on corresponding ISO standards and containing quality (ISO 9001) [5], environment (ISO 14001) [6] and often also occupational health and safety (OHSAS 18001) [7]. The latter is not based on ISO standards, but on a document of the British Standard Institute, which has generically adopted the structure of ISO 14001 and has been recognized in many countries. The ISO 14001 and OHSAS 18001 both contain requirements concerning emergency and safety management. Although the management systems, based on ISO standards, are structured differently from the SMS presented in the Appendix III of the Seveso II Directive, there are noticeable similarities between these systems, providing a basis to an integrated approach.

Until now many studies involve both: the safety management systems and the ISO standardized and certified management systems but, simultaneously only a few studies have been carried out about the integration of these two categories. The situation is discussed more thoroughly in the next section of the paper.

Taking into account what was discussed so far, the essential goal of the current study is to explain the application of the unified management system and to find characteristic features for further recommendations. The particular aims and closer research interests concern the following issues: management policies; counteractions between ISO-based management systems and the SMS during the integrated development; the application of risk assessment and emergency planning in the SMS-containing IMS; the applicability and compatibility of such components of the IMS as operational control, management of change, monitoring performance and also audit and review to fulfil the corresponding requirements of the SMS.

The work discussed was carried out within the frames of a research workgroup on risk management and civil protection of the Estonian Academy of Security Sciences.

2 Integration of SMS to IMS

2.1 Safety Management System

The Seveso II Directive requires the compilation of a "Major Accident Prevention Policy" (MAPP) and "Safety Management System" (SMS) from all establishments with a major accident hazard [3, 8] on the basis of a summarized qualifying quantity by Annex I of the Directive. In accordance with Annex III of the Directive the SMS must embrace the following issues [3, 9]:

1. Organisation and personnel
2. Identification and evaluation of major hazards
3. Operational control
4. Management of change
5. Planning for emergencies
6. Monitoring performance
7. Audit and review

The Safety Management System can be briefly defined as the system for implementing safety management [10]. SMS substantially means multiple activities, initiatives, programs, etc., consolidated by organisational, human and technical aspects [11]. SMS in a formal sense is a framework, holding a large package of documents, containing different procedures, manuals, charts, reports, records, emergency plans, etc. [12]. The safety management system is considered to be a basic component of the organisations' safety culture [13, 14]. The size and orientation of SMS procedures are deeply dependent on identification and evaluation of major accident hazards and selection of risk analysis method(s) [15]. The integration of the principles of inherent safety and land use planning into the plant safety management system permits the reduction of possible consequences [16]. The SMS of neighbouring Seveso establishments may be organized in clusters, which enables observing common risks and possible counteractions as well as knowledge exchange and coordinated planning of pro-active and re-active measures [17].

2.2 Integration

The integration of legally required and standardised management systems is possible and recommendable due to the fact that they have several analogous or similar system components, although structured in different ways. In principle the activities for the prevention of accidents and the mitigation of consequences generically follow the PDCA management scheme, on which the ISO standards are based [12]. It is important to implement the SMS in consistence with a broader management system, like an integrated health, safety and environment

(HSE) management system, total quality management (TQM) system, etc. which, already exist and cover the entire management of a particular organisation [10].

Slovenian researchers conducted a study, where they, among other things, also observed the integration of SMS and IMS [18]. They brought out that 22 (71%) of their selected 31 establishments with a major chemical accident hazard had introduced the SMS as being related or completely integrated within ISO/OHSAS management system(s).

3 SMS in IMS of Estonian enterprises

According to the data of the Estonian Rescue Board [19] there are 51 establishments with a major chemical accident hazard in Estonia (further also Seveso II establishments). Among these, 19 organisations (37%) have implemented and been certified by ISO management standards, whereby 17 (33%, that makes about 1/3 of the total) have an integrated approach, based at least on two standards [20]. More precisely: 12 Seveso II establishments have integrated quality (ISO 9001) and environmental (ISO 14001) management systems, 4 have, in addition to the two mentioned, an occupational health and safety management system (OHSAS 18001), in addition 1 also has Environmental Management and Audit Scheme (EMAS) registration.

Table 1: Contingent correspondence between SMS and ISO 14001.

Safety Management System (SMS)	**ISO 14001**
Organisation and personnel	4.2 Environmental policy 4.3.2 Legal and other requirements 4.3.3 Objectives, targets and programme(s) 4.4.1 Resources, roles, responsibility and authority 4.4.2 Competence, training and awareness 4.4.3 Communication
Identification and evaluation of major hazards	4.3.1 Environmental aspects
Operational control	4.4.4 Documentation 4.4.5 Control of documents 4.4.6 Operational control
Management of change	4.3.3 Objectives, targets and programme(s)
Planning for emergencies	4.4.7 Emergency preparedness and response
Monitoring performance	4.5.1 Monitoring and measurement 4.5.2 Evaluation of compliance 4.5.3 Nonconformity, corrective action and preventive action
Audit and review	4.5.5 Internal audit 4.6 Management review

Recently we carried out a study, concerning the implementation of SMS in Estonian Seveso II establishments. During the study we turned our attention to the connections between safety management systems and the ISO 9001, ISO 14001 and OHSAS 18001. Other directions of the study were the evaluation and audit of companies safety management systems in Estonian conditions, but these are not under observation in the current paper.

One important outcome of the study was the guidance, where the previously mentioned connections were brought in as correspondence between the 7 main components of SMS and the subdivisions of ISO 9001, ISO 14001 and OHSAS 18001. The excerpt of that work, demonstrating the proposed correspondences of SMS with ISO 14001 is presented in Table 1.

The guidance was made publicly available and has been introduced and recommended to many Estonian Seveso II establishments for practical application purposes.

4 Selected case studies

4.1 General

Today, as previously stated, about 1/3 of Seveso II establishments in Estonia have implemented the integrated management system. We selected for our case studies three of these, belonging to different economic activities. One aim of the selection was finding organisations, which were not competitors with each other. This allowed for good prerequisites for possible further cooperation between the specialists of the organisations in the field of IMS and SMS development.

The common characteristics of the organisations were the following: firstly, all three belonged to international corporations and secondly, all the establishments had implemented and certified at least the ISO 9001 and ISO 14001 as IMS and thirdly, all three have the additional duty to follow the internal standards of their international corporations. One of the three case study establishments belongs to the upper tier and the two others to the lower tier, according to the quantity of dangerous substances by thresholds, brought out in Annex I of the Seveso II Directive [3, 21].

Our study is derived from the previously described guidance, where the connections between the SMS and ISO management standards are brought forth. The document analysis was carried out, concerning: safety reports or descriptions of SMS-s, handbooks of IMS-s, procedures and guides of IMS-s and also emergency plans. During the case studies relatively more attention was paid to the SMS-specific components: identification and evaluation of major hazards (risk assessments) and planning for emergencies.

4.2 Establishment A: a process industry

This establishment is a plant, producing chemical products. The major accident hazard originates mostly from the use of extremely flammable gases in the

processes. The establishment belongs to the lower tier by Annex I of Seveso II Directive.

The SMS was implemented on the basis of and integrated to the already existing ISO 9001 quality management system (QMS). As a matter of fact the first step of implementing SMS and integrating it to QMS was the compilation of the procedure for emergency preparedness, through which the obligatory components of the SMS were integrated. Later, when the environmental management system (EMS) on the basis of ISO 14001 was implemented, the emergency management part of it was already adopted from the SMS subdivision of the initially integrated system of quality and safety management. Today the formal part of the management system is generically Intranet-based. It is divided into functional modules and the SMS components belong mostly to the module of environmental and occupational health and safety management.

The establishment had no need to compile special safety politics or MAPP, as safety was natural component of the management politics of the international company, which the establishment belonged to. The handbook of quality (actually the handbook of IMS) serves as a central guidance document, which embraces also the key elements and links to the SMS-specific documents. The organisational structure scheme and responsibilities of the personnel, initially defined by QMS, were revised and amended during the implementation of SMS and EMS.

Identification and evaluation of major hazards and planning for emergencies are both regulated by the emergency preparedness procedure of the IMS, which has references to the procedures of environmental aspects assessment and the assessment of occupational hazards and risks. Additionally, the internal standards of the corporation are considered. The identification of hazards is carried out by the well-known HAZOP [22, 23] methodology in combination with the risk matrix for the assessment of risks. The risk matrix used is rather ordinary: 5*5 – with five-point scales for both, likelihood and consequences. The risk assessment outcome documents are in the status of appendixes of the IMS emergency preparedness procedure. The environmental aspects and occupational risks are assessed separately, but the principles are quite similar to major hazard risk assessment. The Emergency plan of the establishment with its guides is also formally standing as the appendix of the same IMS procedure. So the specific requirements, emanating from Seveso II Directive and Estonian Chemicals Act [24], are completely integrated to the IMS of that establishment.

The required elements of SMS such as operational control, management of change, monitoring performance, audit and review were covered by ISO 9001 based QMS procedures and were taken over during the implementation of the SMS and ISO 14001 based EMS. The management documentation was amended only with some new procedures and guides, concerning mainly the hazardous parts of the technological processes.

4.3 Establishment B: an oil terminal

The main activity of this establishment is the handling of oil products at a port terminal being one of the largest of its kind in Estonia. The establishment

belongs to the upper tier by Annex I of the Seveso II Directive. The corporation, to which the establishment belongs, has several terminals in Estonia and abroad.

The company implemented an integrated quality, environmental and safety management system from the very beginning applying the standards ISO 9001 and ISO 14001 and so the SMS documents were adapted to the IMS framework since their compilation. The central guidance document is the handbook of the management system, which gives directions to all components of the system. The handbook presents, among other things, the structural scheme of the personnel and the special duties of the personnel concerning safety are precisely set forth in job descriptions

The establishment has a uniform management policy, including the essential elements of MAPP. There is no special procedure of emergency preparedness in the framework of IMS. Instead of this, the essential elements of SMS such as safety report, risk assessment and emergency plan are integrated into IMS to cover the provisions of the subdivision 4.4.7 "Emergency preparedness and response" of the ISO 14001. Until today the risk identification of major hazards was carried out primarily by deterministic approach, relying on the competent opinions of specialists, experts and consultants. The risks were assessed by a 5*5 risk matrix. The establishment is planning the application of HAZOP to improve the identification of hazards.

Operational control, management of change, monitoring performance, audit and review were conceived from the outset of the implementation of ISO-based IMS to cover also the safety management issues, taking into consideration the specific requirements for SMS as obliged by the Seveso II Directive.

4.4 Establishment C: a water treatment plant

The establishment specialises in water treatment. The dangerous chemical – chlorine – is only used in one of the many sites, where the company operates: the water treatment plant. Therefore the IMS, covering the entire company, and the SMS, being required only in one certain site, were developed quite separately until recently. The water treatment plant is a lower tier establishment.

The company at first implemented and certified the ISO 9001 and ISO 14001 management systems and so the application of the SMS in water treatment had taken place already within the conditions of the existing IMS. The IMS of quality and environmental management involved the procedure of crisis management, covering the provisions of 4.4.7 "Emergency preparedness and response" of the ISO 14001. The procedure was designed to organise preparedness against different types of possible emergencies beyond the whole company and one of the guides, emanating from the procedure was addressed to a chlorine accident.

Simultaneously, to better respond to the SMS requirements, special documents such as a chlorine accident risk assessment and emergency plan were compiled for the water treatment plant with the help of a consultation company. The risks were assessed by a 5*5 risk matrix. Today the emergency plan is integrated with the crisis management procedure and the guide for chlorine accidents.

Later, during the implementation of OHSAS 18001 and its integration into the IMS the whole subject of risk was thoroughly revised and a special procedure of risk management was compiled. The procedure is designed to enable a uniform approach to different types of risks as well as environmental aspects. In relation to the former the company actuated the HAZOP methodology, covering all the production units, including the water treatment. The future orientation, concerning major accident risk from chlorine, is the revision of the possible major accident scenarios on the basis of HAZOP and drawing the risk assessment step-by-step together with the methodological process, derived from the risk management procedure of the IMS. Today there are good outlooks for this as the outputs of generic (of the whole company) and the chlorine emergency specific risk assessment result on 5*5 risk matrixes, although the scales, levels and other criteria are currently diversely defined.

The company had no need to develop special solutions for SMS components such as operational control, management of change, monitoring performance, as well as, audit and review since the corresponding measures of the standards-based IMS enabled complete coverage of these requirements.

5 Conclusion

The results of the case studies confirmed the expectations about the mutual impacts of the ISO-based IMS and SMS, enabling their integration into a unified management system. The case study establishments had composed unified policies in the framework of IMS, which contained the essential elements of quality, environmental and safety management and therefore there was no need for the compilation of a special MAPP.

The identification and evaluation of major hazards in the case study organisations was conducted by risk assessment, as is required by the Estonian Chemicals Act [24]. The major chemical accident risk assessment process was integrated to the IMS, although to a different degree, depending on the particular establishment. The three case study establishments received orientation to introduce the HAZOP methodology, which serves a broader target than only major chemical hazard identification, enabling systematic support for the improvement of the whole risk management in the frames of IMS. The default selection in the three establishments for risk assessment outputs was the risk matrix method, being simultaneously used also for other risk types and aspects. In spite of the multiple drawbacks of the risk matrix technique [25, 26], we still suggest the use of it for establishments, where a quantitative risk assessment approach is not the default selection, as it enables the comparison of major accident risks with other risk types in the organisation – either directly, if the defined scales and criteria are universal enough, or with the help of additional assessment tools for comparison and converting, specially worked out for that purpose.

The emergency planning principles were decreed and described in the corresponding IMS procedures. The emergency plans, designed for major accidents, were integrated to the IMS frameworks of the organisations.

The IMS based on ISO/OHSAS permitted the direct execution of the requirements of the SMS, involving operational control, management of change, monitoring performance as well as on audit and review.

Finally we recommend, on the strength of the current study experience, more cooperation and information exchange between the Seveso II establishments in the field of safety management and its integration to the ISO/OHSAS based management system.

Acknowledgements

European Social Fund's Doctoral Studies and Internationalisation Programme DoRa supported this research. The authors would like to thank the organisations, which agreed to participate in the case studies and also Tia Ruutopõld for linguistic advice and correction.

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VI

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EMERGENCY PREPAREDNESS IN INTEGRATED MANAGEMENT SYSTEMS: CASE STUDY OF THE PORT OF TALLINN

Disaster Management and Human Health Risk: Reducing Risk, Improving Outcomes. Duncan, K., Brebbia C.A. (eds.). WIT Transactions on the Built Environment, Volume 110. Ashurst Lodge, Ashurst, Southampton: Wessex Institute of Technology Press, 65–76.

Emergency preparedness in integrated management systems: case study of the Port of Tallinn

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Abstract

The paper discusses the problem of the integration of emergency preparedness and safety management into the ISO-based integrated management system (IMS). The international and national legal requirements for ports embrace different aspects of safety, but unfortunately do not give an entire conception of safety management. The standard ISO 14001 requires procedures for emergency preparedness from the organisations which have implemented it, but at the same time, emergency is not strictly defined in the standard and the formulation of the requirements' permit various interpretations. Thereof, our goal was to analyse the existing situation in the port of Tallinn and develop an updated conceptual approach during the improvement process of the integrated management system, suitable for the specific port and maybe partly applicable in other similar organisations.

The problem was observed in the context of a case study of the Port of Tallinn, which has implemented the integrated quality and environmental management system. The work, presented in this paper, was carried out in the frames of the Interreg IIIB programme DaGoB "Safe and Reliable Transport Chains of Dangerous Goods in the Baltic Sea Region". The first step was the analysis of the management system, bringing out the gaps and ambiguities, concerning emergency preparedness and safety management. The second step was working out solutions and proposal; the third step, the compilation of a relevant thematic handbook, in addition to a general handbook of the IMS.

Keywords: emergency preparedness and response, risk assessment, public safety.

WIT Transactions on The Built Environment, Vol 110, © 2009 WIT Press
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/DMAN090071

1 Introduction

During the history of mankind, human beings have always been exposed to different hazards. Emergencies have occurred in the past, occur nowadays and will occur in the future. Or in other words: accidents will happen again – it is only a question of time [1]. Therefore, the approaches for avoiding accidents, and creating a safer environment and society, have a long history. Currently the requirements concerning emergency preparedness and response can be found in several international/national legal documents and also in various standards. At the same time the meaning of emergencies differ remarkably in different issues.

The ISO 14001 for Environmental Management Systems is one of the standards containing direct requirements for emergency preparedness and response. [2] Since 1996 more than 87,000 organizations in 128 countries have been certified observing the ISO 14001 Environmental Management System standard [3]. Emergency preparedness and response is one of the key elements of the standard, which is closely connected with other elements. In Estonia today, there are over 270 enterprises certified observing the ISO 14001 standard [4]. All these organisations have taken responsibility for the subject of emergency preparedness and response.

The Port of Tallinn is one of the Estonian ISO 14001 certified enterprises. The Port of Tallinn has implemented an integrated (quality and environmental) management system (IMS), responding on both: ISO 9001 and ISO 14001 [5]. The port has 5 different harbours on different sites, 3 of which are situated in Tallinn or in close proximity. Dangerous goods (DG) in large quantities are handled in four of the five ports. A number of enterprises with major chemical accident hazard are situated directly on the territories of the harbours. These enterprises have their own safety management systems. In spite of different hazardous activities taking place on the territories and aquatic areas of the harbours, the port has only limited legal responsibility, concerning emergency preparedness and response. At the same time the organisation is voluntarily taking more duties in this field due to the implementation of ISO 14001 standards (together with ISO 9001). Currently environmental protection in companies is increasingly conducted using IMS [6].

The essential goals of our study were first analyse the existing situation in the Port of Tallinn, bringing out the gaps and ambiguities, addressing emergency preparedness and safety management. Secondly, to develop an updated conceptual approach during the improvement process of the integrated management system, containing relevant solutions and proposals. The final outcome was the compilation of a handbook of emergency preparedness and response for the Port of Tallinn on the basis of the study, as an additional manual to the handbook of IMS, facilitating both routine activities and continual improvement. The research materials used were existing documents, outcomes from interviews with key people and results of the observations. The work was carried out in the frames of the Interreg IIIB programme DaGoB "Safe and Reliable Transport Chains of Dangerous Goods in the Baltic Sea Region" [7]. Although the programme was directed mainly to dangerous goods, our study

observed a broader circle of risks of the emergencies in the context of IMS of the port.

2 Emergency preparedness in ISO 14001

The ISO 14001 standard provides a practical and workable framework for controlling environmental risk to prevent accidents and environmental regulation violations [8]. Emergency preparedness is one of the key elements of ISO 14001 [2]. The avoidance of environmental risks arising from the activities of the organisation and mitigation of the impact deriving from accidents and emergencies is one of the goals of implementing the environmental management system (EMS) [9]. The organizations voluntarily follow set standards to establish, implement and maintain procedures to identify potential emergency situations as well as potential accidents and respond to them. These organizations are also compelled to respond to actual emergency situations and accidents while preventing or mitigating associated adverse environmental impacts.

At the same time the meanings of emergency or emergency preparedness are not defined in the ISO 14001. Certain ambiguities may cause different understandings of the standard requirements. The Estonian Emergency Preparedness Act [10], for example, designates an emergency as an event or a chain of events which endangers national security, the life and health of persons, significant damages to the environment, or causes extensive economic damage. Responding to any of these requires the co-ordinated action of the Government of the Republic, government agencies and local governments. It is obvious that this definition, although being the legal one in Estonia, does not fit into the context of the ISO 14001, as it is almost equivalent with Smith's [11] definition of disaster. This is the following: an event, concentrated in time and space, in which a community experiences severe danger and disruption of its essential functions, accompanied by widespread human, material, or environmental losses, which often exceed the ability of the community to cope without external assistance.

The EU Civil Protection Financial Instrument [12] defines emergency as any situation which has or may have an adverse impact on people and their preparedness as a state of readiness which the capacity of human and material means enable them to ensure. This definition permits the observation of almost any kind of accident, where human beings suffer (even slightly), as an emergency. Martin [13] brings out that emergencies include releases of all types to the environment, whereby natural disasters that might lead to releases, and process hazards that might become emergencies. In our opinion an emergency, in the context of the environmental management system (as well as IMS), can be principally defined as an accident where outside aid is additionally required for adequate response. For organizations or enterprises of different sizes, emergencies are accidents for which rescue, ambulance, police etc. are called for.

Although the ISO 14001 does not define or include the word 'risk', the identification of potential emergency situations and accidents is actually the

assessment of the risk of emergency situations and accidents. In spite of the absence of the term 'risk' in the standard(s), different sources within the ISO 14001 contemplate risk assessment and management. Besides, risk in the different issues of ISO 14001 [14–16] is observed in a broader context than that of the merely emergencies and accidents, covering additional uncertain and undesirable environmental impacts.

Usually an accountable part of hazards the organisation is faced with are on-site hazards being (or connected with) environmental aspects. The potential accidents and emergency situations arising from these have to be observed during the assessment of environmental aspects as the impacts of such aspects. The ISO 14001 sets [17] that environmental aspects should not be limited only to normal operational conditions; abnormal and emergency situations must also be considered. This presumes that the selected methodology for environmental aspect assessment is obliged to take into account probability (e.g. assess the risk). Voorhees and Woellner [16] point out, that for understanding the degree of risk, ISO 14001 requires the following environmental concerns need to be addressed: the scale of the impact, the severity of the impact, the probability of occurrence, and the duration of impact. Organizations, in addition to first-string, often engage risk management specialists to assist in the identification of potential emergency or accident situations that could lead to human injury, environmental damage, or economic loss [18].

The ISO 14001 does not specify that the accidents and emergency situations, covered by the procedure(s), descend only from the elements of an organisation's activities, products and services, (e.g. environmental aspects – on-site hazards). Conversely, the responding guidance of ISO 14004 [19] mentions that in establishing its procedure(s), the organization should include consideration of the potential for (an) emergency situation(s) or accident(s) at a nearby facility (e.g. plant, road, railway line). Therefore, the organisation has to broaden the circle of potential emergency situations. Hence the coordination of additional risk assessment(s) or the analyse of the outcomes of out-site risk assessments are necessary for the complete identification of the potentially hazardous events.

The ISO 14001 only requires the existence of the procedure(s), covering inter alia the response to accidents and emergencies. The laconic and unspecified formulation in the standard enables various viewpoints and interpretations. A number of authors [9, 16, 20, 21] recommend the compilation of emergency plan(s) in addition to or emanating from the procedure(s). Batts [20] points out, that large companies usually have such plans already implemented at all sites. Voorhees and Woellner [16] make the point that, according to ISO 14004 recommendations, emergency plans can document emergency organization and responsibilities; a list of key personnel; details of emergency services; internal and external communication plans; actions taken in the event of different types of emergencies; information on hazardous materials, such as material safety datasheets; and training plans and testing for effectiveness. Belmane et al [9] (in addition to previous) mention the overview of special resources and equipment and guidelines for handling the accident residue.

An important requirement of the ISO 14001 concerns the periodic testing and simulation of emergency procedures, but leaves open the ways and frequency of such testing, which can lead to disagreements between auditors and clients [20]. Belmane et al [9] express that the absence of such periodical testing has appeared as a typical mistake in the maintenance of the EMS.

3 Case study of the Port of Tallinn

3.1 Brief overview of the port of Tallinn

The Port of Tallinn is the largest port in Estonia and, as far as both cargo and passenger traffic are taken into account, the biggest port on the Baltic Sea [22]. The Port of Tallinn is a state-owned company that unites five ports: Muuga Harbour, Old City Harbour, Paljassaare Harbour, Paldiski South Harbour, and Saaremaa Harbour. The organisation's main activities are ship traffic and port infrastructure management. Today, Port of Tallinn operates as a landlord type of port with no cargo handling operations of its own. Cargo handling and passenger transport are managed by the port operators, who are wholly responsible for the safe operation of the ports.

Aimed at improving customer satisfaction and effectiveness of environmental actions, Port of Tallinn has utilized, since 2003, an integrated quality and environmental management system which meets the requirement of the international standards ISO 9001:2000 and ISO 14001:2004 [23]. The safety management of the Port of Tallinn has been integrated with the quality and environmental management system for effective prevention of, and operative response to, hazards. All port facilities also have security plans approved by the national maritime authority and are compliant with ISPS requirements.

Subsequently the five harbours are briefly exemplified. All harbours are navigable all the year round and easily approachable with depths of up to 18 meters enabling them to receive all vessels able to pass the Danish Straits. Taking into account that the DaGoB project, in the frames of which this study was conducted, had orientation on dangerous goods (DG), additional attention is turned to this topic, characterizing the five ports. There are numerous risks related to the transportation of dangerous goods, including risk to human health and safety, risk to environment, risk to property and other types of risk [24]. Large volumes of hazardous cargo, mediated by the operators, are passing through the ports. Thus, serious accidents during their handling may endanger the employees of the Port of Tallinn and the normal operation of the ports.

Muuga Harbour is the biggest cargo harbour in Estonia and specializes in handling transit origin goods. It is the main cargo harbour for Port of Tallinn and is located approximately 17 km east of Tallinn. The port area covers territories of three different municipalities. The cargo volume handled at Muuga accounts for around 80% of the total cargo volume of Port of Tallinn and approximately 90% of all the transit cargo volume passing through Estonia. Nearly 75% of cargo loaded in Muuga Harbour includes crude oil and oil products, but the harbour also handles dry bulk (mostly fertilizers, grain and coal) as well as other types of

cargo. The three oil and/or chemical terminals and one enterprise which handles ammonium nitrate, are enterprises with major chemical accident hazard potential according to the Seveso II directive (EU-directive 96/82/EC) [25] criteria (hereafter also: 'Seveso enterprises'). The two other oil terminals in the neighbourhood of the port area, also 'Seveso enterprises', use the loading equipment on the berth, which has pipeline connections with these terminals.

The Old City harbour is one of the biggest and busiest passenger harbours in the Baltic region. It is also the biggest passenger harbour for both the Port of Tallinn and all of Estonia. In 2008, the total number of passengers travelling through the Port of Tallinn was 7,247,366. Not only passengers but also trucks with dangerous goods move through the harbour. The most hazardous of these is chlorine, used by the Tallinn Water Treatment Plant.

Paljassaare Harbour is situated on Paljassaare Peninsula in Tallinn. It is a cargo port which primarily specialises in handling mixed cargo, coal and oil products, as well as timber and perishables. Two of the operators have 'Seveso enterprises': one handles oil products and another ammonium nitrate.

Paldiski South Harbour is located 45 km west of Tallinn. The emphasis is placed on ro-ro activity, export of local goods and transit of liquid bulk and metals. One terminal, which handles oil, chemicals and LPG and is a 'Seveso enterprise', is situated in the neighbourhood and has its loading equipment on one of the berths, connected by pipelines with the terminal.

Saaremaa Harbour is a new passenger harbour on Saaremaa, the largest island of Estonia. The harbour has 2 quays available for cruise vessels accompanied by a quay for auxiliary vessels and a floating berth for small crafts. The only considerable chemicals handling operation is the occasional bunkering of the ships.

3.2 Analysis and improvement of emergency preparedness and response in the Port of Tallinn

3.2.1 Port safety in general

The analysis of the safety control and management systems was the first step of our study and development work. This analysis included an assessment of the conformity to Estonian legislation of the management and control systems for hazard prevention and response and of the sufficiency of the mentioned systems for preventing and responding to hazards. The analysis brought out a number of problems that need additional attention and made specific proposals for their resolution.

The ISO 14001 standard has special subdivision, concerning legal and other requirements. The implementation of ISO-based IMS presumes conformance with these requirements. Thus our study turned special attention to this matter. The ports are, at the same time, dry land and maritime structures. Therefore the legislative requirements, concerning port safety exist in several international and national legal acts. There are no strict requirements, obliging the ports to create a consistent emergency management system (or approach). Thus we observed only selected legal acts, which were more directly connected with emergency preparedness and response theme. The conformity with the following acts was

examined: The Ports Act [26], the Emergency Preparedness Act [10], the Rescue Act [27], The Chemicals Act [28] and the Occupational Health and Safety Act [29].

The Ports Act enacts a port authority as one who possesses a port and organises the activities of the port as a whole. Originating from this definition the port authority is not univocal in the landlord-type ports like the Port of Tallinn. This can give birth to contradictory interpretations and indeterminable responsibilities, e.g. no one answers for the safety in general on port areas and water areas on ports, which means there is dispersed responsibility. We consider that the best solution here could be for developing cooperation and the specification of the duties of the parties. For instance, in the sites where previously mentioned isolated oil terminals have loading equipment on the berths located on main port area and other places, the liabilities in the case of emergency are the most entangled.

The Ports Act is also the legal basis of port rules in the Estonian context. The Port Rules of the Port of Tallinn insist that companies operating in the port ensure tidiness, order and fulfill due diligence of fire precaution, environmental and health protection requirements on the territory, at the quays, in the buildings and facilities used by them. The rules require the immediate reporting of all accidents, either with people and/or equipment, pollution of the port territory, damage to vessels, quays and fenders to the Harbour Master's Office. The rules also require that the operators provide the port owner with the requisites of the person responsible for the safe handling of dangerous cargo, which seemed to function according to expectations. The rules oblige the operators of oil terminals to develop organizational and technical measures, which ensure the safety of workers, prevention of fire and sea pollution and localization and liquidation of their aftereffects, to be developed in the terminal. This is, in part, the intersection with the requirements of Seveso II directive, Chemicals Act and also ISO-based EMS or IMS for the operators, who have implemented these systems.

3.2.2 Emergency preparedness

The Emergency Preparedness Act provides the legal basis for the organisation of emergency preparedness of, and for, crisis management by the Government of the Republic, government agencies and local governments. The act requires the preparation of emergency plans of the enterprises pursuant to the Chemicals Act. For this reason the port operators, relevant to Seveso II Directive and some others are subjects of this obligation. The Emergency Preparedness Act simultaneously determines that, on the basis of risk assessments of rural municipalities and cities, the rural municipality and city governments shall designate the enterprises and agencies, which additionally shall prepare emergency plans. Although the municipalities have assessed the risks of responding port areas, not one municipality has posed in its risk assessment report the requirement to the port(s) to compile the emergency plan(s). Therefore the Port of Tallinn has no obligation to follow the provisions of the act, concerning the enterprises and thus its systematic approach to emergency

preparedness and response is essentially based only on voluntary obligation in the framework of IMS, emanating from ISO 14001.

The previous version of the emergency preparedness and response procedure (hereafter also: 'procedure') was in the centre of our attention during the analysis. The 'procedure' generically conformed to the essential requirements of the ISO 14001. The detected problems concerned basically the identification of emergencies and the distribution of actions and responsibilities.

The identification of emergencies was carried out by groups of competent port employees. The lists of emergencies were composed qualitatively, relying on experiences and expert decisions – independently of the assessment of environmental aspects and other similar procedures. The participants were certainly aware of the environmental aspects assessment, as well as of the risk assessments of the operators of 'Seveso enterprises' on the port areas, the municipalities etc., but the outcomes of these were only indirectly taken into account. During the detail study of the problem, we discovered several paradoxical moments. The assessed (indirect) environmental aspects (of the terminals) were fire and releases of hazardous chemicals, but as a matter of fact the assessment methodology in use classified these as non-significant. This could be an explanation as to why we did not find the relevant environmental objectives and targets in the programmes of IMS. The 'procedure' enacted the duty of coordinating the risk assessments of the operators, handling dangerous goods, to the safety personnel of the ports. Actually the safety personnel did not even have copies of the risk assessment outcomes or safety reports. Further, it became evident that one security company, a partner of the Port of Tallinn, had conducted the general emergency risk assessment, but the outcomes were somehow forgotten or neglected by the interested parties. Therefore we recommended the composition of a systematic overview of the existing outcomes of different risk assessments and further application of additional assessment methodologies for accident and emergency risks as well as for risk-related environmental aspects and impacts. The risks of accidents were also considered in the occupational risk assessments, which will be discussed further.

The actions and responsibilities were determined rather impersonally in the 'procedure'. Thus we recommended the further specification of the duties and responsibilities during the composition of new versions of the procedure. The specification was carried out by the departments and divisions.

Emergency plans were existing for all the five ports, deriving from the 'procedure'. As the risk assessment was a weak point in emergency preparedness, the information about the emergencies and hazard zones was rather cursory. The plans contained the response resources but not the guidance as to how to use them. The instructions for action, in several cases, comprised only the emergency communication and references to the emergency plans of the operators. Therefore we once more recommend giving more attention to the opportunities of identification of the potential accidents and emergencies. Secondly we proposed the precision of the concrete emergency actions and exploitation of relevant resources.

The port rules included a requirement, by which all companies operating on port territory shall prepare a plan of activities for the protection of people and assets in case of fire, natural disaster, catastrophe, accident, explosion, etc. The copy of the plan of activities shall be submitted to the port owner. Operators with 'Seveso enterprises' and some others had submitted such plans, but most of the small operators had not. We supposed that every small company with almost no hazardous activities had no urgent need for their own separate emergency plan. Therefore our recommendation was the elaboration of the circle of operators, from whom the existence of the plan was reasoned in the first place.

The 'procedure' also determined the main principles of counter-pollution. The analysis ascertained that the water areas of the ports were well covered with responding measures. Each port had its marine counter-pollution plan, which realization chances were covered with competence and resources. The marine counter-pollution plans were the functional appendices of the emergency plans of the ports. Concurrently it was discovered that the counter pollution of the port (dry land) areas was set as an objective, but simultaneously without coverage. Because of this we proposed the determination of resources, operations and responsibilities for the dry land accidental pollution cases and composition of dry land counter-pollution plans for each port as appendixes to the ports (general) emergency plans.

3.2.3 Fire safety

The previously mentioned Rescue Act [27], among other things, enacts the organisational and construction fire safety requirements. In accordance with the act the port has delegated the performance of the fire safety requirements mainly to the operators and tenants who possess a great part of the ports areas and buildings.

In spite of the formal delegation of the full responsibility for fire safety to the operators, the real liabilities were actually distributed between the port and the operator(s), but the details were not comprehensibly fixed in the contracts. Therefore we recommended the further specification of the roles of the parties. We also suggested the improvement of general fire safety guidance and the compilation of special guidance manuals for the maintenance of fire safety installations and fire fighting water supply systems.

3.2.4 Occupational safety – accident hazard in working environment

Occupational safety as a whole was not the subject of our study, as the Port of Tallinn had not implemented and integrated to IMS their system of occupational health and safety management by OHSAS 18001 [30] or some other standard. Regardless, the Estonian Act of Occupational Health and Safety [29] contains the requirements for the employers in the case of emergencies and this is the only law, which claims carrying out of risk assessments (of working environment) in almost every organisation. Therefore it was decided to observe this subject in a more specific context.

Further review of the occupational risk assessment reports brought out a number of contradictions concerning the accident risks. Subsequently some examples are presented:

1) fire risk was not assessed in certain groups of workers, but the preventive measures were described;
2) chemical accident risks were not identified and assessed for another group of port workers, who are regularly in touch with dangerous chemicals (of the operators);
3) fire risk was assessed for the office but not for the groundwood plant.

We considered the need for checking over the outcomes of the risk assessment of the working environment, concerning serious accidents and in principle proposed the further actuation of these as one source in the identification framework of the potential accidents and emergencies.

3.3 Compilation of a handbook

Combining experiences and observations with advice of different port specialists, a dual meaning was attributed to the handbook of emergency preparedness and response: the narrower and the broader. The handbook was composed in three parts:. The first part being a handbook in the direct sense – a guidance manual of emergency preparedness and response for persons, involved with the application and continual improvement of IMS. This part (the guidance manual) gave an overview of the risk factors occurring in the ports and of the possible hazards associated with these. The second part was the directory of safety and emergency preparedness documents, concerning specific ports, persons and events. This part, which included safety documents, was designed primarily for those port employees who were responsible for hazard prevention and response. The third part of the handbook contained plans (instructions) related to hazard prevention and response. The general starting point was the corresponding chapter of the handbook of IMS of the Port of Tallinn and the basic document of the existing procedure of emergency preparedness and response.

The first part of the handbook contained six chapters. The first and the second chapter were respectively the introduction and the scope. The third chapter included an overview of four types of hazards, which can develop into emergencies. These were: accidents with dangerous substances, pollution of the port area with oil products or other dangerous substances, fires, and bomb risks. The fourth chapter handled the general principles of safety management and guidelines for hazard response. The fifth chapter presented a review of safety assurance in the ports.

4 Conclusion

The study generally brought out that the integration of emergency preparedness and response to the IMS was evidently the optimal consistent solution for assuring the continuous development and improvement of that field in the Port of Tallinn.

The results of the analysis demonstrated a foreseeable need for turning attention to the following important moments in the field of emergency preparedness and response. Firstly, the improvement of the identification

methodology of potential accidents and emergencies, secondly, the specification of the responsibilities of the departments, divisions and staff in chief of the Port of Tallinn, and thirdly, the better cooperation between the port administration, operators and municipalities.

The experiences of the study were taken into account for the compilation of the new version of the emergency preparedness and response procedure and handbook, which practically denoted the renovation and improvement of that specific part of the IMS of the Port of Tallinn. Finally we supposed that our observations and proposed solutions could serve as comparative examples for others, who were engaged with the safety and emergency problems as well as with ISO-based management systems.

Acknowledgements

This study was additionally supported by the Target Funding Project No. 1090050s07 of the Ministry of Education and Science, Estonia. The authors would like to thank the personnel of the Port of Tallinn for their cooperation and Evelin Uiga from Risk Management OÜ company for help with the expert advise.

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Tammepuu, A., Sepp, K., Kaart, T. 2014

EMERGENCY PREPAREDNESS IN THE ISO 14001 ENTERPRISES: ESTONIAN CASE STUDY. INTERNATIONAL JOURNAL OF EMERGENCY MANAGEMENT

Manuscript (in press).

EMERGENCY PREPAREDNESS AND RESPONSE IN ISO 14001 ENTERPRISES: AN ESTONIAN CASE STUDY

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ABSTRACT

This paper discusses emergency preparedness and response in environmental management systems. Emergency preparedness and response is one of the key elements of the 14001 standard of the International Organisation for Standardization (ISO). ISO 14001 requires participating organisations to implement procedures for emergency preparedness and response, but the standard does not strictly define the word 'emergency', and consequently, the formulation of the requirements is subject to various interpretations. Organisations implementing and certifying environmental management systems are obliged to identify potential emergency situations and accidents that can impact the environment and plan an appropriate response. The identification of potential emergency situations and accidents requires risk assessment. However, the standard does not define what is meant by 'emergency situation', 'accident' and 'risk'. The special requirements in ISO 14001 and the guidelines in ISO 14004 are fairly laconic and imprecise, which allows for many ambiguous in-

terpretations. In this context, we studied Estonian enterprises to analyse the variety of approaches to emergency preparedness and response. The main aim of this survey was to examine the identification and assessment of, as well as the response to, accidents and emergency situations in a selection of Estonian organisations that had implemented the requirements of ISO 14001. As a result of this study, we reached a number of conclusions that organisations can consider during the implementation and later improvement of their environmental or integrated management systems.

Keywords: environmental, management, hazard, risk, assessment, emergency procedure, preparedness, response

1. INTRODUCTION

Throughout history, humans have been exposed to hazards. Emergencies have occurred in the past, occur in the present and will occur in the future (Tammepuu et al., 2009). In hazardous environments, as argued by [Flynn and Theodore, (2001), p. 80], accidents will reoccur; it is only a question of time. Risks, hazards and threats can be hidden and kept out of the public eye until something serious happens (Tammepuu et al., 2008). Therefore, finding approaches to avoid accidents and create a safer environment and society has a long history. Major accidents and hazards are examples of destabilising factors, which can cause serious setbacks and breakdowns in the continuity of a society's development processes. Currently, the requirements concerning emergency preparedness and response in economic enterprises are detailed in international and national legal documents and a variety of international standards. Nevertheless, the meaning of the word 'emergency' differs remarkably in these documents and depends on the context.

The International Organization for Standardization's (ISO) standard for Environmental Management Systems (EMS), ISO 14001, is recognised globally and directly details requirements for emergency preparedness and response (ISO 14001, 2004). The global scope of the standard is reflected in the 129,199 organisations in 140 countries that were certified as observing the ISO 14001 EMS standard in 2006 (Balzarova and Castka, 2008; ISO/Survey, 2006). Emergency preparedness and response is one of the key elements of the standard for which all certified organisations have responsibility.

In Estonia, the number of organisations certified as observing ISO 14001 has grown continuously from 50 in 2002 to 419 in 2012. Most of these organisations are small- and medium-sized companies (SMEs) that have developed integrated quality and environmental management systems (IMS); this has led to improvements in their environmental protection (Belmane et al., 2002). Many of these enterprises have also developed occupational health and safety management systems in compliance with OHSAS 18001 (BSI, 2007).

A number of studies have been carried out concerning the emergency preparedness of ISO 14001 certified enterprises. Some of these studies focus on major chemical hazards and their relationships to ISO 14001. For example, Rosenthal and Theiler (1998) discuss the ISO 14000 option of implementing the United States Environmental Protection Agency's rule on Risk Management Programs for Chemical Accidental Release Prevention. Gerbec and Kontic (2009) conducted a survey of the implementation of the Seveso II Directive in enterprises in Slovenia, in which they found that the majority of the 'Seveso enterprises' were combining the Safety Management System required by the directive with voluntary management systems, including ISO 14001. Other studies that focus on any of a broad range of ISO 14001 topics also include emergency preparedness and response. In a survey of the implementation status of EMS in U.S. colleges and universities, Savely et al. (2007) demonstrate that environmental emergency preparedness and response procedures were present in 88% of the cases studied. Sambasivan and Yun Fei (2008) argue that organisational preparedness for emergency situations is a key component of organisational change. Marazza et al. (2010) studied the environmental aspects under the control of local authorities and emphasise that the risks of environmental accidents could be included. Saengsupavanich et al. (2009), as part of an environmental performance evaluation of a Thai port and the adjoining industrial estate, studied emergency preparedness and planning. They identify the availability of an emergency plan as one of the indicators of environmental performance (Saengsupavanich et al., 2009). Tammepuu et al. (2009) conducted a case study of emergency preparedness in a landlord port, Tallinn, in Estonia. Although emergency preparedness and response is an important component of ISO 14001, we could not find any studies specifically directed at the meaning of the key phrase of the standard, 'emergency preparedness and response'.

Consequently, we decided to perform a case study of 'emergency preparedness and response' solutions for selected organisations in Estonia.

The three specific aims were to determine (1) how organisations identified and assessed potential accidents and emergencies, (2) how organisations organised their emergency preparedness planning and responses and (3) how organisations arranged the testing of emergency preparedness and any corresponding training. The overall objective was the identification of common features in the organisations' approaches that could then be recommended to interested organisations and stakeholders.

2. EMERGENCY PREPAREDNESS IN ISO 14001

The ISO 14001 standard provides a practical and workable framework for controlling environmental risk and thus preventing accidents and violations of environmental regulations (Kwon et al., 2002), and emergency preparedness is one of the key ISO 14001 measures. Avoiding the environmental risks that arise from an organisation's activities and mitigating the impacts of accidents and emergencies is one of the goals of implementing an EMS (Belmane et al., 2002). Organizations voluntarily follow a set of standards to establish, implement and maintain procedures to identify and respond to potential emergency situations and accidents. While organisations voluntarily devise and develop the EMS, the ISO 14001 system compels them to respond to actual emergency situations and accidents while preventing or mitigating associated adverse environmental impacts.

Nevertheless, ISO 14001 defines neither 'emergency' nor 'emergency preparedness', and consequently, certain ambiguities may lead to differing interpretations of the standard's requirements. For example, the Estonian Emergency Preparedness Act of 2000, valid until the 23rd of July 2009, defined an emergency as 'an event or a chain of events, which endangers national security, the life and health of persons, causes significant damages to the environment or extensive economic damage' [Parliament of Estonia, (2000), Section 2 of General Provisions]. Responding to an emergency requires 'the co-ordinated action of the Government of the Republic, government agencies and local governments' [Parliament of Estonia, (2000), Section 2 of General Provisions]. Although this is the legal definition in Estonia, it does not fit into the context of ISO 14001 as it is almost the equivalent of Smith's (2001, p.7) definition of disaster as 'an event, concentrated in time and space, in which a community experiences severe danger and disruption of its essential functions, accompanied by widespread human, material, or environmental losses, which often exceed the ability of the community to cope without ex-

ternal assistance'. The new Estonian Emergency Act (2009) defines an emergency as 'an event or chain of events that threatens the life or health of many people or causing great damage to property or large and extensive environmental damage or serious disruption in the maintenance of critical services and for the resolution of which is necessary the expeditious co-ordinated action of several institutions or the persons engaged by these institutions' [Parliament of Estonia, (2009), Section 2 of General Provisions]. This definition is more suitable to the legal requirements for the implementation of an ISO 14001 based EMS.

The EU Civil Protection Financial Instrument (2007) defines emergency as 'any situation, which has or may have an adverse impact on people and their preparedness as a state of readiness, which the capacity of human and material means enable them to ensure' [EC, (2007), Article 3]. This definition permits the classification of almost any type of accident in which humans suffer as an emergency. Martin (1998, p.69) emphasises that emergencies 'include releases to the environment of all types, natural disasters that might lead to releases and process hazards that might become emergencies'. In our opinion, an emergency, in the context of either an EMS or IMS, can be principally defined as an accident for which external aid is additionally required to provide an adequate response; i.e., organisations need to call emergency services such as the fire-brigade, ambulance, police etc.

2.1 Risk in the context of the standard

Although ISO 14001 does not define or include the word 'risk', the identification of potential emergency situations and accidents is based on the assessment of the probability that they will occur. Despite omitting the term 'risk', sources cited within ISO 14001 do contemplate risk assessment and management. The various requirements of ISO 14001 view risk not as just encompassing emergencies and accidents but in a broader context that covers additional uncertain and undesirable environmental impacts (Jones and Mason, 2002; Martin and Edgley, 1998; Voorhees and Woellner, 1998). An organisation's management applies risk assessment to the process of identifying significant aspects of the environment, including those that can cause accidents and emergencies (Põder, 2006). Furthermore Zobel et al. (2002) recommend that incident risk be taken into account when monitoring abnormal conditions. Clarke and Kouri (2009) account for both direct and indirect environmental interactions in risk-benefit analysis when choosing appropriate EMS for universities

or colleges. In principle, a risk analysis-based approach is possible for the implementation of both IMS and EMS (Labodova, 2004).

2.2 On-site and off-site hazards

Usually, the hazards faced by an organisation are on-site and either directly or indirectly environmental in aspect. The potential accidents and emergency situations that may arise from these hazards have to be accounted for during an environmental assessment. ISO 14001 states that environmental aspects of risk assessment should not be limited to normal operational conditions; abnormal and emergency situations must also be considered. This presumes that the selected methodology for environmental hazard assessment is sufficient to account for that probability (e.g., assess the risk). Voorhees and Woellner (1998) note that to understand the degree of risk, ISO 14001 requires the following environmental concerns to be addressed: the scale of the impact, the severity of the impact, the probability of occurrence and the duration of impact. Organizations often hire outside risk management specialists to assist with the identification of potential emergency situations or accidents that could cause human injury, environmental damage or economic loss (Schaarsmith, 2005).

ISO 14001 does not specify that the potential accidents and emergency situations covered by the procedure(s) could only result from an organisation's activities, products and services (e.g., environmental aspects of on-site hazards). The guidelines of ISO 14004 (2004) state that in establishing its procedure(s), an organisation should also consider the potential for any emergency situation or accident at a nearby facility (e.g., plant, road, railway line). Therefore, the organisation has to broaden the scope of potential emergency situations. Hence, the coordination of additional risk assessment(s) or the analysis of off-site emergency outcomes is necessary for the complete identification of potentially hazardous events.

2.3 Emergency response and testing

ISO 14001 only requires the existence of procedures to respond to accidents and emergencies. The lack of specificity in the standard enables multiple interpretations. A number of authors recommend that emergency plans emanating from or in addition to the procedures be compiled (Batts 1999; Belmane et al., 2002; Voorhees and Woellner, 1998;

Whitelaw 2004). Large companies usually implement the necessary plans at all of their sites (Batts, 1999). According to the recommendations of ISO 14004, plans can document the organisation and related responsibilities in case of an emergency including a list of key personnel, details of emergency services, internal and external communication plans, actions specific to different types of emergencies, information on hazardous materials (e.g., material safety datasheets) and training plans and tests for effectiveness (ISO 14004, 2004; Voorhees and Woellner 1998). Belmane et al. (2002) provide an overview of the special resources, equipment and guidelines for handling accident residue.

An important requirement of ISO 14001 concerns the periodic testing and simulation of emergency procedures, but it leaves the methods and frequency of such testing open to interpretation and that can lead to disagreements between auditors and clients (Batts, 1999). The absence of periodic testing is a typical mistake in the maintenance of EMS (Belmane et al., 2002).

3. MATERIALS AND METHODS

This study was conducted by sending a survey to selected Estonian ISO 14001 certified organisations. The questionnaire consisted of 16 questions, including 7 open questions, 6 questions with a selection of answers and 3 closed questions, that were designed to elicit information about the structure of the enterprises and their compliance, aspirations and problems with ISO 14001 certification in the context of emergency preparedness and response. The questions embraced the following topics:

- Identification of possible emergencies and accidents
- Types of identified accidents and emergencies
- Emergency preparedness and response procedures and emergency plans
- Training and testing
- Proposals for continuing improvement
- Sources of information

Our quantitative analysis was based on either the percentage and/or the number of responses. We rounded percentages to the nearest integer, and if the number of responses fell short of the total (45) due to a questionnaire being incomplete, the shortened total was recorded, e.g., 30% of 43.

Initially, we selected 84 companies with the longest records of having certified environmental management systems; therefore, we included

organisations that had certified environmental management systems in place before the publication of the new version of the ISO 14001 standard in 2004. We sent our questionnaire to these 84 companies. Forty-five of these organisations returned completed or partially completed questionnaires, and the results are presented in Table 1.

Table 1. Activities of the Estonian ISO 14001 Certified Businesses Surveyed (N=45)

Frequency	Business Activity Category	Size of Workforce and Chemical Accident Hazard (+)
6	Electronics and electrical equipment	70,110,110,130,490,520
5	Construction	90,220,270,290,330
4	Chemical industry	60+,60+,110+,210+
4	Energy Production and distribution	140,160+,300,990
3	Petroleum products	50+,110+,150+
3	Printing	40,50,180
2	Building materials	80,130
2	Design	70,100
2	Furniture industry	130,200
2	Metalworking	70,650
2	Waste management	210,350+
1	Animal husbandry	180
1	Aviation	Data Not Available
1	Automobile components production	800+
1	Forestry	1300
1	Medical equipment production	90
1	Oil shale production	4600
1	Port services	740
1	Textile industry	150
1	Transport and logistics	60
1	Wood industry	250

The workforce sizes were rounded to 'tens' and ranged from 40-4600 for an average workforce size of 350 and a median of 150 for the 44 enterprises. Almost 23% (10 of 44) were companies with potential 'major chemical accident hazards', according to the criteria of the Seveso II Directive (1997), or 'hazardous enterprises' according to the criteria of Estonia's Chemicals Act of 1998 (Parliament of Estonia, 1998). Despite the fact that the prescribed threshold quantities of chemicals in the Chemicals Act are significantly lower than in the Seveso II Directive, the companies are still obliged by the Chemicals Act to compile an emergency preparedness plan (Tammepuu et al., 2007).

In addition to simple descriptive statistics, we used factor analysis in SAS software (SAS Institute Inc., Cary, NC, USA) to uncover the main patterns and structures in emergency preparedness and response.

4. RESULTS

4.1 Identification of possible emergencies and accidents

The results indicated that 96% of the enterprises identified possible accidents and emergencies during their assessment of environmental aspects. The causes of possible accidents, the non-environmental aspects, were considered by 73% of the organisations. Enterprises identified possible accidents using an occupational risk assessment in 82% of the cases, and 40% of the organisations, mainly those with chemical hazards, conducted additional environmental risk assessments. Other methodological approaches for conducting assessments were used by 13% of the organisations and were comprised of qualitative assessments based on expert knowledge, methods originating from object-specific requirements, identification during environmental impact assessments and specific methods of risk assessment such as for raw materials and products. In 45% of the 44 cases, enterprise personnel conducted the identification of possible accidents and emergencies. External consultants were employed in 32%, and a combination of both was used in 23% of the cases.

4.2 Types of identified accidents and emergencies

The categories of accidents and emergencies that the enterprises identified covered a broad range from the traditional (fire and vandalism) to the modern (bomb threats and IT security). The enterprises, as expected, ranked fire (100%) as the most common possible accident. Four-fifths of the enterprises (80%) identified accidents with dangerous chemical substances as a serious potential hazard although only 23% of the enterprises were considered hazardous under the Estonian Chemicals Act or were deemed to have a major chemical accident hazard by the Seveso Directive. The enterprises identified accidental pollution of soil and/or water (62%) as more probable than air pollution (31%). A noteworthy hazard was explosions (58%), which may be due to the identification of bomb threats as a potential cause of explosive events. Other accidents identified were vandalism, technical break-downs, occupational accidents, natural gas accidents, slips, electrical accidents, animal epidemics, bomb threats,

transportation accidents, security and IT risks and off-site events, such as major accidents at neighbouring enterprises, extreme natural conditions, epidemics, disruptions to the power supply and other networks as well as radioactive pollution of the surroundings.

4.3 Emergency preparedness and response procedures and emergency plans

All of the enterprises declared the existence of an emergency preparedness and response procedure (the 'main procedure'), which is a precondition for implementing an ISO 14001 management system. The majority of the organisations (89%) disclosed the existence of supplementary documents of preventive measures. Only 5 organisations (11%) declared that the main procedure was their sole document that described both measures for prevention and mitigation of adverse environmental impacts.
Of the 44 enterprises that answered the question, the majority admitted to the existence of supplementary documents of preventive measures. Almost half of the companies had a fire safety document (48%), close to a third had both a chemical safety document (32%) and an occupational health and safety document (27%) and a fifth had a collection of safety guidelines (23%) and an operational control manual (18%). Less common were emergency plans (9%) and plans for the maintenance and cleaning of equipment, handling of problematic waste, security, evacuation plans, veterinary and sanitary guides (5% or less).

The 23 enterprises that answered the question claimed to have documents pertaining to mitigation measures. The most frequently cited documents addressed counter-pollution (43%), fire safety (30%) and operational control as well as waste and dangerous chemicals handling (17%). Emergency plans and procedures were both disclosed twice (9%), and documents concerning automatic control and other mitigation specific issues, such as ignition of machinery, automatic monitoring and high-pressure equipment, were mentioned once (4%).

The survey did, however, demonstrate that a majority of the enterprises (67%) had, in addition to their 'main procedure', emergency plans for their responses, which are not directly required by ISO 14001. Almost half of the enterprises (49%) described the structures of their emergency plans. The emergency plans of these 22 enterprises contained a variety of components including response action guides (86%), names and contacts of responsible personnel (68%), information and communication data (50%), descriptions of possible emergencies and consequences

(45%), details of response resources (41%), guidelines for co-operation with neighbours (18%), evacuation guides (9%) and systems for energy and communication exchange (9%). Other components were less disclosed. As expected, the most complete and detailed emergency plans were those of the 10 enterprises considered to be hazardous or have the risk of a major chemical accident. Because all of these enterprises involve both hazardous chemicals and combustible materials (petroleum and oils), they need to abide by the regulations of either or both the Seveso II Directive and the Estonian Chemicals Act, which have strict requirements for the development of emergency plans. The need to have an emergency plan is as important as having regular reviews (ISO 14001 4.4.7). The importance of regular reviews is reflected by the frequencies of the reviews claimed by the enterprises: every three years (1/45), every two years accompanying internal audits (1/45), annually (30/45), bi-annually (3/45) and quarterly (1/45). As these responses indicate, the timing of the reviews is not necessarily linked to regular time-frames. Reviews occur: during ordinary internal audits and more frequently if needed, when necessary, when situation or conditions have changed, before internal audits or after an emergency and during continuous amendments to response plans. The need for the practical application of the emergency plan or emergency response procedure(s) was highlighted by 33% of the organisations.

4.4 Training and testing

ISO 14001 4.4.2. clearly states that certified enterprises have the responsibility to identify training requirements and ensure that every staff member whose actions may have an impact on the environment receive suitable training. The enterprises took one of four routes to deliver a procedure for identifying training needs and devising and delivering training courses to the relevant staff: (i) 27% employed foreign consultants to manage the entire procedure; (ii) 47% employed foreign consultants to support their in-house personnel; (iii) 24% required their in-house personnel to manage on their own (24%); (iv) 2% chose thematic external training courses. The long-term advantage of the second option is that the companies' in-house personnel should be competent to manage on their own within a few years. In addition, 60% of organisations dispatched their selected categories of workers' to thematic external courses. Thirty-four of the 45 enterprises responded to the question about the subjects of the training courses and ranked the most important topics

covered as follows: 1st general emergency preparedness and response (56%), 2nd fire safety (44%), 3rd environmental pollution (24%), 4th evacuation (15%), 5th first aid (12%), 6th welding safety (6%), 7th electrical safety (6%) and 8th occupational safety (3%).

We expected fire safety, occupational safety, and first aid to be the most important as legal requirements exist for all three topics. We assume the respondents did not associate the topics of occupational safety and first aid with the theme of emergency preparedness and response as required by the ISO 14001 standard.

We have categorised the content of the emergency training courses as 'general' when aimed at all employees, 'semi-specific' for a particular group of the workforce, or 'specific' for a few specialists. The results of the organisations' responses to this question are presented in Table 2 and clearly indicate that Estonian businesses believe a broad range of employees would benefit from emergency procedure training.

Table 2. Degree of Content Specificity in Emergency Training Courses by Estonian ISO 14001 Certified Enterprises in (n=37)

Target Employees	**Content Category**	**Choice of Enterprises**
All employees	General	46%
Specialists	Specific	46%
Workers	Semi-specific	41%
Managers	Semi-specific	24%
Foremen	Semi-specific	14%
First aid providers	Specific	14%
Masters	Semi-specific	8%
Drivers	Specific	5%
Rescue team members	Specific	5%

The testing of the emergency preparedness and response procedures was performed as follows: 73% of the organisations practised theoretical training with role-playing; 64% also conducted practical training with selected employees, and 57% also organised practical exercises for most of their employees. Training exercises, as distinct from role-plays, enable trainees to apply theoretical knowledge to practical situations. Two-thirds of the enterprises involved emergency services (police, fire, ambulance) and other local or governmental offices; 23% practiced the exercises in cooperation with neighbouring enterprises, and 39% of the organisations employed external instructors to supervise the training exercises.

4.5 Proposals for continuing improvement

Proposals for continuing improvement in the field of emergency preparedness and response inside the framework of ISO 14001 were presented by 20 of the 45 respondents (44%) and resulted in 13 recommendations: urgent need for more practical training (4 of 20 enterprises), comprehensive identification of possible accidents and emergencies and implementation of risk assessments (3), more careful compliance with legal acts and other requirements (3), regular training (2), more detailed safety instructions (1), compilation of emergency plans (1), creation of rescue teams (1), improvements to security systems (1), cooperation with scientific and development organisations (1), improvements in communication between partners (1), comparative analysis of the experiences and emergency preparedness systems of similar organisations (1), continuous review of the risk assessment processes (1), and the need for more specific information sources (1).

4.6 Information sources

One of the open questions referred to the availability of reference materials and facilities for use in preparing and maintaining emergency preparedness and response procedures and corresponding measures. Twenty-nine organisations answered, and we have identified eight categories of sources of information: legal acts and regulations (13), materials from consultants and training courses (8), guiding information from rescue service(s) (7), ISO standards and guides (6), unspecified sources including thematic guides and instructions from the Internet (6), specific guidance for subject fields and concern(s) relevant to the organisation(s) (5), experiences and conventions (4), and responses of other enterprises to previous accidents (1). One of the 29 organisations complained of the lack of pertinent information sources.

4.7 Common patterns and structures according to the factor analysis

The results of the factor analysis covering 34 answers to the questions about the identification of possible emergencies and accidents, preparedness, training and testing are presented in Figure 1. Only questions answered variably by the 44 enterprises were included. This means, for instance, that fire was excluded from the factor analysis as it was iden-

tified by 100% of the respondents, so there was no variability. The first two factors account for 23.7% of the total variability.
The first factor mainly characterises the relationship with the hazard and the second factor with safety. The factor analysis enabled the following inferences. The specific methods for the identification of possible emergencies and accidents were used by the organisations with more haz-

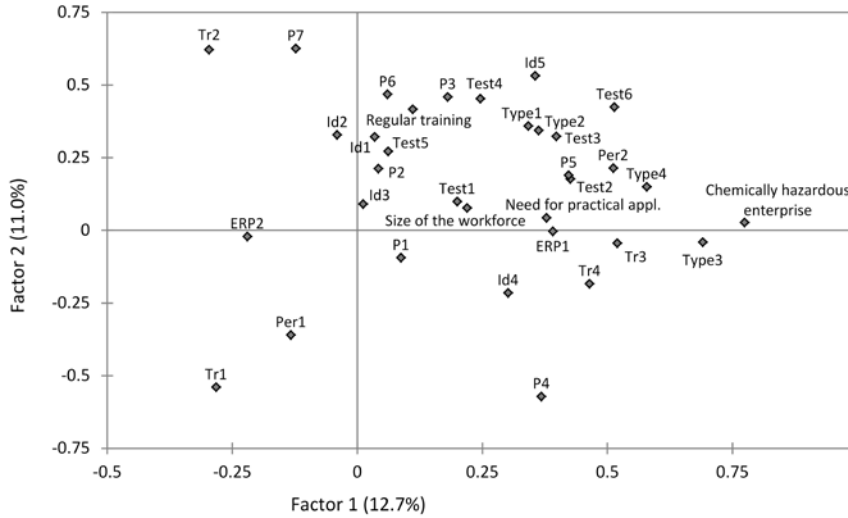

Figure 1. Results of the factor analysis of selected questions. Abbreviations used in the figure: Id – identification of possible emergencies and accidents (Id1: assessment of environmental aspects, Id2: assessment of off-site hazards, Id3: occupational risk assessment, Id4: additional environmental risk assessments, Id5: other methodological approaches), Per – persons identifying possible accidents and emergencies (Per1: enterprises' own personnel, Per2: external consultants), Type – types of identified accidents and emergencies (Type1: explosion, Type2: dangerous chemical substances, Type3: accidental air pollution, Type4: accidental pollution of soil and water), P – emergency preparedness and response procedures (P1: supplementary documents of preventive measures, P2: collection of safety guidelines, P3: fire safety document, P4: operational control manual, P5: occupational health and safety document, P6: emergency plans, P7: chemical safety document), ERP – general emergency response procedures (ERP1: common plan, ERP2: specific procedures not originating from the common plan), Tr – route to deliver a training procedure (Tr1: in-house personnel required to manage on their own, Tr2: foreign consultants employed to manage the entire procedure, Tr3: foreign consultants employed to support their in-house personnel, Tr4: selected categories of workers dispatched to thematic external courses), Test – testing of the emergency preparedness and response procedures (Test1: theoretical training with role-playing, Test2: practical training with selected employees, Test3: practical exercises for most of the employees, Test4: training exercises supervised by external instructors, Test5: practical exercises in cooperation with neighbouring enterprises, Test6: practical exercises in cooperation with emergency services (police, fire, ambulance) and other local or governmental offices.

ard(s), and external consultants were used more often in these cases. The organisations with low levels of hazard but with well-developed safety measures mainly used foreign consultants to manage their entire emergency preparedness and response procedure, including the organisation and execution of training. Emergency plans existed in the more hazardous organisations, while the less hazardous ones preferred using separate procedures. The enterprises with larger workforces were relatively more hazardous. Testing of the emergency procedures through practical training was related to the hazard factor, except in the case of practical exercises in cooperation with neighbouring enterprises. The regularity of training was related to the safety factor.

5. CONCLUSIONS

The survey indicated that the Estonian organisations that have implemented certified ISO 14001-based Environmental Management Systems have, despite the ambiguous requirements in the standard, largely taken similar approaches to compiling emergency procedures. Nevertheless, there were also many variations. The majority of the studied organisations combined the identification of possible accidents and emergencies with the assessment of the significant environmental aspects, which is consistent with Põder (2006), and occupational risks. Most of the organisations also took into account off-site hazards as recommended by ISO 14004. The most frequently identified accident was fire, a logical outcome, but less expected among the majority of answers were potential explosions and chemical accidents. The organisations with higher hazard levels preferred to incorporate foreign consultants into the identification of emergencies and risk assessment. The majority of these enterprises included accident prevention and loss mitigation measures in their special emergency response procedures and EMS documents. About two-thirds of the enterprises declared emergency plans, which is in accord with observations from several studies (Batts, 1999; Belmane et al., 2002; Voorhees and Woellner, 1998). Emergency plans frequently contained subdivisions, such as response action guides for concrete emergencies, the names and contacts of selected responsible personnel, brief descriptions of consequences, resources for response and special information and communications. The responsibility for conducting emergency training courses was held by enterprise staff in approximately a quarter of the cases, by off-site consultants in another quarter and by a combination of both in half of the cases. As expected,

the organisations with higher hazard factors employed more practical emergency training exercises. According to the survey results, we recommend a similar approach to the identification and assessment of significant environmental aspects and possible accidents and emergencies. The outcomes of the current study also led us to suggest the compilation of emergency plans to promote more capable and effective systematic emergency responses, even though such a compilation is not required by the standard.

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2002–2008	PhD studies, Estonian University of Life Sciences
1980–1986	MD studies, University of Tartu

Academic degree:

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Professional employment:

2010 –	Estonian Academy of Security Sciences, lecturer
2000 –	Risk Management OÜ, analyst-consultant,
2002–2005	Tartu Health Care College, teacher
1998–1999	Tartu County Rescue Service, head of emergency centre
1995–1997	Tartu County Emergency Centre, director
1993–1994	Tartu Fire and Rescue Department, senior inspector of civil protection
1991–1992	University of Tartu, Institute of Molecular and Cell Biology, assistant professor
1989–1990	University of Tartu, Department of Hygiene and Health Organisation, junior researcher

Research interests:

Environmental management; environmental risk assessment and management; risk and safety studies; civil protection; crisis management

Membership:

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Professional training:

2009	training project of Environmental Management consultants and managers BE-SMARTER, Stockholm Environment Institute Tallinn centre (SEI Tallinn), Estonia
2006	NOVA PhD course "Reproduction Toxicology", Norway
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2003–2004	Course "Vocational Pedagogy" University of Tartu, Estonia
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2003	course "Catastrophes and Globalization" Central European University (CEU), Hungary
2003	course "Riski Asessment and Management" MATRA (Netherlands), Estonia
2002	course "Environmental assessment and management" CEU, Hungary
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1997	course of fire supervision, Estonian Training Center of Civil Protection, Estonia
1996	Catastrophe aid training , Fire and Disaster School and Academy for Crisis Management, Emergency Planning and Civil Protection, Germany
1994	training in Finnish and Swedish rescue services as a grantee of the Nordic Council of Ministers in the frames of the project of exchange of the civil servants, Finland and Sweden
1993	course "Environmental Management" University of Gothenburg, Sweden
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Teaduskraad:	
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Uurimistöö põhisuunad:	
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Täiendus:

2009	keskkonnajuhtimise konsultantide ja keskkonnajuhtide täiendõppe koolitus BE-SMARTER, Säästva Eesti Instituut, Eesti
2006	NOVA doktorikursus "Reproduktsioonitoksikoloogia" , Norra
2006	Euroopa Ühenduse keskkonnajuhtimise ja -auditeerimise süsteemi (EMAS) tõendajate koolitus, Keskkonnaministeerium, Eesti
2005	doktorikursus "Tehnoloogia ja risk"Oslo Ülikool, Norra
2004	kursus "Ökokaardistamine" Säästva Eesti Instituut, Eesti
2003–2004	kutsepedagoogika täienduskursus, Tartu Ülikool, Eesti
2003–2004	EL struktuurifondide nõustajate koolitus, EV Rahandusministeerium, Eesti
2003	kursus "Katastroofid ja globaliseerumine" Kesk-Euroopa Ülikool, Ungari
2003	MATRA (Holland) koolitusprojekt "Riski hindamine ja riskijuhtimine" Eesti
2002	kursus "Keskkonnamõju hindamine ja keskkonnajuhtimine" Kesk-Euroopa Ülikool, Ungari
2002	kõrgkoolipedagoogika täienduskursus, Tartu Ülikool, Eesti
1997	tuletõrjejärelevalve alane kvalifikatsioonikursus, Eesti Kodanikukaitse Koolituskeskus, Eesti
1996	katastroofiabi alane koolitus, Heyrothsberge Tuletõrje ja Katastroofikaitse Kool ja Saksamaa Liitvabariigi Kodanikukaitse Akadeemia
1994	Põhjamaade Ministrite Nõukogu stipendiaadina stažeerimine Soome ja Rootsi päästeteenistustes ametnike vahetuse projekti raames
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LIST OF PUBLICATIONS

Publications indexed in the Thomson Reuters (ISI) Web of Science database:

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Papers in Estonian peer-reviewed research journals with a local editorial board:

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Tammepuu, A., Tammepuu, O., Sepp, K. 2009. Emergency preparedness in integrated management systems: case study of the Port of Tallinn. First International Conference on Disaster Management and Human Health Risk 23 -25 September 2009, New Forest, UK.

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ISBN 978-9949-536-29-0

roheline trükis
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