

**Resilience as an Imperative
in
Public Transport Organizations**

by

Jan Willem Proper



**Dissertation presented
for the
Degree of Doctor of Philosophy in
Transport and Logistics Studies
at
Stellenbosch University**

**Promoter: Professor W.J. Pienaar
Faculty of Economics & Management Sciences
Department of Logistics**

December 2011

DECLARATION

By submitting this dissertation, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner therefore (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it obtaining any qualification.

Signature:

Date: December, 2011

Copyright © 2011 University of Stellenbosch

All rights reserved

ABSTRACT

The role of public transport is to stimulate urban, social, sustainable and economic developments by transport of passengers based on their needs with public transport organizations functioning as operators in this environment. This dissertation reports on the research done on resilience in urban public transport organizations; it presents the guiding principles and the framework of resilience and the ability of public transport organizations to embed this capability.

The emerging discipline of resilience studies is multidimensional and multidisciplinary. The phenomenon has been examined to present a holistic perspective on resilience through an extensive review of the literature, supplemented by empirical research in the European public transport sector. Resilience has been defined as the capacity of an organization to survive, adapt and grow in the face of turbulent change. Existing research tends to focus on the relevance of the concept of resilience in a diversity of environments. There is little information or research that reflects the design principles and specific success factors in the public transport sector.

The literature research produced several logical conclusions, which were reviewed by using structured interviews with a selected group of specialists in this field. This made it possible to determine guiding principles, to structure the framework, and to develop a unique classification of (i) the most fundamental vulnerability factors that make an organization susceptible to disruptions; and (ii) the capability factors as attributes required for sustained performance or accomplishment.

All these findings are synthesised and this research establishes the ability of public transport organizations to implement a resilience approach within the boundaries of their level of advancement and prioritised direction statements.

Recommendations for further research include extending the proposed framework empirically to other functions and to other organizations than urban public transport organizations.

Keywords: Public transport, resilience, framework design, vulnerability factors, capability factors, decision support, proactive planning

OPSOMMING

Die rol van openbare vervoer is om stedelike, sosiale, volhoubare en ekonomiese ontwikkeling te stimuleer deur die vervoer van passasiers op grond van hul behoeftes. Openbare vervoerorganisasies funksioneer as operateurs in hierdie omgewing. Hierdie proefskrif doen verslag oor die navorsing oor veerkrag in stedelike openbare vervoerorganisasies en verskaf die basiese beginsels en die raamwerk van veerkrag en die moontlikheid dat openbare vervoerorganisasies hierdie vermoë insluit.

Die opkomende dissipline van veerkragstudies is multidimensioneel en multidissiplinêr en die verskynsel is ondersoek om 'n holistiese perspektief op veerkrag aan te bied deur 'n omvattende oorsig van die literatuur, aangevul deur empiriese navorsing oor die Europese openbare vervoer. Veerkrag word gedefinieer as die vermoë van 'n organisasie om te oorleef, aan te pas en te groei ten spyte van turbulente verandering. Bestaande navorsing neig om te fokus op die toepaslikheid van die konsep van veerkrag in 'n verskeidenheid van omgewings. Min inligting of navorsing weerspieël die ontwerpbeginne en spesifieke suksesfaktore daarvan in die openbare vervoer.

Die literatuurnavorsing het tot verskeie logiese gevolgtrekkings gelei, wat hersien is deur die gebruik van gestruktureerde onderhoude met 'n geselekteerde groep spesialiste in hierdie veld. Dit het dit moontlik gemaak om riglyne op te stel, die raamwerk te struktureer, en 'n unieke klassifikasie te ontwikkel van (i) die mees basiese kwesbaarheidsfaktore wat 'n organisasie vatbaar maak vir ontwinging, en (ii) die vermoëfaktore as eienskappe wat vereis word vir volgehoue prestasie of vervulling.

Al hierdie bevindings word gesintetiseer en hierdie navorsing vestig die vermoë van openbare vervoerorganisasies om 'n veerkragbenadering te implementeer binne die grense van hul vlak van vooruitgang en geprioritiseerde rigtingverklarings.

Aanbevelings vir verdere navorsing sluit in die uitbreiding van die voorgestelde

raamwerk empiries na ander funksies en na ander organisasies as die van stedelike openbare vervoer.

Sleutelwoorde: openbare vervoer, veerkrag, raamwerkontwerp, kwesbaarheidsfaktore, vermoëfaktore, beslissingondersteuning, proaktiewe beplanning

ACKNOWLEDGEMENTS

I wish to express my gratitude to the following persons who made it possible for me to complete this dissertation:

Prof. W. J. Pienaar, my promoter, for his input, guidance and constructive support;

Prof. E. Hees, for his supporting comments and feedback;

Participants in the interviews and expert meetings for their constructive data and informative support;

NHTV University of Applied Sciences, my employer, for their financial and moral support;

Letta for her patience and love, while I had fun with my research project;

Family and friends for their encouragement and support.

GLOSSARY OF TERMS AND DEFINITIONS

These terms and definitions are used in the text

<i>Accessibility:</i>	ease (perceived) with which destinations can be reached.
<i>Agglomeration</i>	contours of a territory without regard to administrative boundaries. It incorporates the population in a city or town plus that in the suburban areas lying outside of, but adjacent to, the city boundaries.
<i>Awareness:</i>	state of having understanding or knowledge.
<i>Assessment:</i>	practice of judging or appreciating identified disruptions and susceptibilities, and developing a corresponding prioritisation list.
<i>Balanced resilience:</i>	ability to measure, rank and to identify critical linkages between vulnerabilities and capabilities.
<i>Behavioural resilience:</i>	ability to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to respond systematically when something unexpected occurs.
<i>Capability:</i>	attributes required for performance or accomplishment.
<i>Case study:</i>	empirical inquiry that investigates a contemporary phenomenon within a real-life context.
<i>Conceptual resilience framework</i>	structure, based on deductive orientation, designed to identify, to assess and to respond to disruptions in order to create a resilient organization.
<i>Consumer surplus:</i>	difference between what a consumer is willing to pay and the price that the consumer actually pays for a product.
<i>Construct validity:</i>	generalizability of results across conditions of measurement.
<i>Cognitive resilience:</i>	orientation that enables an organization to identify, assess and respond in order to become a resilient organization.
<i>Contextual resilience:</i>	property that ensures that an organization has the capacity to identify its role and function in the context of possible disturbances.

<i>Demand:</i>	quantity of a product that consumers are willing to buy at all possible prices over a particular period, often referred to as the demand schedule.
<i>Disruption:</i>	combination of (1) an unintended, exceptional triggering event, and (2) a consequential situation which significantly threatens the normal course of business operations of the affected organization.
<i>Disruption analysis:</i>	disruption identification and assessment approach that takes into account disruptions arising from various states of the environment of the organization, both current and future.
<i>Event:</i>	occurrence of a particular set of circumstances with consequences.
<i>Exposure analysis:</i>	focus on the susceptibility to loss, perception of risk, or a threat to an asset and asset-producing processes of organizations that depend heavily on their assets for goal achievement.
<i>Externality:</i>	consequences of an activity that affects others who are not party to the activity, for better or worse, without those others paying or being compensated for the consequences of the activity as a result of the failure of the market to arrange for payment or compensation.
<i>External cost:</i>	uncompensated cost or disutility imposed on someone who is not party to an activity as a result of that activity. (External costs are also known as “negative externalities” or “external diseconomies”.)
<i>Framework</i>	overview, outline or skeleton of interlinked items which supports a particular approach to achieving a specific objective, and serves as a guide that can be modified as required by adding or deleting items.
<i>Function:</i>	accountability of the public transport stakeholders based on statements, environmental focus, reliable information and clear responsibilities.
<i>General conditions:</i>	conditions derived from existing methods and approaches and that refer to existing circumstances.
<i>Generalised trip cost:</i>	degree of perceived disutility, based on user sacrifice, which leads to resisting the undertaking of, or participation in, a trip.

<i>Hypothesis:</i>	a provisional assumption made in order to draw out and test its logical or empirical consequences.
<i>Internal control:</i>	process, affected by an entity's board of directors, management and other personnel, designed to provide reasonable assurance regarding the achievements of goals and objectives.
<i>Likelihood:</i>	probability that control will fail to detect or prevent a risk occurrence.
<i>Mission:</i>	reason for an organization's existence.
<i>Mobility:</i>	measure of transport activity taking place, or the intensity with which users make use of a transport system or service by travelling in vehicles and making use of pedestrian facilities.
<i>Perception:</i>	psychological and emotional aspects of disruptions which have been shown to have an enormous impact on individual and group behaviour.
<i>Perspectives</i>	generic conditions without reference to a specific approach.
<i>Place utility:</i>	value derived by a person from being at a specific location or by reaching a destination.
<i>Postulate:</i>	to assume or claim as true, existent, or necessary.
<i>Public transport:</i>	system for collective transport of people, with different services, based on different social and economic objectives and based on licenses to operate.
<i>Resilience</i>	capacity of an organization to survive, adapt and grow in the face of turbulent change.
<i>Reliability:</i>	difference between the distributions of actual travel times for the trip and its scheduled travel time.
<i>Risk:</i>	negative deviation from the expected value of a certain performance objective, resulting in undesirable consequences for the focal firm.
<i>Risk criteria:</i>	terms of reference by which the significance of risk is assessed.

<i>Risk identification:</i>	identifying an organization's exposure to uncertainty.
<i>Role of public transport:</i>	stimulate urban, social, sustainable and economic developments by transport of passengers based on their needs.
<i>Security:</i>	protection capability with measures taken to guard people.
<i>Snowball sampling:</i>	sampling that relies on previously identified members of a group to identify other members of the population.
<i>Stakeholder:</i>	any individual, group or organization that can affect, be affected by, or perceive itself to be affected by, an event.
<i>Strategy:</i>	determination of the basic long-term goals and objectives of an organization, the adoption of courses of action and the allocation of resources necessary for carrying out these goals.
<i>Structured approach:</i>	focus-based approach through a structure that establishes a process that is efficient and effective in a given area and period of time on areas of change.
<i>Subsidy:</i>	payment by a government to members of the public for which it does not receive products in return.
<i>Susceptibility:</i>	sensitivity of existing organizational or functional practices or conditions to disruptions.
<i>Theory:</i>	set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena.
<i>Urban public transport:</i>	public transport in an agglomeration.
<i>Validity:</i>	the extent to which a concept, conclusion or measurement is well-founded and corresponds accurately to the real world.
<i>Vision:</i>	how the organization wants to manifest its mission in future, both internally and externally.
<i>Vulnerability:</i>	fundamental factors that make an organization susceptible to disruption.

TABLE OF CONTENTS

Resilience as an Imperative in Public Transport Organizations

<i>DECLARATION</i>	I
<i>ABSTRACT</i>	II
<i>OPSOMMING</i>	IV
<i>ACKNOWLEDGEMENTS</i>	VI
<i>GLOSSARY OF TERMS AND DEFINITIONS</i>	VII
<i>FIGURES</i>	XIV
<i>TABLES</i>	XV
<i>1 Orientation</i>	1
1.1 Introduction	1
1.2 The relevance of passenger transport	2
1.3 Public transport	5
1.3.1 Public transport in the European policy context	6
1.3.2 Public transport in an urban context	8
1.3.3 Transition to a customer-focused public transport	10
1.4 The role of public transport in society	11
1.5 Public transport organizations as object of experience	12
1.6 Resilience approaches in different disciplines	14
1.7 Strategy analysis for acknowledgement of properties of resilience	20
1.8 Overall research objective	24
1.9 Research objectives and structure of research	26
<i>2 Research methodology</i>	29
2.1 Introduction	29
2.2 Research design	30
2.3 Research validation	31
2.4 Relevance of verification and generation	33
2.4.1 Case study	35
2.4.2 Cohort design: selecting stakeholders and participants	36
2.4 Approaches followed for conducting empirical research	39
2.4.1 Analysis of empirical research data	44
<i>3 Contextual resilience</i>	46
3.1 Introduction	46
3.2 Organizations' environmental focus in perspective	47
3.3 Structuring the environmental focus of public transport organizations	48
3.3.1 Supply side of the public transport market	49
3.3.2 Public transport market	50
3.3.3 Public transport system	51
3.3.4 Contexts of the public transport system	55
3.4 The structure of contextual resilience	58
3.5 Summary and interpretations	63

4	<i>Conceptual resilience framework with guiding principles</i>	65
4.1	Introduction.....	65
4.2	Risk management approaches.....	66
4.3	Perspectives on a resilience framework.....	67
4.4	Conditions from institutional bodies of knowledge.....	70
4.5	General conditions from existing approaches.....	72
4.6	Interpretations of risk.....	74
4.7	Risk as a concept.....	76
4.8	Resilience strategies and frameworks.....	81
4.9	Guiding principles of the resilience concept.....	88
4.10	Structure of a conceptual strategic resilience framework.....	91
4.10.1	Vulnerability identification.....	92
4.10.2	Capability identification.....	93
4.10.3	Effects of vulnerabilities and capabilities on performance.....	95
4.10.4	Connecting resilience and performance.....	96
4.11	Structure of the conceptual resilience framework	97
4.12	Summary and interpretations	99
5	<i>Cognitive resilience</i>	100
5.1	Introduction.....	100
5.2	Approach and process of empirical research	101
5.3	Cohort design: selecting stakeholders and participants	101
5.3.1	Stakeholder selection	102
5.3.2	Participant selection	103
5.4	Interview findings	105
5.4.1	General research findings	105
5.4.2	Findings on concepts and definitions.....	109
5.4.3	Discussion on framework relations.....	114
5.4.4	Findings on progress in developing a resilience approach	117
5.5	Verified resilience framework for public transport organizations.....	120
5.6	Summary and interpretations	121
6	<i>Behavioural resilience</i>	122
6.1	Introduction.....	122
6.2	Characteristics of resilience	123
6.3	Identification and classification possibilities.....	125
6.4	Identification of vulnerability factors	128
6.5	Identification of capability factors	136
6.6	Approach of empirical research.....	150
6.6.1	Cohort design: selecting stakeholders and participants	150
6.7	Interview findings	152
6.7.1	General research findings from interviews	153
6.7.2	Findings on verification of (sub-) factors and adjustments	155
6.7.3	Findings on level of progress of resilience approaches	161
6.8	Summary and interpretations	164

7	<i>Balanced resilience and managerial implications</i>	165
7.1	Introduction.....	165
7.2	Capability to rank vulnerability and capability factors.....	165
7.2.1	Ability to undertake measurement and ranking	167
7.3	Identification of critical linkages	173
7.3.1	Research on linkage capability by using a experiment method.....	175
7.3.2	Research on linkage capability using the case study method	178
7.4	Expert meeting to extract inferences on managerial capabilities.....	180
7.4.1	Results of expert meeting.....	182
7.5	Summary and interpretations	186
8	<i>Conclusions and future directions</i>	187
8.1	General.....	187
8.2	Overview of research stages	189
8.2.1	Knowledge extended by the research	195
8.3	Future directions for research	196
	<i>References</i>	199

- Appendix 1: Interview on resilience framework verification for inclusion with empirical findings.(Questionnaire dealt with in Chapter 5.)*
- Appendix 2: Interview on vulnerability and capability verification for inclusion with empirical findings. (Questionnaire dealt with in Chapter 6.)*
- Appendix 3: Survey on measurement, ranking of importance and linkages between vulnerabilities and capabilities for inclusion with empirical findings. (Questionnaire dealt with in Chapter 7.)*
- Appendix 4: Expert meeting to extract inferences on managerial capabilities in public transport organizations. (Parts 1, 2 and 3 dealt with in Chapter 7.)*

FIGURES

Figure 1: Public transport system 55
 Figure 2: Environmental focus of public transport organizations 58
 Figure 3: Policy Statements of Transport Security Administration 2007 60
 Figure 4: Contextual awareness of resilience 64
 Figure 5: The concept of risk..... 80
 Figure 6: Areas of concern in relation to risk identification and assessment 81
 Figure 7: Resilience framework, Part 1: creating awareness of resilience 91
 Figure 8: Resilience framework, Part 2: identification of vulnerabilities 93
 Figure 9: Resilience framework, Part 3: identification of capabilities 94
 Figure 10: Effects of vulnerabilities and capabilities on resilience 95
 Figure 11: Resilience framework, Part 4: connecting to performance 97
 Figure 12: Conceptual resilience framework 98
 Figure 13: Verified resilience framework for public transport organizations 120
 Figure 14: Classification of vulnerabilities 126
 Figure 15: Zone of balance between vulnerabilities and capabilities 174
 Figure 16: Matrix of capabilities linked to vulnerabilities 177
 Figure 17: Difference in time to recover (TTR) 188
 Figure 18: Resilience framework for public transport organizations 192

TABLES

Table 1:	Public transport consumer preferences	11
Table 2:	Definitions of resilience in context of transport management	17
Table 3:	Acknowledging the properties of resilience	23
Table 4:	Overview of stakeholders for verification of framework	102
Table 5:	Overview of participants for verification of framework.....	104
Table 6:	Main considerations for strategic approaches.....	107
Table 7:	Change descriptions by Anshoff.....	111
Table 8:	Overview of advantages and complications of resilience approach	119
Table 9:	Sources of vulnerability factors	130
Table 10:	Vulnerability factors with description and sub-factors	131
Table 11:	Sources of capability factors	137
Table 12:	Capability factors with description and sub-factors.....	139
Table 13:	Participants in interviews on vulnerability and capability lists	151
Table 14:	Overview of performance elements	153
Table 15:	Classification of performances, based on Global Risk Model.....	154
Table 16:	Vulnerability (sub-)factors after verification	159
Table 17:	Capability (sub-)factors after verification.....	161
Table 18:	Vulnerability factor ranking and measurement.....	168
Table 19:	Capability factor ranking and measurement	169
Table 20:	Importance of vulnerability factors.....	170
Table 21:	Importance of capability factors	171
Table 22:	Importance of level of vulnerability and its measurement.....	172
Table 23:	Importance of level of capability and its measurement	172
Table 24:	Participants in expert meeting.....	181

1 Orientation

1.1 Introduction

Are passenger transport organizations poised for a period of solid growth? Perhaps! (Ministerie van Verkeer en Waterstaat, 2001; Van de Velde *et al.*, 2008). Are passenger transport organizations able to rely only on customer and brand loyalty? Unlikely! (UITP, 2005b, Wegewijs, 2008; Vervoort, 2010). Are passenger transport organizations facing more and new challenges, and is it really necessary to think about different structures, new management tools, new alliances and new markets, and to think more globally? Undoubtedly! (European Commission, 2004 and 2008e, UITP, 2008).

Public transport organizations operate and develop under dynamic circumstances (UITP, 2008 and 2009; Van Wee, 2000; White, 2002; Wegewijs, 2008). Disturbances occur, with possibly extensive consequences. One area of interest is related to the identification of disruptions and response strategies to address them and, consequently, how to create a resilient organization. In the context of this research *the property of resilience* describes the capacity of an organization to identify major severe disturbances that can affect it, to know how to detect the occurrence of disturbances, and to know how to respond in order to minimize the negative consequences of the disturbance (Hollnagel and Wood, 2006).

There is a need for systematic resilience approaches in general and for public transport organizations more specifically (Christopher and Peck, 2004b; Fiksel, 2006a; Proper, 2008; UITP, 2008). This chapter addresses the relevance of a resilience approach in public transport. This approach can be motivated on the basis of the discussions on the relevance of public transport in general, policies on public transport, and more specifically the urban public transport policy context. Along with the transition to a more customer-focused transport, this will explain the role of public transport in society and the relevance of developing resilience in that sector. Public transport organizations are one of the stakeholders in public transport and are the object of experience in this research.

Strategy statements of public transport organizations are analyzed to understand the level of awareness of the concept of resilience in them. This chapter will introduce the concept of resilience by analyzing different resilience approaches in different disciplines. The research goal and the structure of the research will be explained in this chapter.

1.2 The relevance of passenger transport

Traditional location theories from Von Thunen and Weber as well as economic theories of origin from Adam Smith and Ricardo already mention the importance of transport in general. Present developments in service industries, e-commerce and global manufacturing have complicated location behaviour and passenger transport substantially. What is relevant is the fundamental understanding of the complex interactions between passenger transport and spatial developments (Geurts and Van Wee, 2004a and 2006; Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieu, 2008). Disturbances in the actual transport of passengers do not affect the users only, but can have severe implications for other activities such as the accessibility of places of work and leisure.

David Ricardo is credited with using the principle of comparative advantage to explain how it can be beneficial for two parties (countries, regions, cities) to trade, if one has a lower relative cost of producing some good. With respect to transport, including passenger transport, some of his assumptions are interesting, although often subject to criticism (Lambooy, 1972). The assumption of perfect competition implies full employment and perfect mobility of all factors of production, including transport of passengers. Perfect mobility requires public transport systems that work under all circumstances.

Most contemporary approaches build on the traditional approaches (Scholler *et al*, 2007; Van de Velde, 2005b; Thomson, 1974). In *Transport Economics* Thomson (1974:15-17)

identifies four main reasons for transport that address the present role of passenger transport.

The first reason is referred to as the *different degrees of specialization*, although the reasons mentioned by Thomson are not researched on the basis of their relative importance to explain transport, even though they are partly interrelated. Thomson (1974:16) describes “transport as the greatest impediment to the achievement of the economics of mass production in general. The pursuit of science and technology and the highest skills of craftsmen can influence the concentration of socio-economic activities”. This in turn requires well-organized passenger transport to optimize flows from the perspective of public transport operators as well as from the employer’s point of interests in addition to the transport needs of passengers as customers. An example of this can be found at the Rotterdam Container Terminal; many workers need to travel, in a safe and reliable system, to and from the Terminal in their different working shifts every day of the week (Vipre, 2009).

The second argument mentioned by Thomson is the performance of the transport system required for *economic processes related to political, including military, objectives*. This is no different for transport of people than of goods. Mixed airports (Wells and Young, 2004) are an example of the use of combined objectives for socio-economic purposes of trade and tourism in conjunction with, for example, military use. Political priorities and control require support and selection of transport facilities near and between political and economic centres. The issue of maintaining a safe society, with safe terminals and routes, as well as conserving a sustainable environment, explains policy regulations and restrictions on different routes and modes of transport (Banister and Marshall, 2007).

Geographical difference is the third element that relates to the fact that the planet is not a homogeneous place. For passenger transport the geographical differences are related not only to climate or nature, but also to differences in skills and knowledge. Supply and demand, as far as passengers are concerned, are related to the locations in which they appear. Specific geographical or historical elements, such as in the case of the Kruger

Park in South Africa, the Grand Canyon in Arizona or the Great Wall in China, impact on the growth and prosperity of different regions in the world, partly as a result of good accessibility (Proper, 2007b; Schouten, 2005). London, New York or Beijing as financial and/or political centres, all depend on a reliable and safe transport system to accommodate passenger flows with specific time and place characteristics.

The fourth element mentioned by Thomson has to do with *social relationships and cultural opportunities*. Distance and time are interrelated. With increasing technology in different modes of transport, the possibilities of travelling greater distances in shorter times have increased (Bovy *et al.*, 2000). In highly motorized societies it is common to find people maintaining social relationships that are almost entirely beyond the walking distance between them. Cultural differences also make some places of the world different from others. For example, exhibitions at the Louvre Museum in Paris and pilgrimages to Mecca are places with specific cultural or historical properties. World events such as the Olympic Games or World Soccer Cup matches, and on smaller scale pop festivals or local events are all place and time related. It is clear that these places and events have impacts on the demand and supply aspects of the operations of the transport of passengers. A trustworthy passenger transport is essential to support access to these social and cultural activities.

Although the emphasis is placed on socio-economic arguments to explain the context of passenger transport, there is also an increasing understanding that users benefit from technological and service developments (Beckmann, 2007; UITP, 2005b). Technological developments in the air with the Airbus 380, high-speed train technology and operations, but also the sustainability technology of CO₂-free bus operations, together with developments on infrastructure and information technology, improve the reliability, safety, quality and efficiency of transport operations.

It is evident from the above discussions that dependable and safe passenger transport is a vital element in society in general, and in urban areas more specifically. Its meaning goes beyond only the transportation function of connecting different places in time. It indicates

also why/how possible disturbances can have a range of consequences. Passenger transport is a distinct activity in its own right, but it needs to be studied in the mix of these perspectives.

1.3 Public transport

Passenger transport can be segmented on the basis of different criteria. In this research collective passenger transport will be distinguished from individual private passenger transportation, which is about self-organized transport by car or bicycle. Collective passenger transport is promoted in many national and regional planning initiatives (Ministerie van Verkeer en Waterstaat, 2000, 2005; Provincie Brabant, 2007).

The Dutch law on public transport describes public transport as an open and available system for the collective transport of persons in accordance with a timetable and using different modes such as buses, trains, metro or other guided vehicles (Ministerie van Verkeer en Waterstaat, 2000).

The international association of public transport (UITP), represents over 3,100 urban, local, regional and national mobility actors from more than 90 countries on all continents (UITP, 2008). The organization covers all modes of collective transport including metro, bus, light rail, regional and suburban railways, and waterborne transport. Within this organization public transport – often described as public transportation, public transit or mass transit – comprises all transport systems in which the passengers do not travel in their own vehicles. There are several arguments in support of the importance of public transport, because it offers many advantages over individual transport modes:

- Less cost to the community;
- Less urban space used;
- Less energy-intensive;
- Less pollution;
- The safest mode;
- Improved accessibility and mobility for all.

After analyzing different definitions, Proper (2008: 5) formulated a description of public transport, which will be used in this research: “*Public Transport* is a system for collective transport of people, with different services, based on different social-economic objectives and based on licenses to operate”. This research will focus on public transport and will exclude collective transport without general public access, such as touring cars, as well as water and air transport and individual public transport such as taxis.

The broad objectives of governments in public transport service provision can be summarized as providing a good-quality, integrated and continually improving transport service that is available to all at a fair price, with reasonable returns to operators that give value for money under a regime of continuity. Consistent with this objective is a focus on securing appropriate services for the community.

1.3.1 Public transport in the European policy context

Some important contributions to the role of public transport are presented and prioritized in the European policy context. The Treaty of Rome, 1957, articles 74–84, serves as the legal foundation for implementing a common transport policy (European Commission, 2004). Although the respective public transport policies are still mostly under the control of the member states, European policy has become stronger and its statements have great influence on national public transport policies (Scholler *et al.*, 2007).

One of the main objectives of the first White Paper, “The Future Development of the Common Transport Policy” (1992), was to reduce the imbalance between modes (European Commission, 2008b).

The Commission’s 1995 Green Paper on “Fair and Efficient Pricing in Transport” (European Commission, 2008c) and the 1998 White Paper on “Fair Payment for Infrastructure Use” (European Commission 2008d) have given rise to a discussion on the introduction of direct user charges in transport (mainly in connection with road users), in

order to cover infrastructure as well as external costs and to stimulate a modal shift to public transport.

The European Commission has recognized the functional and environmental crisis facing European transport, described in the 2001 White Paper “European transport policy for 2010: Time to decide” (European Commission, 2008e; UITP, 2005a, 2005b). The 2001 White Paper groups the proposed measures into four selections as follows:

- Shifting the balance between modes;
- Eliminating bottlenecks;
- Placing users at the heart of policy;
- Managing globalization of transport.

In the 2001 White Paper the importance of having a European-wide policy on public *urban* transport was made explicit for the first time.

In the European Union over 60% of the population lives in urban areas. Just less than 85% of the EU GDP is created in urban areas. The Green Paper of 2007 emphasizes that towns and cities are the drivers of the European economy (European Commission, 2002, 2008f). They attract investment and jobs, and are essential to the smooth functioning of the economy.

The Green Paper addresses the main challenges related to urban mobility through five themes:

1. Free-flowing towns and cities;
2. Greener towns and cities;
3. Smarter urban transport;
4. Accessible urban transport;
5. Safe and secure urban transport.

Both the 2001 White Paper and the 2007 Green Paper are explicit about creating a safe and secure urban transport system, but the focus is very much on traffic safety and on personal security. Policy documents in general are not clear on the issue of disruption

analysis and the associated responsibilities of public transport organizations, transport authorities, and/or national and local governments.

At the end of the ten-year period covered by the 2001 White Paper, which set out to define a vision for the future of transport, the first ‘milestone’ was reached with the publication of the “Communication on the Future on Transport”, adopted by the Commission on 17 June 2009. The document is at the same time a strategy document and a consultation document aiming at identifying policy options to be tested and eventually included in the next White Paper in 2011. Based on the input collected during the public consultation and the outcome of the conference, Commission services are preparing the new transport White Paper. Its adoption is foreseen for 2011 and its discussions shows that EU transport policies aim at fostering clean, safe and efficient travel throughout Europe with a strong focus on transport in urban areas.

1.3.2 Public transport in an urban context

Many observations and statistics describe the growth and the development of public transport in general (European Commission, 2002 and 2008e; Ministerie van Verkeer en Waterstaat, 2001; World Bank, 2008; United Nations, 2003 and 2008 and 2008a). The importance of transport can only be evaluated with varying degrees of accuracy (Rodrique *et al.*, 2006). The Mobility in Cities database (UITP, 2005a) shows that, despite the decreasing urban density (-1% in Europe) and rising motorization (+2% per year), the larger cities manage to maintain or increase the modal share of public transport (Cavalieri, 2006).

The concept of land-use impacts can be measured in different dimensions and one indicator often used is the population by urbanization type. Geurts and Van Wee (2006) distinguish three types: central urban, suburban and peripheral areas to indicate the compactness of the built-up area. In “World Urbanization Prospects: The 2003 Revision of the United Nations” (United Nations, 2004: 111) the concepts of Urban Area and Urban Agglomeration are explained. An *agglomeration* refers to a population contained within the contours of a territory without regard to administrative boundaries. It usually

incorporates the population in a city or town plus that in the suburban areas lying outside of, but adjacent to, the city boundaries. The term ‘urban’ will be used in this context.

The “Mobility” section of the 10th Venice Biennale of Architecture presented research which had as its main objective finding a new way of understanding the *urban* transport mechanism (Casiroli, 2007). The changeable shapes of a city system from the focal points of its occupation patterns are transformed according the mode of transport used, the time of day and the days of the week when the cities are occupied and utilized. The research looks at 12 mega cities, using data from 2006, and analyzes their geography using a standard area of 80 by 80 km, including cities such as London, Johannesburg, Los Angeles and Tokyo. The research defined in theoretical terms a number of configurations as certain “city types”.

The first type is called the “working city”, described as a city where the income-generating activities are concentrated and become evident every weekday morning and evening with implacable constancy. Public transport is based on efficiency principles and is depending on the limitations of the infrastructure. The second functional city is called the “leisure city”, with its main attractions being recreational activities of various kinds (theatres, public gathering places and cinemas). Transport gears up and becomes visible in the early evening rush hours. The main strength of public transport in this city type is based on integrated networks fully operational even outside working hours. The third functional city is the “city of sports”, which draws huge crowds of fans in the evenings or on the weekends. These facilities are often situated near the edges of cities. The research observed transport patterns already revealed by the concept of the “leisure city”. The fourth and last one is called the “cultural city”, with focal points such as universities that attract large crowds of students on weekdays and close to the morning rush hour. This research will focus on *urban public transport*, further simply referred to here as public transport.

These discussions clearly show the importance of time and place utility, involving intelligent location of specific urban functions, near to nodes that are well served by

trustworthy public transport systems, to make cities more accessible to all. The main focus of this research is on the concept of resilience, with a focus on the occurrence of severe disturbances. It is clear that severe disturbances can have major implications in the urban areas that go beyond the primary function of transport.

1.3.3 Transition to a customer-focused public transport

With most citizens living in urban areas, the concept of a citizen's transport network is based on increasingly demand-driven orientations. Service-level demands have increased and consumers from all socio-economic groups opt for higher reliable and greater secured availability of public transport. An efficient lifestyle requires a safe, reliable, inter-modal, customer-oriented door-to-door transport system (European Commission, 2008b, Isotope 2000; Schouten, 2005).

Public transport offered will first give opportunities to those who have no right or no possibility to use private transport (Ministerie van Verkeer en Waterstaat, 2001). These passengers are described as "captive users" of the public transport system, fully depending on its functioning. Next are passengers who can choose between different modes of transport and will use public transport as it brings a higher consumer surplus compared to the alternatives. As a result of societal mega trends, individual and household demands for public transport have become increasingly complex, placing a lot of emphasis on transport operators' adaptability (Bovy *et al.*, 2000).

The importance of the "voice of the customer" becomes more apparent. The Dutch tendering system requires the transport authority to hold discussions beforehand with customer groups' representatives, and the transport operator to hold discussions with customer groups during the period of the concession.

Also within the European context more customer-focused developments are evident. The UITP publication *Passenger charter: A charter for a customer-focused approach* and the "rights of the passengers" implemented in 2009 are all elements of the development of a more customer-oriented approach (European Commission, 2009; UITP, 2006).

Research has resulted in a better understanding of customer expectations of the different services in public transport. Table 1 provides an overview of the most relevant customer preferences (not in order of importance), with the associated public transport supply elements (Quattro Project, 1998; Vervoort, 2010).

<i>Public transport customer preferences</i>	<i>Public transport supply elements</i>
Availability	Network, timetable.
Accessibility	External and internal interface, ticketing.
Transport	Speed and travel time, frequency, punctuality, reliability, capacity, safety (physical, social), capacity.
Information	General information, travel information (normal conditions), travel information (abnormal conditions).
Costs	Transport costs (tariff structure), information costs.
Customer care	Commitment, customer interface, staff, physical assistance, ticketing options.
Comfort	Ambient conditions, facilities, ergonomics, ride comfort.
Experience	image, perception, facilities, environment.

Table 1: Public transport consumer preferences

The occurrence of severe disturbances can have a direct effect on public transport customer behaviour. It can influence the actual transport of the customer as well as the decision to use public transport in the future.

1.4 The role of public transport in society

In the context of this research the relevance of passenger transport in general and public transport more specifically can be specified on the basis of many arguments, as discussed. In addition to the direct transport operations, also relevant are economic, environmental, political, cultural, technological, behavioural and other arguments. The *role of public transport* will be defined as being “to stimulate urban, social, sustainable and economic developments by transport of passengers based on their needs”.

In general public transport operates in a dynamic environment and the concerns are sometimes shifting (Van de Velde *et al.*, 2008). Lately discussions about pollution, use of natural resources and more generally the sustainability of urban development have increased. Public transport as a more sustainable mode of transport has been argued in many research reports and other publications (Krygsman, 2004; Raad voor Verkeer en Waterstaat, 2004; UITP, 2005a; Van Wee, 2002; Trip, 2007). In addition to the concept of sustainability, the notion of secured public transport is drawing increasing attention through many different actions ranging from strikes and technological interruptions to terrorism attacks. Various disturbances in public transport have received attention from the media, the public and policy makers.

In all approaches the relevance of continuity of operations and the functioning of all system stakeholders is emphasised. *Function* in this research will be used to describe the responsibilities of the different stakeholders in the public transport system. Public transport organizations are part of these dynamic environments and they need to understand how to manage disruptions both internally and in cooperation with other stakeholders.

1.5 Public transport organizations as object of experience

The point of departure here is that Dutch public transport organizations can be seen as representative of what is developing in the public transport sector from a European perspective. Currently a number of national and international public transport organizations are active in the Dutch market. The three largest players outside the four largest cities all belong to international transport groups, which also perform activities beyond the scope of this research. Public transport organizations have different legal structures and are divided into private and (semi-)public entities. In 2007 Arriva, Connexxion and Veolia were the largest private operators in the Netherlands and represented 85 percent of the private public transport bus operators outside the four largest cities. But the market is open to new players. Qbuzz entered the Dutch public transport market in 2008 and in three years acquired a more than 20% market share. In

2008 Trandev obtained a majority of shares in Connexxion and in 2009 Veolia started the process of acquiring Transdev and so becoming the largest public transport organization in the world. In 2010 Deutsche Bahn showed interest in the public transport activities of Arriva and could enter the Dutch market through a take-over. Semi-public organizations are offering public transport in the four largest cities and are in the process of discussing priorities and possible cooperation.

Within the context of the role of public transport, public transport organizations are the objects of study in this research. These organizations are open systems (Keuning and Eppink, 2000; Van de Velde, 2007; Wegewijs, 2008). They receive inputs from their environments and produce services as output to that environment. The organizations also have to balance their external and internal accomplishments. They face a permanent dilemma in balancing the demands of clients or customers, and operating with what they can offer with their available capacities and capabilities.

In recent years new developments have emerged that have had an impact on the strategies of public transport organizations.

The first of such developments worth mentioning is the recent series of crises and catastrophes that have attracted public attention (Christopher and Peck, 2004b; Grandjot, 2006; Sheffi, 2001). Direct transport-related examples are terrorist acts in Madrid and London, and indirect examples are natural disasters such as SARS, which had an impact on land and air transport, Hurricane Katrina or the tsunami and consequent meltdown of the Fukushima nuclear plant, devastating large areas and creating major disruptions in public transport. In 2010 the eruption of the Eyjafjallajokull volcano in Iceland resulted in thousands of flights being cancelled across Europe, which in turn increased demand for land transport, which required great flexibility from passenger transport operators. But also events such as disrupted deliveries of new buses, strikes or widespread theft can influence the quality and continuity of the public transport services planned and offered. There is evidence that these events are becoming more frequent, with an increase in both their potential for disruption and in their magnitude (Coleman, 2006; Elkens *et al.*, 2005).

The second development over the last decade has been that almost all industries have seen increased competitive pressures in the business environment and in enlarged – partly even global – market developments. Provision of public transport is increasingly based on the concept of competitive tendering to produce better operational quality and lower costs (Ministerie van Verkeer en Waterstaat, 2000). Ecorys research (2002) distinguishes two relations in public transport: one between the public transport authority and the public transport operator, and one between the public transport operator and the passenger. These changes have compelled organizations to issue adjusted direction statements and to make their intra-firm business processes and inter-firm networks more efficient and/or more responsive, and/or to increase intensive collaboration with the other network actors (Wagner and Bode, 2008). Strategic priorities are influenced by the demands of both public transport operators and passengers. Strategic approaches need to be selected in the context of both internal and contextual developments.

1.6 Resilience approaches in different disciplines

During the past decade resilience has received attention in the academic world from different bodies of knowledge with relations to transport in general. The following leading institutions have been analyzed in terms of their main arguments to research and implement resilience:

- Centre for Resilience at the Ohio State University,
- Centre for Transport and Logistics at MIT,
- Cranfield Resilience Centre at the Cranfield University,

In summary, it can be concluded that there is a high degree of agreement among these institutions on general arguments related to research on the concept of resilience:

- The world is becoming turbulent more rapidly than organizations are becoming resilient;
- The complexity of connectivity as well as the physical, economic, financial, legal and regulatory, and technological environment has increased;
- Interdependency has increased;

- Plans need to be put in place that anticipate external and internal events;
- The concept of resilience can be described as multifaceted (discipline- and event-related) and focused on benefits to organizations and society;
- Risk and resilience need to be approached as occurring along a continuum;
- Cutting-edge research centres need to be created.

Business reports are also increasingly explaining how to manage, monitor and mitigate disruptive events. All argue for a management approach to a wide range of disruptions and events that would include interdisciplinary cooperation (OECD, 2003; Sheffi, 2007; Transportation Security Administration, 2007). This research furthermore includes the experiences of practitioners from the Council of Competitiveness, IBM and General Motors and organizations in the fields of public transport, security, risk and resilience

Research and business experiences describe the concept of resilience from the perspective of several different fields of study. No research is found specifically related to the field of public transport. There is a gap between “the role of public transport” as discussed and the absence of structured approaches to manage potential disruptions in that sector.

This section will further describe resilience by analysing a variety of disciplines (Pettit, 2008). The concept of *resilience* emerged as a critical characteristic of complex, dynamic systems in a range of disciplines, including engineering (Hassenzahl, 2005; Hale and Heijer, 2006), economics (Sheffi, 2007), ecology (Carpenter *et al.*, 2001; Perrings, 2006), psychology (Gorman *et al.*, 2005; Steward *et al.*, 1997), sociology (Adger 2002; Holling, 1973), risk management (Hansson, 1996; Starr *et al.*, 2003; Kleindorfer and Wassenhove, 2004, Pettit *et al.*, 2010) and network theory (Callaway *et al.*, 2000, Wagner and Bode, 2008).

A basic definition of resilience can be found in the field of engineering: “*the tendency of a material to return to its original shape after the removal of a stress that has produced elastic strain*” (www.engineersedge.com). However, it may be beneficial for a public

transport organization not to return to its original “shape” following a disruption, but rather to learn from the disturbance and adapt into a new configuration (Pettit *et al.*, 2010). Traditional systems engineering practices have tried to anticipate and resist disruptions, but may be vulnerable to unforeseen factors. An alternative is to design systems with *inherent* resilience by taking advantage of fundamental properties such as diversity, efficiency, adaptability and cohesion (Fiksel, 2006b). Hale and Heijer (2006) describe resilience from an engineering perspective as the characteristic of managing the organization activities to anticipate and circumvent threats to its existence and primary goals.

As engineering research has emphasized resilience or robustness as entailing recovery from malfunctions, ecological resilience also emphasizes adaptive capacity, which may lead to new equilibriums. The standard definition of resilience in ecological sciences is “*the ability of an ecosystem to rebound from a disturbance while maintaining diversity, integrity and ecological processes*” (Folke *et al.*, 2004). Resilient systems, including biological and socio-economic entities, need to be able to survive, adapt and grow in the face of uncertainty and unforeseen disruptions.

More specifically, in the managerial context, organizations need to grow, just as natural organisms do, and “the concept of a static, no-growth enterprise is absurd in the business world” (Rice and Caniato, 2003; Fiksel, 2006a). Faced with a dynamic and unpredictable business environment, management theorists are increasingly identifying the need for resilience (Hamel and Valikangas, 2003; Hollnagel, 2006; Pettit *et al.*, 2010; Stolz, 2004).

Resilience has also been studied in the context of organizational leadership. From this perspective Stolz (2004) describes resilience as: the ability to bounce back from adversity and to move forward stronger than ever. Creating resilient leaders will ensure that resilient organizations will prosper in a chaotic and uncertain future and those organizations consistently outlast their less resilient competitors (Coutu, 2002; Stoltz, 2004; Rydzak *et al.*, 2006; Pettit, 2008; Rasmussen and Svedung, 2000). Hamel and

Valikaangas (2003) stress that resilience is not only concerned with recovery, flexibility or preparedness; it is a distinct source of sustainable competitive advantage. Coutu (2002) indicates that resilience is a critical capability to success and Stolz (2004) argues that resilience is the only sustainable, portable strategic plan. The Council of Competiveness (2008) describes resilience as: the capacity of complex systems to survive, adapt evolve and grow in the face of turbulent change. The resilient enterprise is intelligent, flexible and agile.

Definitions of resilience, in the context of transport management and supply chain management are shown in Table 2.

<u>Source</u>	<u>Definition</u>
Rice and Caniato (2003)	<i>Ability to react to an unexpected disruption and restore normal operations.</i>
Christopher and Peck (2004) (Cranfield)	<i>Ability of a system to return to its original state or move to a new, more desirable state after being disturbed.</i>
Sheffi (MIT) (2005)	<i>Containment of disruption and recovery from it.</i>
Fiksel (2006) (Ohio State)	<i>Capacity for complex industrial systems to survive, adapt and grow in the face of turbulent change.</i>
Hollnagel (2006)	<i>Intrinsic ability of an organization (system) to maintain and regain stable state, which allows it to continue operations after a major mishap and/or in the presence of a continuous stress.</i>
Centre of Resilience: Ohio State University (2008)	<i>Capacity of a system to survive, adapt and grow in the face of unforeseen changes, even catastrophic incidents.</i>
Pettit (2008) (Ohio State)	<i>Capacity of an enterprise to survive, adapt and grow in the face of turbulent change.</i>
MIT (2008)	<i>The ability to react to unexpected disruption and restore normal supply network operations.</i>

Table 2: Definitions of resilience in context of transport management

These definitions share common elements that will be used to discuss the concept and to define resilience as the starting point for an approach to develop a framework and embed resilience in the public transport sector.

First, resilience is the concept which emphasizes that *complex systems are dynamic*. A state of dynamic stability in public transport can change into a state of instability abruptly or through a gradual erosion of margins. Levenson *et al.* (2006) describe resilience from a system management approach as: the ability of systems to prevent or adapt to changing conditions in order to maintain (control over) a system property. Public transport organizations must be dynamically stable, or constrained, in the sense that the adjustments cannot be allowed to get out of hand, but must at all times remain under control. Hollnagel (2006) describes resilience as the challenge of the unstable.

Second, resilience is about the ability or capacity to react or move. The focus is on *actions to deal with unexpected disruptions and/or turbulent change* and making a response to, or recovering from, a disturbance requires adjustment of the public transport organization (or system). Wreathall (2006) describes an initial view of two characteristics of a resilient organization:

- a holistic approach that does not focus only on technical or social processes;
- an integrated approach, with the appropriate structures and tools, to core processes and activities by which the organization accomplishes its mission.

Public transport organizations lack both approaches to deal with disruptions (UITP, 2006; UITP, 2008; Quak, 2008; Timmer, 2008).

Third, the concept of resilience can contribute to the *adaptive process*. In this research an adaptive process includes a defensive and reactive strategy, as well as a proactive strategy. The notion of adaptive fit presumes that a public transport organization should invest in developing capabilities and organizational structures needed to move to the desired level to achieve greater immunity from fluctuation (Venkatraman and Camillus, 1984; Lengnick-Hall and Beck, 2005; Pickett, 2006; Pettit, 2008). Millikan (1987) argued that there are three distinct situations in the organization: state, effect and response, and

describes the complications of cause and effect relations. In all cases the public transport organization needs to realize that something has happened and that it is serious enough to warrant a response. This phase can be influenced by decision latency. Next the organization that has noticed the problem must decide how to react. This phase is influenced by change design latency. The next step concerns the implementation of the change, called change implementation latency, and last but not least is validation latency, when the public transport organization assesses the quality of its response. The value of a resilient approach is related to the adaptive reduction of latency times to a minimum (Verstraete, 2008). This research, aimed at developing and embedding the concept of resilience in the public transport sector, can fill these gaps, thus enabling public transport organizations to adapt, survive and create competitive advantage.

Finally, an organization must assess its vulnerability across its entire environment (Sheffi and Rice, 2005; Ahlquist *et al.* 2003; Lambert, 2006). A comprehensive solution requires a new focus on response strategies that “extends beyond the four walls of the single firm” (Christopher and Peck, 2004a). Traditional risk management techniques lack the ability to assess the complexities of networks and chains (Slone *et al.*, 2007). In this research the public transport organization will be the starting point. Public transport chains and networks are part of the environmental focus and hence the concept of collaboration will be included in the resilience approach. There is no collaborative approach related to resilience found in the public transport sector (UITP, 2008; Quak, 2008; Timmer, 2008).

Analyzing the definitions from Table 2 on similarities and in alignment with the definition adopted by the Council on Competitiveness, based on research conducted by Fiksel (2006a), the following definition on *resilience* will be used in this research: “*the capacity of an organization to survive, adapt and grow in the face of turbulent change*”.

There is a close relation between resilience, risk, security, disruption and mitigation; a terminology map indicating these relationships will be developed in the subsequent chapters. It is important to recognize that all these features refer to the need for management to act and react on the basis of a proactive approach. Furthermore, all these

approaches demand systematic organizational approaches within the need for continuity of business operations. In this research *security* will refer to protection capability, including the measures taken to guard the public transport organization. The concept of security will not be further researched from a strategic perspective or as a point of focus by itself. Risk and resilience approaches will be researched to understand their similarities and differences. This research will focus on the strategy-building processes of public transport organizations to enable them to become resilient.

Eventually every system is destabilized now and again by one or more disruptions. However, this process provides opportunities for innovation – new scientific discoveries, new institutions, new relationships and new business processes – so that the system shifts into a more resilient state and re-enters the growth phase (UITP-Security Commission, 2006; Pettit, 2008). Public transport organizations must be aware of the concept of resilience; they must give priority to analysis and research in alignment with their direction statements and must have the right information, procedures, culture, methods and knowledge to manage identification, assessment with prioritizing, and an appropriate response. In addition to this, public transport organizations need leadership, finance and collaboration before they can take the appropriate action.

1.7 Strategy analysis for acknowledgement of properties of resilience.

The term ‘company’ is often used to describe a results-driven entity, as an organization is more focused on the processes to reach its goals (Van Dam and Marcus, 2005). In this research the term ‘public transport organization’ will be used in both senses.

There is a need for public transport organizations to acknowledge the concept of resilience. This will be discussed by examination of annual reports and websites of public transport organizations to analyse their awareness of the properties of resilience and to clarify the direction of the respective organizations. The research is based on Dutch and Belgian public transport operators. It is assumed that they are representative from a

European perspective and that their abilities to manage are not transport specific or geographically determined.

Public transport organizations identify themselves by means of mission, vision and goals as strategy statements. Kaplan and Norton (2008) define a *mission* as the reason for the organization's existence, while the *vision* states how the organization wants to manifest its mission in future, both internally as externally. The vision is constituted from the mission based on external opportunities and threats, and internal strengths and weaknesses. Chandler (1962) defines *strategy* as the determination of the basic long-term goals and objectives of an organization, the adoption of courses of action and the allocation of resources necessary for carrying out these goals.

In terms of EU regulations, the annual reports of all EU organizations need to report on their financial results and their strategic position, *including relevant uncertainties* they might be confronted with (Van Zeijl, 2009).

Analysis of Dutch public transport organizations' annual reports for 2007 and the information on their websites (2008) will offer an overview of how they acknowledge "the property of resilience" as strategically relevant. No assessment is given here on the level or intensity of this acknowledgment.

Apart from the four largest cities in the Netherlands – Amsterdam, Rotterdam, The Hague and Utrecht – all public transport concession areas have been tendered. Outside these cities Connexxion, Veolia and Arriva were the largest public transport organizations in 2007. Public transport organizations in the larger cities are GVB in Amsterdam, RET in Rotterdam, HTM in The Hague and GVU in Utrecht. The last one has been part of the Connexxion Group since 2006. Legally all of them are private companies. In reality, larger city public transport organizations do have some typical semi-public features. For example, each one can only operate in its own city concession area and the shares are owned only by the city authorities.

The public transport organizations' websites and 2007 annual reports were analyzed in terms of functionality, goals and strategic statements to understand their recognition and acknowledgement of disturbances in general and of resilience and risk more specifically.

The functionality describes the responsibility of the organization towards its environment. All organizations describe their relevance in stimulating spatial and socio-economic developments as well as in offering safe, affordable and reliable transport (Quak, 2008). All organizations recognize their responsibilities to society and customers, which reflects the role of public transport described above.

Goals are set by all the organizations. Most private organizations stress specifically the relevance of a strong financial position. All mention the relevance of operational excellence and quality of service. Dutch public transport organizations like to distinguish themselves in terms of financial, operational and customer service goals (Quak, 2008; Timmer, 2008).

Statements on risk and resilience have been examined from the perspective of coordinated activities to supervise and control a public transport organization with regard to disturbances. The assumption made is that operators would mention security, disruption and risk, i.e. resilience-related management-related activities, in their strategy statements, if these factors are regarded as being of some significance. A limitation of this part of the research at this stage is that only publicly available sources have been examined.

Because specific management information on risks or on response strategies can be regarded as sensitive information, it is unlikely that all documentation on this subject would be publicly accessible. The information abstracted from annual reports and websites is rather regarded as indicating whether or not organizations acknowledge disturbances and elements of the property of resilience. The national rail transport organizations NS (Main Dutch rail operator) and NMBS (main Belgian rail operator) and the largest public transport operator in Flanders (de LIJN) have also been examined from

this perspective. Annual reports of internationally operating organizations such as Veolia or Arriva have been studied as far as they concern Dutch-related operations.

From the analysis of the discussed public transport organizations it is possible to understand that (Table 3):

- Most transport organizations mention disturbances and security and risk-related management explicitly in their annual reports. Arriva, for instance, uses a classification for five different types of principal disturbance areas: market, operational, commercial, financial and other risks;
- Organizations in the larger Dutch cities reveal a more diversified picture. GVU did not mention risk-related activities and HTM, the city public transport company of The Hague, dedicated an entire chapter in their annual report to risk control;
- Descriptions of the Belgian operators are less specific than those of the Dutch.

Property of Resilience acknowledged in 2007 Annual reports and 2008 websites	Clearly- (+), Moderate (-/+) and Not (-) visible statements
<i>Dutch operators:</i>	
<u>Connexion</u>	+
<u>Veolia-transport</u>	+
<u>Arriva</u>	+
<u>GVB</u>	-/+
<u>RET</u>	-/+
<u>HTM</u>	+
<u>GVU</u>	-
NS (national rail)	+
<i>Belgian operators:</i>	
De Lijn	-/+
NMBS (national rail)	-/+

Table 3: Acknowledging the properties of resilience
Organizations ranked in terms of clearly visible statements (+), moderately visible (-/+) and not visible statements (-).

The researched public transport organizations acknowledge elements of resilience, but there are no specific references to coherent resilience approaches. Comparing the public transport strategic statements with the elements of the property of resilience as discussed

in the previous section, it is clear that no *comprehensive* approach to manage resilience is evident. Analyzing information on resilience in the public transport sector based on information available at UITP (International Organization of Public Transport), on a global level, showed the same result (UITP, 2005a and 2008; Timmer, 2008; Transport for London, 2010). Transport for London is the only organization mentioning resilience explicitly in their annual reports, but without referring to a structured approach. This gap in the public transport sector is the starting point for this research on the concept of resilience in public transport organizations.

1.8 Overall research objective

The *role* of public transport in society is discussed and emphasizes the relevance of urban public transport as a safe, reliable and sustainable mode of transport. The emerging need for public transport to analyse disturbances in order to address them and respond to the possible effects on their activities is becoming more relevant (European Commission, 2008e; UITP, 2005b; Vrijling *et al.*, 2004). Looking for an adequate systematic approach, the question emerges not only whether one needs directions but also how to manage the system (Bounfour, 2002; Dyer *et al.*, 2001; Neumann, 2001; Pearce and Doh, 2005; Van Eyck, 2006). This knowledge is the core of the *disturbance life cycle* of a resilient organization (Christopher, 2006; Sheffi, 2007). This demands a coherent approach to structure and manage resilience, something which is not available in the public transport sector.

Public transport organizations are the object of experience in this research. Several authors have proposed a strategic management approach to mitigate the consequences of disruptions for their organizations (Christopher, 2006; Hallikas *et al.*, 2002; Hayes and Weelbriht, 1979; Mintzberg *et al.*, 1998; Van de Heiden, 2006; Wu *et al.*, 2006). The conception of *function* in this research is used to explain the accountability and responsibility of *the public transport* stakeholders. From the analysis of publicly available strategy statements of Dutch and Belgium operators it became clear that public transport organizations lack a coherent, structured, model-based approach. The limitation

of examining only publicly available sources will be taken into consideration when case studies are used in the following chapters. The need to become more resilient and to manage resilience is becoming a common part of social corporate governance of public transport organizations (Drew *et al.*, 2006; UITP, 2009). Resilience has been defined and for the moment it can be identified as the feature of an organization that processes the three main activities of anticipation, attention and response behaviour. There is a need to create structure, to define conditions for a resilience framework, and to create a roadmap to facilitate a structured resilience strategy-building process in the public transport sector. Public transport organizations lack insight into a systematic organizational approach.

Further justification of this research can be found in the potential usefulness of the research outcomes to other public transport stakeholders and to urban public transport policy in general, as well as to attract and retain value out of collaboration.

Finally, this research may be beneficial for those organizations that are hoping to increase their business and business results in a sustainable way. This research will provide valuable insights for industry practitioners in general and demonstrate how they can keep their competitive advantage sustainable.

The overarching purpose of this research is the development of a systematic organizational approach to create a resilient life cycle within a public transport organization through a critical revision of scientific and practical activities related to disruptions.

The **overall research objective** is formulated as: designing a framework to embed resilience in public transport organizations.

Scientific approaches are characterized by two kinds of objects (Vosselman, 1996). The *object of experience* is the urban public transport organization with, more specifically here, a focus on the resilience strategy adopted in such organizations. The *object of science* is not specific, but is based organizational and management studies. Research

without a focus, is possible but not desirable (Vosselman, 1996). The justification for the research mentioned in the previous section reflects the need for a *systematic organizational approach*. Systematic refers to a methodical approach repeatable and learnable through a step-by-step procedure. It will focus on how an organization can structure itself to become more resilient. The field of organization is focused on improving the effectiveness of organizations and the people in those organizations.

1.9 Research objectives and structure of research

This research, with its emphasis on developing a resilience framework for public transport organizations, is organized into different sections.

Chapter 2 motivates the research design and the methodologies for validation of the research, followed by descriptions of approaches that have been applied in this research. A preliminary outline of the research and its context is discussed in this Chapter by explaining the research objective and the context of the research. The research methodology is influenced by the academic and business settings in which the research is done. The research work reported will be structured in terms of the achievement of the research objectives.

In *The Structuring of Organizations* Mintzberg (1979) presents an approach that synthesizes most of the important organizational theories, and concludes that there is no “best” approach to explain the success of organizations. Most theories, however, explain the importance of understanding the environment of the organization in general. This understanding is explicitly stressed in contingency theory and in more recent theories. Contingency theory is guided by the general orienting hypothesis that organizations whose internal features best match the demands of their environments will achieve the best adaptation (Scott, 2003). The literature on resilience, risk and disruption-related approaches in general also emphasises the importance of the relation of the organization to its environment (Christopher, 2006). In the literature on transport in general “the contingency approach has a dominant place” (Ploos van Amstel, 2002: 63).

Hence the first research objective is: “To establish the starting point(s) and limitations regarding the (re-)design of a resilient public transport organization”. This objective entails discussing and analyzing the *position* of the public transport organization within its environment. Its position explains the *role* of public transport together with the *function* of the public transport organization. This part of the research will be denoted as the study of *contextual resilience*. This is the property that ensures that an organization has the capacity to identify its role and can define its function in the context of possible disturbances. This part of the research will lead to the formulation of the first research propositions, which will be described in Chapter 3. Verification will take place in the subsequent steps in the research.

The next part of this research project relates to the research objective: “To structure and design a comprehensible and comprehensive resilience framework for public transport organizations”. The resilience framework will be motivated based on deductive reasoning from a variety of concepts and experiences, from both the fields of risk and resilience management. The guiding principles for the resilience framework will be motivated and research propositions will be formulated. This part of the research will be referred to as the study of the *conceptual resilience framework*. This refers to the concept of deductive orientation to enable the public transport organization to identify and assess and respond to disturbances in order to make it a resilient structure. This issue will be addressed in Chapter 4.

Chapter 5 reports on discussions of this framework with practitioners from public transport organizations and from organizations specifically active in the fields of risk and resilience, using structured interviews. The different interviews can be seen as case studies to verify the deductively presented framework, and they will address the formulated definitions and research propositions. This will also clarify the coherence and cohesiveness of the framework and consider advances in resilience approaches in public transport. From this a verified structure will unfold, referred to as *cognitive resilience*. This is the orientation that enables a public transport organization to identify, assess and

respond to disturbances in order to become a resilient organization. The focus is on the design and structure of the framework.

The third research objective is: “To identify the main elements that create knowledge about the resilience design”. This part of the research supplements the conceptual and cognitive resilience orientation, and will discuss the main elements that determine the concept of resilience and will motivate how resilience management contributes to improved performance of the public transport organization. The public transport organization must be able to address issues before they become problems and ensure that critical capabilities are available. This requires a proactive diagnostic tool to give the public transport organization a competitive edge and move away from exclusively reactive resolutions. These embedded diagnostics can help to structure and analyze vulnerabilities and capabilities to predict and explain potential organizational behaviour. *Behavioural resilience* is the ability to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to structure and to react systematically when something unexpected occurs. Focus will be on the content of the most relevant elements of the framework. This will be discussed in Chapter 6.

Chapter 7 will discuss the fourth research objective: “To ensure that public transport organizations are able to make linkages between vulnerabilities and capabilities”. The ability to determine the importance, to rank and to identify critical linkages between vulnerabilities and capabilities will give the public transport organization the possibility to derive a *balanced resilience position*. The ability to link vulnerabilities and capabilities will be motivated through triangulation, with the potential to employ iterations between the literature review, experiments, case study evidences and expert focus.

Finally, Chapter 8 will reflect on the overall research objective to design and embed a structured resilience approach. It will consolidate the formulated research objectives and the knowledge produced by this research; it will also indicate further research directions.

2 *Research methodology*

2.1 *Introduction*

This central challenge is to develop a framework for public transport organizations to become resilient and to manage this in a cyclic process for continuation and improvement. In this research the definition of *theory* given by Friedrich (2000) and Kerlinger (1986: 9) is applied: “A theory is a set of interrelated constructs (concepts), definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena”. Glaser and Strauss (2006) stress that good theory should not only explain and predict, but also be useful. This implies that it has to be useful in theoretical advances as well as in practical applications, in order to provide a perspective on behaviour and to guide and provide an appropriate mode of research on particular areas of behaviour.

A formal theory deals with a domain of science and is more general and conceptually abstract. A *substantive theory* deals with a particular limited domain and is close to the real-world situation. An emerging substantive theory is in most cases “the result of believing that existing formal theories or substantive theory in other areas can be applied to the area of research, and will supply concepts and hypotheses” (Glaser and Straus, 2006: 34). This research proceeds along these lines. In order to develop a resilience framework for public transport organizations, this research started to analyze literature from a wide range of perspectives. The literature study will not be limited to public transport-related data sources only. The learning effects of exploring different circumstances in different environments on the concept of resilience will increase understanding and will add to the quality of the framework for public transport organizations to be developed.

This chapter will explain the elements that influence research design as well as the process of the actual research development and approaches to the collection and analysis of data.

2.2 *Research design*

Research is exploratory when no earlier model or structure can be used as the basis (Gephart, 2001). In the public transport sector no framework and coherent resilience approach is evident. Other disciplines provide insights into elements of the concept of resilience. Concepts that are in the process of development and used in other disciplines are discussed as part of this research. This research will follow a gradual process of accumulating data. A preliminary notion of the object of study and of its context has been presented in Chapter 1. The research will start with presenting a holistic overview, which will be refined and defined more precisely during the research process. In exploratory research “the objective is to gather preliminary information that will help define problems and suggest hypotheses” (Kotler *et al.*, 2006: 122). This research will follow the principles of an *exploratory research*.

In addition, exploratory research often relies on a combination of deductive and inductive research with secondary research, such as reviewing the available literature and/or data, and qualitative approaches such as in-depth interviews, focus groups, projective methods, case studies or pilot studies (Davies and Lang, 2002; Kotzab *et al.*, 2005). Analysis in exploratory research is essentially concerned with abstraction and generalization. Extensive literature and data analysis and a structured approach are used to translate information, empirical observations, etc. into concepts relevant to the public transport sector. Generalization means focusing on those structures that have common factors. When the study of new items or cases no longer reveals interesting new information in relation to the development of a resilience framework for public transport organizations, this will be seen as the “saturated” state of the research. This research will use *a mix of deductive and inductive data-collection processes*.

Qualitative research and quantitative research methods are used for different purposes (Denzin 1994). The strengths and weaknesses of qualitative and quantitative research are still hotly debated, especially in the social sciences. Some researchers suggest that some blend of both quantitative and qualitative analysis should be used (Glaser and Barney, 1995). The “clash” between advocates of quantitative and qualitative data is historically

linked with the change in the relative emphasis on the generation of knowledge and the verification of results. However, there is no fundamental clash between the purposes and capacities of quantitative and qualitative data. Glaser and Straus (2006: 17) state that “each form of data is useful for both verification and generation of theory, whatever the primacy of emphasis”. Primacy depends only on the circumstances of the research and on the kind of material needed for research. Glaser and Straus (2006) propose many valid reasons for undertaking qualitative research. One reason is that the thinking style or the culture of the organizations to be researched may be under-recognized as a key factor in determining the preferred choice of method. Another reason is the nature of the research problem, as discussed in Chapter 1 as “Justification for the research”. Some areas of study naturally lend themselves more to qualitative types of research with qualitative methods for data gathering, for example, research that attempts to investigate how and why organizations experience a phenomenon (Kotzab *et al.*, 2005). This research will apply *qualitative research*. It will generate research propositions on the public transport resilience framework to be verified.

2.3 Research validation

There is no single agreed definition of *validity* in science and statistics, but it generally refers to the extent to which a concept, conclusion or measurement is well founded and corresponds accurately to the real world (Eisenhardt, 1989a). Within this research the following aspects have been taken into consideration: external and internal validity and construct validity.

External validity refers to how accurately the results represent the phenomenon being studied, establishing the generalizability of the results (Ellram, 1996). It refers to whether the results of the study can be generalized beyond the specific research context in which the investigation was conducted (Bryman, 2004). This research will select literature from bodies of research and from academic and professional leadership, and will use a wide range of perspectives to develop a conceptual resilience framework for the public transport sector. This framework will be discussed with public transport organizations

operating in Europe. For that reason the generalizability of this research is limited to that geographical region.

It is necessary to make a distinction between statistical and analytical generalization (Buijs, 1994). The case-study approach is often criticized for making this first type of generalization. The power of the case-study approach rather derives from the second type of generalization. As Yin (1998: 44) states: “In analytical generalization, the investigator is striving to generalize a particular set of results to some broader theory”. The difficulty of generalization can partly be solved by using “a positive sampling method” (Eisenhardt 1989a; McClutcheon and Meredith, 1993). This chapter will motivate the use of case studies and the approach to the selection of stakeholders and participants for the interviews to generalize the study results to public transport organizations.

Internal validity relates to the quality of the research in process. Internal validity is based on the question of whether a finding is sound and whether concepts are clear and consistent (Ellram, 1996). In this research the study field will be clearly demarcated, the validity of measurements tools will be explained, and the reliability of the data will be motivated. The research will follow a structured transferable approach. The research will develop a resilience framework for public transport organizations through an examination of the relevant literature and through analyzing multiple case studies as well as by making direct sequential comparisons between cases; feedback on individual and collective results will also be obtained.

Construct validity is about establishing the correct operational measures for the studied concepts and is closely related to the issue of reliability. Reliability is the extent to which the way that you measure a variable or concept is consistent, so that repeated measures would yield similar results. The concept of *reliability* in qualitative research has to do with being “in principle repeatable” (Peters, 2006: 632). Internal consistency is achieved through the reliability of the survey instruments and definitions (Bryman, 2004). This research will use a consistent approach in every interview to gather data. By examining data collected from different participants, findings can be explained and corroborated

across the data sets, reducing the impact of potential biases that may exist in a single study (Koulikoff-Souverin and Harrison, 2005). This research will motivate the approach of every survey; it will explain the protocol for the analysis and will outline the chain of events to provide final conclusions (Dijk *et al.*, 1991).

2.4 Relevance of verification and generation

Glaser and Strauss (2006) argue persuasively that theory should be inductively generated through the systematic analysis of empirical data. Sieber (1973: 1340) contends that the integration of field and survey methods constitutes a new style of research that opens up “enormous opportunities ... for improving our research strategies. That is, in order to discover the basic conceptual elements of theory, one must systematically compare similar, and sometimes dissimilar, events or situations. Only in this way can theory be progressively built up so that it is generally applicable to the phenomena being studied”. This research will also proceed along these lines. Furthermore, in their view the key to successful theory generation is the use of general methods, such as case studies.

The research phases connected to the research objectives result in research propositions, a conceptual resilience framework for public transport organizations and lists of the most important resilience-related factors. These are developed based on deductive reasoning from a variety of concepts and experiences, from the fields of both risk and resilience, but not specifically from public transport organizations.

Matching the conceptual framework with empirical evidence from the public transport sector and from resilience practitioners is relevant to analyse whether different stakeholders have different or similar reactions to the resilience structure developed here and the formulated research propositions and definitions. *Verification* is a quality assessment process that is used to evaluate whether or not a product, service or system complies with a regulation, specification or conditions imposed at the start of a development phase (KTH: School of Industrial Engineering and Management, 2008; Leslie *et al.*, 2009). Verification ensures the resilience framework is designed to deliver

functionality to the public transport organization; it typically involves reviews and meetings to evaluate requirements and specifications (Scandura and Williams, 2000; Eurostat, 2009).

In addition to the verification of data is the generation of information/data in the service of modifying the conceptual resilience framework and vulnerability and capability lists. The interviews with practitioners from public transport organizations and from the fields of risk and resilience can generate new insights. While verifying is seen as a vital task in the research process, the purposeful systematic generation of information/data is the main goal in the development of the resilience framework. The key is *generating* new information to adjust the formulated conceptual resilience framework.

A question that invariably arises in doing research is: how does one know when enough data have been collected (Long *et al.*, 1980; Seuring, 2005; Eisenhardt and Greaber, 2007)? A category is saturated when continued data collection yields no new information. This is simply the point at which incremental learning is minimal, because the arguments and elements have been encountered before (Eisenhardt and Greaber, 2007).

In practice theoretical saturation is often linked with pragmatic considerations such as the availability of actors, time and money. Both Eisenhardt (2007) and Yin (2003) argue that there is no ideal number of cases, but a number between four and six usually works. Less than four creates difficulties in generating substantive theory and more than ten becomes too complicated to process (Pettit, 2008). This research will follow this approach, but only in the context of a homogeneous group. Case studies are conducted within public transport organizations and with stakeholders outside such organizations. For that reason the discussion on dealing with participant homogeneity is relevant. When the research population is not a homogeneous group, then six to twelve case studies are recommended (Ellram, 1996; Koulikoff-Souviron and Harrison, 2005; Yin, 2003).

2.4.1 Case study

Case studies are relevant because they draw on real-life experiences, with possible longitudinal perspectives prevailing in addition to states of equilibrium; they can provide access to secondary data and make cross-case comparisons possible, and they are multifaceted (Peters, 2006; Seuring, 2005). Theory-building research using cases more broadly provides answers to research questions that address “how” and “why” in unexplored research areas particularly well (Edmondson and McManus, 2007). It is possible to go beyond simple description to achieve more incisive and generalizable findings (Hatchuel and Mollet, 1986). In this research the definition of a *case study* by Yin (2003: 13, 14) is used: a case study is an empirical inquiry that investigates a contemporary phenomenon within a real-life context. The issue is whether to conduct a single- or multi-case study. Eisenhardt and Graeber (2007: 27) state that “theory building from multiple cases typically yields more robust, generalizable and testable theory than single-case studies”. A multi-case study is also appropriate for generation arguments.

Case studies were chosen as the primary data-collection method to verify the findings from the literature surveys. The kind of information needed for this research can be best collected from in-depth interviews rather than from focus groups, as people tend to express more genuine opinions without their counterparts being present and in the knowledge that the research ensures anonymity (Dick, B, 2000). The fact that there is competition between public transport organizations will not set up the right conditions for sharing sensible and reliable information. This research will use case studies and include cross-case analysis in the orientation, design and evaluation of the resilience framework (Kotzab *et al.*, 2005; Yin, 1998).

The process of data collection will use a structured interview approach, with a procedure to extend the discussions for increasing the acquisition of qualitative information (Oishi, 2003). All respondents are asked the same question in the same way. This makes it easy to repeat (replicate) the interview. This type of method is easy to standardise and it is relatively quick and easy to code and interpret. The interview effect that the researcher can influence various answers, thereby biasing the responses, is limited in this way.

Participants received a letter of introduction to explain the purpose of the interview, the relevance of participation and the process to be followed.

The development of a resilience framework presented in the different stages of the research will be discussed with selected interviewees to verify the research propositions formulated and to gather information about current practices in the public transport sector. This will be followed by an analysis in which agreements and exceptions will be identified, as well as disagreements, and then explanations of the difference(s) put forward. Multiple discussions generate a more robust theory, because the propositions are more deeply grounded in varied empirical evidence (Eisenhardt and Greaber, 2007; Yin, 2003). This research adopts the position of Glaser and Strauss (2006: 28) that comparative analysis of cases both subsumes and assumes verifications and accurate descriptions, but only to the level that the latter are in the service of data generation.

In summary, following Peters (2006: 621), this case study approach has three functions:

- To explore and develop knowledge as theory generating;
- To describe context and structure as “plausibility probes”;
- To explain factors of influence as crucial or deviant.

2.4.2 Cohort design: selecting stakeholders and participants

Cohort design refers to that part of the study that concerns selecting particular cohorts or groups (Fink, 2003). The purpose of the interviews is to develop the resilience approach and the sampling will be appropriate if the participants are suitable for extending the relationships and logic within the construct. The persistent problem of deciding with whom to discuss the relevant issues is seen as not very different from the process of selection from the literature. To provide the appropriate modes of conceptualization for description and explanation, a structure and strategy for gathering and processing the data in research are needed (Dijk *et al.*, 1991; Ellram, 1996).

The challenge of processing interview data is best mitigated by data-collection approaches that limit bias. The selections are based on the principle of positive sampling, also referred as purposive sampling, using the same criteria for selection in all selection processes in this research (Bernard, 2002). A structured approach and process with a standardized questionnaire will make it possible to limit interpretations from the interviewer.

Another approach to mitigating bias is to combine retrospective and real-time information (Leonard-Barton, 1990). Retrospective cases rely on a number of in-depth cases to enable sense making, while real-time cases employ longitudinal data collection. Experience with disruptions in public transport organizations is not used as a selection criterion.

The element of the level of representation of interview participants is relevant. *Stakeholders* are defined as the types of organizations involved and the *participants* as the individuals within the selected organizations to be interviewed.

The first challenge is to decide which *stakeholders* to select for data collection. Given the specific scope and context of the research, the number of stakeholders is limited. It is necessary to note to what degree public transport stakeholders are varied in terms of their diverse environmental positions and conditions. Stakeholder analysis is based on a technique to identify and assess the importance of key stakeholders that may significantly influence the success of the research project (Unicef, 1998). The process of analyzing stakeholders involves the following steps:

- Identify groups and institutions that might be affected by, or can influence, a resilience management approach in the public transport sector (either positively or negatively). They are listed as Stakeholders.
- Identify the specific interests these stakeholders have in the topic such as: benefit(s) to the stakeholder; the changes the stakeholder might be required to make; and the activities that might cause damage or conflict for the stakeholder. They are listed as: Stakeholder(s) Interest(s).

- Identify how significantly the stockholder's interests are based on expected responsibilities, activities and potential impacts.
- Analyze overlapping interests, responsibilities and impacts.

A second challenge concerns the further selection of specific responsible *participants* for the interviews based on their position and their function within the organization, and on whether they have a generic or more specific orientation towards the subject of resilience.

In comparative analysis the purpose is also to select a set of participants that is justified by common factors. In order to control the effects on generality, the stakeholders and participants are selected on the basis of their understanding of the expected scope of the public transport system and/or the expected conceptual level of awareness of the properties of risk and resilience. Some participants will have a greater focus on one of these aspects than on any others. With some participants more involved with public transport, on the one hand, and other participants more concerned with risk and resilience approaches, on the other hand, it is clear that all the participants together cannot be regarded as one homogeneous group. With regards to public transport organization policy and awareness, it is assumed that only transport organizations and transport authorities can provide the relevant information on the public transport sector. In the analysis a distinction is made between these stakeholders in comparison with others.

The next requirement is that participants will need to have managerial competences. This enables one to make a distinction between possible operational performers and participants with managerial competences and, it is assumed, a certain level of overview of the organization in the context of conceptual awareness.

These two *generic arguments* will support the purpose of this research (McClutcheon and Meredith, 1993). The assumption involved is that this approach will create a systematic and relevant control of data collection.

It is clear that two results are possible. Through minimizing the differences between the participants on for example, framework relations, interpretations of definitions and varying research propositions common ground is created. But maximizing differences can broaden the scope of the research. The purpose of this research, however, is not to maximize the degree of similarity among participants, nor to maximize the diversity of their reactions. The purpose is not primarily to compare participants, but to compare statements and arguments. If a new data-collection opportunity arises, or if a new line of thinking emerges during the interviews, it makes sense to take advantage of this by expanding or changing stakeholders or participants, if such a change is likely to provide new theoretical insights. This level of flexibility is not seen as being unsystematic in an exploratory approach (Maso and Smaling, 1998).

Participants from different hierarchical levels and functional areas are included in this research. The awareness of context among the different participants may vary in terms of their knowledge, depending on their responsibilities within the organization. Every discussion with a participant is seen as a specific or distinct case. If more than one actor is questioned in the same organization, all are treated as equally important in the discussions. The relevance of the argumentation and explanations is of more importance to the discussions and review of the framework than is the position of the actor (Koulikoff-Souverin and Harrison, 2005). The responsibilities of the participants within their respective organizations are mentioned.

2.4 Approaches followed for conducting empirical research

The empirical research aims are to verify and understand the gaps between the conceptual findings from the literature and the experiences of the European public transport practitioners (Bryman, 2004; Crabtree and Miller, 1999; Sieber, 1973).

The processes followed for conducting empirical research include the following:

- Connected to the first, second and third research objectives, two sets of interviews are developed, mainly needed to verify and generate information on the structure of the framework, on definitions, on the guiding principles of

the framework and on the content of the most important elements of the framework (see Appendices 1 and 2);

- Connected to the fourth research objective, empirical research is conducted to analyze critical linkages in the framework developed (see Appendix 3);
- With regard to the fourth research objective and the overall research objective, a meeting with experts is organized (see Appendix 4).

The approach of the first two sets of interviews related to the first three research objectives is outlined below in three stages: preparation, execution and analysis.

Firstly the preparation of interviews: this entailed:

- Draft of structured interview structure and questions. The interviews will adopt a structured approach, with an open-ended procedure to extend the discussions;
- Identification of stakeholders and participants;
- Screening of interview structure and questions, and of selected stakeholders and participants with promoter;
- Invitation to participants and confirmation of their willingness to participate;
- Introductory letter with information on other participants, confidentiality and schedule of interviews, and including interview structure and questions.

Secondly the interviews are conducted and administrated. All interviews are standardized with segmentation into relevant distinctive sections (Oishi, 2003; Booij *et al.*, 2006).

Thirdly, the interviews are analyzed; this process entails:

- Analysis of interviews with review and feedback;
- Summary of findings, without reference to specific interview or stakeholder, and screening with promoter;
- Distribution of draft to stakeholders for feedback and review;
- Consolidate comments into summarized findings. The search for confirmatory evidence as well as for exceptions will receive equal attention.

Finally, the empirical findings are reported in a structured way. All information received from the various participants will remain anonymous and the outcome of the empirical research was aggregated to ensure that no confidential information would be revealed (Delnooz, 1996; Strauss, 1987). All participants receive the results of the empirical research.

For the fourth research objective, namely to analyze critical linkages between the different elements in the framework on resilience, following approach was adopted.

The literature reviews and interviews conducted in relation to the first three research objectives does not ensure that public transport organizations are able to develop linkages in the public transport framework. As the study is exploratory in nature, the appropriate method to conduct further research in order to develop a holistic understanding was not based on a single approach, but on a series of mixed approaches (Boyer and Swink, 2008; Delnooz, 1996, Jick, 1979; Fink, 2003). Relevant insights are incorporated from different research streams. This part of the research proposes the use of the theory development process, also referred to as *triangulation*. Triangulation is the most appropriate method for confirming substantive topics that are relatively underdeveloped and has the potential to employ iterations between the different research methods (Saunders *et al.*, 1998; Pettit, 2008). The result of one approach can be used as the starting point for the next iteration (Lewis, 1998; Jick, 1979). In comparing and contrasting emerging constructs and theory across different settings, a chain of evidence is maintained and the convergence of multiple methods provides additional validation (Frankel *et al.*, 2005).

Research methods in organizational management can be categorized according to the method of data acquisition: theoretical study, survey, case-study based and experimental (Frankel *et al.*, 2005; Leslie *et al.*, 2009; Saunders *et al.*, 1998). This phase of the exploratory research combined – in addition to the developed theory from previous chapters – evidence building by using a pilot as an experiment, case studies by using interviews, and qualitative interpretation of experts to triangulate these methodologies.

To issues are considered. First, to assist participants of interviews in this part of the research to respond adequately, considerable care was given to develop a tool to support the design of the interview. With regard to the ability to link factors a pilot as an experiment was carried out to test the tool. The pilot experiment, further referred to as experiment, needed to be developed for researching the ability of creating linkages between vulnerabilities and capabilities and supports to the evidence building. Based on that and building understanding, these linkages were discussed in academic sessions with fifty fourth-year students in the Department Traffic Studies at the NHTV University of Applied Studies in Breda, the Netherlands, who were attending a module on strategic developments in public transport. In the session two distinct groups were divided. Based on different position statements, one group based its analysis on the perspective of cost leadership position and the other group based its analysis on the perspective of operational excellence. The groups were informed about the process and received instructions. Information presented is equal as what is presented to the interviewees and experts in the subsequent parts of the research. Each group was sent to a different room and later to discuss the findings combined. The purpose was not to compare these groups, but to *discuss arguments* that support defining and potentially analysing linkages from both perspectives.

Concerning the interviews a second issue was anticipated. Format and design of the interviews used elements of effective web-based surveys, e.g. clear introduction, detailed instructions, consistent page layout, limited length and back paging (Dillman, 2000). Data collection was done by using an online survey with internet and telephone support to distribute and collect the questionnaires in a user-friendly and cost-effective way (Griffis *et al.*, 2003).

Connected to both the fourth research objective and to the overall research objective, a meeting with experts was organized. A resilient public transport organization needs to design skills that are essential to creating a competitive advantage. Public transport organizations need to balance revenue streams with preparation and recovery costs, short-

term customer service and long-term values in terms of return on assets (Ahlquist *et al.* 2003; Anshoff, 2007; CapGemini, 207; Slone *et al.*, 2007).

Expert groups are an excellent source of qualitative data when exploring complex issues, particularly in studying emerging phenomena (Boyer and Swink, 2008; Cooper and Schindler, 2005; Morgan, 1996). The *purpose* of the expert meeting is to extract inferences on the potential relationship between resilience and performance in order to ensure resilience in public transport organizations. The expert meeting is also to reflect on the framework and on the previous results of the triangulation regarding the measurement, ranking and ability to create linkages and to create successful rules that provide managerial direction. The results of the different research objectives and the overall goal of the research are discussed in this meeting.

The meeting is guided by a protocol to provide information on definitions, the resilience framework and the assessment tool as well as by the agenda of the meeting (Dijk *et al.*, 1991; Fink, 2003).

The meeting consisted of following parts:

- Introduction and clarification by researcher of research goal and research objectives, followed by discussion;
- Discussion on relation between vulnerability and capability (sub-)factors and on strategic relevance;
- Discussion on previous findings and evaluation of ability to conduct measurement, ranking and linking of factors;
- Discussion on introduction and redesigning resilience in public transport organizations.

2.4.1 Analysis of empirical research data

Coding and categorizing have an important role in analysis of empirical data. The establishment of categories is both an organizational tool and an important part of the outcome of the research (Friedrich, 2000; Koulifoff-Souverin and Harrisson, 2005; Miles and Huberman, 1994). The process entails organizing the data in ways useful for the analysis and establishing how the category will fit in the wider context.

An electronic method of coding was considered but not selected, because of the relatively small number of participants in the surveys (Miles and Huberman, 1994; Sieber, 1973). Interviews are not recorded and notes were made using key words (Delnooz, 1996; Dijk *et al.*, 1991). After the interview each participant received a copy and was asked to confirm its accuracy (Strauss, 1987). All participants confirmed and in two cases the participant added information on some questions, which was considered as part of a legitimate answer to the question and included in the coding and analysis process.

Questions can be categorized and following approach to coding is used (Bryman, 2004; Fink, 2003):

- Confirmation questions: These questions are coded in terms of Boolean categories. Confirmation questions are related to the verification process. Only answers with a 100% (dis-)confirmation are considered to verify the requested topic.

Research propositions, confirmation on definitions, guiding principles and framework relations are analyzed this way. When a different (dis-)confirmation setting is used, this will be motivated.

- The other questions can be classified into the taxonomy of informational, interpretive, explanatory or relational categories and have been analyzed by using the method of keywords. Questions in these categories are used to generate information to support the explanatory approach in the generation of information.

The concept of constant comparison is used to register significant patterns. Consistent coding and comparison of results of the interviews allow consideration of the dimensions

of phenomena (Friedrich, 2000; Glaser and Straus, 2006). If lists with informative, interpretive, explanatory or relational data were analyzed, then all keywords are regarded as of equal importance. If statements are interpreted differently, then comparison of arguments with other participants is discussed and analyzed. A majority position approach is followed to adjust statements, if necessary (Kotzab *et al.*, 2005).

The empirical research connected to the fourth research objective required different approaches. The results are subsequently analyzed and used to explore new dimensions. The results of the pilot experiment are also considered to contribute to the research. Next, interviews with selected participants based on the generic arguments discussed above, using the develop tool, are conducted to also analyze the ability or competence of public transport organizations in measuring, ranking and linking of elements in the framework. A comparative analysis of average value and min-max value of participants' responses shows the usefulness of measurement and ranking. Because no assumptions are made about the distribution of the data, only factor means are used to rank on an ordinal scale. Finally, the results of the expert meeting are included in the findings. Although each method has its limitations, the evidence is built up and verified through triangulation (Lewis, 1998; Leslie *et al.*, 2009).

The expert meeting was scheduled for three hours and findings are reported as meeting results and not related to individual participants (Cooper and Schindler, 2005). Participants received the minutes of the meeting for their comments, which have been incorporated into the findings. The purpose was to provide managerial direction and to confirm the ability of public transport organizations to embed resilience by using the framework developed. The expert meeting adopted a holistic approach to all research objectives and the overall research goal.

3 *Contextual resilience*

3.1 *Introduction*

Resilience approaches lead to a reduction in problem-identification time, a reduction in problem-resolution time, and a reduction in response time to problems. Such approaches are basically about *building organizational capabilities* for bouncing back quickly (Sheffi, 2001). The property that ensures that an organization has the capacity to identify its role and function in the context of possible disturbances will be referred to as *contextual resilience*.

Accordingly, the first research objective is formulated as: “To establish the starting points and limitations regarding the (re-)design of a resilient public transport organization”.

Chapter 1 discussed the fact that Dutch and Belgian public transport organizations acknowledge the properties of resilience. This acknowledgement of the need to understand resilience will be regarded as one of the starting points in the context of developing contextual awareness.

This chapter will consider the following:

- The concept of organizations as open systems means that they receive inputs from their environment. According to contingency theory, the different activities of public transport have a natural cohesion with the environment. The concept of environment will be discussed and this will lead to the development of a structure to support, dividing the environmental input focus of public transport organizations into awareness areas of sources of *actual* and *potential* disruptive events;
- Public transport organizations need to structure their information and organization to be able to identify and manage their responsibilities to develop a systematic approach.

Next, this chapter will present the research propositions on the contextual awareness of resilience in public transport organizations, which will be discussed and verified in further research.

3.2 Organizations' environmental focus in perspective

A classic approach in strategic management research is to divide the concept of strategy into two distinct parts: the process of how the strategy is formed, and the content of what is decided (Ketchen *et al.*, 1996; Kothler *et al.*, 2006; Mintzberg *et al.*, 1998). The role of constructs such as “context” or “environment” has received a great deal of attention in strategic management research, with various conceptualizations being formulated (Mintzberg *et al.*, 1998: 722-73; Wagner and Bode, 2008). In addition to content and process, the external context of the organization plays an important role in decision making and should therefore be incorporated into the concept (Ketchen *et al.*, 1996; Malone *et al.*, 1999; Pettigrew and Whipp, 1993; Lawrence and Lorsch., 1967). Organizations must match structure to context or environment, i.e. forces outside of the decision maker's control. If this “fit” is not achieved, costs rise and opportunities are lost, and the continuity of the organization is threatened (Child, 1972: 8).

In addition to the theoretical approaches, industry in general is also aware of this situation. In *Managing Enterprise Risks in Global Automotive Manufacturing Operations* General Motors (2006: 26) presented an approach which also emphasizes understanding and researching the environment of the business. At the Johannesburg Council of Supply Chain Management Professionals (CSCMP) conference in 2008 Christopher also stressed the importance of understanding the context or environment of the organization when analyzing disturbances and developing resilience approaches in transport chains (Christopher, 2008). One of the main themes of the UITP World Conference in Dubai 2011 is the relevance of a trustworthy public transport under all circumstances. Causes of disruptions are not limited only to the internal public transport operations. The environment of the public transport organization needs to be analyzed to understand what kind of internal and external disruptions can affect public transport operations.

In May 2006 some 200 experts attended a workshop in Vienna organized by the Organization of Security and Co-operation in Europe (OSCE) and the UITP. Two statements emanating from the workshop were: “Public transport networks are the arteries of contemporary societies, without which modern urban life is impossible”; this reflects the role of public transport as described in Chapter 1. The other statement reflects the awareness of possible disturbances: “Making urban transport networks harder targets for terrorists to strike helps to mitigate the threat and makes our citizens more secure” (Wycoff, 2006). Public transport organizations need to understand the wide spectrum of possible disturbances and respond to these developments and trends in a consistent way. Christopher (2005: 242) states that in many companies there is “an amazing lack of awareness” of the wider supply/demand network of which the organization is a part.

3.3 Structuring the environmental focus of public transport organizations

In this section the environmental focus of public transport organizations will be discussed, based on the structure of the scenario project QUESTA. This project entails cooperation between the Dutch Ministry of Transport and Research Institutes RAND Europe and TNO in the Netherlands to analyze future developments on public transport (Rand-Europe, 1998). The structure is used and tested in theory and practice by many, such as the research centre on Innovative Public Transport, CVOV (Centrum Vernieuwing Openbaar Vervoer) and NHTV University of Applied Science, both in the Netherlands.

The structure is based on market demand and supply relations and on a system of interactions between different but connected markets as well. First, public transport organizations will be discussed from the perspective of *transport supply and transport demand*; secondly, the transport market is placed in the context of the *public transport system*; and thirdly, this system is considered in *its wider context*.

3.3.1 Supply side of the public transport market

Public transport operations are activities executed and managed within the sphere of responsibility and accountability of the public transport organization. Axhausen (2006: 1) states: “The operational definition of the activity is left to the survey designer to suit the needs of the particular study”. In parallel with the distinction made by Peak (1994: 59) in *Transport in Transition*, supply activities and the connected processes of decision making will be explained in terms of two dimensions.

The first dimension has to do with the activities and associated decisions on the actual transport of passengers and falls into the domain of the accountability of the public transport organization. This will be referred to as “net” related activities and decisions. In public transport the passenger is regarded as a (potential) customer, while the public authority as contract owner is regarded as client (Proper, 2007a). In a demand-driven environment the developed and organized net activities reflect the “useful components of services or products” (Chapter 1: Table 1). Decisions made by the public transport organization include decisions of out-sourced activities, within the authority of the public transport organization. Disturbance-related decisions as well as service-level agreements with customers can also be classified among these net-related activities and decisions.

As for the second dimension, net activities and decision processes of public transport organizations are framed within wider decision processes. In addition to conforming to policies on deregulation and tendering, public transport organizations need to comply with legal requirements and other regulations. The scope of “gross” transport activities involves decisions of the other stakeholders related to the supply side of the public transport market, which can affect decision-making processes of the public transport organization. They impact on the *supply conditions to operate*. For example, in the latest Dutch tender procedures it is clear that transport authorities have a tendency to ask for new buses, or to use a specific fuel. Also the structure of the tariff system in the Netherlands is not the responsibility of the operator. Another example, as discussed, is the 2006 decision of the Dutch government that tender processes in the four largest cities will not be mandatory, but this will change again with the new 2010 government in place.

Public transport supply decisions and responsibilities are in this way segmented into two different entities: the net activity decisions of the public transport organization relates to accountability for the *actual provision* of transport, and the gross activity decisions of all other stakeholders involved with the supply side of the public transport market relates to *supply conditions to operate*.

In the environmental context changes in the supply conditions need to be recognized and to be judged by their effects on public transport organizations. In structuring the public transport organization environment, the first part of the process is to analyze and define *supply conditions* and identify associated events that *might* occur.

3.3.2 Public transport market

The public transport market is a segment of the larger passenger transport market. The main purpose of a market definition is to identify in a systematic way the constraints that the organizations involved face (European Commission, 1997). The varying proportion of different transport modes is reflected in modal split statistics (European Commission, 2002; Van Nes, 2000; Rijkswaterstaat, 2008; United Nations, 2003).

Modes of transport may be seen as competing services, and particularly so in the rivalry between private cars and public transport systems (Dijst *et al.*, 2002; Ministerie van Verkeer en Waterstaat, 2004). From a transport demand perspective, passengers are not only concerned with how to get to their destination, in terms of routes and frequencies offered, but include in their considerations also the elements of comfort, time spent on travelling and the exact time of departure and arrival (Dijst *et al.*, 2002). In many cases the travelling time and comfort of a car journey outweigh out-of-pocket costs and play an important part in determining the modal choice (Hansen *et al.*, 1999).

Established markets and organizations are, from an economic point of view, subject to at least two main sources of constraints: demand substitutability and supply substitutability. Demand substitution constitutes the most immediate and effective disciplinary force on

the suppliers of a given service or product. The question to be answered is whether the public transport customers would switch to readily available substitutes or to other suppliers (Proper, 2008; Van de Velde and Pruijboom, 2005a).

The competitive constraints arising from supply-side substitutability are in general less immediate and responding to these constraints requires an analysis of additional factors. Public transport suppliers are expected to be able to switch production to relevant products or services and market them in the short term without incurring significant additional costs or risks. The question to be answered is whether the public transport organizations could switch to readily available substitutes of products or services, or to different market segments. Their capability to be flexible is tested in that respect.

The *transport market* considers the balanced results of supply and demand relations and constraints of all passenger transport (sub-)systems and connected activities. The public transport market is part of this transport market. Services can be influenced in competition with offerings of other modes of transport, by competitors in the same market segment and by generic or behaviour changes according to specific demands. The transport operator needs to recognize and analyze these changes in market boundaries and conditions, and to be capable of defining the effects on the organization and the way to act upon and control them. In the environmental context the second part of the process is that public transport organizations analyze and define *market conditions* and identify connected events that *might* happen.

3.3.3 Public transport system

Transport is, in general, subject to place and time utility (Pienaar and Vogt, 2009: 23). Time utility, in the context of the passenger transport market, is related to the availability of passenger transport supply at the right time. The 'right time' in the context of transport needed is mostly based on time preferences that are connected to place utility. This place and time utility model is described in Chapter 1 and is complex.

In passenger transport most trips are not made for pleasure and would not have been made if there were not some additional or compensating objectives in place utility outside the boundaries of the transport market. As discussed, working hours, opening hours of shops, university schedules or leisure events very much determine the time frames in which passenger transport is demanded. Developed operational public transport activities, on the other hand, have a great influence on flows of travel, for they make these flows more economical and open up economic or market opportunities (Lambooy, 1972: 38).

According to Bruton (1970: 150), the measures of competitiveness in the transport system are based on three factors.

- The first relates to the characteristics of a journey or travel as the sequence of trips starting and ending at relevant locations for a person, with elements such as travel purpose and absolute or relative length of time. This confirms the importance of understanding the relevance of different places of origin and destination in our society that justify travel (Axhausen, 2006: 4).
- The second factor relates to the characteristics of the user, the person(s) involved as customer. These factors are often described in terms of different dimensions such as age, education, car ownership or social position (Rijkswaterstaat, 2008).

Krygsman states (2004: 18) that “understanding the mechanisms of activity engagement, i.e. what activities to pursue, when, where, for how long, with whom and in what sequence, and how these activity engagement pattern change over time, will lead to a better understanding of the demand for travel and subsequently of travel behaviour”.

From a travel demand perspective, if a person has a choice of destinations, that choice will be for the destination with the highest consumer surplus, defined as the excess of the benefit of reaching that destination minus the generalized cost of getting there (Bruton, 1970: 155). Powell (2001: 78) distinguishes the following

components of the generalized cost: the time spent in transport from origin to destination; comfort of the journey; convenience of time of departure and of time of arrival; perceived comfort and perceived safety of the journey; and the combined financial cost to the traveller for all the modes used from origin to destination. There will be a trade-off between these factors and the advantage gained at the destination. Over the course of time the passenger preferences for reaching the destination and the generalized cost of the options may change – consumer surplus is not a constant or rigid factor in time. From the perspective of resilience it is relevant that public transport organizations understand the customer preferences to use the system. Disturbances of these preferences can affect the potential use of public transport.

The demand side of the passenger transport market can so also be explained through other characteristics than only those influenced from the supply side of that transport market. The demand side of the transport market is influenced through demand and supply travel characteristics, in addition to the transport market, which will be referred to as the *travel market*.

- The third factor of the transport system mentioned by Bruton reflects the characteristics of infrastructure in terms of availability, cost and service levels, and traffic facilities such as terminals and traffic management systems. Accessibility indices have been researched by many (Bruton, 1970; Van Wee and Van Dijkstra, 2002; Trip, 2007) and measured in different ways. Accessibility can be measured as the index for connecting one place to all other zones by a given mode of transport, but also as the number of routes serving a place or zone. The routes available as well as the traffic facilities are relevant to the functioning of the public transport market, but the resulting balance of the public transport market will also have a direct impact on the demand for infrastructure. The demand and supply of infrastructure and related facilities will be described as the *traffic market*.

Travel and traffic markets are markets in the sense of having supply and demand relations, and they are connected to the transport market. The relationship between travel

behaviour, land use and urban form is a well discussed topic (Krygsman 2004: 20-23; Trip, 2007). New infrastructure (supply side of the traffic market) affects the demand side of that traffic market and allows new opportunities for time and place utility in the transport and travel market.

While some transport systems have favoured the dispersion of socio-economic activities (e.g. automobiles and suburbanization), others have favoured their concentration (e.g. city centres and business parks). Clustering continues to be a powerful force in location policy (supply side of the travel market), as the reduction in transport costs favours the agglomeration of retail, manufacturing and distribution activities at specific locations (Trip, 2007).

Sudden changes can also have a great impact. On Queens Day (30 April 2002) in Amsterdam an unexpected change in weather conditions created a sudden and unexpected change in demand in volume and time, which could not be served, and this created a chaotic public transport situation and damaged the image of the operators involved.

The *transport system* will consider the public *transport market* in the context of relevant interconnected relations with both *travel and traffic markets*. The concept of the transport system makes clear the complexity and the possible interactions between disruption(s) in one market that can have influences on the processes in other markets.

Public transport organizations need to be aware of, and able to respond to, all possible changes in a coherent way. In the environmental context the third part of that process is for public transport organizations to analyze and define *system conditions* and the related events that might emerge from them (Figure 1).

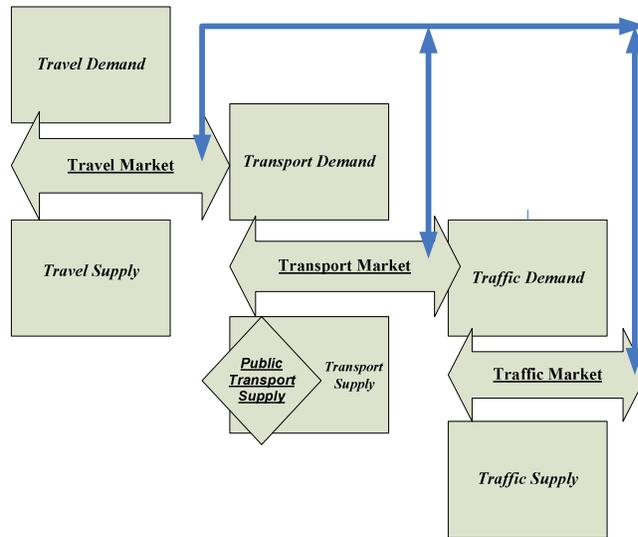


Figure 1: Public transport system
(Source: Proper, 2007c)

3.3.4 Contexts of the public transport system

The key objective of a transport policy should be to provide a transport system that enables an optimal number of passenger travels to take place with the most cost-effective mode of transport (Powell, 2001: 19). The concept of ‘least cost mode’ is used extensively in the literature. As discussed, travel will take place where the benefit the user obtains from travel exceeds the generalized cost of travel to that user. Travel may also generate cost and benefits for others, so-called external costs and benefits. The least cost mode then reflects the mode that has the lowest combined total cost to society as a whole. This includes the generalized cost to the user, the net cost (cost less receipts) to the supplier, the net cost to society including the net external cost (external costs less external benefits).

The transport system can be researched within the scope of political preferences, as well as in terms of economic, socio-economic, technological and hazardous developments; these will be addressed below as *the wider context of the transport system*.

- Political preferences and impacts are complex. Ultimately there are only two ways that transport can be provided. Either the user pays or the government pays. If the government cannot or will not pay, the user has to pay, and if the potential passenger is not able to pay, then there will be no travel (Powell, 2001: 273).

In the context of this sub-section two issues will be discussed.

- First, with respect to the provision of infrastructure, government mostly takes the prime responsibility for planning and financing of infrastructure (Dijst *et al.*, 2002; Trip, 2007). The owner of the transport infrastructure will most often have some monopoly power. The most important consideration, however, is not who owns the infrastructure, but who regulates access rights and determines the infrastructure charges.
- Second, with respect to supply of services, it is not always possible for the provision of services to be left solely to market forces. If the market for transport is not perfectly competitive and will not lead automatically to an optimum distribution of resources, the government can in that case review the working of the market. It needs to adapt transport services to the requirements of the market as a part of the community as a whole. This is particularly important if there is competition between the private and the public sector.

- Economic developments and impacts are potentially diverse and can be categorized in many ways. The art of research models is not yet well developed and lacks standardization, or is subject to rather complex mechanisms with an uncertain net outcome (Geurts and Van Wee, 2004b). A first grouping is between economic developments and impacts that directly influence the economic cost and benefits of the public transport market and the wider economic impacts, referring to economic effects that are not directly related to the transport market, such as income distribution.

- The environmental developments and impacts are also diverse. The OECD (1996) grouped them into four categories: (1) environmental pressure, including greenhouse gases and noise emissions from transport; (2) environmental quality, which focuses on air quality and noise levels that are the result of local effects of emissions; (3) ecosystems and landscape impacts, which refer to biodiversity and habitat quality and, regarding transport, to loss of land and green space; and (4) conservation of natural resources, which refers to the consumption of mineral oil, a finite resource with many other uses.

- Demographic and social developments and impacts vary; they are difficult to calculate and perceptions about their relative importance vary widely (Geurts and Van Wee, 2004b). A distinction can be made between developments on and around the transport modes.

- Technological developments are also diverse and their impacts are difficult to classify. The technological developments have to be related to their relevance for the public transport organization and its activities.

- One distinctly separate group is the impact of hazardous materials, the climate or terror attacks. This group is discrete because there will mostly not be a specific stakeholder interest to connect to.

In principle there are no limits to a wider context and this demands a delimitation of the scope to monitor. Many authors use DEPEST, or variants such as SLEPT or STEEPLE categories, to structure this wider context of the organization. In structuring the environment the fourth part of that process is for public transport organizations to analyze and define *context conditions* and identify connected events that might come out of that.

Based on the QUESTA structure and to summarize and conclude this section, the environmental focus of public transport organizations can be divided into four connected awareness areas of sources for *actual* and *potential* events (Figure 2):

- Supply conditions with evolving events;
- Market conditions with evolving events;
- System conditions with evolving events;
- Context conditions with evolving events.

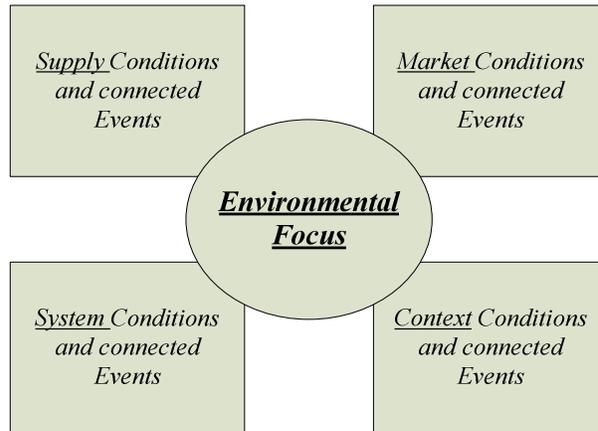


Figure 2: Environmental focus of public transport organizations

3.4 The structure of contextual resilience

Introducing a strategic resilience approach does not represent a sudden change of course (Booij *et al.*, 2006). The approach focuses rather on a *comprehensible and comprehensive* attempt to significantly enhance the resilience posture of the public transport organization currently and in the future. The property that ensures that a public transport organization has the capacity to identify its role and function in the context of possible disturbances is denoted as *contextual resilience*. Contextual awareness is the starting point of the resilience approach and structure.

Awareness of resilience builds upon the *role* of public transport, which is defined in Chapter 1 as being to stimulate urban, social, sustainable and economic developments and to transport passengers based on their needs (Ministerie van Verkeer en Waterstaat, 2000 and 2003; UITP, 2006, Van de Velde and Pruijboom, 2005a;). Public transport organizations must take this role into account, while the *function* of the organization is to take action if/when needed. A postulate will be formulated in the light of the literature

survey that by definition is accepted to provide the necessary foundation for building on existing theory.

Postulate 1: Awareness of resilience is built on an understanding of the role of public transport in society.

The other relevant components of contextual awareness will be formulated as research propositions, which will be verified at a later stage. According to Cooper and Schindler (2005), there is disagreement in the research literature about the meaning of the terms 'proposition' and 'hypothesis'. This research will use the term 'proposition' rather than 'hypothesis' for this research is of an exploratory nature. The research propositions will be discussed in the next chapters for verification of research propositions and for the generation of new information.

The first research proposition is acknowledgement of the property of resilience, especially by higher management in public transport organizations (Christopher, 2008; Pettit, 2008; Sheffi, 2007). This awareness is the driver for understanding the forces for change, for the involvement of management, for setting priorities and (proactive) response actions. Problems of ownership and accountability are connected to this. If disruptions are not taken into account on a higher level, that level probably also prevents commitment to analyses at the operational level, for there is no structured plan or procedure that guides such analysis or internal control (Booij *et al.*, 2006). The strategic approach will enable public transport organizations to make effective and appropriate resilience-based decisions and resource allocations. The analysis of Dutch and Flemish public transport organizations' direction statements has revealed only fragmented indications of awareness of the concept of resilience. As an example of a more coherent approach at this level, the US Department of Homeland Security (Transportation Security Administration) defined a protection plan for transport systems, describing the following set of directions to consider (Figure 3: Transportation Security Administration, 2007):

Mission:	<i>The Transportation Security Administration protects the Nation's transportation systems, enabling legitimate travellers and goods to move without undue fear of harm or significant disruption of commerce and civil liberties.</i>
Vision:	<i>The Transportation Security Administration will continuously set the standard for excellence in transportation security through its people, processes, and technology.</i>
Goals:	<ol style="list-style-type: none"> 1) <i>Prevent and deter acts of terrorism using or against the transportation system,</i> 2) <i>Enhance resilience of the US Transportation System,</i> 3) <i>Improve the cost-effective use of resources for transport security.</i>

Figure 3: Policy Statements of Transport Security Administration 2007
(Source: Transport Security Administration, USA)

The vision, mission and goal statements set the stage for developing specific goals and defining performance in terms of a resilience approach. Accordingly, the following research proposition (RP) is formulated:

RP-1: Contextual awareness of the concept of resilience is positively influenced by clear and consistent direction statements.

Public transport operators face a complex landscape of potential disasters, accidents and attacks. The complexity can be explained by a number of reasons. One is that the sector is composed of many different assets, links and nodes spread over a diversified spatial environment. Some assets are stationary, such as stations and infrastructure, and some are mobile, such as buses and trains, and widely distributed in time and place (Transport Security Administration, 2007).

A second reason for complexity is the interconnectedness and network implications related to the assets and systems that comprise it.

Another reason is the numerous and diverse stakeholders, including government, owners and users, who all have to deal with different incentives and constraints in their decision making. The environment of public transport organization is an open, accessible, interconnected system with cross-market and cross-sector dependencies

Understanding public transport organizations' environmental dynamics needs to be developed by looking at *possible* events that create unexpected changes. This entails discussing the conceptualization of the environment. Decision makers in public transport organizations must align their organization to the changed environment in order to achieve a strategic fit which creates opportunities but also addresses threats to the organizational resources (Ploos van Amstel, 2002; Venkatraman and Camillus, 1984). According to Arminas (2003), awareness is enhanced when managers understand the business context they operate in and the strategic goals they focus on. Because of the implications and the cascading effects resulting from triggering events, it is important for the public transport organization to structure and analyze its environment. The following research proposition is therefore formulated:

RP-2: Contextual awareness of the concept of resilience is positively influenced by a clear environmental focus.

In the contingency approach the relation between organization and environment is central, but the importance of a fitting internal structure is also considered relevant. If top management does not take responsibility, processes and procedures might be introduced only after devastating consequences have been unleashed (Zdidisin *et al.*, 2004). A *systematic organizational approach* needs to be structured and tuned for internal consistency as well as external consistency with the environment. The two research propositions presented thus far are directly related to the object of experience. From the object of science two further research propositions will be added.

Although there are different approaches to management and organization, all agree that organizations depend on a structure that enables management to make decisions (Mintzberg and Waters, 1985; Ploos van Amstel, 2002). If a public transport organization decides to adopt a new strategy, then the structure needs to be adapted as well as the enablers. This is often summarised as “structure follows strategy”. Mintzberg and Waters (1985) discusses this as a “matching claim”. To improve decision making and improve performance, a decision-making process is needed (Ploos van Amstel, 2002). In order to

have a formal resilience process and procedure in place, there should be a clear understanding of responsibilities (RACI, 2009). The concepts of responsibility and accountability are not addressed frequently in the resilience management literature (Booij *et al.*, 2006). The following research proposition is therefore formulated:

RP-3: Contextual awareness of the concept of resilience is positively influenced by clear lines of responsibilities.

Identification, assessment and response analysis depend on expert judgment, field findings and information (Norrman and Lindroth, 2004; Deleris *et al.*, 2004). In turn the assessments should provide reliable information on probability and impacts (Kleindorfer and Saad, 2005). This means that data used for analysis should be reliable, because no tool or analysis method can turn unreliable data into reliable information. Collecting data is a collective effort and will in addition demand some action on verifying, updating and protecting data.

The overall information identification process will continue to rely heavily on current processes and information sources (Transport Security Administration, 2007; NCTb, 2009). Real-time sharing of correct information within the public transport organization and between its stakeholders and partners is essential to maximize responsiveness and flexibility of response (Blackhurst *et al.* 2005). The following research proposition is therefore formulated:

RP-4: Contextual awareness of the concept of resilience is positively influenced by reliable information.

3.5 *Summary and interpretations*

Public transport organizations as open systems have an active and indissoluble interaction with the environment, and problems and opportunities are related to that perspective. In addition to the role of public transport, four environmental focus areas with respect to disruptive events have been recognized for public transport organizations to identify and to analyze: *supply conditions*; *market conditions*; *transport system conditions* and *context conditions*.

The ability of the public transport organization needs to be to:

- analyze the role of public transport;
- develop direction statements relevant to the property of resilience;
- create an environmental analysis of disruptive events;
- develop the relevant clear responsibilities and reliable information.

This is motivated and assumed to be relevant to create awareness of resilience in the public transport organization. This ability is referred to as *contextual resilience*, to be considered as the first component of the framework, which will be further discussed in the subsequent chapters as part of building organizational capabilities in the context of developing resilience.

The contextual awareness of resilience is structured (see Figure 4). A postulate and research propositions have been formulated to structure the concept of contextual resilience as part of the resilience framework. The research propositions will be discussed for reasons of verification and for the generation of information on the concept of resilience in the following chapters.

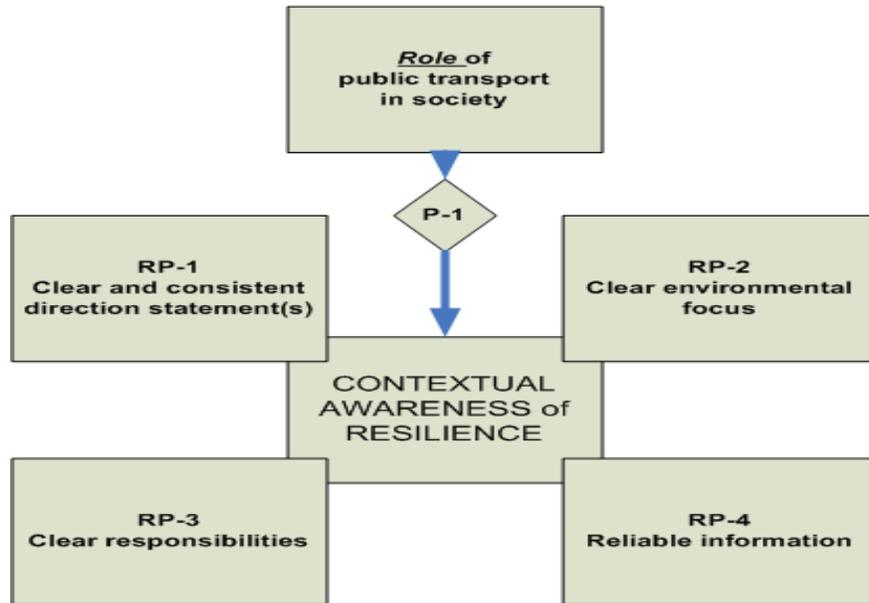


Figure 4: Contextual awareness of resilience
(P: Postulate, RP: Research Proposition)

The first research objective is formulated as: “To establish the starting points and limitations regarding the (re-)design of a resilient public transport organization”. The development of this concept of a contextual awareness of resilience has now met this first research objective.

4 Conceptual resilience framework with guiding principles

4.1 Introduction

Catastrophic events such as fire (Norman and Lindroth, 2004) and earthquakes (Papadakis, 2002), but also severe unforeseen operational variability (Deleris *et al.*, 2005), can cause major disruptions and delays that interfere with the optimal functioning of public transport organizations. This can result in lost sales, increased cost and reputation damage and even drive organizations into bankruptcy (Booij *et al.*, 2006; UITP, 2008). In this context public transport organizations have a broad responsibility for continuity of operations and their activities have economic, social and environmental impacts.

Disruptions and threats are always connected to a lack of knowledge (Fiksel, 2003 and 2006a; Pettit, 2008; National Research Council, 1998; Transportation Security Administration, 2007). A challenge for those attempting to explain this lack of knowledge is to understand the nature of disruptions, how the issues are addressed, how decisions involving disruptions are made and how these processes can be managed to the advantage of individuals, organizations, networks and society (Fiksel, 2006a).

Chapter 3 discussed the property of contextual awareness of resilience, as the first part of the resilience framework. This chapter responds further to the second research objective: To structure and design a comprehensible and comprehensive resilience framework for public transport organizations. This objective will be discussed in the next two chapters.

This chapter will outline a *conceptual resilience framework*: this is a structure, based on a deductive approach, designed to identify, to assess and to respond to disruptions in order to create a resilient organization. In the following chapter this conceptual resilience framework will be discussed with practitioners for the sake of verification and the generation of new information. The capacity to utilise the framework is one of the

constructive organizational capabilities of the public transport organization in the context of a resilience approach.

This section discusses two main concepts: risk and resilience. From a timing perspective, approaches to modelling risk started before discussions and research on resilience, and the literature on resilience most often relates to approaches to risk. Because each one has different implications, it is important to understand their principles, similarities and differences.

First the concepts of risk and disruption management will be discussed. Risk management approaches will be analyzed to understand their framework structures, to create a first set of perspectives and conditions for frameworks that mitigate disruptions in general, and to understand the limitations of these risk approaches. The next section of this chapter will elaborate on these perspectives and conditions, and will discuss resilience frameworks in view of guidelines needed to develop a resilience approach.

These two discussions will together describe the guiding principles for the resilience approach. Finally, framework elements will be synthesised to produce a conceptual resilience framework relevant for public transport organizations. The research propositions corresponding to this framework will be motivated.

4.2 Risk management approaches

‘Perspectives’ and ‘general conditions’ are terms used to discuss and to formulate relevant elements in the process of creating *guiding principles* for the resilience framework for public transport organizations. *Perspectives* are seen in this research as referring to more generic conditions without reference to a specific approach and will be discussed first. *General conditions* are derived from existing methods and approaches and refer to existing circumstances.

An analysis of risk approaches is relevant for three reasons. Firstly, both the literature and international bodies of knowledge characterize risk approaches as systematic and effective managerial approaches. The literature review will assist in analysing structuring the principles of these approaches. Following this, additional managerial conditions will be analyzed. The following influential bodies will be valuable sources of knowledge:

- International Organization for Standardization (ISO);
- Institute of Risk Management (IRM).

Secondly, currently, the leading approach to enterprise risk management comes from the Committee of Sponsoring Organizations of the Treadway Commission (COSO) (COSO, 2006; Pettit, 2008; Timmer, 2008). Analysis of the Dutch public transport organizations showed similarities to approaches similar to those of the COSO approach and/or the use of methods that are close to FMEA (Failure Mode and Effects Analysis) (Quak, 2008; Timmer, 2008). Managerial conditions formulated in terms of the COSO and FMEA structures will be discussed.

Thirdly, it is necessary to analyze risk approaches to understand their limitations and to understand the similarities and differences to resilience approaches. Risk approaches will be analyzed to understand their guiding principles. The concept of risk will be described and evaluated.

4.3 Perspectives on a resilience framework

Risk is an elusive construct that has a variety of different meanings, measurements and interpretations depending on the field of research (Jemison, 1987; Wagner and Bode, 2008). There is an extensive body of literature on risk in decision theory (Arrow, 1965; Berger, 1985), finance (Altman, 1968; Allen and Gale, 1994), marketing (Cox, 1967; Morgan and Hunt, 1994), management (Eisenhardt, 1989b; March and Shapira, 1987) and psychology (Kahneman and Tversky, 1979). Several publications have advanced conceptual clarity of terms in the domain of the awareness, sources, analysis and management of risk (Carter, 1972; Hertz and Thomas, 1983). Yet there is no commonly

agreed nomenclature and conceptual clarity on the content and context of risk threats, disruptions or vulnerabilities (Jutter *et al.*, 2003; Sheffi, 2007; Wagner and Bode, 2008). The nature of risk and its derivative concepts is difficult to define. Horlick-Jones (1996) refers to a sprawling literature on risk. Hansson (2005b) challenges the myth that risk must have a single, well-defined meaning. The literature is analyzed with a view to understanding the guiding principles needed of a resilience approach.

The first perspective to mention is that in the previous chapters the discussions were mainly based on the perspective of an *environmentally-based* approach. In addition to the environmentally based approach, two more approaches are recognized in risk management. One relates to the identification of events that could affect assets, called the *exposure analysis* (McNamee, 2006). This entails a focus on the susceptibility to loss, perception of risk, or a threat to an asset and the asset-producing processes of organizations that depend heavily on their assets for goal achievement, such as fleet operations, software activities and cashiering operations. The other approach is the *threat scenario approach*, which is mainly used when dealing with fraud or security issues. This research will adopt the environmental approach as this is regarded as the most appropriate for service organizations (McNamee, 2006; Timmer, 2008).

The second perspective is the *discipline-based* approach, which distinguishes between awareness and identification, assessment, mitigation and context-oriented disciplines (Deleris *et al.*, 2004; Glendon, 2006; Hallikas *et al.*, 2002; Wagner and Bode, 2008). These studies have shown that the awareness, identification and assessment processes are a crucial prerequisite for effective and efficient response strategies (Kleindorfer and Saad, 2005). Context-oriented disciplines are focused on values and moral issues. Following on from this, the concept of a contextual awareness of resilience was discussed as the first part of the framework and as the precondition for the identification and assessment processes within the context of a resilience approach. This research will also adopt the discipline-based approach.

The third perspective is *the model-based approach*. The term ‘model’ is used rather than ‘theory’ on the grounds that it represents alternative approaches rather than theories in the scientific sense. Four approaches are outlined below.

- In the *technical approach*, also described as the engineering approach, risk is described as the “probability * magnitude” of an event. The approaches are mainly probabilistic and deterministic, and seek to measure all components and impose managerial control of risk (Salvi and Gaston, 2004; Hansson (2005a).
- The *economic approach* takes expected utility rather than harm as the central criterion for managing risk. Economists tend to see hazards as market externalities requiring intervention (Viscusi, 1983). Krinsky and Golding (1992) refer to the economic approach as one-dimensional. It shares with the technical approach a scientific-rationalist perspective. The economic approach relates to relevant consequences being valued as well as to determining prices and probabilities objectively, although there is no market for determining values such as human lives and so arbitrary values are signed.
- The *cultural theory* approach adopts anthropological frameworks for understanding how groups in society interpret danger. The cultural approach assumes an active perceiver – not an individual, but an institution or organization – driven to select a risk to manage (Douglas, 1992; Thomson *et al.*, 1990). A risk management implication of cultural theory is that, because group attitudes differ, risk information operates differently.
- The fourth approach is called the *psychometric approach*. A consistent finding is that the perceptions of experts differ on several risk dimensions (Loewenstein *et al.*, 2001; Slovic, 2000). This approach has contributed towards understanding how policy makers weigh the risk and benefits of a range of decisions and towards acknowledging the amount of intuition in such policy making, in addition to the role of cognitive biases (Siegrist *et al.*, 2005).

Within the perspective of the *model-based approach* all four above approaches will be considered as relevant and as contributing to a structured approach to resilience.

The last perspective relates to the origin of *events*. Althaus (2005) distinguishes two approaches described as the outside-in and the inside-out approaches. The outside-in approach considers events as being externally imposed. The inside-out approach takes into account all organizational (internal) activities and its focus is on continually facing and managing uncertainty deriving from adaptations, interventions, conflicting interest and power relations, which are inherent in many organizational decision-making processes. Both perspectives are seen valuable in this research.

The *perspectives* discussed are all considered relevant and will be included in the discussions and the development of an overall set of guiding principles to design the conceptual resilience framework.

4.4 Conditions from institutional bodies of knowledge

ISO: The International Organization of Standardization is a worldwide federation of national bodies dealing with standards (ISO member bodies). ISO Guide 73 was prepared by the ISO technical management board Working Group on risk management terminology (ISO: Guide 73). The guide is generic and is compiled to encompass the general field of risk management and not deal only with a specific sector. The guide deals with risk management from both positive and negative perspectives, and it aims to provide a coherent approach to the description of risk management activities and the use of risk management terminology to develop a common understanding among organizations across countries. This differs from ISO Guide 51, where risk is understood as producing only negative consequences. ISO Guide 51 defines risk as a combination of the probability of occurrence of harm and the severity of that harm (ISO: guide 51).

Institute of Risk Management: The Risk Management Standard is the result of work by a team drawn from major risk management organizations in the UK –The Institute of Risk Management (IRM), The Association of Insurance and Risk Managers (AIRMIC) and ALARM, the National Forum for Risk Management in the Public Sector. The Standard has wherever possible used the terminology for risk and risk management set out by ISO. The Standard considers risk from both positive and negative perspectives. The Federation of European Risk Management Associations (Ferma, 2003), in parallel with IRM, suggests a classification as terms of reference, by which the significance of risk is *assessed* as follows: strategic, operational, financial and knowledge management and compliance directions.

The Standard researched the views and opinions of a wide range of professional bodies during an extensive period of consultation (IRM, 2002). Some of these statements will be discussed:

- Risk management is a rapidly developing discipline and there are many and varied views on, and descriptions of, what risk management involves: this statement motivates the need for a coherent approach and set of definitions;
- Risk management should methodically address all events surrounding the organization – past, present and in particular future: this statement emphasizes the relevance of this research;
- Risk management should be a continuous and developing process, which runs throughout the organization’s strategy and the implementation of that strategy.

From these two researched bodies of knowledge, the following *conditions* are regarded as relevant to the discussion on the guidelines principles of the resilience approach:

- Disruption management is part of broader management approaches:
 - Goals and strategy statements and priorities can differ over time. The focus can change to a more external or internal perspective, and/or to more organizational or network perspectives;
- External and internal disruptive events create forces of change:

- Exposure to forces of change can have positive and negative implications for public transport organizations;
- Events can be ranked. From this the term *event* will be defined as an occurrence of a particular set of circumstances (ISO: guide 73).
- The internal control perspective reflects the importance of compliance and reporting. The importance of knowledge management is relevant to (i) the building of organizational capabilities to develop and manage both response and mitigation strategies, and to (ii) the capacity to identify and analyze risk. The first one will be referred to as *capability to assure continuity* or survival and the second as *control capability*.

4.5 General conditions from existing approaches

Public transport organizations do not use one common approach to manage disruptions, but the approaches applied show similarities with both the COSO and the FMEA approaches (Timmer, 2008). Basically FMEA can be described as a tool that is used to prevent problems from occurring (Quality Associates International, 2008a and 2008b). The FMEA method is applied in many quality systems such as QS 9000, ISO/TS 16949 and DIN 25448. The FMEA template is a powerful DMAIC Lean Six Sigma tool used to anticipate quality problems, and to take actions to minimize risks. In summary, FMEA is used:

- to initially design any system, product or process;
- to subsequently change the system, product or process;
- to define “*foreseeable*” risks;
- to prioritize attention to key process input variables that could have the most probable impact on the desired and undesired outcomes; and
- to assess the effectiveness of attempts to control variability.

COSO states that an organization’s objectives can be jeopardized intentionally and unintentionally, and that no system of internal control can guarantee that all control weakness will be detected and prevented (COSO, 2004 and 2007). COSO developed a

monitoring model to improve the efficiency and effectiveness of the entire system of internal control. Monitoring is designed to “ensure that internal control continues to operate effectively” (COSO, 2004: 5). Effective internal control is regarded as a continuous process built into the activities of an organization and its policies, procedures and technology (COSO, 2004). The COSO 2004 model has been up-dated with a focus on the whole internal control system and is currently described as COSO II or Enterprise Risk Management Framework (ERMF). Although COSO has a clear internal focus, it enables management to deal with changes in both external and internal environments. It structures the relations between organizational risks components focused on the objectives in the following categories (COSO, 2007):

- achievement of strategic goals (Strategic);
- efficiency and effectiveness of processes (Operations);
- reliability of financial information (Reporting);
- acting in terms of relevant regulations and laws (Compliance).

FMEA and COSO developed specific conditions to be taken into consideration when developing a systematic management approach to assess and mitigate risk.

- *Proactive approach*: The organization is expected to identify and correct weaknesses before they affect achievement of the organization’s objectives.
- *Objective- and competence-based approach*: Organizations begin the process by defining objectives and placing competent people in roles throughout the organization.
- *Structured approach*: This is an appropriate focus-based approach that is efficient and effective in a given area and period of time on areas of change. Both COSO and FMEA describe the possibility of ranking events.
- *A persuasion-based information approach*: Gathering and analyzing information that is suitable and sufficient.
 - Suitability is a measure of quality of information and refers to relevance, reliability and timeliness (ongoing monitoring).
 - Sufficiency is a measure of quantity of information and refers to sampling or testing.

- *A communication-based structural approach*: Depending on the level of importance, results are reported to the appropriate people.
- *A continuous process*: Both FMEA and COSO describe the relevance of a continuous process approach.

The size and complexity of the organization have an impact on the scope of these conditions, the degree to which operations are subject to disruptions or threats, internal and external purposes, and the relative importance of the underlying controls in meeting the organization's objectives to satisfy the requirements of internal as well as external stakeholders.

The above general conditions are considered relevant in the analysis to define the guiding principles applicable to a resilience framework.

4.6 Interpretations of risk

There is a persistent tension between, on the one hand, risk purely as danger and, on the other hand, risk as both danger and opportunity (Mitchell, 1995). According to decision theory, the fluctuations around the expected value (mean) of a performance measure are used as proxy for risk (Wagner and Bode, 2008). That is, risk is equated with variance and consequently has both a potential “downside” and an “upside”. Following these considerations in the field of supply chain management, Jüttner *et al.* (2003: 200) define risk as a “variation in the distribution of possible outcomes, their likelihood, and their subjective value.” It is critical to note that disruptions can also bring unexpected opportunities for success. The Los Angeles Metrolink Transit System increased its ridership by 20-fold immediately following the January 1994 Northridge earthquake. The 2010 Iceland volcano disruption also created opportunities for European rail transport operators. Such disruptions “can offer an opportunity to impress customers and win their loyalty” (Knemeyer *et al.*, 2003), and successful recovery and adaptation to new market forces can lead to competitive advantage (Rice and Caniato, 2003).

Although many have tried to make the concept of risk as objective as possible, on a fundamental level it is essentially a value-laden concept. More precisely for the purposes of this research, it is negatively value-laden (Hansson, 2005a). Risks are unwanted phenomena (Sheffi, 2005; Wagner and Bode, 2008). Several researchers in the field of transport and supply chain management share this view. March and Shapira (1987) examined how managers perceive and respond to risk. They found that the majority tend to exaggerate its “downside”. Harland *et al.* (2003: 52) discussed several definitions and concluded that supply chain risk is associated with the “chance of danger, damage, loss, injury or any other undesired consequences.” In this research, and in the light of the impact of recent disruptions, the notion of risk and disruption as purely negative corresponds best to business reality and will be considered in that way further in this research.

There are more distinctions to be made (Blackhurst *et al.*, 2005; Christopher 2005; Jüttner *et al.*, 2003; Norman and Lindroth, 2004; Sheffi, 2007; Wagner and Bode, 2008). The words ‘risk’ and ‘disruption’ are used in many senses, which are often not sufficiently distinguished from one another. Four of the most common meanings are:

- Risk or disruption as an *unwanted event* that may or may not occur;
- In addition, it can be necessary to determine the magnitude of the risk. The numerical value most often used for this purpose is the probability of the event in question: *risk as the probability of an unwanted event* that may or may not occur;
- A concept has been developed in risk and disruption analysis that aims at quantifying the total amount associated with an organization or system: *risk or disruption as the statistical expectation value of unwanted events* that may or may not occur. Expectation value means probability-weighted value;
- Risk or disruption can be used to denote the event that caused the unwanted event, rather than the unwanted event itself: as *the cause of an unwanted event* that may or may not occur.

4.7 *Risk as a concept*

The overall risk management process generally involves, in addition to awareness, at least three main phases: identification, assessment and mitigation (Deleris *et al.*, 2004; Hallikas *et al.*, 2004; Harland *et al.*, 2003). Response strategies or mitigation is the phase in which proactive measures are taken to prevent future disruptions and to influence vulnerability (Zsidisin *et al.*, 2004; Hallikas *et al.*, 2004; Wagner and Bode, 2008).

Most definitions of risk focus on identification and assessment. This section will discuss two such definitions and will further explain the terminology to be used in this research.

First, risk has been identified as (1) the probability of an event, and (2) its consequence or impact (Booij *et al.*, 2006; Hallikas *et al.*, 2004; ISO Guide 73). ISO and COSO both mention probability, but in different settings. ISO relates it to the occurrence of (external) events and COSO to internal control and prevention.

Knowledge about risk has a mildly paradoxical quality, since, as discussed, it is knowledge about the unknown (Hallikas *et al.*, 2002; Hansson, 2005b). From a decision maker's point of view, it is useful to have risks quantified so that they can easily be compared and prioritized.

With regards to *probability*, when abundant information is available, such as in the example of operational variability, a frequency probability can easily be fairly assessed using rigorous statistical methods (Vollman *et al.*, 2005).

A different logical interpretation of probability is that the probability of an event can be assessed by giving another event as evidence. Of concern, however, is the extent to which quantification can be achieved without distorting the true nature of the risks involved.

Finally, the subjective interpretation of probability is identified. Watson (1994) suggests that by using the subjective interpretation of probability, risk assessment can be seen as a tool for the sake of argument rather than an objective representation of the truth. It may

be hard to assess probabilities even within the organization, because professionals from different disciplines could perceive very different risks (Zsidisin *et al.*, 2004; Harland *et al.*, 2003).

There are some areas of concern related to *probability*.

- First are the *unknown probabilities*, when there is a lack of statistics to provide sufficient data as in the case of, for example, new and untested technologies and systems, or about new environments to operate in.
- Second are *unforeseen dangers* or dangers influenced by anxiety about possible dangers, although there may be only a vague idea about what these dangers might be. Connected to this are *unknown reactions*; in a sense, any decision may have catastrophic unintended consequences (Hansson, 1996).
- Finally, it is important to note that probability, and hence risk, is described in the first and second sense of the previous section as referring to a specified event. An area of concern is *not having a total overview of all the possible negative events* associated with the organization at large as described in the third sense.

Significance is related to the potential impact of the risk, if the disruption occurs. The impact can be assessed against control objectives and organizational goals. Concerning the *impact or consequence* of risk, two kinds of consequences should be recognized (Booij *et al.*, 2006). The first kind is often most visible and includes the loss of tangible quantifiable consequences such as costs (Hallikas *et al.*, 2004). Consequences are fairly easy to assess when they involve operational variability (Vollman *et al.*, 2005). The other consequences are intangible in nature and include the loss of other assets such as credibility, reputation, status, authority and trust (Harland *et al.*, 2003). The consequences that have an impact on long-term strategy are more difficult to convert into monetary value (Hallikas *et al.*, 2004). Moreover, these consequences also depend on the circumstances under which the organization operates (Harland *et al.*, 2003). The stage in the service or product life cycle, for example, influences where the consequences will have an impact and who will suffer from potential losses. This leads to another area of concern: *unintended consequences*.

There is a second approach to the construct of risk. Risk is defined as “the negative deviation from the expected value of a certain performance objective, resulting in undesirable consequences for the focal firm” (Juttner *et al.*, 2003; Peck, 2005; Sheffi, 2007; Svensson, 2002 and 2004; Wagner and Bode, 2008). The focal firm in this research is the public transport organization.

In many risk management approaches the term ‘disruption’ is often used. A *disruption* is defined as the combination of (1) an unintended, exceptional triggering event – in this research this means that the harmful event materializes somewhere in the external or internal public transport environment, and (2) a consequential situation which significantly threatens the normal course of business operations of the affected organization (Kleindorfer and Saad, 2005, Wagner and Bode, 2006: 304).

For the affected public transport organization, the disruption is an exceptional situation in comparison to its everyday business and the unintended, untoward situation leads to a risk (Wagner and Bode, 2008). The disruption can be associated with a certain probability of occurrence and be characterized by its consequence as a direct or an indirect effect (Cohen and Kunreuther, 2007; Wagner and Bode, 2008). Disruptions can materialize from areas within (internal) and from outside (external) the organization and their nature can be highly diverse. Since public transport disruptions also involve time pressures, this implies that decisions for mitigation must be made swiftly (Wagner and Bode, 2006: 304). An area of concern is *unforeseen disruptions*.

While a harmful event in public transport leads to the occurrence of risk, it is not the sole determinant of the final result. The susceptibility (or predisposition) of the public transport organization to the harm of this situation is of significant relevance. *Susceptibility* is the sensitivity of existing organizational or functional practices or conditions to disruptions. The loss or harm to the organization is a consequence of its susceptibility to a given disruption. The objective here is to provide both an estimation of the disruption and the organization’s susceptibility to the disruption to help understand its

severity and probability factors (Hallikas *et al.*, 2002). An area of concern is *unknown susceptibilities*.

In this research the second definition will be followed. This makes it possible to discuss situations in which the disruption can be looked at independently from susceptibility, which can change in time and place and can be influenced by better internal control. Within this context a disruption can lead to a different risk when the susceptibility changes by introducing capabilities to mitigate that disruption. This stresses the importance of building in assurance of control as well as underlining the importance of knowledge management. This approach also emphasizes the relevance of having direction statements with explicit goals and performance objectives, which structure the analysis process. Finally, this approach reflects a more proactive orientation with regard to providing persuasive information and timely communication.

This research will therefore define *risk* as *the negative deviation from the expected value of a certain performance objective, resulting in undesirable consequences for the focal firm*.

In this definition risk, in the public transport organization, is influenced by triggering events and the consequences of these events, which are together referred to as disruptions, and the susceptibility to the disruption. Understanding triggering events and their consequences in the public transport organization will first reduce its disruption identification time. This understanding is also meant to reduce susceptibility to the disruption by formulating and executing a response strategy that effects not only reduction-identification time, but also problem- resolution time (Figure 5).

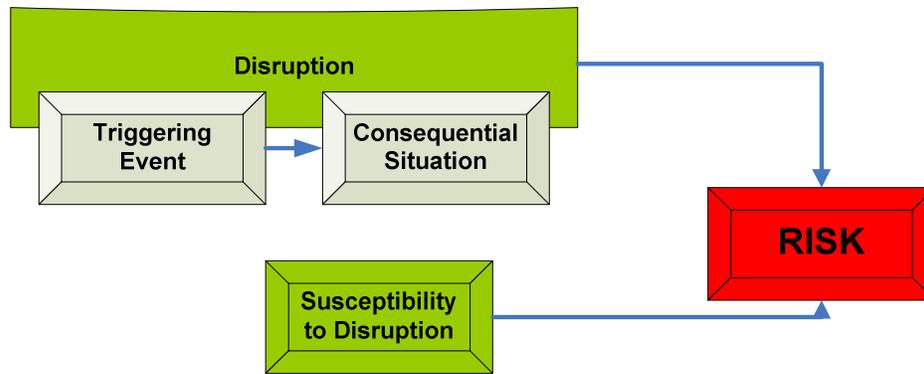


Figure 5: The concept of risk
(Based on: Wagner and Bode, 2008)

Risk assessment entails the combination of a disruption and susceptibility assessment. *Assessment* of a disruption will be used in the context of evaluating the likelihoods and consequences, either by the use of frequency data or on the basis of expert judgments, scenarios and subjective probabilities (Cohen and Kunreuther, 2007). From this it is possible to develop a corresponding prioritization list (McNamee, 2006). Two elements are relevant in this respect (Figure 6).

- In using a discrete high/low classification on both probability/likelihood of an event and on impact/consequences, a matrix can be constructed with four cells. In the light of the definition of resilience, the focus is on *turbulent change*. The concept of resilience is less focused on events with low consequences/impacts, because they are not associated with the *needed capacities of an organization to survive, adapt and grow in the face of turbulent change*.
- On the other hand, the dynamics of events in time and place in terms of unforeseen dangers, unknown probabilities and susceptibilities and unintended consequences can change the position in the classification of events with corresponding prioritization of capacities needed.

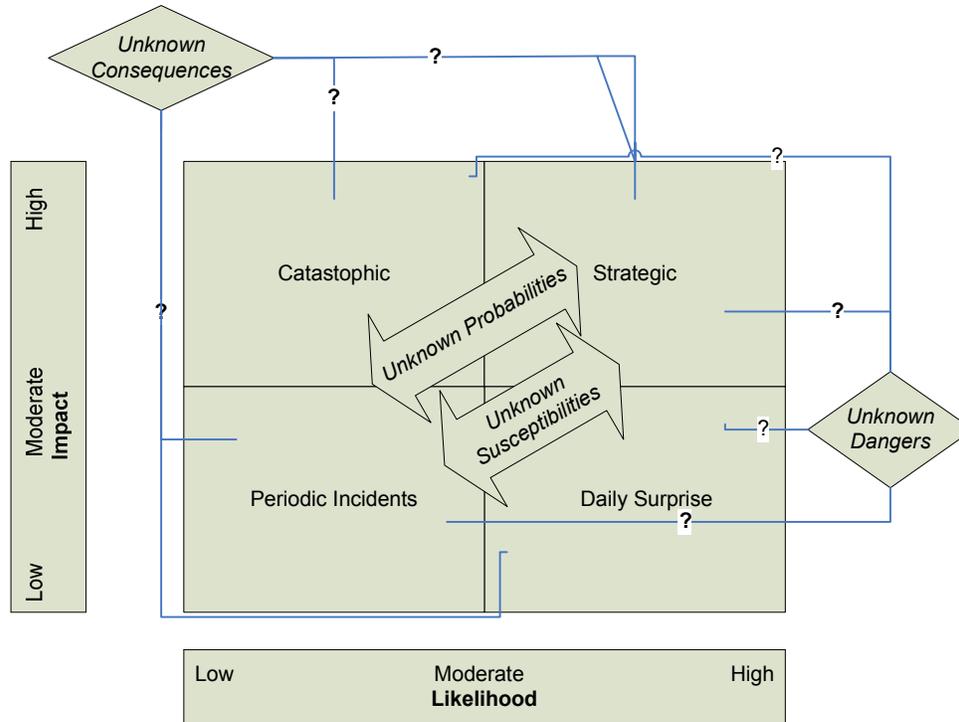


Figure 6: Areas of concern in relation to risk identification and assessment

4.8 Resilience strategies and frameworks

Faced with a dynamic and unpredictable business environment, management theorists are increasingly identifying the need for resilience as “the intrinsic ability of an organization to maintain and retain a dynamically stable state” (Hollnagel, 2006: 16). Resilience must become a part of the strategic vision of leadership (Council on Competitiveness, 2007). The concept of resilience is broader in scope than only continuity planning and risk management; it entails an amalgamation of these disciplines (Peck, 2005). Many key elements, the relationships among them and methodologies to manage the key issues of resilience are poorly understood (Blackhurst *et al.*, 2005; Hertz and Thomas, 1983; Starr *et al.*, 2003).

Studies by the Council for Competitiveness found that generally, although effectively managing operational disruptions directly affects financial performance, a majority of corporate board members were under-informed about disruptions (Council on

Competitiveness, 2008). Even after widespread disruptive events, most organizations, including public transport organizations in general, still do not think systematically about managing threats, disruptions and vulnerabilities (MIT, 2008; Peck, 2003; Quak, 2008; Sheffi, 2005). As they become aware of these gaps, many researchers are beginning to understand the value of the concept of resilience (Fiksel, 2006b; Pettit *et al.*, 2010).

In addition to the literature sources, the following bodies of knowledge are used as valuable and more specific sources for developing guiding principles and to structure the resilience framework:

- Cranfield Resilience Centre at Cranfield University;
- Massachusetts Institute of Technology (MIT);
- Centre of Resilience of Ohio State University;
- IBM Global Services;
- The Council of Competiveness.

* Following transportation disruptions from fuel protests in 2000 and from the outbreak of foot-and-mouth disease in early 2001, one of the first extensive studies on transport and supply chain resilience started in 2003 at the Cranfield Resilience Centre of Cranfield University, (Cranfield, 2003). From these studies the notion of the term ‘vulnerability’ as “a fundamental factor that makes an organization sensitive to disruptions” developed (Wagner and Bode, 2008; Sheffi and Rice, 2005). The study explored the UK’s knowledge base on vulnerabilities and found that:

- 1) Vulnerability is an important business issue;
- 2) Little research has been conducted on transport and chain vulnerability;
- 3) Awareness of the subject is poor; and
- 4) A methodology is needed for managing vulnerability.

The study relates to the fields of transport and supply chain management and resulted in a model presented by Christopher and Peck (2004b) that distinguishes five categories of turbulence – demand, supply, process, control and environmental turbulence – and the

main focus is on minimizing their effects. An approach to addressing the issue of resilience is based on a framework that includes the following capabilities:

- Agility to reduce response time;
- Collaboration and collaborative planning with knowledge sharing;
- (Re-)design and engineering to create flexibility and to reduce redundancy;
- Creation of a management culture including knowledge management and reporting.

This model underlines the relevance of categorizing, judgment and creating capabilities to counteract to vulnerabilities. Capabilities are described as features required to achieve the goals of the organization. The focus on internal as well as external processes and collaborative planning is also an important element in this approach.

The analysis of disruptions and identifying vulnerabilities gets less attention in the study. The model is more focused on prevention of events and less on restricting consequences. In their model the phenomenon of ‘low probability and high consequence’ might not get enough attention, which is one of the core competences of resilience. The element of contextual awareness is not addressed.

On the basis of empirical research Christopher and Peck (2004b) developed an initial framework for a resilient supply chain. They asserted that resilience can be created through key conditions:

- Resilience can be built into a system in advance of a disruption (i.e. re-engineering);
- A high level of collaboration is required to identify and manage disruption;
- It is essential to react quickly to unforeseen events. Characteristics or capabilities are agility, availability, efficiency, flexibility, redundancy, velocity and visibility;
- A culture of resilience management is essential.

These key conditions will be taken into consideration in the development of guiding principles and structure of the resilience framework.

* Researchers at the Massachusetts Institute of Technology (MIT) analyzed disruptions in many case studies. Attention is on identifying vulnerability characteristics and management responses such as flexibility, redundancy, security and collaboration (Sheffi, 2007). The MIT framework has a clear focus on concrete disruptions and about the capabilities to manage these (Sheffi and Rice, 2005).

The resilience framework is based on four elements:

- Mapping of vulnerabilities;
- Analysis of failure modes;
- Creation of flexibility;
- Redundancy.

The framework is based on a systematic management approach. The framework is also not clear on the contextual awareness, but its strength is the concept of the reduction of many possible disruptions as a result of some main failure vulnerability modes that can be responded to with different strategies.

* The Centre of Resilience of Ohio State University adopts a more holistic approach and describes resilience in the context of achieving a sustainable shareholder value and contributing to sustainable development. The concept of organizational resilience is coupled to social, environmental and economic systems (triple bottom line). The key to the sustainability of these systems is resilience, described as the ability to resist disorder. An organization can focus on being “sustainable” by enhancing its own resilience relative to the systems in which it operates. Relevant in this approach is the notion of both contextual awareness and of improved performances. The approach is based on the achievement of organizational goals. The Centre is in the process of developing an approach of designing the most relevant capabilities to counteract vulnerabilities (Pettit, 2008; Pettit *et al.*, 2010).

* To help organizations understand and manage the process of becoming resilient, Li (2008) and Lammers *et al.* (2009) describe the framework developed by IBM. IBM has developed an object-oriented framework and transformation lifecycle called: “Beyond disaster recovery: becoming a resilient business” (Cocchiara, 2005). A business

resilience framework is designed to help identify the object layers that make up an organization; ranging from the strategic overlay all the way down to “the nuts-and-bolts” technologies and facilities.

IBM analysis six key areas that a business resilience framework should address:

- Continuity of business operations: become more anticipatory, adaptive and robust;
- Regulatory compliance: comply with new and changing government rules and regulations more quickly and cost effectively;
- Integrated management to reduce costs: remain competitive by managing disruptions more efficiently and cost effectively;
- Security, privacy and data protection: protect against internal and external threats, and help develop a critical information management policy;
- Access to expertise and skills: develop easy acquisition and management of expert assistance in maintaining continuous business operations;
- Market readiness: anticipate and respond to changing market conditions and accelerating research and development to get the right products to the right buyers at the right time.

In the past businesses typically addressed these concerns separately. However, many companies now recognize that it is more cost effective to combine them into a holistic approach. The framework presented by Cocchiara (2005) has a clear focus on internal resources to create a resilient structure. The framework makes it clear that it is necessary to develop a strategy, to structure clear responsibilities, to manage processes, to use and develop IT technology as well as applications and infrastructure. The goal is to achieve resilience in all these areas in a coherent way. Capabilities needed are: control, detection, adaptability and protection. The focus of this model is on devising a strategic approach, on internal resources and on cohesion of actions. The model does not describe the necessary capabilities to counteract vulnerabilities.

* The Council of Competiveness describes the relevance of a resilient approach more on a policy level, without referring to a specific framework. It highlights the strategic relevance and motivates business leaders and policymakers to take action and collaborate.

In addition to the above approaches, other research describes related properties in counteracting vulnerabilities:

- Agility and responsiveness: Christopher (2000) describes agility as one of the most powerful ways of achieving resilience;
- Flexibility enables an organization to respond quickly and efficiently to dynamic market changes (Swamidass and Newell, 1987; Christopher (2005) states that those resilient processes are flexible and agile and are able to change quickly;
- Visibility: Increasing the visibility of demand information reduces impacts (Chopra and Sodhi, 2004);
- Structure and knowledge: Knowledge and understanding of chain structures – both physical and informational – are important elements of resilience (Hong and Choi, 2002);
- Collaboration: Collaborative partnerships help to manage disruptions effectively (Sinha *et al.* 2004; Lee, 2004);
- Christopher (2000 and 2006) discusses reduction of complexity through business process re-engineering initiatives.

Although existing frameworks are informative, at first sight they present fragmented perspectives on guiding principles and on a structure of a resilience framework. The relevance of a systematic approach to the classification of disruptions and structuring of vulnerabilities is covered. Also the relevance of creating and categorizing capabilities to counteract to vulnerabilities is well analyzed. Moreover, it is clear that a coherent strategic organizational approach is justified. Several formative elements, such as flexibility, agility, visibility, are also discussed separately, and the internal and external focus is explained.

Examining existing frameworks and research in more detail, however, demonstrates that the differences are marginal rather than substantive and result primarily from the differing perspectives taken. These differences, in fact, can contribute to the richness and depth of this research. They are also indicative of an emerging discipline in that “research is grappling with definitional issues” (Ponomarov and Holcomb, 2009).

The concept of resilience needs to combine previous tenets with studies on vulnerability and capability. There is a broad set of definitions and interpretations. Svensson (2002) defines vulnerability as “*unexpected deviations from the norm and their negative consequences.*” Mathematically, vulnerability can so be measured in terms of “risk” in the sense of a combination of the likelihood of an event and its potential severity (Sheffi 2007; Craighead *et al.* 2007: 166). Wagner and Bode (2008) define vulnerability in the context specifically of vulnerability to disruptions as “*A firm’s susceptibility to the negative consequences of a disruption*”. Both these definitions have foundations in traditional risk management techniques and are expanded by other authors (Svensson, 2002 and 2004; Zsidisin, 2004; Peck, 2003). Researchers at the Massachusetts Institute of Technology (MIT) analyzed disruptions in many case studies, with a focus on identifying *vulnerability characteristics and management responses* (Sheffi, 2007).

Consistent with previous research (Svensson, 2002; Cranfield, 2002; Peck, 2005; Sheffi and Rice, 2005; Pettit *et al.*, 2010) the following definition of *vulnerability* is: “*fundamental factors that make an organization susceptible to disruptions*”. The notion of ‘fundamental’ here relates to the analysis of a broad spectrum of disruptions, and to discussing and analysing these to a high-level description as first-order approaches. In this research sub-factors will describe the second-order level with, for example, weather events, labour disruptions, technology failures, loss of key personnel. These fundamental and sub-factors will be analyzed in the following chapters.

Capabilities have been defined in relation to internal control and to capabilities to respond (or survive). Capabilities are necessary:

- to prevent an actual disruption;
- to mitigate the effects of a disruption;
- to enable adaptation following a disruption.

The literature also suggests many different types of capabilities (Peck, 2003; Hamal and Valikanges, 2003; Fiksel, 2003; Peck, 2005; Sheffi and Rice, 2005). Consistent with this, in this research the following definition will be used: *capabilities* are “*attributes required for performance or accomplishment*” Capability factors are first-order approaches. The capability first-order factors and second-order- or sub-factors will also be analyzed in the following chapters.

Examination of the literature sources shows that resilience is a multidimensional concept. Management can increase value through better resilience-based decision making as a top imperative. The next section will discuss the guiding principles adopted in the structure of a conceptual resilience framework.

4.9 Guiding principles of the resilience concept

Based on the discussions in the previous sections on risk and resilience approaches, this section will present the guiding principles for the structured resilience framework and its organizational embedding. Perspectives and conditions discussed in the context of risk management approaches are in parallel with the logic of the resilience approaches discussed thus far. On this basis the *guiding principles* of the resilience framework are presented below.

* Resilience is defined in terms of the productive tension between stability and change. The basic stability and integrity of a public transport organization is an important dimension, as is the capacity to absorb major disturbances from the operating environment and to recover from failure. Resilience needs to become a characteristic of

the public transport organization in order for it to survive in the short time, but resilience also provides the ability to adapt to change over the long term (McDonald, 2006). The concept of contextual awareness is stressed, based on environmental challenges and internal challenges to reach goals and priorities. From a managerial point of view, *resilience will provide competitive advantage especially in turbulent times and it needs to be performance based*. To measure performance and classify consequences in terms of goals and objectives, a wide spectrum of strategic, operational, financial, compliance and knowledge management activities must be taken into consideration.

* To become resilient, the public transport organization that evolves must address four challenges: the cognitive challenge, the strategic challenge, the political challenge, and the cultural or ideological challenge (Hamel and Viliakangas, 2003). Resilience will address these challenges at the level of the organization as entity. Network relations are discussed in the context of environmental focus and collaboration between organizations.

The notion of resilience is based on a holistic approach; resilience is part of the broader management processes:

- at operational level, with processes and relevant technology to produce the required result or output;
- at managerial level, which incorporates, organizes, coordinates and supports the operations that produce the output to fulfil the organization's mission;
- at system level, which designs, critical knowledge and collaborative approaches.

* Resilience is not simply about being able to change (on the one hand) or just maintaining stability (on the other hand). In coherence with the previous principles, resilience is about the appropriateness of stability or change to the requirements of the environment. More accurately, resilience is about the planning, enabling or accommodating of change to meet the requirements of the future environment, as anticipated and construed, within which the system operates. *Strategic imperatives call for a more adaptive and structured approach to change* in the design, in processes, in

visibility of demand and supply, in relation management in the public transport system and in infusing a culture of resilience (Pettit, 2008).

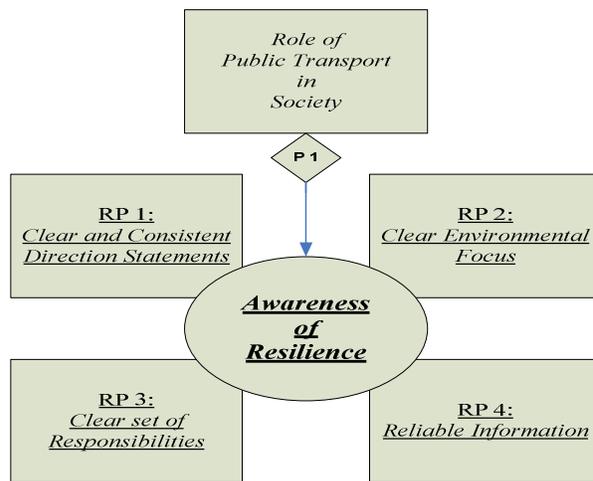
* From a systems approach, as risk is more related to system operations, *a resilience approach is based on the concept of system development*. The most basic aspect of resilience is not on the level of the event and its consequential effects, but more on the dynamic level of the public transport organizational capabilities as constraints to vulnerabilities. Instead of examining events, events are regarded as forces of change that violate the constraints. The varying viewpoints on resilience, as presented in the previous sections, often intersect with the domain of the role of traditional risk management in identifying and reducing threats (COSO, 2004 and 2007; Tang, 2006; Manuj and Mentzer, 2008). Between these two, effective channels of communication are needed: both a downward reference channel, providing the information necessary to impose constraints on the operational level, and a measuring feedback channel to provide information on how effectively the constraints were enforced (Leveson, 2006: 99-102). Designing a resilient system requires ensuring that controls do not degrade despite the inevitable changes that occur over time, or that such a degradation is detected and corrected before a loss occurs. It is evident from this that resilience approaches are continuous cyclic activities and are also competence based with feedback (Hamel and Valikangas, 2003).

* The President of the Council on Competitiveness states that “managing this rapidly changing risk landscape is an emerging competitive challenge” and meeting that challenge demands resilience (Council of Competitiveness, 2007). Strategies to deal with change need to be purposely aligned with the organization earning drivers (Ahlquist *et al.*, 2003). Traditional risk management techniques are lacking in their ability to assess the complexities of networks and chains in order to evaluate the complex interdependencies of threats and prepare an organization for the unknowns of the future. *The ability to balance coordination or integration with system partners must be developed in a coherent and structured resilient approach*. Christopher and Peck (2004a) believe that this is a new priority for business planning.

4.10 Structure of a conceptual strategic resilience framework

The section will discuss a conceptual strategic resilience framework for public transport organizations that will identify the particular starting points discussed.

In Chapter 3 the first part (referred to from now on as *Part 1*) of the resilience framework was identified as the part stemming from acknowledgement and awareness, especially by higher management in public transport organizations. Controllable factors that positively influence that process have been discussed. This section will discuss the other associated parts. Also in this section research propositions (RP) will be formulated, to be verified later. Figure 7 is the overview of part 1 together with the postulate and research propositions formulated in Chapter 3.



Postulate 1 (P 1):	Awareness builds on role and function of public transport.
RP- 1	Awareness is positively influenced by a clear and consistent
(Research Proposition)	direction statement on resilience.
RP- 2	Awareness is positively influenced by a clear environmental
	focus.
RP- 3	Awareness is positively influenced by clear responsibilities
RP- 4	Awareness is positively influenced by reliable information

Figure 7: Resilience framework, Part 1: creating awareness of resilience

4.10.1 Vulnerability identification

Part 2 of the resilience framework will discuss the link between contextual awareness, disruption analysis and vulnerability. Smallman (1996: 12) notes that “the operating environment for many companies has become unpredictable. Many managers accept such instability and disruption management is becoming an increasingly common term in business life”. From the considerable amount of literature it can be concluded that, both among academics and practitioners, awareness of the concept of resilience, as described in part 1 of the framework, has increased a focus on, and confirmed the need to, analyse disruptions (Pettit, 2008; Sheffi and Rice, 2005; Zsidisin *et al.*, 2004). This is also the case for measures to control, which will be addressed later. These reviews lead to the following research proposition, which will be numbered consecutively to follow from the previous research propositions (RP):

RP-5: A higher level of awareness on resilience has a positive effect on the level of identification and assessment of disruptions as forces for change.

At the 2009 International Security Conference on Public Transit Systems and Security the General Secretary of UITP stated: “Achieving the right balance is managing this changing landscape in public transport as an emerging competitiveness challenge”. Public transport disturbances can be highly diverse and different in time, but they all result in some more fundamental forces of change. Comparing events, where considerable historical and scientific data exist (e.g. accidents, natural disasters), to those where there is greater uncertainty and ambiguity (e.g. terrorism, climate change), there is a much greater degree of “discomfort” in undertaking traditional risk assessments and a greater need to assess and structure *fundamental* factors that make an organization susceptible to disruptions.

Resilience has been defined as the capacity of a, in this case the public transport organization, to survive, adapt and grow in the face of turbulent change. Based on the literature search, two constructs are assumed to be relevant: vulnerability and capability.

To begin, a resilience framework builds upon the basic concept of vulnerability, defined as: “*fundamental factors that make an organization susceptible to disruptions*”.

The framework for resilience must take into account those fundamental factors which encompass the broadest possible range of disruptive threats (Fiksel, 2006b; Pettit, 2008). Disruption identification and assessment will be referred to as *disruption analysis*. The disruption analysis is the source of defining the *forces of change* as well as for defining vulnerabilities as fundamental factors. This leads to the following research proposition:

RP-6: Forces for change create vulnerabilities.

Based on the previous two research propositions, the following partial structure of the framework will emerge, referred to as *Part 2*.

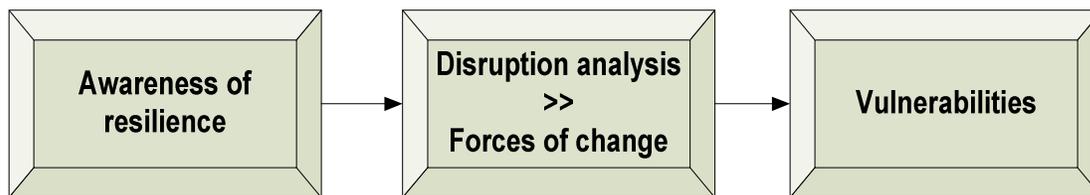


Figure 8: Resilience framework, Part 2: identification of vulnerabilities

4.10.2 Capability identification

Part 3 of the framework will deal with the link between awareness, management control activities and capabilities. Referring to the previously mentioned literature, the link between awareness and management control can be supported. The awareness will influence the organization to take action as a reactive and as a proactive activity. These reviews lead to the following research proposition:

RP-7: A higher level of awareness has a positive effect on the level of internal control.

Capabilities are described as attributes that enable an organization to anticipate and overcome vulnerabilities. These capabilities could prevent actual and future disruptions (e.g. security measures deterring a terrorist attack), mitigate the effects of a disruption, or enable adaptation following a disruption (e.g. development of new products or services, or entering a new market) (Pettit, 2008). Concepts such as flexibility, agility, adaptability and visibility are just a few commonly discussed managerial capabilities (Lee, 2004). The literature suggests many different types of capabilities (Cranfield, 2002 and 2003; Fiksel, 2003; Hamal and Valikangas, 2003; Rice and Caniato, 2003; Peck, 2005; Sheffi, 2007).

In order to counteract vulnerabilities, research has shown that organizations can develop capabilities that assure short-term and long-term survival. Internal control factors create capability attributes as fundamental attributes or characteristics. Capabilities have been defined as “*attributes required for performance or accomplishment*”. This will lead to the following research proposition:

RP-8: Internal control creates capabilities.

The third part of the framework connects awareness to vulnerabilities through internal control. Based on the previous two research propositions, the following partial structure of the framework will result, referred to as *part 3*.

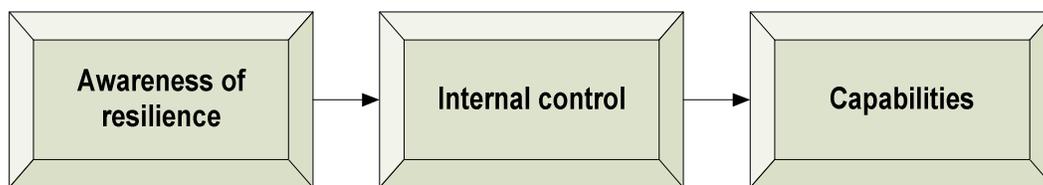


Figure 9: Resilience framework, Part 3: identification of capabilities

4.10.3 Effects of vulnerabilities and capabilities on performance

The resilience framework is based on the link between the two proposed constructs: vulnerability and capability. The scope of the framework should encompass all processes, relationships and resources that offer capabilities to overcome vulnerabilities. The essence of resilience lies in this. This leads to the next research proposition:

RP-9: Resilience increases as capabilities increase and/or vulnerabilities decrease.

Developing capabilities that are best linked to overcoming the vulnerabilities create “a state of balance” between investments and forces for change (Pettit, 2008: 20). For example, a high vulnerability on a symbolic profile of the public transport organization as a service quality brand can directly threaten the organization and a high priority should be placed on resources to ensure high-service quality.

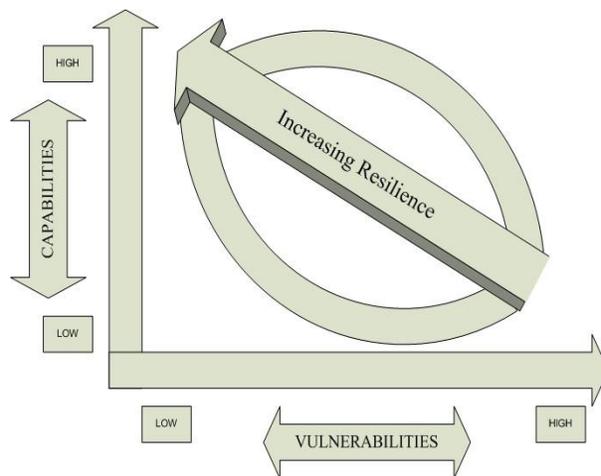


Figure 10: Effects of vulnerabilities and capabilities on resilience

In summary, based on the contextual awareness level, the public transport organization will identify and assess disruptions. Analyzing these disruptions will provide forces for change that create an overview of vulnerabilities. An increase in vulnerabilities has a negative influence on the existing balance of resilience.

The awareness also constitutes input into the level of internal control. Analyzing this will provide an overview of capabilities. An increase in capabilities has a positive influence on the existing balance of resilience.

4.10.4 Connecting resilience and performance

Balanced resilience will result from a fit between the vulnerability factors and the capability factors. The *fourth part* of the framework is about the relation between resilience and the performance of the organization. The public transport resilience framework must deliver potential for providing public transport management with insight into its strengths, weaknesses and priorities. The framework needs to provide guidance to develop a strategy for improving the level of resilience, to focus on resource investments to fill gaps, and to weigh such investments against the potential returns. Periodic assessment of resilience is necessary in a turbulent environment and the organization that does so realigns its resources faster than its rivals (Hamel and Valikangas, 2003; Brechbuhl, 2007).

Resilience takes into consideration the portfolio of capabilities matched to the pattern of vulnerabilities. Excessive vulnerabilities relative to capabilities will result in an overly exposed condition to threats, and conversely excessive capabilities relative to vulnerabilities will influence financial results and erode profitability.

A balanced result will improve the organizational performances. A variety of organizations discussing the agile and resilient enterprise at the Tuck School of Business at Dartmouth in 2007 confirmed this relation (Brechbuhl, 2007). A balanced resilience will take into consideration all direction statements and all organizational levels. From this the following research proposition is formulated:

RP 10: Performance improves when capabilities and vulnerabilities are balanced.

With the research propositions formulated in the *second, third and fourth* parts of the development of a conceptual resilience structure, the following framework can be presented (Figure 11):

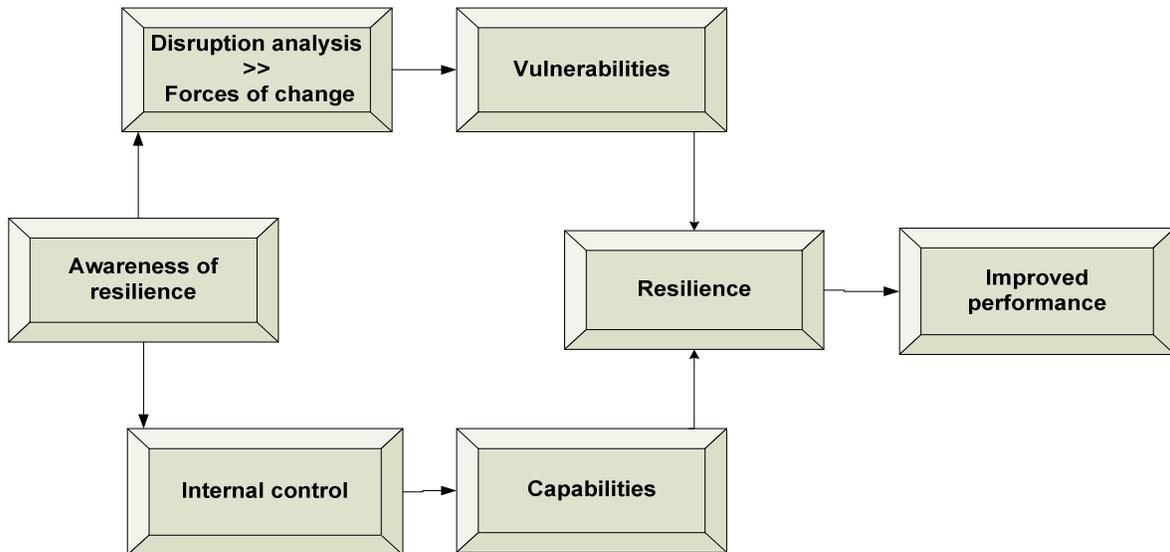


Figure 11: Resilience framework, Part 4: connecting to performance

4.11 Structure of the conceptual resilience framework

Measurement of vulnerabilities and capabilities can provide an evaluation of the current level of resilience, and it is therefore a tool to direct improvements as well as to knowledge development. The literature notes that awareness itself is positively influenced by the negative consequences of disruptions, delays and failing control. This awareness reflects on external and internal disruptions. Experiencing the consequences of disruptions can have a significant impact on organizational awareness. Research on social amplification confirms that an adverse event results in a large increase in the perception of disruptions within a company (Smallman, 1996).

The literature and the risk and resilience approaches indicate that the recognition of feedback loops is relevant. In this research the assumption is that the improved performance will have a higher impact on awareness as feedback mechanism than the disruption analysis itself. The following research proposition is formulated:

RP-11: Improved performance will have a positive feedback effect on creating awareness of resilience.

In summary, the conceptual resilience framework for public transport organizations is designed as follows (see Figure 12):

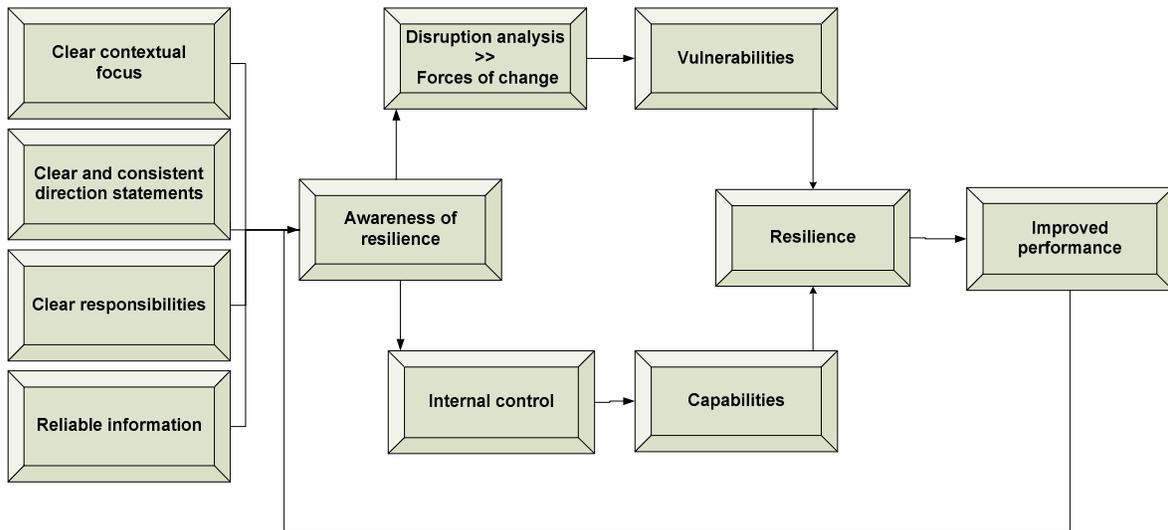


Figure 12: Conceptual resilience framework

4.12 Summary and interpretations

The second research objective deals with how to structure and design a comprehensible and comprehensive resilience framework for public transport organizations. Based on the above discussions, the guiding principles of resilience structure are formulated as:

- Resilience provides competitive advantage and is performance based;
- Resilience approach is based on a holistic view and part of the broader management processes;
- Strategic imperatives call for an adaptive and structure-based resilience approach to change;
- Resilience is based on the concepts of system development;
- Resilience approach must have the ability of to balance coordination and integration with network partners.

Resilience has been defined and its relation to risk discussed. The concept of resilience builds on the concepts of risk. The risk approaches are limited to unforeseeable events, unknown probabilities, unintended consequences and unknown susceptibilities.

The concept of resilience can overcome these gaps. Public transport organizations are facing turbulent change in a dynamic setting and there are no formal resilience frameworks to manage this. The concept of resilience will have to balance vulnerabilities and capabilities, which will result in improved performance of the public transport organization. In this chapter the resilience framework is structured and motivated, and research propositions have been formulated. This has produced a conceptual framework: a structure, based on a deductive approach, to identify, to assess and to respond to disruptions in order to create a resilient organization.

The framework supports public transport organization expertise to structure both the identification of vulnerabilities based on the analysis of disruptions as well as the identification of capabilities, based on an analysis of internal control. The organization needs to develop capacities to use the framework and to understand its current level of resilience within the perspective of achieving improved performance.

5 *Cognitive resilience*

5.1 *Introduction*

This chapter addresses the second research objective: to structure and design a comprehensive and comprehensible resilience framework for public transport organizations. Research propositions have been formulated in the previous chapters and a conceptual resilience framework has been motivated based on deductive reasoning. The purpose of this chapter is to assess the results of the developed conceptual framework to ascertain its fit with the empirical situation. Strauss uses the term “fit” to describe the meaning and relevance of concepts in the real world (Strauss, 1987). Inductive and deductive logics are mirrors of one another, with deductive logic building from concepts to create new constructs and inductive logic building up concepts from experience, producing added information or new concepts from data. They are a natural complement to mainstream deductive research (Eisenhardt and Greaber, 2007).

While verifying is seen as a vital task in the research process, a purposeful systematic generation of information/data is the main goal in the development of the resilience framework.

Findings from both public transport organizations and from organizations specifically active in the fields of risk and resilience will be discussed and adaptations of the framework will be motivated. From this a verified structure will be developed. This will be referred to as *cognitive resilience*. This is the conceptual orientation that enables an organization to identify, assess and respond to disruptive events. Also findings on the progress in developing resilience approach in public transport organizations will be discussed. The discussions include the concept of contextual awareness as well as the demarcation of terms such as vulnerabilities and capabilities.

5.2 Approach and process of empirical research

Participants were asked the same questions in the same way, with a distinction being made between participants working within and working outside public transport organizations. The interviews were expected to take one and a half hours.

The approach followed for conducting empirical research is discussed in Chapter 2. The interview consisted of the following sections:

- Section 1: Explanations of terms of reference with explanation of the theoretical framework and related set of definitions. Questions for clarification of definitions and structure of framework and basic company information;
- Section 2: Questions to verify the research propositions defined in the development of the theoretical framework;
- Section 3: Questions to clarify the completeness of the framework and the level of advancement in implementing the organizational resilience approach.

All information received from the various participants will remain anonymous and the outcome of the empirical research was aggregated to ensure that no confidential information would be revealed. All participants will receive the results of the empirical research. The final structure and questionnaire used is attached as Appendix 1.

5.3 Cohort design: selecting stakeholders and participants

The selections of *participants* as the individuals to be interviewed are based on the principle of positive sampling. The sampling will be appropriate if the participants are suitable for extending the relationships and logic within the construct of the resilience framework. These two *generic arguments* for selection of participants have been motivated in Chapter 2 and the assumption involved is that this approach will create a common base. The purpose is not primarily to compare stakeholders or participants, but to compare the arguments related to the conceptual resilience framework. In this research public transport organizations and organizations specifically active in the fields of risk and resilience are not regarded as a homogeneous sample base. When the research population is not regarded as a homogeneous group, then six to twelve case studies are

recommended. In this part of the research six public transport organizations and four other stakeholders have been selected, using positive sampling.

5.3.1 Stakeholder selection

The stakeholders are chosen from the system of the Dutch public transport organizations and organizations specifically active in the fields of risk and resilience. The assumption is made that they are representative. The result of the process of analyzing stakeholders is listed in Table 4. Stakeholders marked with (*) will be discussed later.

<i>Stakeholder(s)</i>	<i>Stakeholder(s) Interest(s)</i>	<i>Assessment of responsibilities, activities and impacts</i>
Public Transport Organization	Public transport contextual awareness, role and function. Public transport demand and supply. (net-activities)	<ul style="list-style-type: none"> - Accountable for strategy; - Responsible for network activities; - Responsible for identification, assessment and response processes; - Responsible for disruption and mitigation (vulnerabilities / capabilities) balances.
Transport Authority (tender related)	Role of public transport, Public transport demand and supply. (gross activities)	<ul style="list-style-type: none"> - Defining supply conditions; - Responsible for monitoring within national regulations; - Financial conditions within regulations.
National Government: - Ministry of Transport (*) -----	Role of public transport, Public transport supply and system. (gross activities, travel and traffic conditions) -----	<ul style="list-style-type: none"> - Defining public transport system and financial conditions; - Monitoring national transport policy
National Government: - NCTb (National Coordinator for Counter-Terrorism)	Role of public transport and public transport market and system. (terror alerting)	<ul style="list-style-type: none"> - Responsible for alerting triggering events; - Manager contract on risk with public transport organizations.
Customers (*) (representatives)	Public transport market. (demand)	<ul style="list-style-type: none"> - User claims, habits and reactions on disturbances; - Modal split (time and place) characteristics.
Security Organizations	Public transport environment.	<ul style="list-style-type: none"> - Responsible for mitigation operations; - Knowledge of multi-sector comparative response management.
Risk Consulting Organization	Public transport system and environment.	<ul style="list-style-type: none"> - Management and control processes; - Compliance and alignment to internal and external procedures.
Mobility Experts	Public transport system.	<ul style="list-style-type: none"> - Research on innovation in transport sector; - Knowledge of resilience developments.

Table 4: Overview of stakeholders for verification of framework

The Dutch system of tendering requires by law that transport authorities take into consideration the interests of (potential) customers. This is formalized in prescribed deliberations with the different consumer organizations.

In addition, it is to be expected that the transport authorities take into consideration the balance of the interests of the customers and the community as a whole. After awarding the tender, the public transport organization is required to hold discussions with the transport authority as well as with the representative customer organizations. For these reasons customers are not interviewed as a specific group.

The national government will not be interviewed. The Dutch government has given the regions and their respective transport authorities' extensive powers and the obligation to organize tender procedures based on compliance with guidelines in general and not specifically on resilience.

The NCTb (National Coordinator for Counter-Terrorism) is the Dutch national body dealing with issues of terrorism and security in the public transport sector and is selected as stakeholder.

5.3.2 Participant selection

The participants involved in this interview schedule are listed below in Table 5, which includes participant responsibilities and function. It has been explained that there are two groups with a different profile, those within and those outside of public transport organizations. Public transport organizations have been defined as the object of experience. There is no clear up- or downstream relations between all the different stakeholders.

This has led to two decisions:

- First, public transport stakeholders and others will be interviewed alternately rather than in clusters. The process of an ongoing inclusion of data is better served in this way;
- Secondly, the results of all the interviews with participants from public transport organizations will be analyzed concurrently with the analysis of the other interviews to research differences in perception on the approach to resilience.

<i>Stakeholder</i>	<i>Organization</i>	<i>Participant name</i>	<i>Relevant Position</i>
Public Transport Organization	Veolia	Roel van de Pas	- Manager Business Development; - Operational and contracts expert.
Security Organization	The Security Company	Gerard van Duykeren	- CEO. - Expert on security and response planning.
Public Transport Organization	Connexion	Tim de Bruin	- Risk Manager. - Strategy expert on risk and resilience.
Government (national organization on terrorism)	NTCb: National Coordinator for Counter-terrorism	Itsart de Vries	- Manager transport terror alert and - coordination.
Public Transport Organization	Veolia	Gosse Veenstra	- CFO and manager marketing. - Strategy and finance expert.
Public Transport Organization	RET	Krishna Baboelal	- Advisor social security.
Risk Consulting Organization	AON Global Risk Consulting	Bas van Eijk	- Consultant public transport sector. - Expert in compliance management.
		Iwan Drost	- Managing consultant risk management.
Public Transport Organization	Arriva	Jaap Schuurmans	- Risk & Insurance Manager.
		Jan Politiek	- Security advisor.
Mobility Expert	TNO - Knowledge Center	Bart Lammers	- Senior advisor. - Author on risk and resilience.
Transport Authority	Stadsgewest (City-District) Haaglanden	Ton Hilhorst	- Manager public transport. - Expert in public transport tendering / management.

Table 5: Overview of participants for verification of framework

5.4 Interview findings

The comments raised by all participants will be treated as of equal importance. This will be followed by a motivated list of changes to be compared with the conclusions in previous chapters. This section will provide an overview of findings of the interviews in following sections:

- First, the general research findings and findings more related to the guiding principles will be discussed. The questionnaire has also been used to control and update the findings of previous chapters. Final conclusions on the findings on the guiding principles will be discussed in the next chapter;
- Secondly, the findings on concepts and definitions are discussed;
- Thirdly, the verification of research propositions will be discussed. All participants agreed that the presented resilience framework can be valued as a clear and systematic approach, and the definitions were considered to be clear and consistent. Discussions need to be placed in this context;
- Finally, the conceptual framework and the level of progress of public transport organizations in developing a systematic resilience approach will be discussed.

Modifications will be presented with motivated changes to the previous findings and statements.

5.4.1 General research findings

This section will present the general findings and findings related to the guiding principles.

Stakeholders and participants. All stakeholders operate in the Netherlands. Eight major public transport organizations operated in the Netherlands at the time of the interview. This includes four organizations serving only the four largest cities and four serving the rest of the country, including all other larger and smaller cities. From the six interviews, two were held with representatives of larger cities and four representing other areas,

responsible for about 80% of all land public transport kilometres outside the four largest cities, excluding inter-regional and intercity rail transport.

At Arriva two persons participated with the same responsibility which is considered as a single interview. Veolia was interviewed twice, with participants who have different responsibilities; this is considered as two interviews. Because of their close relationships, the transport authority Haaglanden is considered to have the same knowledge as the public transport organization HTM in The Hague regarding transport policy and knowledge of the research subject. Six participants with public transport responsibilities and knowledge have therefore been interviewed. The other four participants have more specific knowledge on the subject of disruption management. The average time of all interviews was about two hours. Participants were well prepared for the interview and had taken time to read the interview and the terms of reference in advance.

The transport authority and all interviewed public transport organizations had experiences of tender processes or are aware of future developments and the relevance of understanding the context of the research, their environment and market forces. All mentioned having had experience with identification, analysis and mitigation of disruptions.

All participants were asked to comment on the stakeholder list to ascertain whether some other organizations needed to be included, based on the presented goal of the questionnaire and the generic arguments discussed. None of the participants suggested altering the proposed stakeholder list.

Public transport operators are all able to identify the major other stakeholders in general. Three major categories are recognized (listed not in order of relevance in Table 6. The main considerations for a strategic approach in general were discussed with these stakeholders.

<i>Other stakeholders most relevant to public transport organizations:</i>	<i>Main consideration for strategic approaches:</i>
Transport authorities	Continuity: Market access and execution (and monitoring) of services.
Customers	Customer Service: Image and confidence in executing operations
Government	Operation: Compliance with permissions to operate and availability of infrastructure services

Table 6: Main considerations for strategic approaches

Strategic and performance-based resilience approach. All participants agreed on the strategic relevance of resilience as a concept and the relevance of a systematic approach. At the same time the corporate focus sets a higher priority on cost control, operational excellence and customer orientation. The focus on cost and operational issues is strongest on the short-term level. The focus on customer satisfaction and growth of passengers is strongest on the medium-term level, and continuity and growth of market share strongest on the long-term level. Security is often explicitly mentioned in the direction statements. Statements on resilience are not specifically mentioned, but elements are evident in a diversity of activities related to the direction statements.

All participants agreed on the need to relate resilience to performance and added that this will provide competitive advantage.

Responsibility and information. The necessary organizational embedding of resilience is part of the overall view of the public transport organizations on the distribution of responsibilities. The interview findings show different approaches to this issue. Most public transport organizations follow a model of segmentation of responsibilities along the lines of the different geographical areas they serve after obtaining the tender. These public transport organizations, serving different transport areas, have two different management approaches with a more or a less decentralized execution of responsibilities, including monitoring and reporting on disruptions. Although strategic policy statements are formulated on corporate level, the responsibilities for the operational execution and monitoring processes are different. The organizations that have a more formalized and

decentralized approach have fewer formal structures to learn from experiences, do not share information in a structured way and lack a feedback system on disturbances from the different transport areas that can provide information to the level of corporate organizational coordination. Discussions showed that organizations with a more centralized approach display greater focus on the topic of risk and resilience, and are able to structure their findings and experiences at the corporate organizational level in order to respond and adapt. This experience is mentioned in all interviews with the public transport organizations and supports the relevance of the second guiding principle.

Different modes of transport. Rail-connected public transport has to address different aspects of concern, compliance and attention compared to an organization that deals only with road-connected transport. For example, the concern with the flexibility of alternative routes is different for rail than for roads. In the Netherlands the responsibilities for infrastructure are diffuse. For national and inter-regional rail transport the trend is to spread responsibilities to the use of rail by the operators and to owning infrastructure and/or capacity management by other organizations. In the cities there are different structures. In some cities the public transport organization consists of the activities operator, capacity manager and owner of the infrastructure, with other cities have a more diversified structure. The effect of introducing and managing resilience with respect to the differentiation of transport modes in public transport organizations is not researched. All participants share the opinion that different modes of transport will have different specific processes and technologies with associated possible disruptions and required mitigation activities. All participants believe that a holistic approach will make it possible to structure vulnerabilities and capabilities within the proposed resilience framework.

Structured framework. Chapter 4 discussed the guiding principles of a resilience approach. Participants confirmed the relevance of these principles and agreed on the following aspects:

- Resilience management can complement and enhance risk management approaches;
- Resilience is part of a broader strategic management approach but needs to be considered on cost-benefit relations of the resilience approach;

- Resilience and risk are both seen in terms negative effects;
- Events can occur inside and outside of the organization;
- Resilience requires specific conditions in order to develop as a structured approach; for example, it must be:
 - o Objective based;
 - o Information and communication based;
 - o Knowledge and competence based;
 - o Culturally and ideologically based.

This supports the guiding principles. The public transport sector does not have a single defined approach at sector level for the identification and assessment of disruptive events. This is not seen as a constraint to introducing a resilience approach in specific organizations. The competition between different public transport organizations will not support a common sector approach.

There is agreement among the participants about the structure and sequence of awareness, identification, assessment and response. Identification starts mainly with environmental awareness. The approach of asset exposure is recognized in the sector. The two approaches are seen more as aligned than as distinctive.

In previous chapters the postulate was formulated that *awareness of resilience is built on an understanding of the role of public transport in society*. Although formulated as a postulate, this was discussed in the interviews and there is overall agreement on this.

5.4.2 Findings on concepts and definitions

In the first section of the questionnaire five concepts were presented: resilience, vulnerability, disruption, capability and risk. From the discussions three topics will be highlighted for additional clarification. The discussion topics need to be clarified in the light of the earlier statement that the definitions were regarded as clear and consistent. So the purpose is primarily to clarify and not to modify them. The clarification developed in the discussions with the participants adds a degree of sophistication to the particular

dimension. No further discussions will be presented on the descriptions of vulnerability, capability, disruption and risk.

Resilience has been defined as the capacity of an organization to survive, adapt and grow in the face of turbulent change.

The relevant discussion points are:

- the content of turbulence;
- the distinction between ability and capacity;
- the relevance of “growth” as a specific element in the definition.

In compliance with the definition, the concept of resilience is relevant in the “face of *turbulent* change”. Siggelkow and Rivkin (2005: 103) explain, on the basis of an extensive literature search, that change has a number of different associated features such as dynamics, velocity or uncertainty, and they describe turbulence mainly from an environmental point of view as occurring “if the mapping from a firm actions to performance outcomes *changes frequently, profoundly, and in ways that are difficult to predict*”. All participants agreed that turbulence is a metaphor for understanding disorder in organizations and all participants also recognized a difference between turbulent changes and ordinary changes. The discussions revolved around how to make this distinction clearer and how to understand the level or degree of change that makes it “turbulent”. One way to study this is to take the organizational process dynamics as a starting point. Turbulence can be seen as an indication of disorder other than randomness (Polley, 1997; Tsoukas, 1998). This alludes to the theory of chaos as a completely confused or disordered condition. Such metaphorical use may help to stipulate the difference between ordinary and turbulent change and can be useful to explain the different dimensions. The successful use of the metaphor, however, depends on an ability to identify similarities and differences as part of the description of disorder.

In this research Ansoff’s identification of changes will be adopted. Ansoff introduced the concept of turbulence to describe five environments in which organizations operate (Pun, 2009). They have been classified into five turbulence levels (Table 7).

<i>Turbulence Level</i>	<i>Environment description</i>	<i>Change description</i>
<i>LEVEL 1:</i>	<i>Repetitive environment</i>	<i>No changes</i>
<i>LEVEL 2:</i>	<i>Expanding environment</i>	<i>Slow incremental changes</i>
<i>LEVEL 3:</i>	<i>Changing environment</i>	<i>Fast incremental</i>
<i>LEVEL 4:</i>	<i>Discontinuous environment</i>	<i>Relatively predictable</i>
<i>LEVEL 5:</i>	<i>Surprise-full environment</i>	<i>Unpredictable</i>

Table 7: Change descriptions by Anshoff

Ansoff's strategic success formula states that for optimum return on investment, both the aggressiveness of the firm's strategy and its capabilities must match the turbulence of the environment. At one extreme is the stable, placid environment where nothing changes; at the other is the environment characterized by, for example, major technological breakthroughs or social and political upheavals. In the first levels of environmental turbulence the future can be extrapolated from the past and there are few surprises. The company's strengths and successful strategies in the past are likely to remain relevant in the future.

In the environments of higher turbulence levels, profits do not follow growth and extrapolation of the past into the future; dangerous surprises are frequent, historical strengths can become weaknesses and what were successful strategies in the past may not be successful in the future.

The concept of balanced resilience explains the links between turbulent changes and required capabilities. Anshoff (2007) indicates that capabilities that are appropriate for a high level of turbulence will be costly and wasteful for firms operating in a low level of turbulence. But capabilities that are adequate in a low-turbulence environment "will leave a firm badly positioned in a highly turbulent environment" (Pun, 2009: 4).

In turbulent environments organizations will be confronted with frequent shifts in strategic success factors. One of the major challenges for management is to be continuously on the alert for such shifts and to adapt to them. In such environments the output of strategic planning is a clear sense of direction rather than a detailed fixed plan (Anshoff, 2007). The company operating in a turbulent environment should have a

compass rather than a detailed road map, “for a road map with detailed instructions is of little use when the topography is unknown and fast changing” (Pun, 2009: 6). A compass will point in the right direction and the management team can, with ingenuity and teamwork, deal with unforeseen obstacles and unanticipated opportunities that open the way to the destination. In this research turbulence will be further discussed in the context of the three higher turbulence levels of Anshoff’s classification. This is in accordance with the observations in Chapter 4 on the definition of disruption and with the discussed dynamics of context of risk as a concept.

The next discussion point relates to the different definitions of resilience as presented in Chapter 3, uses of “*ability*” as well as “*capacity*”. Merriam-Webster’s *Dictionary of Synonyms* and other dictionaries make no formal distinction between the latter two terms. From discussions with the participants it emerged that the concept of ‘ability’ was understood more in relation to the current situation and the concept of ‘capacity’ more to potential. Hollnagel (2006) argues that capacity is a broader concept than ability. The definitions as formulated will thus not be altered as resilience is meant to represent the *capacity* of an organizational system with regard to its readiness to respond to disruption(s).

The last topic related to the concept of *growth* as incorporated into the expression “adapt and *grow* in the face of turbulent change” from the definition on resilience.

First, the analysis of public transport mission/vision statements showed that all organizations explicitly mentioned expansion to more geographical areas through tendering (claims), growth of passengers and/or growth in efficiency. The concept of growth is an integral part of normal business practice.

Second, a resilient organization must be able to change from one state to another in the course of time, but must also be able to return to normal functioning when the unusual conditions are over or as the danger signals pass. This does not necessarily imply that the organization should go back to the same status or procedures as before the disruptions. It

means that it should be able to resume durable and sustainable performance, which includes the earlier intention to grow. If this process is not working optimally, it means that from a resilience point of view the organization was not sufficiently resilient (Hollnagel, 2006:144).

The discussions on the concept of growth referred to two distinctive positions. Disruptions cause turbulence in many different ways. A sudden breakdown of energy supply of the public transport organization, for example, may have severe but only short-term effects. A negative effect on its image may have longer-term effects. In both cases resilience is the capacity to survive, adapt and grow in these turbulent environments. The differences between *business continuity* and *business sustainability*, both related to the concept of growth, were discussed. Both constructs have been researched intensively. *Business continuity* in this research is seen in the context of plans that will keep the public transport organization “up and running” through interruptions of any kind, such as power failures, IT system crashes, severe weather and chain problems, but this continuity was thought of more as proceeding, over a predetermined time, after an extended disruption. *Business sustainability*, on the other hand, entails a proactive approach to ensure the long-term viability and integrity of the business and managing resources while not compromising profitability.

It is not relevant to provide an in-depth analysis of these two constructs; their relevance is more closely related to the effects of resilience on growth in terms of different time horizons, which is acknowledged by the participants. From this perspective “*growth*” *needs to be discussed in the context of both business continuity and business sustainability.*

In summary it can be stated that the definitions presented have been verified and no changes are required on the basis of the discussions with participants.

5.4.3 Discussion on framework relations

The presented framework exists of different parts that are inter-related to each other. The discussion on the relations and direction of the relations is discussed from the right side to the left side of the framework. In this approach the discussion started with the notion of balanced resilience. The relation between balanced resilience and improved performance will be discussed next.

Participants all agreed on the following research propositions:

- Increase in vulnerabilities has a negative interrelation with resilience;
- Increase of capabilities has a positive interrelation with resilience.
- From the above accepted assumptions, the next assumption was discussed and accepted: Resilience increases as capabilities increase *and/or* vulnerabilities decrease.

In the discussions the possibility of a time gap between changes in the two entities in relation to each other was considered. This time gap can have two directions. Public transport organizations can anticipate vulnerabilities in general and take action to increase capabilities in *anticipation* of this change. On the other hand, new or more intensive capabilities can arise as a *reaction* to increasing vulnerabilities.

- Forces for change result in public transport vulnerabilities.
- Internal control creates public transport capabilities.

Participants agreed that these last two research propositions are correct from a theoretical point of view. The public transport participants confirmed that a fundamental approach to discuss these relations is not available.

- A higher level of awareness of resilience has a positive effect on the level of identification and assessment of disruptions as forces for change.
- A higher level of awareness to resilience has a positive effect on in the level of identification and assessment of internal control.

The relevance of creating awareness was recognized by all participants. The level of awareness in the framework is based on four elements and all participants agreed on the following points.

- Awareness is positively influenced by a clear environmental focus. This element was discussed intensively and participants emphasised this strongly.
- Awareness is positively influenced by clear and consistent policy statements on resilience. As discussed, this is recognized by all public transport participants, within the context of the priority of a customer and efficiency focus. Some organizations made reference to security, which is seen as a capability factor rather than a statement on resilience.
- Awareness is positively influenced by the level of sophistication of information. In previous chapters this was formulated as “reliable information”. Participants referred to this frequently. The discussions made it clear that the issue is not the reliability of data itself, but also the way it is processed to make it relevant and reliable information. The public transport organization needs an accurate information structure to support identification of events and disruptions as well as to support management and internal control. In this new statement *‘reliable information’ has been replaced with ‘accurate information structure’*.
- Awareness is positively influenced by clear lines of distribution of responsibilities. All participants agreed on, and at the same time mentioned the complexity of, this aspect. In most public transport organizations the responsibilities for, for example, mitigation of risks in out-sourcing, the safety responsibilities of the employers, safety responsibilities for the passengers, assets-connected risk and environmental risk analysis are not viewed within a holistic approach.

From these statements the discussion about the inter-relation between the four elements evolved. Participants agreed on the existence of complex inter-relations between the four elements that create awareness. It is evident that the environmental awareness and

direction statements relate to organization and responsibilities as well as to information (structure). Following this discussion, the four elements that create awareness were viewed as being interrelated in that a change in one element may have effects on the other elements.

Finally, participants all agreed on the following point: improved resilience will have a positive effect on performance. The discussion on feedback or closed-loop principles evolved from this.

Disruption is defined as the combination of unintended, exceptional triggering event(s) and a consequential situation which significantly threatens the normal course of the business operation of the affected public transport organization. These triggering events have been described as external and/or internal. The first discussion was on the need for a direct link between “internal control” and “analysis of disruptions”. An internal event can also be regarded as a change of internal control. In this research the following line of reasoning is adopted. Vulnerabilities can have external and internal causes. To prevent a situation whereby an internal cause is seen as affecting both vulnerability and capability, no link will be added to the framework between “internal control” and “disruption analysis”. A sudden unexpected change of management control will be regarded as a disruption, and both event and cause need to be analysed.

The closed loop of the resilience framework was also discussed. For participants it is clear that improved performance affects awareness based on change of one or more of the four elements that create awareness, and no priority is given to any one of them. From this the following alteration in the framework is presented: *A feedback loop will be created between improved performance and the four interrelated elements that create awareness in the context of a positive relation.*

In summary, it can be stated that the framework has been verified regarding its structure and its interrelations. As far as the framework is concerned, in summary the following conversions are formulated:

- Awareness is positively influence by reliable information. This has been re-formulated to: *Awareness is positively influenced through accurate information structures;*
- The four elements that create awareness will not be seen as independent but as *interrelated;*
- *The feedback loop will operate between improved performance and the interrelated four elements that create awareness.*

5.4.4 Findings on progress in developing a resilience approach

This section will discuss the progress in developing resilient approaches in public transport organizations.

Overview of vulnerabilities and capabilities: In the interviews public transport organizations provided input on vulnerability and capability sub-factors. This term ‘sub-factors’ is used to make a distinction between these factors and fundamental factors. In the next chapter the content of the concepts ‘vulnerability’ and ‘capability’ will be discussed and an overview of the recognized sub-factors will be presented. From the discussions it became clear that the public transport organizations were not able to present a list of vulnerabilities and capabilities that is structured, complete or can be fully motivated.

Level of awareness: Concerning awareness of resilience, the majority of participants described the integrated approach of the four elements that create awareness is not available. It can be observed that the public transport organizations are in the process of understanding the need to increase the awareness of disruptions and internal control, but they have not chosen to adopt a specifically holistic approach. As emerged in the discussions on risk, the identification and assessment components are related to COSO and FMEA methodologies.

Level of approach: The proposed framework and the associated definitions pose challenges both conceptual and practical. These include discussions on defining levels of resilience (Hollnagel, 2006:179). In this part of the research the evidence gap is addressed to *the level of the public transport organization*. Resilience approaches have also emphasised other managerial levels. Resilience can secondly be *division or activity-level* focused. In public transport this implies adopting a different approach to resilience in different entities, for example, one in rail operations and another for bus operations. Findings show that some public transport organizations have taken their approach to disruption and mitigation in that direction, but mostly without adopting a systematic organizational or corporate-level approach. There was no evidence of collaborative cross-checking of events as a critical component of resilience. This aspect is recognized in the literature as a complex element in the resilience approach (Patterson *et al.*, 2007).

Public transport organizations are collaborating with other organizations such as transport authorities, suppliers and other providers. Public transport organizations outsource activities, lease and/or rent assets. Although the organizations state that they are aware of the possible complications, they have not integrated this into a systematic approach in order to understand possible vulnerabilities. This *system or network level* is the third level of resilience. Public transport organizations that also incorporate rail-connected transport have especially emphasized the relevance of this topic, based on the regulations for safety and associated existing protocols to sustain a stable public transport system.

The discussions to develop resilience approach results in two different views. Some agreed about starting with an *organizational level approach*. Others suggested starting by defining the vulnerabilities and associated capabilities first to the *activity level* –for what is required within legal structures and compliance agreements – and from that starting point developing to the next level towards an organizational-level approach. From a knowledge-acquisition point of view, first experiences can be obtained by starting at the activity level, but with the clear aim of developing a systematic organizational approach. All participants also agreed that this network cooperation is the next level of advancement after the organizational introduction and implementation of resilience.

A truly resilient system should be able to survive, adapt and grow at all three levels.

Knowledge of advantages and complications: Concerning the introduction of the framework, public transport organizations are aware of major advantages and complications of a structured resilience approach. Table 8 presents an overview without an order of priority and without implying any direct relations between the two parts.

Advantages	Complications
Structured improvement of monitoring events.	Priority on the strategic level: - lower awareness of resilience.
Introducing of scripts with less dependence on expertise of individual persons.	Cost-benefit ratio difficult to determine: - visibility of core business.
Better alignment to tender contracts and external and internal compliances: efficiency and effectiveness.	Responsibilities and available information: - no communication structure for risk and resilience; - fear of bureaucracy.
Coordination within the public transport sector to enhance the level of knowledge.	Human resources: - lack of content expertise; - lack of understanding of the concept of a structured approach.
Consistency and completeness and less redundancy: efficiency.	Approach must not look academic: - no structured best practices available.
Shorter time to act: learning organization.	Low level of cooperation between public transport organizations.
Balanced structure of capabilities to vulnerabilities to deal with over- and under-reactions.	No structuring from legal or contracts (tenders) requested.
Better prepared for the unforeseeable.	Connection to existing security and risk structures.

Table 8: Overview of advantages and complications of resilience approach

In conclusion, it can be stated that the public transport organizations have not given priority to the introduction of a structured approach, but are aware of possibilities and the needs of the future.

5.5 Verified resilience framework for public transport organizations

It can be concluded that the concepts and definitions, guiding principles and structure of the framework have been acknowledged. With this the orientation that enables an organization to identify, assess and respond to disruptive events has been developed. This will be referred to as *cognitive resilience*. This chapter has presented discussions on research propositions and the connected relations of the framework structure together with the modifications; this results in the following adapted structure (Figure 13).

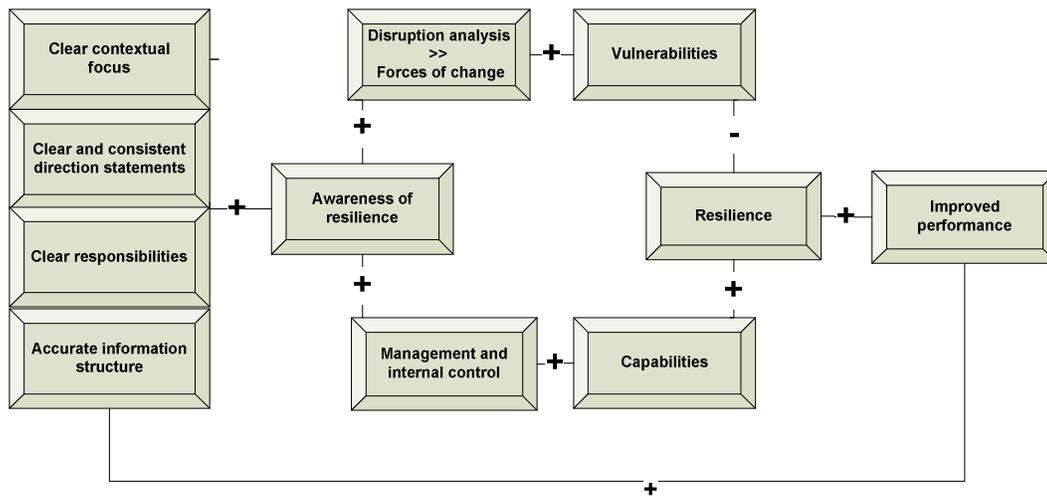


Figure 13: Verified resilience framework for public transport organizations

On the basis of the previous chapters it has become evident that the public transport resilience approach has the potential to provide organizations in a systematic way with insight into their strengths, weaknesses and priorities based on a periodic assessment of resilience. This is relevant in turbulent environments and it realigns resources. Resilience takes into consideration the portfolio of capabilities matched to the pattern of vulnerabilities to achieve improved performance. At this moment it is sufficient to recognize the framework as coherent and functional at the organizational level.

5.6 *Summary and interpretations*

The second research objective was formulated as: To structure and design a comprehensive and comprehensible resilience framework for public transport organizations. This is structured in two steps. First, the conceptual framework is based on deductive reasoning, and second, the framework was discussed with practitioners from public transport organizations and from organizations specifically active in the fields of risk and resilience using structured interviews. The various interviews can be seen as case studies to verify the deductively presented framework. This resulted in a verified framework for resilience in public transport organizations

This also resulted in a set of concepts and definitions, which have been listed. The previous chapters presented 11 research propositions (RPs). These research propositions have been discussed in the case studies, resulting in the acceptance of all, with the modification of research proposition 4 to read: “*Awareness is positively influenced through accurate information structures*”. In addition to that, the four elements that create awareness are shown to be inter-related and a feedback loop between improved performance and the four elements that create awareness has been explained.

The second research objective has been achieved by discussing both the concepts of *contextual resilience* and *cognitive resilience* as providing the conceptual orientation that enables an organization to identify, assess and respond to disruptive events.

6 *Behavioural resilience*

6.1 *Introduction*

Standardized definitions of vulnerabilities and capabilities and a verified resilience framework were discussed in the previous chapter. The attributes of vulnerabilities and capabilities of the resilience framework need to be identified, defined and categorized.

The third research objective is: To identify the main elements that create knowledge about the resilience design. This chapter will first discuss the *fundamental* factors that make an organization susceptible to disruption. Next, the *attributes* required for performance and accomplishment will be considered.

Proactive diagnostics help to structure and analyze vulnerabilities and capabilities in order to predict and explain potential organizational behaviour. Such a proactive approach puts the organization at an advantage by moving beyond reactive resolutions. *Behavioural resilience* is the ability to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to respond in a systematic way when something unexpected occurs.

The identification, definition and categorization of vulnerabilities and capabilities are derived from a variety sources. The information from the interviews conducted for verification of the framework in the previous chapter will be integrated with the findings from the literature survey. This results in a provisional draft of descriptions of vulnerability and capability factors with added sub-factors. For reasons of verification and generating information, this provisional draft will be discussed with practitioners. Data gathered from six European public transport organizations is used to evaluate the draft using a qualitative methodology. The taxonomy of the characteristics of both constructs will be defined.

6.2 *Characteristics of resilience*

First, resilience cannot be measured in itself but only in terms of potential: it is not enough that the organization is reliable or that failures can be measured below a certain value; it must also have the capacity to recover from irregularities. Knowledge is obviously important for knowing what to expect and for knowing what to look for. This knowledge, however, entails more than just experience; it also implies the ability to go beyond experience. Adamski and Westrum (2003) describe this as “mandatory imagination”, which is a sine qua non for resilience.

Public transport managers have to find a point of balance between varying and even antithetical positions. If there is a serious problem and they do not react accordingly, the delayed response may cause severe damage (Lammers, 2009; Svensson, 2002). On the other hand, if they go onto the alert and trigger actions that later prove not to be necessary – because there was no real disruption – this will cost the organization money and will be a manifestation of faulty judgment. There are no hard-and-fast rules for deciding to go onto the alert and to escalate response levels (Sheffi, 2007). The challenge lies in being able to recognize the changed situation, i.e. the triggering conditions for the transition. This is the first step. Detection of problems can take time because of the many ambiguities involved, such as establishing whether there is a problem, where it is, and so on (Sheffi, 2007). The main feature of a resilient organization is the ability to ensure that the time lag between any kind of change and its detection is as small as possible.

Secondly, resilience requires a continuous monitoring of performance; it cannot be engineered simply by adding more procedures, securities or barriers (Hollnagel, 2004). Recognizing the magnitude of a large disruption at an early stage goes beyond statistical analysis only. It requires the ability of the public transport organization to understand the meaning of the disruption. Given the functions of the public transport organizations, boards should insist on a clear and updated analysis of vulnerabilities and possible capabilities to determine the level of resilience (Sheffi, 2007: 272).

The vulnerability and capability maps need to be updated continuously, because each public transport organization may be confronted with, introduce or eliminate its own distinctive vulnerabilities and change their overall likelihood and potential severity. The ongoing effort to redesign processes, to transform organizational culture, to change the service design, to change the relationships with external partners and to change the organizations themselves should pass through assessment processes.

Thirdly, organizations face yet another level of challenge: finding the root cause and/or data about a disruption and absorbing and communicating these data internally, so that the relevant parties can take possible timely action with sufficient clarity. One of the recurrent themes in the literature on resilience is that resilience is something an organization *does* rather than something an organization *has*. Regardless of the structure used, the result is based on the management information processes and organizational effectiveness that focus on core processes and the way doing so contributes towards ensuring the convergence of resilience plans at the different levels of the organization in the management of resilience.

Resilience then concerns the capacity of public transport organizations to recognize and adapt to situations that call into question the existing model of competences. This implies that resilience is concerned with monitoring the boundary conditions of the current business model for competence, and adjusting or expanding that model to better accommodate the changing boundaries. Mitroff and Featheringham (1974) discuss the error of the under-adaptation failure, which occurs when organizations persist in applying textbook plans and activities to address the evidence of changing circumstances. The purpose of a resilient organization is also to ensure that the most effective action is taken. It is necessary to recognize that the purpose of a resilience approach in an organization is to ensure that the time lag between detection and responsive action is as small as possible.

The creation of a resilience framework is built on the concept of vulnerabilities that result from some type of change, and the capacity to react and adapt (Christopher and Peck,

2004b). Following this reasoning, first the fundamental factors of vulnerability will be examined and, second, the attributes of capability. The purpose of this section is to develop a set of the potential elements of vulnerability and capability relevant to the public transport organization. It should be noted that this is *not* about doing an *assessment* or calculation of the degree of severity or mishap. Instead, it is about an *analysis* that is intended to identify, define and categorize factors that contribute to resilience in the public transport sector.

Based on the literature and the outcomes of the interviews conducted to verify the conceptual framework, a number of disruptions have been presented as *sub-factors*. This term is chosen to stress the difference from *fundamental factors and attributes*. This chapter will discuss both.

6.3 Identification and classification possibilities

An MIT study of corporate responses to the potential of large-scale disruptions found that most organizations are still not thinking systematically about disruptions or vulnerabilities (Sheffy, 2007). This section addresses the evidence of the *possibility of making classifications*, to ensure that it is possible to diagnose vulnerability and capability classifications in the public transport sector.

One of the measurements used to identify disruptions is the four-quadrant method with high and low probability of occurrence of a disruption with respect to its light and severe consequences, as discussed in Chapter 4. Each quadrant has its own meaning. Such maps serve to *identify and possibly classify* disruptions along these two dimensions, leading the public transport organization to focus on those disruptions to which they may be most vulnerable.

Based on this, various authors (Pettit, 2008; Manuele, 2005) have discussed the following classification model (Figure 14). A critical step in the identification and classification of vulnerabilities is based on the estimated assessed probability of occurrence of a

disruption and the estimated severity if the event occurs. The greatest weakness of statistical process control (SPC) is its inability to adequately characterize low-probability, high-consequence (LP/HC) events, i.e. the upper-left corner of Figure 14 (Kunreuther, 2006). Additionally, the traditional disruption assessment approaches cannot deal with unforeseeable events with respect to their character, time or place. As discussed, the concept of resilience can fill these gaps and supplement existing management programmes, thus enabling the public transport organization to survive unforeseen disruptions and create competitive advantages.

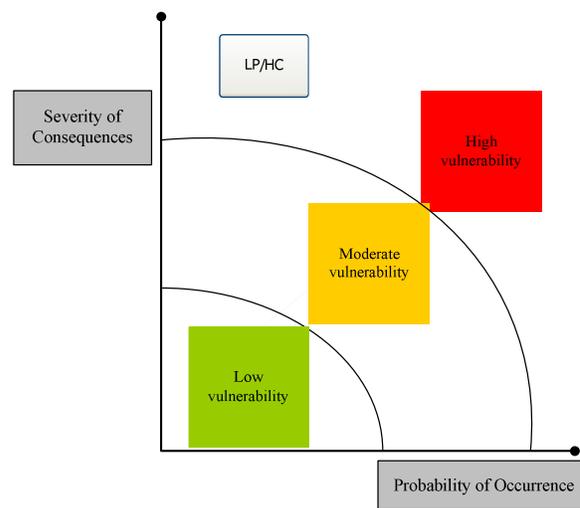


Figure 14: Classification of vulnerabilities

This model is also used in the public transport sector for both identification and classification. Transport for London (TfL) presented at the conference on Anti-Terrorism in Public Transport (UITP, 2005c) a comparable systematic approach which categories and associated actions. It is important to note that these categories and actions have both been defined as “organization specific” (Transport for London, 2006). For example, a deliberate threat to a metro system could have a severe impact. Next to the loss of life, the consequential impact on confidence among the customers might be devastating. The loss of a single metro train may not be material in terms of the assets of the public transport organization. The consequences of an attack on a taxi or minibus are not likely to be as severe as an attack on the metro, because of the highly distributed structure of the

taxi industry. Also, organizations with a high union worker percentage might be more susceptible to labour action than a non-union organization. The actions required related to the different risk categories are derived from internationally defined category differentiations such as the standard Euro Norm 50126 (Mann, 1999).

The interviews referred to in Chapter 5 also produced a list of evidence of identifying (sub-)factors in public transport organizations. With the data available, it is not possible to assess the success with which the operators are able to handle disruptions to their usual goals.

In addition to these sources, information from the Global Risk report 2008 and 2009 of the World Economic Forum has been analyzed. This report categorizes the landscape of disruptions in a dynamic perspective based on five categories: economic, geopolitical, environmental, societal and technological (World Economic Forum, 2009). The report also presents countries' exposure overviews and Risk Interaction Maps (RIM). The report assesses 36 disruptions, and creates a risk barometer on the basis of the research results. They are considered as contributing to a potential list of vulnerability sub-factors.

The General Motors Enterprise Risk Team also started to identify and categorize events. The company constructed a four-quadrant map of risks that include financial, strategic, operational and hazard vulnerabilities. Financial vulnerabilities include a wide range of macro-economic and internal financial issues such as exchange rate fluctuations and irregularities in financial statements. Strategic vulnerabilities include everything from new competitors to boycotts. Operational vulnerabilities include mainly disruptions directly connected to the service delivered such as technical stuttering, small injuries or theft. Hazard vulnerabilities include accidental or random disruptions and deliberate threats such as sabotage and terrorism.

The diagram also arranges the vulnerabilities on a radial, internal to external dimension. Vulnerabilities more central in the diagram tend to come more from within the organization, while those located at the periphery of the circle tend to arise more from outside the organization. GM categorized different possible disruptions and asked

management how many of these events actually occurred in the previous twelve months (General Motors, 2006).

Collecting the information across GM companies gave the firm a picture of its vulnerabilities, providing the organization with an actual perspective on disruptions. Other organizations have also used similar approaches to develop overviews and databases in the organizations which show the inevitability of disruptions.

From these discussions it can be concluded that it is *possible to identify and classify disruptions and to analyse sub-factors to create more fundamental factors*. With these vulnerability maps public transport organizations can simulate the impact of the disruption and the efficacy of proposed capabilities to take the organization to a higher level of resilience. The essence lies in the capacity to deal with the vulnerabilities identified. From the theory of control processing and quality management it is clear that in principle capabilities can also be identified and classified (Smith and Fingar, 2003; Tracey *et al.*, 2005; Davenport, 1994). This part of the research will focus on the initial set of possible vulnerability and capability factors.

6.4 Identification of vulnerability factors

The starting point in this part of the research is the studies of The Center for Resilience (2008) and the study by Pettit (Pettit, 2008), that identified sources of forces of change in the field of logistics. The Center for Resilience defined six such sources and the study by Pettit seven. There is a great degree of overlap between them. From these lists seven categories of vulnerabilities are identified: Turbulence, Deliberate threats, External pressures, Resource limits, Sensitivity, Connectivity and Supplier/Customer disruptions. The last one was not identified by the Center for Resilience. These vulnerabilities must be counterbalanced with managerial controls that create capabilities. In the same research Pettit defined fourteen capabilities and the Center for Resilience identifies sixteen.

For the starting of this capability identification process the shortest list is chosen, based on the arguments of the participants of the interviews on managerial challenges. This list identified: Flexibility in sourcing, Flexibility in order fulfilment, Capacity, Efficiency,

Visibility, Adaptability, Anticipation, Recovery, Dispersion, Collaboration, Organization, Market position, Security and Financial strength. The Center for Resilience identifies, in addition, Flexibility in manufacturing and Product stewardship.

Following these conceptual foundations to diagnose vulnerability and capability factors, including sub-factors, this research will in addition draw on the following literature sources to complement and verify the above described forces of change:

- *Resilience Engineering: Concepts and Precepts* by E Hollnagel (2006);
- *Resilient Enterprise: The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage* by Y Sheffi (2007);
- *Risico Management en Logistiek (Risk Management and Logistics)*, by B. Lammers *et al.* (2009).

These sources are based on recent research and together present a wide overview of the concept of resilience. Two sources (Lammers and Sheffi) have a background in transport and supply chain management. Hollnagel presents a more generic approach within a context of more competitive and managerial advantage.

Analyzing these sources and analyzing the interviews discussed in the previous chapter on the presence of mentioned vulnerability (sub-)factors, it is clear that the vulnerability (sub-)factors mentioned by The Center for Resilience (2008) and the study by Pettit (2008) are recognizable in all of them.

If a sub-factor is mentioned, it is regarded in Table 9 as supporting the relevance of the vulnerability factor and added to that list.

Vulnerability factor based on structure of Center for Resilience (2008) and the study by Pettit (2008)	<i>Resilience Engineering: Concepts and Precepts</i> by Hollnagel (2006)	<i>Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage</i> by Sheffi (2007)	<i>Risiko management en logistiek</i> by Lammers <i>et al.</i> (2009)	Interview findings: from framework verification in public transport sector. (Appendix 1) (2009)
Turbulence	XX	XX	XX	XX
Deliberate threats	XX	XX	XX	XX
External pressures	XX	XX	XX	XX
Resource limits	XX	XX	XX	XX
Sensitivity	XX	XX	XX	XX
Connectivity	XX	XX	XX	XX
Supplier/Customer disruption	XX	XX	XX	XX

Table 9: Sources of vulnerability factors
(XX): vulnerability (sub-)factor mentioned.

In addition to these literature sources and the interviews conducted to develop the framework in the previous chapter, which are specifically focused on public transport-related organizations, (sub-)factors from the Global Risk report of the 2008 World Economic Forum and the GM vulnerability map are also analyzed to develop comprehensive lists. Taking the classification of factors from The Center for Resilience (2008) and the study by Pettit (2008) as the reference list, sub-factors are added to complement the lists. The description of the factors is used as a reference to allocate sub-factors to the factors list.

Table 10 provides an overview of vulnerability factors with descriptions and sub-factors. Because this list will be discussed with practitioners from public transport organizations for verification as well as to generate new information, it is referred to as “vulnerability factors with description and sub-factors”, while the list after the empirical research will be referred to as “Vulnerability (sub-)factors after verification”. The vulnerability factors refer to the factors the organization is exposed to.

<u>Vulnerability</u> (<i>exposure to factor</i>) (Predominantly based on structure of Pettit and Center for Resilience)	<u>Description</u> (Predominantly based on Pettit and Center for Resilience)	<u>Sub-factors</u> <i>Descriptors (not exhaustive) from literature, Global Risk Report of World Economic Reform and GM vulnerability map, and from interviews with public transport organizations</i>
Turbulence Accidental	<i>Environment characterized by: changes in external factors beyond internal control.</i>	Natural disasters (floods, earthquakes); Health disasters, pandemics; Geopolitical disruptions; Unpredictability of markets ; Unforeseen technology and IT failures; Fluctuation in financial issues.
Threats Intentional	<i>Deliberate attacks aimed at disrupting operations or causing human or financial harm.</i>	Terrorism and sabotage (internal, external) incl. cyber disruption, piracy and theft and espionage; Media pressures, offensive advertising, brand attacks; Labour disruptions, union activities, strikes; Special interest groups.
Pressures, External	<i>Influences not specifically targeted at the public transport organization that create business constraints or barriers.</i>	Competitive innovation; Social/cultural changes; Political/regulatory change; Price pressures (competitive); Environmental, health, safety concerns; Corporate responsibility concerns
Resource Limits	<i>Constraints on output and productivity based on availability of connected factors of production</i>	Natural resources; Intellectual property; Supplier and utilities availability; Asset utilization; Distribution availability; Data-storage capacity; Human resources.
Sensitivity	<i>Relevance of carefully controlled conditions for product, service and process integrity and liability</i>	Complexity of design and product purity; Complexity of process operations; Consumer requirements for quality; Restricted utilization of materials and data; Reliability of (key) equipment and IT; Potential safety hazards; Loss of key personnel; Visibility of disruption to stakeholders; Symbolic profile of brand; Concentration of capacity.
Connectivity	<i>Degree of reliance and interdependencies on outside entities</i>	Scale/extent of (travel and traffic) networks; Degree of outsourcing; Information interdependence and reliance; Reliance upon specialty sources and information flows.
Supplier/ Customer disruption	<i>Susceptibility of suppliers and customers to external forces or disruptions</i>	Supplier trust and reliability; Customer and loyalty relations; External relations; Reliability of relations.

Table 10: Vulnerability factors with description and sub-factors

In the following section motivation about the (sub-) vulnerability factors will be presented.

Disruptions can be random, accidental or intentional. Random disruptions are mostly analyzed based on the likelihood inferred from available statistical data. In this research random disruption with high probability and low impact will not be discussed further, in compliance with the definition of resilience and the concept of turbulence, as discussed in Chapter 5.

Accident-related disruption is more difficult to predict. Probably the most widely mentioned accidental disruptions are causes of organizational *turbulence* such as natural disasters like hurricanes, earthquakes and the like (Pettit, 2008; Sheffi, 2007; Svensson, 2004; Lammers, 2009). The public transport organization needs to ascertain whether it faces potentially significant turbulence from such disasters that could have impact on its performances. In addition to natural disasters, flu epidemics have shown that the turbulence may affect not only consumer demand, but also the organization's human resources and those of the partner organizations. The 2009 Mexican flu had an impact on business by disrupting major public transport organizations. Other turbulence factors are related to unforeseen technical failures, as with Eurostar operating between France and the UK in the winter of 2009/2010. Turbulence can also arise from other fluctuations such as a sudden unpredictable market demand. The discussion in the Netherlands about the continuation or ending of "free" public transport to students may result in unpredictable demand shifts. Other mentioned sub-factors are unexpected price or currency exchange rate fluctuations and geopolitical changes as in the Middle East in 2011.

Whereas random and accidental disasters might follow some statistical law curves or estimates from small mishaps, intentional disruptions follow a different logic. Intentional disruptions present threats in which the organizers or perpetrators seek maximal damage in the attack. The 2001 attack on the Twin Towers in New York is a world-renowned example. A variety of *intentional or deliberate threats* are posed to public transport organizations, including actions from special interest groups, including terrorism as well as (direct or indirect) action from unions. In 2005 French workers participated in their second nationwide strike to protest against measures proposed by the government. In Paris bus drivers from "Régie Autonome des Transports Parisiens" (RATP/Autonomous Operator of Parisian Transports) decided to support them and created an intentional disruption. The buses blocked the main RATP garage and within hours the entire bus system came to a halt. They knew exactly what they were doing (Sheffi, 2007)! Clearly political and labour manoeuvring has nothing to do with terrorism, but managers need

only to understand that intentional disruptions will strike at the most inconvenient time and often at the least defended place. The Madrid bombers did not blow up an airline because airports around the world had implemented enhanced security measures after 9/11. The bombers struck an undefended target instead. The attack took place at the height of the rush hour with packed trains to ensure maximum effect. If these threats are not aimed directly at the public transport sector or organization and/or do not directly harm the organization in first line of attack, the resultant damage can harm the operation indirectly. The public transport organization needs to address the issue if it is frequently the target of deliberate threats. Other mentioned sub-factors are media pressure and brand attacks.

External pressures can be exerted over short and long periods of time. The relevant issue for the public transport organization is that it faces pressures from a wide variety of sources that suddenly can become of great influence. Competitive innovation and social and cultural developments can suddenly become issues that might have a disruptive effect. The financial dependence of public bodies in general has a profound impact on operations in the public transport sector. In public transport in the Netherlands the tariff system and level are set and changed by the national government and changes do not always reflect cost development in operations. For public transport the rules of tendering may change and affect the opportunities. More multi-modal tenders in the public transport sector will give organizations that are able to offer all these services an advantage. Government policies and regulations can also impose significant external pressures on market accessibility. For example, after both the 2006 and 2010 elections in the Netherlands, the policy to mandatory tender the biggest cities changed. This affects the position of some public transport organizations in the Netherlands in the race to provide competitive product offerings. In addition, the focus on more CO₂-friendly buses affects tenders and influences the use of other materials as well as depreciation periods. Furthermore, environmental, health and safety concerns influence the design of the services and products. Short-term security regulations imposed in the interests of society can have sudden impacts on public transport organizations. Use of cameras in buses and stations is just one example. Changes in other stakeholders' expectations

concerning corporate responsibility and ethical issues are other examples. Although this may be a “Green” trend, sudden exposure is possible and more short-term media pressures can occur.

Resource limits can be internal or external. What needs to be addressed by public transport organizations are -potential- shortages of resources. The discussion on the availability of natural resources is multidimensional. This can influence a modal split in favour of public transport, but also demands the use of other natural resources in the public transport operations. The availability of national resources can become an issue if a distribution boycott comes into effect. Evaluation of asset utilization is important when unscheduled demand occurs or when different maintenance is required. The focus on excess capacity can be looked at purely as a waste issue, or as necessary within the scope of unplanned events (Pettit, 2008; Lammers, 2009). Resources limits can also be related to external factors such as, for example, the utility infrastructure or the supplier capacity in general. In public transport the most valuable asset of all production processes is human capital (UITP, 2009). The availability of a trained workforce is critical to continuous operations and includes overtime work and/or additional hired manpower, certainly in turbulent times of demand for operations. As for the many service industries, the required data and information availability also create new challenges. The introduction of the chip-card as the only way of ticketing in public transport in the Netherlands has, in addition to the financial implications, also had an impact on both data and information availability. Other mentioned resource constraints are intellectual property, patent and design rights.

The level of sensitivity depends on the design, product and service and process complexity and interdependency. *Sensitivity* may lead to a disruption in the service and/or gives rise to claims based on the promised service reliability. In essence, the issue is how sensitive the organization is to disruptions or variations in materials and/or processes. To address this, the reliability of material and equipment must be tested to perform under given and unexpected circumstances. Similarly, reliability is demanded from the employees and consequently human accidents represent a failure of the human system. It

can also be important to protect the brand name and customers have stringent quality standards for services rendered to them. For public transport operators in the bigger cities this image often relates to the image of the city. The symbolic profile of the brand can also create vulnerability with respect to deliberate threats and external pressures (Pettit, 2008). The use of delicate and/or particular equipment, or the fact that workers operate in extreme or hazardous conditions, all add to the phenomenon of sensitivity. In public transport the operators are also highly dependent on the quality of suppliers of utility and infrastructure. If capacity is concentrated, the effects of a disruption can be more harmful because of major loss. The presence of restricted materials, such as toxic or hazardous or other substances, can also be a factor. Finally, operations are sensitive to the visibility of disruptions to the relevant stakeholders in public transport, for example, the general public, the media, owners, employees.

Each organization has its own vulnerabilities (Pettit *et al.*, 2010; Sheffi, 2007). The unique *degrees of connectivity* create additional nodes and links, and each organizational boundary represents yet another source of vulnerability. In previous chapters the link between the transport market and the travel and traffic market has been discussed. In essence, the issue is whether the organization requires a high level of connectivity with system and environment members (Siggelkow and Rivkin, 2006). Specific elements are the reliance on specialised resources, where the organization has limited options that can lead to a greater risk of disruption. The uses of specific infrastructure or dynamic traffic management for buses are examples. In a similar way information requirements create connectivity and corresponding risks between partners. In recent decades a shift from total ownership to vertically integrated chains has become common (Lammers, 2009). IT support and maintenance can also be outsourced and influence the degree of connectivity. With the tendering processes the extent of connectivity becomes more challenging and more diversified. The diversity of ownership of tracks, stations and information reveals the differences in the levels of connectivity.

Public transport organizations depend on suppliers for the delivery of buses and other materials. *Supplier's disruptions* affect the organization's ability to deliver a product or service. Each issue depends on the supplier's own level of resilience. An example in public transport is the use of chip-card technology. The liability of that system maybe a supplier issue, but it can be experienced by the customer as an operator failure. These disruptions may also be intended to attract media attention and such threats can have a significant impact on consumer behaviour. The vulnerability map of the supplier can have an influence on the selection of preferred suppliers, monitoring of their activities and a search for alternative solutions. It is interesting that with the managerial trust in aligning performance with metrics, it has been repeatedly shown, as Peck (2005) notes, that cost and the resulting profitability are the only common measures relevant in the negotiations between partners. In addition, collaborative programmes such as open data and risk sharing have been developed to assess effects on costs and profitability.

Profitability is directly and negatively affected when *customer disruptions* in terms of lower revenues or decreased sales occur, or positively affected with a sudden and unexpected increase, within the given capacity constraints. An organization must be prepared to withstand short-term disruptions with flexible options, and to adapt if long-term impacts are expected. There are a number of reasons for unexpected drops. Anticipating severe disruptions in demand boosts the collaborative programmes between partners.

The discussed vulnerability and sub-factors described are not exhaustive. The purpose is to develop a guiding compass rather than a complete prescriptive list, which is by definition not possible in a turbulent environment. This also includes the discussion of sub-factors.

6.5 Identification of capability factors

Many organizations can recover quickly from disruption(s), if they are prepared and know what to expect. The overall principle underlying all the measures taken is that they must be in accordance with the organization's mission/vision statements. The challenge

for professionals in the field of resilience is to make “the business case” an integral part of supporting and enhancing the main mission (Sheffi, 2007).

An important effect is often rooted in the competitive positioning of the organization. Public transport organizations have only limited operational competition, but the air passenger transport market, for example, is more competitive. On the other hand, gaining new business when a competitor is disrupted also involves the ability to seize the opportunity.

Analyzing the literature sources and interviews by using the same approach as discussed in the previous section, it is clear that the capability factors mentioned in the study by Pettit (2008) are evident in most of the other sources. If a sub-factor is mentioned, it is regarded in Table 11 as supporting the relevance of the capability factor and added to that list.

Capability factor based on structure of Center for Resilience (2008) and the study by Pettit (2008) based on Pettit (2008)	<i>Resilience Engineering: Concepts and Precepts</i> by Hollnagel (2006)	<i>Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage</i> by Sheffi (2007)	<i>Risico management en logistiek</i> by Lammers <i>et al.</i> (2009)	Interview findings: from framework verification in public transport sector. (Appendix 1) (2009)
Flexibility	XX	XX	XX	XX
Flexibility in sourcing	XX	XX	----	----
Flexibility in order fulfilment	----	XX	XX	XX
Capacity	XX	XX	XX	XX
Efficiency	XX	XX	XX	XX
Visibility	XX	XX	XX	XX
Adaptability	XX	XX	XX	XX
Anticipation	XX	XX	XX	XX
Recovery	XX	XX	XX	----
Dispersion	----	XX	----	----
Collaboration	XX	XX	XX	----
Organization	XX	XX	XX	XX
Market position	XX	XX	XX	XX
Security	XX	XX	XX	XX
Financial strength	----	XX	XXX	XX

Table 11: Sources of capability factors
(XX): capability factor mentioned.

The purpose is to create a portfolio of capabilities that can create a balanced state of resilience in relation to the vulnerabilities, which will be discussed in the next chapter. Applying the same approach and based on the same variety of sources as in the previous section the following attributes are then detailed in sub-factors, without being exhaustive, while the attributes are described in Table 12.

Because this list will also be further discussed with practitioners from public transport organizations for verification as well as to generate new information this list is referred to as “capability factors with description and sub-factors” while the list after the empirical research will be referred to as “Capability (sub-) factors after verification.

<u>Capability factors</u> <i>Structure (predominantly based on Pettit and Center for Resilience)</i>	<u>Description</u> <i>(predominantly based on Pettit, and Center for Resilience)</i>	<u>Sub-factors</u> <i>Descriptors (not exhaustive) from literature, Global Risk Report of World Economic Forum and GM vulnerability map and from interviews with public transport organizations</i>
Flexibility	<i>Ability to change quickly</i>	
Flexibility in <u>sourcing</u>	<i>Ability to quickly change <u>inputs</u> or the mode of receiving inputs</i>	Modular product design; Standardization and commonality of parts; Multiple sources; Contract flexibility with suppliers.
Flexibility in <u>order fulfilment</u>	<i>Ability to quickly change <u>outputs</u> or the mode of delivering outputs</i>	Alternative transport and distribution offering; Multiple service centers; Update of information; Postponement.
Capacity	<i>Availability of <u>assets</u> to enable sustained production or service levels</i>	Utilities back-up sources; Asset reserve capacity beyond normal deviations; Labour capacity flexibility; Communication and IT back-up systems.
Efficiency	<i>Capability to produce outputs with minimum resource requirements</i>	Waste elimination; Labour productivity; Asset utilization; Quality management/ service variability reduction; Failure prevention; Process standardization; Preventive maintenance.
Visibility	<i>Knowledge of the status of operating assets and the environment</i>	Business intelligence gathering; Information/automation technology; Status of all personnel; Market visibility, external monitoring; Service and equipment visibility; People visibility.
Adaptability	<i>Ability to modify operations in response to challenges and opportunities</i>	Learning from experience / feedback mechanism; Strategic simulation; Alternative technology development; Fast Re-routing and Re-scheduling; Seizing advantages from disruptions; Product life cycle management;

Anticipation	<i>Ability to discern potential future events or situations</i>	Monitoring early warning signals; Forecasting (horizon); Deviation and near-miss analysis; Preparedness planning; Business continuity planning; Emergency preparedness; Government lobbying.
Recovery	<i>Ability to return to normal operations state rapidly</i>	Crisis management; Equipment reparability; Resource mobilization; Communication strategy; Mitigation processes.
Dispersion	<i>Broad distribution of assets</i>	Asset and key resources decentralization; Distributed decision making; Dispersion of markets; Location-specific empowerment.
Collaboration	<i>Ability to work effectively with other entities for mutual benefit</i>	Disruption sharing with partners; Supplier relation management; Client and customer relation management; Collaborative forecasting; Information and communications exchange.
Organization	<i>Human resources structures, policies, skills and culture</i>	Empowerment; Creative problem solving; Accountability including reporting; (Cross-) training and workforce flexibility; Culture of caring.
Market position	<i>Status of organization or its product / services in specific markets</i>	Product positioning; Market share; Brand equity; Customer service management; Sustainable position; Customer loyalty/retention.
Security	<i>Defence against deliberate intrusion or attack</i>	Access restrictions; Employee involvement; Collaboration with governments; Personal security; Cyber security; Layered defences; Information pooling.
Financial strength	<i>Capacity to absorb fluctuations in cash flow</i>	Financial reserves and liquidity; Price margin; Insurance; Portfolio diversification.

Table 12: Capability factors with description and sub-factors

The following section will explain the capability (sub-)factors.

Service providers such as public transport organizations cannot keep an inventory of their product. Consequently, an operation-related disruption will lead to an immediate service failure, unless there is extra capacity or some other redundancy or flexibility. Ultimate *flexibility* means having variable alternatives in any situation. Standardisation of material, processes and information creates options for interchange abilities as well as for when there is a shortfall. Shifting public transport services from one disrupted facility to an

alternative requires not only the ability to shift, but also the ability to provide a service from that alternative facility.

Flexibility can be related to different factors such as market supply, or operational, informational or organizational factors (Duclos *et al.*, 2003). Pettit (2008) distinguishes two categories: flexibility in sourcing and flexibility in order fulfilment, as the Center for Resilience also describes flexibility in manufacturing. Comparing both lists of factors, some differences can be discerned. Pettit uses adaptability as a factor, whereby the ability to modify operations is described, while the Center for Resilience relates adaptability more to modifying the organization. Based on the fact that service providers such as public transport organizations are different from manufacturing organizations, and also the fact that fewer factors will increase the applicability of the framework, certainly in the initial phases, the classification of Pettit (2008) is adopted. This research will differentiate between flexibility in sourcing and flexibility in order fulfilment.

In the discussions with the public transport sector the above capability list will be discussed as well as the relevance of (sub-)factor divisions in general and, in this case more specifically, of the factor flexibility to the public transport sector. This implies that the other categories will also be discussed to find whether other relevant subdivisions are needed.

Flexibility in sourcing can be discussed in many ways, for example, in terms of quantitative portions or of the use of alternative suppliers with back-up agreements. The issue is how flexible the public transport organization is in sourcing supplies and services. Multiple possible sources, the use of modular service design, and standardization and commonality of parts will increase the degree of flexibility. Tenders often indicate different demands about material or about information availability to customers. This implies that the use of needed material in case of a disruption in one area can become restricted, if material from other tender areas has different specifications. The availability of alternative suppliers, such as the use of touring cars or the use of material that is temporarily not within the boundaries of the tender contract, can support flexibility

in sourcing. The public transport sector is well known for creating alternative transport offerings in case of operational disruptions such as, for example, traffic accidents or sudden closure of infrastructure. Most organizations have standing agreements to use third parties for excess capacity which can be quickly implemented. This also includes being able to serve customers from multiple locations and fast re-routing, including fast rescheduling and clear information about the new situation.

Flexibility in order fulfilment is basically about responding in a flexible way to increased or decreased demand. This includes the ability to ramp up services to meet surge demand without carrying large amounts of excess capacity (Pettit, 2008). This phenomenon is well known in the public transport sector in relation to peaks and seasonal demand differences. In the service industry it is more difficult to postpone activities in time than in the production industry as it is difficult to use inventory management as a critical tool for flexibility. Public transport markets are on average stable and a change to new market segments can take a long time.

The capability factor *capacity* can be measured by including or excluding reserve capacity to meet limited surge requirements of labour, assets or materials.

In this research the following reasoning is followed. Planned redundant resources require additional investments and maintenance that need to be designed in the business model. These redundancies already show the organization's readiness to adapt to events with "normal" deviations. Indeed, most organizations are accustomed to protecting themselves against small fluctuations (Pettit, 2008). Resilience, as defined in previous chapters, addresses turbulent change (Fiksel, 2006a) or unexpected changes (Svensson, 2002). From this perspective the capacity factor will be defined by excluding planned reserve capacity for random changes, because that capacity is not characterized as being responsive to turbulent change or unexpected changes, but more to fluctuations as part of normal business. Redundant IT systems can be relevant because in our modern service society loss of information systems means loss of business. The availability of back-up utilities (e.g. electricity, water), and their availability in areas where they cause least

ecological inconvenience, can support the direct use of capacity. With flexible labour contracts, it is possible to expand the workforce.

Excess capacity available will effect operational flexibility, if needed, and so increase resilience, allowing the organization to respond more quickly to disruptions. This capacity/flexibility relation shows that the factors described are not independent of each other and sometimes need to be *looked at in cohesion as a cause and effect relation*. The relevance is that the public transport organizations develop those capabilities that best respond to the vulnerabilities in time and place. With competitive pressures, short-term financial expectations and continuous improvements, including quality processes and programmes, all aimed at reducing waste and redundancy, it may be difficult to argue for capacity redundancy and sufficient reserves.

Efficiency is targeted to reduce all cost drivers, while still meeting performance indicators, contracts or customer demand. The objective is to improve the overall organizational system efficiency without sub-optimizing specific system sub-factors (Goldratt, 1984). In this research quality improvement will be seen as an activity to increase efficiency. Tenets of 6-Sigma methodology can be used to reduce the variability of processes. Stripping out redundant or ‘unproductive’ activities may also direct attention to effects on other capabilities such as flexibility or safety requirements as well as to the nature of the vulnerabilities. The concept of failure prevention is a key investment factor to reduce recovery efforts and down time. Organizations with a culture of, and a methodical design for, reliability contribute to the prevention of disruptive events (Svensson, 2002). This does not imply that such prevention strategies will automatically enable a response to all unexpected and turbulent changes. The tender processes in recent years in the Netherlands have been very much focused on reducing the operational hour price and have increased insight into costs structures, the relevance of preventive maintenance and labour productivity (Timmer, 2008).

Visibility is an enabler of rapid and effective decision making in normal operations and especially in turbulent times. The issue is accurate visibility into the current state of all

operations of the public transport organization. Knowledge does not only mean data. Data must give accurate information in a relevant format. Information technology is able to create monitoring and filtering options and can be fast and cost effective. For example, in times of crisis it is relevant to understand the status of the assets. This exceeds normal communication and organization with other supply and demand partners. The information systems need to provide information about the status of all personnel in the public transport organization and probably from all connected stakeholders. For effective decision making this information needs to be communicated to the right people. External conditions that influence operations need to be monitored, including weather, financial markets, etc. Effective means of gathering and disseminating information about current internal organizational conditions must also be available. Business intelligence is both a process and a service that goes beyond the boundaries of the partnership (Jourdan *et al.*, 2008). The monitoring systems also proved their worth in helping to find causes or perpetrators quickly, as was proven in the 9/11 and London underground attacks. The relevant issue is ascertaining where the disruption lies on the organizational horizon.

In this respect three major dimensions of resilience are relevant:

- Resilience is the capacity to prevent something bad from happening;
- Resilience is the capacity to prevent something bad from becoming worse;
- Resilience is the capacity to recover from something bad once it has happened.

These competences to foresee and to avoid both belong to the domain of resilience. In that respect visibility, anticipation and adaptability are connected capabilities. A complicated issue is the scope of visibility. How big should the picture be? Within the framework presented the scope has been defined to include the travel, transport and traffic market as well as the wider environment. This can be defined as the external area of visibility. The internal visibility is on the organizational effectiveness that focuses on core processes by which the organization accomplishes its direction statements.

Adaptability is basically about knowing when and where to implement flexibility (Pettit, 2008). It provides the organization with the capacity to adequately respond to

vulnerabilities. Gaming and simulation are applications to improve system performance and to increase the level of confidence. Seizing advantage from disruptions is another form of adaptability that can be profitable to a public transport organization. Opportunities can also arise from a competitor's disruptions. Especially in the service industries an adequate response can create increasing customer goodwill (Hart *et al.*, 1990). Studies have shown that in the service industry a strong or even light service experience is more important than problems that might occur during operations (Johnston, 1995). A permanent shift can occur if customers are pleased with the substituted services offered. In order to remain competitive, organizations have to become learning entities. Many organizations move on to putting out the next "fire" without analyzing the cause of the disruptions and the process of the recovery, and consequently fail to implement changes for improvement (Hanssen-Bauer and Snow, 1996). The feedback stage must, however, be formalized within the organization (Perrow, 1999.) A relevant issue is the timing of the adaptation of systems. This depends on a distinction between understanding how a system is competent at designed-for uncertainties, which defines 'text-book performance' and understanding how a system recognizes when situations fall outside that envelope (Csete and Doyle, 2002).

Anticipation is meant to prevent disruptions, if possible, and to mitigate the effects if a disruption cannot be avoided. The issue is whether the public transport organization employs a wide range of approaches to anticipate changes. Identification requires at least some historical data or subjective estimates. Recognition of early warning signals can provide a key capability. The aviation industry has long recognized the wisdom of learning from a mistake, even when it does not cause an accident (Wells and Young, 2004). It has established the Aviation Safety Reporting System (ASRS), which is used to collect and analyze confidential aviation incidents reports. Similarly the European Union Directive 96/82/EC specifies processes for reporting major accidents and hazards involving severe disruption (European Commission, 1996). The US National Transportation Safety Board also publishes studies with the results of its investigations and data analysis, including recommendations for infrastructure, rolling stock and practices (NTSB, 2009).

Management also involves prioritizing of disruptions, and in that way management is a critical component of the anticipation process. Identifying and taking early action can make the difference between a smooth or complex return to normal operations. However, organizations cannot prepare for every eventuality, as identification of all possible disruption scenarios is an infinite task (Sheffi, 2007). But advance planning and training and using the concept of business continuity planning can significantly improve the chances of survival or quick recovery (Rigby and Bilodeau, 2007).

As discussed, capabilities need to be analyzed in a coordinated way. Research, based on the Dutch railways, discussed the link between anticipation and adaptability. One of the conclusions was that very clearly advanced definitions and procedures were formulated for passenger safety. When the train moves outside the clearly defined safety boundaries the train stops. But at the same time traffic volume and punctuality goals are sacrificed. An extreme version of a command-and-control strategy might conflict with the need for an adaptable organization. The safety performance level is very high, but not the overall resilience, because of the inflexible approach and low organizational capabilities in such situations (Hollnagel, 2006: 146).

Many view *recovery* as the essence of resilience (Center for Resilience, 2008). This implies that the organization is very effective at quickly recovering from disruptions. Quick reactions in terms of detecting and mobilizing resources, managing the crisis, communicating the situation and mitigating the consequences can limit the overall severity of a disruption in terms of loss of lives or loss of profitability (Craighead *et al.*, 2007; Hart *et al.*, 1990). In public transport the relevance of developing an effective strategy for communication in a variety of extraordinary situations was proven in the extreme winter of 2009/2010 in Europe. This concerns communication internally, as well as to partners in the operation and to customers. The organization must take immediate actions to mitigate the effect of disruptions in order to quickly restore operations. Recovery plans are common in most organizations but not to the level of a systematic structured and integrated level (Christopher, 2000 and 2008).

Dispersion is more than only physically separating facilities and equipment, but also includes workforce and leadership (Cranfield University, 2003; Sheffi 2007). Market dispersion is essential to the public transport organization in terms of sales, if customers are unable or unwilling to purchase services (Pettit, 2008). Market dispersion protects against a localized weather threat, such as Hurricane Katrina in 2005, which may prevent individual travel and create demand shifts. Geographical dispersion relates to a variety of geographical locations. The larger internationally operating public transport organizations operate in different parts of the world with highly differentiated offerings and with senior leaders based at a variety of different locations. Empowerment develops experts to make key decisions, regardless of the level of authority and location.

Collaboration is a form of sharing that includes disruption sharing. Within a collaborative environment, information networks and links are relevant for joint purposes. They can provide early warning signals when something goes awry somewhere in the process and this enables coordinated actions. In addition, collaboration builds up trust between the members and allows learning from each other. Transparency is typically defined as a two-way exchange of information and knowledge between partners both in supplier and customer/client relations and can take many forms (Lamming *et al.*, 2001). The US Homeland Security strategy refers to the private transport sector in general as its members on the front line holding relevant information. Involvement of up-stream and down-stream partners in a joint life-cycle management programme can influence profitability and prolong the revenue stream (Pettit, 2008).

Resilience considerations can become important in the process of choosing partners, suppliers and other providers and has necessitated new types of contracts and relationships. However, in situations with power imbalances the organization with the greater financial strength might bear a larger burden of the investment risk. Communication between different organizations can be vital to save lives. In Israel bus bombings have occurred many times and when a disruption occurs there is direct communication between the operator, the hospital, the ambulance services, police and

other organizations. This includes early reporting and subsequent evaluation. In the aviation industry the sharing of data in GAIN (Global Aviation Information Network) is an example of collaboration on safety issues. No single airline may have enough experience from its own operations for a clear pattern to emerge from its own incidents reports, or it may not yet have encountered any events of that type. Collaboration with Fsuppliers can be relevant in case of technical failures in material, which has impact on the image of the operator. Collaboration with customer organizations is also relevant to prevent problems from becoming bigger and to respond quickly in a coherent way when there is a problem. Carbon footprint reduction requires collaboration in design and consumption to minimize potential environmental, health and safety problems.

Organizations need to be aware of the boundaries and to understand how close they are ‘to the edge’ in terms of degraded defences and barriers. What needs to be addressed are the culture and structure that enhances resilience. The public transport organization needs to balance accountability with empowerment. A learning organization uses several tactics to improve itself by means of internal reviews and through external feedback mechanisms such as benchmarking. Another organizational capability is diversity of skills and experience to create workforce flexibility and creativity. Like the organization’s leadership, the workers must be able to substitute for one another to create a flexible environment. Creativity is the source of new and competitive ideas through which the organization can position itself advantageously in its environment. Flexibility and creativity include training at all organizational levels to avoid panic or paralysis that typically ensue in emergencies. In addition to these features, MIT interviews with dozens of managers point to the importance of one element common to most resilient organizations – its culture (Sheffi, 2007; Zohar, 2003).

Culture is difficult to define, almost elusive, but can be described as a pattern of beliefs and expectations shared by the organization’s members. The artefacts are the visible structures and processes such as language, rituals and the way meetings are conducted. The espoused values include strategy, mission statements and goals. The organizational culture contributes to resilience by endowing employees with a set of principles regarding

the proper response. It suggests a course of action, even if the formal policy does not cover the situation at hand. An organization with a true culture of caring for its employees will foster both security and loyalty (Pettit, 2008). Within this system the organizational culture also needs to be sufficiently favourable to allow members to speak up if they are concerned about these issues. In this respect the auditing of operations and processes, and keeping track of environmental, health and safety performance, are needed. This also needs to be communicated to partners in all markets.

Knowing how to meet customer needs is essential for building and retaining *market position*. The relevant issue is having a competitive advantage in the market. The main effort in the process of recovering from a disruption is to isolate the customers from the effects of the disruption or to help them recover as quickly as possible. The customer-contact functions such as marketing, sales and distribution play a pivotal role in prioritizing services and communicating with the customers. Deciding which customers are vulnerable, and to what extent, requires an assessment of the critical situation of different consumer populations. Disruptions can be caused by external or political events, such as the closure of roads or shutting of petrol stations. Assurance of continued operations can provide competitive advantages as well as improved customer loyalty. Also, in the direct aftermath of a disruption the organization has to decide which customers to serve first.

Disruptions can offer organizations the opportunity to make a positive impression with a ready response and so enhance the brand. Brand equity is identified as a prevailing advantage that spans the entire failure and recovery sequence (Brady *et al.*, 2008). Customer loyalty helps to regain sales and market share after the event. Keeping one existing customer is five to seven times more profitable than attracting one new customer (Robert-Phelps, 2001). Established levels of trust are relevant to understand the changing of needs, especially during disruptions at critical times. The inevitable confusion and uncertainty connected to large-scale disruptions can be mitigated by open and effective communication. Feedback from customers and efficient communication will improve the organization's ability to anticipate, respond and adapt.

Security: the primary objective here is prevention either through deterrence, early identification or restrictions, and having effective, multifaceted security programmes in place (Center for Resilience, 2008). Layered defences are effective in both deterring and restricting access and do not depend on a single type of security measure (Christopher and Peck, 2004a). Access restrictions to facilities, material and equipment are necessary to safeguard assets. Keeping the public transport workforce alert and efficient is important at any time, but it may be crucial during disruptions. The use of a variety of personal security programmes includes awareness, threat assessments and travel restrictions. Securing information from theft and tampering is a factor in cyber-security. Given the high level of information dependency in public transport information, security levels need to be high. Recent media attention to the theft of customer identification data raises the issue of liability and potential losses. Organizations must collaborate with local and other governmental bodies to ensure security.

Financial reserves are especially critical in sustaining operations during periods of disruptions. The public transport organization needs to be financially secure. Reduced revenue or the extra expenses incurred during recovery operations may affect financial reserves (Hamel and Valikangas, 2003). Portfolio diversification includes the spreading of cash reserves. Organizations use many forms of insurance to protect themselves against major losses of the value of physical property, intellectual property rights and employees. Financial strength is related to the service price margin. Research has shown that higher price margins can contribute to a larger set of recovery operations available (Pettit, 2008). Pricing is an important weapon in the struggle to balance supply and demand, although in public transport tariffs are more or less a governmental responsibility and the competition for tenders is strongly based on low operational costs.

In the approach of the Center for Resilience the capability factor ‘product stewardship’ is also described. This deals with the assurance of sustainable business practices throughout the product life cycle. The issue is whether the organization has an effective product stewardship programme. In the approach of Pettit (2008) these elements are integrated

into other factors such as organization and collaboration. The motivation to follow that approach here is based on the applicability of the resilience framework approach to constrain the number of capability factors in the introductory phase.

The (sub-) capability factors discussed above are not exhaustive. The purpose is again to develop a compass rather than a complete list, which is by definition not possible in a turbulent environment. This also includes the discussion of sub-factors. The following section reports on the discussions of the above list with the public transport sector for reasons of verification.

6.6 Approach of empirical research

The approach for conducting the empirical research is discussed in Chapter 2. The interview was standardized and the search for confirmatory evidence as well as for exceptions will receive equal attention. The interviews consisted of the following sections:

- Section 1: For information and context: Terms of reference with explanation of theoretical framework and set of definitions;
- Section 2: Overview of identified, categorized and described vulnerability and capability elements with questions for clarification;
- Section 3: Interview to clarify the completeness of the elements and level of advancement in the resilience approach.

All information received from the various participants will remain anonymous and the outcome of the empirical research will be aggregated to ensure that no confidential information would be revealed. The final questionnaire used is attached as Appendix 2.

6.6.1 Cohort design: selecting stakeholders and participants

The generic arguments for selection of participants were discussed in Chapter 2. With the focus of the research on verifying vulnerability and capability lists and on generation new information specific relevant to public transport organization, stakeholders will be in principle public transport operators and transport authorities. They are responsible for

strategy as well as for identification, assessment and response processes, and in that respect they are responsible for managing the balance between vulnerabilities and capabilities. Through applying these criteria a homogeneous research group is developed and, according to Yin (2003) and Eisenhardt and Greaber (2007), six cases will be sufficient.

The participants involved in this interview are listed in Table 13, which lists the participants' names, organization and respective positions. In several interviews more than one participant contributed and no second separate interviews were conducted in the same organization. The findings of the interviews and information obtained have been clustered to the level of the participating organization (stakeholder level) and no distinction is made between the different responsibilities in the organizations. All findings were analyzed and sent back to the participants for confirmation.

<i>Stakeholder</i>	<i>Organization and country</i>	<i>Participant's name</i>	<i>Position and relevance</i>
Transport Operator	Veolia Netherlands	G. Veenstra	CFO and manager; Marketing; Strategy and finance expert.
		R. van de Pas	Manager business; Development and operational contracts expert.
Transport Operator	QBuzz Netherlands	A. ten Have	Member of the Board; Project manager.
Transport Operator	Connexion. Netherlands	R. Verstegen	Director Internal Control.
Transport Operator	Wiener Linien Austria	K. Bamberger	Deputy head: Organization and general economic affairs.
		M. Treiber	Corporate control (responsible for Corporate Risk Management System).
		N. Szivak	Corporate control (responsible for Corporate Risk Management System).
Transport Operator	RATP group. France	S. Dassonville	Risk Manager Officer.
Transport Authority/ Transport Operator	Transport for London United Kingdom	J. Burton	Head of Corporate Governance and Risk Management.
		N. Furlong	Group Resilience Advisor.
		A. Milter	Corporate Governance and Risk Manager.

Table 13: Participants in interviews on vulnerability and capability lists

The different participating organizations were not interviewed in a specific order. The five transport operators are divided into three Dutch and two other operators in European capitals (Paris and Vienna), and the interviewed transport authority is Transport for London (UK). Transport for London has a dual responsibility. It has a role as transport authority and of transport operator. Transport for London was selected mainly because they have recognized the need for resilience within their organization and have great insight into the activities of operators.

6.7 Interview findings

First the general findings will be presented. Second, the questionnaire findings on verification of vulnerability and capability (sub-) factors will be discussed and adjustments will be explained. Finally the level of progress in implementing resilience will be discussed.

Before discussing a these findings, a general conclusion can be formulated based on results from interviews presented in the previous chapter and this chapter. There is general consensus about the following points:

- A resilience policy needs to adopt an adaptive and structured approach;
- The framework, verified in the previous chapter, is relevant and applicable and needs to be based on the concepts of system development;
- Resilience needs to be integrated into the organization and not be a stand-alone function. It needs to reflect stakeholder's interests at operational, organizational and system level;
- Resilience approaches need to performance based;
- Resilience is an organizational responsibility, but needs to be coordinated and integrated with partner organizations. Specifically mentioned are infrastructure-related and policy-related (transport authority) organizations.

In line with the previous chapter, the conclusion can be formulated that the guiding principles, as discussed in Chapters 4 and 5, are accepted.

6.7.1 General research findings from interviews

All organizations mentioned experiences and strategic discussions in the domain of disruption management. With the exception of Transport for London, the corporate strategy statements of the five interviewed public transport operators do not explicitly mention the concept of resilience.

A systematic organizational approach based on the discussed framework has not been found, which confirms earlier observations, although elements of it are evident. They all also agreed about the relevance of developing a comprehensive structure. Identifying this gap has a bearing on the overall research goal.

In the framework the issue of improved performance is explained. From the discussions on improved performance a number of elements emerged. The list (Table 14) is arranged in sequence of mentioned performance elements. The number in the right-hand column indicates the frequency that items were mentioned in the six interviews in absolute numbers. Elements mentioned by a minority of two or less participants are not listed.

<i>Performance element</i>	<i>Frequency (max =6)</i>
Shorter time lag to detecting	6
Shorter time lag to reacting	6
More efficient reaction with cost awareness; better total cost of ownership	6
Better understanding of fundamental disruption factors	6
Better understanding managerial opportunities	5
Positive effects on image and reputation	5
Better systematic reporting	5
Better understanding of financial impacts	4
More targeted strategic approach to capabilities	4
Quicker creation of a resilient culture	4
Better knowledge about resilience	4
Better insight in collaboration and knowledge sharing	4
Better focus on core processes	4
Better relation with other topics like quality management or sustainability	3
Better understanding of governmental cooperation	3
Structured understanding of environment (+ partners)	3

Table 14: Overview of performance elements

The above frequently mentioned elements have been compared and classified to develop more generic performance indicators, with the ‘5i’ framework used in the Global Risk Network model “Global Risks” of the 2008 World Economic Forum. A better performance of these generic indicators will support the resilience approach.

On the basis of the interviews the positive contribution of a resilience approach can be described in the generic performance indicators (Table 15).

<i>Generic performance indicators based on the ‘5i’ framework of the World Economic Forum 2008.</i>	<i>Mentioned performance element from interviews</i>
<i>Insight</i> (improvement in managerial decisions through a more sophisticated understanding of the drivers and impacts of disruptions and the capabilities to use)	<ul style="list-style-type: none"> - Shorter time lag to detection; - Shorter time lag to reaction; - Better understanding of managerial opportunities; - More targeted strategic approach to capabilities; - Better focus on core processes.
<i>Information</i> (improvement of knowledge and reporting to improve the quality and flow of information – which should encourage transparency in the resilience framework)	<ul style="list-style-type: none"> - Better understanding of fundamental disruption factors; - Better systematic reporting; - Better knowledge of resilience.
<i>Incentives</i> (improvement, external and internal, as an incentive for ex-ante mitigation measures and even, where appropriate, disruption avoidance)	<ul style="list-style-type: none"> - Positive effects on image and reputation; - Quicker creation of a resilient culture.
<i>Investment</i> (improvement of financial judgements to indemnify the consequences of disruptions)	<ul style="list-style-type: none"> - More efficient reaction with cost awareness; better total cost of ownership; - Better relation with other topics such as quality management or sustainability.
<i>Institutions</i> (improved collaboration with partners and government is a prerequisite for expanded use, and to help improve resilience)	<ul style="list-style-type: none"> - Better insight in collaboration and knowledge sharing - Better understanding for governmental cooperation; - Structured understanding of environment (including partners).

Table 15: Classification of performances, based on Global Risk Model

Concerning the framework, all participants agreed about the closed-loop approach defined as part of the systematic approach, linked to improved performance.

Regarding the concepts of vulnerability and capability as determinants of resilience, participants all agreed on the following:

- Descriptions of vulnerability factors are clear;
- Descriptions of capability factors are clear.

Participants described lists of vulnerability and capability (sub-)factors as comprehensive, complete and applicable to the sector, and agreed that the discussed framework is in principle applicable in public transport organizations.

6.7.2 Findings on verification of (sub-) factors and adjustments

Within the context of the fact that all participants agreed on the descriptions of the vulnerability and capability factors and regarded both lists as complete and comprehensive, two main issues were discussed.

The first discussion dealt with possible connectedness within the vulnerability and capability factors lists. In the capability list the interrelationship between ‘Capacity’ and ‘Flexibility’ has been discussed already. One other example is the possible connectedness between “Connectivity” and “Supplier/Customer” in the vulnerability list that both reflect on external stakeholders. Participants agreed that this connectedness exist and that discussions about sub-factors linked to one specific factor will be part of the resilience approach discussions in the public transport organizations. Relevant is the focus on resilience as defined in connection with turbulent change. From that perspective the public transport organization needs to decide how it prioritizes vulnerabilities and capabilities. Interrelations are recognized and participants agreed that public transport organizations are professional organizations that understand the consequences of individual vulnerabilities and capabilities, but also understand that vulnerabilities and capabilities are interrelated. This will be discussed in the next chapter.

The second discussion item concerned the impact on the organization if the capability factor list becomes longer. Participant expressed concerns about the introduction of a structured resilience approach if too many capability factors are included. This will be further discussed in the next section on the level of progress in implementing a resilience approach.

In addition to this, although participants agreed about the completeness of both (sub-) factor lists suggestions for adjustment will be listed and commented on.

Proposals for changes to the vulnerability (sub-)factor overview – for further use they are numbered below, but not listed in order of priority:

- V1 'Turbulence' should reflect only accidental physical and health issues, such as pandemics, natural disasters and technological failures, and not social/political/economic issues, which should be a sub-factor in 'Pressures External';
- V2 Resource limits should have a sub-factor added to reflect financial resources i.e. *finite funding*;
- V3 Political/regulatory pressures as a sub-factor in 'Pressures External' is correct, but their relevance to the public transport operator is experienced to be much larger compared to the other sub-factors;
- V4 Adding *external inspections* to the list of sub-factors of 'Pressures External'.
- V5 The descriptions of the vulnerability factors *connectivity and supplier/customer disruption* are clear, but were not seen as substantively different.

Proposals for changes to the capability (sub-)factor overview – for further use they are numbered, but listed not in order of priority:

- C1 Sub-factors to be changed in 'Security' are replacing personal security with *staff and customer security*, adding *fraud detection* and adding to *layered defences* the issue of *protective measurements*;

- C2 Strengthen the relevance of the sub-factor “information pooling” in adding this to both the sub-factors of ‘Collaboration’ for external coordination and to ‘Organization’ for internal coordination;
- C3 *Process optimisation* to add as a sub-factor to ‘Efficiency’;
- C4 Changing the wording of ‘Flexibility in Order Fulfilment’ to ‘Flexibility in Demand Fulfilment’.

Proposals for change should be understood within the context of both lists having been rated as complete and comprehensive. If the suggestion for change was formulated by a participant, then after the interview with the subsequent participants, the question was posed as to whether that change would be supported. If two or more added responses were supportive, this was regarded as a positive contribution, reflecting a majority opinion. If the suggestion for change was made in the last interviews, then the question was posed by email to the previous participants. In all cases three or more supportive reactions were sufficient for motivating the change. This resulted in adaptations of V2 and V4 in the vulnerability lists and of C1, C2 and C3 in the capability lists according to the proposals above.

Concerning V1 that ‘Turbulence’ should reflect only accidental physical issues, pandemics, natural disasters and technological failures and not social/political/economic issues, which should be reflected in ‘External pressures’, no agreement was reached regarding this proposal and no adjustment will be formulated.

Concerning V3, ‘Political/regulatory pressures as a sub-factor in ‘Pressures External’ is correct, but their impact on, and relevance to, the public transport operator are experienced as being of greater relevance compared to the other sub-factors. The discussion is about possible different notions or values regarding the recognition of specific sub-factors within the vulnerability factor ‘Pressures External’. Political/regulatory changes and specific inspections together with environmental, health and safety requirements mostly from public bodies are regarded as having a greater impact than competitive innovation, social/cultural changes and price pressures,

corporate responsibility and environmental, health and safety concerns, if these have not been imposed by regulations. Price pressures following regulatory changes are considered to belong to the first group and are about the tariff system, but if deriving from competition, are considered to belong to the second group. From the discussions the following solution emerged. To express the relevance of political/regulatory changes in general, the sub-factors of 'Pressures External' will be divided into two categories: one related to *public bodies* and one to *other external pressures*.

Concerning V5, both factors "connectivity" and "suppliers/customer disruption" are considered as relevant. The difference between "connectivity to outside entities" in general to "suppliers and customers" more specifically was discussed in connection with the degrees of interdependencies. From these discussions the following solution emerged. The two factors will be combined to form one factor, i.e. "connectivity", and sub-factors will be subdivided into two groups. One group of sub-factors reflects interdependencies most related to the public transport organization's *net activities*, also discussed in Chapter 3, and mostly related to public bodies. The other group reflects *outside entities in general*, including interdependencies arising from the environmental structure. The environmental structure is also discussed in Chapter 3.

Concerning C4, the discussion on the wording 'Flexibility in Order Fulfilment' or 'Flexibility in Demand Fulfilment' led to rephrasing this as 'Flexibility in Order and Demand Fulfilment'. Order fulfilment is regarded by most participants as contract fulfilment with the transport authority, and demand fulfilment relates to the customers as –potential- users. Public transport organizations need to be flexible in reacting to demand turbulence as well as to contract turbulence.

The discussions led to the following vulnerability and capability lists (Tables 16 and 17):

Vulnerability <i>(exposure to factor)</i>	Description	Sub-factors Descriptors (not exhaustive) after verification
Turbulence Accidental	<i>Environment characterized by: changes in external factors beyond internal control.</i>	Natural disasters (floods, earthquakes); Health disasters, pandemics; Geopolitical disruptions; Unpredictability of markets ; Unforeseen technology and IT failures; Fluctuation in financial issues.
Threats, Intentional	<i>Deliberate attacks aimed at disrupting operations or causing human or financial harm.</i>	Terrorism and sabotage (internal, external) incl. cyber disruption, piracy and theft and espionage; Media pressures, offensive advertising, brand attacks; Labour disruptions, union activities, strikes; Special interest groups.
Pressures, External	<i>Influences, not specifically targeted at the public transport organization that create business constraints or barriers.</i>	<u>Related to public bodies:</u> * Political/regulatory change (including tariff); External inspections; * Environmental, health, safety concerns, <u>Related to all other than public bodies:</u> * Competitive innovation; Social/cultural changes; Price pressures (competitive); Corporate responsibility.
Resource limits	<i>Constraints on output and productivity based on availability of connected factors of production</i>	Natural resources; Intellectual property; Supplier and utilities availability; Asset utilization; Distribution availability; Data storage capacity; Human resources; Finite funding.*
Sensitivity	<i>Relevance of carefully controlled conditions for product, service and process integrity and liability</i>	Complexity of design and product purity; Complexity of process operations; Consumer requirements for quality; Restricted utilization of materials and data; Reliability of (key) equipment and IT; Potential safety hazards; Loss of key personnel; Visibility of disruption to stakeholders; Symbolic profile of brand; Concentration of capacity.
Connectivity	<i>Degree of reliance and interdependencies on outside entities</i>	<u>Outside entities in general:</u> * Scale/extent of (travel and traffic) networks; Reliance upon specialty sources and information flows. Reliability of external relations. <u>Net activity related outside entities:</u> * Supplier trust and reliability; Degree of outsourcing; Information independence and reliance; Customer and loyalty relations;

Table 16: Vulnerability (sub-)factors after verification
(* Sub-factors in bold are changes compared to the initial lists)

<i>Capability factors</i>	<i>Description</i>	<i>Sub-factors (not exhaustive) after verification</i>
Flexibility	<i>Ability to change quickly</i>	
Flexibility in Sourcing	<i>Ability to quickly change <u>inputs</u> or the mode of receiving inputs</i>	Modular product design; Standardization and commonality of parts; Multiple sources; Contract flexibility with suppliers.
Flexibility in Order And Demand Fulfilment	<i>Ability to quickly change <u>outputs</u> or the mode of delivering outputs</i>	Alternative transport and distribution offering; Update of information; Multiple service centers; Postponement.
Capacity	<i>Availability of <u>assets</u> to enable sustained production or service levels</i>	Utilities back-up sources; Asset reserve capacity beyond normal deviations; Labour capacity flexibility; Communication and back-up IT systems.
Efficiency	<i>Capability to produce outputs with minimum resource requirements</i>	Waste elimination; Labour productivity; Asset utilization; Quality management/ service variability reduction; Failure prevention; Process standardization and optimisation ; Preventive maintenance.
Visibility	<i>Knowledge of the status of operating assets and the environment</i>	Business intelligence gathering; Information/automation technology; Status of all personnel; Market visibility, external monitoring; Service and equipment visibility; People visibility.
Adaptability	<i>Ability to modify operations in response to challenges and opportunities</i>	Learning from experience/feedback mechanism; Strategic simulation; Alternative technology development; Fast re-routing and re-scheduling; Seizing advantages from disruptions Product life cycle management.
Anticipation	<i>Ability to discern potential future events or situations</i>	Monitoring early warning signals; Forecasting (horizon); Deviation and near-miss analysis; Preparedness planning; Business continuity planning; Emergency preparedness; Government lobbying.
Recovery	<i>Ability to return to normal operations state rapidly</i>	Crisis management; Equipment reparability; Resource mobilization; Communication strategy; Mitigation processes.
Dispersion	<i>Broad distribution of assets</i>	Asset and key resources decentralization; Distributed decision making; Dispersion of markets; Location-specific empowerment.
Collaboration	<i>Ability to work effectively with other entities for mutual benefit</i>	Disruption sharing with partners; Supplier relation management; Client and customer relation management; Collaborative forecasting; Communication and information pooling .*

Organization	<i>Human resources structures, policies, skills and culture</i>	Empowerment; Creative problem solving; Accountability including reporting; (Cross-) training and workforce flexibility; Culture of caring; Functional information coordination.*
Market position	<i>Status of organization or its product/services in specific markets</i>	Product positioning; Market share; Brand equity; Customer service management; Sustainable position; Customer loyalty/retention.
Security	<i>Defence against deliberate intrusion or attack</i>	Access restrictions; Employee involvement; Collaboration with governments; Staff and customer security;* Cyber security; Layered defences and protective measurements;* Fraud detection.*
Financial strength	<i>Capacity to absorb fluctuations in cash flow</i>	Financial reserves and liquidity; Price margin; Insurance; Portfolio diversification.

Table 17: Capability (sub-)factors after verification
(* Sub-factors in bold are changes compared to the initial lists)

6.7.3 Findings on level of progress of resilience approaches

Addressing resilience explicitly. Among the participants only Transport for London (TfL) addresses resilience considerations explicitly. A systematic approach to resilience management has been developed. The TfL Resilience Management Policy Framework sets out the approach to minimising the likelihood of operational and non-operational disruptions, and by maintaining adequate capability to prepare for, manage and recover: ‘We will prepare for and be able to efficiently recover from whatever cause’ (Transport for London, Safety, Health and Environment Assurance Committee, 2010: 2). All resilience planning and responses are based on the principle of ‘prudent over-reaction’ and support the TfL business plan. Their approach includes assessment, recovery planning and assurance. Emergency and contingency plans identify a worst-case scenario, likely foreseeable event to be mitigated against. Assurance of implementation of the TfL Resilient Management Policy Framework will be provided via four principal mechanisms: Management involvement, TfL Risk Management processes, Internal Audit and Resilience Assurance Letter. The latter consists of a series of compliance statements

related to resilience management. Series of questions are addressed to each of the operational modes and corporate directorates that need to address issues of resilience. Respondents complete the questionnaires, which are signed off by managing directors as being correct and complete. Although not applying the framework developed in this research, the concepts of a systematic approach as described in Chapter 4 and 5 can be recognized in this procedure. The TfL approach follows the guiding principles of the framework presented in this research. TfL has no lists of vulnerability and capability (sub-)factors and has no structured contextual resilience approach. The balance between vulnerabilities and capabilities is not approached in relation to better overall performance. TfL is willing to share their knowledge.

Applying resilience in the public transport organization. Participants agreed on the relevance of specific focus on turbulent changes and severe consequences. Participants have not experienced all vulnerability factors and sub-factors listed in this research, but confirmed their potential relevance. There is agreement about the considerable efforts needed to get higher management to justify the attempts to analyze these factors within a shrinking finite budget and resource pool. The discussions on applying a resilient approach revealed a concern about 'having just another next system', which needs to be taken into consideration. The introduction of quality management and the 6-Sigma methodology or Human Resources Management, and the competence matrixes were mentioned as examples. In principle two options are recognized:

- A differentiated approach: introducing resilience, including the proposed framework, from a strategic perspective in addition to risk management as the more operationally oriented perspective;
- An integrated approach: introducing resilience to be developed in conjunction with the existing risk management tools as a comprehensive and systematic organizational approach.

A majority of the participants support the concept of introducing resilience, based on a differentiated approach but with a strategic perspective, followed by an integrated approach. The concept of integration refers to planning levels (strategic to operational), data and information integration, and functional integration (departments involved). The

main concern about a differentiated approach is that it does not have enough synergetic advantages. All participants agreed about the knowledge-developing process as part of achieving a higher level of resilience in time and the use of integrated reporting systems. The TfL Resilience Assurance Letters are an example.

Applying presented lists of vulnerability and capability overviews. Identifying and categorizing vulnerabilities and capabilities are recognized by all the respondents as relevant and considered as achievable in their own organizations, based on the lists provided, within the context of the previously stated concerns about applying resilience in the organization. The discussions addressed the option of generic lists in addition to more specific vulnerability and capability factor and sub-factor lists oriented to specific transport modes used in public transport. Participants agreed about the relevance of formulating the factors at a generic level and the sub-factors more on a generic/sector-specific level. Organizational or mode-specific sub-factors can be seen as supplementary. Arguments for this are the strategic view needed for the possible inter-organizational or sector knowledge sharing and the communication and interaction with linked partners. In this respect the relation between the operator and the transport authority was specifically mentioned. All participants agreed about the relevance and opportunities that could emerge if the concept of resilience were expanded to a coordinated level, but did not see this as a priority. In all cases participants supported the use of vulnerability and capability lists in general from the perspective of enabling possible longitudinal analyses.

6.8 *Summary and interpretations*

The third research objective is: To identify the main elements that create knowledge about the resilience design. The research was structured in two parts. Based on literature sources and experiences stating vulnerability and capability factors, including the descriptions and sub-factors, two lists were designed. These list were discussed with participants representing public transport organizations for the sake of verification and generation of new information. This produced the *following conclusions*:

- Based on interviews, the formulated *guiding principles* can be regarded as justified;
- In addition to the *verified framework*, this chapter contributes with *verified lists of vulnerability and capability factors* with definitions and with linked sub-factors.

The preceding chapters presented *contextual* and *cognitive resilience*, while this chapter presents *behavioural resilience* as the ability to use diagnostic tools proactively in the creation of potential lists of vulnerability and capability factors. These factors enable the public transport organization to analyze its current vulnerabilities and capabilities. The embedded diagnostic tools can help to structure and analyze vulnerabilities and capabilities to predict and explain potential organizational behaviour. The public transport organization will have to analyze its relevant vulnerabilities and needs to balance them with the appropriate capabilities. The next chapter will analyze the concept of *balanced resilience* and discuss the ranking of vulnerability and capability lists to ascertain whether public transport organizations are able to create linkages between the two lists.

7 *Balanced resilience and managerial implications*

7.1 *Introduction*

This chapter will continue to develop an understanding of the resilience management process. It will discuss the fourth research objective: To ensure that public transport organizations are able to make linkages between vulnerabilities and capabilities. For this to occur, it is essential that public transport organizations are able to measure and rank vulnerability and capability factors to determine their importance. This can also be referred to as the positioning of the *as-is status*. In addition, critical linkages between vulnerabilities and capabilities need to be recognized. By identifying critical linkages, public transport management can utilize this information to manage purposeful change toward the desired state of resilience – to be referred to as the *to-be status*. The capacity of the public transport organization to measure, to determine the importance of, and to identify critical linkages between vulnerabilities and capabilities will be referred to as *balanced resilience*. Therefore a two-step approach is developed to achieve this. First, a survey-based assessment tool is developed to measure and rank the vulnerabilities and capabilities. Second, the validity of the identification of critical capability linkages is discussed. In this way the ability to accurately measure the construct of resilience will be attained.

7.2 *Capability to rank vulnerability and capability factors*

Both external and internal forces will sooner or later create an inadequacy within the existing resilience system. No stage of resilience can exist permanently in a given system. The notion of dynamic loops at the management level is not new. The Deming circle is a concept that has been advocated for several decades already, but it is possible to detect some paradoxes. First, the reluctance or resistance to shift can in itself be part of the concept of resilience. Second, if the change of type of resilience is positioned at higher levels, the lack of visibility in vulnerabilities and the potential of capabilities, as the system improves, makes resilience more complicated. As the system of resilience

improves, the likelihood of new vulnerabilities developing could decrease. This growing difficulty in foreseeing the next stage of resilience and the absence of the ultimate visibility of the resilience system may create its own vulnerability. In addition, the concept of resilience, along with the anticipated tools to deal with it, needs to address these issues head on as a new management discipline that encompasses resilience management being integrally entwined with other aspects of management. Essential is the ability to define linkages between vulnerabilities and capabilities.

From the interviews it became clear that participants do not consider every vulnerability and capability factor as of equal importance at a certain moment in time, and yet at the same time they were clear about the possible ability to measure their current relative position of importance. Additional evidence is necessary to validate this ability. In order to determine priorities and to compare results between participants, an assessment tool has been developed to measure the relevance of factors that *currently* challenge the public transport organization with questions about the possibility of rating the relative importance of factors. A matter of concern during the development of the survey was the large number of sub-factors and so, in order to maintain a reasonable survey length, the research was focused on the level of vulnerability and capability factors (Appendix 3). Ranking leads to the selection of the most important factors of the different public transport organizations and this can in turn provide an overview of generalizable weaknesses. The essence, however, is to validate the ability to measure and rank these factors.

Only public transport organizations participated in this part of the research. Participation in assessments was based on selecting from the previous interview participants in accordance with the criteria discussed in Chapter 2. From this total list of eight interviewed public transport organizations, four participants were selected and HTM (transport operator in the city of The Hague) was added. The transport authority of The Hague was asked to participate in previous interviews, but based on the fact that it is the public transport organization that is responsible for measuring and ranking, HTM was approached in its capacity as transport operator instead, resulting in a total of five public

transport organizations to interview. Participating organizations are Transport for London, Wiener Linien, Veolia transport, QBuzz and HTM; the last three are located in the Netherlands.

This exceeds the minimum requirements identified by case study designers to reach a state of saturation (Crabtree and Miller, 1999; Yin, 2003) and is in accordance with the studies evaluated by Groves and Peytheva (2008), about the impact of non-response rates to non-response bias. The goal in this section is not to promote consensus building or decision making, but to gather information and to understand whether ranking and prioritizing are possible, and so to accomplish the *ability to measure and rank* the vulnerabilities and capabilities.

7.2.1 Ability to undertake measurement and ranking

In order to determine the priorities of factors, the survey (Appendix 3) included questions concerning the as-is status by both measurement of factors and by rating the relative importance of those factors (Lambert, 2006). To assist participants to respond adequately, considerable care was given to the design of the questions (Tables 18 and 19). The average time to complete the assessment on measuring and ranking was 30 minutes. The survey responses are in ordinal form according to the Likert Scale “Disagree/Agree” ranging from 1 to 5. A “Don’t Know” category was added. Data recorded showed no blanks and the “Don’t Know” category was 5 percent, spread out over all participants. All personal identifying data have been removed in the analysis to ensure confidentiality.

Analysing the results from the different participants provided strong validation of the ability of the assessment tool to measure and rank vulnerabilities and capabilities on average value. Feedback on the assessment tool was positive. With this ability proved, it is assumed that public organizations can also measure and rank towards a future situation.

The purpose of the following part of this section is to explain *the relevance of the analysis opportunities* of measurement and ranking to reach the as-is status and not so much to focus on the relevance of the results of this analysis.

Although data used came from different organizations, the same approach to analyzing data can be followed when there is more than one assessment in the same organization. The development of an understanding of similarities and differences in valuing factors when using a systematic approach can provide the organization with more in-depth information. The approach is to review each assessment individually and later make a comparative analysis. This research combines the five assessments of different participants in order to justify the approach (Table 18).

Ranking	Vulnerability factor	Average value on scale 1-5	Min-Max value
1	<i>Resource limits:</i> Our organization faces constraints on output and productivity is based on availability of relevant factors of production.	4.6	4 - 5
2	<i>External Pressures:</i> Our organization faces influences, not specifically targeted at our organization, that create business constraints or barriers.	4.4	4 - 5
3	<i>Connectivity:</i> Our organization has a high degree of reliance on, and inter-dependencies with, outside entities.	3.9	2 - 5
4	<i>Sensitivity:</i> Our organization depends on the relevance of carefully controlled conditions for product, service and process integrity and liability.	3.2	2 - 4
5	<i>Deliberate Threats:</i> Our organization faces deliberate attacks aimed at disrupting operations or causing human or financial harm.	3.2	2 - 5
6	<i>Turbulence:</i> Our environment is characterized by frequent changes in external factors beyond our control.	2.4	2 - 4

Table 18: Vulnerability factor ranking and measurement
(Values of five public transport organizations)
(Rank from 1 to 6; values: Disagree = 1 to Strongly Agree = 5)

Analysis of vulnerability factors shows ‘Resource Limits’ and ‘Pressures External’ as the highest rankings with a relatively small differentiation in the min-max ranking pattern, followed by ‘Connectivity’ with a more mixed value pattern. Finally ‘Sensitivity’, ‘Deliberate Threats’ and ‘Turbulence’ also show more mixed values (Table 18). In the discussions it became clear that the ‘Pressures External’ ranking was mostly based on pressures related to ‘public bodies’, which is also discussed in Chapter 6. The literature

on resilience often places more emphasis on ‘Turbulence’ and ‘Deliberate Threats’ than these results indicate, within the limitations of data available.

Capabilities measurements can also be ranked based on the available data (Table 19).

Ranking on average value	Capability factor	Average value on scale 1-5	Min - Max Value
1	<i>Visibility:</i> Our organization has knowledge of the status of its operating assets and the environment.	4.4	4 - 5
2	<i>Market position:</i> The status of the organization or its product/services in specific markets is clear and strong.	4.2	4 - 5
3	<i>Anticipation:</i> Our organization has the ability to discern potential future events or situations.	4.0	4 - 4
4/5	<i>Capacity:</i> Our organization has the availability of assets to enable sustained production or service levels.	3.8	3 - 4
4/5	<i>Collaboration:</i> Our organization has the ability to work effectively with other entities for our mutual benefit.	3.8	3 - 4
6	<i>Recovery:</i> Our organization has the ability to return to normal operational state rapidly.	3.8	3 - 5
7	<i>Financial strength:</i> Our organization has the capacity to absorb fluctuations in cash flow.	3.8	2 - 5
8	<i>Adaptability:</i> Our organization has the ability to modify operations in response to challenges and opportunities.	3.6	3 - 5
9	<i>Dispersion:</i> Our organization has a broad distribution of assets.	3.4	3 - 4
10	<i>Security:</i> Our organization has stringent and layered defence mechanisms against deliberate intrusion or attack.	3.3	3 - 5
11/12	<i>Flexibility in order and demand fulfilment:</i> Our organization has the ability to quickly change outputs or the mode of delivering outputs.	3.2	2 - 4
11/12	<i>Organization:</i> Our organization develops human resources structures, policies, skills and culture.	3.2	2 - 4
13	<i>Efficiency:</i> Our organization has the capability to produce outputs with minimum resource requirements.	2.8	3 - 5
14	<i>Flexibility in sourcing:</i> Our organization has the ability to quickly change inputs or the mode of receiving inputs.	2.6	1 - 4

Table 19: Capability factor ranking and measurement
(Values of five public transport organizations)
(Rank from 1 to 14; values: Disagree = 1 to Strongly Agree = 5)

The results show that major strengths are ‘Visibility’, ‘Market position’ and ‘Anticipation’.

The ability to measure and rank of sub-factors was discussed. Most participants agreed that if the sub-factors are analysed in advance and, on that basis, selected as relevant or not relevant to the public transport organization at the time of the measurement, a more precise result is achievable. The overall conclusion is that public transport organizations are able to rank these sub-factors and, in doing so, provide a basis for decision making on capability factors.

Following the measurement assessment, each participant was asked to report on the perception of the relative importance of each of the factors. To ensure that the participants were exposed to each of the vulnerability and capability factors, the questions were presented directly after the discussion on measurement. As vulnerabilities represent the *fundamental* factors that make the public transport organization susceptible to disruptions, this ranking is considered not likely to be affected in the short term. In the long term, with a changing environment, a re-evaluation is required.

Although each public transport organization presented its own data, a compilation of priorities of the five participants together is shown, more in the context of analysis than to evaluate the data in Tables 20 and 21.

Vulnerability factor ranking of importance	Level of importance on a scale of 1-5	Min-Max Value
1: External Pressures	4.4	3 - 5
2: Resource Limits	4.0	2 - 5
3: Sensitivity	3.6	3 - 5
4: Deliberate Threats	3.4	1 - 5
5: Connectivity	2.1	1 - 3
6: Turbulence	2.0	1 - 4

Table 20: Importance of vulnerability factors
(Rank from 1 to 6; values: Disagree = 1 to Strongly Agree = 5)

Analysing the capabilities of public transport organizations provides interesting insights into their relative priorities. Highest ranking factors with a small differentiation in Min–Max pattern are ‘Market position’ and ‘Financial strength’. ‘Security’ shows a larger Min-Max distribution.

Capability factor Ranking of importance	Level of importance on a scale of 1-5	Min-Max value
1/2 : Market position	4.6	4 - 5
1/2 : Financial strength	4.6	4 - 5
3 : Efficiency	4.2	3 - 5
4 : Flexibility in sourcing	4.0	3 - 4
5/6/7/8 : Flexibility on order/ demand fulfilment	3.6	2 - 5
5/6/7/8 : Capacity	3.6	2 - 5
5/6/7/8 : Visibility	3.6	3 - 5
5/6/7/8 : Recovery	3.6	2 - 5
9 : Security	3.5	1 - 5
10/11/12: Anticipation	3.2	2 - 5
10/11/12: Collaboration	3.2	2 - 4
10/11/12: Organization	3.2	2 - 4
13 : Dispersion	2.6	1 - 5
14 : Adaptability	2.0	1 - 3

Table 21: Importance of capability factors
(Rank from 1 to 14; values: Disagree =1 to Strongly Agree = 5)

Combining the assessment of measurement and of ranking of importance can provide insight into possible managerial priorities. Although each public transport organization presented its own data, a compilation of data of the five public transport organizations is presented in Tables 22 and 23. The analysis is intended to underline the relevance of the ability to measure and rank. Taking *ranking of importance* as a starting point and based on the presented data on the average factors for vulnerabilities, Table 22 shows a general balance, with the exception of ‘Connectivity’. It is a matter of concern when the measurement and the level of importance are not in alignment and therefore further managerial attention might be needed.

Vulnerability factor ranking of importance based on five public transport organization	Average level of importance on a scale of 1-5	Average measured value on a scale of 1-5
1: External Pressures	4.4	4.4
2: Resource limits	4.0	4.6
3: Sensitivity	3.6	3.2
4: Deliberate Threats	3.4	3.2
5: Connectivity	2.1	3.9
6: Turbulence	2.0	2.4

Table 22: Importance of level of vulnerability and its measurement

Analysing capabilities in the same way might make evident areas of concern with low measurement scores and high importance that should be prioritized for improvement, such as ‘Efficiency’ and ‘Flexibility in sourcing’, or with high measured capabilities and low importance, like ‘Anticipation’ or ‘Adaptability’ that may erode profits.

Capability factor ranking of importance based on five public transport organizations	Average level of importance on a scale of 1-5	Average measured value on a scale of 1-5
1/2 : Market position	4.6	4.2
1/2 : Financial strength	4.6	3.8
3 : Efficiency	4.2	2.8
4 : Flexibility in sourcing	4.0	2.6
5/6/7/8 : Flexibility on order/ demand fulfilment	3.6	3.2
5/6/7/8 : Capacity	3.6	3.8
5/6/7/8 : Visibility	3.6	4.4
5/6/7/8 : Recovery	3.6	3.8
9 : Security	3.5	3.3
10/11/12: Anticipation	3.2	4.0
10/11/12: Collaboration	3.2	3.8
10/11/12: Organization	3.2	3.2
13 : Dispersion	2.6	3.4
14 : Adaptability	2.0	3.6

Table 23: Importance of level of capability and its measurement

It should be noted again that the purpose of this section is not the analysis of the results themselves, but to explain or establish *the ability of public transport organizations to measure and rank and analyse* vulnerability and capability factors. In summary, it can be concluded that public transport organizations are able to measure and rank vulnerability

and capability factors with the tool provided. Based on this, it is possible to analyse the most important factors and to analyse whether a gap exists between the relative ranking position and the measurement. Given that, the current as-is condition of resilience can be determined.

7.3 Identification of critical linkages

Knowing the current state of resilience is only the first step towards a managerial approach to dealing with disruptions. Managers need to improve their organization's resilience to devise strategies for survival and long term-growth. In order to implement the construct of resilience, it is necessary to understand the linkages between the vulnerability and capability se factors. This section will discuss the *ability to identify critical linkages*. The proposition "Resilience increases as capabilities increase and/or vulnerabilities decrease" (RP-9) is accepted on the basis of the preceding research. Furthermore, the relation between resilience and performance is discussed with the presumption of a balance between vulnerability and capability factors. In that discussion there was no emphasis on the possible differences in relevance and from the previous section it is evident that factors are not of equal relevance to the public transport organization at a certain moment.

Outside the balanced zone, imbalances can have two different positions (Figure 15). Extensive vulnerabilities relative to capabilities will result in excessive exposure to disruptions, while excessive capabilities relative to vulnerabilities will erode the profitability of the public transport organization. Both positions are considered as states of unbalanced resilience and therefore undesirable; this has been discussed and confirmed in discussing the research proposition: "(Public transport) performance improves when capabilities and vulnerabilities are *balanced*" (RP-10).

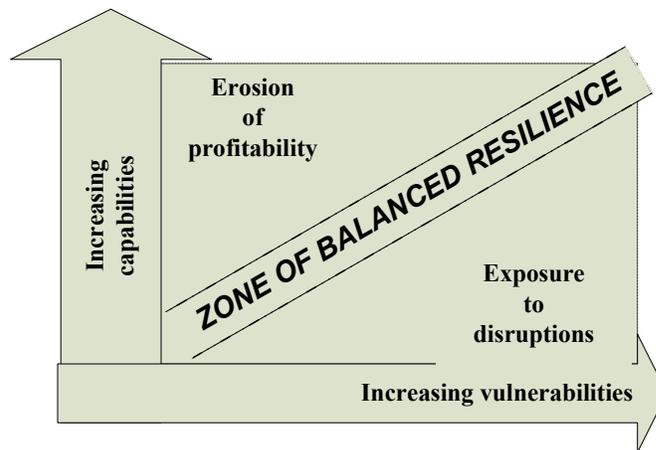


Figure 15: Zone of balance between vulnerabilities and capabilities

The zone of balanced resilience arises from a fit between vulnerability and capability factors. In this section the identification of capability linkages will be the starting point. By identifying capability linkages that have direct effects on specific vulnerabilities, public transport management can purposefully create a portfolio of capabilities best matched to their pattern of vulnerabilities, and change toward achieving their desired state of resilience. Higher resilience levels will improve anticipation, reaction and adaptation to the changing environment and thus improve performance. A well-balanced resilience prevails in the combination of low vulnerabilities matched with low capabilities, as well as with high vulnerabilities matched with high capabilities. Through measurement and ranking of vulnerabilities and capabilities, and by balancing both, the condition of balanced resilience can be achieved. Given its exploratory perspective, this study does not attempt to define or predict the relationships between vulnerability and capability factors and scores.

This phase of the exploratory research combined – in addition to the theory developed from previous chapters – evidence building by using a pilot experiment, case study methods by using interviews, and qualitative interpretation of experts to triangulate these methodologies to improve confidence in the ability to develop critical linkages.

7.3.1 Research on linkage capability by using a experiment method

With 6 vulnerability factors and 14 capability factors recognized, the potential number of linkages is 84. For reasons of building understanding and testing the tool, these linkages were discussed in academic sessions with fifty fourth-year students in the Department Traffic Studies at the NHTV University of Applied Studies in Breda, the Netherlands, who were attending a module on strategic developments in public transport. The results achieved during two subsequent sessions of two hours each are outlined below.

First there was a discussion on the starting point for developing critical linkages. In Chapter 6 the following proposition was formulated to start building the resilience construct: “The creation of a resilience framework is built on the concept of vulnerabilities, which results from some type of change, and the adaptive capacity to react and adapt”. Following this reasoning, the linkages can be formulated from the perspective of the vulnerability that needs to be mitigated. The relation could be formulated as: “If this vulnerability were to occur, which of the 14 capabilities would have a mitigating effect”? This perspective took the vulnerability as starting point. The question could also be formulated differently. Reasoning from the capability site, the linkage could be formulated as: “If this capability were well developed, would it minimize the effect of one of the following vulnerabilities”? This would take the capability as starting point.

Both options were discussed from the perspective of developing a strategic proactive approach. It has been seen that both lists of factors were described by the respondents as complete and comprehensive. Both starting point approaches can also be analyzed together from the perspective of creating linkages and developing a critical set that may be utilized for a change to the desired level of resilience. Clearly, because of the researcher’s knowledge and experience of the research, the first option is used in this part of the research. In the following sections this will be discussed further.

Secondly, the descriptions of vulnerability and capability factors have been modified to “if-then relations” to stipulate the possible linkages.

* Vulnerability factors have been rephrased in the form of questions. For example, turbulence was initially described as “Environment characterized by frequent changes in external factors beyond internal control”. This has been rephrased to a question: “Is our public transport organization characterized by an environment with frequent changes in external factors beyond our internal control”?

* Sub-factors (in this case of Turbulence) were listed as indicators of that factor. This will provide more insight into that factor.

* Capability factors were described in Chapter 6. This description is used to formulate a statement. For example, the concept of efficiency has been rephrased using this description and by adding a value account as: “A *high* capability to produce outputs with minimum resource requirements”.

This means, using the above examples, that the following relation is discussed: “If our public transport organization is characterized by an environment with frequent changes in external factors beyond internal control (such as natural disasters, pandemics, geopolitical disruptions, unpredictability of markets, fluctuations in financing and unforeseen technology failures), then a high capability to produce outputs with a minimum of resource requirements (such as high level of waste elimination, asset utilization, labour productivity, failure prevention, process standardization, service variability reduction and preventive maintenance) would have a strong (S) or moderate (M) and low or no (N) effect”.

If questions could not be answered, or if no arguments could be put forward, this would result in a blank, which occurred in 30% of the potential linkages. Results have been presented in a matrix-type document. These results were discussed with the two student groups. It should be noted that the absence of a relation does not in itself negate the possibility of a linkage existing, but only that the participants in the limited sample base did not assess the relationship accordingly.

Although the reformulation took considerable effort, the following findings are relevant:

- 1) Linking capabilities to vulnerabilities was not different using different statement perspectives such as cost leadership and operational excellence;
- 2) All capabilities have been recognized more than once with the qualification of a strong or moderate relation. Clearly some developed capabilities mitigate more than one vulnerability, as discussed in the previous chapter.

Figure 16 is the result of the presentation from the group focusing on cost leadership.

Matrix of capabilities linked to vulnerabilities														
CAPABILITY:	FLEXIBILITY		CAPACITY	EFFICIENCY	VISIBILITY	ADAPTABILITY	ANTICIPATION	RECOVERY	DISPERSION	COLLABORATION	ORGANIZATION	MARKET POSITION	SECURITY	FINANCIAL STRENGTH
	s	o												
TURBULENCE (ACCIDENTAL)					s	s		s				c	c	s
THREATS INTENTIONAL		n	m			s	s	s			s	s	s	s
PRESSURES EXTERNAL		n		n		s	s	s	n		s	s		s
RESOURCE LIMITS	n	s	n	s	s	s	s	s	n	s	s		n	s
SENSITIVITY	n	n	s		s	s	s	m			s		n	m
CONNECTIVITY	s	s	n	n	s	s	s	n	n	m		n	n	n

Figure 16: Matrix of capabilities linked to vulnerabilities
 (Perspective of cost leadership by NHTV students; 18 January 2010;
 s = strong relevance; m = medium relevance, n: not relevant)

7.3.2 Research on linkage capability using the case study method

With the same population of the five public transport organizations mentioned above, the identification of linkages is researched. Each interview is regarded as a specific case. The average time of this part of the interview was 15 minutes.

After measurement of factors and ranking of importance, the participants were asked to select *one* vulnerability factor in the category “critical” based on the provided list of importance of vulnerability factors produced before.

In order to mitigate this vulnerability, participants were asked to link this to the capability list in the following categories:

- “strong effect (S) of this capability to mitigate the chosen vulnerability”;
- “moderate effect (M) to mitigate the chosen vulnerability”;
- “low or no effect (N) to mitigate the chosen vulnerability”;
- and finally the category “Don’t Know”.

The five participants chose three different vulnerabilities to link to: ‘Resource limits’ twice, ‘External pressures’ twice, and ‘Sensitivity’ once. The category “Don’t Know” was used twice out of the total of 70 linkages (5 interviews with one vulnerability selected to 14 capabilities) discussed with the five participants. Participants were able to link the capabilities to the chosen vulnerability and were able to provide a motivation when asked for one.

The participants were then asked to choose *one* capability in the category “critical” from the list of importance of capability factors produced before. Using the same categorization (strong, moderate or low effect, or “Don’t Know”), participants were asked if this capability was extensively employed in their own public transport organization, and on which vulnerabilities it would have a mitigating effect in the above-mentioned categories. Participants selected the following five capabilities: ‘Organization’, ‘Efficiency’, ‘Capacity’, ‘Collaboration’ and ‘Financial strength’.

Participants used the category “Don’t Know” only once out of the 30 linkages discussed with the five participants (5 interviews with 1 capability selected to 6 vulnerabilities).

From this it can be concluded that participants showed *the ability* to determine linkages in the selected situations and the assumption made is that they are capable of doing this with all possible linkages. Consistency in responses has not been analyzed, as organizations mentioned different critical vulnerabilities and capabilities, depending on the local situation.

Creating a balanced resilience approach is possible with vulnerabilities as the starting points and then the relevant associated capabilities can be identified. But alternatively, analyzing capabilities first would also give the opportunity to determine on which vulnerabilities there has been a potential mitigating effect. Participants were asked which of the two approaches described would be most workable in their organization.

The overall response was that this should not be reduced to an either-or question and that both approaches have their justification. A mixed approach would entail aligning both approaches and could play a role of cross-checking and leading to better understanding. The second approach is seen as a more active and self-confident approach. Linking this to existing approaches such as the Balanced Score Card and Change Management approaches might support this view. Furthermore, accountability and responsibility for managing capabilities are found to be more linked to the existing organizational structures. At the same time participants believe that the first approach, regarded as a more defensive approach, will be followed because the public transport organization has a more problem-oriented focus. The culture is described as more reactive than proactive, and such an approach connects better to current security and risk approaches.

Finally, participants all reacted positively to the question of whether organizations are also able to analyze linkages at the sub-factor level. The issue of the time to analyze this was mentioned as a point of concern. A process of connecting to sub-factors was seen as

an interactive feature to take advantage of in the discussion process and to move more quickly to the discussion of relevant linkages.

The finding, as a complement to the literature survey as well as the empirical research and the experiment discussed, is that public transport organizations are able to define linkages and that the approach of starting with vulnerability analysis and then identifying capability linkages is adopted. The results of the triangulation approach are encouraging. For further validity the confluence of all research methods is desirable; however, “the absence of results from a single method does not negate a potential linkage” (Pettit, 2008: 162).

7.4 Expert meeting to extract inferences on managerial capabilities

A resilient public transport organization needs to design appropriate levels of anticipation, preparedness and adaptability in addition to the responsive skills that are essential to creating a competitive advantage. Previous sections showed that public transport organizations can identify the state of resilience and such organizations are able to create a portfolio of best-matching capabilities. Organizations need to balance revenue streams with preparation and recovery costs, short-term customer service and long-term values in terms of return on assets (Slone *et al.*, 2007).

Strategies to deal with changes need to be aligned with an organization’s earning drivers (Ahlquist *et al.*, 2003). Resilience is not a feature intended only for responding to disasters; Flynn (2008) points out the economic benefits of resilience, because virtually all of the attributes that make a company resilient are things that make a company work better anyway. Resilience is also not only the static state, but the responsiveness to an ever-changing environment. Flynn describes the concept of resilience in terms of the four R’s: robustness, resourcefulness, recovery and review.

The purpose of this section is to discuss the managerial capabilities for applying resilience in public transport organizations. The structure of the framework, the

overviews of vulnerability and capability (sub-)factors and the ability to measure, rank and link these factors are the starting points.

Experts have been selected on the basis of the criteria formulated in Chapter 2 ranging from high expertise to strategic-level developments and knowledge about transitions (Table 24).

<i>Participants</i>	<i>Role and function</i>
G.A. Kaper	Expert: CEO (HTM) until 2010, consultant.
T. Kienhorst	Expert: CEO (Veolia) until 2010, consultant.
B.R.H. Lammers	Expert: Senior Advisor TNO research; Co-author: <i>Risk Management and Logistics</i> .
M. Timmer	Secretary.

Table 24: Participants in expert meeting

The expert meeting was scheduled for three hours and findings are reported as meeting results and not related to individual participants. Participants received the minutes of the meeting for comments, which have been incorporated into the findings. The meeting is guided by a protocol (Appendix 4, Part 1) to collect the necessary data, while maintaining the highest level of reliability possible. The protocol allows flexibility for the experts to assist the researcher as the moderator in order to keep the group focused on the topic and to cover all necessary areas; the protocol was sent to the participants in advance. The protocol provides information on definitions, the resilience framework and the assessment tool (part of Appendix 3) as well as the agenda of the meeting.

7.4.1 Results of expert meeting

The findings of the expert meeting are presented in Appendix 4, Part 3. From this several points may be abstracted.

- 1) Public transport organizations have unique features, in addition to their common activities. Comparisons between public transport operators must be viewed in the context of different legal structures [in Europe] as well as from the perspective of the different modes of transport (bus or rail (tram, metro) or water). The identification and measurement, ranking and linking of vulnerabilities and capabilities must be placed in the perspective of the *function* of the public transport organization.

- 2) The resilience approach needs to focus on the strategic level. The approach is based at the level of the organization. Organizations have different approaches to the distribution of responsibilities. The *framework is applicable* within a more centralized as well as with a decentralized distribution of responsibilities. The results of the identification of vulnerabilities and capabilities may differ, based on the organizational approach (leading to insights related to responsibilities in the organization on vulnerabilities and capabilities), which has implications for the measurement, ranking and linkages between vulnerabilities and capabilities.

Public transport organizations are in principle also able to link at sub-factor level, but this more detailed level is not considered as strategic. Analyzing sub-factors might support a tactical approach and is relevant to understand the context of the factors.

- 3) The concept of resilience is applicable in public transport organizations and they have the ability to derive a balanced resilience position.
 - Public transport organizations are, like any other organization, learning entities. The framework provides a structure for the organizations. The concept of

contextual resilience is considered important and public transport organizations are able to develop this.

- The framework is considered as comprehensible and comprehensive, and relevant to public transport organizations. Public transport organizations are able to identify, assess and respond to disturbances in order to become resilient organizations. The concept of *cognitive resilience* is accepted and public transport organizations are able to use the framework.

- Taking the context of the previous results into account, public transport organizations are able to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to structure and to react systematically when something unexpected occurs. The concept of *behavioural resilience* is accepted and public transport organizations are able to analyze the vulnerabilities and capabilities presented.

Within in this context:

- Public transport organizations are aware of the limitations of their knowledge in a rapidly changing environment. This is part of the level of progress of resilience, connected like to the capability *organization*;
- Public transport organizations are able to measure, rank and create linkages at factor level and to judge their relevance in relation to the performance indicators related to the mission statements.

- Vulnerabilities and capabilities need to be linked. Given short time-gaps between analyzing both, it is not relevant with which one to start the linking process. Organizations will most likely start with analyzing disruptions. The short-cycle approach is relevant when using the framework. Public transport organizations are able to work towards a *balanced resilience approach*.

4) Introducing resilience is possible, but its urgency is not evident.

- It is relevant to understand the culture of the organization. How open are organizations to disruptions and in what ways are they willing to discuss this internally and externally? There is a need for more openness to understand vulnerabilities.

- Contracts with the transport authority will determine the priorities. There is the effect of penalties if contracts are not fulfilled. Performance indicators need to include what is asked in contracts or what is critical to customers. Resilience can become a competitive element if triggered by authorities or customers.
 - Public transport organizations are not network-oriented for improvement.
- 5) Public transport organizations need to introduce the management process of resilience systematically as an innovative action from a strategic point of view. From the discussion the following challenges are identified (not in order of importance):
- Complexity increases: organizations are challenged more frequently externally;
 - Limited visibility: priority of day-to-day business interruptions rather than of vulnerabilities;
 - Accountability is not clear: who is problem owner and what are the responsibilities of the respective stakeholders?
 - Willingness to engage is limited: what are the benefits internally and externally?
 - Justification: absence of metrics in cost and revenue indicators;
 - Relevance in relation to other strategic issues: relevant but not urgent.

From this, the following suggestions are offered for implementation of a systematic organizational approach:

- Because both risk and resilience management will become competitive elements in the future, knowledge of the resilience management process of public transport organizations needs to be improved.
 - o Strategic priorities are focused based on the contracts between operator and transport authority. Transport authorities are introducing elements of risk and resilience into their contracts; this will stimulate the use of the framework.
 - o A more strategic orientation towards customers in general is regarded as necessary and supportive. Transport operators in the larger cities that have not been tendered show a more customer-oriented approach.

- UITP is developing knowledge on disruptions and creates data and information. This can stimulate the analysis of disruptions.
- Introduction of the resilience approach needs to be enforced from the outside.
 - Public transport organizations will not take the lead. The attitude of parties regarding their accountability for resilience needs to become clear.
 - External forces need to stimulate initiation of the resilience management process.
 - Customers: but customers are hardly organized and the power of customers (organizations) is considered as weak.
 - Clients: transport authorities by introducing a level of resilience as a competitive element. The competition between operators is currently not at the level of the concept of resilience. Incentives in tender processes are not evident.
 - Legal initiatives by national or European bodies are not planned at the level of a resilience approach.
 - Bodies of knowledge such as European Commission, IPO-SKVV, NCtB and “Raad voor Verkeer en Vervoer” need to trigger the process of introducing resilience.
 - The culture of the public transport organization needs to be transformed to adopt a more trial-and-error-oriented perspective.

In summary it can be concluded that the expert meeting confirmed the relevance of the concept of a resilience approach and the use of the framework, and affirmed the ability of public transport organizations to create a balanced resilience

7.5 *Summary and interpretations*

This chapter discussed the fourth research objective: To ensure that public transport organizations are able to make linkages between vulnerabilities and capabilities. As it is possible to measure and rank vulnerability and capability factors and to recommend a direction for action, this research provides the initial foundation. The possibility of creating linkages, combined with the importance of the vulnerability factors, provides management of public transport organizations with an incentive to implement actions.

This exploratory study is the beginning of that process. The framework is applicable and introducing resilience is possible. Public transport organizations are considered to have the ability to develop contextual resilience, cognitive resilience and behavioural resilience. Balanced resilience is described as: the property of the public transport organization to rank, to determine the importance of, and to identify the critical linkages between vulnerabilities and capabilities. Actions monitored and managed over time will lead the public transport organization to a more balanced condition of resilience and create the capacity to survive, adapt and grow.

It is necessary to develop and to evaluate a resilience management process within the context of a cost-benefit relation. Public transport organizations do not consider this to be a matter of urgency and will not systematically introduce the management process as an innovative action; this needs to be generated by outside initiatives.

8 *Conclusions and future directions*

8.1 *General*

This research contributes to the existing body of knowledge on several existing perspectives on the phenomenon of resilience, identifying possible gaps in the literature on resilience with a specific focus on public transport, and proposing a direction to address existing gaps. Specifically, a systematic approach for public transport organizations, under-represented in the existing literature, is directly addressed. The research provides the initial foundation to structure resilience and recommend directions for action in the public transport organization. This foundation is based on the inference of a positive relationship between resilience and performance, based on the strategic direction chosen.

This research advances the understanding of resilience through the development of the resilience framework, the lists of vulnerability and capability factors relevant to public transport organizations, and identification of potential ability to develop vulnerability-capability linkages to implement a process-improvement initiative. Applying the concepts creates the capacity to survive, adapt and grow in the face of turbulent change, which is defined as the essence of a resilience-oriented approach.

The primary objective of this research is designing a framework to embed resilience in public transport organizations and four research objectives have been formulated accordingly to structure the research. Justification of the research and the delimitation of its scope are discussed.

Although further research is required, public transport managers should be encouraged to determine their current state of resilience and analyse the different effects, on for example, productivity and the difference in time to recover (TTR), when incorporating a resilience approach and when not (Figure 17).

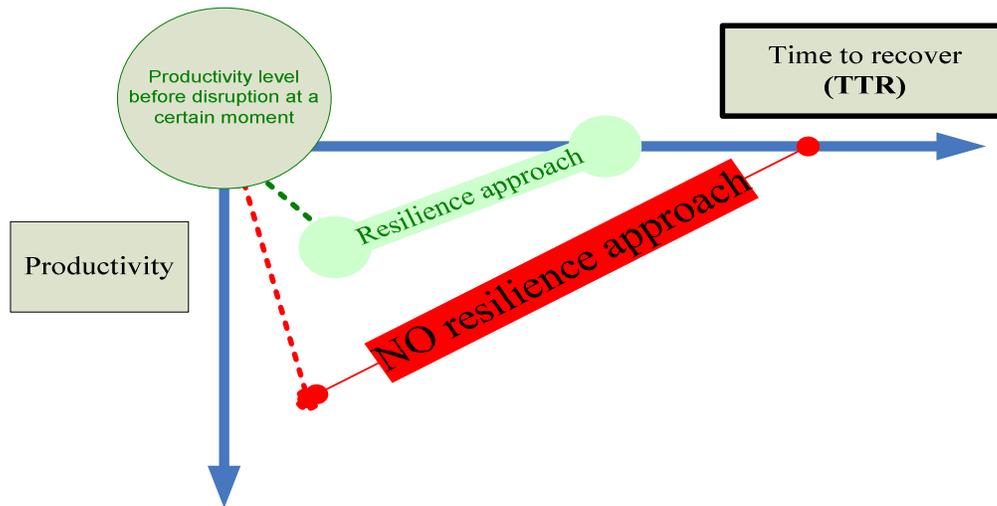


Figure 17: Difference in time to recover (TTR)

The ability to structure linkages presented in this research provides clear directions for the management of public transport organizations to take the necessary actions to improve critical capabilities, maintain high-priority strengths and reduce unnecessary expenses. These actions closely monitored and managed over time, will lead an organization toward a state of more balanced resilience. Public transport organizations need to balance revenue streams with preparation and recovery costs, short-term customer service and long-term value in terms of return on assets. Thus assessment and periodic reassessment form the basis of managing the dynamic portfolio of capabilities that are best matched to the pattern of inherent vulnerabilities to ensure resilience in public transport organizations in a world of turbulent change.

The idea of establishing a systematic approach for public transport organizations to develop a framework with meaningful linkages between vulnerabilities and capabilities was a central formative idea for this research. This chapter will first provide an overview of the different research stages based on the research objectives, followed by recommendations for further research.

8.2 *Overview of research stages*

The *role* of public transport in society is to stimulate, urban, social, sustainable and economic developments by the transport of passengers based on their needs. In this the public transport organization in terms of its *function* as operator in the *urban environment* is the starting point. The first research objective is formulated as “To establish the starting point(s) and limitations regarding the (re-)design of a resilient public transport organization”. Analyzing annual reports and using the information from the different case studies during the research shows that public organizations are able to acknowledge elements of the property of resilience, but a conceptual framework and coherent approach are absent. The property of the public transport organization which indicates it has the ability to identify its role and define its function in the context of a resilience approach is denoted as *contextual resilience*. This contextual awareness is an integral part of the framework and in this research is used as the starting point for the development of that framework. Based on the concepts of the contingency approach, the environmental focus of the public transport organization is discussed and systemised under conditions that apply to supply, market, system and context. The evolving events need to be analyzed in accordance with the mission statements of that particular organization.

Public transport organizations are open systems that have an active and indissoluble interaction with the environment, and problems and opportunities are related to this. The object of experience is formulated as: the public transport organization and its focus on developing a resilience strategy, so contextual awareness is derived from clear and consistent direction statements (research proposition RP-1) and by a clear environmental focus (RP-2). From the object of science established in the systematic organizational approach, the contextual awareness is positively influenced by a clear distribution of responsibilities (RP-3) and an accurate information structure (RP-4).

Interviews confirmed these research propositions as starting points to create awareness and, furthermore, that public transport organizations have the *ability to create contextual awareness*. Chapter 1 provides the delimitation of the scope of this research, with the justification for the research. It is relevant to mention that the focus is on urban passenger

transport organizations. The context of the research strategy adopts the qualitative research methodology, including selection of participants for interviews. Within that context the first research objective has been achieved.

The traditional conception of managing disruptions is the risk management approach and research on resilience most often relates to the concept of risk. Constructs of risk and resilience have been analysed in the context of the second research objective: “To structure and design a comprehensible and comprehensive resilience framework for public transport organizations”. This includes the development of guiding principles based on an analysis of the concepts of both risk and resilience.

Risk is defined as the negative deviation from the expected value of a certain performance objective, resulting in undesirable consequences for the public transport organization. From the concepts of risk, areas of concern are analysed as: unknown probabilities, unforeseen dangers of events, unintended consequences and unknown susceptibilities. Finally, the unknown dangers of decisions influenced by internal and external threats can have unforeseen consequences.

The concept of resilience has its foundation in different disciplines. Researchers are aware of the gaps in the risk management approach and supplement this partial understanding with the concept of resilience.

Resilience is defined in this research as “the capacity of the public transport organization to survive, adapt and grow in the face of turbulent change”. Resilience in the public transport sector and more specifically in public transport organizations is not a developed concept. There is no framework to support the management of resilience in a systematic approach.

On the basis of the concepts of risk and resilience approaches, guiding principles were developed and have been confirmed in interviews as relevant. The guidelines are:

- Resilience needs to provide competitive advantages, especially in turbulent times, and needs to be performance based;
- Resilient approaches need to be based on a holistic view;
- Strategic resilient approaches call for adaptive and structure-based approach;
- The resilient approach is based on the concepts of system development;
- The ability of balanced coordination and/or integration with partners must be developed in a coherent and structured resilient approach.

Based on the definitions and guidelines developed, a framework is structured and several other research propositions (RP5 to RP11) were formulated to relate the different parts of the framework to a *comprehensible and comprehensive conceptual framework*.

Empirical research was conducted to verify the framework and to generate new insights. Criteria for selecting the participants were formulated and the subsequent discussions led to acceptance of the definitions, guidelines and framework structure as well as the confirmation of the research propositions, including the relations between the different parts of the framework. Other findings of the empirical research resulted in a list of potential advantages and complications of a structured resilience approach and the concept of a closed-loop approach supporting a continuous management approach. Figure 18 the supplements Figure 13 with the 'role of public transport' .

A resilience orientation enables public transport organizations to identify, assess and respond to disruptive events; this ability is referred to as *cognitive resilience*. The development of the conceptual framework based on deductive analysis, together with the empirical research, led to the concept of cognitive resilience; hence the second research objective has been achieved.

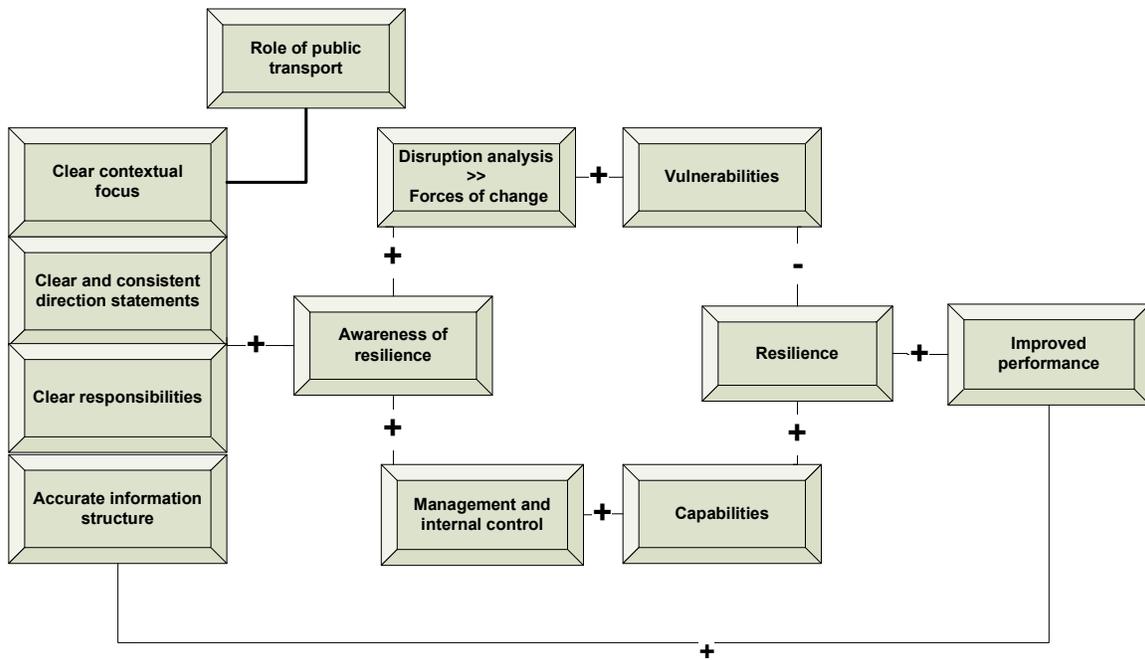


Figure 18: Resilience framework for public transport organizations

Within the context of the developed framework, the third research objective was “To identify the main elements that create knowledge about the resilience design”. This concerns the identification of vulnerability and capability factors. *Vulnerability* is defined as the fundamental factors that make the public transport organization susceptible to disruption, and *capability* as the attributes required for performance or accomplishment. What is also relevant is the distinction between sub-factors regarded as elements compared to fundamental factors and attributes. Based on the literature, two lists of vulnerability and capability factors and connecting sub-factors were developed.

Public transport organizations must be able to address disruptions before they happen and must be able to diagnose vulnerabilities and ensure the availability of critical capabilities. *Behavioural resilience* is the property of the public transport organization to use proactive diagnostics in the identification of potential vulnerabilities and capabilities. Further empirical research was conducted in the context of verification and generation. Based on the selection criteria, resulting in positive sampling and taking into consideration the concept of validation in qualitative research, the research findings confirmed the relevance of a systematic and strategic approach and identified the

vulnerability and capability lists with descriptions and described sub-factors. The positive link between resilience and performance has been identified and the factor and sub-factor lists are considered in principle to be complete and comprehensive.

Within this context some adjustments were accepted when a majority of participants agreed to them. This resulted in some changes in specifications in the sub-factor lists. The most important adjustment was made in the vulnerability list. The vulnerability factors *connectivity* and *supplier/customer disruption* were not seen as substantively different and this resulted in combining the two factors into one factor *connectivity*, and some specifications being added to the sub-factor lists. This results in the definitions of a total of 6 vulnerability factors and 14 capability factors for the public transport sector. The development of the vulnerability and capability lists with descriptions and sub-factors based on the literature and empirical research together means the third research objective has been achieved. This enables public transport organizations to use a proactive diagnostic tool. Based on the empirical research, it can be concluded that public transport organizations have the capacity to work with the tool and are able to use a proactive diagnostic approach in the identification of potential vulnerability and capability factors.

The fourth research objective was “To ensure that public transport organizations are able to make linkages between vulnerabilities and capabilities”. The ability to measure, rank and to identify critical linkages between vulnerabilities and capabilities will provide the public transport organization with the opportunity to create a *balanced resilience* position. This will have a positive effect on the performance of the organization. Unbalanced positions will erode profits or increase exposure to disruptions.

The purpose of the fourth part of the research was twofold: first, to ensure that public transport organizations have the ability to measure and rank, followed by research into whether they have the ability to define critical linkages.

The ability to measure and rank is based on the literature and empirical research and has been confirmed. Based on measuring both the level of importance of the factors and the

present measured value, public transport organizations are able to describe their current status and to analyse possible gaps specifically.

By using mixed methods it was possible to identify the next step of a resilience improvement process by comparing theoretical connections between specific vulnerability and capability sub-factors with a more refined set of potential linkages. Although none of the individual methods (experiment, case study and expert meeting) were without bias and limitations, the confluence and especially the triangulation of the three methods provides a high level of confidence in the resulting linkage capability.

The ability to measure and rank, and the ability to create critical linkages, will provide the public transport organization with an opportunity to use this as a proactive diagnostic tool to derive a balanced resilience position; this means the fourth research objective has been achieved.

The expert meeting was also an opportunity to discuss the confluence of the methodologies used for the research and to discuss rules for the introduction and re-design of resilience in the public transport sector. The relevance of a systemic and strategic approach in the context of the role of public transport in society and the function of the public transport organization is confirmed. Public transport organizations understand the relevance of introducing a resilient approach, but do not acknowledge the urgency of doing so. Introduction of the approach in response to pressures from outside parties and introducing resilience as a competitive element in the tender processes will change this and ensure that the knowledge and management skills of the public transport organization will be developed.

With the conceptualization of a framework, the case for establishing the conceptual link between public transport vulnerabilities and public transport capabilities is made and the overall research objective achieved.

8.2.1 Knowledge extended by the research

It would be presumptuous to assume that public transport organizations would be willing and able to directly apply the results of this research. At the same time the research results bring to light the reality of the situation and might well first raise their awareness of the opportunities inherent in a resilient management process. Case studies in the different public transport organizations found advanced levels of understanding of the relevance of the resilience framework applications. The research resulted in ascertaining the ability of public transport organizations to create this awareness of the resilience approach and to understand the advantages and effects on performance indicators, but the complications of implementation are also acknowledged. The results of this research will support the introduction of resilient management in the public transport sector.

This research fills a gap in research on the public transport sector and is the first of its kind. Approaches from the current literature and research cover only fragments that relate to resilience in the public transport sector. This research presents a coherent research approach, resulting in the design of the initial framework to articulate the scope of the development of a resilient management process in the public transport sector. It provides relevant information on the level of progress in public transport organizations with regard to a resilient management approach. A structured and creative approach has led to defining and structuring the framework, the guiding principles and the ability to create a balanced resilience position. A coherent set of developed definitions supports this.

Empirical evidence has been gathered and provides relevant information regarding the understanding of the specific features of resilience compared to risk management. Public transport organizations understand that resilience is not just about avoiding losses or preserving shareholder value, but also about being poised to seize opportunities that suddenly become available in order to create value.

As globalization, technological complexity, policy directions and interdependence have created new opportunities, they have also created new uncertainties. In this environment resilience is emerging as a new and increasingly critical priority for public transport

organizations. This research has structured these uncertainties by structuring a verified list of vulnerabilities as well as a structured list of capabilities specific to the public transport sector.

The research defines the ability of public transport organizations to measure and rank both vulnerabilities and capabilities. The ability to define capability linkages and the concept of a balanced approach support has been confirmed.

The research brings together a selection of specialized research findings and factual observations together with empirical data, expert opinions and everyday practice that will help to add to the knowledge on resilience management in the public transport sector. This will make it possible to investigate strategic objectives and will enable further development of research. This research will help to produce a systematic basis on which to explore the defined content of further funded research programmes.

Lastly, the potential usefulness of the research and its possible benefits can also support the general knowledge on resilience. Incorporating the results of this research provides an excellent tool for further research and for theoretical science and practical implementation to progress hand in hand towards a new level of resilience.

8.3 *Future directions for research*

More detailed research can be conducted in some of the areas indicated below.

- This research has certain limitations. Firstly, it is exploratory in nature and so its conclusions should be used for exploring issues further rather than for generalizing to a wider population. Testing of theory for its generalizability will be a future task. The body of knowledge and level of advancement in public transport organizations may be enhanced by expanding the scope to other areas of responsibilities and types of passenger transportation.
- Structural organized resilience involves a systematic approach to reach a balanced resilience position. The issues of resources needed for the desired functionality,

- the management of organizational procedures and routines, and the distribution of responsibilities in the organization must be addressed.
- The learning aspect in relation to public transport organizations has just recently been introduced in the literature. Knowledge-based theory could help to develop the learning perspective on resilience and its relation to public transport organizational learning. This could help to clarify the role of capabilities in that process, systems theory and the theory of constraints to advance understanding of the topic of resilience.
 - It is necessary to define appropriate opportunities for collaboration and levels of sophistication of the collaboration. As is common in change management, even if it is understood *what* to change, the process of *how* to change raises questions of a different order of complexity. The roadmap to an internal and external integrated resilient approach needs to be developed and can be distinguished into three phases of evolution. The foundational phase is coordination; this can also be thought of as integration and focuses on how information is shared across functional areas. Second, building on the integration of processes and practices, the public transport organization is able to move towards collaboration with a focus on partners in the network. The third phase is cooperation. This level of analysis is concerned with the connected environment as a whole.

The empirical research has shown that a sustained strategic focus on resilience is not recognized as an urgent priority for public transport organizations. What it does show is:

- Public transport organizations are facing a new set of disruptions that demands new approaches. The paradigms of security and risk need to be analysed as partly *illusory* remedies and responsible organizations need to supplement these with resilience and emphasise accessible actions;
- Society requires public transport organizations to create innovative approaches to manage capabilities to reduce vulnerabilities in order to attain a balanced resilience position: disciplined, systematic and cross-functional thinking across the organization, even to the point of re-considering its mission statements.

In such a world resilience is no longer an afterthought: resilience is an imperative in public transport organizations.

References

- Adamski, A. and Westrum, R. 2003. Requisite Imagination; The fine art of anticipating what might go wrong. In E. Hollangel (ed). *Handbook of cognitive task design*, pp. 193-220. Mahwah, NJ: Lawrence Erlbaum Associates.
- Adger, W.N. 2002. Social and ecological resilience: Are they related? *Progress in Human Geography*. Vol. 24, No. 3, pp. 347-364. Viewed 3 September 2008 <<http://www.ecologyandsociety.org/vol9/iss2/art10/main.html>>.
- Ahlquist, G., Irwin, G., Knott, D and Allen, K. 2003. Enterprise resilience, *Best Review*, Vol. 104, No. 3, pp. 88-89.
- Allen, F. and Gale, D. 1994. *Financial innovation and risk sharing*. Cambridge, MIT Press.
- Althaus, C.E. 2005. A disciplinary perspective on the epistemological status of risk. *Risk Analysis*, Vol. 25, No. 3, pp. 567-588.
- Altman, E. I. 1968. Financial Ratios, Discriminating Analysis and the prediction of Corporate Bankruptcy. *Journal of Finance*, Vol. 23, No. 4, pp. 589-609.
- Anshoff, I, 2007. *From Strategic Planning to Strategic Management*. New York: Wiley.
- Arminas, D. 2003. Managing risk set to be the key task of purchasers in 2003. *Supply Management*, Vol. 8, No. 2, p. 9.
- Arriva Transport. 2007. *Annual report*. Viewed 12 July 2008 <www.arriva.co.uk/arriva>.
- Arrow, K.J. 1965. *Aspects of the Theory of Risk-Bearing*. Helsinki: Yrjo Jahnssonin Saatio.
- Axhausen, K.W. 2006. Definition of movement and activity for transport modelling. *Handbooks in Transport: Transport Modelling*. Zurich: IVT, ETH.
- Banister, D. and S. Marshall. 2007. *Land Use and Transport Planning - European Perspectives on Integrated Policies*. London: Elsevier.
- Beckmann, K.J. 2007. Verkehrspolitik and Mobilitätsforschung – Die angebotsorientierte Perspektive. *Handbuch Verkehrspolitik*. Wiesbaden: Verlag für Sozialwissenschaften, pp. 710-734.
- Berger, J.O. 1985. *Statistical Decision Theory and Bayesian Analysis*. New York: Springer.
- Bernard, H. R. 2002. *Research Methods in Anthropology* (3rd. ed.). Walnut Creek: Altamira Press.

- Blackhurst, J., Craighead, C.W., Elkins, D. and Handfield, R.B. 2005. An empirically derived agenda of critical research issues for managing supply chain disruptions. *International Journal of Production Research*, Vol. 43, No. 19, pp. 4067-4081.
- Booij, W.M., Idserda, H.A. and Prager, L.E. 2006. *Prerequisites of Effective Supply Chain Risk Analysis: Case Study Research*. Eindhoven: University of Technology.
- Bounfour, A. 2002. *The Management of Intangibles, The Organisation's Most Valuable Assets*. London, New York: Routledge.
- Bovy, P.H.L., Schoemaker, J.H., Van Binsbergen, A.J. and Van Nes, R. 2000. *Vervoersystemen en verkeersnetwerken*, Course: VK 3750, Delft: University of Technology, Faculty of Civil Engineering and Geosciences, Section Traffic.
- Boyer, K.K. and Swink, M.L. 2008. Empirical elephants: Why multiple methods are essential to quality research in operations and supply chain management, *Journal of Operations Management*, Vol. 26, pp. 337- 348.
- Brady, M.K., Cronin, J.J., Fox, G.L. and Roehm, M.L. 2008. Strategies to offset performance failures; The role of brand equity, *Journal of Retailing*, Vol. 84, No. 2, pp. 151-164.
- Brechbuhl, H. 2007. *The agile and resilient enterprise*. Tuck School of Business at Dartmouth. Viewed 3 November 2009 <www.tuck.dartmouth.edu/roundtable>.
- Bruton, M.J. 1970. *Introduction to Transportation Planning*. London: Hutchinson Educational.
- Bryman, A. 2004. *Social Research Methods*, Revised edition. Oxford University Press.
- Callaway, D.S., Newman, M.E.J., Strogatz, S.H. and Watts, D.J. 2000. Network Robustness and Fragility: Percolation on Random Graphs. *Physical Review Letters*, Letter 85, pp. 5468–5471.
- CapGemini, 2007. *Enterprise Risk Management*, Viewed 20 February 2007 <http://www.au.capgemini.com/m/en/tl/tl_Enterprise_Risk_Management.pdf>.
- Carpenter, S., Walker, B., Anderies, J. and Abel, N. 2001. From metaphor to measurement: Resilience of what to what? *Ecosystems*, Vol. 4, No. 8, pp. 765-781.
- Carter, E.E. 1972. Where are the risks in risk analysis? *Harvard Business Review*, Vol. 50, Nr. 4, pp. 72-82.
- Casiroli, F. 2007. The changeable shape of the city, Brussels: *Public Transport International*, No. PTI-5-2007, pp. 9-12.
- Cavalieri, R. 2006. Public transport: moving cities, moving people, Brussels: *Public Transport International*, No. PTI-1-2007, pp. 5-7.

- Center for Resilience, Ohio State University. Viewed 20 November 2008
<<http://www.resilience.osu.edu/CFRsite/index.htm>>.
- Chandler, A., 1962. *Strategy and Structure*. Cambridge, Mass: MIT Press.
- Child, J. 1972. Organisational Structure, Environment and Performance: The role of Strategic Choice. *Sociology*, Vol. 6, No. 1, pp. 1-22.
- Chopra, S. and Sodhi, M.S. 2004. Managing Risk to Avoid Supply-Chain Breakdown. *Sloan Management Review*, Vol. 46, No. 1, pp. 53-61.
- Christopher, M. 2005. *Logistics and supply Chain Management*. 3rd ed. Harlow: Pearson Educated Limited.
- Christopher, M. 2000. The agile supply chain: competing in volatile markets. *Industrial Marketing Management*, Vol. 29, No. 1, pp. 37-44.
- Christopher, M. 2006. Resilient Transport Chains, Dubai CSCMP Conference: The Bottom-Line Value of Supply Chain Management. Viewed 21 February 2007
<http://www.cscmp.org/downloads/public/releases/2006/3_29_06Dubai.pdf>.
- Christopher, M. 2008. Charting the route to supply chain excellence. Keynote presentation: CSCMP conference, Johannesburg, 3 March 2008.
- Christopher, M. and Peck, H. 2004a. The five principles of supply chain Resilience. *Logistics Europe*, Vol. 12, No. 1, pp. 1-13. Viewed 20 August 2008
<www.martinchristopher.info/downloads/buildingtheresilientsupplychain.pdf>
- Christopher, M., Peck, H. 2004b. Building a resilient supply chain. *International Journal of Logistics Management*, Vol. 15, No. 2, pp. 1-13.
- Cocchiara, R. 2005. *Beyond disaster recovery: becoming a resilient business – an object oriented framework and methodology*. Somers, NY: IBM Global Services.
- Cohen, M.A. and Kunreuther, H. 2007. Operations risk management; Overview of Paul Kliendorfer's Contributions. *Productions and Operation Management*, Vol. 15, No. 5, pp. 525-541.
- Coleman, L. 2006. Frequency of Man-Made Disasters in the 20th Century. *Journal of Contingency and Crisis Management*, Vol. 14, No. 1, pp. 1-13.
- Connexion Transport. 2007. Annual report 2007. Viewed 12 July 2008
<www.corporate.connexion.nl>.
- Cooper, R.C. and Schindler, S.S. 2005. *Business Research Methods*. Boston: Irwin/McGraw-Hill.

COSO. 2004. *Enterprise Risk Management-Integrated Framework*. Viewed 12 September 2008 <http://www.coso.org/documents/COSO_ERM_ExecutiveSummary.pdf>.

COSO. 2006. *Executive Summary 2006*. Washington DC: Committee of Sponsoring Organisations of the Treadway Commission.

COSO. 2007. *Internal Control Integrated Framework: Guidance on monitoring internal control systems*. Discussion Document. Washington DC: Committee of Sponsoring Organisations of the Treadway Commission, USA.

Council on Competitiveness. 2007. *Transform: The Resilient economy; Integrating Competitiveness and Security*. Viewed 12 October 2008 <<http://www.scribd.com/doc/430078/The-Resilient-Economy>>.

Council on Competitiveness. 2008. *The resilient economy: Integrating competitiveness and security*. Viewed 8 September 2009 <<http://www.compete.org>>.

Coutu, D.L. 2002. How resilience works. *Harvard Business Review*, Vol. 28, No. 1, pp. 46-51.

Cox, D.F. 1967. *Risk Taking and Information Handling in Consumer Behaviour*. In *Risk Taking and Information Handling in Consumer Behaviour*, pp. 289-316. Boston: Harvard University Press.

Crabtree, B. F and Miller, W.J. 1999. *Doing Qualitative Research* (2nd edition). London: Sage Publications.

Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J. and Handfield, R.B. 2007. The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities. *Decision Sciences*, Vol. 38, No. 1, pp. 131 - 156.

Cranfield University. 2002. *Supply Chain Vulnerability: Executive report*. Cranfield: School of Management.

Cranfield University. 2003. *Creating resilient supply chain: A practical Guide*. Cranfield: Center for Logistics and Supply Chain Management.

Csete, M.E. and Doyle, J.C. 2002. Reverse engineering of biological complexity, *Science*, No. 295, pp. 1664-1669.

Davenport , T. H. 1994. The coming of commoditization of processes, *Harvard Business Review: Journal of Operations Management*, Vol. 11 No. 4, pp. 339-366.

Davies, A.M. and Lang, R. 2002, Designing Choice Experiments Using Focus Groups. *Qualitative Social Research*, Volume 3, No. 3. Viewed 20 September 2009 <<http://www.qualitative-research.net/index.php/fqs/index>>.

- De Lijn (Vlaamse Vervoersmaatschappij). 2007. *Annual report 2007*. Viewed 13 July 2008 <www.delijn.be>.
- Deleris L.A., Elkins, D.A. and Paté-Cornell, M.E, 2004. *Analyzing Losses From Hazard Exposure: A Conservative Probabilistic Estimate Using Supply Chain Simulation*. Washington, Winter Simulation Conference Proceedings, pp. 1384-1391.
- Deleris, L.A., Erhun, F. and Pate-Cornell, M.E. 2005. *Quantitative Risk Assessment of Supply Chain Performance*. Orlando, Winter Simulation Conference Proceedings, pp. 1643-1649.
- Delnooz, P. 1996 . *Onderzoeks praktijken*. Amsterdam: Boon.
- Denzin, N. K. 1994. *Handbook of Qualitative Research*. Thousand Oaks: Sage Publications, pp. 500-515.
- Dick, B., 2000. Data-driven action research. Viewed 28 October 2008 <<http://www.scu.edu.au/gcm/ar/arp/datadriv.html>>.
- Dijk, J., De Goede, M., 't Hart, H. and Teunissen, J. 1991. Onderzoeken en veranderen. *Methoden van praktijkonderzoek*., Leiden, Stenfert Kroese.
- Dijst, M., K. Geurs, B. and Van Wee, B. 2002. Bereikbaarheid: perspectieven, indicatoren en toepassingen. In: Van Wee, B., M. Dijst (eds.). *Verkeer en vervoer in hoofdlijnen*. Bussum: Coutinho.
- Dillman, D.A. 2000. *Mail and Internet surveys: The tailored design method*, New York: Wiley.
- Douglas, M. 1992. *Risk and Blame: Essays in Cultural Theory*. London: Routledge.
- Drew, S.A., Kelley, P.C. and Kendrick, T. 2006. Class: five elements of corporate governance to manage strategic risks. *Business Horizons*, No. 49, pp. 127-138.
- Duclos, L.K., Vokurja, R.J. and Lummus, R. R. 2003. A conceptual model of supply chain flexibility, *Industrial Management & Data Systems*, Vol. 103, No. 6, pp. 446-456.
- Dyer, J. H., Kale, P. and Singh, H. 2001. How to Make Strategic Alliances Work. *MIT, Sloan Management Review*, Vol. 42, pp. 37-43.
- Ecorys Research and Consulting. 2002. *Concurrentieverhoudingen en marktkracht in het OV*, Den Haag: Adviesdienst Verkeer en Vervoer, Ministerie van Verkeer en Waterstaat.
- Edmondson, K. M. and McManus, S.E. 2007. Methodology fit in organisational field research. *Academy of Management Review*, Vol. 32, No. 4, pp. 1155-1179.
- Eisenhardt, K.M. 1989a. Building theories from case study research. *Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

Eisenhardt, K.M. 1989b. Agency Theory, an assessment and review. *The Academy of Management Review*, Vol. 14, No. 1, pp. 57-74.

Eisenhardt, K.M. and Greaber, M.E. 2007. Theory building from cases: opportunities and challenges. *Academy of Management Journal*. Vol. 50, No. 1, pp. 25-32.

Elkins, D., Handfield, R.B., Blackhurst, J and Craighead, C. W. 2005, 18 Ways to Guard Against Disruption. *Supply Chain Management Review*, Vol. 9, No. 1, pp. 46-55.

Ellram, L.M., 1996. The use of case study method in Logistics Research, *Journal of Business Logistics*, Vol. 17, No. 2, pp. 93-138.

European Commission. 1996. Council Directive 96/82/EC on the control of major accident hazards, Viewed 12 December 2009 <<http://ec.europa.eu/environment/seveso/index.htm>>.

European Commission, 1997. *EU Commission notice on the definition of the relevant market for the purposes of Community competition law*. Brussels: OJ C 372.

European Commission, Directorate for Transport & Energy. 2004. *Project Voyager. Treaty of Rome, 1957*. Brussels: EU, Official Journal: D/2004/0105/29.

European Commission. 2008b, *White Paper 1992: The Future Development of the Common Transport Policy*. Viewed 20 April 2008 <www.europarl.europa.eu/facts>.

European Commission. 2008c. *Green Paper 1995: Towards Fair and Efficient Pricing in Transport Policy*. Viewed 20 April 2008 <europa.eu/documents/comm/green_papers/index_en.htm>.

European Commission. 2008d. *White Paper 1998: Fair Payment for Infrastructure Use*. Viewed 20 April 2008 <europa.eu/documents/comm/white_papers/index_en.htm>.

European Commission. 2008e. *White Paper 2001: European transport policy for 2010: Time to decide*. Viewed 27 April 2008 <ec.europa.eu/transport/white_paper/index_en.htm>.

European Commission. 2008f, *Green Paper 2007, Towards a new culture for urban mobility*. Viewed 27 April, 2008 <ec.europa.eu/transport/clean/green_paper_urban_transport/index_en.htm>.

European Commission. 2009. *Passenger Rights*, Viewed 28 April 2009 <http://ec.europa.eu/transport/passengers/index_en.htm>.

European, Commission, Energy & Transport in Figures. 2002. *Statistical Pocketbook*. Brussels: Directorate General for Transport in co-operation with Eurostat.

Eurostat, 2009. Management of Statistical Information Systems (MSIS). Viewed 22 May 2009 <www.unece.org/stats/documents/ece/ces/ge.50/.../wp.15.e.pdf>.

- Fawcett, P. 2000. *Managing Passenger Logistics; The comprehensive Guide to People and Transport*. London: Kogan Page.
- Ferma. 2003. *De Risk Management Standaard*, Brussels, Belgium. Viewed 21 August 2008 <www.theirm.org/publications/documents/rm_standard_nl_15.11.04.pdf>.
- Fiksel, J. 2003. Designing resilient, sustainable systems. *Environmental Science and Technology*, Vol. 37, No. 23, pp. 5330-5339. Viewed 21 August 2008 <<http://pubs3.acs.org/acs/journals/toc.page?volume=37&issue=23>>.
- Fiksel, J. 2006a. Sustainability and resilience: towards a systems approach. *Sustainability Science, Practice & Policy*, Vol. 2, No. 2, pp. 1-8.
- Fiksel, J. 2006b. A framework for sustainable materials management, *Journal of Materials*, Vol. 58, No. 8, pp. 15–22. Viewed 3 September 2008 <<http://ejournal.nbii.org/archives/vol2iss2/0608-028.fiksel.html>>.
- Fink, A. 2003. *The Survey handbook. The survey kit*, 2nd ed. London: Sage Publications.
- Flynn, J. 2008. Building a resilient nation: Enhancing security, ensuring a strong economy, Keynote address 27 March 2008, Reform Institute, New York, NY.
- Folke, C., Carpenter, S., Walker, B., Scheffer, M. and Elmqvist, T. 2004. Regime shifts, resilience and biodiversity in ecosystem management. *Annual Review of Ecology, Evolution & Systematics*, Vol. 35, No. 1, pp. 557-581. Viewed 3 September 2008 <<http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.ecolsysjournalCode=ecolsys>>.
- Frankel, R., Naslund, D. and Bolumole, Y. 2005. The ‘white space’ of logistics research: A look at the role of methods usage. *Journal of Business Logistics*, Vol. 26, No. 2, pp. 185-208.
- Friedrich, G. W. 2000. *Methods of Inquiry*. Syllabus 17, pp. 194-514. New Jersey, State University of New Jersey, School of Communication and Information.
- General Motors (GM). 2006. Managing Enterprise Risks in Global Automotive Manufacturing Operations. Government-University-Industry Research Roundtable, Presentation 16 February, *National Academies*, Washington, DC, USA.
- Gephart, R.P. 2001. Safe Risk in Las Vegas. *M@n@gement*, Vol. 4, No. 3, pp.141-158.
- Geurs, K.T and Van Wee, B. 2004b. Back casting as a tool for sustainable transport policy making: the Environmental Sustainable Transport study in the Netherlands. *European Journal of Transport and Infrastructure Research*, Vol. 4, No. 1, pp. 47-69.
- Geurs, K.T. and Van Wee, B. 2004a. Land-use/transport interaction models as tools for sustainable impact analysis of transport investments: review and research directions.

Delft: *European Journal of Transport and Infrastructure Research*, Vol. 4, No. 3, pp. 333-355.

Geurs, K.T. and Van Wee, B. 2006. Ex post evaluation of thirty years of compact urban development in the Netherlands. *Urban Studies*, Vol. 43, No. 1, pp. 139-160.

Glaser, B.G. and Barney G. 1995. A look at grounded theory: 1984-1994. In Glaser, Barney G.(eds.) *Grounded theory 1984-1994*, Vol. 1. Mill valley, Ca: Sociology Press, pp. 3-17.

Glaser, B.G. and Strauss, A.L. 2006. *The Discovery of the Grounded Theory; strategies for qualitative research*. Chicago: Adline Transaction.

Glendon, A.I., Clarke, S.G. and McKenna, E.F. 2006. *Human Risk and Safety Management*. Second Edition. Boca Raton: Taylor and Frances.

Goldratt, E.M., 1984. *The goal: A process of ongoing improvement*, New York: North River Press.

Gorman, C., Dale, S.S., Grossman, W., Klarreich, K., McDowell, J. and Whitaker, L. 2005. The Importance of Resilience, *Time Canada*, Vol. 165, No. 3, pp. 76-79.

Grandjot, H.H. 2006. Risikomanagement aus betrieblicher Sicht in einem Logistik Unternehmen. *Riskmanagement in der Logistik*. Hamburg: Deutscher Verkehrsverlag, pp. 19-29.

Griffis, S.E., Goldsby, T. J. and Cooper, M. 2003. Web-based and mail surveys: a comparison of response, data and cost, *Journal of Business Logistics Management*, Vol. 24, No. 2, pp. 237-258.

Groves, R.M. and Peytcheva, E. 2008. The Impact of Nonresponse Rates to Nonresponse Bias, *Public Opinion Quarterly*, Vol. 72, No. 2, pp. 167-189.

GVB (Gemeentelijk Vervoer Bedrijf Amsterdam). *Annual Report 2007*. Viewed 12 July 2008 <www.gvb.nl/overgvb/jaarverslag>.

GVU (Gemeentelijk Vervoerbedrijf Utrecht) . *Annual Report 2007*. Viewed 17 July 2008 <http://www.gvu.nl/lib/Jaarverslag_gvu_2006/jaarverslag_PDF_combined/verslagvande_directie.pdf>.

Hale, A. and Heijer, T. 2006. Defining Resilience. In *Resilience Engineering, Concepts and Precepts*, (eds) Hollnagel E., Woods, D.W., Leveson,N. Aldershot: Ashgate.

Hallikas, J., Karvonen, I, Pulkkinen, U., Virolainen, V, M and Tuominen, M. 2004. Risk Management Processes in Supplier Network. *International Journal of Production Economics*, Vol. 90, No. 1, pp. 47-58.

- Hallikas, J., Virolainen, V and Tuominen, M. 2002. Risk analysis and assessment in network environments: A dyadic case study. *International Journal of Production Economics*, Vol.78, pp. 45-55.
- Hamel, G. and Valikangas, L. 2003. The Quest for Resilience, *Harvard Business Review*, Vol. 81, No. 9, pp. 52-63.
- Hansen. I.A., De Kort. A.F. and Wiggeraad, P.B.L. 1999. *Public Transport Course* CTvk4810, Delft: University of Technology, Faculty of Civil Engineering and Geosciences.
- Hanssen-Bauer, J. and Snow, C.C. 1996. Responding to hyper-competition; The structure and process of a regional learning network organisation, *Organisation Science*, Vol. 7, No. 4. pp. 413-427.
- Hansson, S.O. 1996. Decision-Making under Great Uncertainty. *Philosophy of the Social Sciences*, Vol. 26, pp. 369-386. Viewed 2 September 2008
<<http://scholar.lib.vt.edu/ejournals/SPT/v9n2/hansson.html>>.
- Hansson, S.O. 2005a. The Epistemology of Technical Risk, *Research in Philosophy and Technology*, Vol. 9. No. 2, pp. 68-81. Viewed 30 August 2008
<<http://scholar.lib.vt.edu/ejournals/SPT/v9n2/pdf/hansson.pdf>>.
- Hansson, S.O. 2005b. Seven myths of risk. *Risk Management*, Vol. 7, No. 2, pp. 7-17.
- Harland, C., Brenchley, R. and Walker, H. 2003. Risk in supply networks. *Journal of Purchasing & Supply Management*, Vol. 9, No. 2, pp. 51-62.
- Hart, C.W.L., Heskett, J.L., Sasser, W.E. 1990. The profitable art of service recovery, *Harvard Business Review*, Vol. 68, No. 4, pp. 148-156.
- Hassenzahl, D.M. 2005. The effect on 'risk rationalizing' decisions. *Journal of Risk Research*, Vol. 26, No. 1, pp. 119-138.
- Hatchuel, A. and Mollet, H. 1986. Rational modelling in understanding and aiding human decision making: about two case studies. *European Journal of Operational Research*. Vol. 2. pp. 178-186.
- Hayes, R.H. and Weelbright, S.C. 1979. The Dynamics of Process-Product Life Cycles. Boston, *Harvard Business Review, Strategic Management Resources Readings*, Vol. March-April, pp. 127-136.
- Hertz, D.B. and Thomas, H. 1983. *Risk Analysis and its implications*. Chichester: Wiley and Sons.
- Holling, C. S. 1973. Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics*, Vol. 4, pp. 1-23.

- Hollnagel, E. 2004. *Barriers to accident prevention*, Aldershot: Ashgate.
- Hollnagel, E. 2006. Resilience: The Challenge of the Unstable. In Hollnagel, E., Woods, D.D., Leveson, N. (eds) *Resilience Engineering: Concepts and Precepts*, pp. 9-19. Aldershot: Ashgate.
- Hollnagel, E. and Wood, D.D. 2006. *Resilience Engineering Perspectives*. In E Hollnagel, D.D. Woods and N. Levenson, (eds). *Resilience Engineering: Concepts and Percepts*. pp. 1-6. Aldershot: Ashgate.
- Hong, Y. and Choi, T.Y. 2002. Unveiling the structure of supply networks: case studies in Honda, Acura and Daimler Chrysler. *Journal of Operations Management*, Vol. 20, pp. 469-93.
- Horlick-Jones, T. 1996. Prospects for a coherent approach to civil protection in Europe. In Horlick-Jones, T., Amendola, A. & Casale, R. (eds.) *Natural Risk and Civil Protection*. London: E, & F.N. Spon, pp. 1-12.
- HTM (Haagse Tram Maatschappij). *Annual Report 2007*. Viewed 15 July 2008 < http://www.htm.net/Documenten/jaarverslag_2007.pdf>.
- IRM: Institute of Risk Management, 2002. *A Risk Management Standard*. Viewed 23 October 2008 <http://www.theirm.org/publications/documents/Risk_Management_Standard.pdf>.
- ISO: International Organisation for Standardization. 1999. *Guide 51*. Viewed 30 August 2008 <www.iso.org/iso/catalogue>.
- ISO: International Organisation for Standardization, 2001. *Guide 73*. Viewed 30 August 2008 <<http://www.iso.org/iso/catalogue>>.
- ISOTOPE. 2000. *Improved structure and organisation for urban transport of Passenger in Europe*. Luxemburg: Transport Research, Fourth Framework Program, Urban Transport, European Communities.
- Jemison, D. B. 1987. Risk and the relation among Strategy, Operational Processes and Performance. *California Management Review*, Vol. 43, No. 3, pp. 106-124. Viewed 4 September 2008 <http://www.emeraldinsight.com/Insight/FullTextArticle/Pdf/0240160506_ref.html>.08.
- Jick, T.D. 1979, Mixed qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly*, Vol. 24, No. 4, pp. 602-611.
- Jourdan, Z.R., Rainer, R.K., Marshall, T.E. 2008. Business intelligence; an analysis of literature, *Information System Management*, Vol. 25, No. 2, pp. 121-131.

- Jüttner, U., Peck, H and Christopher, M. 2003. Supply Chain Risk Management: Outlining an Agenda for Future Research. *International Journal of Logistics: Research and Applications*, Vol. 80, No. 4, pp. 197-210.
- Kahneman, D. and Trevsky, A. 1979. Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, Vol. 47, No. 2, pp. 263-291. Viewed 4 September 2008 <<http://portal.acm.org/citation.cfm?id=1127278>>.
- Kaplan, R. and Norton, D. 2008. Mastering the Management System. Boston: *Harvard Business Review*, Vol. 86, No. 1, pp. 62-77.
- Kerlinger, F.N. 1986. *Foundations of behavioural research* (3rd. ed.). Fort Worth, Texas: Holt, Rinehart, and Winston.
- Ketchen, D.J., Jr., Thomas, J, B. and McDaniel Jr., R. 1996. Process, Content and Context. *Journal of Management*, Vol. 2, pp. 231-257.
- Keuning, D. and Eppink, D.J. 2000. *Management & Organisatie, theorie en toepassing*. Houten: Stenfert Kroese.
- Kleindorfer, P.R. and Saad, G.H. 2005. Managing Disruption Risks in the Supply Chain. *Production and Operations Management*, Vol. 14, No. 1, pp. 53-68.
- Kleindorfer, P.R. and Van Wassenhove, L.N. 2004. Managing Risk in Global Supply Chains. In Gatingnon, H., Kimberly, J.R. and Gunther, R.E. (eds) *The INSEAD-Wharton Alliance on Globalizing*. , Cambridge: Cambridge University Press.
- Knemeyer, A.M., Corsi, T.M. and Murphy, P.R. 2003. Logistics outsourcing relationships: Customers' perspectives. *Journal of Business Logistics*, Vol. 24, No. 1, pp. 77-109.
- Koninklijk Nederlands Vervoer. 2008. Annual Reports 2006-2008. Viewed 29 August 2008 <<http://www.knv.nl/knv/site.nsf/pages/KNV/Missie.html>>.
- Kotler, P., Adam, S., Brown, L and Armstrong, G. 2006. *Principles of Marketing*, 3rd ed., New Jersey: Prentice Hall.
- Kotzab, H., Seuring, S., Muller, M., and Reiner, G (eds). 2005. *Research Methodologies in Supply Chain Management*, Heidelberg, Germany: Physica Verlag.
- Koulikoff-Souverin, M. and Harrison, A. 2005. Using case study methods in research in supply chains, in Kotzab, H., Westhaus, M., Seuring, S.A., Muller, M. and Reiner, G. (eds), *Research Methodologies in Supply Chain Management*, pp. 267-282. Heidelberg, Germany: Physica-Verlag.
- Krimsky, S and Golding, D. 1992. *Social Theories of Risk*. Westport, CT: Praeger.

Krygsman, S. 2004. Activity and Travel Choice(s) in Multimodal Public Transport Systems. Unpublished PhD thesis, Urban and Regional Research Center. Utrecht: Utrecht University.

KTH. School of Industrial Engineering and management, 2008. *System verification and validation*. Viewd 12 January 2009
<http://www.kth.se/polopoly_fs/1.22835!Lecture13eng2008.pdf >.

Kunreuther, H. 2006. Risk and reaction. *Harvard International Review*, Vol. 28, No. 3, pp. 37-42.

Lambert, D. 2006. *Supply Chain Management: Processes, Partnerships, Performance*, 2nd Ed. Sarasota, FL: Supply Chain Institute.

Lambooy, J.G. 1972, *Economie en ruimte: inleiding in de economische Geografie en de regionale economie*. Assen: Van Dorkum & Co.

Lammers, B., Ploos van Amstel, W. and Eijkelenbergh, P. 2009. *Risicomanagement en logistiek*. Amsterdam: Pearson Education Benelux.

Lamming, R.C., Caldwell, N.D., Harrison, D.A., Phillips, W. 2001. Transparency in supply chain relations: Concepts and practice, *Journal of Supply Chain Management*, Vol. 37, No. 4, pp. 4-10.

Lawrence, P.R. and Lorsch, J.W. 1967. *Organisation and Environment*. Cambridge, MA: Harvard University Press.

Lee, H.L. 2004. The Triple A Supply Chain, *Harvard Business Review*, Vol. 82, No. 10, pp. 102-112.

Lengnick-Hall, C. A and Beck, T. E. 2005. Adaptive Fit Versus Robust Transformation: How organisations respond to environmental change. *Journal of Management*, Vol. 31, pp. 738-757.

Leonard-Barton, D. 1990. A dual methodology for case studies: Synergistic use of a longitudinal single site with replicated multiple sites. *Organisation Science*, No. 1, pp. 1-19.

Leslie A., Curry, M.P.H., Ingrid. M., Nembhard, M.S., Bradley, E.H. 2009. Qualitative and Mixed Methods Provide Unique Contributions to Outcomes Research. *Circulation*, Vol. 119, pp.: 1442-1452.

Leveson, N. 2006. Engineering Resilience into Safety-Critical Systems. In *Resilience Engineering, Concepts and Precepts*, (eds) by Hollnagel, E., Woods, D.W., Leveson, N., pp. 95-125. Aldershot: Ashgate.

Lewis, M.W. 1998. Iterative triangulation: a theory development process using existing case studies. *Journal of Operations Management*, Vol. 4, No. 4, pp. 455-469.

- Li, X. 2008. *Ensuring business continuity under the threat of disruptions*. Rotterdam, PROTECT, Erasmus University/TNO research center.
- Loewenstein, G. E., Weber, C. Hsee, E and Welch. 2001. Risk as feelings. *Psychological Bulletin*, Vol. 127, pp 267–286.
- Long, H.B., Hiemstra, R. and Associates. 1980. *Changing Approaches to Studying Adult Education*. San Fransisco: Jossey-Bass Inc.
- Malone, T.W., Crowston, K., Lee, J., and Pentland, B. 1999. Tool for Inventing Organisations; Toward a Handbook of Organisational Processes, *Management Science*, Vol. 45. No. 3, pp. 425- 443.
- Mann, P. 1999. *Fire Risk Assessment Study for a High Speed Train*. Warwickshire: PMSC Limited, Saturn Business Facility. Viewed 12 November 2009 <<http://www.pmsafety.com>>.
- Manuele, F.A. 2005. Risk assessment and hierarchies of control, *Professional Safety*, Vol. 50, No. 5, pp. 33-39.
- Manuj, N.K. and Mentzer, J.T. 2008. Global supply-chain risk-management strategies. *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 3, pp. 192-223.
- March, J. G. and Shapira, Z. 1987. *Managerial Perspectives on Risk and Risk Taking*. Management Science, Vol. 33, No 11, pp. 1404- 1418. Viewed 5 September 2008 <http://www.emeraldinsight.com/Insight/ViewContentServlet?Filename=Published/EmeraldFullTextArticle/Pdf/0500140201_ref.html>.
- Maso, I. and Smaling, A. 1998. *Kwalitatief onderzoek: praktijk en theorie*. Amsterdam: Boom.
- McClutcheon, D.M. and Meredith, J.R. 1993. Constructing case study research in operation management. *Journal of Operations Management*, Vol. 11, No. 3, pp. 239-256.
- McDonald, N. 2006. Organisational Resilience and Industrial Risk. In *Resilience Engineering; Concepts and Precepts*, (eds.) Hollnagel, E., Woods, D.D. and Leveson, N., pp. 9-17. Aldershot: Ashgate.
- McNamee, D. 2006. *Business Risk Assessment*. Altamonte Springs, FL: Institute of Internal Auditors Research Foundation, USA.
- Miles, M.B. and Huberman, A.M. 1994. *Qualitative Data-analysis. An Expanded Sourcebook for New Methods*. Beverly Hills, CA: Sage Publications.
- Millikan, F. J. 1987. Three types of perceived uncertainty about environment: state, effect and response uncertainty. *Academy of Management Review*, Vol. 12, pp. 133-143.

- Ministerie van Verkeer en Waterstaat. 2000. *Wet Personenvervoer 2000*. Den Haag: Staatsdrukkerij.
- Ministerie van Verkeer en Waterstaat. 2001. *Van A naar Beter*. Beleidsvoornemen Deel A, Ministerie van Verkeer en Waterstaat. Den Haag: Staatsdrukkerij.
- Ministerie van Verkeer en Waterstaat. 2003. *Consumentenparticipatie in het stads en Streekvervoer*. Rapport 17. Rotterdam: Centrum Vernieuwing Openbaar Vervoer.
- Ministerie van Verkeer en Waterstaat. 2004. *Nota Mobiliteit, part I to IV*. Viewed 27 April 2008 <www.notamobiliteit.nl>.
- Ministerie van Verkeer en Waterstaat. 2005. *Uitvoeringsagenda: van Nota naar Mobiliteit*. Den Haag: Staatsdrukkerij.
- Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieu. 2008. *Ruimte voor ontwikkeling*. Viewed 27 April 2008 <www2.minvrom.nl/notaruimte>.
- Mintzberg H. and Waters, J.A. 1985. Of Strategies, Deliberate and Emergent. *Strategic Management Journal*, Vol. 6, No. 3, pp. 257-272.
- Mintzberg, H. 1979. *The structuring of organisations*, Englewood Cliffs: Prentice Hall International.
- Mintzberg, H., Quinn, J.B. and Ghoshal, S. 1998. *The Strategy Process*. European Edition. London: Prentice Hall Europe.
- MIT: Center for Transportation and Logistics. 2008. Collected Works. Viewed 19 November 2008 <<http://ctl.mit.edu/index.pl?iid=6716>>.
- Mitchell, V.W. 1995. Organisational Risk Perception and Reduction: A Literature Review, *British Journal of Management*, Vol. 6, No. 2, pp. 246-275.
- Mitroff, I.I. and Featheringham, T.R. 1974. On systemic problem solving and the error of the third kind. *System Research Behavioral Science*, Vol. 19, No. 6, pp. 383-393.
- Morgan, D.L. 1996. Focus Groups, *Annual Review of Sociology*, Vol. 22, No.1, pp. 129-152.
- Morgan, R.M. and Hunt, S.D. 1994. The Commitments-Trust of Relationship Marketing. *Journal of Marketing*, Vol. 58, pp. 20-38.
- National Research Council: Committee of Risk Perception and Communication. 1998. *Improving Risk Communication*. Washington: National Academy Press.
- National Travel Survey Great Britain, 2008. Viewed 3 August 2008 <<http://www.dft.gov.uk/pgr/statistics/datatablespublications/personal/mainresults/nts2008>>

- NCTb (National Coordinator Terrorisme Bestrijding). 2009. *Homepage*, Viewed 30 march 2009 <<http://www.nctb.nl/Informatie>>.
- Neumann, K-Th. 2001. Warum ein weiteres Buch zu diesem Thema? In: Brain, M., Feige, A., and Sommerlatte, T (Ed), *Business Innovation*, Frankfurt: F.A.Z. Institut fur Management, Markt- und Medieninformationen, Vol. 9, Nr. 11.
- NMBS (Belgian Railways), 2007. *Annual Report 2007*. Brussels: NMBS.
- Norman, A. and Lindroth, R. 2004. Categorization of Supply Chain Risk and Risk Management. In Brindley, C. (Ed): *Supply Chain Risk*, Aldershot: Ashgate.
- NS (Nederlandse Spoorwegen). 2007. *Annual Report 2007*. Viewed 20 July 2008 <<http://www.ns.nl/cs/Satellite/jaarverslag>>.
- NTSB: National Traffic Safety Board. 2009. Viewed 14 June 2009 <www.nts.gov/ntsb/query.asp>.
- OECD. 1996. *Environmental criteria for sustainable transport*. Report on Phase one of the Project on Environmentally Sustainable Transport, Paris. Viewed 29 April 2008 <www.statistics.gov.uk/statbase>.
- OECD; Maritime Transport Committee, 2003. *Security in Maritime Transport; Risk Factors and Economic Impact*. Paris: OECD.
- Oishi, S.M. 2003. *How to conduct In-Person Interviews for Surveys*. London: Sage.
- Papadakis, Y. 2002. *A model for production decisions affecting safety when risk cannot be reliably assessed*. Proceedings of Decision Sciences Institute, Washington DC: National Academy Press.
- Patterson, E., Woods, D.D., Cook, R.I. and Render, M.L. 2007. Collaborative cross-checking to enhance resilience. *Cognition Technology & Work*, Vol. 9, pp. 155-162.
- Peak, S. 1994. *Transport in Transition , Lessons from the History of Energy*. Royal Institute of International Affairs; Energy and Environmental Programme. London: Earthscan Publications.
- Pearce, J.A., Doh, J.P. 2005. Initiatives: The High Impact of Collaborative Social Initiatives. *MIT Sloan Management Reviews*, Vol. 46, pp. 9-11.
- Peck, H. 2003. *Creating A Resilient Supply Chain – A Practical Guide*. Cranfield: Center For logistics and Supply Chain Management.
- Peck, H. 2005. Drivers of Supply Chain Vulnerability: An Integrated Framework. *International Journal of Physical Distribution & Logistics Management*, Vol. 35, No. 4, pp. 210-232.

Perrings, C. 2006. Resilience and sustainable development. *Environment & Development Economics*, Vol. 11, No. 4, pp. 417-427.

Perrow, C. 1999. Organizing to reduce vulnerabilities of complexity, *Journal of Contingencies & Crisis Management*, Vol. 7, No. 3, pp. 150-155.

Peters, V. 2006. *Onderzoekstypen in de Communicatiewetenschap*. Ed: Wester, F., Renckstorf, K. Scheepers, P. Deventer: Kluwer.

Pettigrew, A. and Whipp, R. 1993. Managing the Twin Processes of Competition and Change – The Role of Intangible Assets. In: Lorange, P., Chakravarthy, B., Roos, J. and Van de Ven, A. (Eds), *Implementing Strategic processes: Change, Learning and Co-Operation*, Cambridge, MA: Blackwell, pp. 3-42.

Pettit, T. J. 2008. Supply Chain Resilience: Development of a conceptual frame work, an assessment tool an implementation process. Unpublished PhD thesis, Columbus: Ohio State University.

Pettit, T., Fiksel, J. and Croxton, K.L. 2010. Ensuring supply chain resilience: development of a conceptual framework. *Journal of Business Logistics*, Vol. 31, No. 1, pp. 1-21.

Pickett, C. 2006. Prepare for supply chain disruptions before they hit. *Logistics Today*, Vol. 47, No. 6, pp. 22-25. Viewed 18 September 2008 <<http://www.ohiolink.edu/etd/send-pdf.151680271>>.

Pienaar, W.J. and Vogt, J.J.. 2009. *Business Logistics Management; A Supply Chain Perspective*. Cape Town: Oxford University Press.

Ploos van Amstel, W. 2002. Het organiseren van logistiek beheersing. Unpublished PhD thesis, Faculty of Management. Amsterdam: Vrije Universiteit van Amsterdam.

Polley, D, 1997, Turbulence in organisations; New Metaphors in Organisational Research. *Organisational Science*, Vol. 8, no 5, pp. 445-457. Viewed 15 April 2009 <<http://www.jstor.org/pss/2635215?cookieSet=1>>.

Ponomarov, S.Y. and Holcomb, M.C. 2009. Building Supply Chain Resilience through Logistics Capabilities. Orlando: *Proceedings of the 20th. Annual Production and Operations Management Society (POMS) Conference*, Abstract 011-0411.

Powell, T. 2001. *The principles of Transport Economics*. London: PTRC Education and Research Services Ltd.

Proper, J. W. 2007a. *Openbaar vervoer; het spel*. Breda: NHTV University of Applied Sciences.

Proper, J. W. 2007b. *How to create a resilient environment for transport organisations*. Presentation at ATIM conference on disruption management in supply chains; 30 January 2007, Den Bosch, the Netherlands.

Proper, J. W. 2007c. *Evenementen en verkeer en vervoer*. Breda: NHTV University of Applied Sciences.

Proper, J. W. 2008. *Openbaar Vervoer*, Breda: NHTV University of Applied Sciences.

Provincie Brabant. 2007. *OV-Netwerk Brabant*, Den Bosch: Provincie Brabant.

Pun, S. S. 2009. Managing in Turbulent Environments: Igor Ansoff's Strategic Success Model. *Singapore Institute of Management*. Viewed 14 April 2009 <<http://www.ansoffasia.com/article002.pdf>> .

Quak, S. 2008. *Structuur voor risico identificatie voor de openbaar vervoer organisatie*, Unpublished Bachelor's Thesis, Breda: NHTV University of Applied Science.

Quality Associates International, Incorporated. 2008a. *FMEA (Failure Mode and Effects Analysis)*. Viewed 28 October 2008 <<http://www.quality-on.com/services/fmea.php>>.

Quality Training Portal resource Engineering, Incorporated. 2008b. *10 steps to conduct an FMEA*. Viewed 29 October 2008 <http://www.qualitytrainingportal.com/resources/fmea/fmea_10step_dfmea.htm>.

Quattro. 1998. *Quattro Final Report – Synthesis and recommendations*. Brussels: European Commission. Transport RTD Programme, 4th Framework.

Raad voor Verkeer en Waterstaat. 2004. *De waarde van het openbaarvervoer*. Den Haag: Staatsdrukkerij.

RACI model. 2009. Viewed 2 October 2009 <http://www.valuebasedmanagement.net/methods_raci.html>.

Rand-Europe, 1998. *Systeemdiagram voor het beleidsveld verkeer en Vervoer*. Viewed 24 April 2008 <http://www.rand.org/pubs/rand_europe/2008/RE98003.pdf>-

Rasmussen, J. and Svedung, I. 2000. *Proactive risk management in a dynamic society*. Karlstad: Swedish Rescue Services Agency.

RET (Rotterdam Elektrische Tram). *Annual report 2007*, Viewed 14 July 2008 <<http://www.ret.nl/overret/organisatie/~media/PDF/Jaarverslagen>>.

Rice, J. B. and Caniato, F.C. 2003. Building a secure and resilient supply network. *Supply Chain Management Review*, Vol. 7, No. 5, pp. 22-30.

Rigby, D. and Bilodeau, B. 2007. A growing focus on preparedness, *Harvard Business Review*, Vol. 85, No. 7. pp. 21-22.

- Rijkswaterstaat, 2008. *Mobiliteitsonderzoek Nederland*. Viewed 24 April 2008 <www.rijkswaterstaat.nl/dvs/themas/mobiliteit/personenvervoer/mon/index>.
- Robert-Phelps, G., 2001. *Companies don't succeed – people do!*. Ideas to create profits through people, London: Hawksmere.
- Rodrigue, J. P., Comtois, C. and Slack, B. 2006. *The Geography of Transport Systems*. New York: Routledge.
- Rydzak, Felicjan, Piotr Magnuszewski, Jan Sendzimir, and Edward Chlebus. 2006. A concept of resilience in production systems In: A. Grossler, E. A. J. A. Rouwette, R. S. Langer, J. I. Rowe and J. M. Yanni (ed). *Proceedings of the 24th International Conference of the System Dynamics Society*, July 23-27, Nijmegen, Radboud University.
- Salvi, O. and Gaston, D. 2004. Risk assessment and risk decision making process related to hazardous installations in France. *Journal of Risk Research*, Vol. 7, No. 6, pp. 599-608.
- Saunders, M., Lewis, P. and Thornhill, A. 1998. *Research Methods for Business Students*, 5th edition. Harlow, UK: Pearson Educated Limited.
- Scandura, T.A. and Williams, E.A. 2000. Research methodology in management: Current practices, trends and implications for further research, *Academy of Management Journal*, Vol. 43, No. 6, pp. 1248-1264.
- Scholler, O., Canzler, W. and Knie, A. 2007. *Handbuch Verkehrspolitik*. Wiesbaden, Germany: Verlag fur Sozialwissenschaften.
- Schouten, F. 2005. Managing visitors; helping the frail to prevail. Breda: NHTV Academic Studies, No. 1.
- Scott, W. R. 2003. *Organisations: Rational, natural, and open systems*, 5th ed. Upper Saddle River, NJ: Prentice Hall.
- Seuring, S. 2005. Case Study research in Supply Chains, An Outline and Three Examples. *Research Methodologies in Supply Chain Management*, Kotzab, H, Seuring, S, Muller, M, Reiner, G (Eds), pp. 235-250, Heidelberg: Physica Verlag.
- Sheffi, Y and Rice, J.B. 2005. A Supply Chain View of Resilient Enterprise. *MIT Sloan Management Review*, Vol. 49, No. 1, pp. 41-48.
- Sheffi, Y. 2001, Supply Chain management under the threat of international terrorism. *International Journal of Logistics Management*, Vol. 12, No. 2, pp. 1-11.
- Sheffi, Y. 2007. *The resilient enterprise: overcoming vulnerability for competitive advantage*. Cambridge, MA: MIT Press.

- Sieber, S. D. 1973. The Integration of Fieldwork and Survey Methods. *American Journal of Sociology*, Vol. 78, pp. 1335-1359.
- Siegrist M, Earle T.C., Gutscher, H. and Keller C. 2005. Perception of mobile phone and base station risks. *Risk Analysis*. Vol. 25, pp. 1253-1264.
- Siggelkow, N and Rivkin, J.W. 2006. Designing Organisations for Turbulence and Complexity. *Organisation Science*. Vol. 16, No. 2, pp. 101–122. Viewed 15 March 2009 <www.management.wharton.upenn.edu/siggelkow/pdfs/SpeedOS.pdf>.
- Sinha, P.R., Whitman, L.E. and Malzahn, D. 2004. Methodology to mitigate supplier risk in an aerospace supply chain. *Supply Chain Management: An International Journal*, Vol. 9, No. 2, pp.154-168.
- Slone, T.P., Mentzer, J.T. and Dittmann, J.P. 2007. Are you the weakest link in your company's supply chain? *Harvard Business Review*, Vol. 85, No. 9, pp. 116-127.
- Slovic, P. 2000. *The perception of risk*. London: Earthscan.
- Smallman, C. 1996. Risk and organisational behaviour: A Research Model. *Disaster Prevention and Management*, Vol. 5, No. 2, pp. 12-26. Viewed 20 September 2008 <www.thebci.org/BCI/GPG/Introduction.pdf>.
- Smith, H. and Fingar, P. 2003. *Business Process Management: The Third Wave*, Tampa (FL): Meghan-Kiffer Press.
- Starr, R., Newfrock, J. and Delurey, M. 2003. Enterprise resilience: managing risk in the networked economy. *Strategy+Business*, Vol. 30, No. 1, pp. 1-15.
- Steward, M., Reid, G and Mangham, C. 1997. Fostering children's resilience. *Journal of Paediatric Nursing*, Vol. 12, pp. 21-31.
- Stoltz, P. 2004. Building resilience for uncertain times. *Leader to Leader*. Vol. 31, No. 4, pp. 16-17. Viewed 16 September 2008 <www.springerlink.com/index/875q55mn04444347.pdf>.
- Strauss, A. 1987. *Qualitative analysis for social scientists*. New York: Cambridge University Press.
- Svensson, G. 2002. Dyadic vulnerability in companies' inbound and outbound logistics flows. *International Journal of Physical Distribution & Logistics Management*, Vol. 5. No. 1, pp. 13-44.
- Svensson, G. 2004. Vulnerability in business relationships: The gap between dependence and trust. *Journal of Business and Industrial marketing*, Vol. 19, No. 7, pp. 469-483.

- Swamidass, P.M. and Newell, W.T. 1987. Manufacturing strategy, environmental uncertainty and performance: a path analytic model. *Management Science*, Vol. 33, pp. 509-524.
- Tang, C. 2006. Perspectives in supply chain risk management. *International Journal of Production Economics*, Vol. 103, No. 2, pp. 451-488.
- Thomson, J.M. 1974. *Modern Transport Economics*. Harmondsworth: Penguin Books.
- Thomson, M, Ellis, R and Wildavsky, A. 1990. *Cultural Theory*. Boulder: Westview Press.
- Timmer, M. 2008. *The public transport organisation @ tools to implement risk management*. Unpublished Bachelor's Thesis. Breda: NHTV University of Applied Science.
- Tracey, M., Lim, J. and Vonderembse, M.A. 2005. The impact of supply-chain management capabilities on business performance. *Supply Chain Management: An International Journal*, Vol. 10 No. 3, pp. 179-191.
- Transport for London. 2006. *Impacts Monitoring*. Fourth Annual Report, Viewed 2 April 2009 <www.tfl.gov.uk/tfl/cclondon/pdfs/FourthAnnualReportFinal.pdf>.
- Transport for London, Safety, Health and Environment Assurance Committee. 2010. Review of TFL Resilience Management Policy, Viewed 22 August 2010 <<http://www.tfl.gov.uk/assets/downloads/corporate/9-Review-of-TfL-Resilience-Management-Policy-Framework.pdf>>
- Transport Security Administration. 2007. *Homeland Security Transport Systems*. Viewed 25 August, 2008 <http://www.tsa.gov/assets/pdf/transportation_base_plan_appendixes.pdf>.
- Trip, J. J., 2007. *What Makes a City? Planning for 'Quality of Place'*, Unpublished PhD Thesis, Delft: Delft University.
- Tsoukas, H. 1998. Introduction: Chaos, Complexity and Organisation Theory. *Organisation*, Vol. 5, No. 3, 291-313.
- UITP- Security Commission, 2006, Chairman: Geoff Dunmore, Protecting passenger transport systems from the threat of terrorism, Viewed 20 April 2008 <<http://www.uitp.org/Public-Transport/security>>.
- UITP, 2005a. *Mobility in Cities; Millennium Cities Database for Sustainable Transport*. Brussels: UITP.
- UITP. 2005b. *Public Transport in 2020; From Vision to Action, Category Recommendations*. Brussels: UITP.

UITP. 2005c. International security conference: Anti-Terrorism in Public Transport, Transport for London, Presentation.

UITP. 2006. *Passenger Charter; a charter for a customer focused operator*. Viewed 20 April 2008 <<http://www.uitp.org/mos/brochures/37-en.pdf>>.

UITP. 2008. *Manual for the Development of Bus Transport System Safety Management*. Brussels: UITP.

UITP. 2009. *Year report*, Brussels: UITP.

Unicef. 1998. The Guide to Managing for Quality. Viewed 5 November 2008 <<http://erc.msh.org/quality>>.

United Nations, Economic Commission for Europe, 2003. Working Party on Transport Trends and Economics, TRANS/WP.5/2003. New York: UN Publications.

United Nations. 2008. *Demographic Yearbook 2005*, New York: United Nations, Department of Economic and Social Affairs.

United Nations, Department of Economic and Social Affairs. 2004. World Urbanization Prospects: the 2003 revision. Viewed 24 September 2009 <<http://www.un.org/esa/population/publications/wup2003/WUP2003Report.pdf>>.

United Nations, Department of Economic and Social Affairs. 2008a. Trends in sustainable development. Viewed 1 September 2008 <<http://www.un.org/esa/sustdev/publications/trends2008/fullreport.pdf>>.

University of Georgia. 2008. *Risk Quadrants Maps*. Viewed 20 November 2008 <http://www.usg.edu/infosec/risk_management/risk_quadrant_maps>.

Van Dam, K. and Marcus, J. 2005. *Een praktijkgerichte benadering van Organisatie en Management*. Groningen: Noordhof.

Van de Velde, D.M. 2005b. Coordination, integration, and transport sector regulation, In: Handbook of Transport Strategy, Policy & Institutions (Eds.: Hensher, D.A. and K. Button), Handbooks in Transport, Vol. 6, 115-134, Amsterdam; Elsevier.

Van de Velde, D.M. 2007, Regulation and competition in the European land transport industry: recent evolutions, In: *Competition and Ownership in Land Passenger Transport, Selected papers from the 9th International Conference (Thredbo 9), Lisbon, September 2005* (Eds.: Macario, R., J. Viegas and D.A. Hensher), 81-94, Amsterdam: Elsevier Science.

Van de Velde, D.M. and E.A.M. Pruijboom. 2005a. First experiences with tendering at the tactical level (service design) in Dutch public transport, In: *Competition and Ownership in Land Passenger Transport* (Ed.: Hensher, D.A.), 213-237, Amsterdam: Elsevier.

- Van de Velde, D.M., Veeneman, W.W. and L. Lutje Schipholt, L. 2008. Competitive tendering in The Netherlands: Central planning vs. functional specifications", *Transportation Research Part A*, 42, 1152–1162.
- Van der Heijden, W. 2006. *Risicomanagement in de aderen*. Research project NS Project Consult, Enschede: University Twente.
- Van Eyk, M. 2006. *De waarde van stedelijke mobiliteit*, Masters Thesis, Utrecht: Universiteit van Utrecht.
- Van Nes, R. 2000. *Design of multimodal transport systems – Setting the scene: Review of literature and basic concepts*. Delft: TRAIL Research School.
- Van Wee, B. 2000. Land use and transport: research and policy changes. *Journal of Transport Geography* Vol. 10, pp. 259-271.
- Van Wee, B. 2002. *Multi-modaal personenvervoer: dood paard of volop kansen? Een essay over Multi-modaal personenvervoer vanuit milieuoptiek*, Bilthoven: RIVM.
- Van Wee, B. and van Dijkstra, M. 2002. *Verkeer en vervoer in hoofdlijnen*. Bussum: Coutinho.
- Van Zeijl, A.M.M.M. 2009. *Wetteksten*. Groningen: Noordhoff.
- Venkatraman, N. and Camillus, J.C. 1984. Exploring the Concept of 'Fit' in Strategic Management. *Academy of Management Review*, Vol. 9, No. 3, pp. 513-525.
- Veolia Transport. 2007. *Year report*. Viewed 12 July 2008 <www.veolia-transport.nl>.
- Verstraete, C. 2008. Share and share alike. *Supply Chain Quarterly*, Vol. 2, pp. 32- 38.
- Vervoort, D. 2010. *De H van Hoogwaardig: De successen en faalfactoren van HOV per bus*. Unpublished Bachelor Thesis, Breda: NHTV of Applied Sciences.
- Vipre. 2009. *Bedrijfvervoer: Bus of Vanpool*. Viewed 2 May 2008 http://www.verkeersonderneming.nl/home/bedrijven/woon_werkverkeer/bedrijfvervoer.
- Viscusi, W.K. 1983. *Risk by Choice*. Cambridge, MA: Harvard University Press.
- Vollman, T.E., Berry, W.L., Whybark, D.C. and Jacobs, F.R. 2005. *Manufacturing planning and control systems for supply chain management*. New York: McGraw-Hill.
- Vosselman, E.G.J. 1996. De betekenis van de bedrijfskundige gevalstudie voor theorievorming. *Bedrijfskunde*, Vol. 2, Deventer: Kluwer Bedrijfswetenschappen.
- Vrijling, J.K., Van Gelder, P.H.A.J.M., Goossens, L.H.J., Voortman, H.G. and Pandey, M.D. 2004. A framework for risk criteria for critical infrastructures. *Journal of Risk Research*, Vol. 7, No. 6, pp. 569-579.

Wagner, S. and Bode, C. 2006. An empirical examination of supply chain performance. *Journal of Purchasing and Supply Management*, No. 12, pp. 302-312.

Wagner, S. and Bode, C, 2008. An empirical examination of supply chain performance along several dimensions of risk. *Journal of Business Logistics*, Vol. 29, No. 2, pp. 307-325.

Watson, S.R. 1994. The meaning of probability in probabilistic safety analysis. *Reliability Engineering and System Safety*, Vol. 45, pp. 261-269.

Wegewijs, F., 2008. *Dynamische concessies*, Unpublished Bachelor Thesis, Breda: NHTV University of Applied Sciences.

Wells, A.T. and Young, S.B. 2004. *Airport Planning & Management*. 5th ed. New York: McGraw-Hill.

White, P. 2002. *Public Transport: Its Planning, Management, and Operation*. London: Spon Press.

World Bank. 2008. Launch of the World Bank Group's Transport Business Strategy for 2008-2012. Safe, Clean, and Affordable Transport for Development. Viewed 25 August 2008 <<http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT>>.

World Economic Forum. 2009. *Global Risks 2009*, Switzerland, Viewed 12 august 2009 <www.weforum.org>.

Wreathall, J. 2006. Properties of Resilient Organisations: An Initial View. In *Resilience Engineering. Concepts and Precepts*, (eds) Hollnagel, E., Woods, D.W., Leveson, N., pp. 275-288. Aldershot: Ashgate.

Wu, T., Blackhurst, J. and Chidambaram, V. 2006. A model for inbound supply risk analysis. *Computers in Industry*, Vol. 57, pp. 350–365.

Wycoff, K., 2006. Presentation OSCE, Viewed 20 June 2008 <<http://www.osce.org/atu/20642.html>>.

Yin, R.K. 1998. The Abridged Version of Case Study Research: Design and Method. In: L.Bickman and D. J. Rog. *Handbook of Applied Social Research Methods*. Thousand Oaks: Sage Publications.

Yin, R.K. 2003. *Case study research: design and methods* (3rd. ed.). Newbury Park, CA: Sage.

Zohar, D. 2003. The influence of leadership and climate on occupational health and safety, In: D. Hofman & Tetrick (Eds) *Health and safety organisations, A multilevel perspective*, San Francisco: Jossey Bass.

Zsidisin, G.A., Ellram, L.M. ,Carter J.R. and Cavinato J.L. 2004. An analysis of supply risk assessment techniques. *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 5, pp. 397- 413.

Appendix 1: Interview on resilience framework verification for inclusion with empirical findings. (Questionnaire dealt with in Chapter 5.)

Introductory letter

Dear Participant,

In recent years some new developments have emerged which have had an impact on the public transport sector. Among the first to mention are a series of crises and catastrophes that have attracted public attention. Terrorist acts in Madrid and London, disrupted deliveries of new buses and trains, strikes or increased violence directed at drivers and passengers are just a few of such situations. There is evidence that these events are becoming more frequent and they show an increase in both their potential for disruption and their magnitude.

Secondly, over the last decade almost all organizations in the public transport sector have seen increased competitive pressure in the business environment. These changes have compelled public transport organizations to make their intra-firm business processes and inter-firm networks more efficient and responsive.

Resilience is basically about building organizational capabilities for bouncing back quickly. It includes reduction in problem-identification time, reduction in problem-resolution time and reduction in response time to problems. The topic of resilience in public transport organizations is receiving more attention, but there is not a structured or systematic approach and the introduction of a framework is needed, including a capability model.

The above are some of the challenging reasons that motivated me to undertake a PhD dissertation. The research objective is formulated as follows: “designing a framework to embed resilience in public transport organizations”. This research is being conducted under the guidance of my promoter, Prof. W.J. Pienaar from the Department of Logistics at the Stellenbosch University, South Africa.

The research is exploratory in nature and includes an extensive literature study combined with empirical research. The literature study – which has already been completed – has enabled the formulation of a theoretical framework.

Empirical research is needed to assess the framework and to understand the level of advancement in implementing the resilience approach in the public transport sector. The empirical research will entail the structured interview methodology with the use of questionnaires.

The most important stakeholders have been identified from the theoretical research. A positive sampling approach enabled a selection of participants in the different stakeholder categories, based on a functional differentiation and experience, regarding public transport and/or resilience. By working with these participants, the objective of this empirical research is to verify the framework relations, to use their experience and understanding gained in order to clarify the completeness of the model, and to understand the advances in the approach to increasing organizational resilience.

You have been identified as one of the participants in this empirical part of the research and I am convinced that your support could make a substantial contribution to my research. It is my belief that with your participation and my promoter's support, I can make a positive contribution towards creating new knowledge in the domain of resilience in the public transport sector.

The interview is expected to take one and a half hours of your time. I realise that during the interview information required may not be immediately available. I will send you the questionnaire in advance and after the interview I will send you the outcome, so that you may finalise outstanding items. The interview results will also be used to validate your responses to the questions.

The interview will consist of the following sections:

- Section 1: Explanations of terms of reference with explanation of the theoretical framework and related set of definitions. Questions for clarification of definitions and structure of framework and basic company information;
- Section 2: Questions to verify the research propositions defined in the development of the theoretical framework;
- Section 3: Questions to clarify the completeness of the framework and the level of advancement in implementing the organizational resilience approach.

All information received from the various participants will remain anonymous and the outcome of the empirical research will be aggregated to ensure that no confidential information would be revealed. The interviews will be scheduled from January 2009 to March 2009. I will schedule a suitable time and location with you to conduct the interview and to complete the questionnaire.

After I have completed my dissertation, I will give all participants a CD copy of the research. My motivation for this research is also based on the expectation that, with your participation, an orientation and guide for initiatives in this domain of resilience in the public transport sector can be achieved.

I would like to thank you in advance for your participation, and I trust and hope that you are as anxious as I am to realise the outcome of this empirical research in the final dissertation.

With kind regards,

Jan Willem Proper

Interview for framework verification and for inclusion from empirical findings

Introduction

This interview is part of a research project with the overall objective: “designing a framework to embed resilience in public transport organizations”.

The purpose of the interview is first to verify a framework that has been constructed based on an extensive literature study. Further to that, the purpose is to obtain information about the completeness of the framework and the level of advancement in implementing the resilience approach in public transport organizations.

The interview will consist of the following sections:

- Section 1: Explanations of terms of reference with explanation of the theoretical framework and related set of definitions. Questions for clarification of definitions and structure of framework and basic company information;
- Section 2: Questions to verify the research propositions defined in the development of the theoretical framework;
- Section 3: Questions to clarify the completeness of the framework and the level of advancement in implementing the organizational resilience approach.

Section 1: Terms of reference with an explanation of the theoretical model and the related set of definitions

From a theoretical perspective, a framework is developed for a resilience approach to be adopted by public transport organizations. In this part the structure of the framework will be explained together with to the most important definitions.

Resilience is defined as: the capacity of an organization to survive, adapt and grow in the face of turbulent change.

The concept of balanced resilience is based on the alignment of vulnerability and capability.

Vulnerability is defined in the research as: fundamental factors that make an organization susceptible to disruptions.

Disruptions are defined as: the combination of (1) an unintended, exceptional triggering event, and (2) a consequential situation which significantly threatens the normal course of business operations of the affected public transport organization.

Capabilities refer to the management of (internal) control and management to response (or survive). In this research the following definition is used: Capabilities are attributes required for performance or accomplishment.

The level of sophistication of disruption identification and management control is assumed to be related to the level of awareness. The awareness of the concept of resilience as subject of interest can be discussed on the basis of four components:

- The way the approach to resilience and risk is described in clear and consistent (external) statements;
- The clear contextual and environmental focus of the public transport organization;
- The way the responsibility to maintain resilience is defined;
- The reliable data required and the information available.

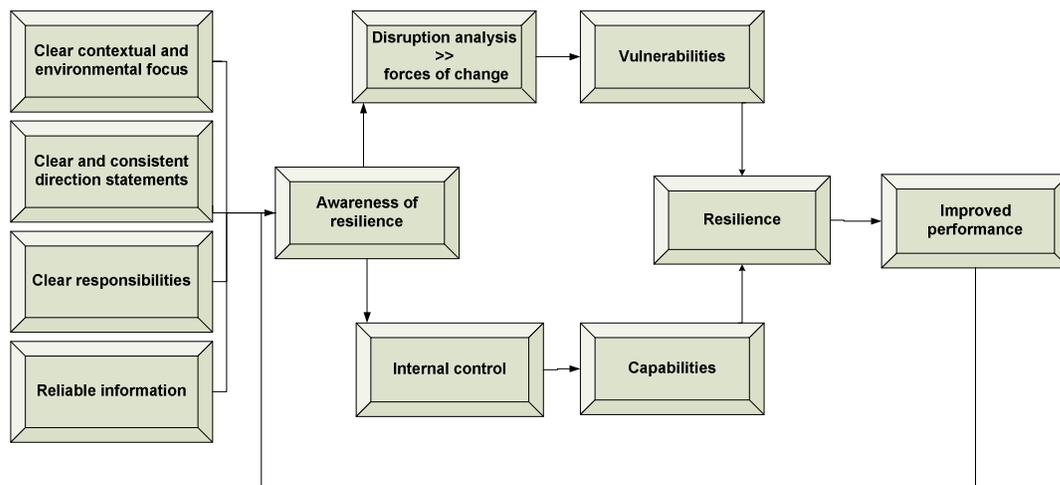
The environmental focus is segmented into four areas for identification of events:

- Supply conditions for analysing evolving events: these conditions describe the conditions of the *supply side* of the public transport market and include all activities and decisions that are not fully and directly managed by the public transport organization.
- Market conditions for analysing evolving events: these conditions describe the *demand and supply relations* of the public transport organization that are influenced directly by changes in demand behaviour and indirectly by changes of characteristics of other transport supply or suppliers.
- System conditions for analysing evolving events: these conditions describe the conditions that are *outside the public transport market and derive from travel market and/or traffic (infrastructure) market*.
- Context conditions for analysing evolving events: these conditions relate to conditions in the *wider context* of the public transport system.

In the light of these conditions, a postulate is formulated that there is a positive relation between awareness and the role and function of public transport in society. An increasing relevance of public transport will create an environment of higher awareness of what might occur and the influence(s) of that on the performance of the organization.

Finally, the result of the alignment between vulnerability and capability is described as balanced resilience. An increasingly balanced position will impact on the performance of the organization.

The figure below shows the different elements of the resilience approach in cohesion.



The varying viewpoints on resilience often intersect with the role of traditional risk management in identifying and reducing threats. The phases of identification, assessment and response are present in both. This interview will make a link with risk management. In this research *risk* is defined as “the negative deviation from the expected value of a certain performance objective, resulting in undesirable consequences for the focal firm”. *Risk assessment* is the practice of judging or appreciating identified disruptions and vulnerabilities and developing a prioritisation list.

The concept of resilience supplements analytical techniques with strategies that do not require exact quantification, complete enumeration of possibilities or assumptions of a representative future. With operational risk often rated as the most important, management faces increasing value through better disruption-based decision making as a top imperative. Strategic imperatives call for a more adaptive approach to change as in design, processes, visibility to demand and supply, and relation management in the transport system network and for infusing a culture of resilience.

Questions marked () are applicable only for participants from public transport organizations**

1.1 Questions for clarification of definition and structure of model

1.1.1 What are your organization's experiences with risk-management approaches?

1.1.2 What are your organization's experiences with approaches to resilience?

1.1.3 Clarification of definitions.

a) Do you consider the definitions presented to be clear and consistent?

1.1.4 Clarification of model structure.

a) Do you consider the model presented as well structured? (Note: the links between the different elements will be discussed later.)

1.2: Basic information of public transport organization ()**

1.2.1 Business structure

a) How is the organization structured? (e.g. product market combination and corporate, division and regional structure)

b) What are the main corporate strategy statements?

c) How are divisions, regional or department statements related to corporate level (e.g. independent or dependent to corporate level, and responsibility and accountability at department level)?

d) Which major external stakeholders influence the supply of public transport and what is their influence on the business in general?

Stakeholder: _____ Influence _____

Stakeholder: _____ Influence _____

Stakeholder: _____ Influence _____

- e) What are the most important challenges and related considerations for your organization?

Term	Challenges	Considerations
Long term: Corporate level		
Medium term: Corporate level		
Short term: Corporate level		

1.2.2 Business information and indicators

- a) What are the main market segments and how do they develop?
(e.g. growth or decline)
_____ perc: _____ growth/stable/decline
_____ perc: _____ growth/stable/decline
- b) What are the main products or services offered and how do they develop?
(e.g. increasing, decreasing supply)
_____ perc: _____ growth/stable/decline
_____ perc: _____ growth/stable/decline
- c) Company turnover in euro terms for main product market segments and total?
Total: _____
Pareto principle:
Product market segment 1: _____ percentage: _____
Product market segment 2: _____ percentage: _____
- d) What are the most important cost drivers? (Pareto principle in euro terms)
1) _____ % _____
2) _____ % _____
- e) Percentage of outsourced operational activities in cost?

- f) Percentage of fixed cost?

- g) Which assets are leased or rented?
Leased: _____
Rented: _____
- h) What are the main performance indicators related to the main operational goals?
Goal: _____ Indicators: _____
Goal: _____ Indicators: _____

Section 2: Questions to verify the research propositions defined in the development of the theoretical framework

2.1 Organization’s orientation and understanding of resilience ()**

a) Does the organization incorporate resilience and risk considerations into business strategies (e.g. what is the relation with other strategies)?

b) Are there clear and consistent statements on risk or resilience in annual reports or other publicly available publications? If so, where are they published and what is the content?

Publication: _____ Content: _____
 Publication: _____ Content: _____

c) Are there clear and consistent statements on risk or resilience in internal statements? If so, where are they published and what is the content?

Publication: _____ Content: _____
 Publication: _____ Content: _____

d) Does the organization follow a structured approach towards a risk and/or resilience identification approach?

If yes, how is this structured?

Risk: _____
 Resilience: _____

e) Does the organization have a clear description of responsibilities related to risk and resilience?

If yes, what are the functions and responsibilities?

Risk: _____
 Resilience _____

f) What are the most important tools for identifying, assessing and mitigating risk or resilience?

<i>Processes</i>	<i>Tools used by the organization</i>
Identifying	
Assessing	
Mitigating	

g) Does the organization have enough information to identify triggering events?

h) How does the organization monitor the environment in relation to triggering events that might cause disruptions?

i) Does the organization’s risk or resilience identification process starts with a focus on the goals or policy statements?

- j) Does the organization outsource operational activities to third parties? If yes, are risk or resilience issues involved in the decision-making process?

- k) Is the organization using external sources for obtaining information on risk or resilience?

- l) What are the critical competences to achieve the maximum contribution to the goals of risk management or resilience?

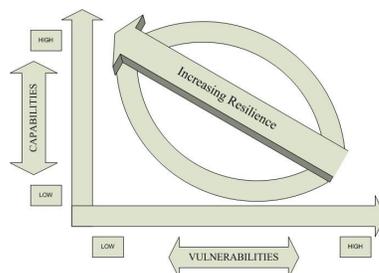
2.2 Verification of research propositions

In section 1 the definitions and structure of the framework are described. In this part of the interview the focus is on the direction of the relations between the different parts of the model. In the theoretical development some statements have been formulated. In this section of the interview these assumptions and hypotheses will be presented. The questions will be on verification of the assumed relation and the direction of that relation (positive or negative).

- a) Resilience is defined as: “the capacity for an organization to survive, adapt and grow in the face of turbulent change”.
Vulnerability is defined as: “fundamental factors that make an organization susceptible to disruptions”.
Do you agree with following statement?
“Increase of vulnerabilities has a negative relation to resilience”
YES: _____
NO: _____

- b) Resilience is defined as: “the capacity of an organization to survive, adapt and grow in the face of turbulent change”.
Capabilities are “attributes required for performance or accomplishment”.
Do you agree with following statement?
“Increase of capabilities has a positive relation to resilience”
YES: _____
NO: _____

- c) Do you agree with following statement?
“Resilience increases as capabilities increase and/or vulnerabilities decrease”.



- YES: _____
- NO: _____

- d) The framework for resilience must take into account fundamental factors that encompass the broadest possible range of disruptive threats. Disruptions are defined as: the combination of (1) an unintended, exceptional triggering event, and (2) a consequential situation which significantly threatens the normal course of business operations of the affected organization. The analysis of disruptions creates forces for change.

Do you agree with the following statement?

“Forces for change result in public transport vulnerabilities”.

YES: _____

NO: _____

- e) In order to counteract vulnerabilities, the organization can develop capabilities that ensure long-term survival. These capabilities could prevent an actual disruption, mitigate the effects of a disruption or enable adaptation following a disruption. Concepts such as flexibility, visibility and adaptability are commonly discussed managerial capabilities.

Do you agree with the following statement?

“Internal control creates public transport capabilities”.

YES: _____

NO: _____

- f) Awareness is formulated as “the state of having understanding or knowledge”. In this research this awareness refers to knowledge on resilience. The level of advancement of awareness is assumed to depend on four different elements in a positively related way. In this research it is stated that awareness must be created. Do you agree with the following assumptions?

	<i>Assumption on level of awareness</i>	Yes	No	Remarks
f-1	<i>Awareness is positively influenced by a clear and consistent direction statement on resilience.</i>			
f-2	<i>Awareness is positively influenced by a clear contextual and environmental focus.</i>			
f-3	<i>Awareness is positively influenced by clear responsibilities.</i>			
f-4	<i>Awareness is positively influenced by reliable information.</i>			

Awareness is described as a precondition for identifying and assessing disruptions and in developing capabilities to prevent, to mitigate and to enable adaptation.

f-5: Do you agree with the following statement?

“A higher level of awareness on risk and/or resilience has a positive effect on the level of identification and assessment of disruption”?

YES: _____

NO: _____

f-6: Do you agree with the following statement?
 “A higher level of awareness on risk and/or resilience has a positive effect on the level of internal control”?

YES: _____

NO: _____

Section 3: Questions to clarify the completeness of framework and level of advancement in implementing the resilience approach

3.1 Structuring resilience approach for public transport organizations ()**

a) With regards to the environment of the organization, how would you describe the importance of the following points of focus?

<i>Corporate Focus</i>	<i>Relative Importance: High---Low</i>	<i>Motivation</i>
Cost focus		
Consumer focus		
Operational excellence		
Resilience		

- b) What are the most compelling factors driving the need for change?

- c) What are the key enablers for managing change (in the public transport organization)?

- d) What are the biggest advantages of using a structured resilience approach?

- e) What are the major complications in using a structured resilience approach?

- f) What are some of the main fundamental differences between the processes used in your organization compared to the model presented here?

- g) What are advantages and disadvantages of using an opportunistic approach? (e.g. proactive or reactive approach)
 Advantage: _____
 Disadvantage: _____
- h) What are the main obstacles to working (in public transport organizations) with the model described here?

- g) What do you consider the most important responsibilities of the corporate level and the business units concerning the resilience approach?

<i>Level</i>	<i>Most important responsibilities</i>
Corporate	
BU	

3.2 Level of awareness of resilience

a) What are the dominant opportunities for using a resilient approach?

b) What approaches and processes are used to identify, assess and mitigate risk or resilience?

c) (**) Which part of the organization is most involved in the risk and resilience approach and processes?

d) (**) Indicate what level of awareness has been achieved by your organization on the following matrix?

Use of scale: Not applicable (NA) or Moderate (M) or low (L) or High (H)

Elements of awareness	NA	M	L	H
The public transport organization has clear processes and procedures for a resilient approach.				
The public transport organization has a clear description of responsibilities and accountability for the resilience approach.				
The public transport organization has a clear view of the environment in which the triggering events may occur.				
The public transport organization has an accurate information structure to identify disruptions.				

3.3 Measurement of disruption(s) and performance

a) How are triggering events derived?

b) What are the criteria for the events to be judged as triggering events?

c) What are the procedures for measuring the severity of the triggering events to determine the consequences?

d) What critical competences are required to get the best measurement and analysis of disruptions?

e) Can you describe some relevant disruptions that have occurred in your organization in recent years?

f) Who are involved in the decision-making processes to classify the consequences of disruptions?

g) What do you consider the most important (fundamental factors) vulnerabilities of your organization?

h) What are the most important capabilities to overcome these vulnerabilities?

i) Do you agree with the following statement?
“Performance improves when capabilities and vulnerabilities are balanced.”
YES: _____
NO: _____

j) What do you consider the most relevant performance indicators in case of improvement of the level of resilience?

k) Is the risk and/or resilience approach based on a closed loop?
(e.g. check, act, plan, do)

l) Do you agree with the following statement?
“Improved performance will have a positive feedback effect on creating awareness of resilience.”
YES: _____
NO: _____

m) What opportunities are available for collaboration with partners and other stakeholders in the field of a resilient approach?

3.3 Is there any information you would like to share that has not been referred to in the questionnaire?

Appendix 2: Interview on vulnerability and capability verification for inclusion with empirical findings. (Questionnaire dealt with in Chapter 6.)

Introductory letter.

Dear Participant,

In the past few years some new developments have emerged which have impacted on the public transport sector. The first of these has been a recent series of crises and catastrophes that have attracted public attention. Terrorist acts such as those in Madrid and London not only caused considerable damage. Disrupted deliveries of new buses and trains, strikes or increased violence to drivers and other passengers on public transport are other examples of such crises. There is evidence that these events are becoming more frequent and, with an increase in their number, there is also a potential for greater disruptions and increase in magnitude.

Second, over the last decade almost all organizations in the public transport sector have seen increased competitive pressure in the business environment. These changes have compelled public transport organizations to make their intra-firm business processes and inter-firm networks more efficient and responsive. All these events or disturbances have an impact on the long-term and operational activities of public transport.

Resilience is basically about building organizational capability for bouncing back quickly. It includes reduction in problem-identification time, reduction in problem-resolution time and reduction in the response time to problems. The topic of resilience in public transport organizations is receiving more attention, but there is no structured approach and the hence introduction of a framework is needed, including a capability model.

The above are some of the challenging reasons that motivated me to undertake this research for a PhD dissertation. The research objective is formulated as “designing a framework to embed resilience in public transport organizations”. This research is being conducted under the guidance of my promoter, Prof W.J. Pienaar from the Department of Logistics at the Stellenbosch University, South Africa.

The research is exploratory in nature and includes an extensive literature study combined with empirical research. The literature study – which has already been completed – has led to the formulation of a theoretical structure to model the resilience framework. Empirical research is undertaken to assess the framework and to understand the level of progress in the public transport sector. This framework has been discussed with the public transport sector and with representatives of the academic and risk and security sector.

From these discussions it became clear that the main elements that define resilience are (i) vulnerabilities that make an organization susceptible to disruptions; and (ii) capabilities that enable it to respond (or survive).

In the public transport sector no research is available on the identification, categorisation and definitions of these two dimensions. Based on academic literature, information from conferences and information available through publications, together with the information derived from the first empirical questionnaire, a list of vulnerability and capability elements has been developed.

It is relevant to my research to obtain others' reflection on this and to get feedback from the passenger transport sector. The empirical research will use the structured interview methodology with the use of questionnaires. A positive sampling approach has entailed selecting participants based on functional differentiation and experience regarding public transport and/or resilience. By working with these participants, the objective of this empirical research is to use their experience and understanding to clarify the vulnerability and capability factors in the public transport sector and to understand recent progress in the resilience approach.

You have been identified as one of the participants in this empirical phase of the research and I am convinced that your support could make a substantial contribution to my research. It is my belief that with your participation and my promoter's support, I can make a positive contribution to new knowledge in the domain of resilience in the public transport sector.

The interview is expected to take an hour and a half (90 minutes) of your time. I realise that during the interview itself not all relevant information required may be available. I will therefore send you the questionnaire in advance and after the interview will send you the outcome, so that you can finalise any outstanding items. The interview results will also be used to validate your answers to the questions.

The interview will consist of the following sections:

- Section 1: For information and context: Terms of reference, with explanation of theoretical framework and set of definitions;
- Section 2: Overview of identified, categorised and described vulnerability and capability factors;
- Section 3: Clarification of the relevance and completeness of the vulnerability and capability (sub-) factors and level of advancement in the resilience approach.

All information received from the participants will remain anonymous and the outcome of the empirical research will be aggregated to ensure that no confidential information would be revealed. The interviews will be scheduled from October 2009 to December 2009. I will schedule a suitable time and location with you to conduct the interview and to complete the questionnaire.

Once I have completed my dissertation, all participants will receive a CD copy of the research. My motivation for this research is also based on the expectation that, together with your participation, an orientation and guide for initiatives in this domain of resilience in the public transport sector will be achieved.

I would like to thank you in advance for your participation and trust and hope that you are as anxious as I am to see the successful outcome of this empirical research and the final publication of my dissertation.

With kind regards,

Jan Willem Proper

Interview on vulnerability and capability verification for inclusion with empirical findings

Introduction

This interview is part of a research project with the overall research objective stated as follows: “designing a framework to embed resilience in public transport organizations”.

The purpose of the interview is first to verify the identified vulnerability and capability factors and sub-factors and the descriptions that have been constructed on the basis of an extensive literature survey. In addition to that, the purpose of the interview is to gather information about the completeness and level of progress of the resilience approach in public transport organizations.

The interview will consist of the following sections:

- Section 1: For information and context: Terms of reference, with explanation of theoretical framework and set of definitions;
- Section 2: Overview of identified, categorised and described vulnerability and capability factors;
- Section 3: Clarification of the relevance and completeness of the vulnerability and capability (sub-) factors and level of advancement in the resilience approach.

Section 1: Terms of reference with explanation of theoretical framework and set of definitions

Resilience is defined as: the capacity of an organization to survive, adapt and grow in the face of turbulent change. The concept of balanced resilience is based on the alignment of vulnerability and capability.

Vulnerability is defined as: fundamental factors that make an organization susceptible to disruptions.

Disruptions are defined as: the combination of (1) an unintended, exceptional triggering event; and (2) a consequential situation which significantly threatens the normal course of business operations of the affected public transport organization.

Capabilities are about management of (internal) control and management of how to respond (or survive). In this research the following definition is used: capabilities are attributes required for performance or accomplishment.

The varying viewpoints on resilience often intersect with the domain of traditional risk management roles in identifying and reducing threats. The phases of identification, assessment and response are recognised in both approaches. In this interview a link to risk management will be made. In this research *risk* is defined as: the negative deviation from the expected value of a certain performance objective, resulting in undesirable consequences for the focal firm.

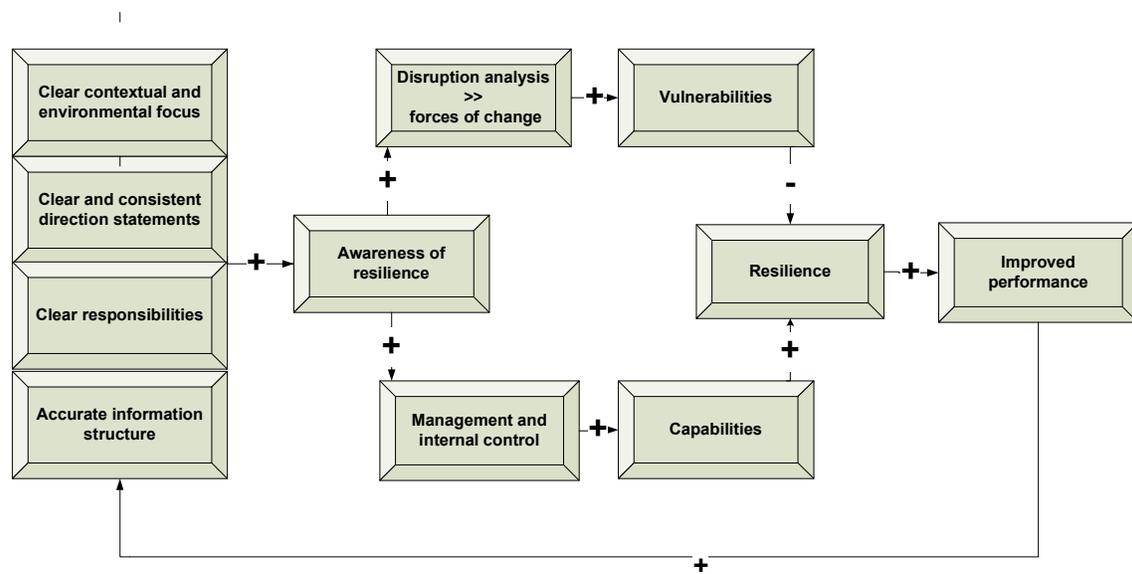
The concepts of resilience supplement analytical techniques with strategies that do not require exact quantification, complete enumeration of possibilities or assumptions of a representative future. With operational risks rated as the most important, management can generate increasing value through better disruption-based decision making as a top imperative. Strategic imperatives call for a more adaptive approach to bring about change in aspects such

as design, processes, visibility to demand and supply, and relation management in the public transport system network, and to infuse a culture of resilience.

The level of sophistication of disruption identification and management control is related to the level of awareness. The awareness of resilience as subject of interest can be discussed based on four components:

- The way the approach to resilience and risk are described in clear and consistent (external) statements;
- The clear contextual and environmental focus of the public transport organization;
- The way the responsibilities for resilience are clearly defined;
- The accurate information structures.

On the basis of these conditions, a postulate is formulated that there is a positive relation between awareness and the role and function of public transport in society. The increasing relevance of public transport will create an environment of higher awareness of what might occur and its influence(s) on the performance of the organization. Finally, the result of the alignment between vulnerability and capability is described as “balanced” resilience. An increasingly balanced position will impact on the performance of the organization. The figure below shows the different elements of the resilience approach in cohesion.



Section 2: Overview of identified, categorised and described vulnerability and capability (sub-)factors.

Based on the literature and findings from the empirical study, vulnerability and capability (sub-) factors are identified, categorised and described. The (sub-) factors are also based on sources other than from the public transport sector and the main purpose is to verify their relevance and completeness for the public transport organizations.

For vulnerability the following factors with descriptions and sub-factors are distinguished:

Vulnerability (exposure to) factor:	Sub-factors: Descriptors ("not exhaustive")	Description
Turbulence Accidental	Natural disasters (floods, earthquakes); Health disasters, pandemics; Geopolitical disruptions; Unpredictability of markets ; Unforeseen technology and IT failures; Unpredictable financial issues.	<i>Environment characterised by: changes in external factors beyond internal control.</i>
Threats Intentional	Terrorism and sabotage (internal, external) incl. cyber disruption, piracy and theft and espionage; Media pressures, offensive advertising, brand attacks; Labour disruptions, union activities, strikes; Special interest groups.	<i>Deliberate attacks aimed at disrupting operations or causing human or financial harm.</i>
Pressures, External	Competitive innovation; Social/cultural changes; Political/regulatory change; Price pressures (competitive); Environmental, health, safety concerns; Corporate responsibility concerns	<i>Influences, not specifically targeted at the organization, that create business constraints or barriers</i>
Resource Limits	Natural resources; Intellectual property; Supplier and utilities availability; Asset utilization; Distribution availability; Data-storage capacity; Human resources.	<i>Constraints on output and productivity based on availability of connected factors of production</i>
Sensitivity	Complexity of design and product purity; Complexity of process operations; Consumer requirements for quality; Restricted utilization of materials and data; Reliability of (key) equipment and IT; Potential safety hazards; Loss of key personnel; Visibility of disruption to stakeholders; Symbolic profile of brand; Concentration of capacity.	<i>Relevance of carefully controlled conditions for product, service and process integrity and liability</i>
Connectivity	Scale/extent of (travel and traffic) networks; Degree of outsourcing; Information interdependence and reliance; Reliance upon specialty sources and information flows.	<i>Degree of reliance and interdependencies on outside entities</i>
Supplier/ Customer disruption	Supplier trust and reliability; Customer and loyalty relations; External relations; Reliability of relations.	<i>Susceptibility of suppliers and customers to external forces or disruptions</i>

For capabilities the following factors with description and sub-factors are distinguished:

Capability factors	Sub-factors: Descriptors ("not exhaustive")	Description
Flexibility		<i>Ability to change quickly</i>
Flexibility in sourcing	Modular product design; Standardization and commonality of parts; Multiple sources; Contract flexibility with suppliers.	<i>Ability to quickly change <u>inputs</u> or the mode of receiving inputs</i>
Flexibility in Order-fulfilment	Alternative transport and distribution offering; Multiple service centers; Update of information; Postponement.	<i>Ability to quickly change <u>outputs</u> or the mode of delivering outputs</i>
Capacity	Utilities back-up sources; Asset reserve capacity beyond normal deviations; Labour capacity flexibility; Communication and IT back-up systems.	<i>Availability of <u>assets</u> to enable sustained production or service levels</i>

Efficiency	Waste elimination; Labour productivity; Asset utilization; Quality management/ service variability reduction; Failure prevention; Process standardization; Preventive maintenance.	<i>Capability to produce outputs with minimum resource requirements</i>
Visibility	Business intelligence gathering; Information/automation technology; Status of all personnel; Market visibility, external monitoring; Service and equipment visibility; People visibility.	<i>Knowledge of the status of operating assets and the environment</i>
Adaptability	Learning from experience / feedback mechanism; Strategic simulation; Alternative technology development; Fast Re-routing and Re-scheduling; Seizing advantages from disruptions. Product life cycle management.	<i>Ability to modify operations in response to challenges and opportunities</i>
Anticipation	Monitoring early warning signals; Forecasting (horizon); Deviation and near-miss analysis; Preparedness planning; Business continuity planning; Emergency preparedness; Government lobbying.	<i>Ability to discern potential future events or situations</i>
Recovery	Crisis management; Equipment reparability; Resource mobilization, Communication strategy; Mitigation processes.	<i>Ability to return to normal operations state rapidly</i>
Dispersion	Asset and key resources decentralization; Distributed decision making; Dispersion of markets; Location-specific empowerment.	<i>Broad distribution of assets</i>
Collaboration	Disruption sharing with partners; Supplier relation management; Client and customer relation management; Collaborative forecasting; Information and communications exchange.	<i>Ability to work effectively with other entities for mutual benefit</i>
Organization	Empowerment; Creative problem solving; Accountability including reporting; (Cross-) training and workforce flexibility; Culture of caring.	<i>Human resources structures, policies, skills and culture</i>
Market position	Product positioning; Market share; Brand equity; Customer service management; Sustainable position; Customer loyalty/retention.	<i>Status of organization or its product/services in specific markets</i>
Security	Access restrictions; Employee involvement; Collaboration with governments; Personal security; Cyber security; Layered defences; Information pooling.	<i>Defence against deliberate intrusion or attack</i>
Financial strength	Financial reserves and liquidity; Price margin; Insurance; Portfolio diversification.	<i>Capacity to absorb fluctuations in cash flow</i>

Section 3: Interview to clarify the relevance and completeness of the listed vulnerability and capability (sub-) factors and level of progress in the resilience approach.
(Questions marked with (**) are only applicable for participants from public transport organizations that did not participate in previous empirical research.)

1 Questions for clarification of public transport organization. ()**

1.1 What are the main corporate strategy statements?

1.2 Does the organization incorporate resilience and risk considerations into business strategies (e.g. what are they and what is the relation)?

1.3 Are there clear and consistent statements on risk or resilience in annual reports or other publicly available publications?
If so, where are they published and what is the content?
Publication: _____
Content: _____
Publication: _____
Content: _____

1.4 Are there clear and consistent statements on risk or resilience in internal statements?
If so, where are they published and what is the content?
Publication: _____
Content: _____
Publication: _____
Content: _____

1.5 What are your organization's experiences with risk and resilience approaches?

1.6 Does your organization follow a structured approach towards a risk and/or resilience identification? If yes, how is this structured?
Risk: _____
Resilience: _____

1.7 Does the organization have a clear description of responsibilities related to risk and resilience? If yes, what are the functions and responsibilities?
Risk: _____
Resilience: _____

2.1 Clarification of definitions and descriptions.

2.1.1 Do you consider the presented definition of vulnerability to be clear and consistent?

2.1.2 Do you consider the presented definition of capability to be clear and consistent?

2.1.3 Do you consider the descriptions of the vulnerability factors to be clear and consistent?

2.1.4 Do you consider the descriptions of the capability factors clear and consistent?

2.2 Recognisable vulnerability and capability factor and sub-factors.

2.2.1 Can you describe some relevant vulnerability and/or sub-factors from the above lists that have occurred in recent years *in your organization*?

2.2.2 Can you describe some relevant vulnerability and/or sub-factors from the above list that occurred in recent years *in the public transport sector in general*?

2.2.3 Can you describe some relevant capability and/or sub-factors from the above list that occurred in recent years *in your organization*?

2.2.4 Can you describe some relevant capability and/or sub-factors from the above list that occurred in recent years *in the public transport sector in general*?

2.3 Completeness and relevance of lists.

2.3.1 Do you consider the above list of vulnerability factors *complete*?

Yes: _____

No, there are missing factors: _____

2.3.2 Would you *combine or subdivide vulnerability factors in new/other factors*?

Combine: _____

Subdivide: _____

2.3.3 Do you consider the above list of vulnerability sub-factors *relevant* to the connected factor?

2.3.4 Could you *add vulnerability sub-factors* to the above list, based on your experiences?

2.3.5 Would you consider some of the vulnerability factors as sub-factors or sub-factors as factors?

2.3.6 Which are the most important vulnerabilities from the above list?

- 2.3.7 Do you consider the above list of capability factors *complete*?
Yes: _____
No: missing factors: _____
- 2.3.8 Would you *combine or subdivide capability factors in new/other factors*?
Combine: _____
Subdivide: _____
- 2.3.9 Do you consider the above list of *capability sub-factors relevant* to the connected factor?

- 2.3.10 Could you *add capability sub-factors* to the above list, based on your experiences?

- 2.3.11 Would you consider some of the capability factors as sub-factors or sub-factors as factors?

- 2.3.12 Which are the most important capabilities from the above list?

- 2.4 **Level of advancement in resilient approach.**
- 2.4.1 There is a possible inter-dependence between vulnerability and capability factors? The capacity/flexibility relation shows that the factors described are not completely independent of each other and sometimes need to be *looked at in cohesion as a cause and effect relation*. Do you agree that factors are to be looked at from a cause and effect perspective?

- 2.4.2 Do you agree with the following statement? “With the vulnerability factors *identified and categorised*, it is possible to draw up a vulnerability map. With these *vulnerability maps* showing detected vulnerabilities, organizations can simulate the impact and the efficacy of proposed capabilities to raise the organization to a higher level of resilience”.
Yes: _____
No: _____
- 2.4.3 One opportunity of a resilient organization is to ensure that the time lag between detecting a vulnerability and capability as a kind of action is as small as possible. Do you consider these lists of factors as making a contribution to developing a resilient approach in the public transport organization?
Yes: _____
No: _____

2.4.4 Do you think it is relevant and possible to connect the list of vulnerability factors to strategic categories or directions affected (economic, operational, hazard, etc.) of the public transport organization?

Yes: _____

No: _____

2.4.5 Do you believe that the vulnerability factors and capability factors are very organization specific, sector specific, or generic?

2.4.6 The result of the alignment between vulnerability and capability is described as a “balanced” resilience. Do you believe it is possible to balance vulnerability and capability factors?

2.4.7 How would you describe the *improved performance* resulting from a balanced resilience in the public transport organization?

2.4.8 The presented framework needs to be extended with closed-loop approaches. What do you consider as the most important closed loops?

2.4.9 What opportunities are available for collaboration with partners and other stakeholders in the field of a resilient approach?

2.4.10 Could you describe the relevant issues when this framework and connecting lists is applied in an organizational tool?

2.5 Is there any information you would like to share that has not been referred to in the previous questions?

Appendix 3: Survey on measurement, ranking of importance and linkages between vulnerabilities and capabilities for inclusion with empirical findings.
(Questionnaire connected to Chapter 7.)

Introduction

You are invited to participate in my PhD research by assessing resilience in your organization. Your participation is important for gaining a meaningful insight into the concept of resilience and at this stage, more specifically, into vulnerabilities and capabilities. The objective of this part of the research is to understand whether linkages between vulnerabilities and capabilities can be identified as well as to ascertain whether ranking and validating are possible. During previous research a framework, definitions and list indicating vulnerability and capability factors were developed.

By assessing and quantifying vulnerabilities and capabilities, and by drawing on your experience and knowledge to link these concepts, the goal of establishing how to cope with a turbulent environment and thus creating competitive advantage will be strengthened.

Concept of Resilience

The concept of resilience has emerged as a critical characteristic of complex and dynamic systems, such as public transport organizations. In this research *resilience* is defined as: *the capacity for an organization to survive, adapt and grow in the face of turbulent change.*

Public transport organizations are susceptible to *vulnerabilities*: fundamental factors that make an organization susceptible to disruption. Susceptibility refers to the sensitivity of an organization to a disruption within existing organizational or functional practices or organizational conditions.

To overcome and anticipate disruptions organizations need to develop *capabilities* as the attributes required for optimal performance or accomplishment.

Structure of Questionnaire

This stage of the research is divided into four parts. The first and second parts address your ability to identify vulnerabilities factors and next to that capabilities factors from the perspective of your own organization. The third part will ask you to rate the relative importance of each factor from both lists. The last part will focus on the linkage between vulnerabilities and capabilities. Completion of this questionnaire would require approximately 45 minutes.

Thank you for participating in this part of my research. Your responses will be kept strictly confidential. Once this research has been finalized, I will send you a CD copy of the findings.

Jan Willem Proper

Could you describe your functional role in your organization?

What are the main strategic statement(s) in your organization?

Part 1: Findings on Vulnerabilities

In this part of the questionnaire you are asked to assess, from the perspective of your own organization, vulnerability and capability factors. To support your assessment, for every factor a limitative description of sub-elements will be provided. Your assessment can be categorized in one of five responses from “Strongly Agree” to “Strongly Disagree”. If you do not have personal knowledge of the subject, you can select “Don’t Know”. Mark only one category.

The first part of this questionnaire deals with **vulnerabilities** that have been identified from earlier research.

<p>Factor: Turbulence Accidental</p> <p><i>Descriptors:</i> Natural disasters (floods, earthquakes); Health disasters, pandemics; Geopolitical disruptions; Unpredictability of markets ; Unforeseen technology and IT failures; Unpredictable financial issues.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our environment is characterized by frequent changes in external factors beyond our control.</u></p>						

<p>Factor: Threats Deliberate</p> <p><i>Descriptors:</i> Terrorism and sabotage (internal, external) incl. cyber disruption, piracy and theft and espionage; Media pressures, offensive advertising, brand attacks; Labour disruptions, union activities, strikes; Special interest groups.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization faces deliberate attacks aimed at disrupting operations or causing human or financial harm.</u></p>						

<p>Factor: Pressures External</p> <p><i>Descriptors:</i> Related to public bodies: Political/regulatory change (including tariff); External inspections; Environmental, health, safety concerns, Related to all other then public bodies: Competitive innovation; Social/cultural changes; Price pressures (competitive); Corporate responsibility.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization faces influences, not specifically targeted at our organization, that create business constraints or barriers.</u></p>						

<p>Factor: Resource Limits</p> <p><i>Descriptors:</i> Natural resources; Intellectual property; Supplier and utilities availability; Asset utilization; Distribution availability; Data storage capacity; Human resources; Finite Funding.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization faces constraints on output and productivity based on the availability of relevant factors of production.</u></p>						

<p>Factor: Sensitivity</p> <p><i>Descriptors:</i> Complexity of design and product purity; Complexity of process operations; Consumer requirements for quality; Restricted utilization of materials and data; Reliability of (key) equipment and IT; Potential safety hazards; Loss of key personnel; Visibility of disruption to stakeholders; Symbolic profile of brand; Concentration of capacity.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization depends on the relevance of carefully controlled conditions for product, service and process integrity and liability.</u></p>						

<p>Factor: Connectivity</p> <p><i>Descriptors:</i> <u>Outside entities in general</u> Scale/extent of (travel and traffic) networks; Reliance upon specialty sources and information flows. Reliability of external relations.</p> <p><u>Net activity related outside entities</u> Supplier trust and reliability; Degree of outsourcing; Information independence and reliance; Customer and loyalty relations;</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has a high degree of reliance on, and inter-dependencies with outside entities.</u></p>						

Part 2: Findings on Capabilities

The next part deals with findings related to capabilities that have been identified from earlier research.

<p>Factor: <i>Flexibility in sourcing</i> <i>Descriptors:</i> Modular product design; Standardization and commonality of parts; Multiple sources; Contract flexibility with suppliers.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the ability to quickly change inputs or the mode of receiving inputs.</u></p>						

<p>Factor: <i>Flexibility in order and demand fulfillment</i> <i>Descriptors:</i> Alternative transport and distribution offering; Update of information; Multiple service centers; Postponement.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the ability to quickly change outputs or the mode of delivering outputs.</u></p>						

<p>Factor: Capacity <i>Descriptors:</i> Utilities back-up sources; Asset reserve capacity beyond normal deviations; Labour capacity flexibility; Communication and back-up IT systems.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the availability of assets to enable sustained production or service levels.</u></p>						

<p>Factor: Efficiency <i>Descriptors:</i> Waste elimination; Labour productivity; Asset utilization; Quality management/ service variability reduction; Failure prevention; Process standardization and optimisation; Preventive maintenance.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the capability to produce outputs with minimum resource requirements.</u></p>						

<p>Factor: Visibility</p> <p><i>Descriptors:</i> Business intelligence gathering; Information/automation technology; Status of all personnel; Market visibility, external monitoring; Service and equipment visibility; People visibility.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has knowledge of the status of its operating assets and the environment.</u></p>						

<p>Factor: Adaptability</p> <p><i>Descriptors:</i> Learning from experience/feedback mechanism; Strategic simulation; Alternative technology development; Fast re-routing and re-scheduling; Seizing advantages from disruptions Product life cycle management.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the ability to modify operations in response to challenges and opportunities.</u></p>						

<p>Factor: Anticipation</p> <p><i>Descriptors:</i> Monitoring early warning signals; Forecasting (horizon); Deviation and near-miss analysis; Preparedness planning; Business continuity planning; Emergency preparedness; Government lobbying.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the ability to discern potential future events or situations.</u></p>						

<p>Factor: Recovery</p> <p><i>Descriptors:</i> Crisis management; Equipment reparability; Resource mobilization; Communication strategy; Mitigation processes.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the ability to return to normal operational state rapidly.</u></p>						

<p>Factor: Dispersion</p> <p><i>Descriptors:</i> Asset and key resources decentralization; Distributed decision making; Dispersion of markets; Location-specific empowerment.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has a broad distribution of assets.</u></p>						

<p>Factor: Collaboration</p> <p><i>Descriptors:</i> Disruption sharing with partners; Supplier relation management; Client and customer relation management; Collaborative forecasting; Communication and information pooling.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the ability to work effectively with other entities for our mutual benefit.</u></p>						

<p>Factor: Organization</p> <p><i>Descriptors:</i> Empowerment; Creative problem solving; Accountability including reporting; (Cross-) training and workforce flexibility; Culture of caring; Functional information coordination.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization develops human resources structures, policies, skills and culture.</u></p>						

<p>Factor: Market position</p> <p><i>Descriptors:</i> Product positioning; Market share; Brand equity; Customer service management; Sustainable position; Customer loyalty/retention.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>The status of the organization or its product/services in specific markets is clear and strong.</u></p>						

<p>Factor: Security</p> <p><i>Descriptors:</i> Access restrictions; Employee involvement; Collaboration with governments; Staff and customer security; Cyber security; Layered defences and protective measurements; Fraud detection.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has stringent and layered defence mechanisms against deliberate intrusion or attack.</u></p>						

<p>Factor: Financial strength</p> <p><i>Descriptors:</i> Financial reserves and liquidity; Price margin; Insurance; Portfolio diversification.</p>	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Don't Know
<p><u>Our organization has the capacity to absorb fluctuations in cash flow.</u></p>						

Part 3: Importance of Factors

For all vulnerability and capability factors you are asked to rate the relative level of importance for each factor to your organization. Response choices range from “Minor Importance”, “Important” to “Critical”. You are asked to mark only one out of the six categories.

<u>Vulnerability Factors</u>	<i>Minor Importance</i>	<i>---</i>	<i>Important</i>	<i>---</i>	<i>Critical</i>	<i>Don't Know</i>
<i>Turbulence</i>						
<i>Deliberate threats</i>						
<i>External pressures</i>						
<i>Resource limits</i>						
<i>Sensitivity</i>						
<i>Connectivity</i>						

<u>Capability Factors</u>	<i>Minor Importance</i>	<i>---</i>	<i>Important</i>	<i>---</i>	<i>Critical</i>	<i>Don't Know</i>
<i>Flexibility in sourcing</i>						
<i>Flexibility in order and demand fulfillment</i>						
<i>Capacity</i>						
<i>Efficiency</i>						
<i>Visibility</i>						
<i>Adaptability</i>						
<i>Anticipation</i>						
<i>Recovery</i>						
<i>Dispersion</i>						
<i>Collaboration</i>						
<i>Organization</i>						
<i>Market position</i>						
<i>Security</i>						
<i>Financial strength</i>						

Part 4: Linking Capability and Vulnerability Factors

In previous research and discussions the possibility of a time gap between changes in the two entities to each other was discussed. This time gap can have two interpretations. Public transport organizations can anticipate vulnerabilities in general and take action to increase capabilities in *anticipation* of their occurrence. On the other hand, new or more intensive vulnerabilities can be discussed as a *reaction* to the process of increasing the development of capabilities. For this reason you are asked to consider two different points of view.

First: Select one of the vulnerabilities that you positioned in the category *critical* (if not available, chose from the category *important*). To mitigate this vulnerability you are asked to link it to the capabilities in the following categories:

- “strong effect of this capability to mitigate the chosen vulnerability”;
- “moderate effect (M) to mitigate the chosen vulnerability”;
- “low or no effect (N) to mitigation of chosen vulnerability”;
- and finally the category “Don’t Know”.

<i>Vulnerability factor from the category critical: - - - - -</i>				
<i>Relevance of capability factors to mitigate the selected vulnerability factor</i>	<i>Strong Effect</i>	<i>Moderate Effect</i>	<i>Low or No Effect</i>	<i>Don't Know</i>
<i>Flexibility in sourcing</i>				
<i>Flexibility in order and demand fulfillment</i>				
<i>Capacity</i>				
<i>Efficiency</i>				
<i>Visibility</i>				
<i>Adaptability</i>				
<i>Anticipation</i>				
<i>Recovery</i>				
<i>Dispersion</i>				
<i>Collaboration</i>				
<i>Organization</i>				
<i>Market Position</i>				
<i>Security</i>				
<i>Financial Strength</i>				

Second:

Select one of the capabilities that you positioned as in the category *critical* (if not available, chose from the category *important*). If this capability was very extensively employed in your organization, on which vulnerabilities would that have a mitigating effect? You are asked to link this in the following categories:

- “strong effect of this capability to mitigate the chosen vulnerability”;
- “moderate effect (M) to mitigate the chosen vulnerability”
- “low or no effect (N) to mitigation of chosen vulnerability”
- or finally to the category “Don’t Know”.

<i>Capability from category critical: -----</i>				
<u><i>Relevance to the connecting vulnerability factors</i></u>	<i>Strong Effect</i>	<i>Moderate Effect</i>	<i>Low or No Effect</i>	<i>Don't Know</i>
<i>Turbulence</i>				
<i>Deliberate threats</i>				
<i>External pressures</i>				
<i>Resource limits</i>				
<i>Sensitivity</i>				
<i>Connectivity</i>				

From the two above two approaches, which one do you consider the most workable in your organization?

Motivation:

In this research you have been asked to link the vulnerability and capability factors. Do you believe it is possible to do the same at the level of sub-factors (in this questionnaire described as *descriptors*)?

Y:

N:

Discussion points: _____

Appendix 4: Expert meeting to extract inferences on managerial capabilities in public transport organizations. (Appendix connected to chapter 7.)

Part 1: Introductory letter

Date: 1 November 2010

Location: The Hague (Prinsessegracht 23, 2514 AP Den Haag)

Time: 13.30- 16.30

This document provides the basis for discussion at the expert meeting. At the start of our meeting there will be a PowerPoint presentation to complement this information to give enough insight for the discussion. This document can help us during the meeting and you have the relevant information in front of you. I look forward to your support – it is highly appreciated.

Table of contents:

- *Introduction*
 - o *Objective of PhD study*
- *Some relevant terms*
- *Purpose and agenda of expert meeting*
 - o *Participants*
- *Structure of research with relevant research questions and objectives*
 - o *1: Contextual resilience*
 - o *2: Cognitive resilience*
 - o *3: Behavioural resilience*
 - o *4: Balanced resilience*
- *Concept of measuring, ranking and linking capabilities and vulnerabilities*
- *The link between resilience and performance*
- *Managerial issues*

1) Introduction

The title of the PhD thesis is: Resilience as an Imperative in Public Transport Organizations.

The overarching purpose of this research is development of a structured approach to create a resilient life cycle within an organization through a critical revision of scientific and practical activities related to disruptions, and the associated management value of strategy responses, collaboration and knowledge management in public transport.

The **overall research objective** can thus be formulated as: designing a framework to embed resilience in public transport organizations.

2) Some relevant terms

Resilience: capacity for an organization to survive, adapt and grow in the face of turbulent change.

Balanced resilience: property of ranking in order to determine the importance of, and to identify, critical linkages between vulnerabilities and capabilities.

<i>Behavioural resilience:</i>	capacity to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to respond in a systematic, proactive way when something unexpected occurs.
<i>Capability:</i>	attributes required for performance or accomplishment.
<i>Cognitive resilience:</i>	orientation that enables an organization to identify, assess and respond in order to become a resilient organization.
<i>Contextual resilience:</i>	property that ensures that an organization has the capacity to identify its role and function in the context of possible disturbances.
<i>Disruption:</i>	combination of (1) an unintended, exceptional triggering event, and (2) a consequential situation which significantly threatens the normal course of business operations of the affected organization.
<i>Public transport:</i>	system for collective transport of people, with different services, based on different social and economic objectives and based on licenses to operate.
<i>Risk:</i>	negative deviation from the expected value of a certain performance objective, resulting in undesirable consequences for the focal firm.
<i>Role of public transport:</i>	stimulate urban, social, sustainable and economic developments by transport of passengers based on their needs.
<i>Security:</i>	protection capability with measures taken to guard passengers.
<i>Vulnerability:</i>	fundamental factors that make an organization susceptible to disruption.

3) *Purpose and agenda of expert meeting*

The resilient public transport organization designs appropriate levels of anticipation, preparedness and adaptability in addition to the responsive skills that are essential to creating a competitive advantage (Pettit, 2008). Previous research showed that public transport organizations need to identifying the desired state of resilience and those organizations are able to create a portfolio of best matching capabilities. Organizations need to balance revenue streams with preparation and recovery costs, short-term customer service and long-term supply chain value in terms of return on assets (Slone *et al.*, 2007).

The expert meeting is intended to identify managerial capabilities for applying resilience in public transport organizations. Expert and focus groups are an excellent source of qualitative data when exploring complex issues, particularly in studying emerging phenomena (Morgan, 1996). The *purpose* of the expert meeting is to extract inferences on the potential relationship between resilience and performance to ensure resilience in public transport organizations. The *method* of the expert meeting is to reflect on issues of measurement, ranking and ability to create linkages between vulnerabilities and capabilities and to create effective rules to provide managerial direction. The meeting is expected to last three hours and findings will be reported as meeting results and not related to individual participants. Participants will receive the minutes of the meeting and will have an opportunity to comment.

<u>Participants</u>	<u>Role and function.</u>
G.A. Kaper	Expert: CEO (HTM) until 2010, consultant;
T. Kienhorts	Expert: CEO (Veolia) until 2010, consultant;
B.R.H. Lammers	Expert: Senior Advisor TNO research; co-author: <i>Risico Management and Logistiek.</i>
M. Timmer	Secretary.

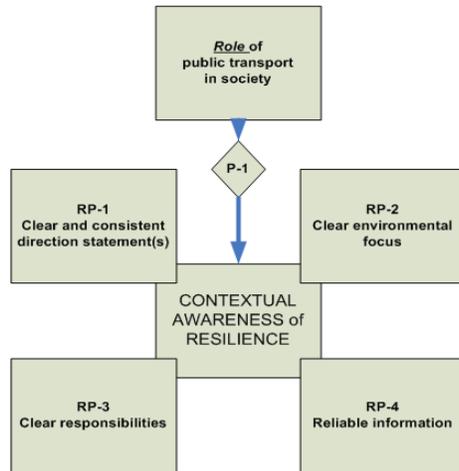
The meeting agenda:

- Part 1: Introduction:
 - o Purpose of the meeting and introduction of interviewer and participants.
 - o Clarification by researcher on framework, list of vulnerability and capability factors, and results of measurement, ranking and linkages.
- Part 2: Evaluation of ability to measure and rank: Reactions to previous findings
- Part 3: Relation between vulnerability and capability (sub-) factors.
 - o Discussion on linking relations from both sides.
 - o Discussion on process of selecting on sub-factor level before linking on factor level.
 - o Discussion on time-gap of the two entities. This time gap can have two directions. Public transport organizations can describe vulnerabilities in general and take action to increase capabilities in *anticipation*. On the other hand, new or more intensive capabilities can be discussed as a *reaction* to identified vulnerabilities.
 - o Balanced resilience: Discussion on the ability of the public transport organization to rank, determine the importance and identify critical linkages between vulnerabilities and capabilities.
- Part 4: Introduction and re-designing resilience in public transport organizations.
 - o Relation to performance indicators.
 - o Internal processes: The intention is to learn which anticipation, reaction and adaptation efforts are of most value to the public transport organization based on the previously discussed exploratory results. Discussion on implementing resilience.
 - o Network processes: To develop a competitive advantage in the global business world, professionals have to coordinate relations beyond the organizational entities and improve coordination of identification, assessment and collaborative responses. Discussion on cooperation beyond the organization.
 - o Developing rules for introduction and redesign.
- Part 5: Summary and Conclusions.

The following sections will be presented and explained during the meeting..

4) *Connecting research questions/objectives*

The first research objective is: “To establish the starting point(s) and limitations regarding the (re-)design of a resilient public transport organization”. This objective is answered by discussing and analyzing the *position* of the public transport organization within its environment. Its position explains the *role* of public transport together with the *function* of the public transport organization. The organization needs to identify its position within the context of the concept of resilience. This part of the research will be denoted as the study of ***contextual resilience***. (see figure below: Contextual awareness of resilience (P: Postulate, RP: Research Proposition))

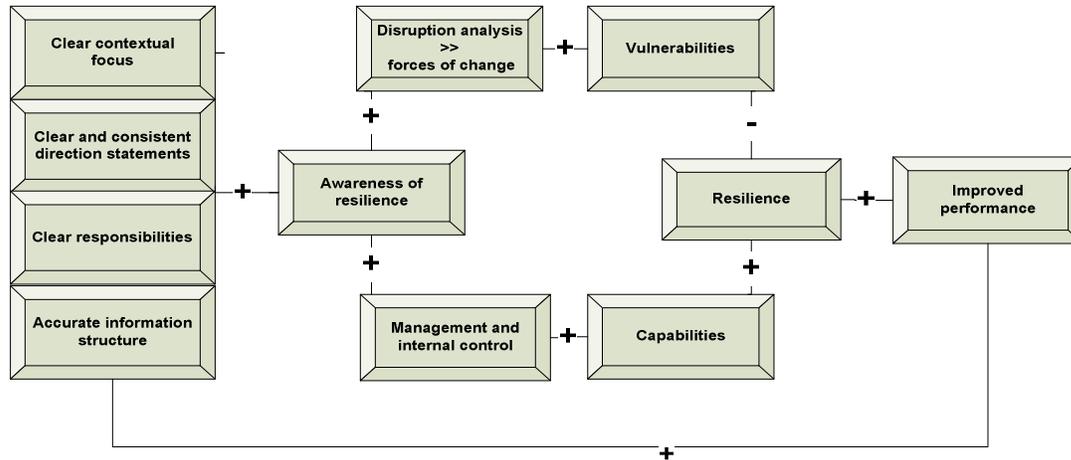


The second part of this research project relates to the research objective: “To structure and design a comprehensible and comprehensive resilience framework for public transport organizations”.

The resilience framework is explained based on deductive reasoning from a variety of concepts and experiences from the fields of both risk and resilience. Resilience framework guiding principles are explained and research propositions are formulated. The structure of the resilience framework and a coherent set of definitions is presented. This part of the research is referred to as the study of the *conceptual resilience framework*.

This framework is discussed with practitioners from public transport organizations and from organizations specifically active in the fields of risk and resilience, using structured interviews. The different interviews can be seen as case studies to verify the deductively presented framework and they will address the formulated definitions and research propositions, as well as used as opportunities to clarify the completeness of the framework and consider advances in resilience approaches in public transport. From this a verified structure will be developed. This will be referred to as *cognitive resilience*. This is the orientation that enables an organization to identify, assess and respond to disturbances in order to become a resilient organization. The focus is on the structure of the framework.

Resilience takes into consideration the portfolio of capabilities matched to the pattern of vulnerabilities to achieve improved performance. To develop competitive advantage, boundary-spanning analysis, information and knowledge-sharing processes are needed on all levels. At this moment it is sufficient to recognize the framework at the level of the organizational responsibilities. This results in the following *verified framework for resilience for public transport organizations* presented in the next figure.



The third research objective is: “To identify the main elements that create knowledge about the resilience design” This part of the research supplements the conceptual orientation and cognitive structure and discusses the main elements that determine the concept of resilience and will motivate how resilience management contributes to improved performance of the public transport organization. The public transport organization must be able to address issues before they become problems and to ensure that critical capabilities are available. This requires a proactive diagnostic tool to give the public transport organization a competitive edge and move away from reactive resolutions. These embedded diagnostics can help to structure and analyze vulnerabilities and capabilities to predict and explain potential organizational behaviour. **Behavioural resilience** is the capacity to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to structure and to react in a systematic, proactive way when something unexpected occurs. The discussions led finally to the following vulnerability and capability lists:

List of vulnerability factors with description and sub-factors after verification:

Vulnerability <i>(exposure to factor)</i>	Description	Sub-factors <i>Descriptors (not exhaustive) after verification</i>
Turbulence	<i>Environment characterized by: changes in external factors beyond internal control.</i>	Natural disasters (floods, earthquakes); Health disasters, pandemics; Geopolitical disruptions; Unpredictability of markets; Unforeseen technology and IT failures; Unpredictable financial issues.
Threats Intentional	<i>Deliberate attacks aimed at disrupting operations or causing human or financial harm.</i>	Terrorism and sabotage (internal, external) incl. cyber disruption, piracy and theft and espionage; Media pressures, offensive advertising, brand attacks; Labour disruptions, union activities, strikes; Special interest groups.
Pressures, External	<i>Influences, not specifically targeted at the public transport organization that create business constraints or barriers.</i>	<u>Related to public bodies:</u> Political/regulatory change (including tariff); External inspections; Environmental, health, safety concerns, <u>Related to all other than public bodies:</u> Competitive innovation; Social/cultural changes; Price pressures (competitive); Corporate responsibility.

Resource limits	<i>Constraints on output and productivity based on availability of connected factors of production</i>	Natural resources; Intellectual property; Supplier and utilities availability; Asset utilization; Distribution availability; Data storage capacity; Human resources; Finite Funding.
Sensitivity	<i>Relevance of carefully controlled conditions for product, service and process integrity and liability</i>	Complexity of design and product purity; Complexity of process operations; Consumer requirements for quality; Restricted utilization of materials and data; Reliability of (key) equipment and IT; Potential safety hazards; Loss of key personnel; Visibility of disruption to stakeholders; Symbolic profile of brand; Concentration of capacity.
Connectivity	<i>Degree of reliance and interdependencies on outside entities</i>	Outside entities in general Scale/extent of (travel and traffic) networks; Reliance upon specialty sources and information flows. Reliability of external relations. Net activity related outside entities Supplier trust and reliability; Degree of outsourcing; Information independence and reliance; Customer and loyalty relations;

List of capability factors with description and sub-factors after verification:

Capability factors	Description	Sub-factors: Descriptors (not exhaustive) after verification
Flexibility	<i>Ability to change quickly</i>	
Flexibility in Sourcing	<i>Ability to quickly change <u>inputs</u> or the mode of receiving inputs</i>	Modular product design; Standardization and commonality of parts; Multiple sources; Contract flexibility with suppliers.
Flexibility in Order And Demand Fulfilment	<i>Ability to quickly change <u>outputs</u> or the mode of delivering outputs</i>	Alternative transport and distribution offering; Update of information; Multiple service centers; Postponement.
Capacity	<i>Availability of <u>assets</u> to enable sustained production or service levels</i>	Utilities back-up sources; Asset reserve capacity beyond normal deviations; Labour capacity flexibility; Communication and back-up IT systems.
Efficiency	<i>Capability to produce outputs with minimum resource requirements</i>	Waste elimination; Labour productivity; Asset utilization; Quality management/ service variability reduction; Failure prevention; Process standardization and optimisation; Preventive maintenance.
Visibility	<i>Knowledge of the status of operating assets and the environment</i>	Business intelligence gathering; Information/automation technology; Status of all personnel; Market visibility, external monitoring; Service and equipment visibility; People visibility.
Adaptability	<i>Ability to modify operations in response to challenges and opportunities</i>	Learning from experience/feedback mechanism; Strategic simulation; Alternative technology development; Fast re-routing and re-scheduling; Seizing advantages from disruptions Product life cycle management.

Anticipation	<i>Ability to discern potential future events or situations</i>	Monitoring early warning signals; Forecasting (horizon); Deviation and near-miss analysis; Preparedness planning; Business continuity planning; Emergency preparedness; Government lobbying.
Recovery	<i>Ability to return to normal operations state rapidly</i>	Crisis management; Equipment reparability; Resource mobilization; Communication strategy; Mitigation processes.
Dispersion	<i>Broad distribution of assets</i>	Asset and key resources decentralization; Distributed decision making; Dispersion of markets; Location-specific empowerment.
Collaboration	<i>Ability to work effectively with other entities for mutual benefit</i>	Disruption sharing with partners; Supplier relation management; Client and customer relation management; Collaborative forecasting; Communication and information pooling.
Organization	<i>Human resources structures, policies, skills and culture</i>	Empowerment; Creative problem solving; Accountability including reporting; (Cross-) training and workforce flexibility; Culture of caring; Functional information coordination.
Market position	<i>Status of organization or its product/services in specific markets</i>	Product positioning; Market share; Brand equity; Customer service management; Sustainable position; Customer loyalty/retention.
Security	<i>Defence against deliberate intrusion or attack</i>	Access restrictions; Employee involvement; Collaboration with governments; Staff and customer security; Cyber security; Layered defences and protective measurements; Fraud detection.
Financial strength	<i>Capacity to absorb fluctuations in cash flow</i>	Financial reserves and liquidity; Price margin; Insurance; Portfolio diversification.

The expert meeting will focus on the fourth research objective: “To ensure that public transport organizations are able to make linkages between vulnerabilities and capabilities”. The ability to determine the importance of, to rank and to identify critical linkages between vulnerabilities and capabilities will give the public transport organization the possibility to derive a ***balanced resilience position***.

5) *Concept of measuring, ranking and linking capabilities and vulnerabilities*

The ability to link is explained by using *triangulation*, with the potential to employ iterations between the literature review, experiments and case study evidence.

Taking *the level of importance* as a starting point and based on the presented data regarding the vulnerabilities average factors, the table below shows the comparison of *vulnerability*

importance to measurement values with a general balance with the exception of connectivity. An area of attention is when both are not aligned like in the case of “Connectivity”.

<i>Vulnerability factor ranking of importance based on five public transport organization</i>	<i>Average level of importance on a scale of 1-5</i>	<i>Average measured value on a 1-5 scale</i>
1: External Pressures	4.4	4.4
2: Resource limits	4.0	4.6
3: Sensitivity	3.6	3.2
4: Deliberate Threats	3.4	3.2
5: Connectivity	2.1	3.9
6: Turbulence	2.0	2.4

The table below shows the comparison of *capability* importance to measurement values. Analysing capabilities in the same way might make evident areas of concern with low measurement scores and high importance that should be prioritized for improvement, such as efficiency and flexibility in sourcing, or areas with high measured capabilities with low importance, such as anticipation or adaptability that may erode profits.

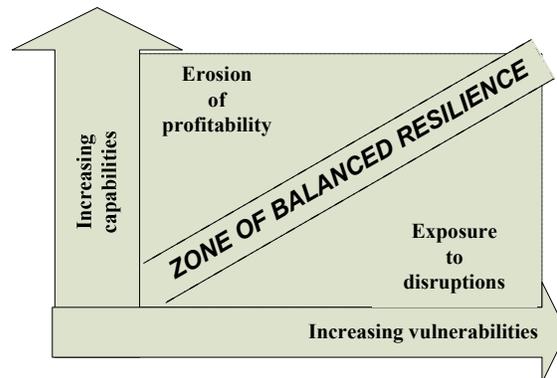
<i>Capability factor ranking of importance based on five public transport organizations</i>	<i>Average level of importance on a scale of 1-5</i>	<i>Average measured value on a 1-5 scale</i>
1/2 : Market position	4.6	4.2
1/2 : Financial strength	4.6	3.8
3 : Efficiency	4.2	2.8
4 : Flexibility in sourcing	4.0	2.6
5/6/7/8 : Flexibility on order/ demand fulfilment	3.6	3.2
5/6/7/8 : Capacity	3.6	3.8
5/6/7/8 : Visibility	3.6	4.4
5/6/7/8 : Recovery	3.6	3.8
9 : Security	3.5	3.3
10/11/12: Anticipation	3.2	4.0
10/11/12: Collaboration	3.2	3.8
10/11/12: Organization	3.2	3.2
13 : Dispersion	2.6	3.4
14 : Adaptability	2.0	3.6

In summary, it can be concluded that public transport organizations are able to measure and rank vulnerability and capability factors with the tool provided. Based on this, it is possible to analyse the most important factors and to analyse whether there is a gap between the relative ranking position and the measurement. With that the current “as is” situation of resilience can be determined.

6) *The link between resilience and performance*

“Resilience increases as capabilities increase and/or vulnerabilities decrease” is accepted as a premise. Also the relation between resilience and performance is discussed with the presumption of a balance between vulnerability and capability factors. In that discussion there was no emphasis on the possible differences in relevance, while from the previous section it is evident that factors are not of equal relevance to the public transport organization at a certain moment. Outside the balanced zone, imbalances can have two different positions as shown in the figure below. Extensive vulnerabilities relative to capabilities will result in excessive exposure to disruptions and excessive capabilities relative to vulnerabilities will erode the profitability of the public transport organization. Both positions are considered as states of

unbalanced resilience and therefore undesirable, as has been discussed and proved in discussing research proposition (RP) 10: (Public transport) performance improves when capabilities and vulnerabilities are balanced.



The figure below is an example of the presentation of the results and shows the matrix of linking capabilities to vulnerabilities from the perspective of cost leadership by NHTV students (s= strong relevance; m= medium relevance, n: not relevant)

Matrix of linking capabilities to vulnerabilities														
CAPABILITY:	FLEXIBILITY		CAPACITY	EFFICIENCY	VISIBILITY	ADAPTIBILITY	ANTICIPATION	RECOVERY	DISPERSION	COLLABORATION	ORGANIZATION	MARKET POSITION	SECURITY	FINANCIAL STRENGTH
	s	o												
TURBULENCE (ACCIDENTAL)					s	s		s				n	n	s
THREATS INTENTIONAL		n	m			s	s	s			s	s	s	s
PRESSURES EXTERNAL		n		n		s	s	s	n		s	s		s
RESOURCE LIMITS	n	s	n	s	s	s	s	s	n	s	s		n	s
SENSITIVITY	n	n	s		s	s	s	m			s		n	m
CONNECTIVITY	s	s	n	n	s	s	s	n	n	m		n	n	n

7) Managerial issues

Knowledge of advantages and complications: Concerning the introduction of the framework, public transport organizations are aware of major advantages and complications of a structured resilience approach. The following table presents an overview, not in order of priority and without implying any direct relations between the two parts.

Advantages	Complications
Structured improvement of monitoring events.	Priority on the strategic level: - lower awareness of resilience.
Introducing of scripts with less dependence on expertise of individual persons.	Cost-benefit ratio difficult to determine: - visibility of core business.
Better alignment to tender contracts and external and internal compliances: efficiency and effectiveness.	Responsibilities and available information: - no communication structure for risk and resilience; - fear for bureaucracy.
Coordination within the public transport sector to enhance the level of knowledge.	Human resources: - lack of content expertise; - lack of understanding of the concept; of a structured approach.
Consistency and completeness and less redundancy: efficiency.	Approach must not to be academic: - no structured best practices available.
Shorter time to act: learning organization.	Low level of cooperation between public transport organizations.
Balanced structure of capabilities to vulnerabilities to deal with over- and under-reactions.	No structuring from legal or contracts (tenders) requested.
Better prepared for the unforeseeable.	Connection to existing security and risk structures.

Frequently mentioned elements of performance have been compared and classified to develop more generic performance indicators, with the ‘5i’ framework of mitigation that is used in the Global Risk Network model “Global Risks” of the 2008 World Economic Forum. An improved performance of these generic indicators, obtained by applying the resilience approach, will sustain relevance. On the basis of the interviews, the positive contribution of a resilience approach can be described in the generic performance indicators below.

Generic performance indicators based on the ‘5i’ framework of the World Economic Forum 2008.	Mentioned performance element from interviews
Insight (improvement in managerial decisions through a more sophisticated understanding of the drivers and impacts of disruptions and the capabilities to use)	- Shorter time lag to detection; - Shorter time lag to reaction; - Better understanding of managerial opportunities; - More targeted strategic approach to capabilities; - Better focus on core processes.
Information (improvement of knowledge and reporting to improve the quality and flow of information – which should encourage transparency in the resilience framework)	- Better understanding of fundamental disruption factors; - Better systematic reporting; - Better of knowledge of resilience.
Incentives (improvement, external and internal, as an incentive for ex-ante mitigation measures and even, where appropriate, disruption avoidance)	- Positive effects on image and reputation; - Quicker creation of a resilient culture.
Investment (improvement of financial judgements to indemnify the consequences of disruptions)	- More efficient reaction with cost awareness; better total cost of ownership; - Better relation with other topics such as quality management or sustainability.
Institutions (improved collaboration with partners and government is a prerequisite for expanded use, and to help improve resilience)	- Better insight in collaboration and knowledge sharing; - Better understanding for governmental cooperation; - Structured understanding of environment. (including partners)

**Appendix 4:
Expert meeting to extract inferences
on managerial capabilities in public
transport organizations.**

**Part 2:
Information presented at expert
meeting**

***Resilience as an Imperative
in
Public Transport Organizations***

Expert meeting
November 1, 2010
The Hague

Information presented at expert meeting

Organized by Jan Willem Proper under the PhD research for the
Degree of Doctor of Philosophy in Transport and Logistics
at the University of Stellenbosch.

Promoter: Professor W.J. Pienaar

Expert meeting

- The **overall research objective** is formulated as: designing a framework to embed resilience in public transport organizations.
- The expert meeting's *purpose* is to extract inferences on the potential relationship between resilience and performance to ensure resilience in public transport organizations.
- The expert meeting *method* is to reflect on the measurement, ranking and ability to create linkages between vulnerabilities and capabilities as presented in this chapter and to create successful rules that provide managerial direction.

Participants:

- G.A. Kaper.
- T. Kienhorst.
- B.R.H. Lammers.
- M. Timmer.

Role and function.

Expert: CEO (HTM) until 2010, consultant.
Expert: CEO (Veolia) until 2010, consultant.
Expert: Senior Advisor TNO research,
co-author "Risico Management and Logistiek".
Secretary.

Provided information before expert meeting:

- Purpose and goal of expert meeting with invitation and agenda,
- Set of definitions.
- Framework structure after verification,
- List of vulnerability and capability factors,
- Results for measurement and ranking,
- Results of ability to link vulnerabilities and capabilities,
- Overview of advantages and complications of a structured resilience approach,
- Classification of performances, based on Global Risk Model structure.

Agenda:

- Part 1: Introduction:
 - Purpose of the meeting and introduction of interviewer and participants,
 - Clarification by researcher on framework, list of vulnerability and capability factors and results of measurement, ranking and linkages.
- Part 2: Evaluation of ability to measure and rank: Reactions to previous findings.
- Part 3: Relation between vulnerability and capability (sub-)factors:
 - Discussion on linking relations from both sides,
 - Discussion on process of selecting on sub-factor level before linking on factor level.
 - Discussion on time gap of the two entities: This time gap can have two directions. Public transport organizations can anticipate vulnerabilities in general and take action to increase capabilities in *anticipation* if this. On the other hand, new or more intensive vulnerabilities can be discussed as a *reaction* to the process of increasing the development of capabilities.
 - Balanced resilience: Discussion on the ability of the public transport organization to rank, to determine the importance and to identify critical linkages between vulnerabilities and capabilities.
- Part 4: Introduction and re-designing resilience in public transport organizations:
 - Relation to performance indicators.
 - Internal processes: The intention is to learn what anticipation, reaction and adaptation efforts are of most value to the public transport organisation based on the previously discussed exploratory results. Discussion on implementing resilience
 - Network processes: To develop a competitive advantage in the global business world, professionals have to coordinate relations beyond the organizational entities and improve coordination of identification, assessment and collaborative responses. Discussion on cooperation beyond the organization
 - Developing rules for introduction and redesign.
- Part 5: Summary and Conclusions.

First research objective:
 "To establish the starting point(s) and limitations regarding the (re-)design of a resilient public transport organization"

- the *role* of public transport,
- the *function* of the public transport organization.

The organization needs to identify its position within the context of the concept of resilience: **contextual resilience** (see Figure).

Property of Resilience acknowledged

Property of resilience acknowledged in 2007 annual reports and 2008 websites	Clearly (+), Moderate (+/-) and Not (-) visible statements
<i>Dutch operators:</i>	
Connexxion	+
Yecolia-transport	+
Arriva	+
GVB	+/-
RET	+/-
HTM	+
GVL	-
NS (rail)	+
<i>Belgian operators:</i>	
De Lijn	+/-
NMBS (rail)	+/-

Second research objective:
 "To structure and design a comprehensible and comprehensive resilience framework for public transport organizations"
2-step approach

1) conceptual resilience framework.

- link to risk management and resilience structure
- development of framework guidelines, definitions.

Definitions:

Resilience: capacity of an organization to survive, adapt and grow in the face of turbulent change.

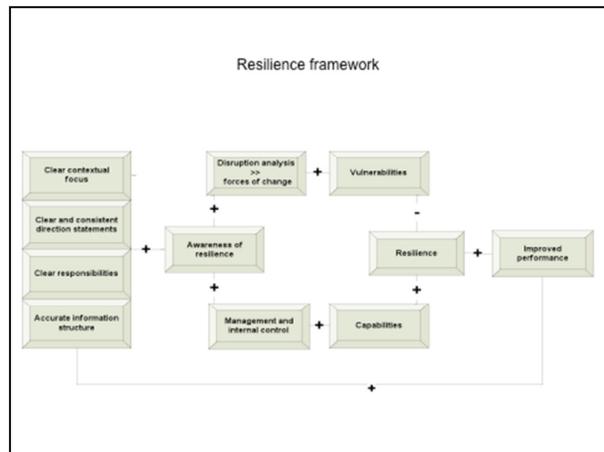
- *Balanced resilience:* property of ranking in order to determine the importance of, and to identify, critical linkages between vulnerabilities and capabilities.
- *Vulnerability:* fundamental factors that make an organization susceptible to disruption.
- *Capability:* attributes required for performance or accomplishment.

- Guiding principles of the resilient framework:**
- Resilience will provide competitive advantage especially in turbulent times and needs to be performance based.
 - The notion of resilience is based on a holistic view.
 - Strategic imperatives call for a more adaptive and structure-based approach to change.
 - A resilience approach is based on the concepts of system development.
 - The ability of balanced coordination or integration with system partners must be developed in a coherent and structured resilient approach.

Second research objective:
 "To structure and design a comprehensible and comprehensive resilience framework for public transport organizations"
2-step approach

2) Cognitive resilience

- This framework is discussed with practitioners from public transport organizations and from organizations specifically active in the fields of risk and resilience, using structured interviews.
- From this a verified structure will unfold. This will be referred to as **cognitive resilience**. This is the orientation that enables an organization to identify, assess and respond to disturbances in order to become a resilient organization. The focus is on the structure of the framework.



Third research objective:
"To identify the main elements that create knowledge about the resilience design"

This part of the research supplements the cognitive structure.

- discusses the main elements that determine the concept of resilience
- explains how resilience management contributes to improved performance of the public transport organization.

- The public transport organization must be able to address issues before they become problems and to ensure that critical capabilities are available.

Behavioural resilience is the capacity to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to structure and to react in a systematic, proactive way when something unexpected occurs. The discussions led finally to the vulnerability and capability lists (*Vulnerability and capability lists are provided*).

The expert meeting will focus on the fourth research objective and the overall research goal:

- Fourth research objective: "To ensure that public transport organizations are able to make linkages between vulnerabilities and capabilities".
- In the expert meeting the focus will be on:
- The ability to determine the importance, to rank and to identify critical linkages between vulnerabilities and capabilities will give the public transport organization the possibility to derive a **balanced resilience position**.
- In this part of the research the discussion is about embedding resilience in public transport organizations (see overall goal)

Discussion Part 1 and 2

- Part 1: Introduction:
 - Purpose of the meeting and introduction of interviewer and participants,
 - Clarification by researcher on framework, list of vulnerability and capability factors and results of measurement, ranking and linkages.
- Part 2: Evaluation of ability of measurement and ranking:
 - Reactions to previous findings

Discussion Part 3

- Part 3: Relation between vulnerability and capability (sub-)factors.
 - Discussion on linking relations from both sides,
 - Discussion on process of selecting on sub-factor level before linking on factor level,
 - Discussion on time-gap of the two entities: This time gap can have two directions. Public transport organizations can anticipate vulnerabilities in general and take action to increase capabilities in *anticipation* of this. On the other hand, new or more intensive vulnerabilities can be discussed as a *reaction* to the process of increasing the development of capabilities.
 - Balanced resilience: Discussion on the ability of the public transport organization to rank, to determine the importance and to identify critical linkages between vulnerabilities and capabilities.

Discussion Part 4

- Part 4: Introduction and re-designing resilience in public transport organizations:
 - Relation to performance indicators.
 - Internal processes: The intention is to learn what anticipation, reaction and adaptation efforts are of most value to the public transport organisation based on the previously discussed exploratory results. Discussion on implementing resilience.
 - Network processes: To develop a competitive advantage in the global business world, professionals have to coordinate relations beyond the organizational entities and improve coordination of identification, assessment and collaborative responses. Discussion on cooperation beyond the organisation.
 - Developing rules for introduction and redesign.

Discussion Part 5

- Part 5: Summary and Conclusions
- Follow-up
 - Findings in short presentation (timing)
 - Reactions for verification (timing)

Appendix 4: *Expert meeting to extract inferences on managerial capabilities in public transport organizations.*

Part 3: *Report of expert meeting.*

Introduction

In preparation for the expert meeting, attendees received the agenda and information on the structure of the research, including the framework, lists of vulnerabilities and capabilities, and material on the concept of measuring, ranking and linking of vulnerabilities and capabilities. The meeting took place on 1 November 2010 from 1.30 pm to 4.30 pm in The Hague, The Netherlands. The researcher started with a clarification of the framework, the research questions and overall goal, and provided information on framework, lists of vulnerabilities and capabilities factors and the linkages between these factors.

Results

- 1) *Public transport organizations have, in addition to common activities, many unique features.*
 - Awareness of resilience must be placed within the context of the organization's function as operator (and not in relation to other activities such as, for example, infrastructure responsibilities).
 - Transport for London (TfL) is different compared to the other public transport organizations interviewed. In addition to its role as operator, it also has the role of Transport Authority.
 - Comparison between public transport organizations is difficult, because they operate within different legal structures [in Europe] and operate different modes of transport (bus or rail (tram, metro) or water).

The identification and measurement, ranking and linking of vulnerabilities and capabilities must be placed in the perspective of the function of the public transport organization.

- 2) *The approach needs to focus on the strategic level.*
 - The approach is based at the level of the organization and more specifically its function as operator. Organizations have different approaches concerning distribution of responsibilities. The framework is applicable with a more centralized distribution as well as with a decentralized distribution of responsibilities. The results of measurement, ranking and linkages between vulnerabilities and capabilities may differ, based on the organizational approach. More specifically, it does not affect the framework or lists of vulnerabilities and capabilities.
 - Strategic priorities are focused based on the contracts between operator and transport authority. A more strategic orientation towards customers in general is regarded as necessary. Transport operators in the larger cities that are not involved in tender processes show a more customer-oriented approach.
 - The concept of resilience is considered as relevant but not urgent. It is difficult to measure both cost and revenues. There is little competition on resilience between operators. Incentives in tender processes are not evident.

The identification of the strategic approach needs to be placed in the context of the relevance and urgency of a resilient approach.

- 3) *The relation between vulnerability and capability factors within the framework.*
The concept of resilience is applicable in public transport organizations and they have the ability to derive a balanced resilience position.
- Public transport organizations are, like any other organization, learning entities. The framework provides a structure for the organizations. It is relevant to start with the awareness and the elements mentioned are important. The concept of contextual resilience is considered important and public transport organizations are able to create this awareness.
 - The framework devised in this research project is considered as comprehensible and comprehensive, and relevant to public transport organizations. Public transport organizations are able to identify, assess and respond to disturbances in order to become resilient organizations. The concept of cognitive resilience is accepted and public transport organizations are capable of working with the framework presented.
 - Within the context of the previous results, public transport organizations are able to use proactive diagnostics in the identification of potential vulnerability and capability factors that enable the organization to structure and to react in a systematic, proactive way when something unexpected occurs. The concept of behavioural resilience is accepted and public transport organizations are able to analyse the vulnerabilities and capabilities presented.

Within the context of the above:

- Public transport organizations are aware of the limitations of their knowledge in a rapidly changing environment. This is part of the capability organization;
- Public transport organizations are able to measure, rank and create linkages at factor level;
- Vulnerabilities and capabilities need to be linked. Given the short time-gap between analyzing each one separately, it is not relevant at which point to start the linking process. Organizations will most likely start with analyzing disruptions. The short-cycle approach is relevant when using the framework;
- Public transport organizations are in principle able to link at sub-factor level. Analyzing sub-factors might support a tactical approach and it is relevant to understand the context of the factors.

- 4) *Introduction and redesign of resilience in public transport organizations.*
- It is relevant to understand the culture of the organization. How open are organizations to disruptions and in what ways are they willing to discuss this internally and externally: there is a need for more openness to understand vulnerabilities.
 - Contracts with the transport authority will determine the priorities. There is the effect of penalties if contracts are not fulfilled. Performance indicators need to include what is asked in tender contracts or what is critical to customers. The power of customers (organizations) is considered as weak.
 - Resilience can become a competitive element if triggered by authorities or customers.
 - Organizations are not network oriented for improvement.

Introducing resilience is possible, but its urgency is not evident.

5) *Developing rules for introduction and redesign: what are the challenges?*

From the discussion with the experts the following challenges for public transport organizations were identified (not in order of importance):

- *Complexity increases (organizations are challenged more frequently external);*
- *Limited visibility (priority to day-to-day business interruptions compared to vulnerabilities);*
- *Accountability is not clear (who is problem owner and who else has responsibilities);*
- *Willingness to engage is limited (what are the benefits internal and external?);*
- *Justification (absence of metrics in cost and revenue indicators);*
- *Relevance in relation to other strategic issues (relevant but not urgent)*

On the basis of these findings, the following suggestions are offered.

- Because risk and resilient management will become a competitive element, knowledge of the resilience management process of public transport organizations needs to be improved.
 - o Transport Authorities are introducing elements of risk and resilience into their contracts; this will stimulate the use of the framework.
 - o UITP is developing knowledge on security and generates data and information. This will stimulate the analysis of disruptions
- Introduction of the resilience approach needs to be enforced from outside.
 - o Public transport organizations will not take the lead. The attitude of parties regarding their accountability for resilience needs to be clarified.
 - o External forces need to stimulate initiation of the resilience management process.
 - Customers: but customers are not organized.
 - Clients: transport authorities by introducing level of resilience as a competitive element.
 - Legal initiatives by national or European bodies.
 - Bodies of knowledge such as European Commission, IPO-SKVV, NctB and “Raad voor Verkeer en Waterstaat” need to trigger the process of introducing resilience.
- The culture of the public transport organization needs to be transformed to adopt a more trial-and-error perspective.

Public transport organizations need to systematically introduce the management process of resilience as an innovative action from a strategic point of view.