How to manage Resilience in Public Transport Organizations

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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 paper reports on the research done on resilience in urban public transport organizations; it presents the framework of resilience. 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. 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 create a structured framework

SAMENVATTING

De rol van openbaar vervoer is om stedelijke, sociale, duurzame en economische ontwikkelingen te stimuleren door het vervoer van passagiers op grond van hun behoeftes. Openbare vervoerorganisaties functioneren als de operators in die omgeving. Dit document rapporteert over een onderzoek dat betrekking heeft op het invoeren van resilience (veerkracht) in stedelijke openbaar vervoer bedrijven; het accent ligt op het ontwikkelen van een kader voor openbaar vervoer bedrijven. De opkomende discipline van resilience studies is multi dimensioneel en -disciplinair en wordt benaderd vanuit een holistisch perspectief op resilience op basis van een extensieve literatuur studie en een empirisch onderzoek in de Europese openbaar vervoer sector. Resilience wordt gedefinieerd als de capaciteit van een organisatie om te overleven, aan te passen en te groeien bij turbulente situaties. Bestaande onderzoeken richten zich op het fenomeen van het concept van resilience vanuit een brede diversiteit van disciplines. Literatuur onderzoek resulteerde in verscheidene logische conclusies, die beoordeeld zijn door geselecteerde specialisten. Hierbij is gebruik genaakt van gestructureerde interviews. Dit heeft geresulteerd in een raamwerk .

Sleutelwoorden: openbaar vervoer, resilience (veerkracht), raamwerkontwerp.

1 Orientation

Public transport organizations operate and develop under dynamic circumstances (UITP, 2009; 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 paper *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. The primary objective is to design a framework to embed resilience in public transport organizations. This paper will focus on *urban public transport*, further simply referred to here as public transport. 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 1).

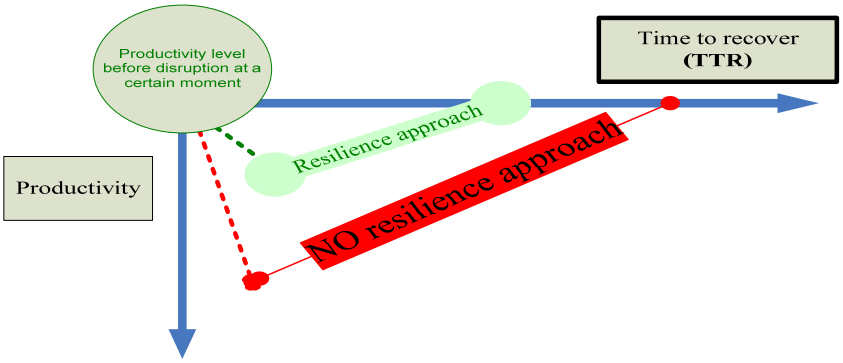

Figure 1: Difference in time to recover (TTR)

1.1 The relevance of passenger transport

The *role of public transport* is defined as being "to stimulate urban, social, sustainable and economic developments by transport of passengers based on their needs". In recent years new developments have emerged that have had an impact on the strategies of public transport organizations. One worth mentioning is the recent series of crises and catastrophes that have attracted public attention (Christopher and Peck, 2004; Grandjot, 2006). Direct transport-related examples are terrorist acts in Madrid and London, and indirect examples are Hurricane Katrina and Irene or the tsunami in Japan, creating major disruptions in public transport. 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). Strategic approaches need to be selected in the context of both internal and contextual developments (Wagner and Bode, 2008).

Analysis of Dutch and Belgian public transport organizations' annual reports from 2007 to 2010 and their websites will offer an overview of how they acknowledge "the property of resilience" as strategically relevant. 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, 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. This gap in the public transport sector is the starting point for this research on the concept of resilience in public transport organizations.

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, 2008). 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.

2. Resilience approaches in different disciplines

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 and Cranfield Resilience Centre at the Cranfield University. In summary, it can be concluded that there is a high degree of agreement among these institutions that the world is becoming turbulent more rapidly than organizations are becoming resilient. Plans need to be put in place that anticipates external and internal events. 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.
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). Faced with a dynamic and unpredictable business environment, management theorists are increasingly identifying the need for resilience (Hollnagel, 2006; Pettit et al., 2010). The resilient enterprise is intelligent, flexible and agile. Analyzing the definitions on similarities and in alignment with the definition adopted by the Council on Competitiveness, based on research conducted by Fiksel (2006), the following definition on resilience will be used in this paper: "the capacity of an organization to survive, adapt and grow in the face of turbulent change".

3 Contextual resilience

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. 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*. In this section the elements of this property are described.

3.1 Structuring the environmental focus of public transport organizations

Based on the QUESTA structure (Rand-Europe, 1998), 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.

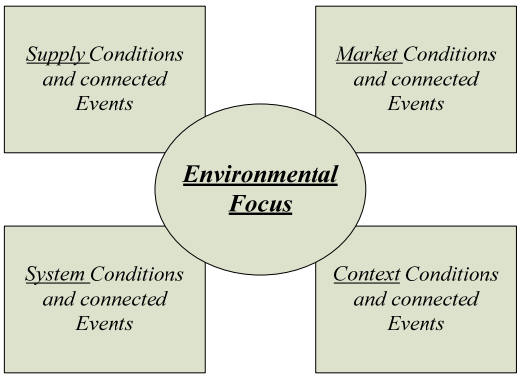

Figure 2: Environmental focus of public transport organizations

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. The following research proposition is formulated:

RP-1: Contextual awareness of the concept of resilience is positively influenced by a clear environmental focus.

The following research proposition is acknowledgement of the property of resilience, especially by higher management in public transport organizations (Pettit, 2008; Sheffi, 2007). Accordingly, the following research proposition (RP) is formulated:

RP-2: Contextual awareness of the concept of resilience is positively influenced by clear and consistent direction statements.

If a public transport organization decides to adopt a new strategy, then the structure needs to be adapted as well as the enablers. To improve decision making and improve performance, a decision-making process is needed. The following research proposition is 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 information (Norrman and Lindroth, 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. The following research proposition is formulated:

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

Further a postulate is 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.***

In summery this results in the following structure of the elements of contextual awareness:

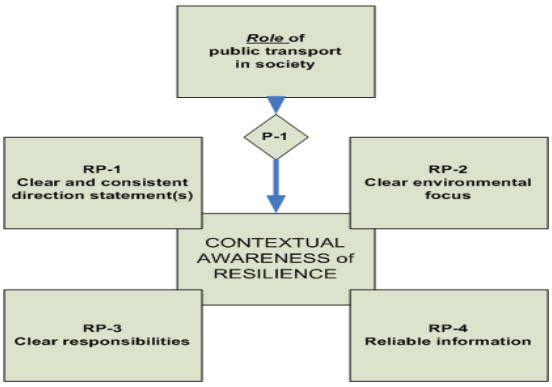

Figure 3: Contextual awareness of resilience (P: Postulate, RP: Research Proposition)

4 Resilience strategies and frameworks

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 Universit. From these studies the notion of the term ‘vulnerability’ as “a fundamental factor that makes an organization sensitive to disruptions’’ developed. On the basis of empirical research Christopher and Peck (2004) 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;
- 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.

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.

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). 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.

Examining existing frameworks and research in more detail, 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 research on resilience.

The concept of resilience needs to combine previous tenets with studies on vulnerability and capability. Consistent with previous research (Peck, 2005; Pettit *et al.*, 2010) the following definition of <u>*vulnerability*</u> 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.
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 and to enable adaptation following a disruption.
The literature also suggests many different types of capabilities (Sheffi and Rice, 2005). Consistent with this, in this paper the following definition will be used: <u>*capabilities*</u> 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.

5 Structure of a conceptual strategic resilience framework

This section will discuss the other associated parts of the resilience framework. Also in this section research propositions (RP) will be formulated, to be verified later.

5.1 Vulnerability identification

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). 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.

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, 2006; 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*.

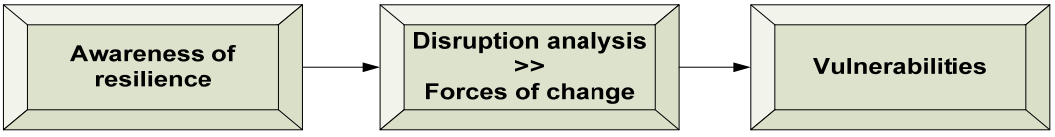

Figure 4: Resilience framework, Part 2: identification of vulnerabilities

5.2 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.

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.

Based on the previous two research propositions, the following partial structure of the framework will result, referred to as *part 3*.

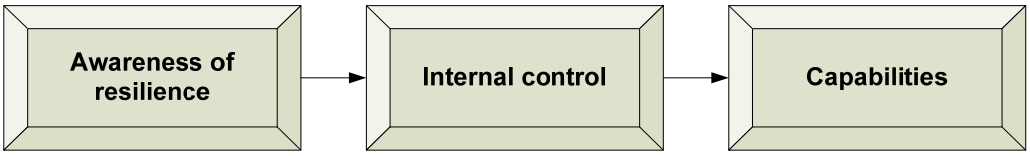

Figure 5: Resilience framework, Part 3: identification of capabilities

5.3 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.

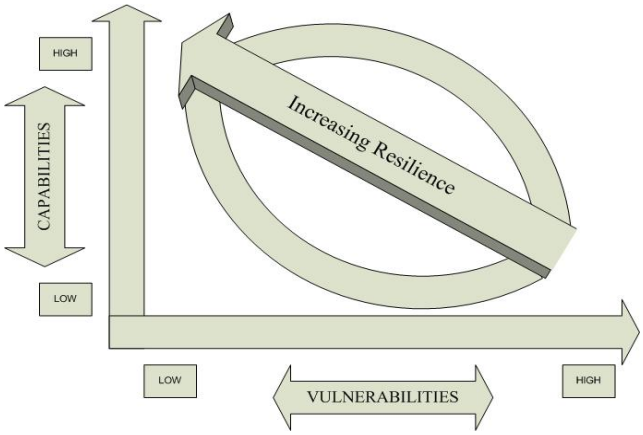

Figure 6: Effects of vulnerabilities and capabilities on resilience

In summary, 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.

5.4 Connecting resilience and performance

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 it strengths, weaknesses and priorities. 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. From this the following research proposition is formulated:

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

5.5 Feedback and the conceptual resilience framework

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.

6 Cognitive resilience

Research propositions have been formulated in the previous sections. 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 are from both public transport organizations and from organizations specifically active in the fields of risk and resilience. In this part of the research six public transport organizations and four other stakeholders have been selected and interviewed, using positive sampling.
From this a verified structure is 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.

6.1 Research findings

- All participants agreed on the strategic relevance of resilience as a concept and the relevance of a systematic approach;
- All participants agreed on the need to relate resilience to performance;
- 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;
- Participants all agreed on the formulated research propositions;
- Participants all agreed on the following point: improved resilience will have a positive effect on performance.
- Public transport organizations are aware of major advantages and complications of a structured resilience approach.

  Table 1 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 1: Overview of advantages and complications of resilience approach

6.2 Verified resilience framework for public transport organizations

It can be concluded that the concepts and definitions 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.*

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 (Figure 8). 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. There is a need for systematic resilience approaches in general and for public transport organizations more specifically (Fiksel, 2006; Proper, 2008; UITP, 2008).

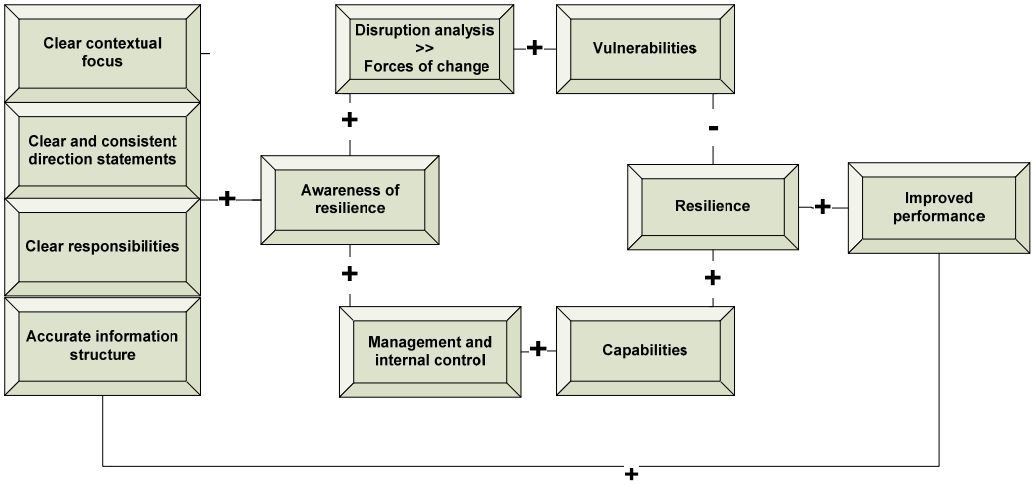

Figure 8: Verified resilience framework for public transport organizations

The 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. Public transport organizations are one of the stakeholders in public transport and are the object of experience.

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