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A review of resilience management application tools in the transport sector

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Abstract

Considering that resilience implies the ability of a system to continuously adapt in order to respond to its operational goals, a system is considered as more or less resilient depending on the level and time of recovering from disruptive events and/or shocks to its initial state. RESOLUTE (RESilience management guidelines and Operationalization appLied to Urban Transport Environment) Horizon 2020 research project is answering those needs, by proposing, among others, to conduct a systematic review and assessment of the state of the art in resilience assessment and management concepts. In this view, the present paper investigates resilience management in transport applications, by examining the behavior of selected case studies under acute disruptions. An extended state-of-the–art review of a number of initiatives in different countries has been conducted, to examine resilience management methodologies and applications in transport systems. Based on social factors, timing, economic characteristics, environmental aspects, system characteristics and physical dimensions, the findings of the above review are presented, along with a comparative and critical analysis of the examined solutions.

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1. Introduction

Transport systems provide critical support to every socio-economic activity, while being one of the most important economic sectors. In this perspective, the resilience of transport systems against natural or man-made disasters is of utmost importance, not only for the system as such, but also for the effective operation of a series of other systems, for which transportation is part of their chain of functions. At the same time, the paths that convey people, goods and information, are the same through which risks are propagated; this consideration provides an additional reason why transport systems' resilience enhancement is an imperative necessity.

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2. Background

Resilience has been analyzed in different ways as it is multifunctional and depends on each system's dynamics. It is strongly related to risk management and safety and security issues, but mostly reflects the level of adaptability of the risks, externalities and shocks in order for the system to remain sustain and/or stable. The broad content and the diversity of the term, depending on the system and the circumstances, is also reflected in the great variety of definitions that may be found in the literature.

Holling (1973) described resilience as "the ability to absorb change and maintain the same relationships between state variables". In 1999, Comfort linked the resilience of a system with the level of the system adaptability. He stated that "the capacity to adapt resources and skills to face new situations and operational targets is the level of resilience of the system".

Adger (2000) described resilience as "the ability of groups of people to cope with external stresses". He issued that these stresses may derive from social, political and environmental changing conditions. Five years later Allenby and Fink (2005) described resilience considering the capability of a system to maintain and to degrade when facing internal and external changes. Hale & Heijer (2006) referred to resilience describing the ability to steer the activities of the organization so that it may sail close to the area where accidents will happen but always staying out of the dangerous area. The ability of a system to efficiently adjust to harmful influences, rather than to shun or resist them, was discussed by Hollnagel (2006, 2011a). He considered the intrinsic ability of a system to react to and recover from disturbances at an early stage, with minimal effect on its dynamic stability and to adjust its functioning prior to, during or following changes and disturbances, under both expected and unexpected conditions. The U.S. Department of Homeland Security Risk Steering Committee (2008) studied the capacity of an organization to recognize threats and hazards and make adjustments that will improve future protection efforts and risk reduction measures and the ability to resist, absorb, recover from or successfully adapt to adversity or changing situations occurring.

Therefore, when discussing resilience, there raises the need to consider a series of different aspects: processes, disciplines and infrastructures that need to be in place to make sure that undesired events do not happen or that systems may survive such events and maintain operation (Jackson, 2010); the proper use of internal and external resources to successfully resolve issues (Sutcliffe & Vogus, 2003; Tierney & Bruneau, 2007); the ability to keep or recover quickly to a stable state, allowing it to continue operations during and after a major mishap, or in the presence of continuous significant stresses (Wreathall, 2006); the time related level of resilience (Westrum, 2006), considering how to prevent a shock from happening, the elimination of consequences in case it happens and the level of recovering.

Except of the research on resilience described above, several R&D projects, co-funded by the European Commission, have been undertaken, aiming to support the mitigation of a crisis. Selected examples of them are: DRIVER[1] – Driving Innovation in Crisis Management for European Resilience (2015), SECUR-ED[2] - Competence Framework for mass transportation (2013), ACRIMAS[3] - Aftermath Crisis Management System-of-systems Demonstration (2012) and SAVE ME[4] –System and Action for Vehicles and transportation hubs to support Disaster Mitigation and Evacuation (2009).

3. Analyzing resilience

Measuring and/or analyzing resilience is also a multifunctional activity, as it refers to complex systems and depends on the scale and level of desired detail, varying by the needs of each system.

Hollnagel (2011b) introduced the four cornerstones of resilience analysis:

1. a) Knowing what to do
2. b) Knowing what to look for

1 http://www.driver-project.eu/

2 http://www.secur-ed.eu/

3 http://www.acrimas.eu

4 http://www.save-me.eu/