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Application of the "Behind the Barriers" resilience conceptual model to a flooded rail transport system

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The vulnerability of guided transport systems facing natural hazards is a burning issue for the urban risks management. Experience feedbacks on guided transport systems show they are particularly vulnerable to natural risks, especially flood risks. Besides, the resilience concept is used as a systemic approach for making an accurate analysis of the effect of these natural risks on rail guided transport systems.
In this context, several conceptual models of resilience are elaborated for presenting the various possible resilience strategies applied to urban technical systems. One of this resilience conceptual model is the so-called "Behind The Barriers" model based on the identification of four complementary types of resilience: (i) cognitive resilience, linked to knowledge of the risk and the potential failures; (ii) functional resilience, representing the capacity of a system to protect itself from damage while continuing to provide services; (iii) correlative resilience, that characterises the relationship between service demand and the capacity of the system to respond; (iv) organisational resilience, expressing the capacity to mobilise an area much wider than the one affected.
In addition to the work already published during the 7th Resilience Engineering Symposium, the purpose of this paper is to offer an application of a resilience conceptual model, the "Behind the Barriers" model, relating to a specific urban technical system, the public guided transport system, and facing a particular risk, a flood hazard. To do that, the paper is focused on a past incident on a French Intercity railway line as a studied case. Indeed, on June 18th and 19th 2013, the rise of the level of the "Gave de Pau" river, located in the municipality of Coarraze, caused many disorders on the intercity line serving the cities of Tarbes, Pau and Lourdes . Among the disorders caused by the flooding, about 100 meters of railway embankments were collapsed. With a constraint to reopen the line before August 15th, reinforcements were studied in order to stabilize the railway embankment. During the works, substitute shuttle service was set up, providing services between cities.
This French past incident is studied through the "Behind The Barriers" model:
i. cognitive resilience: what was the level of knowledge of the stakeholders concerning the flood hazard?;
ii. functional resilience: what could be done in order to maintain the railway service between the cities?;
iii. correlative resilience: what was the operator's response about the service demand with respect to the capacity of the railway line to ensure service?;
iv. organizational resilience: what was the mobilization of the impacted cities, the impacted French department, the National authorities... on a wider scale than the flooded area in order to restore the line?
The paper gives the main qualitative conclusions of the application of the "Behind The Barriers" model to this railway flooding event. The relevance of these conclusions are also confronted with feedbacks from other experienced railway incidents due to flooding events: on October 2015, heavy rains in French Region of Provence-Alpes-Côte d'Azur that provoked damages of railway equipments in Cannes and Marseille cities; on June 2016, the rise of the Seine River in Paris strongly impacted intercity railway lines and subway lines.