# Improving the resilience of complex socio-technical systems: an application to the Mexico City subway

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## Abstract

In academic literature, the term *resilience* was originated in 1973 from Holling´s work with ecological and socio-ecological systems, where he defines it as persistence of system relationships and the ability of a system to absorb external changes. As suggested by Taysom and Crilly (2017), engineered systems are designed to reliably perform specific tasks with predictable external influences, but ecological systems must persist when confronting extreme change and uncertainty despite that lack of stability. Improving the resilience of socio-technical systems is a goal increasingly adopted in our modern world. The aim of this study is to develop a framework for improving the resilience of socio-technical systems. First, we describe broadly the elements that constitutes the resilience of socio technical systems. Then, we propose a framework for improving the resilience of socio-technical systems. After that, we conceptualize the Mexico City subway as a socio-technical system and finally, we implement the framework proposed for improving its resilience. We consider the results from this study are very useful for supporting the decision making on the management of the Mexico City subway.

**Keywords:** socio-technical systems; resilience; subway; Mexico City.

## 1. Introduction

On the one hand, the term *socio-technical system* was originally coined by Emery and Trist (1960) to describe systems that involve complex interactions between humans, machines and the context aspects, as health public system, transportation systems, organizations, etc. According to Badham *et al.* (2000), there are five characteristics of open socio-technical systems: 1) Interdependent parts, 2) System´s goals in external environments, 3) Interdependent technical and social subsystems, 4) Equifinality, and 5) System performance that relies on the joint optimization of the technical and social subsystems. Focusing on one of these subsystems to the exclusion of the other is likely to lead to degraded system performance and utility. On the other hand, the term *resilience* was originated in 1973 from Holling´s work with ecological and socio-ecological systems, where he defines it as persistence of system relationships and the ability of a system to absorb external changes. As suggested by Taysom and Crilly (2017), engineered systems are designed to reliably perform specific tasks with predictable external influences, but ecological systems must persist when confronting extreme change and uncertainty despite that lack of stability. Improving the resilience of socio-technical systems is a goal increasingly adopted in our modern world. An increasing number of studies on resilience of sociotechnical systems developed by researchers such as Ruault *et al.* (2012), Luzeaux (2011), Woods (2016), and more recently Tayson and Crilly (2017) have been undertaken in the last years. Interestingly, a state of art of resilience of complex systems is presented by Fraccascia *et al.* (2019). Nevertheless, there is a lack of understanding of resilience as an intrinsic emergent property of