COMPREHENSIVE ASSESSMENT OF RESILIENCE AND OTHER DIMENSIONS OF ASSET MANAGEMENT IN METROPOLIS-SCALE TRANSPORT SYSTEMS

Eyuphan Koc

ekoc@usc.edu

Abstract

Disasters exert profound impacts on human societies. Direct costs of disasters have exceeded 2.5 trillion US dollars in the 21st century affecting more than 3 billion people and causing more than 1.2 million casualties around the globe (UNISDR 2018)[1]. Stemming from the inability to grow in a sustainable fashion, as well as to build resilience at the rate of urban growth, many cities are facing increasingly complex resilience challenges. In the definition urban resilience (Meerow et al. 2016), the *urban system* is characterized by its components such as its governance networks, networked material and energy flows, urban infrastructure and form, and socio-economic dynamics. Among the components of the urban system, infrastructure systems or *lifelines* are key facilitators that support the lives, interactions, and dynamics of urban dwellers. Lifelines or Critical Infrastructures (CIs) (transportation, water, power, telecommunications etc.) are essential to the well-being of the society not only under business as usual conditions, but also during times of disaster for the entire response and recovery timeline. In this setting, it is argued that the transportation system is one of the most significant lifelines, because disturbance to transportation imposes extra burdens on other lifelines (Hopkins et al. 1991) (e.g. handling of a power substation failure due to earthquake damage requires a connected road network or other functioning modes of transportation for dispatch teams). Despite this, *analytical* tools and approaches advising policy making to improve resilience are scarce (Ganin et al. 2017). In this thesis, the author contends that there is also a lack of *synthetic* approaches that handle the diversity of challenges associated with transportation system disruptions. Most investigations practically exclude one or more dimensions of the problem that stem innately from exposure to hazards, vulnerability of the physical infrastructure, and the direct and indirect losses that result from this coupling. Having this in mind, the author intends to achieve a balance between the two overlapping views—analytical and synthetic— with a framework that is designed generate holistic and actionable resilience insights related to transportation network disruptions in metropolitan areas. This convergent framework is called *CRAFT* for *Comprehensive Resilience Assessment Framework for Transportation Systems* and consists of: (1) a hazard characterization and damage assessment module that simulates the governing event causing the disruption and estimates the physical damages to network components leveraging a novel image-based modeling methodology, (2) a transportation analysis module (implemented with a high-resolution travel demand model) investigating the disruption and (3) a socioeconomic impact analysis module based on CGE (computable general equilibrium) analysis

[1] These statistics do not account for the ongoing COVID-19 pandemic with devastating impacts on global economy. COVID-19 to slash global economic output by $8.5 trillion over next two years. (2021). Retrieved May 21, 2021, from https://www.un.org/en/desa/covid-19-slash-global-economic-output-85-trillion-over-next-two-years)

supplemented by a multi-sector income distribution matrix that calculates the business interruption losses and income distribution impacts, and quantifies economic resilience. *CRAFT* is deployed in a Greater Los Angeles Area case study to investigate a magnitude 7.3 earthquake scenario on Palos Verdes Fault.

The author additionally asserts that the shortcomings in transportation systems research in targeting holistic and actionable insights (that are strengthened by an enhanced use of traditional and novel data sources) are not limited to the disaster context but also exist in broader asset management of transportation systems. In the case of bridges, the most critical links in multi-modal transportation networks due to the low redundancy associated with their closure, the asset management decisions on alternative maintenance, rehabilitation, and replacement (MRR) strategies are often not as informed as they could be since the data, tools and methods employed are not up to speed with the ongoing 'data revolution' in the civil systems domain. Thus, this thesis also explores the currently underutilized dimensions of data by investigating maintenance, repair and reconstruction decision-making in the context of its impacts on system-level performance indicators (e.g., changes in total VHT, VMT, Delay, etc. in a region), on accessibility to jobs and services as well as on local/regional/national economies fueled by the supply chains utilizing the transportation infrastructure. This is achieved through another system-based, analytical framework including data, tools and methods leveraged to investigate transportation, economic and social systems in urban areas. The mentioned explorations are demonstrated with a Los Angeles case study developed in collaboration with the asset management team of California Department of Transportation (Caltrans) District 7.

References

Ganin, A. A., Kitsak, M., Marchese, D., Keisler, J. M., Seager, T., and Linkov, I. (2017). "Resilience and efficiency in transportation networks." *Science Advances*, 3(12), 1–9.

Hopkins, D. C., Lumsden, J. L., and Norton, J. A. (1991). "Wellington's Lifelines in Earthquake Project: An Outline of a Major Review." *Lifeline Earthquake Engineering*, ASCE, 774–804.

Meerow, S., Newell, J. P., and Stults, M. (2016). "Defining urban resilience: A review." *Landscape and Urban Planning*.

UNISDR. (2018). "Disaster Statistics." <https://www.unisdr.org/we/inform/disaster-statistics>.