The impact of network and demand disaggregation on modeling transportation system resiliency measures

The highway transportation system in the United States was used more than 4.2 million passenger-miles and 2.3 billion freight ton-miles in 2012[1]. Any disruption in the system, whether natural, human-caused, intentional or unintentional, can have a significant impact on society in terms of the economy, safety, security and the environment. It is necessary to develop strategies to prevent such events, minimize their impacts and protect the most critical elements of the system. To prioritize the most critical segments, one needs to model operations the transportation system under normal conditions and with disruptions. In this study, we focus model the network robustness of individual road links by considering link capacity reduction and using the known travel demands between the origin and destination (OD) zones in the network.

This paper will investigate two questions. First, how detailed does the network model need to be so as to analyze accurately assess criticality of the links? It is common practice in the industry to only model main arterial highways for planning purposes or congestion management. However, less major roads provide redundancy to major roads affecting their relative criticality. Similarly, most models use aggregate zone-based OD matrices, where each element $T_{ij}$ in the matrix shows the number of trips from origin $i$ to destination $j$. The second question in this paper is how the accuracy of the measures of relative link criticality is impacted by the spatial aggregation level of the OD matrix. To address the above questions, we use one hypothetical regional road network (148 links and 128 miles), and the road network of Chittenden County, Vermont (population 156000, 619 square miles, 8000 links). The rank order of importance or criticality for links in the networks are calculate based on Network Robustness Index (NRI) method which repeats user equilibrium traffic assignment while disrupting individual link capacities one by one. Changes in rank order between different cases if model aggregations are compared by using Spearman’s correlation coefficient.