Freight activities are directly related to a country’s Gross Domestic Product and economic viability. In recent years, the U.S. transportation system supports a growing volume of freight, and it is anticipated that this trend will continue in the coming years. To support the projected increase in freight volume, an efficient, reliable, and low-cost freight logistics system is necessary to keep the U.S. competitive in the global market. In addition, intermodal transport is becoming an increasingly attractive alternative to shippers, and this trend is likely to continue as state and federal agencies are considering policies to induce a freight modal shift from road to intermodal to alleviate highway congestion and emissions. However, the U.S. intermodal freight transport network is vulnerable to various disruptions. A disruptive event can be a natural disaster or a man-made disaster. A number of such disasters have occurred recently that severely impacted the freight transport network. To this end, this dissertation presents five studies where mathematical models are developed for the road-rail intermodal freight transport considering the network uncertainties.

The first study proposes a methodology for freight traffic assignment in large-scale road-rail intermodal networks. To obtain the user-equilibrium freight flows, gradient projection (GP) algorithm is proposed. The developed methodology is tested on the U.S. intermodal network using the 2007 freight demands for truck, rail, and road-rail intermodal from the Freight Analysis Framework, version 3, (FAF3). The results indicate that the proposed methodology’s projected flow pattern is similar to the FAF3 assignment. The second study formulates a stochastic model for the aforementioned freight traffic assignment problem under uncertainty. To solve this challenging problem, an algorithmic framework, involving the sample average approximation and GP algorithm, is proposed. The experiments consider four types of natural disasters that have different risks and impacts on the transportation network: earthquake, hurricane, tornado, and flood. The results demonstrate the feasibility of the model and algorithmic framework to obtain freight flows for a realistic-sized network in reasonable time.

The third study presents a model for the routing of multicommodity freight in an intermodal network under disruptions. A stochastic mixed integer program is formulated, which minimizes not only operational costs of different modes and transfer costs at terminals but also penalty costs associated with unsatisfied demands. The routes generated by the model are found to be more robust than those typically used by freight carriers.

The fourth study develops a model to reliably route freight in a road-rail intermodal network. Specifically, the model seeks to provide the optimal route via road segments, rail segments, and intermodal terminals for freight when the network is subject to capacity uncertainties. The proposed methodology is demonstrated using a real-world intermodal network in the Gulf Coast, Southeastern, and Mid-Atlantic regions of the U.S.

Lastly, the fifth study formulates a model to determine the optimal collaboration plan for domestic intermodal transportation that would minimize the participating truck carriers’ cost. The truck travel time variations are also considered. Using empirical data, the proposed strategy is tested and is demonstrated to be effective in meeting all of the shipment constraints while minimizing the cost.