Capacity and Flexibility of Transportation Networks

PI: Edward K. Morlok, Co-PI: Zhi-Long Chen

ABSTRACT

This research seeks to answer the question of how to measure the capacity and flexibility of a transportation system, considering uncertainty in system performance and traffic. The emphasis is on the term system, for methods already exist to measure the capacity of individual links and nodes of a network in terms of volume-delay functions. But as we have learned with the recent capacity problems of U.S. freight railroads, capacity is dependent on many other system elements, including the fleet, labor, and energy, among others. And information technology -- vehicle and cargo tracking systems, mobile communications, real-time movement control, etc.-- can increase fleet productivity and shift link volume-delay curves.

This research will develop overall metrics for system capacity. These are intended to address questions of the maximum amount of traffic a system can accommodate, and the flexibility of the system in accommodating different mixes of traffic. Such mixes include changes in: spatial patterns resulting from shifts in national or international trade patterns, the mix of commodities carried, and speed or other level of service features required by industry. We term these different quantities and mixes of commodities and related features "traffic scenarios."

The methods developed are intended to address fundamental questions that face those responsible for providing transportation infrastructure, including: Is the system capable of accommodating an expected future traffic scenario? If not, what are the bottlenecks? How flexible is the current system in accommodating various traffic scenarios that might arise? How adequate and flexible will the system be given planned investments and other changes? Traditional transportation models have focused on estimating the performance-- cost and level of service--of a given system with given traffic scenario, and generally do not consider uncertainty. This research addresses different but related questions, namely, the ability of a system to accommodate various possible traffic scenarios. Our results should provide improved methods by which private and public sector infrastructure mangers can assess the state of their systems and also evaluate improvements resulting from investments and operational changes. In undertaking this research, we will build upon existing models of the system, but structure these into an optimization formulation that enables us to posit different measures of capacity and flexibility. One version will be deterministic. But our goal is to develop a stochastic model that will take into account stochastic variations in such features as link performance and the quantity and mix of different commodities over time. Thus we also intend to develop a Monte Carlo simulation version of the model, which will provide a basis for developing a combined optimization and stochastic approach to the problem. We expect to use current capacity problems in the freight transportation system as examples and tests of the methodology that we develop.

SPONSOR: NSF