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RESEARCH PROBLEM

This project addresses problems associated with the movement of freight using trucks in urban areas. Initially the project started as a demand modeling effort, but it became apparent that there are many pressing issues related to the impacts of the specific vehicle stops and deliveries themselves. The work in this project consisted of two parts: 1) development of models for demand responsive transportation systems in order to model network-level characteristics of the logistics system of urban goods delivery, and 2) development of traffic models to quantify the impact of urban freight deliveries on street capacity and delays. This second effort addresses a gap in the Highway Capacity Manual (HCM), which contains guidelines for estimating capacity and delays on streets under a variety of operating conditions but does not account for blockages associated with freight deliveries. Together, these research efforts shed light on the operations of urban freight systems and the impacts that these deliveries have on other users of the street network in a city. Ultimately, the research on demand responsive models was restricted by available trucking data, so the main research effort for this project has focused on modeling traffic interactions associated with vehicle stops for urban freight delivery.

METHODOLOGY

Network-level models for the distribution of goods across an urban region were developed using continuum approximation methods. For these models, the assumption is that the demand for goods delivery is distributed throughout the region, so a fleet of trucks must be routed to make many randomly distributed stops throughout the region in order to serve the demand. This amounts to a vehicle routing problem that is mathematically very closely related to the problem for demand responsive passenger transportation systems. The focus of the models is to identify the conditions that favor direct delivery of goods by long distance trucks directly to their destinations versus transshipment of goods from larger vehicles to a fleet of smaller local delivery vehicles.

Capacity and delay models for the effect of individual freight deliveries on traffic were developed using a few different methods. First, observations were collected from New York City DOT traffic cameras and direct observations in Boston (Fig. 1). Second, a simple analytical model was developed by applying methodologies that the 2010 HCM presents for estimating the impacts of bus stops on traffic. Third, a more detailed analytical model was developed based on kinematic wave theory, which is consistent with the dynamics of queuing at intersections and behind delivery vehicles (Fig. 2). These models were then compared to reveal the conditions that the simplified approach provides an appropriate extension of the HCM as well as some important differences that should be accounted for in reality.



Figure 1. Freight delivery in New York

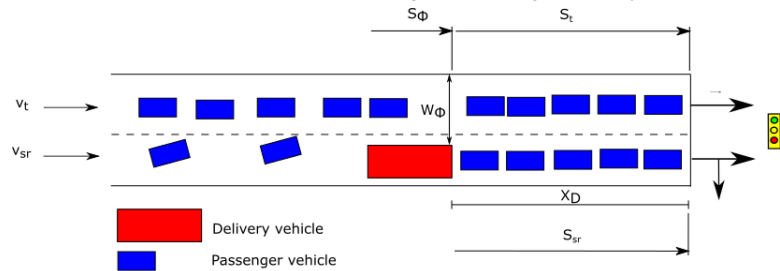


Figure 2. Diagram of a freight delivery blocking traffic on a signalized arterial.

RESULTS

The result of the demand responsive modeling research is the development of analytical models that account for the costs of operating trucks over distance for line haul and local delivery circulation; the costs of stopping for deliveries; the costs of loading and unloading at origins, destinations, and transshipment terminals; and the costs of the terminal facilities themselves. The models show that when the operating costs and operating speeds of long distance and local delivery trucks is similar, transshipment centers have little value. A benefit exists when smaller local delivery trucks are cheaper to operate and/or able to maneuver more quickly through a city's network. A number of findings related to zoning strategies for demand responsive passenger transportation systems show that there can be benefits for breaking a large service region down into smaller service districts, especially if a zoning strategy can reduce the empty vehicle distance traveled. Operations of empty vehicles are costly and wasteful from the supplier's perspective and also make unnecessary contributions to traffic congestion.

The model for the effect of freight deliveries on traffic accounts for the location on the block of the delivery, the number of lanes that are blocked by the truck, and the duration of the delivery within an analysis period (e.g., and hour). The simplified method that is adapted from the HCM's treatment of bus stops is consistent with special cases that the delivery is at the stop bar or far enough upstream of the intersection that it does not interact with the traffic signal at the intersection. The analysis accounted for the effects of the freight delivery blockage on intersection capacity, average vehicle delay, and the maximum length of queue. A comparison of the delays estimated with the simplified and detailed analytical models is presented in Figure 3. Each color represents a different duration of delivery, and the results show that the simplified model sometimes overestimates and other times underestimates the delays that a more detailed kinematic wave model accounts for.

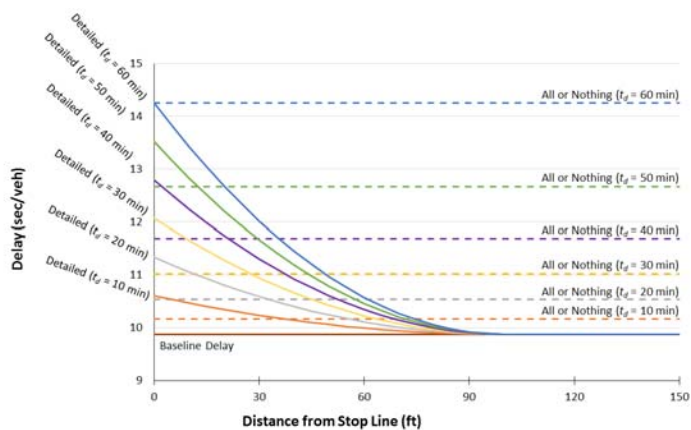


Figure 3. Comparison of delays for various delivery locations and durations

CONCLUSIONS

The conclusions of this research are that freight deliveries in urban areas are associated with significant costs for freight distribution and in terms of congestion effects for general traffic. In many cases, transshipment to smaller vehicles can save money at the expense of longer delivery times. The model of traffic impacts shows that there are potentially significant impacts on traffic congestion caused by freight deliveries, especially on the streets with the highest traffic volumes. There have been many proposals to reschedule deliveries to off-peak hours. This research reveals the value of making such shifts and also can be used to identify which specific deliveries should be targeted for rescheduling.

Results of distribution models are in preparation for two journal publications. Results of the traffic models will be presented at a conference and in a forthcoming Master's Thesis.