

ATTACHMENT D

The Importance of Managing Demand

Congestion Pricing is widely recognized as an effective, justifiable method for transportation demand management (TDM). This briefing document provides an overview of the reasons that TDM is such an important topic, particularly in the context of facilities carrying vehicular traffic such as freeways.

GOVERNING PRINCIPLE

According to traffic flow theory, there is a key fundamental relationship between the flow of vehicles in a given lane and the corresponding density of vehicles in that lane. When traffic is uncongested, flow and density increase proportionally, and all vehicles get to travel at full speed. This is intuitive, and can be easily seen in Figure 1 and Figure 2, where density doubles when flow doubles, but speeds remain the same because the lane has not yet reached its capacity threshold.

Figure 1: ExpressLanes traffic conditions for a demand of 360 vehicles per hour

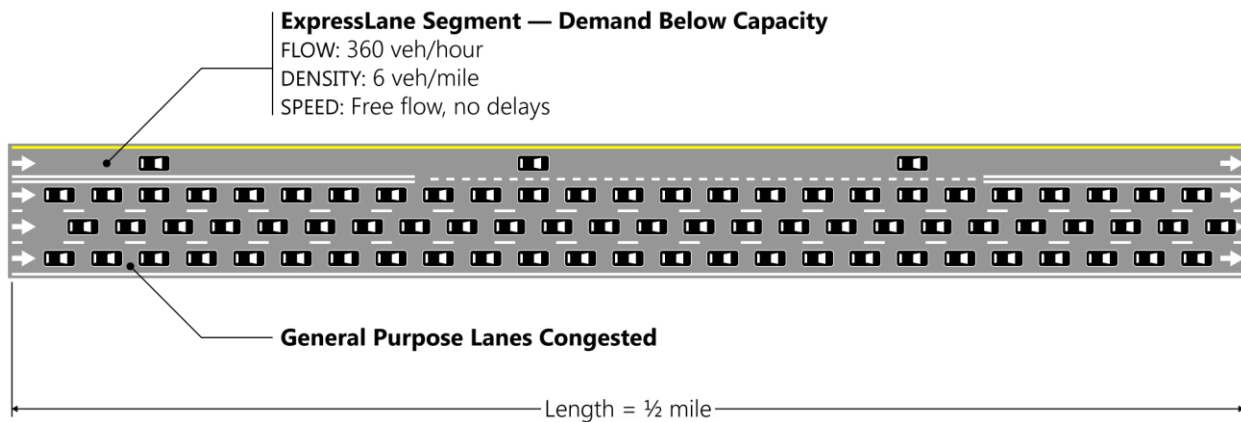
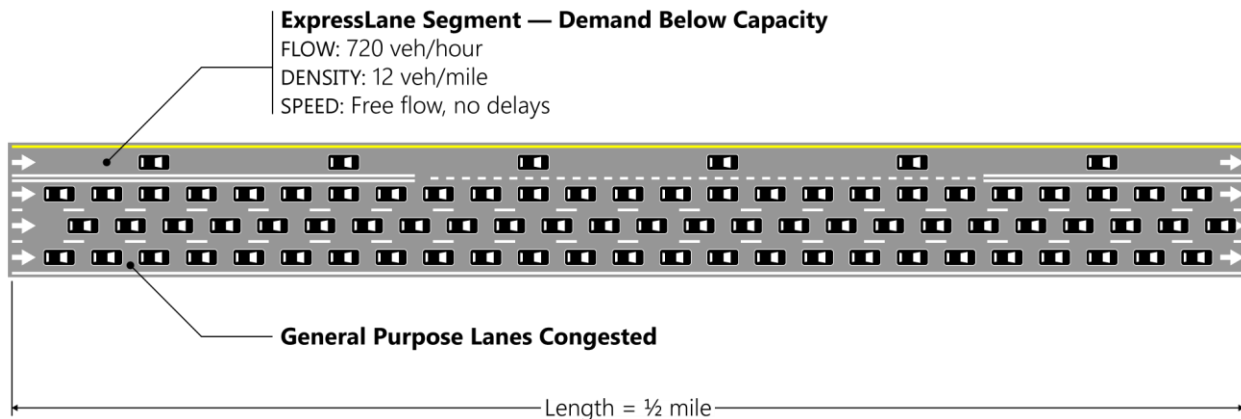
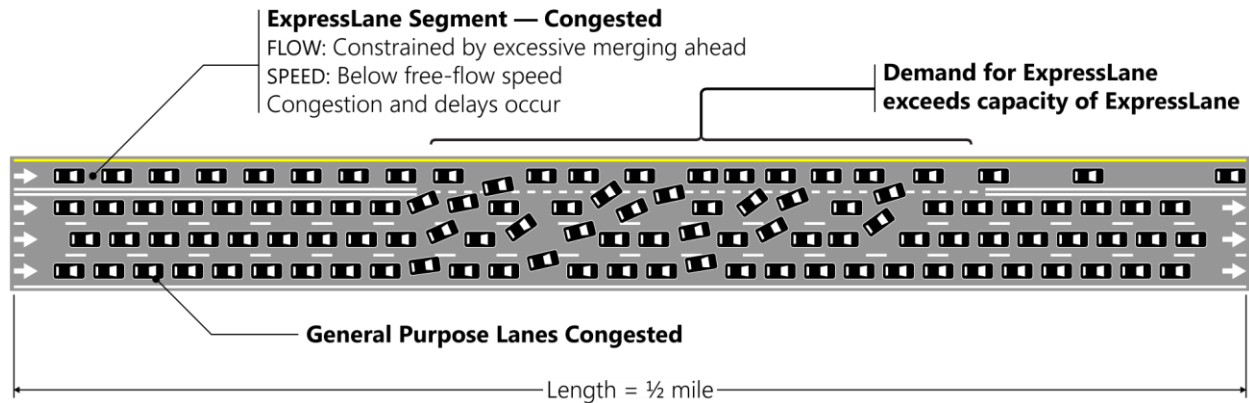


Figure 2: ExpressLanes traffic conditions when demand doubles to 720 vehicles per hour



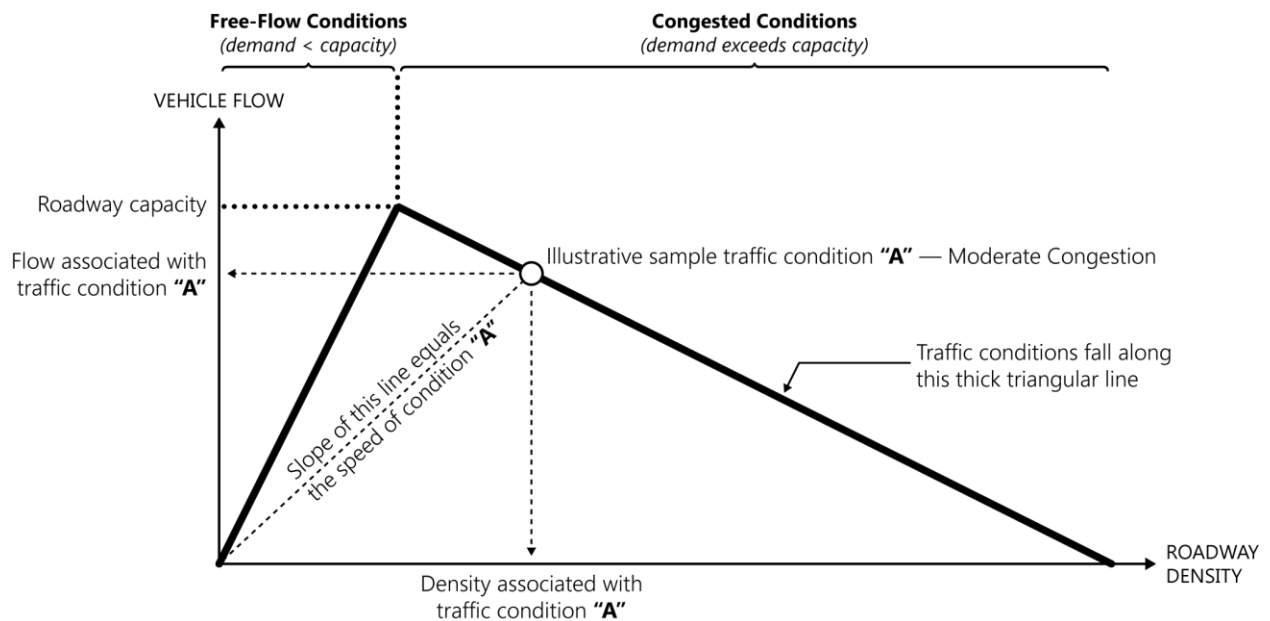
When demand exceeds the maximum capacity of a road, conditions shift from being uncongested to being congested and the relationship between flow and density changes drastically—yet predictably. Flow becomes constrained as more vehicles attempt to access the road than it can accommodate. Queues form, delays rise, and speeds drop. In these congested conditions, the more constrained the flow becomes (or the greater the imbalance between demand and capacity), the farther the speeds drop. This condition is shown in Figure 3.

Figure 3: ExpressLanes traffic conditions when demand exceeds capacity



The relationship between speed, flow, and density can be represented visually in what is referred to as the “fundamental diagram,” which is shown in Figure 4. As the figure shows, traffic speeds start dropping immediately once demand rises above capacity. The extents of the resultant delays caused by the congestion are specific to each roadway configuration and demand profile.

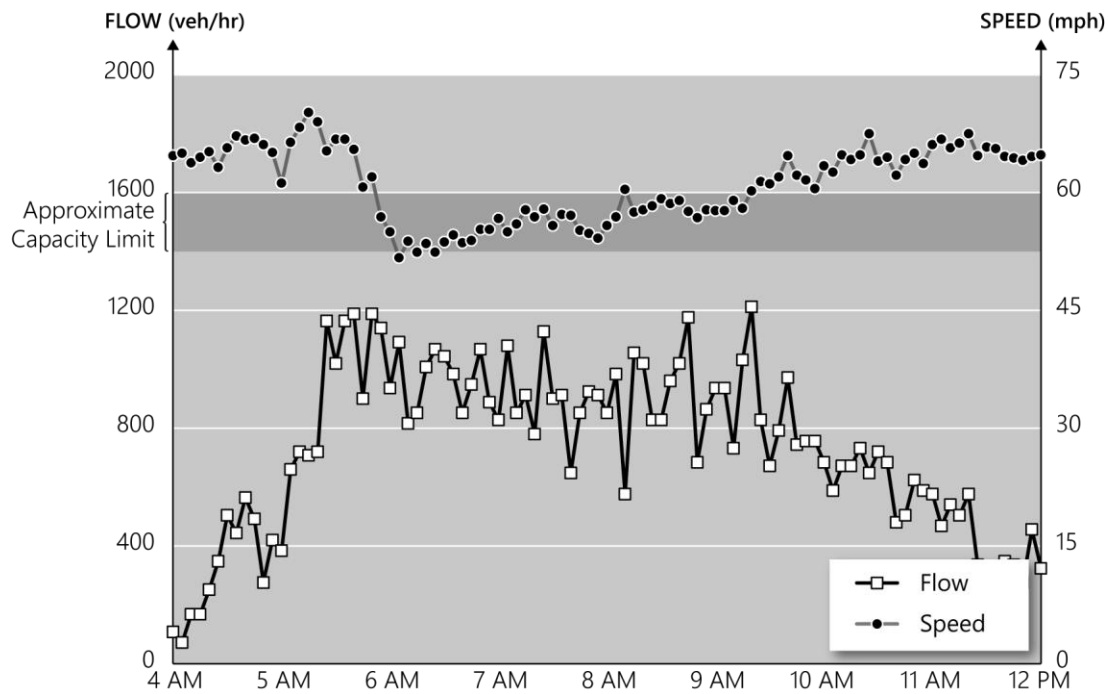
Figure 4: Fundamental diagram showing relationship between traffic flow, density, and speed



REAL-WORLD DATA

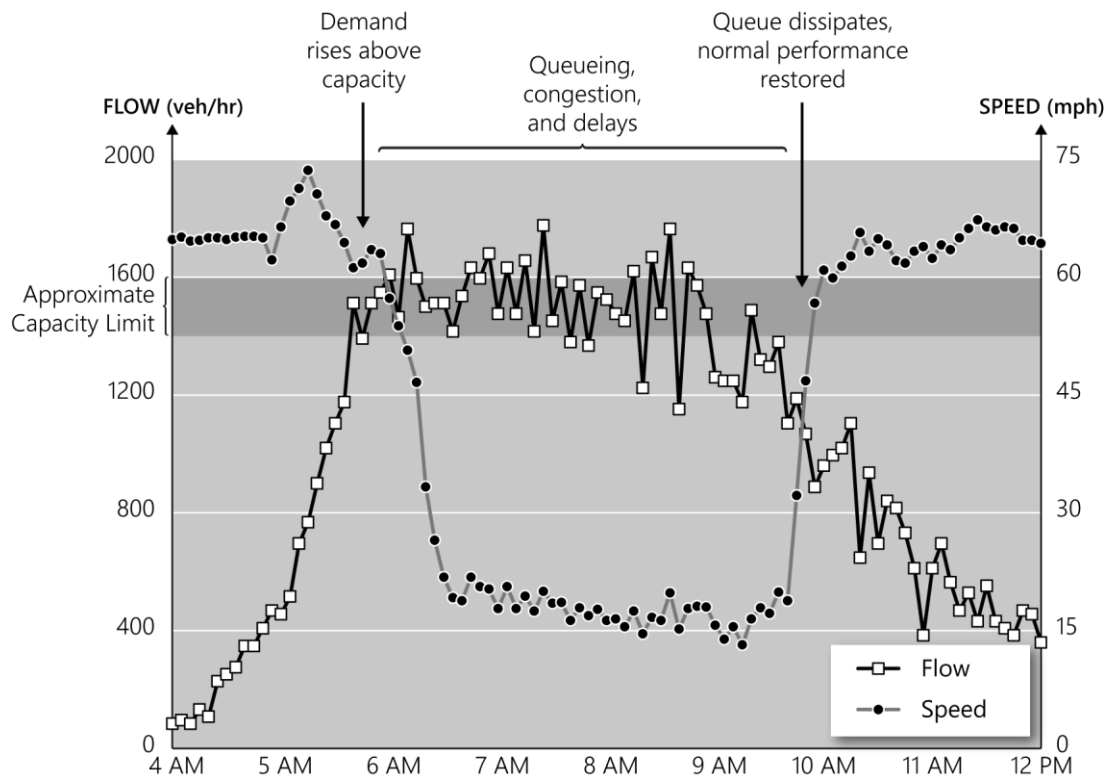
The effects described in the previous theoretical discussion can be readily observed in the Metro ExpressLanes. Measurements taken from the I-10 Westbound ExpressLanes at the 710 Freeway split reveal the negative impacts of allowing demand to exceed capacity. Figure 5 shows traffic data from a date where the traffic demand never exceeded the ExpressLanes capacity, which is approximately 1,400–1,600 vehicles per hour on this segment. As the speed data reveal, the ExpressLanes continued to provide customers with a high-speed journey the entire time.

Figure 5: Speed and flow data from I-10 West ExpressLanes at I-710 when demand stays below capacity



In contrast, Figure 6 shows traffic data from a date where the traffic demand exceeded capacity during the AM Peak period, resulting in an extended period of congestion as indicated by the lower speeds. During this period of excessive demand, flows were constrained to approximately 1,600 vehicles per hour, queues formed upstream, and travelers experienced delays. Demand eventually dropped, allowing the queues to dissipate and the ExpressLanes to return to normal operations (e.g., free-flow speeds).

Figure 6: Speed and flow data from I-10 West ExpressLanes at I-710 when demand exceeds capacity



Once demand exceeds capacity and traffic shifts from an uncongested state to a congested state, additional flow-related inefficiencies often occur (which often reduce roadway capacity even more, thereby further exacerbating the congestion), and it can take a substantial amount of time for the facility performance to fully recover. This underscores the importance of keeping traffic demand from rising above roadway capacity to ensure travelers can still reach their destinations expeditiously.