Speed Thresholds

Traffic flow relies heavily on maintaining an optimal speed that balances safety with throughput. There is a critical speed threshold below which traffic flow shifts from a stable state to an unstable, congested state. When vehicle density increases to the point where drivers must decelerate below this threshold, the flow breaks down, and speeds drop largely independent of the road?s theoretical limit.

Operating speeds are also influenced by road design and perceived safety. Narrow lanes, sharp curves, or the presence of pedestrians can naturally lower the speed at which drivers feel comfortable, regardless of the posted speed limit. Monitoring these operating speeds is vital, as significant deviations from the design speed often indicate either a capacity failure or a safety hazard that requires engineering intervention.

The relationship between speed, flow, and density is described by the "Fundamental Diagram of Traffic Flow." As density increases, speed remains relatively constant until a critical point is reached. Beyond this critical density, speed drops precipitously, and flow rate actually decreases. This phenomenon explains why adding more cars to a saturated road actually creates a jam where fewer cars get through per hour.

"Phantom traffic jams" occur when a minor speed reduction by one driver forces the follower to brake slightly harder, creating a shockwave that amplifies as it moves upstream. By the time this wave reaches vehicles a mile back, it can cause a complete standstill. These jams appear without any visible cause like an accident, purely as a result of flow instability near the critical speed threshold.

Variable Speed Limits (VSL) are a tool used to harmonize speeds to prevent this breakdown. By slightly lowering the speed limit during building congestion, the system encourages uniform flow and reduces the speed differential between vehicles. This "smoothing" effect can often delay or prevent the onset of stop-and-go conditions, maintaining a higher overall throughput for a longer period.