CHAPTER 12

Operations Strategies

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Highways are traditionally viewed as transportation facilities with fixed capacity, carrying traffic that peaks with commuters twice each weekday. Available capacity, however, is highly dynamic; it can be reduced by the actions of individual drivers or by severe weather. Within the confines of available capacity, traffic flow can be improved by implementing different types of operational strategies.

Traffic demand does not only peak twice daily during AM and PM "rush hours", but peaks throughout the day, week, and season for many reasons. Some traffic variability is recurring and predictable, but capacity constraints can be driven by temporary and less predictable events. The negative consequences of both predictable and unpredictable variations can be minimized with advanced traffic control systems, timely responses to incidents, and other highway operations strategies. This chapter highlights the variability in traffic demand and highway capacity and examines the operations strategies used by highway agencies to maximize the highway system in the face of this variability.

Dynamic Traffic and Capacity

The traditional view is that traffic demand and highway capacity are relatively static, with traffic volumes increasing in morning and afternoon peak periods each weekday and congestion occurring when the fixed capacity of the highway system is exceeded. This view ignores the large volume of nonwork trips, the volume of freight movements, and the impact on these trips caused by the actions summarized in *Exhibit 12-1.*

Exhibit 12-1 *Sources of Congestion*

Peaks in Demand	Recurring weekday commuting in urban areas Recurring weekend shopping in urban areas Seasonal vacation travel on rural and intercity highways Major generators of freight traffic (ports, factories, distribution centers) Large events (sporting venues, concerts, disasters)
Capacity Limitations	Network extent and coverage Bottlenecks (interchanges and intersections, converging lanes, steep slopes, sharp turns) Impediments (toll booths, border crossings, truck inspection stations) Poor traffic control (traffic signal coordination) Traffic calming
Temporary Capacity Reductions	Crashes and breakdowns Work zones Weather Street closures for events (parades, street fairs, marathons, disasters) Rail-highway grade crossings Temporary curb-side obstructions (especially curb-side parking and construction adjacent to rights-of-way) Law enforcement actions

Chapter 4 documents the spread of "rush hour" commuting periods to greater shares of each day in cities of all sizes. Other peaks in traffic demand because of weekend shopping, seasonal recreational travel, freight activity, and large events such as professional sports are less well measured, but probably account for an increasing share of congestion and delay as trips to work become a smaller percentage of total travel.

Any peaks in traffic volume can overwhelm the maximum design capacity of a highway system. Bottlenecks such as interchanges, converging lanes, tollbooths, vehicle inspection stations, or poor traffic control can all adversely affect throughput.

Delays resulting from the lack of capacity to accommodate weekday peaks in commuting are captured by the operations performance measures presented in Chapter 4, as well as in the future investment requirements presented in Chapter 7 and developed using the HERS model. The HERS model is not as robust in estimating delays from bottlenecks, which have been analyzed independently by the American Highway Users Alliance. Its recent study, *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks, 1999–2004,* identified 233 major bottlenecks, a substantial increase over the 167 major bottlenecks it identified just 5 years earlier.

Traffic cannot always take advantage of the maximum capacity of a highway. Reductions in maximum capacity caused by crashes, work zones, bad weather, and other incidents create at least as much delay as the recurring overload of traffic from commuting. Half of the delay reported by the Texas Transportation Institute and cited in Chapter 4 is attributed to incidents alone. Based on a composite of estimates by the Texas Transportation Institute and Oak Ridge National Laboratory, crashes and breakdowns account for about 40 percent of congestion delay, recurring congestion resulting from daily commuting is responsible for approximately 35 percent, work zones account for over 15 percent, and bad weather and poor signal timing account for most of the balance. Cambridge Systematics has developed similar estimates showing bottlenecks creating 40 percent of delay, incidents causing 25 percent, bad weather accounting for 15 percent, and work zones creating 10 percent, with signal timing responsible for approximately half of the remaining balance. Temporary capacity losses due to work zones, crashes, breakdowns, adverse weather, sub-optimal signal timing, toll facilities, and railroad crossings caused over three and a half billion vehicle-hours of delay on U.S. freeways and principal arterials in 1999, adding over four hours of delay per 1,000 miles of travel in addition to delay from recurring congestion.

The traveling public, shippers, and carriers are affected by the dynamic fluctuations in traffic and capacity because these fluctuations translate into delay and cost. As noted in Chapter 13, unexpected delay from temporary capacity loss causes unpredictable travel and arrival times. This situation is especially costly to the freight transportation community and affects the economy and the American consumer. To overcome constraints on maximum capacity and temporary capacity losses, operations strategies are a critical tool.

In addition to mitigating congestion and expanding existing capacity, operations strategies are needed to enhance the safety and security of the transportation system. Crashes, natural disasters, and other threats to life and property must be quickly identified and appropriate responses mobilized. Disruptions to normal traffic flow, such as work zones and bad weather, are as much a safety problem as a source of delay. Congestion and safety problems may be aggravated by the presence of poor traffic control, inadequate signage, and ineffective traveler information systems.

Types of Operations Strategies

As summarized in *Exhibit 12-2,* highway operations strategies can influence the reliability, efficiency, safety, and security of highway use by responding to fluctuations in traffic demand. Several major operations strategies used to address these conditions are highlighted here and discussed in greater length in a report prepared by Cambridge Systematics, Inc., *Traffic Congestion and Reliability: Linking Solutions to Problems.*

Effective operation of freeways and other major arterials includes monitoring roadway conditions; detecting, verifying, responding to, and clearing incidents quickly; identifying recurring and nonrecurring traffic bottlenecks; providing travel condition information; implementing lane management strategies; controlling

Exhibit 12-2 *Traveler Problems and Operational Responses*

What does the traveling public want?	What gets in the way of what the traveling public wants?	What can traffic managers do about it?
Reliability (reliable, predictable travel time)	Special events Work zones Bad weather Vehicle crashes and breakdowns Double-parked vehicles Lack of information on route conditions and alternatives	Reroute traffic or adjust lanes and traffic control Snow and ice removal Incident response vehicles Parking management Traveler information on disruptions and alternatives
Timeliness	All of the above plus: Daily and seasonal peaks of heavy traffic Bottlenecks and impediments Poorly coordinated traffic control	All of the above plus: Adaptive signal control Ramp meters Reversible lanes Electronic toll collection Curbside parking management Adjustments to carrier schedules
Safety	Vehicle crashes and breakdowns, work zones, and bad weather Driver behavior Poor facility design and traffic control Poor physical condition of facilities	Detect and respond to crashes Traveler information on location of crashes and problem areas and on alternative routes Emergency medical services Driver education Better signage and markings Identify and correct unsafe conditions
Security	Property theft Personal assaults Military logistics Terrorism Regional disasters	Visible monitoring as a deterrence Reroute traffic or adjust lanes and traffic control Detect and respond to threats and incidents Identify and correct unsafe conditions Threat assessments and countermeasures and disaster response plans Traveler information

flows onto freeways with ramp meters; and restricting some facilities to High Occupancy Vehicles (HOV). In addition, on minor arterials and major collectors, the timing and coordination of traffic signals are essential to facilitate the flow of traffic.

The operations strategy of access management can be implemented in many different manners and, therefore, can be used to optimize highway performance on all types of roads. One approach, access spacing, increases the distance between traffic signals on major arterials. This improves the flow of traffic, thereby reducing congestion and its effects. Driveway spacing restricts the number of driveways and spaces them farther apart, allowing a more orderly merging of traffic with fewer conflicts for drivers. Dedicated left- and right-turn lanes, indirect left-turns and U-turns, and roundabouts are other useful ways to keep through traffic flowing. Median treatments, such as two-way left-turn lanes and nontraversable raised medians, are effective in regulating access and reducing the number of crashes.

In addition to managing the supply of highways, agencies can affect travel demand. In the past, managing demand consisted of encouraging commuters to change their travel mode from driving alone to choosing a carpool, vanpool, public transit, or other commuter alternative. More recent transportation-demand

Q. How do Intelligent Transportation Systems relate to operations strategies?

A. Intelligent Transportation Systems (ITS) include a wide range of advanced technologies used to manage highway transportation and public transit, such as electronic toll payment, roadway surveillance systems, and advanced traveler information systems. Such systems are being used around the country to improve the operational efficiency and safety of the transportation system. The impetus to employ ITS is growing as technology improves, congestion increases, and building new roads and bridges becomes more difficult and expensive.

ITS technologies are being deployed to actively manage freeways and arterials in many places around the country. For instance, ramp metering on freeways is used to regulate the flow of traffic entering a facility to increase vehicle throughput and speeds. In the Minneapolis-St. Paul region, ramp metering increased vehicle throughput by 30 percent and average speeds in the peak period by 60 percent. Adaptive signal control is another type of ITS that adjusts traffic signal timing based on current traffic demand. In Los Angeles, where nearly 2,500 of the over 4,000 traffic signals use adaptive signal control, delay at intersections with these systems is reduced by an average of 10 percent.

Traveler information systems use a wide variety of ITS technologies to improve highway mobility and safety. These applications are currently being used in many different situations, including road weather information systems and in work zones and during special events. A traveler information system involving traffic cameras, remote traffic microwave sensors, dynamic message signs (DMS), and highway advisory radio is used in work zones on I-30 and I-40 in central Arkansas. In Montana, weather sensors and DMS are being used to warn motorists of high winds on portions of I-90.

In many places, a transportation management center (TMC) coordinates the use of ITS. A TMC is typically a central location for bringing together multiple agencies, jurisdictions, and control systems for managing traffic and transit, incident and emergency response, and traveler information. Transportation management technology includes closed-circuit television cameras, DMS, synchronized traffic signals, vehicle-flow sensors, highway advisory radio, and other high-tech devices. To manage emergencies, Houston TranStar uses a host of technologies in two of its ITS systems: the Road Flood Warning Systems and the Regional Incident Management System.

management tools include providing express and shuttle bus services, guaranteed ride programs, transit-van integration programs, partnerships between transportation agencies and employers, and local land-use controls.

Another way of managing transportation demand is through real-time traveler information. Traveler information can affect demand by influencing the choices that people make about how, when, where, whether, and which way they travel to their destinations. Information on traffic conditions, transit service, parking availability, and weather conditions is being delivered through Web sites, dynamic message signs, e-mail alerts, and highway advisory radio. States and metropolitan areas also are implementing 511, the telephone number dedicated by the Federal Communications Commission for relaying information to travelers.

Information is also critical to locating and clearing crashes, stalled vehicles, spilled loads, and other highway debris. Efficient and rapid response, managing resources at the incident, and providing area-wide traffic control depend on the rapid exchange of accurate and clear information among the responding parties. This requires communications standards and institutional coordination among police, fire, emergency medical services, tow truck firms, hazardous materials contractors, and traffic management centers.

Q. How does the FHWA monitor the deployment of operations strategies?

A. The FHWA monitors the progress of several organizational objectives as part of its performance measurement program. This includes the level of Intelligent Transportation Systems (ITS) deployment; the status of 511 deployment; the development of ITS architectures; the creation of congestion partnerships; and the effectiveness of state and regional roadway operations and work zone, incident, and safety management.

A goal of the U.S. Department of Transportation since 1996 is to integrate deployment of ITS in the top 75 (later expanded to 78) metropolitan areas. To monitor progress toward fulfilling this goal, the ITS Joint Program Office tracks deployment of the nine components that make up ITS infrastructure: Freeway Management, Incident Management, Arterial Management, Emergency Management, Transit Management, Electronic Toll Collection, Electronic Fare Payment, Highway-Rail Intersections, and Regional Multimodal Traveler Information. In addition, the integration of links between agencies operating the infrastructure is also tracked (see http://itsdeployment2.ed.ornl.gov).

The FHWA also separately tracks the implementation of 511 systems and the development of ITS architectures. The 511 tracking system monitors states and cities where 511 service is currently available as well as states that have received funding under the 511 Planning Assistance Program (see http://www.fhwa.dot.gov/trafficinfo/511.htm). The state and regional ITS architecture tracking system monitors the level of architecture development in all 50 states, the District of Columbia, and Puerto Rico. Architectures are classified in one of four levels of development: not needed, have not started, under development, and ready for use (http://ops.fhwa.dot.gov/Travel/Deployment_Task_Force/ ReglArch.htm).

Another goal of the FHWA is to foster regional partnerships aimed at mitigating congestion. To monitor progress, the FHWA is tracking on an annual basis the number of new congestion partnerships developed in each state or metropolitan area. In addition to assessing the status of congestion partnerships in the top 75 metropolitan regions, the FHWA surveys its Division offices on the maturity and effectiveness of partnerships in each state.

Over the past few years, the FHWA has developed several self-assessment tools for states and regions to measure their success in several areas of operations management. These tools are based on concepts developed for the Baldridge Award and are intended to help transportation agencies identify areas for improvement.

Work zones are second only to incidents as a source of delay from temporary capacity loss. Effective work zone management requires fundamental changes in the way reconstruction and maintenance projects are planned, estimated, designed, bid, and implemented. A comprehensive approach to work zone management requires minimizing work zone consequences, serving the customer around the clock, making use of real-time information, and aggressively pursuing public information and outreach.

Adverse weather is the third most common source of delay from temporary capacity loss. Although the weather cannot be changed, its effects on highway safety and operations can be reduced. Today, it is possible to predict weather changes and identify threats to the highway system with much greater precision through the use of roadside weather-monitoring equipment linked to transportation management centers. More precise weather information can be used to adjust speed limits and traffic signal timing; pretreat roads with anti-icing materials; pre-position trucks for de-icing, sanding, or plowing; and inform travelers of changing roadway conditions.

Natural and man-made disasters can have a major impact on a transportation system. These place special demands on the system to bring responders to the scene, transport the ill and injured to medical facilities, and remove the public from potential harm. Effective response requires state and local agencies to cooperate on developing and updating plans and preparing for disasters.

Conclusion

Without greater attention to operations, Americans will continue to waste many hours because of delay caused by recurring congestion, incidents, work zones, weather, and poor traffic control. Also, needless fatalities and injuries may result from unsafe conditions and crashes not being detected and countered in a timely fashion due to the absence of improved operational strategies. Through more effective operations, transportation system reliability, safety, and security can be improved and productivity increased.