Chapter 21

Operations Strategies

Introduction

This chapter explores the advantages of implementing operations strategies to improve the efficiency and effectiveness of the Nation's highway system. Operations strategies include actions taken by public agencies to maintain capacity and safety of highways by controlling traffic, responding to incidents, clearing snow and other obstructions, and providing information to users on highway conditions and alternatives.

The Need for Operations Strategies

Historically, highway agencies have focused most of their attention on building and maintaining road infrastructure. Much less attention has been paid to operating the road system to provide the highest level of service possible. Effective and efficient operation of highways was largely left to motorists and carriers. With increasing road congestion, the expense and difficulty of building new facilities, and the need for safe and secure highways, this view has begun to change. Many highway officials now recognize that operational strategies, including traffic control and enforcement, incident and emergency management, ice and snow removal, and the deployment of Intelligent Transportation Systems (ITS) technologies, can make a major difference in how the highway system performs.

Operations strategies are needed to mitigate congestion in its many forms. Highway congestion is not just a problem of recurring "rush hour" delay in the largest U.S. cities. Over half of the 4.5 billion hours of vehicle delay every year, measured by the Texas Transportation Institute in 68 cities, is due to incidents such as breakdowns and crashes. Oak Ridge National Laboratory estimates that, throughout the Nation, delay caused by freeway work zones, poorly timed traffic signals, and by snow, ice, and fog is greater than delay from breakdowns and crashes. Several sources of non-recurring delay were not considered in these estimates, including special events, rain, rail-highway grade crossings, toll booths, and work zones on arterials other than freeways. The estimates also do not include recurring delay in rural areas on local roads with concentrations of recreational travel and on heavily traveled intercity highways.

As summarized in Exhibit 21-1, operations strategies can influence the reliability, timeliness, safety, and security of highway use while responding to recurring delay and temporary capacity loss. The relationships of operations strategies to these conditions are described in the following sections, as well as in Chapter 12 (national security) and Chapter 20 (safety).

Operations and Reliability

As discussed in chapter 13, reliable, predictable travel times are especially important in a society where travelers put a high value on their own time and where many goods are relatively expensive and are needed in tightly scheduled manufacturing and distribution systems. Late arrivals can have significant economic costs for workers reporting at the beginning of their day or picking up children from day care at the end of the day, for factories waiting for parts to assemble, and for carriers who are missing guaranteed delivery times. Even when the transportation system breaks down, travelers are less disturbed if they can predict with some certainty how long they will be caught in traffic and adapt their plans.

Of the many factors that get in the way of reliability, some can be anticipated well in advance, others have shorter times for adapting, and some happen with little or no advanced warning. For example,

Exhibit 21-1

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?	WHAT DO TRAFFIC MANAGERS NEED TO KNOW TO ACT MORE EFFECTIVELY AND EFFICIENTLY?
Reliability (reliable, predictable travel time)	Special events; Work zones; Bad weather; Vehicle crashes and breakdowns	Reroute traffic or adjust lanes and traffic control; Snow and ice removal; Incident response vehicles; Emergency medical services	Type and location of delay; Amount of traffic being disrupted; Alternative routes, modes, schedules; Type and location of resources to respond to incidents, crashes, and weather
Timeliness	All of the above plus: Daily and seasonal peaks of heavy traffic; Bottlenecks; Poorly coordinated traffic control	All of the above plus: Adaptive signal control; Ramp meters; Reversible lanes; Adjustments to carrier schedules	All of the above plus: Diurnal variations in traffic flow by day of week, week of month, month of year
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; Driver education; Better signage and markings; Identify and correct unsafe conditions	Type and location of incident; Frequency of incident by type and location; Facility condition; Type and location of resources to respond to incidents
Security	Property theft; Personal assaults; Military logistics; Terrorism; Regional disasters	Visible monitoring as a deterrent; Reroute traffic or adjust lanes and traffic control; Detect and respond to threats and incidents; Identify and correct unsafe conditions; Threat assessments and disaster response plans; Traveler information on location of threats and incidents and on alternative routes	Type and location of threat or incident; Frequency of incident by type and location; Facility condition and vulnerability; Amount of traffic being disrupted; Alternate routes, modes, schedules; Type and location of resources to respond to threats and incidents

special events, from sporting contests to symphony concerts, frequently concentrate large quantities of traffic on limited portions of highway and transit systems. Other events such as parades and races close parts of the street network. There are about 2,000 events each year requiring analysis by a traffic engineer just in the City of Los Angeles. Special events are not limited to densely settled urban areas, as illustrated by the Winter Olympics and the original Woodstock music festival. With adequate notice and preparation, transportation managers can adapt traffic controls and transit schedules to handle the crowds, participants can find the least congested routes or plan for the delays, and other travelers can avoid the traffic by rerouting or rescheduling their trips.

Major reconstruction projects or overnight patching of potholes can significantly reduce highway capacity and cause congestion in urban and rural areas at all hours of the day and night. Like special events, most work zones can be anticipated and effective adjustments made by managers and users if information on the location and timing of the work is provided in advance.

Snow and ice close highways over thousands of square miles for days and block some mountain passes for months. Fog and rain bring traffic to a crawl in both warm and cold climates. Wind blocks trucks and campers from routes in deserts and mountains. Hurricanes force thousands of residents to flee coastal areas as rain and wind make local roads difficult to navigate. While bad weather is notoriously difficult to predict days in advance, technology is providing much better warnings hours in advance and better understanding of how much transportation facilities are likely to be affected (such as whether road surfaces are too cold for de-icing methods to work). Effective weather information helps users make route and schedule decisions, and helps traffic managers know when to reduce speed limits or close facilities, dispatch snow and ice removal equipment, or redirect traffic.

Vehicle crashes and breakdowns are the least predictable events. The most severe crashes often happen at night or on rural roads with little effect on traffic flow, but some crashes (particularly involving large trucks) during rush hours in congested cities can affect the urban area's entire freeway network. More important than traffic disruption is the potential for loss of life, as discussed in Chapters 5 and 20. When transportation managers become aware of a crash or breakdown, they can advise emergency response units and attempt to divert traffic from the site until the disruption has been cleared. When the geographic and temporal pattern of crashes is identified, crashes become more predictable and countermeasures can be deployed more effectively.

Operations and Timeliness

A reliable transportation system is inadequate if it does not get travelers to their destinations within a reasonable time. Traveler needs and economic efficiency are not served if highways slow consistently to a crawl. In addition to the temporary sources of capacity loss and delay, recurring congestion and poor traffic control increase travel time, adding significantly to the cost of travel and goods movement.

Streets in major cities are clogged by commuters during weekday rush hours and by shoppers on weekends. Seasonal throngs of visitors clog routes to recreational areas in rural areas. Intercity corridors and passenger terminals are strained around holidays, most notably on the Sunday following Thanksgiving. If the geographic and temporal patterns of traffic are adequately measured and understood, traffic management strategies such as reversible lanes and ramp meters can be implemented to increase capacity during the peak periods.

Even the most effective operations strategies cannot handle the continuing growth in vehicle travel on a static facility. The size of the population, the number and lengths of trips being taken by each person, and the quantity of goods being moved continue to increase. Congestion is most acute at major interchanges and locations where expressways narrow or transition into surface streets. Border crossings, highway-railroad grade crossings, and local streets that connect terminals with intercity arterials cause additional bottlenecks. Bottlenecks can be identified by their impact on traffic flow and by network analysis methods. Bottleneck removal usually involves significant construction and has the potential to negatively effect the local environment and community.

Motorists are often frustrated by idle time sitting at traffic signals, whether they are caught behind a line of vehicles or stopped at a red light with no other vehicles are in sight. Traffic signals can be set to move large volumes of traffic during rush hour or handle the occasional vehicle late at night, but a vast number of signals are not tied to necessary traffic sensing and control systems, or are not adequately coordinated or calibrated to move traffic efficiently.

Operations and Safety and Security

The relationship of operations and ITS technology to security and safety is discussed in Chapters 12 and 20, respectively. Aspects of these relationships not covered in those chapters are summarized here.

Safety is affected by many conditions beyond the control of traffic managers, such as driver behavior, vehicle design, and condition of highway infrastructure, as well as by traffic control and signage in the traffic manager's domain. Traffic managers can work with public safety officials to respond to bad weather, vehicle crashes, breakdowns, work zones, and other intrusions into the normal flow of traffic that create unexpected situations for drivers, often causing additional crashes. Traveler advisories can also divert motorists from dangerous situations caused by weather, work zones, and other vehicle crashes. A variety of ITS technologies, described in Chapter 20, are available to improve safety.

In addition to the concerns listed in Chapter 12, security involves:

- Property theft and personal assaults. Freight carriers and shippers of high-value goods must constantly deal with property theft. Travelers become concerned, sometimes to the point of changing travel plans, when they hear of incidents involving personal assaults against stranded motorists, taxicab operators or their passengers, or public transit patrons. These incidents are similar to crashes, requiring detection and quick response to minimize damage and identification of geographic and temporal patterns to help guide countermeasures. Detection systems can also be a deterrent if equipment such as video cameras is visible to potential transgressors and can provide evidence to find and prosecute wrongdoers.

- Regional disasters. Emergency responses and evacuations are not limited to acts of terrorism. Transportation managers have coped with evacuations and loss of capacity on the transportation network from hurricanes, earthquakes, floods, extensive fires in Florida and the West, and toxic releases from freight train derailments in both cities and rural areas. Often, some warning is given before a natural disaster strikes, and evacuations can be completed. Manmade disasters usually require more immediate action. In either case, transportation managers and public safety officials must know the threat to roads and travelers and any changes in the condition of the transportation network in order to guide responses for victims and support the logistics of reconstruction.

Implementation of Operations Strategies

A combination of improved operations, capital investments, and behavioral adjustments is needed to maintain flows of people and goods, respond to emergencies, correct unsafe conditions, reduce security threats, and preserve highway assets. Federal and State transportation programs stressed the importance of capital investments throughout the 20th Century, and added an emphasis on the

Q. What types of operations technologies are being developed?

A. Two of the more promising technologies involve Road Weather Information Systems and Traveler Information Systems.

Detailed weather information provided to travelers and road management agencies promises to lessen the effects of poor weather on safety and mobility and to reduce weather-related expenses. Much weather data are already collected by the National Weather Service (NWS), but this information is usually not detailed enough for specific roadways. To overcome this, many state and local governments are implementing Road Weather Information Systems (RWIS). RWIS includes all weather-information sources used in road operation and maintenance. In this discussion, RWIS refers only to the fixed roadside sensor suites for pavement condition and surface weather observations.

A network of information stations is needed to measure and forecast weather conditions at the level needed for road management. A weather station consists of a pavement temperature sensor, subsurface temperature sensor, precipitation sensor, wind sensor, air temperature and humidity sensors, visibility sensors, and remote processing unit. Spacing for this network is estimated to be approximately 15 miles to 30 miles based on climatic conditions (particularly snowfall). Additional information and closer spacing of information collection points is often required based on several factors. These may include local weather problems such as high snowfall, high rainfall, icing, fog, and high winds, places where the terrain makes weather problems more difficult to cope with, and the level of snow maintenance activities.

Traveler information systems provide assistance to the individual surface transportation traveler and allow transportation agencies in urban and rural environments to manage service disruptions and congestion. Information provided by a traveler information system usually includes road closure and restriction information due to construction, maintenance, special events, and HOV rules; current traffic conditions including recurring and non-recurring congestion; current road conditions due to the weather; and major service disruptions, changes, or additions.

Over the next 20 years, an $8 billion investment would be needed to maintain existing traffic signal controls in metropolitan areas that had 50,000 or more residents in 2000 and to maintain remaining technologies in the 78 largest areas. An additional $5 billion would be needed to expand this technology following existing trends. A more aggressive deployment to cover metropolitan areas of significant need would require $29 billion over 20 years in addition to the $8 billion to maintain existing operational improvements.

The major components of a traveler information system include data collection, data processing, and data dissemination. Costs here are based on estimates and include funding needed for data collection and data processing but not data dissemination. Data collection equipment is typically deployed on freeways and major arterials and includes various roadside detection technologies (loops, video image, and microwave radar), CCTV video surveillance cameras, telecommunications infrastructure, and an Internet-based road condition reporting system for traffic and traveler information.

preservation of physical assets in the 1980s. Attention is now turning to improved operations, particularly to the data and institutions needed to support enhanced operations.

Traffic managers, public safety officials, and public works agencies cannot respond effectively to traffic disruptions or life-threatening situations unless they know what is happening on the transportation system on a continuous, comprehensive, and up-to-the-minute basis. Their responses are often hampered by the piecemeal nature of efforts to monitor traffic disruptions and life-threatening situations, gaps in the areas covered by monitoring equipment, monitoring equipment that is not kept in working order, and the failure to share key information among all potential responders.

Effective responses are also hampered by the lack of available personnel and equipment, often attributable to jurisdictional and agency barriers to sharing resources. Accountability for responding to incidents and fixing recurring operational problems with highway facilities is often diffused and hard to establish. Because national and local priorities emphasize the construction and physical preservation of facilities, traffic monitoring and control devices are often out of service due to lack of maintenance.

Data have long been recognized as essential for planning and constructing highways, but data are no less important for operating and preserving highway assets safely and efficiently. Comprehensive, accurate, up-to-the-minute data are essential for highway managers who anticipate problems and are proactive in resolving those problems, making effective tradeoffs among a wide range of resources and consequences. Without adequate data, highway managers have become accustomed to reacting to emergency calls and complaints with whatever resources are immediately at hand. Data collection and integration are given low priority because managers are not experienced with the greater efficiencies and effectiveness of being anticipatory, proactive, and systematic.

Without public visibility and accountability for managing highway facilities, governments will not provide adequate resources for monitoring, and the culture of highway management will remain reactive rather than proactive. An external stimulus is needed to break this cycle and establish a data-driven, anticipatory, proactive culture among highway managers.

Infostructure

The Federal Highway Administration sponsored a National Summit on Operations in October 2001 that brought together more than 200 transportation professionals interested in operations strategies. The National Summit on Operations discussed the development of regional operations collaborations and coordination, continued deployment of ITS technology, and national implementation of an information infrastructure, also known as "Infostructure." At the national level, the Infostructure would include three main elements: (1) statewide reporting; (2) monitoring in large metropolitan areas; and (3) surveillance of key infrastructure facilities.

Statewide reporting would provide a system in place to report on capacity-restricting events, such as accidents, incidents, and weather obstructions. One example is the Condition Acquisition and Reporting System (CARS) implemented in the states of Iowa, Minnesota, Missouri, and Washington to assist various agencies in the acquisition and reporting of incident data by reducing communication difficulties, redundancies, and inaccuracies. Another example of a statewide reporting system is the Highway Closure and Restriction System (HCRS) developed initially by Arizona, but which has been expanded to include Nevada, Utah, and New Mexico. This web-based system reports such information as incidents/accidents, road closures, road maintenance, traffic congestion, weather conditions, etc. These systems are flexible enough to permit states to exchange information with adjoining States and information service providers, and disseminate information to the public via a Web site. This would provide important information about the closing or severe capacity reductions of key highways. This has obvious implications for security as well as normal operations. If transportation and public safety officials cannot obtain such information in near real time, proper response is impossible.

The second national element would involve monitoring metropolitan areas with more than one million residents. This roughly corresponds to the 60 largest cities in the United States. For congestion-management as well as security reasons, it is prudent to have real-time monitoring of volume, speed, and weather covering freeways and principal arterials as well as major rail and bus transit systems in these urban areas. Currently, less than 25 percent of the freeways and virtually none of the other arterials have real-time monitoring. There are a number of different ways that this information could be provided, such as through traditional traffic sensors like loop detectors, technologies that could provide the same information but are not located on the highway right-of-way, or through vehicle-based systems. The private sector will likely play a key role as data provider to State and local governments. While such information is important for any metropolitan area, it is imperative from a security point of view to ensure our largest metropolitan areas are able to monitor their key transportation facilities for both emergencies and other operational needs.

The third national element would involve surveillance of key facilities. There is now increased recognition of the need to more closely monitor key transportation assets for both protection and response. Work to identify critical infrastructure is underway and will likely include bridges, tunnels, key evacuation routes, and certain military routes needed for rapid deployment of military/security assets. Some combination of volume, speed, and weather monitoring along with video surveillance may be needed to ensure the safety and availability of these facilities. Traditionally, most government agencies have addressed security issues in a reactive mode rather that a proactive mode. Protecting our key infrastructure facilities should include a well-balanced plan that takes into account both proactive and reactive measures.

At the local level, there are information needs beyond these national elements that are necessary for local operations. These needs will vary from jurisdiction to jurisdiction and most will be determined at the local level. This information is needed to support such functions as security, traffic and transit management systems, commercial vehicle operations, incident and emergency management, regional traveler information, hurricane evacuation route monitoring, statewide weather and road condition monitoring, and construction management.

Regional Collaborations

Regional operations collaborations and coordination can be considered a "table" at which regional operations policies, protocols, activities, and projects are defined, discussed, debated, and coordinated by transportation system operators, including State and local transportation and public works agencies, public safety personnel, and transit system operators. Representatives at the "table" would be those responsible for day-to-day management and operations activities. These officials would:

- Develop, maintain, and monitor the effective implementation of a regional concept of operations;
- Set performance targets; identify, collect, and store regional data for performance measurement, trend analysis, and monitoring; report to the public on system performance;
- Coordinate region wide operational improvements to enhance highway safety;
- Carry out regional collaboration for security and emergency transportation operations on key evacuation and military routes and the protection of critical NHS and STRAHNET infrastructure and provide for continued operations during an emergency;

- Prepare a Regional Operations Action Agenda; use performance data to identify operational problems, evaluate potential solutions and facilitate their accomplishment;

- Ensure the coordinated delivery of timely traveler and user information on transportation system operations to the full range of system users; and

- Provide substantive input to the Statewide and/or regional transportation planning process on necessary investments to improve system performance.

As long as all appropriate system operators are involved, performance of these functions could be led by an existing regional agency, other existing agencies such as State departments of transportation or large city or county governments, or an organization formed for the specific purpose of focusing on regional operations. In larger States, with several major metropolitan areas, these functions might be carried out in a different fashion in various parts of the State. Agencies serving rural regions could also collaborate together to perform these functions to improve operations. Rural regional operations, for example, may focus on weather, emergency response, and work zone issues.

Conclusion

Operations will become more anticipatory, proactive, and systematic as public visibility and accountability for managing highway facilities improves, particularly as attention is focused on development of timely and comprehensive information, effective traffic management tools, adequate financial resources, and institutional authority and accountability to enable users to make the best use of the transportation system.

Without greater attention to operations, Americans will continue to waste many hours in delay from recurring congestion, incidents, work zones, weather, and poor traffic control; lives will be ruined or lost because unsafe conditions and crashes are not detected and countered in a timely fashion; and Americans will remain vulnerable to natural and manmade disasters. Unless the problems of reliability, timeliness, safety, and security are managed through more effective operations, the Nation will continue to incur economic costs in foregone productivity and wasted fuel, as well as human costs in terms of public health and a reduced quality of life.