Chapter 15
Managing Nonrecurring Congestion

15.1 Introduction

Nonrecurring congestion accounts for over half of all traffic delays in the United States [1] and accounts for up to 2/3 of traffic delays in urban areas larger than one million population [2]. Therefore preventing and reducing the impact of nonrecurring congestion is a key strategy for improving traffic conditions.

Various strategies for addressing traffic delays from nonrecurring events have emerged in recent years, and they are now receiving the same level of priority given to strategies that address recurring congestion.

These nonrecurring strategies are keyed to the type and causes of delay—whether delays are caused by incidents (e.g., crashes, vehicle breakdowns), work zones, special events that generate surges in traffic demand, inclement weather, or construction zones, and major evacuations.

To effectively minimize the adverse road user impacts of nonrecurring congestion requires the use of accurate real-time information that enables transportation agencies to proactively and quickly respond to changes in traffic conditions caused by incidents, adverse weather, road maintenance, or random surges in traffic demand from special events. These changes can consist of traveler advisory information in maintaining safe speed, lane changes, or dynamic traffic control policies that minimize delay, and that inform travelers about the location and extent of congested conditions. Real-time information is a major benefit of Intelligent Transportation Systems (ITS) technology that enables the emerging practice of Active Transportation and Demand Management (ATDM) [3].

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15.2 Incidents

Traffic incidents reduce roadway capacity. Estimates of the amount of freeway capacity reduction, as a function of number of lanes blocked by the incident, are provided in Table 15.1. This table shows that an incident reduces freeway capacity even when it is located at the shoulder of the roadway, and it is not physically blocking a lane. A roadway incident reduces the capacity of the roadway to various degrees depending on the number of lanes on the roadway, the number of lanes blocked by the incident, and the duration of the incident.

The factors involved in determining the amount and duration of delay resulting from an incident are illustrated in Fig. 15.1. They are described to show the intensity (amount of delay), duration (hours of congested conditions), and extent (number of vehicles delayed) of congestion caused by the incident. It can be seen that the duration of delay to the impacted traffic can substantially exceed the duration of the incident.

Definition of terms in Fig. 15.1:

t_0 = time when incident occurs;
t_1 = time when incident is detected;
t_2 = time when incident is reported to the traffic management center (TMC);
t_3 = arrival time of first responders with the means to restore roadway capacity;
t_4 = time when capacity is restored (all lanes are reopened);
t_5 = time when traffic flow is restored to conditions prevailing before the incident with no demand reduction;
t_6 = time when traffic flow is restored to conditions prevailing before the incident but traffic demand is reduced by ramp closings or by diverting traffic to other roads via dynamic traffic information devices;
$(t_1–t_0)$ = time elapsed after incident occurs and when it is detected;
$(t_2–t_1)$ = time elapsed after the incident is detected and when it is reported to the TMC;

Table 15.1 Percentage of freeway section capacity available as a function of incident condition and number of freeway lanes

Number of freeway lanes in each direction	Shoulder disablement	Shoulder accident	Lanes blocked		
			One	Two	Three
2	0.95	0.81	0.35	0	N/A
3	0.99	0.83	0.49	0.17	0
4	0.99	0.85	0.58	0.25	0.13
5	0.99	0.87	0.65	0.40	0.20
6	0.99	0.89	0.71	0.50	0.25
7	0.99	0.91	0.75	0.57	0.36
8	0.99	0.93	0.78	0.63	0.41

Source Reference [1], pp 1–9, Table 1.2

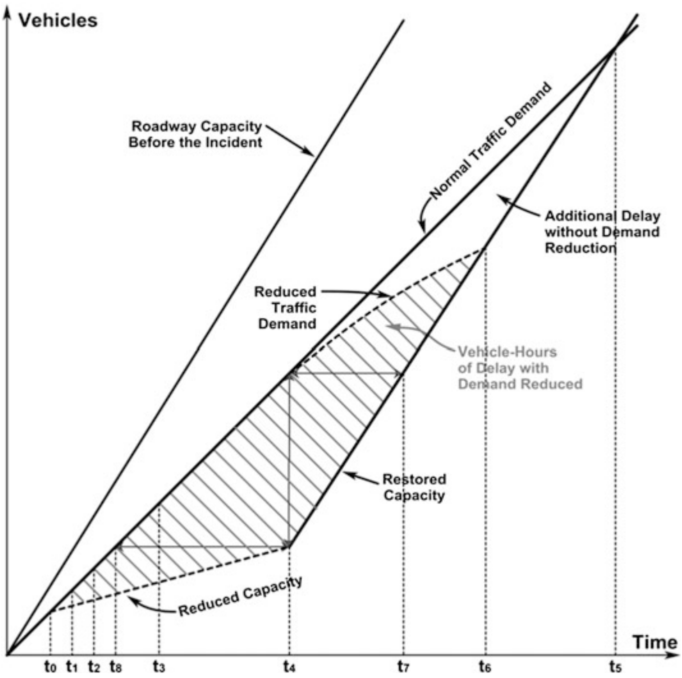

Fig. 15.1 Factors impacting on congestion delay from a roadway incident

(t_3–t_2) = time elapsed after the incident is reported and when the incident team arrives;
(t_4–t_3) = time needed to restore capacity (all lanes reopened);
(t_5–t_0) = duration of delay if traffic demand continues unabated;
(t_6–t_0) = duration of delay if traffic demand is reduced;
(t_7–t_4) = delay time to last vehicle in longest platoon (Q_{max}) before it resumes normal speed;
(t_4–t_8) = maximum delay time before capacity is restored;
(t_4–t_0) = time interval when roadway operates at reduced capacity.

The impact of an incident on delay depends upon:

- The severity of the incident (number of lanes blocked) and the volume of traffic on the roadway at the time of the incident;
- The time the incident is detected;
- The time it is reported to the responding agency;
- The agency response time;
- The time elapsed before the roadway capacity is completely restored;
- The volume of upstream traffic approaching the incident location.

Strategies that reduce congestion delays at incident locations involve reducing detection times, reducing response times, and removing disabled and emergency vehicles from the incident location as quickly as possible. In addition, the availability of adequate shoulders along freeways and major arterial roads can provide refuge for disabled vehicles, and can minimize the number of lanes blocked.

The goal for transportation agencies—highway agencies in particular—is to minimize detection times, response times, and capacity restoration times. The initial response time, for example, depends upon the location and coordination of fire, police, ambulance, and equipment services. The capacity restoration time depends upon the degree of complexity of the incident (e.g., crash severity, simple vehicle breakdown, major flooding, and the capabilities of the response team. The incident duration time depends on the duration of the blockage, the volume of traffic demand (5 am or 5 pm?), the restored capacity of the impacted roadway, and its design features—especially provision of shoulders that can accommodate disabled vehicles.

The extent of congestion can also be reduced by providing real-time information to drivers and/or preventing them from entering the congested roadways.

An critical requirement is having an institutional architecture and arrangements in place that can implement these requirements [4]. Overlapping administrative boundaries and jurisdictions often requires the cooperation among various agencies and governments:

- Responses to non-recurring events should be mainstream rather than ad hoc
- Coordinated approaches require that barriers to institutional change be overcome
- Institutional change can be driven by experiences that expose the weakness of existing institutional structures and by reconfiguring the institutional framework to better meet incident response requirements

Traffic incident management should be a planned and coordinated process to detect, respond to, and remove traffic incidents and restore traffic capacity as safely and quickly as possible. This coordinated process involves a number of public and private sector partners, including: Law Enforcement, Fire and Rescue, Emergency Medical Services, Transportation, Public Service Communications, Emergency Management, Towing and Recovery, Hazardous Materials Contractors, and Traffic Information Media.

Creating congestion management centers at strategic locations in urban areas can provide for a reduced response time to incidents. This helps to reduce impact duration, intensity, and extent.

Specific supply and demand strategies that can reduce incident delay are briefly identified below.

15.2.1 *Supply Strategies*

Key supply strategies include:

- Identifying incidents more quickly, reducing response times, and clearing incident scenes more rapidly will dramatically reduce incident delays—especially in peak hours.
- Stationing of response vehicles at strategic locations to minimize the time needed to remove incidents
- Training emergency responders with practices that minimize their presence at the incident site
- Providing traveler information to divert traffic away from the incident location.

Incident response performance can be improved and response times reduced by widespread deployment of surveillance and detection technologies.

15.2.2 *Demand Reduction Strategies*

Demand reduction strategies include:

- diverting traffic away from incident bottlenecks by:
  - providing real-time information to drivers on incident locations and congested roadways and
  - advising travelers of available alternative routes.
- Closing on-ramp to prevent additional traffic from entering the congested highway section

Advance variable message signs along freeways can help to divert motorists away from congested roads impacted by an incident.

15.3 Special Events

Special events account for up to 5 % of congestion delay [3].

- Special events (e.g., conventions, football games) are time and location-specific. Ideally the starting and ending times of these events should be scheduled outside the peak travel hours.

15.3.1 Supply Strategies

Supply strategies include:

- Pre-event coordination and planning
- Applying traffic engineering actions such as (1) parking bans on major streets serving the event, police control of traffic signals, and reversible travel lanes on streets leading to and from the event
- Developing traffic control plans in response to surges in traffic volume at the start and end of events
- Coordinating operations during the event
- Providing traveler information

15.3.2 Demand Reduction Strategies

Demand reduction strategies include:

- Metering upstream flow to maintain a better balance with downstream roadway capacity (e.g., real-time traffic signal timing; controlling the exit rate from parking lots/garages.
- Possibly closing various entry ramps downstream of the ramps where the event traffic enters the roadway

15.4 Inclement Weather

Adverse weather conditions have a major impact on traffic congestion, safety and operations. Weather affects driver behavior, vehicle performance pavement friction, and roadway infrastructure. Although weather events and their impacts are non-recurring, they are generally predictable. Inclement weather usually has an area wide impact but its severity is sometime concentrated in specific parts of the urban area where it accounts for up to 10 % of total traffic delay [5].

15.4.1 Supply Strategies

Supply strategies include:

- Better prediction and detection of rain, snow, ice, and fog on specific roads to assist transportation managers in roadway treatment strategies
- More effective treatment of roadway surface to improve traction and prevent ice bonding (sand, salt, anti-icing chemicals)
- Posting fog warnings on Dynamic Message Signs (DMS)

- Listing flooded routes on websites
- Reducing speed limit with Variable Speed Limit (VLS) signs and modifying traffic signal timing

15.4.2 Demand Strategies

Demand strategies include actions intended to give guidance to drivers on the safe use of roadways during adverse weather conditions:

- Issuing travel advisory information to drivers about weather events (snow, ice, fog) in specific areas or roadways to minimize crashes.
- Listing flooded routes on web sites to direct drivers to alternate routes
- Establishing control strategies that permit or restrict traffic flow and regulate roadway capacity

15.5 Work Zones

Work zones account for up to 19 % of delay in large urban areas and up to 27 % of delay in small urban areas. The degree to which work zones impact traffic speed depends upon the length of time the work zone is in place, the number of lanes closed or detoured by the work zone, and the hours when the work is performed, and driver awareness of the work zone.

15.5.1 Supply Strategies

Supply strategies include:

- reducing the time to complete the work
- scheduling the work during off peak hours
- maintaining roadway capacity (e.g., temporary contra-flow lanes)
- providing breakdown (shoulder) lanes
- maintaining safe work practices
- providing alternate routes

15.5.2 Demand Strategies

Demand strategies include:

- posting safe speed limits
- real-time monitoring of traffic speeds

- effective enforcement of speed limit
- providing traveler information on work zone locations and times

15.6 Information Technology (IT)

Each metropolitan area needs to establish an IT architecture that enables the monitoring of nonrecurring events, and provides real-time information to travelers on (1) incidents that cause major bottleneck delay (intensity, extent, and duration); (2) work zones; (3) road weather; (4) alternate route/travel modes.

15.6.1 Active Traffic and Demand Management (ATDM)

Application of Active Traffic and Demand Management (ATDM) strategies enables the system operator to manage incident impacts by a number of strategies aimed at real-time coordinated management of traffic controls, lane assignments, traveler information, etc. ATDM comprises a series of strategies (e.g., traffic sensors, traffic management centers, managed lanes, rapid incident response) to dynamically manage roadways and corridors in response to non-recurring sources of congestion [6]. These include:

>Queue warning display systems: to warn drivers of the presence of congestion downstream;

> Dynamic routing and traveler information: the use of dynamic message signs to display rerouting instructions in response to non-recurring congestion events; and

> Dynamic lane markings: the delineation of lanes to manage traffic flow patterns created by the above strategies.

15.7 Examples of Best Practice

Over the last 15 years, many states in the US, have built transportation management centers, deployed intelligent transportation systems (ITS) over critical segments of their road networks, deployed safety service patrols (using HELP vehicles), and developed interagency arrangements to both incident management and traveler information.

15.7.1 Institutional Best Practices

Examples of institutional best practices adopted by several states are summarized in Table 15.2.

Table 15.2 Examples of institutional best practices in operational activities

• An increasing number of states have quick clearance laws to support the removal of stopped vehicles from obstructing the road. Florida DOT (FDOT), for example, carried out an aggressive statewide campaign of signage, radio spots, billboards, and brochures to inform the public about the law and its benefits
• Both the FDOT Rapid Incident Scene Clearance (RISC) program and Georgia DOT Towing and Recovery Incentive Program (TRIP) are public–private partnerships that use both incentive payments and disincentive liquidated damages to ensure shortened clearance times for heavy vehicle wrecks; these programs have reduced the average clearance times by 100 %
• Oregon DOT has used a set of unique contractor requirements (staged tow trucks, traffic supervision, and public advisories) as part of effective work zone traffic control
• Detroit metropolitan area transportation agencies are part of a regional multiagency coalition that tracks and manages weather problems and treatment strategies, including flexible interjurisdictional boundaries for efficient operations
• The 16-state I-95 Corridor Coalition has supported an operations academy, which is a 2-week residential program designed to provide middle and upper managers in state DOTs with a thorough grounding in various aspects of SO&M state of the practice
• The Maryland DOT Coordinated Highways Action Response Team (CHART) is a formal, multiyear budgeted ITS and operations program with an advisory board that provides oversight and strategic direction. It is chaired by the deputy administrator/chief engineer for operations and includes district engineers, the director of the Office of Traffic and Safety, the director of the Office of Maintenance, the Maryland State Police, the Maryland Transportation Authority, the Federal Highway Administration, the University of Maryland Center for Advanced Transportation Technology, and various local governments
• Washington State DOT (WSDOT) has formalized interactions among units and managers involved in its SO&M program. TMC managers from around the state meet every 6 weeks to coordinate with regional Incident Response Program managers, who in turn meet quarterly for operations coordination with the state patrol. TMC managers and incident response managers coordinate activities and issues by meeting with the statewide traffic engineers group and the maintenance engineers group
• The Oregon Transportation Commission moved some capacity funding to the operations program to create an Operations Innovation Program that awards funding to projects selected on a competitive basis for their potential to demonstrate innovative operations concepts related to congestion mitigation and freight mobility
• Virginia DOT has reorganized its senior management to include a deputy director for operations and maintenance responsible for all SO&M activities, as well as maintenance resources
• WSDOT has made a strong and transparent commitment to performance measurement as evidenced by the quarterly Gray Notebook, which tracks performance based on five WSDOT legislative goals, including mobility/congestion, and includes regular updates on progress in the application of operations strategies such as incident management and HOT lanes

Source Reference [4], p 14, Table ES.7

15.7.2 Regional Cooperation in Managing Nonrecurring Events

Examples of regional operational collaboration are given in Table 15.3.

Table 15.3 Examples of regional collaboration in operational activities

Name and location	When started	Members	Operational activities
TRANSCOM	1986	• Metropolitan Transportation Authority – NYC Transit – MTA Bridges and Tunnels • Connecticut Department of Transportation • New Jersey Department of Transportation • New Jersey State Police • New Jersey Transit Corporation • New Jersey Turnpike Authority • New York City Department of Transportation • New York City Police Department • New York State Bridge Authority • New York State Department of Transportation • New York State Police • New York State Thruway Authority • Port Authority of New York and New Jersey • PATH	*Operations Information* • Collects and disseminates real-time regional incident and construction information • During major incidents, construction, and special events, helps marshal regional resources for incident response, including its member agencies' variable message signs and highway advisory radio • Provides services under contract to the I-95 Corridor Coalition *Construction Coordination* • Maintains a long-term database of all construction projects planned or under way *Special Events* • Assists with interagency coordination for special events *ITS* • TRANSMIT: Vehicles equipped with transponders for electronic toll collection are used as probes on road-ways for real-time determination of travel times and speeds and for the detection of incidents • TRANSCOM Regional Architecture: Integrates member agencies' ITS, allowing for the electronic sharing of information among the agencies' operations centers • Trips123: Website with real-time information and transit trip planning services for the general public • Interagency Remote Video Network (IRVN): Enables the sharing of member agencies' CCTV feeds

(continued)

Table 15.3 (continued)

Name and location	When started	Members	Operational activities
TranStar	1993	• The Texas Department of Transportation • Harris County • The Metropolitan Transit Authority of Harris County • The City of Houston	*Incident Management* • Monitors traffic incidents with more than 600 regional closed-circuit television cameras (CCTVs) • Dispatches vehicles to remove debris or hazardous materials • Communicates with emergency vehicles about the most direct routes to an accident scene • Motorist Assistance sends tow trucks to stalled Vehicles • Dynamic message signs (DMS) • Synchronized traffic signals, speed sensors • Highway Advisory Radio • Ramp meters and other devices • Transit authority is a partner, and there are HOT lanes, but TranStar does operations on all roads
Freeway and arterial system of transportation (FAST)—Las Vegas	2003	• RTC • Clark County • NDOT • City of Henderson • City of Las Vegas • City of North Las Vegas	• Operates the TMC • Ramp meters • DMS • Signal timing • Lane-use control signs • Each entity (e.g., city, county) maintains the physical equipment and power for traffic signals, while FAST is responsible for timing, traffic signal synchronization, and the communication network
MTC-BATA	1997	• Part of the Metropolitan Transportation Commission (MTC), San Francisco Bay Area	• The Bay Area Toll Authority (BATA) administers programs and allocates all toll and other rev-enues (except the $1 seismic surcharge) from the seven state-owned toll bridges. BATA funds the day-to-day operations, facilities maintenance, and administration of the bridges

(continued)

Table 15.3 (continued)

Name and location	When started	Members	Operational activities
TSSIP (Denver)	2003	• Denver Regional COG, Colorado DOT, 28 local governments	• Works with the Colorado DOT and local governments to coordinate traffic signals on major roadways in the region • Facilitates the implementation of a regional vision for transportation operations using both technology and regional partnerships
NITTEC	1995	• Buffalo and Fort Erie Public Bridge Authority • City of Buffalo • City of Niagara Falls, New York • City of Niagara Falls, Ontario • Erie County • Ministry of Transportation, Ontario • New York State Department of Transportation • New York State Thruway Authority • Niagara County • Niagara Falls Bridge Commission • Niagara Frontier Transportation Authority • The Niagara Parks Commission • Niagara Region • Town of Fort Erie	• Traffic Operations Center (TOC) • Closed-circuit television (CCTV) • Dynamic message signs (DMS) • Highway Advisory Radio (HAR) • TRANSMIT: Gathers vehicle travel time information • Road Weather Information System (RWIS) • Skyway Closing System: Advanced warning system that alerts motorists to closures on the Buffalo Skyway • Advanced Traffic Controllers (ATC): Traffic counting stations that transmit real-time traffic information to the TOC
• FAST-TRAC • Road Commission for oakland county	1992	• Oakland County, Michigan • Local governments • MDOT	• Operates a TMC • Website with real-time traffic information • Traffic signal control in response to congestion • Special event management. • Maintains a database of road construction projects • Variable message signs

(continued)

Table 15.3 (continued)

Name and location	When started	Members	Operational activities
CLARUS	Designed 2004–2005; tested 2006	• FHWA • NOAA • A number of states	• Research and development initiative to demonstrate and evaluate the value of Anytime, Anywhere Road Weather Information that is provided by both public agencies and the private weather enterprise to the breadth of transportation users and operators
AZTech	1996	• Led by the Maricopa County Department of Transportation and Arizona DOT—more than 75 public and private agencies • Arizona DOT • Arizona Department of Public Safety • Arizona State University • Maricopa County • Valley Metro • Phoenix • Mesa • Glendale • Peoria • Scottsdale • Eight other cities or towns, local police, and fire departments	• AZTech supports the following efforts along with its public and private partners: • Traveler Information at the Phoenix Sky Harbor International Airport • Regional Emergency Response Team (REACT): Focuses on incidents on arterials • When an incident occurs, one incident commander from each agency reports to the command post. The command post will then implement the correct plan of action • Phoenix International Raceway (PIR) Special Event Management • Coordinate between TMCs so all use the same communication protocols and can easily share information

Source Reference [4], p 80, Table D-1

15.7.3 Road User Benefits

Examples of system operating benefits for various types of incident management strategies are detailed in [4]. Reported benefits include the following:

- Effective traffic incident management reduces incident duration by 30–50 %
- Road weather information systems reduce crash rates from 7 to 80 %
- Dynamic message signs reduce crashes by 3 % and improved on-time performance up to 15 %
- Work zone management reduces system delays up to 50 %
- Active traffic management increases traffic throughput up to 7 %, and decreases incidents up to 50 %

15.8 Summary Assessment of Experiences in Managing/Mitigating Nonrecurring Congestion

A 2008 report by Cambridge Systematics et al. [7] contains a review and synthesis of congestion management practices in US metropolitan areas. The report covered both non-recurring and recurring congestion.

The mitigating impacts of strategies that were applied to nonrecurring congestion (Incidents, Work Zones, Road Weather, and Special Events Traffic) and the dissemination of *Traveler Information* about their effects on traffic congestion were evaluated and the findings are summarized below.

Incident Management was found to be *highly* effective in reducing congestion at the *local and area-wide* scales of impact. It was primarily applied to freeways, and could be implemented in the *short term* at *low to medium cost*, with *minimum* institutional or regulatory barriers. The potential future effectiveness of incident management was rated *extensive* (area-wide impacts).

Work Zone management was *highly* effective in reducing congestion at the *local* scale, was applied in some form in up to 2/3 of the metropolitan areas, and could be implemented in the *short term* at *low cost*, with *minimum* institutional or regulatory barriers. The potential future effectiveness of work zone management was rated *moderate* (limited to work zones only).

Road Weather management had a *medium* effect in reducing congestion at the local scale of application and a *low* effect at the area-wide scale. The extent of application in metropolitan areas was *moderate* (up to 2/3 of metropolitan areas use it), and could be implemented at *low cost,* with *minimum* institutional or regulatory barriers. The potential future effectiveness in congestion reduction of road weather management was rated *moderate* (limited to inclement conditions only).

Planned Special Events Traffic management was *highly* effective at the local scale of application, was used in about to 2/3 of the metropolitan areas, and could be implemented at *low cost* with a *medium amount* of institutional or regulatory barriers. The potential future effectiveness in reducing congestion was rated *moderate* (limited to special event locations only).

Traveler Information management was found to be of *low to medium* effectiveness in congestion reduction at both the local and area-wide levels, had a *moderate* to *extensive* application in metropolitan freeways networks, could be implemented at *low to medium cost* within a *short term* timeframe, and with a *minimum* amount of institutional or regulatory barriers. Its potential future effectiveness in reducing congestion impacts on road users was rated *extensive*.

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