Incident response also involves balancing traffic demands to the available reduced capacity due to the incident. Approaches to demand balancing include entrance ramp controls and motorist information. Real-time motorist information displays, which give motorists on-the-spot accurate and timely information, play an important role in achieving effective urban traffic management (12).

Advance Planning

Advance planning for handling traffic when emergency lane closures or freeway closures occur, when emergency environmental conditions dictate, or when special events occur is essential to the orderly movement of traffic. Adequate advance planning minimizes incident effects on highway traffic, and reduces the normal congestion that develops because of these incidents.

Summary

The scope of the problems relative to incidents, roadwork and special events has been briefly discussed. The following are a few challenges that, if considered, help ensure traffic management systems are implemented and operated with effectiveness.

1. What are the optimal system configurations for incident detection and response?
2. What are the trade-offs between response time and cost?
3. What are the total benefits of freeway patrols, call boxes, closed-circuit television, etc. and how do we evaluate these on a common basis so that alternatives can be considered from a cost-effectiveness standpoint?
4. What level of reliability can be expected from the various alternatives, and what maintenance problems and costs are involved?
5. How can government agencies and others establish priorities, plan, and coordinate activities for effective incident management?

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FILM: TRAFFIC MANAGEMENT FOR FREEWAY INCIDENTS

S. C. Tignor, Federal Highway Administration

As a further introduction to both the problem and solutions in traffic management a new film produced by the Federal Highway Administration was shown. This 17-minute film promotes the rapid removal of freeway incidents, and describes lower-cost solutions that highway, police, fire, and other local agencies can use to improve traffic management, safety, and control at incident sites.

While freeways account for only 2 percent of the total miles of highways, they carry about 26 percent of the total travel. In urban areas, freeway incidents are highly visible disruptions, and they typically account for one-half of all freeway congestion.

This 16mm film, which is also available in a videotape format, illustrates how a pre-planned, coordinated interagency approach between traffic engineers, police, fire, media, and other local agencies can be implemented quickly when the need arises. Traffic management approaches are illustrated for both simple and complex incidents. The film incorporates footage from Chicago, Minnesota, Los Angeles, San Antonio, and other locations. The film is of interest to Federal, State, city, and local traffic engineers.

INCIDENT DETECTION AND RESPONSE

J. M. McDermott, Illinois Department of Transportation

The occurrence of traffic incidents on urban freeways presents a most challenging problem to operating agencies. Such incidents vary in severity and nature, and occur on a random basis at any time and any place. Lane-blocking accidents should be detected as soon as possible to effect vehicle removal and restoration of traffic service. Other incidents, such as the motorist with a disabled vehicle, are more subtle. Depending on when, where, and under what circumstances they occur, they may or may not be hazardous situations for other motorists.

To indicate the frequency of incidents on the 135-mile Chicago area freeway system, a daily average of 43 police accident reports were produced in 1983. The Illinois Department of Transportation emergency traffic patrol fleet averaged 203 assist reports (mostly for disabled vehicles) per day in that same year for the most heavily traveled half of the network.

The need for detecting and handling freeway incidents is most critical where the motorist in trouble can cause serious traffic and safety problems, due to roadway geometrics, traffic characteristics, and/or isolation from self-helping techniques. In fact, it is the nonrecurrent congestion caused by the incident that, in many cases, triggers the response mechanism. The objectives of detecting incidents can be stated as: 1) to initiate the earliest response and removal of the incident to keep traffic moving; 2) to aid motorists in trouble; and 3) to reduce the impact of temporary hazards.

One of the methods for detecting incidents is electronic surveillance. This technique typically uses induction-loop vehicle-presence detectors imbedded in the pavement at points along roadways to monitor traffic flow characteristics. In the Chicago area, detectors are provided in each lane every three miles along the freeway. Flow is also sampled in one of the center lanes at half-mile intermediate points. All ramps are monitored to produce a closed subsystem every three miles. The actual field location of detectors usually depends upon the availability of utility service, usually readily available around urban interchange areas. All surveillance (and control) points in a particular service area are brought to a roadside cabinet, through aerial or underground interconnect systems.

Each roadside cabinet contains detector amplifiers, power supplies, and telemetry equipment for coding detector signals onto leased telephone lines, or other interconnect modes. The interconnect lines transmit detector signals to the Surveillance Center, located centrally to minimize communications costs. The tone telemetry equipment in the Surveillance Center decodes and identifies each detector signal and interfaces each pulse into a known position in the surveillance computer.

The surveillance digital computer continuously scans the status of each traffic detector at regular intervals, such as 60 times a second. Since all detectors are of the presence type, for each scan the computer interrogates the binary status of each detector: "YES" or "NO," is there a vehicle present or not? By keeping track of the changes of state from "YES" to "NO" and back again, the computer records vehicle detection data and calculates the traffic flow characteristics for each detection point.

When presence-type detectors are used, the basic measurement at each surveillance point is lane occupancy: the percentage of time the detection zone is occupied by a vehicle. The loop detection equipment for measuring lane occupancy also produces lane volume. Although speed is not measured directly, unless a pair of loops are used to form a short speed trap, speed can be calculated from the lane volume and lane occupancy by assuming an average vehicle length for vehicles in the particular lane.

Lane occupancy is a convenient measurement since it is a summary parameter that includes all the basic aspects of the traffic stream. It considers the volume, the speed, and the composition (vehicle lengths) of the traffic stream as a whole. Lane occupancy can range from 0 percent, when there is no traffic present, up to 100 percent, when there are vehicles continuously in the zone of detection. There should always be some traffic, even at 4:30 a.m., such that the normal operational range is above 0 percent. It is rare to reach 100 percent lane occupancy, even under stoppage conditions, since there are always gaps between vehicles and some movement of the traffic stream.

Lane occupancy gives an indication of traffic stream operations at each detection point. With detectors along each freeway roadway at regular intervals, sampling the flow at points along the route gives an estimate of overall system operations. Typically, optimum peak-period flow occurs with a lane occupancy of 20 percent, where traffic speeds near the speed limit coincide with the highest flow rates. Occupancies less than 20 percent indicate flow generally near the speed limit; the corresponding volumes represent traffic demands ranging from zero up to the maximum. This 0-20 percent range of flow conditions is referred to as "GREEN" or "free flow."

In order to sustain the ideal rush-period 20-percent lane occupancy, 80 percent of the traffic stream must have large enough gaps to keep vehicles moving at high volume and high speeds. Although volume can maintain its maximum throughput, and increase in lane occupancy from 20 percent to 30 percent causes speed decreases due to fewer and shorter gaps, the increasing difficulty of lane changing, and more restrictive flow conditions. These 20-30 percent flow conditions are referred to as "YELLOW" or "impending congestion." In excess of 30 percent lane occupancy, traffic flow conditions are referred to as "RED" or "congested." Speeds continue to degenerate, with volume also decreasing from the maximum. In this "RED" zone, the higher the lane occupancy, the worse the situation. Lane occupancy at the high end of the scale indicates serious serious operational problems, i.e., an accident, a disabled vehicle, or other obstruction to the traffic stream. A major incident would produce very high "RED" conditions at upstream detectors, and the downstream detectors would show very low "GREEN" conditions, indicating the location of serious trouble somewhere between the two condition points.

The "GREEN-YELLOW-RED" zones of operation are used as a convenient on-line expressway surveillance output. The central computer system is used in real time to operate map displays showing the "GREEN-YELLOW-RED" zones along each roadway. The map display gives a quick overview of current operations for an entire instrumented route. In off-peak periods, all roadways should be operating in the "GREEN" zone. Any exceptions are clues to freeway incidents requiring response. In rush periods, a normal pattern of congestion is expected at recurrent bottlenecks. Abnormal patterns help locate operational incidents. Sometimes an incident in one direction can produce flow disruptions in both directions, through the "gaper's block" phenomenon, and help pinpoint problem locations.

Although traffic status displays are monitored by operational personnel, further traffic data, both current and prior, can be retrieved for analysis, by using CRT devices and printers. Automatic incident detection uses the computer to analyze data and signal the occurrence and location of a traffic incident. Computerized incident detection logic attempts to automatically detect incidents with: 1) the highest possible detection rate; 2) the fastest possible response time; 3) the lowest possible false alarm rate; and 4) the minimum manual input. Most logic uses traffic pattern similarity to find significant differences in traffic flow characteristics between adjacent detector stations.

Once the location of an incident has been signaled, it is necessary to find out what the incident is. This can be done by dispatching a standby response vehicle, or a patrol vehicle, or additional electronic surveillance can be used to inspect the nature of the incident. Ground or aerial closed-circuit television could be provided for visual verification of the incident and its problems. With TV cameras to transmit incident pictures back to the traffic management center, personnel can make incident-handling and traffic management decisions.

Roadside motorist aid phones, call boxes, organized Citizen's Band radio networks, motorists with cellular telephones, and various mobile radio-equipped vehicles have been used to help detect and verify traffic incidents. Roving service patrols and police patrols are valuable for providing incident response services.

Selective remote monitoring of CB units stationed at regular roadway intervals is also useful. When combined with electronic roadway detectors, the nearest CB station can be dialed up upon suspected incident detection to selectively listen (only) to conversations on Channel 19. The local CB information is used to verify the nature and details of incidents, with the information increasing as the severity of the traffic problem increases.

Regardless of the incident detection and verification technique used, operating agencies must be prepared with people and equipment to initiate the proper response. This requires communications systems and facilities between all units involved, definition of agency responsibilities, coordination of response activities, and considerable advance planning for handling the range of incidents that occur.

One method for handling incidents is a fleet of service patrol vehicles, either publicly or privately operated. By providing these vehicles with trained drivers, radios, and the proper equipment, most minor and some major incidents can be handled soon after detection. Essential equipment needed includes gas cans, water cans, pressurized air tanks, fire extinguishers, first aid kits, various tools, jacks, brooms, and so forth. Tow rigs are useful for relocating vehicles (and other items) to sites not interfering with traffic flow. Towing is usually for a very short distance; towing to garages or service stations is the responsibility of the vehicle owner, once an initial relocation has been made.

The establishment of traffic regulations is essential to permit operating agencies to remove vehicles from traveled lanes. The use of inconspicuous accident investigation sites is one method for relocating minor accident vehicles.

Without a special patrol or response force, minor incidents are usually handled by nearby commercial operators, upon notification by police or highway agencies.

For major incidents, special units and equipment become involved when called upon. Jackknifed or overturned trucks may require several tow units or heavy wreckers. In many truck incidents the truck load may also need removing from the roadway. Sometimes the load may be salvageable by having highway maintenance workers remove it to a storage site where the owners can claim it upon reimbursement of incident damages and cleanup costs.

Spilled loads can be bulky, troublesome, and very time-consuming to clean up. Some incidents may force closing lanes or whole roadways for several hours, such as for hazardous material spills or flooding conditions. Fire units may be needed for fires or spilled gas washdowns. Some incidents requrire fire, police, towing and ambulance units, as well as cleanup forces and equipment.

To reiterate, the important points in managing incidents are providing people and equipment, communications facilities between all units involved, definition of agency responsibilities, coordination of response activities, and advance planning for all types of incidents that could occur.

For many incidents, considerable effort is needed to control traffic safely and efficiently. Timely and well-planned responses keep roadways operating at the highest reduced capacities circumstances permit. Diversion measures and pre-planned detours may be needed for any major long-lasting incidents. And, finally, incident information should be broadcast to the public to help manage the traffic approaching or planning to use roadways tied up with incidents. The shifting of vehicle trips to other routes, to other modes, or to other time periods, helps relieve traffic pressure at the incident site. Radio and TV traffic reporting, changeable message signing, and highway advisory radio can be used by the operating agencies involved.

ROUTE DIVERSION PLANS AND FREEWAY INCIDENT MANAGEMENT TEAMS

D. H. Roper, California Department of Transportation

Once an incident has been detected, steps must be taken to deal with the problem -- to remove the obstructions as quickly as possible, to restore roadway capacity, to detour traffic as needed, to keep the motoring public informed of the situation. In short, the incident needs to be managed to minimize delays to traffic.

It is essential that advanced planning for incident management take place. Detour plans need to be developed, teams need to be organized, equipment assembled, and procedures established. These all need to be in place in order to respond quickly and effectively.

Virtually every segment of the freeway and street system should be closely analyzed to determine how traffic will be diverted, and to which surface streets it will be detoured. Working together, the State and local enforcement and traffic engineering agencies need to examine such things as diversion