INCIDENT DETECTION AND RESPONSE

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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 at any place. Lane-blocking accidents obviously 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, in that, depending on when, where, and under what circumstances they occur, they may or may not be hazardous situations for the motorists involved or other motorists in the traffic stream.

To indicate the frequency of incidents, the 135-mile Chicago area freeway system, with two million daily vehicle trips, produced a daily average of 51 police accident reports in 1984. The Illinois Department of Transportation emergency traffic patrol fleet averaged 251 assist reports (mostly for vehicle disabilities) per day in that same year for the most heavily travelled two-thirds 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 the roadway geometrics, the traffic characteristics, and/or the isolation from self-helping techniques. In fact, it is the non-recurrent 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. (Such an arrangement can be expanded to give more sensitive system detection, but would probably be the minimum system for installations where entrance ramp control is also contemplated.) 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 communication cables, leased telephone lines, or other interconnect modes. By using frequency-division multiplexing techniques, as many as 22 channels can be used for data transmission on each interconnect line. Since there may not be 22 detector or other signals for any one service location, multipoint techniques are used to connect adjacent locations to one interconnect line, so as to maximize line use, while minimizing line costs.

Each detector location has a tone transmitter in the roadside cabinet to encode the detector presence pulse, from the detector amplifier, onto the interconnect line at a selected frequency. The interconnect lines, usually conditioned, transmit detector signals to the Surveillance Center, located centrally to minimize communications costs, where the signals are decoded by tone receivers at the matching frequency for each detector. 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 and every 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 most convenient measurement since it is a summary parameter which 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 zero 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 zero percent. It is also rare to reach 100 percent lane capacity, even under stoppage conditions, since there are always gaps between vehicles and some movement of the traffic stream.

The basic measurement of lane occupancy gives an indication of traffic stream operations at each particular 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, the 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 zero-20 percent range of flow conditions is referred to as "GREEN" or "free flow".

In order to sustain the rush-period ideal of 20 percent lane occupancy, 80 percent of the traffic stream must have suitable gaps to keep vehicles moving at high volume and high speeds. Although volume can maintain its maximum throughput, an increase in lane occupancy to 30 percent from 20 percent causes speed decreases due to: fewer and shorter gaps available between vehicles; the increasing difficulty of lane changing; and generally 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. Any indications of lane occupancy at the high end of the scale indicate serious operational problems, such as an accident, a disabled vehicle, or other obstruction to the traffic stream. For example, 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 extreme condition points.

The summary "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. A glance at the map displays gives an instant 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 which require response. In rush periods, a normal pattern of congestion is expected at recurrent bottlenecks. Patterns different from normal 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.

Traffic status displays, however, only summarize the prevailing conditions for mainline traffic. For further information or more detail, the computer system usually has several peripheral devices for the real-time retrieval of the actual traffic flow data. A "RED" condition, for example, can be inspected to determine whether the actual lane occupancy is a 32 percent "RED", or a 74 percent "RED".

Although traffic status displays are monitored by operational personnel, further traffic data, both current and prior, can be retrieved for analysis by using computer displays and printers. Automatic incident detection is a further refinement which converts as much manual observation and data checking as possible to computer logic. Such logic analyzes real-time data to quickly and reliably signal the occurrence and location of a traffic incident. All computerized logic schemes attempt 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 signalled, it is necessary to find out what the incident is. This can be done by dispatching a standby response vehicle, equipped to handle most incidents, or a similar vehicle on patrol, or additional electronic surveillance can be used to inspect the nature of the incident. Ground or aerial closed-circuit television, for example, could be provided for visual verification of the incident and its characteristics. 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 programs, and reporting from any and all means available, including 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 particularly valuable for incidents which require handling by these same units.

One unique application of CB radio is the selective remote monitoring of CB units stationed at regular roadway intervals. When combined with electronic sensors, the nearest CB station can be dialed-up upon suspected incident detection to selectively listen (only) to conversations on Channel 19.

Important information can thus be gleaned to verify the nature and details of incidents, with the information availability increasing as the severity of the traffic problem increases.

Regardless of the incident detection and verification techniques used, operating agencies must be prepared with people and equipment to initiate the proper response. This requires communications facilities between all units involved, definition of agency responsibilities, coordination of response activities, and considerable preplanning for handling the range of incidents which can and do 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 includes gas cans, water cans, air pressure tanks, fire extinguishers, first aid kits, various tools, jacks, brooms, and so forth. Tow rigs are particularly useful for relocating vehicles (and other items) to sites not interfering with traffic flow. It should be noted that such towing is usually 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 and inter-agency agreements are essential to permit operating agencies to remove vehicles from traveled lanes. The use of inconspicuous accident investigation sites, as pioneered in Texas, is one method for relocating minor accident vehicles. Obviously, close cooperation between operating agencies and law enforcement agencies is paramount.

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

For major incidents, special units and equipment become involved when called upon. Jackknifed trucks may require several tow units or heavy wreckers. Likewise for truck tipovers, or near plunges from elevated roadways. A complicating factor in many truck incidents is handling the load before the truck can be removed 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 clean-up 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 spilled gas washdowns, as well as fires. Some incidents require fire, police, towing and ambulance units, as well as clean-up forces and equipment.

To reiterate, the important points in actively managing incidents (and special events) are providing people and equipment, communications facilities between all units involved, definition of agency responsibilities, coordination of response activities, and preplanning and training for all types of incidents which could occur. (Expect and prepare for the unexpected, as well as the expected.)

In addition to the handling of the incidents themselves, considerable efforts are also needed in many incidents to control traffic as safely and efficiently as the incident allows. Timely and well-planned response will help keep roadways operating at the highest reduced capacities circumstances permit. Ramp metering controls may help relieve overloaded critical roadway sections. Diversion measures and preplanned detours may be needed for any major long-lasting incidents.

And, last but not least, the provision of incident and traffic information to the public should be emphasized as a means to help manage the traffic demands approaching or planning to use roadways tied up with incidents or special events. The shifting of vehicle trips to other routes, to other modes, or to other time periods, helps relieve traffic pressure at the incident site. Various techniques, such as radio/TV/cable TV traffic reporting, highway advisory radio, and changeable message signing, can be used by the operating agencies involved.

If electronic surveillance information is available, routine and special computerized traffic reports based on the real-time detector information can be provided to the motoring public through the broadcast media. Allowing free media tie-in to pick up freeway traffic reports, issued automatically every five minutes around the clock, whenever any detectors show one mile or more of freeway congestion, can be the backbone traffic information system for the entire urban area. Adding multiple agency terminals to the network allows supplemental special reports to be keyboard-entered to give major incident and special event details, estimated travel times, planned freeway work zones, public transportation reports, and various other information of interest to the media and the traveling public.

Generally speaking, any partnership which helps the broadcast media report traffic tends to help the public agencies involved operate the freeway system. Radio traffic reporting stations, particularly, will use the basic computerized tie-in to expand reporting of special transportation problems, not only in peak periods, but also in off-peak mid-day, overnight and weekend periods. Media awareness of real-time traffic conditions also expands the agency capabilities to spot developing problems and to initiate response activities. Many stations also have mobile units and/or airborne spotters who report new freeway traffic problems back to the operational agencies. As routine day-to-day media/agency cooperation grows, the public awareness of agency efforts also follows growth towards a most favorable profile.

Other informational methods, particularly highway advisory radio and changeable message signing, can be used to direct more specific current traffic information to freeway users approaching problem sections. Highway advisory radio uses a low-power local broadcast to transmit traffic information to passing motorists tuning their car radios to the specified station frequency. Such traffic messages are prepared, recorded and frequently updated remotely by the public agency Communications Center personnel. A current refinement uses computerized roadway sensor information to automatically generate up-to-date traffic reports broadcast via synthesized voice. Changeable message signing, similarly, presents current traffic information, usually in message format via lamp or disk matrix, to advise passing motorists of prevailing traffic conditions immediately downstream.

Regardless of what techniques or combination of techniques are used to help urban freeways operate more efficiently, it is probably most important to establish and maintain active interagency team relationships. Information, communications, and response systems certainly play major roles in determining what the team is able to do, as well as how successful the overall efforts will be. It is hoped that this review of what can be done, and what is being done by some agencies, will help illustrate the role of incident detection and response in operating urban freeways.

INCIDENT MANAGEMENT

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Every day, the flow of traffic on our freeways and streets is slowed as the result of incidents -- everything from vehicle stalls, flat tires, spilled loads, accidents, major events with large crowds, to maintenance/construction activities. And every day, the resulting congestion and additional accidents are costing the travelling public millions of dollars. During one calendar year in the Los Angeles region, there were 220 incidents which caused major blockages of freeway lanes. Delays and secondary accidents are costing Los Angeles freeway drivers a staggering $60 million each year. Clearly, it is a problem that demands attention.

Yet, in many areas, little or nothing is being done to deal with the problem. In fact, there seems to be an attitude that this is just one of those things that must be accepted and about which little <u>can</u> be done. Such is not the case -- plenty can be done.

Further analysis of delays caused by accidents or other lane blockages in Los Angeles revealed the critical nature of the time required to remove the obstruction and restore full roadway capacity. During off-peak hours, each additional minute taken to correct the problem will extend the duration of congestion by four or five minutes. In peak periods, this factor often soars to fifty to one, or more.

Clearly, then, any program to deal with the problem should focus on cutting this total time -- the time to detect that a problem has occurred, the time to move forces into the field to deal with the problem, the time to make decisions and implement diversion routes, the time to clear obstructions and restore capacity, the time to make necessary repairs to the roadway, the time to dissipate congestion and return traffic flows to normal.

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 routings, signal timing, manually controlling intersections, and parking restrictions, and to develop a plan to handle detoured traffic. As a part of this planning phase, it is essential that involved agencies "buy in" to the plan, and commit to implementing their portion of the overall plan when the need arises. Periodically, these plans need to be reviewed and updated as street patterns and traffic conditions change over time.