Abridgment

Methodology for Evaluation of Alternative Low-Cost Freeway Incident Management Techniques

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In some cities, the problems caused by recurrent congestion have been attacked through the implementation of high-technology systems that use electronic loop detectors and closed-circuit television. The high costs of these solutions, however, make them feasible for only the largest freeway systems; in most places, less expensive approaches must be considered. This paper presents a methodology that may be useful for planning low-cost management actions to reduce nonrecurrent traffic delays and congestion caused by freeway incidents. The methodology components include estimating (a) total incident rate; (b) delay-causing incidents; (c) detection, response, and clearance times; and (d) total delay. The final step provides for the selection of appropriate low-cost freeway incident management (FIM) options and solutions.

ILLUSTRATION

To illustrate the magnitude of the FIM problem, consider a six-lane facility, 16 km (10 miles) long, that has shoulders, an interchange spacing of 2.4 km (1.5 miles), a rush-hour volume split of 5000 vehicles/h in the heavy direction and 2600 vehicles/h in the light direction, and two identical rush-hour periods. Our research has shown that the estimated annual incident rate for this facility is 10 000 incidents/year during the rush periods (1, 2, 3, 4, 5, 6).

If taken a step further, it can be shown that a subset of these incidents (the delay-causing incidents) will result in an estimated 550 000 vehicle-h of delay and the wasting of 1 362 711 L (360 000 gal) of gasoline.

INCIDENT-RATE DETERMINATION

As would be expected, systems that have better detection mechanisms identify more incidents and, thus, report greater occurrence rates. This suggests that, to determine an absolute rate, it is necessary to use the results of a continuous detector or of closed-circuit television surveillance. By using and interpreting data obtained on the John C. Lodge Expressway in Detroit (7, 8), it is possible to determine that approximately 124 incidents/million vehicle km (200 incidents/million vehicle miles) is a reasonable estimate of the occurrence rate. [A derivation of this can be found elsewhere (2)].

However, not all incidents cause delay. An incident is a delay-causing incident if it is (a) in-lane and requires a response or (b) an accident that either occurred on the shoulder or has been removed to the shoulder. By using this definition, it is possible to derive an incident distribution that can be used to determine delay-causing incidents, given the total incident rate.

Based on the incident distribution given elsewhere (2), the 10 000 incidents of the illustration are probably distributed as follows:

1. On the traveled way, 400 incidents will occur; of these, in 120 cases, the problem will be solved by the driver and 280 will require assistance in the form of a fire vehicle, an ambulance, or a tow truck.
2. There will be 60 accidents.
3. There will be 220 disablements (out of gasoline, blown tires, fires, out of water, transmission failures, and such).
4. There will be 9600 incidents that make their way to the shoulder.
5. There will be 400 accidents, of which 230 will require assistance from wreckers, ambulances, or fire services.
6. There will be 9200 disablements.

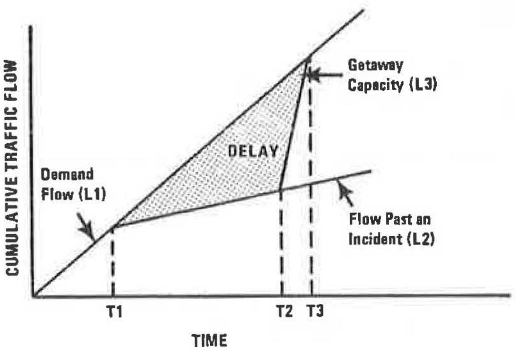
From this distribution and a few simple calculations, it can be shown that about 5 percent of the total number of incidents (i.e., the 280 incidents and the 230 accidents) cause delay. On the surface, this might give the impression that freeway incidents are only a small national problem; however, it has been estimated that the delay caused by urban delay-causing incidents in the United States is about 750 000 000 vehicle-h/year (9) or an amount equivalent to the gasoline produced from the oil flowing through the Alaskan pipeline for 10 d (10).

QUANTIFYING DELAY

To step from the number of delay-causing incidents to the vehicle hours of delay requires an understanding of what takes place when an incident occurs. Graphically, the FIM delay problem can be visualized as indicated in Figure 1, in which the ordinate is defined as the cumulative traffic volume and the abscissa is a time axis. L1, therefore, is a measure of vehicles per hour and can be labeled to represent the total number of vehicles wishing to use the freeway as the demand flow. When an incident occurs, the capacity of the freeway at the incident site is reduced until the incident is cleared, as is indicated by L2. L3 represents the getaway capacity as the maximum rate at which the vehicles behind the blockage can leave the backup. Graphically, T1 is the beginning time of the incident, T2 is the point in time at which the clearance of the incident was completed, and T3 is the point in time at which the last vehicle in the queue begins normal traffic-flow speed. Therefore, the shaded area is a measure of the vehicle hours of delay caused by incident; in terms of this graphic, the object of FIM is to reduce the shaded area.

The theoretical aspect of this model is intuitively appealing; however, its application to the FIM environment is difficult because of the lack of research that has been conducted relative to certain

Figure 1. Impact of incident on traffic flow.



values. In particular, values of the flow past the incident, the duration of the critical T1-to-T2 time period, and the getaway capacity are not widely known. Goolsby's work (4) has been particularly helpful in determining approximations of the various flow rates, although his information is based on a relatively small sample. Nonetheless, it is one of the few published research efforts in this respect and has been used to estimate the flow rates for the example.

Similarly, relatively few values have been published of typical incident durations and those that are available are for specific sites or freeways and vary widely (11, 12) because they are site-specific.

The fact that incident duration is site-specific dictates that a method of determining these values for the delay equation take into account local conditions. In addition, numerous interviews with police officials have indicated that major incidents (such as an overturned and burning tanker) are reported much more quickly than are minor incidents (such as a flat tire in the roadway). This fact and the fact that there are relatively few major incidents suggest also that the methodology should be capable of addressing minor and major incidents separately. Here, the method used to estimate major incidents is simply to project historical information. However, for the much larger minor-incident problem, each component of the duration of the incident (i.e., detection time, response time, and clearance) is calculated separately.

TIME COMPONENTS OF DELAY

As shown in Figure 1, the duration of the incident is T2 minus T1. This time period consists of an incident-detection time, a response time, and a site-clearance time.

1. Detection time is measured from the moment an incident occurs to the moment when it is detected by or reported to an official agency that has incident management responsibilities. Detection time includes related activities such as recognition and notification.
2. Response time is measured from the moment when the official agency becomes aware of the occurrence of the incident to the moment when all of the resources necessary to effect clearance have arrived at the incident site. There is great variability in the length of this time interval. It normally includes activities such as on-site evaluation of incident severity, communication, and the travel time of emergency vehicles and personnel to the incident site.
3. Clearance time is defined as the time required to remove an incident from the freeway and restore full freeway capacity. It begins as soon as the first response unit arrives at the site and ends when the last unit leaves. Clearance time varies considerably and is a function of type of incident and of the capability and availability of response resources.

It is apparent from Figure 1 that these times should be minimized to reduce total delay. To minimize delay requires that the decision maker have estimates of detection, response, and clearance times. If local estimates of these times are not available, then the techniques discussed elsewhere (2) can be used to estimate them.

LOW-COST FIM SOLUTIONS

After the total delay has been quantified and computed, the final step of the methodology involves examining the potential low-cost FIM options available and developing system solutions to reduce nonrecurrent type delay. About 30 options have been developed to solve various aspects of the FIM problem. These options have been classified into four categories, each of which is defined below with examples.

Surveillance Options

Surveillance options enhance the detection capability of the existing system and directly affect detection time. These options include actions such as increasing the frequency of police patrols and monitoring citizens band radio to capture incident information.

Administrative Options

Administrative options are intraagency activities intended to improve the ability of an agency to fulfill its present incident management role or to expand that role to include new responsibilities. Some of the options that have been developed are an emergency-light policy that reduces indiscriminate use of lights and lessens the natural tendency of an emergency vehicle to cause a general traffic slowdown and the use of accident-investigation sites to investigate accidents off the freeway.

Organizational Options

Organizational options may involve several agencies and seek to facilitate the cooperative effort that characterizes a successful incident management system. Typical options include the development of contracts, ordinances, or agreements to control the predominantly private towing services on urban freeways and the use of an FIM response team (13) (which is a multidisciplinary team of individuals who respond to large incidents to coordinate and direct multiagency activities and expedite the incident removal).

Preplanning Options

Preplanning options are designed to prepare an agency and other participating agencies and their personnel for the eventuality of an incident that requires their resources. Some of these include traffic-operations training and alternative route planning (which involves predetermining alternative routes for certain portions of a freeway system, identifying the routes on maps, and distributing the maps and information to FIM personnel).

PRESENT TESTING

At present, this methodology is in the process of being field tested by a cooperative effort between the Florida Department of Transportation and local agencies in the Tampa-St. Petersburg area. The site of the demonstration is the Howard Frankland Bridge between Tampa and St. Petersburg on I-275. The demonstration has progressed through all of the steps of the methodology and is currently in progress. In the near future, additional data will be collected so that the estimated delay savings can be compared with the actual delay being saved.

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Traffic-Condition Grade: Evaluation of Concept

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The quality of service as perceived by drivers in a traffic stream is a function of how they perceive the various traffic-flow characteristics. Because the mental and physical attributes of drivers vary, different drivers will perceive the same condition as being of a higher or a lower relative quality on some idealistic, undefinable scale. Drivers differ in their degree of acceptance of slower travel times, heavy traffic volumes, and unpredictable events. They also differ in their attitudes toward the driving task itself.

Despite the variability of driver attitudes and characteristics, several assumptions can be made relative to how quality of flow is perceived by most drivers. The first of these is that, for each situation experienced, there will be a median perceived value of quality; half of the drivers will rate the instance lower and half of the drivers will rate it higher on the scale. A correlated requirement is that the surrogate scale must be understood and accepted by the highest proportion of drivers possible. In this situation, actual measures of the differences among drivers need not be known. Rather, we can assume that most drivers will be reasonably close to the median estimate of the quality of flow.

A second assumption (simplistic but essential) that can be made regarding perceived quality is that most drivers recognize smooth, fast flow as evidence of a