Generation and Assessment of Incident Management Strategies

Summary Report

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16. ABSTRACT

This summary report describes a study of freeway incidents and incident management strategies in the Seattle area. The study statistically analyzed the frequency and duration of freeway incidents on sections of I-5 and SR 520 in Seattle. In addition, a traffic simulation model was operationalized to assess the traffic related impacts of incidents. The findings show that Seattle-area incident management currently responds well to inclement weather and special events (e.g., major sporting games) but has problems with severe accidents. The ongoing operationalization of accident investigation sites and incident equipment storage sites can be expected to improve severe accident management, but response personnel training and the addition of more dedicated tow truck service are also needed. Finally, the study shows that, from a traffic impact perspective, the section of I-5 in downtown Seattle is in need of the most incident management attention.

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Incident Management Strategies

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SUMMARY REPORT

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SUMMARY

The four technical volumes of this report contain a wealth of information relating to reviews of incident management methods used in the United States, Seattle-area incident characteristics, Seattle-area incident impacts, and an assessment of Seattle's incident management record.

The review of nationwide incident management practices (Volume I, technical report) reveals that Seattle's current range of management strategies is among the best. However, the review also suggests a number of additional strategies that could be of use in Seattle, such as accident investigation sites (which are currently being planned) and better jurisdictional coordination (e.g., incident management teams).

The study of Seattle-area incident characteristics (Volume II, technical report) was based on data relating to freeway incidents on I-5 and SR-520 in Seattle that occurred between April 1987 and March 1989. The results of this analysis showed that incident detection times and incident response times are quite satisfactory. Moreover, current incident response to sporting events and inclement weather seems to be very successful. However, the analysis also showed that problems are created by severe incidents, and improvements to address this deficiency are warranted.

An incident impact traffic model (Volume III, technical report) demonstrated the enormous cost of incidents in terms of lost vehicle- and person-hours. It also revealed that the most severe incident related impacts occur on the sections of I-5 in downtown Seattle as well as on the SR-520 bridge.

The assessment of Seattle's current incident management record (Volume IV, technical report) indicates that the ongoing incident equipment storage site concept has great potential but must be expanded to include strategic locations on freeway on-ramps. The current plan for accident investigation sites is expected to meet with some success, but it is limited because of the high expense of installing such sites (due to space limitations) in the most critical locations (i.e., near I-5 in downtown Seattle). Finally, the

report makes a number of additional incident management recommendations, including a recommendation for more dedicated tow trucks.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the findings detailed in the technical reports, the following recommendations can be made:

1. The models of accident duration indicated that problems exist with the management of severe accidents (i.e., those accidents involving multiple cars and/or fatalities). Incident response storage sites should improve this situation, as should more dedicated tow trucks and better incident response operating procedures. (Fire departments, in particular, seem unaware of the urgency of clearing the incident.)
2. The incident response storage site program shows great promise, but it must be expanded to achieve something of a "critical-mass." Probably eight to ten sites are needed to service the study area (the areas of I-5 and SR-520, shown in Figure 1), and, preferably, they should be located on on-ramps.
3. Accident investigation sites are promising, but not for the most impacted area of the study (I-5, Zones 3 and 4, Figure 1) because of severe space limitations in this area. However, the planned investigation sites should be of some value in Zones 5 and 6, providing WSDOT includes appropriate promotional support.
4. Zones 3 and 4 generate the largest incident impacts in the study area. Although incident response storage sites may help in this area, accident investigation sites are really not economically feasible because of space limitations. The researchers recommend that monitoring/response in this area be improved and that dedicated tow trucks be operated in these zones.
5. The traffic simulation indicated that during peak periods, traffic diversion (i.e., alternative routes) provides some relief, and radio reports offer a

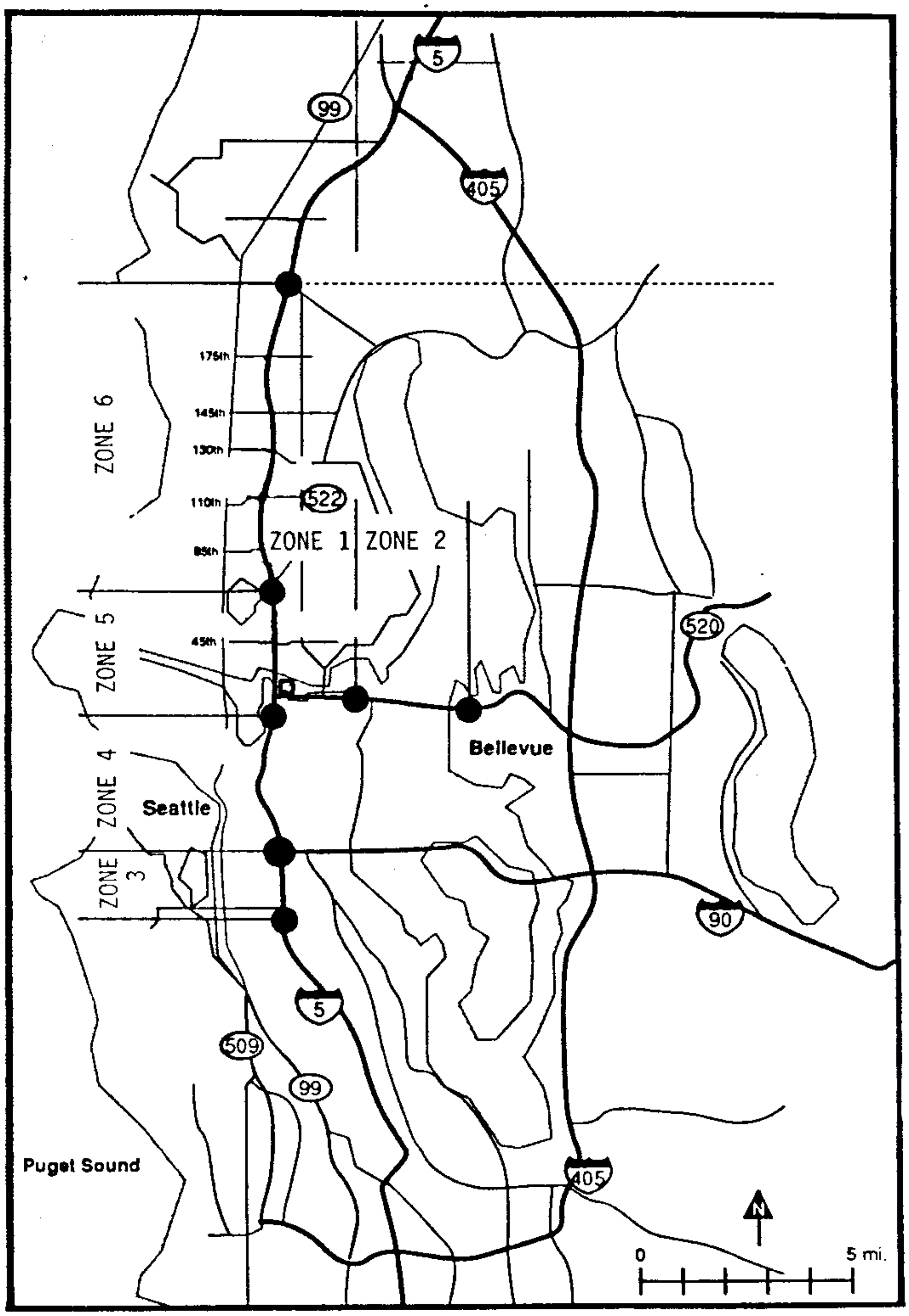

Figure 1. Incident Location Zones

valuable service helping motorists reach these routes. However, significant additional systemwide benefits can not be accrued by physically diverting traffic because of the congestion that is already present on alternative routes. Thus additional route diversion is not the answer; shorter incident duration is.

6. Education and awareness programs offer a very cost-effective approach to incident management. The researchers recommend that regular incident-related information be circulated to WSP and that annual training classes be held so that troopers are aware of new techniques and incident management facilities. Also, a public awareness campaign that stresses the magnitude of incident impacts could provide a reduction in the frequency and length of incidents and increase the use of accident investigation sites (i.e., convince the public of their value).

INTRODUCTION AND BACKGROUND

THE NEED FOR INCIDENT MANAGEMENT

Persistent recurring traffic congestion is a problem facing virtually every major metropolitan area in the United States. With expectations of continued growth in traffic demand and relatively little money available for capital expansion of highway networks, effective management of traffic flow will continue to be an important area of national research focus. Within this context, perhaps one of the least understood and most disruptive phenomena facing traffic flow management is the mitigation of traffic congestion resulting from incidents that include both accidents and vehicle disablements. National recognition of the incident problem has been building rapidly in recent years, but, because of the complexity and random nature of many incidents, truly effective incident management remains a much sought after goal.

Within Washington state, WSDOT's District 1 and the Washington State Patrol (WSP) have recently begun to develop plans, procedures, and systems aimed at the more efficient management of freeway incidents. This ambitious effort includes plans to develop incident response manuals, as well as policies and strategies relating to lighting, accident investigation sites, equipment storage areas, variable message signs, detour routes, incident response teams, and public information and relations. However, important work is needed to determine the effectiveness of this ongoing incident management program and to provide direction for future incident management efforts in District 1 and throughout the state. Such work includes the need to (1) collect appropriate incident related data, (2) measure incident-related traffic impacts, and (3) generate additional incident management strategies.

RESEARCH OBJECTIVES

The objectives of this project included the following:

1. to develop an incident database to aid in the evaluation of incident management options,
2. to develop a suitable incident evaluation procedure to use the collected data,
3. to assess the effectiveness of ongoing District 1/WSDOT incident management strategies,
4. to adopt and/or modify a microcomputer traffic model that can be readily used to simulate incidents, and
5. to suggest site-specific incident management strategies on the basis of the collected data and traffic simulations.

REVIEW OF PREVIOUS WORK

The previous work relevant to the rather broad scope of this project can be classified into three areas:

1. work focusing on the general implementation and assessment of incident management strategies,
2. work focusing on the rigorous statistical analysis of incident frequency and duration, and
3. work focusing on simulation modeling of the traffic-related impacts of incidents.

A summary of the project's literature review is presented below under these three categories.

GENERAL INCIDENT MANAGEMENT WORK

Volume I of the technical report presents an exhaustive list of general incident management literature. For the most part, this literature summarizes incident management experiences in various parts of the country. Costs, benefits, jurisdictional problems, and details of incident management strategies are typically discussed in detail. However, the vast body of this incident management literature provides very weak, if any, statistical justification for the rather bold conclusions that are often drawn. In summary, this body of literature is useful in identifying incident management strategies that may be of value, but not useful for identifying methods of measuring a strategy's value.

STATISTICAL ANALYSES OF INCIDENTS

The review of statistical evaluations of incident characteristics indicated three or four solid research efforts, all of which evolved out of incident/accident analysis work in California. These research efforts used fairly detailed data bases and standard regression-based statistical methodologies. Overall, their findings were interesting and statistically supported. However, the researchers found two areas for possible improvement in these works: (1) more detailed data, and (2) more advanced statistical techniques since, as shown in Volume II of the technical report, standard regression-based techniques have limitations that make them unsuitable for incident analysis.

INCIDENT TRAFFIC IMPACT SIMULATIONS

To enable the researchers to assess the traffic impacts of incidents, they undertook an extensive review of existing traffic simulation models (Volume III, technical report). The findings of this review suggested an unfortunate gap between practical implementability and accuracy. The impact models that were readily implementable provided output that was too general for adequate impact assessment; whereas those that provided adequately detailed output were hopelessly complex in terms of required input. To bridge this gap, this study developed a compromise model from an existing traffic impact model.

PROCEDURES

The procedures used in this study can be categorized into those for analyzing the characteristics of Seattle-area incidents and those for simulating the impacts of these incidents. These are discussed below.

PROCEDURES FOR ANALYZING INCIDENT CHARACTERISTICS

Data Collection

The objective of the incident characteristic analysis was to study the factors that affect incident frequency (number of occurrences) and duration (defined as the amount of time between the time the officer receives a report of an incident and the time he or she leaves the scene of the incident). To analyze incident characteristics in the defined study area (see Figure 1), a major data collection effort was required. In collecting these data, two types of incidents were identified; (1) vehicular accidents and (2) vehicular disablements. The accident data were derived from three sources: (1) the Washington State Patrol (WSP) dispatch records, (2) Washington State accident records, and (3) special events information. The researchers acquired data from the dispatch records by tediously sifting through files and files of dispatcher report cards and computer coding the needed information. The data were from incidents that occurred between April 1987 and March 1989. The accident report data, for all accidents in the study area, were obtained from the state in computer-ready form. Special event data (e.g., for baseball, basketball, and football games) were collected from local agencies and computer coded. These three data sets were then "matched" so that, for specific accidents, all the information on the dispatch forms, accident report forms, and special event schedules was available for statistical analysis. This information was very extensive and included a wide range of data relating to weather and roadway conditions, driver characteristics, injuries, type of vehicle involvement, property damage, and so on.

The vehicle disablement data were collected from WSP dispatch files and only covered the one-year period April 1988 to March 1989 because of WSP's policy to discard older data. Since the vehicle disablement data were generally not as well documented as the accident data, the project's focus was solely on the frequency of disablements.

Incident Analysis

The researchers determined the characteristics affecting the frequency of accidents and disablements by statistically fitting them to a Poisson regression model. Individual Poisson regression models were fitted for each zone of the study area (see Figure 1) because of the large differences in accident frequency from zone to zone.

The characteristics affecting the duration of accidents were statistically fit to a survival model. Survival analysis is a well documented methodology but has seldom been used in the analysis of transportation problems. However, the project showed (Volume II, technical report) that survival analysis methods are the statistically correct way to approach accident duration. The study also empirically showed that the appropriate accident duration distribution is log-logistic.

PROCEDURES FOR ANALYZING INCIDENT TRAFFIC IMPACTS

Data Collection

The analysis of incident traffic impacts necessitated the collection of data from a number of sources. First, to evaluate the flow of traffic in the Seattle area, an afternoon peak-hour trip origin to destination table was needed. This table was obtained from the Puget Sound Council of Governments and translated into a form suitable for the analysis. Next, information relating to the Seattle area street and highway network (number of lanes, capacity, section lengths, speed limits, and so on) was collected from numerous sources. Finally, actual network traffic volumes were obtained from the Washington

State Department of Transportation to ensure that the model-predicted traffic volumes were close to actual counts.

Traffic Impact Analysis

The traffic impact analyses employed the modified user equilibrium traffic assignment model XXEXQ (see Volume III, technical report). The analyses included three incident simulations: (1) an incident on the I-5 Ship Canal bridge, (2) an incident on the SR-520 floating bridge, and (3) the effects of drivers slowing down to view incidents. In addition, 12 incidents were simulated (two in each of the six zones, one in each direction) to assess the relative incident-related traffic impacts by zone.

DISCUSSION

On the basis of the analyses of incident characteristics and incident traffic impacts simulations, a number of important observations can be made.

TROOPER RESPONSE AND ACCIDENT REPORT TIMES

The average trooper response time (i.e., the amount of time between the time the call was received at the dispatch office and the time the trooper arrived at the accident scene) was just over 4 minutes. This must be viewed as an outstanding response time, particularly considering the sparse personnel resources with which the Washington State Patrol (WSP) must often work.

Almost equally impressive is the accident report time of just over 5 minutes (i.e., the amount of time between the time the accident occurred and the time it was reported at the dispatch office). This low report time is a testament to the effective presence of air-traffic reports, cellular phones, and assistance vans, as well as an excellent freeway surveillance system (closed circuit television, CCTV) and generally good communication between the Traffic Systems Management Center (TSMC) at Roanoke and the WSP.

Although these individual response times are impressive, combined they suggest that, on average, nearly 10 minutes transpire before a trooper arrives on the scene of an accident. This time can be very costly in terms of lost vehicle-hours. For example, the traffic simulations undertaken indicated that a 75 percent capacity reduction caused by an accident on the Ship Canal bridge (on I-5, Zone 5) in the p.m. peak rush period will result in 1,123 lost-vehicle hours in the first 10 minutes after the accident. Since the value of a vehicle-hour is roughly $10 (if the average vehicle occupancy is 1.2, including HOVs, this translates into a reasonable person-hour rate of about $8.30), $11,230 of worth of commuting time is lost before a trooper arrives at the scene of an accident. Thus, any improvement in detection and response will be of great value.

ACCIDENT SEVERITY AND DURATION

The accident duration models estimated from the two-year data suggested that management of severe accidents in the study area tends to be problematic. Evidence of this are the positive coefficient estimates for accident severity variables such as number of lanes blocked, number of vehicles involved, property damage in dollars, number of injuries, and whether a truck or bus was involved. The fact that these severity measures increase accident duration implies that substantial benefits could be gained from developing better management strategies to deal with severe accidents. The data collection process and conversations with responsible officials led to two observations about this accident severity problem. First, the response times for tow trucks, which are often required to clear severe accidents (involving trucks, buses, multiple vehicles, high property damage, and so on), are highly variable. This variability is likely the result of troopers being forced to rely on non-dedicated, private tow-truck services. The provision of a dedicated service (as is currently provided on the Lake Washington bridges) in critical locations in the I-5 corridor would be of great value. Second, fire departments, which are often called to the scene of severe accidents, have standard operating procedures that greatly increase durations and impacts, since they typically close additional lanes. There is a critical need for fire departments to improve their incident management proficiency.

As still further modeling evidence of the trouble that currently exists in managing severe accidents, the log-logistic scale parameters were less than 1 for all zones. This means that the hazard function monotonically decreases or, in other words, the longer that the accident lasts the less likely it is to be cleared soon. This hazard function suggests that increasing severity is a problem at all severity levels, not just at the most catastrophic accident extremes, as might be initially expected. If only the most severe accidents were problematic, the log-logistic scale would be greater than 1, indicating an increasing hazard (i.e., less severe accidents would be likely to end sooner, the longer they lasted) rather than a decreasing hazard (i.e., most severe accidents are less likely to end soon the longer they last). Thus, as severe accidents become better managed, the scale parameter would be expected to exceed 1.

RUSH HOUR RESPONSE

The duration model parameter estimates indicated that accidents have shorter durations during rush hours. This likely reflects the generally heightened awareness of the WSP, as well as extra WSP efforts to clear the road as quickly as possible. The rush hour performance is commendable, but it implies that improvements could be made in accident clearing during non-peak periods.

SPECIAL EVENTS AND ENVIRONMENTAL FACTORS

The accident frequency models showed that sporting events, inclement weather, and adverse road surfaces all increase the likelihood of an accident, and that these likelihoods increase at different rates in different zones within the study area. However, the duration model estimates also showed that these special events and weather effects do not affect the duration of the accident. This finding implies that current incident management is responding well to such occurrences.

APPLICATION AND IMPLEMENTATION

On the basis of the study's data collection effort and subsequent analysis, a number of important application and implementation suggestions can be made. These suggestions are broadly classified into three areas: (1) education and awareness, (2) resource and personnel allocations, and (3) detection and reporting. A discussion of these categories follows below.

EDUCATION AND AWARENESS

Experience to date with storage sites and accident investigation sites indicates that awareness is a key obstacle to success. A disappointing decline in the use of the existing TSMC storage site can be largely attributed to a lack of awareness among WSP troopers. Therefore, publicity relating to any incident management program must be a continuing effort (before, during, and after implementation).

Education for incident response personnel is needed to help them better manage traffic around the incident. This education could best be accomplished through an annual, one-day program in which troopers and fire department personnel were briefed and updated on state-of-the-art developments in incident management. Such a program could also serve as a forum for increasing awareness of storage sites, accident investigation sites, and other strategies that might be implemented in the future.

It is important that incident response personnel be made aware of the incredible cost, in terms of lost vehicle hours, of incidents. For example, a 60-minute incident causing a 75 percent reduction in capacity on the I-5 Ship Canal bridge has an average commuting time cost of roughly $2,700 per minute of (assuming a time value of time of $10 per vehicle-hour). Also, the longer the incident lasts, the higher are the per minute costs. Therefore, response personnel (particularly the fire department) must be made aware of the economics involved in restoring roadway capacity.

Driver education and awareness has great potential benefits. Drivers must be convinced not to slow down to view incidents (i.e., to gape). This study's simulation of the gaper effect indicated that hundreds of vehicle hours are lost because of gaping. A public awareness brochure outlining the cost of incidents (i.e., presenting some of the findings of this report) may be effective at increasing public awareness and improving the public's response to incidents.

RESOURCE AND PERSONNEL ALLOCATION

This study's findings suggested that, given the limited resources allocated to incident management, resources and personnel are reasonably well allocated. Evidence of this is the minimal effect that special events and differences in zonal accident rates have on incident duration. However, the responses to incidents need to be prioritized according to the impacts that are likely to result. In this regard, incident management in Zones 3 and 4 seems to be under allocated, particularly since the impacts of an incident in this area are much greater than the impacts of a comparable incident in all other areas. SR-520, for example, appears to have received most of the incident management attention to date (in the study area), perhaps because of the obvious lack of diversion routes (once on the floating bridge) and SR 520's impressively long queues. The I-5 corridor in central Seattle has few, if any, truly feasible diversion routes, and the amount of traffic carried on I-5 is nearly twice that carried on SR-520. Therefore, more attention should be paid to I-5, specifically in Zones 3 and 4. An obvious immediate solution would be the provision of a dedicated tow truck, as is currently available for the Lake Washington floating bridges.

DETECTION/RESPONSE

As discussed earlier, the average incident detection time (just over 5 minutes) and average response time (just over 4 minutes) are both fairly small. However, any additional reduction in these times will have great potential benefits, since the commuter cost per minute can easily exceed $2,000 (see above). Thus, it is important for the TSMC to upgrade its detection methodology as technology progresses, and for WSP troopers to continue to strive toward any reduction in response times. The continued use of cellular phones for reporting purposes should be encouraged either by radio stations or WSDOT.