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Abridgment

Real-Time Diversion of Freeway Traffic During Maintenance Operations

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A changeable message signing system can be used to divert vehicles around an incident and to redistribute traffic to available capacity of an alternate route, such as a service road or parallel arterial street. This diversion will reduce motorists' travel time, improve the level of service on the freeway, and enhance safer operating conditions on the freeway by providing motorists with advance information of unusal traffic conditions.

Messages developed in previous studies were displayed in actual field operation in response to freeway maintenance to determine the relative effectiveness of each message. In addition to routing traffic on the service road around freeway incidents, diversion to alternate arterial routes off the freeway was planned.

The study site was the North Central Expressway, a fully access-controlled freeway, which may be described as a depressed freeway with diamond interchanges in all interchange locations except two. A full cloverleaf interchange is at loop 12 (Northwest Highway) and a directional interchange is at I-635 (LBJ Freeway).

Three study locations were identified for applying management measures, and collection of data was in the northbound (outbound) direction from Mockingbird to loop 12. All service road intersections are under computer control so that real-time operation changes could be made to complement freeway management activities.

STUDY DESIGN

One objective of this research effort is to establish incident management techniques for use in a freeway surveillance and control environment. The three elements to be defined for the incident management studies are (a) incident detection, (b) management measures of alternatives, and (c) measures of effectiveness. Detection of incidents along the study areas on North Central Expressway in Dallas was accomplished by a nine-camera closed-circuit television (CCTV) system; however, for this study information about maintenance operation was known beforehand in most cases.

After the detection and verification of an incident, it is desirable that the driver be given sufficient information to avoid delay and hazardous conditions. Candidate messages for diversion were evaluated by use of two management techniques:

1. The diversion of freeway traffic to the service road around the incident, and
2. The diversion of freeway traffic to arterials around the incident.

Measures of effectiveness for candidate messages were derived from two sources:

1. The change in diversion rates from natural diversion (nonmanagement) to diversion because of informational signing (management), and the varying candidate messages thereof, and
2. Questionnaires, which were distributed to drivers where duration of the incident allowed.

The changes in diversion rates provided a quantitative measure of the effectiveness of various candidate messages. By a comparison of diversion rates as measured at freeway ramps during nonmanagement and management incidents and during the display of various candidate messages, their relative effectiveness could be measured. Questionnaires distributed to drivers who actually passed the sign displays provided a qualitative measure of the adequacy of the information provided. Drivers were asked to evaluate the information displayed as well as to give their opinion about what further information would be helpful.

Hardware Systems

For purposes of this research, it was necessary to design and install sign hardware that would be sufficiently flexible to satisfy the objective of testing a variety of candidate messages.

Three trailer-mounted, computerized, bulb matrix displays (Figure 1) were employed to present diversion information along northbound North Central Expressway in Dallas. The use of these signs provided versatility in message length, display forms, and rate of display, which greatly increased the number and types of messages to be displayed. The ability to display a message is provided to the operator through the use of a digital computer located on the sign trailer in an environmental equipment cabinet.

Procedure

Based on previous studies, a catalogue of candidate

messages for diversion was developed. These candidate messages were set in a priority order for testing during the research period. A message type (such as information only or information and diversion advice) was designated in this priority list; specifics such as exact location were to be determined by the exact location and nature of the incident.

Figure 2 shows the priority of messages to be displayed in conjunction with the freeway matrix signs. Sign 1 was located upstream of the study area, in an area where discontinuous service roads would not allow diversion and was, therefore, an information only or early warning sign.

Roadwork activities allowed testing through priority 3. No maintenance operation occurred at a location that would warrant diversion to alternate arterial routes under Phase 2. The evaluation data to be collected were of four different types: (a) freeway and ramp volumes, (b) intersection volumes, (c) freeway volumes and speeds, and (d) license plate studies for questionnaires.

Data Collection and Comparison

As originally contemplated, extensive data were to be collected on freeway maintenance both under management (informational and advisory signs) and nonmanagement (no sign) conditions to establish a statistical basis for comparison of the various candidate messages. A computer study was made of the freeway surveillance control detector system. The study gave flow rates over all entrance and exit ramp detectors upstream and downstream of the incident.

Because of the limited number of maintenance operations along North Central Expressway during the study, a statistical basis for comparison of the various candidate messages could not be made. Therefore, maintenance under nonmanagement and management operations were analyzed on a case study basis.

Figure 1. Trailer-mounted matrix sign.

Maintenance operations occurred at various times of day; therefore, measures of diversion of the off-ramps were taken in comparison to the flow rates immediately preceding the incident in order to maintain operation as nearly comparable as possible. Maintenance on the freeway in the study area provided the opportunity to collect both nonmanagement and management (with variable messages) data for the same incident. This was accomplished by leaving the sign blank for a period of time and then displaying various messages for approximately the same period of time. Questionnaire studies were made for two matrix-sign maintenance operations.

RESULTS

As previously described, incident management studies were segmented into two primary phases. Phase 1 involved routing traffic along the service road to avoid freeway incidents. This phase involved using matrix

Figure 2. Matrix sign messages to be displayed.

Priority	Sign 1	Sign 2	Sign 3
1	ROADWORK AT_____	ROADWORK AT_____	ROADWORK AT_____
2	ROADWORK AT_____	ROADWORK AT_____ USE SERVICE RD.	ROADWORK AT_____ USE SERVICE RD.
3	ROADWORK AT_____	ROADWORK AT_____ USE SERVICE RD. NEXT XX EXITS	ROADWORK AT_____ USE SERVICE RD. NEXT XX EXITS
4	ROADWORK AT_____ HEAVY CONGESTION	ROADWORK AT_____ HEAVY CONGESTION	ROADWORK AT_____ HEAVY CONGESTION
5	ROADWORK AT_____	ROADWORK AT_____ USE SERVICE RD. TO_____	ROADWORK AT_____ USE SERVICE RD. TO_____
6	Best of Message 2, 3, 5		
7	For Phase II Same as 6, but use TEMP BYPASS Instead of SERVICE RD.		

Special Messages

When all lanes blocked use:

ROADWORK
AT_____

FREEWAY
BLOCKED

Table 1. Case study results.

Case	Change of 5-min Flow Rates for Exiting Traffic (%)			Change in Upstream Demand Exiting (%)			Change of 5-min Flow Rates for Downstream On-Ramps (%)		
	Non-Management	Information Signs	Diversionary Signs	Non-Management	Information Signs	Diversionary Signs	Non-Management	Information Signs	Diversionary Signs
1	+19.0	+324.7	+343.8	+48.6	+146.3	+217.9	+48.6	+146.3	+217.9
2	-	-	-	-	-	-	-	-	-
3	+152.6	+176.3	+227.3	+51.4	+56.5	+58.9	+255.5	+282.0	+239.8
4	+96.2	+125.9	+147.3	+26.2	+36.8	+42.5	+52.3	+134.6	-

signs to inform freeway drivers of diversion from the freeway to the service road. Phase 2 was designed to route traffic to alternate arterial roads when continuous service roads were not available for diversion. Traffic would be diverted from the freeway via the matrix signs and then guided along the alternate route by trailblazer signs, as described in previous sections. No incidents of sufficient duration occurred in locations that would warrant routing to the alternate arterial route (Phase 2).

Data for the four roadwork studies are presented in Table 1. Case 2 data could not be evaluated because of a system breakdown of the freeway detector system during the study. However, questionnaire data were collected. Flow rates of 5-min duration were averaged prior to the maintenance and during each message. The change during each case is presented as the percent change in the table. The first available downstream entrance ramp was also analyzed to determine the effects on its operation during the maintenance.

In order to allow comparisons between different traffic conditions and volumes during each case, it was necessary to determine the percent of the upstream demand that exited. This measure of the exiting traffic negated any effects the demand might have on the number of drivers who diverted from the freeway.

SUMMARY

Many meaningful comparisons were cited in trends from the data collected for maintenance during the incident management studies. In every case comparison, exit ramp volumes increased for signed (managed) incidents compared to nonsigned (nonmanaged), natural diversion conditions. The results showed that diversion was greater under a managed condition than under a nonmanaged condition. For informational signs only, increases ranged from 125.9 to 324.7 percent for the four case studies. When diversion messages were presented, increases ranged from 147.3 to 343.8 percent.

In all case studies, exit volumes were greater for diversionary signs than for informational signs. This would indicate a preference by motorists for diversionary information. This was indicated in questionnaire results for case 1, where 33 percent of the motorists who responded desired alternate routing when no diversionary information was presented. However, none of the motorists who received alternate routing information cared for this type of information.

Downstream entrance ramp volumes also increased under the signed conditions. Increases were greater for diversionary messages than for informational messages. However, in case 3, results indicate motorists entered the freeway before they had cleared the blockage. Some of the drivers may have thought that this particular ramp would be their last opportunity to enter back on the freeway when, in fact, one more ramp downstream would have cleared them from the blockage. This indicates a need for a supplemental sign, such as trailblazing on the frontage road itself or advisories on the changeable messages signs such as, USE SERVICE ROAD TO CARUTH, to tell drivers where to reenter the freeway.

The management of traffic during maintenance conditions was demonstrated to be feasible and advantageous. The addition of diversion information proved to be a benefit. Although statistically sound data bases for comparison were not achievable, trend data were favorable in virtually every case. Questionnaire data show a preference by the motorists for some type of information along their route during maintenance operations. Motorists' preferences included diversionary information as well as advisory information. This was exemplified by the greater increase in diversion when diversionary signs were used.

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**Mr. Carvell was affiliated with the Texas Transportation Institute at the time of this research.*

Pedestrian Movement at the 1980 Winter Olympics Ski Jump

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This paper describes and evaluates options for the location of bus staging areas and the movement of pedestrians between bus staging areas and the Intervale ski jump site at the 1980 Winter Olympic Games at Lake Placid, New York. These options are analyzed in terms of impacts on the environment, spectators walking under winter conditions, traffic flow and accidents, cost, maintenance, and post-Olympic implementation considerations. A comparative analysis is made of these impacts on each of four options for pedestrian flow. Results show that either a pedestrian bridge or signal across the main route appears superior, because it minimizes pedestrian-vehicle conflicts, separates spectators from dignitaries and officials, and consolidates bus staging activities in a single adequately sized location. Options that assume joint use of the road by vehicles and pedestrians should be avoided because of the crucial requirement for maximum road capacity to handle bus circulation.

Lake Placid, a small community in the Adirondacks of upstate New York, will be the site of the 1980 Winter Olympic Games. It is located approximately 140 km south of Montreal and 400 km north of New York City (Figure 1). Highway access to Lake Placid is limited to two routes: NY-86 and NY-73. Because of significant capacity and flow problems anticipated from the planned daily influx of spectators, a 450-bus circulation system feeding peripheral parking lots has been proposed as the basic spectator transportation system for the games (1).

The Intervale ski jump, the site of the 70- and 90-m ski jump competitions, is located at the point where NY-73 crosses the west branch of the Ausable River (Figure 2). Estimated peak periods of use of the facility