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16. Abstract

The Houston Motorist Assistance Program (MAP) assigned two vans to patrol the U.S. 59 Southwest Freeway during the reconstruction projects. These patrols operated from about July 1991 until the majority of the construction was completed in September 1992. This report evaluates the benefits that this program produced during a one-year period.

This study calculated a benefit-cost ratio of 19 for the program. The duration of an average incident on the Southwest Freeway declined from an estimated 46.5 minutes without MAP to approximately 30 minutes with MAP. This incident duration reduction of 16.5 minutes, along with the free services received by assisted motorists, resulted in almost 3.7 million dollars of benefits to the motorists for a one-year period from August 1991 to 1992. This dollar value is based on the total value of time that was saved by the motorists who would have experienced more delay had not MAP been patrolling this freeway.

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EVALUATION OF THE SOUTHWEST FREEWAY MOTORIST ASSISTANCE PROGRAM IN HOUSTON

by

Paul A. Hawkins
Assistant Research Scientist
Texas Transportation Institute

Research Report 1922-1F
Research Study Number 7-1922
Research Study Title: Evaluation of a Motorist Assistance Program Using Freeway Patrol Vehicles

Sponsored by

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The Texas A&M University System
College Station, Texas 77843-3135

IMPLEMENTATION STATEMENT

As our nation's infrastructure reaches maturity, many freeway facilities are being reconstructed in order to meet current design standards, properly address accident prone areas, or simply alleviate congestion. This study documents the results of the implementation of one component of a freeway incident management program, the Motorist Assistance Program (MAP), during the reconstruction of the U.S. 59 Southwest Freeway in Houston, Texas. Because capacity was reduced as a result of construction activities, an effective means of reducing the impacts of minor incidents had to be found. The use of two MAP vans during the reconstruction of U.S. 59 proved to be a cost effective method for efficiently handling minor incidents. Results of this study led to the following observations and recommendations:

- Each freeway should be investigated separately to determine whether or not a motorist assistance patrol would have significant effect in reducing incident related delay.
- The Southwest Freeway was extremely congested, having the highest average daily traffic of any radial freeway in Texas and three major interchanges within fifteen miles of the CBD. These characteristics contributed to the overall success of MAP in reducing delay.
- Assuming that a transportation agency has scheduled the reconstruction of a congested freeway, that an incident on the facility can cause significant delays, and that the incidents are of a nature such that their duration can be significantly reduced by a motorist assistance patrol, the transportation agency should seriously consider the use of a motorist assistance patrol as part of its incident management program.

DISCLAIMER

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes.

ACKNOWLEDGEMENT

The author gratefully acknowledges the cooperation and assistance of the Texas Department of Transportation and the Motorist Assistance Program during this study. Mr. Carlton Allen (TxDOT, Houston District) was especially helpful throughout the data collection effort by coordinating and scheduling trips with the program patrols. Input and cooperation received from all the Sheriff's deputies patrolling the freeway during the study was a major part of the evaluation.

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SUMMARY

The Houston Motorist Assistance Program (MAP) assigned two vans to patrol the U.S. 59 Southwest Freeway (Figure 1) during the reconstruction projects. These patrols operated from about July 1991 until the majority of the construction was completed in September 1992. This report evaluates the benefits that this program produced during a one-year period.

This study calculated a benefit-cost ratio of 19 for the program. The duration of an average incident on the Southwest Freeway declined from an estimated 46.5 minutes without MAP to approximately 30 minutes with MAP. This incident duration reduction of 16.5 minutes, along with the free services received by assisted motorists, resulted in almost 3.7 million dollars of benefits to the motorists for a one-year period from August 1991 to July 1992. This dollar value is based on the total value of time that was saved by the motorists who would have experienced more delay had not MAP been patrolling this freeway.

A freeway simulation model, FREQ10PC, was used to estimate the delay savings for both directions of freeway and for both the AM and PM periods. The model was used to simulate different levels of delay experienced under different conditions, such as the incident type, location, time, and blockage (shoulder or mainlane). The records of the MAP patrols were then applied to determine the total travel time savings.

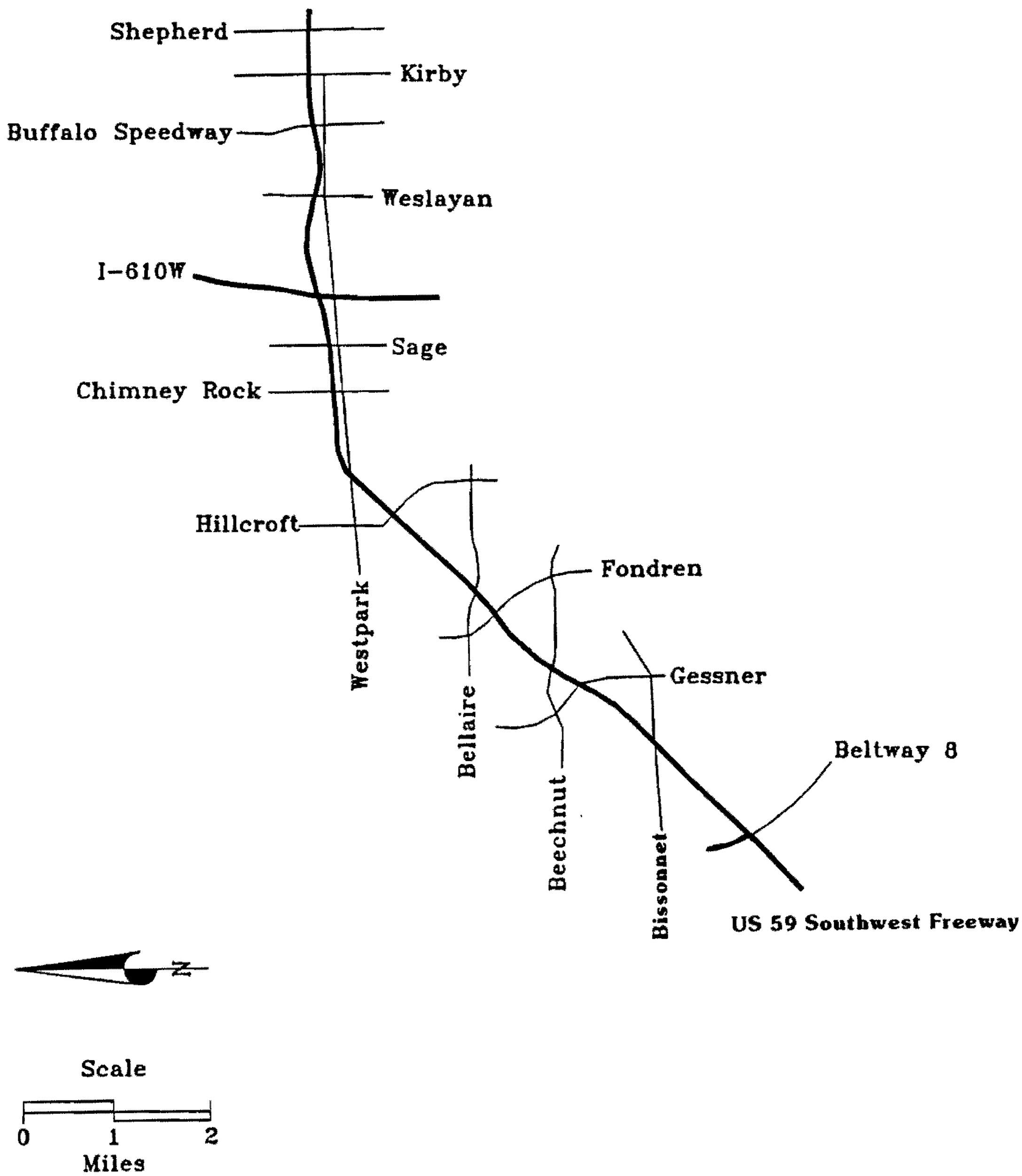

Figure 1. Map of the U.S. 59 Southwest Freeway Patrol Area

INTRODUCTION

Congested urban freeways are highly sensitive to incidents that can temporarily reduce the capacity of the freeway. Reductions in capacity increase travel delays and operating costs to motorists. The U.S. 59 (Southwest) Freeway in Houston is of major concern because of these factors:

- the freeway has the highest average daily traffic for radial freeways in Texas;
- there are three major freeway-to-freeway interchanges within 15 miles (24 km) of the Central Business District (CBD);
- the freeway was scheduled to be reconstructed with the first project underway in September 1989, and the completion of reconstruction expected to be May 1993; and
- the construction projects had traffic control plans that required lane width reductions and the removal of one or both shoulders during all phases of construction in order to maintain the same number of lanes.

Studies have shown that random events such as accidents or disabled vehicles cause fifty percent or more of the traffic congestion on streets and freeways. Freeways under construction are more susceptible to random incidents such as minor accidents and/or stalled vehicles. This can result in greater amounts of congestion because, frequently, there are no shoulders on which to store the disabled vehicles, which thus block the travel lanes. Therefore, it is imperative to remove such incidents as quickly as possible to prevent the formation of congestion.

The Motorist Assistance Program (MAP) is a traffic management strategy used on Houston freeways to quickly remove incidents. MAP was initiated by the Houston Automobile Dealers Association (HADA) and the Harris County Sheriff's Department (HCSD) in November 1986. HADA provided the funding and HCSD operated the MAP vehicles for the program. In 1989, MAP was significantly expanded with funding support by the Metropolitan Transit Authority of Harris County (METRO) and administrative support by the Texas Department of Transportation (TxDOT), which manages the program. TxDOT further supplemented MAP in 1990 by providing the financial support to add an additional vehicle to the fleet to patrol the Southwest Freeway during the reconstruction projects, thus doubling the coverage by the patrols.

The objective of this study is to determine the benefits and costs of using the two MAP patrol vehicles for the Southwest Freeway during the reconstruction of the mainlanes of the freeway. In earlier studies of the MAP program, direct and indirect benefits have been identified as:

- reduced costs to assisted motorists;
- reduced costs to other motorists because of an increase in roadway capacity;
- improved surveillance of roadway and traffic conditions;
- improved safety by reducing traffic conflicts, which reduces travel times by emergency vehicles;
- greater public acceptance of the problems and inconvenience caused by the construction activities;
- reduced TxDOT cost by MAP performing functions normally performed by other TxDOT employees;
- reduced pedestrian movement on the freeway; and
- provided some sense of security to motorists.

The only benefits that will be documented by this report will be the reduced costs to assisted motorists and the reduced costs to other motorists because of the reduced time that incidents impact roadway capacity.

EVALUATION

BENEFITS

The benefits in this evaluation are the reduced costs to assisted motorists and the reduced costs to other motorists on the Southwest Freeway. The reduced costs to assisted motorists refers to the costs they would pay to a private business for the same or a similar service. The reduced costs to other motorists refers to the value of the decrease in delay when incidents are being removed more quickly than if there was no MAP patrolling the freeway.

The costs of services provided by MAP to stranded motorists was included in this evaluation. The actual costs of services were obtained from the Houston Wrecker Association through the Texas Department of Transportation (1). Table 1 uses these costs and the total number of each type of assistance to calculate the total cost savings to the assisted motorists. The total number of each type of assistance on the Southwest Freeway was taken from MAP records used to evaluate the entire Houston program (2). The results indicate that approximately $125,000 was saved by the motorists who received the free services provided by MAP.

Table 1. Cost Savings to Assisted Motorists

Service	Cost per Service[1]	Number of Services[2]	Cost Savings to Assisted Motorists
Gas	$57.00	432	$ 24,624
Call for Wrecker	$ 0.25	289	$ 72
Flat Tire	$35.00	773	$ 27,055
Phone for Assistance	$ 0.25	733	$ 183
Deliver Motorist to Location	$ 0.00[3]	201	$ 0
Push Off Roadway	$57.00	515	$ 29,355
Jump Start Battery	$35.00	233	$ 8,155
Overheated Vehicles	$57.00	131	$ 7,467
Minor Engine Repair	$57.00	493	$ 28,101
Extinguish Fire	$ 0.00[3]	19	$ 0
TOTAL COST SAVINGS			$125,012

1 See reference (1).
2 See reference (2).
3 These services are not usually provided by wrecker services or any other service on a standard basis, so a dollar amount was not used.

The benefits assigned to other motorists are determined from a comparison of freeway operations with MAP and without MAP by first calculating an estimate of additional delay which motorists would experience with no MAP. Secondly, a corresponding dollar value was assigned to the delay using a value of time per person-hour of delay. These calculations will be demonstrated later in this report in the "Delay Calculations" section after the methodology itself and how the data fits into the methodology have been adequately developed.

Since the amount of capacity lost to an incident varies with the type and location of the incident, field data were collected to estimate these capacity reduction factors. The computer simulation model used the capacity reduction factors to calculate delay for various durations of incidents. A graphed function for each type of incident was developed using the duration of the incident and the delay as the variables in the function, since the amount of delay fluctuates as the incident duration increases. Therefore, the types and percentages of incidents were calculated from the MAP records (2) and applied to the simulated delays to estimate the actual delay savings for which MAP was responsible.

COMPUTER SIMULATION MODEL

The FREQ10PC computer simulation model was used to calculate the delays experienced by motorists. This model was selected because it allows the user to reduce the capacity of the modeled freeway at a specific time and location, a feature which is necessary to simulate real incidents.

FREQ is a deterministic macroscopic model for linear directional freeway corridor evaluations. FREQ10PC is the tenth version of the original model and can be run on an IBM-compatible personal computer (3).

The model was calibrated for normal peak period and off-peak traffic conditions for both directions of travel on the Southwest Freeway. The calibration process involves collecting field data, comparing field conditions to FREQ's predicted simulation, identifying and making specific input changes, and repeating the comparisons of FREQ's predicted simulation with field data. The calibration process is repeated until a desirable level of accuracy is obtained. The FREQ model was then used to quantify the delay experienced from increased travel time that occurs during typical incidents.

DATA COLLECTION

The evaluation of the Motorist Assistance Program on the Southwest Freeway requires site specific information. The two types of data necessary for the evaluation are modeling data and incident data.

Modeling Data

The modeling data used to simulate the existing conditions on the Southwest Freeway include freeway geometrics, mainlane and ramp volumes, vehicle occupancy, percentage of trucks in the traffic stream, and the travel times/speeds for the freeway. Most of this data is collected by TTI for other evaluative purposes.

The *geometric data* were obtained by two methods: reviewing maps of the lane and ramp configurations from the Southwest Freeway Phase III construction plans; and reviewing video tape recordings made from a vehicle traveling through the construction zones during Phase III operations. These videos were reviewed and used to confirm the plan configuration. The geometrics of the Southwest Freeway during construction periodically changed to implement traffic control plans corresponding to the different phases of construction. Some data were collected during Phase II, June 1991 to September 1991, but the majority of data was collected during Phase III, September 1991 to July 1992. Therefore, Phase III geometrics were used to simulate the traffic conditions on the Southwest Freeway.

Volume data on the ramps and freeway mainlanes were collected when the Phase III geometrics were in effect. The mainlane data were collected at two locations on the Southwest Freeway; outside of the I-610 (West Loop) Freeway between Hillcroft and Bellaire and inside the West Loop at Mandell.

Vehicle occupancy data and the *percentage of large trucks* in the traffic stream are other variables that are useful in the simulation of the freeway. Under a separate contract with TxDOT, TTI is responsible for collecting quarterly volume data on the Southwest Freeway, as well as on other Houston Freeways. The data include vehicle occupancy by vehicle classification which was used in the MAP evaluation to calculate the delay per person.

Travel time data were also collected for this evaluation. In April and May of 1992, two weeks of travel time data were collected during the AM and PM periods in fifteen minute intervals to coincide with the fifteen minute time slices used in the FREQ model analysis. The data were used primarily to calibrate the simulation model by comparing the measured travel speeds against the speeds that are calculated by the FREQ model.

Incident Data

Incident data were collected to estimate the reduction of capacity during different types of incidents and to determine the types of incidents that the MAP effectively removes from the freeway. The data were collected for as many different types of incidents as possible. The types of incidents refer to the cause of blockage (incidents and accidents) and the effect on the roadway width (total number of lanes/number of lanes blocked).

The impact of incidents on capacity is dependent upon a number of factors. The geometry, traffic condition, time of day, location of incident, type of incident, severity and/or duration of incident, weather condition, police activity, and other factors, each play a role in determining the effect that an incident will have on the capacity of a freeway.

In order to determine the actual reduction in capacity, the maximum capacity must be determined. The process of calibrating the FREQ10 simulation models revealed approximate capacity values of 2000 vehicles per hour per lane (vphpl) for most sections of the freeway models. Therefore, a capacity of 2000 vphpl was selected as the normal capacity value for the study.

Capacity reduction during incidents is the most important factor in the analysis of the impact of disabled vehicles on delay. Field studies were planned to measure the traffic volume passing different types of incidents. A crew was to ride with the MAP vans so that they would be on-site when a disabled vehicle was spotted. A second method was also used that had the field crew driving along the freeway in a TTI van.

The studies involving riding with the MAP vans were to get the most data from the best view on the freeway. The MAP vans could be servicing the incident while TTI employees would be filming the vehicles passing the incident from a vantage point inside the patrol van. However, some problems occurred because a portion of the incidents that were filmed did not produce adequate data. For example, when an incident involves a vehicle that is blocking a lane, but that is able to be moved, the MAP operator is obligated to immediately push the vehicle or have the motorist drive to the nearest shoulder and then give the necessary assistance to remove the incident completely from the freeway. This action reduced the time for collecting the data.

The second method of collecting the data was to patrol the freeway separately from the MAP patrols. The objective was the same as when riding with the MAP vans except that the amount of time spent recording data was not limited by the early removal of the incident. Even so, other problems were encountered that limited the collection of data. For example, the data recorders did not have the authority to stop on the freeway and record the incident. Often, there was no place to stop on the freeway because of the restricted cross-sections in the construction zone. To find an appropriately safe location off the freeway to record the data, the van would exit the freeway and park in the nearest parking lot or other safe location. They would then begin to record the incident before it was removed. This operation often requires an excessive amount of time, and many times the incident was removed from the freeway by the occupants or MAP before any data was collected. This was especially true for incidents inside I-610 because most of the freeway is elevated and there were no off-freeway vantage points to see and record the incident. Therefore, these two methods of data collection resulted in a low amount of usable data. An estimated 20% of all the incidents recorded were considered usable for this study (Table 2). The following section is a summary of Table 2.

- For the three lane section, the average incident blocking a shoulder was a disabled vehicle which resulted in a 29% reduction in capacity; the average incident blocking a single lane of traffic resulted in a 52% reduction in capacity (which would be at 58% if the three construction lane closures were excluded from the data); and the incidents recorded blocking two of three lanes resulted in a 77% reduction in capacity.
- For the four lane section, an incident blocking a single lane reduced the capacity by 43% and an incident recorded on a four lane section blocking 3 lanes resulted in an 82% reduction in capacity.

Table 2. Impact of Incidents on Capacity				
Date of Incident	Type of Incident	Time of Incident	Flow Rate (vph) during Incident	% Capacity Reduction
Three Lanes with Shoulder Blocked				
10/22/91	Stall (Flat Tire)	4:00 pm	5,214	13
08/20/91	Stall (Mechanical)	3:00 pm	3,588	40
12/18/91	Stall	9:50 am	3,292	45
08/21/91	Stall (Mechanical)	3:30 pm	3,210	47
10/22/91	Stall (Flat Tire)	5:00 pm	4,932	18
07/09/91	Stall	9:50 am	5,502	8
Average			4,290	29
Three Lanes with One Lane Blocked				
03/03/92	Accident	12:15 pm	2,316	61
07/07/92	Constr Ln Closure	10:30 am	3,238	46
07/07/92	Constr Ln Closure	2:45 pm	3,398	43
07/07/92	Accident	4:45 pm	2,524	58
03/04/92	Stall	8:15 am	2,696	55
03/17/92	Accident	12:30 am	2,460	59
07/07/92	Constr Ln Closure	10:15 am	3,462	42
Average			2,871	52
Three Lanes with Two Lanes Blocked				
03/04/92	Accident	6:45 am	1,565	74
09/11/92	Accident	4:00 pm	1,692	72
04/13/92	Accident	4:00 pm	1,190	80
02/06/92	Accident	4:15 pm	1,039	83
Average			1,372	77
Four Lanes with One Lane Blocked				
03/16/92	Stall	5:00 pm	4,556	43
Four Lanes with Three Lanes Blocked				
03/16/92	Stall	3:45 pm	1,468	82

This study attempted to verify this data through a review of relevant literature. Reports were found that had also collected and reported capacity reduction data caused by certain types of incidents. One that had three lane data was "I-35W Incident Management and Impact of Incidents on Freeway Operations" (4) published by the Minnesota Department of Transportation in 1982; a second was "Influence of Incidents on Freeway Quality of Service" (5) published by TTI for the Highway Research Board in 1971.

Table 3 compares the results of these two reports with the results of the three lane data collected for this study on the Southwest Freeway. For all of the different types and locations of incidents in Table 3, the Southwest Freeway incidents show a greater reduction in capacity. These numbers seem acceptable, considering that the Southwest Freeway was a construction zone which is characterized by reduced lane widths and lack of shoulders. These characteristics could cause more of an impact on capacity than incidents occurring on freeway cross-sections with normal freeway geometrics.

Table 3. Comparative Results of Three Lane Capacity Reduction Studies

Type and Location of Incident	Average Percent Reduction of Capacity		
	MinnDOT (I-35W, 1982)	Houston (I-45S, 1971)	Houston (U.S. 59S, 1992)
Stall (right shoulder)	19	26[1]	29[1]
Stall (left shoulder)	24	26[1]	29[1]
Stall (1 lane blocked)	43	48	52[2]
Accident (1 lane blocked)	48	50	52[2]

[1] Studies did not distinguish between left and right shoulder in data.
[2] Study did not produce enough data so accident and stalls data grouped together.

A report which evaluated the operational effects of freeway reconstruction activities (6) suggests some reduced capacities for four lane sections during typical maintenance and reconstruction activities that block the shoulder and/or one lane. Table 4 compares these suggested results to the results of this study (Table 2). The data collected by TTI for this study in four lane sections will be used in the delay calculations. Since data was not available for the capacity reduction of a shoulder blockage, it was assumed that the capacity reduction of 12.5% was feasible.

Table 4. Comparative Results of Four Lane Capacity Reduction Studies

Number of Lanes Blocked	Average Percent Reduction of Capacity	
	Results from Ref. (6)	Houston (U.S. 59S,1992)
Shoulder Blocked	12.5	---[1]
1	51	43
2	66	---[1]
3	86	82

[1] See Table 2, data not available.

The *types of incidents* that MAP is servicing on the Southwest Freeway were determined from incident record forms prepared by the MAP vehicle operators. These incident record forms are summarized and reported every three months in MAP Quarterly Reports (2).

MAP was able to reduce the time of blockage for minor incidents, which include shoulder and one lane blockage (96% of the total number of incidents). No significant reduction in the time of blockage could be attributed to MAP for major incidents, such as multi-vehicle accidents, accidents involving injury or death, and those involving large trucks. These types of incidents are handled by other police agencies, therefore, MAP's role is limited to the timely reporting of the incidents to these police agencies and traffic control. Therefore, this study did not consider any benefits from MAP working these major incidents.

Incident duration is one factor in incident management that MAP can reduce. Fortunately, this factor accounts for the major portion of benefits of MAP. The duration of any incident is difficult to determine without automatic monitoring equipment for freeway operations and/or an intense, controlled data collection effort, neither of which was feasible for this project. The difference in incident duration with and without MAP determines the overall delay savings for which MAP is responsible.

A literature review was completed to find more information on incident durations without a MAP type routine to clear incidents. A study by TTI in 1987 (7) estimated the average incident duration without MAP on the Southwest Freeway to be 49 minutes, based on the calculations of incident durations taken from another study in Houston by TTI (8). The durations for different types of incidents from this study, along with the total number of each type of incident determined from the MAP Quarterly reports (2) from August 1991 to April 1992, were used to calculate a weighted average of 46.5 minutes (Table 5). This value will be used as an estimate of the duration of incidents if there were no MAP.

Table 5. Estimated Average Incident Duration Without MAP

Reason for Stop	Number of Stops (per month)	Percent of Total (per month)	Average Stop Time (minutes)	Total Stop Time (minutes)
Gas	33.4	10.2%	30.9	1,033
Flat Tire	63.7	19.4%	41.4	2,636
Mechanical	85.4	26.0%	82.3	7,032
Accident	42.1	12.8%	72.6	3,057
Other	103.8	31.6%	14.6	1,515
Total	328.4	100.0%	46.5	15,273

Incident duration with MAP was determined from records that are collected by the MAP deputies for every incident that they service. An estimate of the total duration that an incident is on the freeway is included in this data. The average total duration of 29.95 minutes was calculated from the average detection, response, and clearance times from August 1991 to April 1992 (Table 6).

Table 6. Southwest Freeway MAP Average Clearance Times (August 1991 through April 1992)

Month	Detection (minutes)	Response (minutes)	Clearance (minutes)	Total Time (minutes)
August 1991	13.59	0.64	16.09	30.32
September 1991	12.55	0.87	16.06	29.48
October 1991	11.06	0.91	14.65	26.62
November 1991	10.58	0.14	15.53	26.25
December 1991	12.82	0.26	19.88	32.96
January 1992	9.10	1.15	21.30	31.55
February 1992	11.46	0.62	19.50	31.58
March 1992	10.51	0.94	17.40	28.85
April 1992	10.80	0.67	20.45	31.92
Monthly Average	11.39	0.69	17.87	29.95

APPLYING THE FREQ COMPUTER MODEL

The FREQ computer model was used to estimate the MAP benefits for motorists on a freeway that is under construction. The modeling process involves the following steps:

1. Input data;
2. Calibrate model;
3. Run model to obtain existing or base conditions;
4. Run model with different capacity restraints to depict incidents and the additional delay that is caused by the incidents; and
5. Compare and differentiate the delay between base conditions and conditions where incidents are present.

The FREQ model was completed for both the inbound (NB) and outbound (SB) directions of the freeway. The FREQ program was simulated using fifteen minute time slices. FREQ can only simulate a maximum of 24 time slices; therefore, the maximum of six-hour time periods were used for those simulations. However, this is sufficient to cover most time periods during which incidents will affect travel times, since the inbound and outbound simulations were divided into peak and off-peak periods. Four simulation periods were used: the inbound AM peak period and outbound AM off-peak period models were simulated from 6:00 a.m. to 12:00 p.m.; the outbound PM peak period and inbound PM off-peak period models were simulated from 1:00 p.m. to 7:00 p.m.

The simulations determine delay during an incident as a function of the incident's location along the freeway, the time of day that the incident occurred, and the part of the freeway that is blocked (shoulder or mainlane). Each one of these categories had to be evaluated and a breakdown of the percentage of incidents in each category had to be calculated to determine the impact of the incidents.

The *incident location* along a freeway will have a direct impact on the delay. For example, an incident close to a major interchange will affect more traffic than one five miles from the interchange. The ideal situation would be to simulate each incident at the actual location where it occurred. But because of the number of incidents serviced during the one-year period (over 3700), the study divided the Southwest Freeway into three different sections. These three sections were: inside of the I-610 (West Loop) Freeway; within the West Loop interchange; and outside of the West Loop (Figure 1). It was assumed that all incidents within each section would occur at the mid-point of each section. This is a valid assumption because incidents occurring farther away from the West Loop interchange would cause less delay than incidents closer to the interchange. Therefore, the mid-point of these sections represent an average situation. Table 7 shows the distribution of incidents in the three sections.

Table 7. Incident Location Distribution

Location	Aug 91	Sept 91	Oct 91	Nov 91	Dec 91	Jan 92	Feb 92	Mar 92	Apr 92	Total	Avg	%-age
Total	311	307	338	283	264	222	272	315	310	2622	291	100%
Inside I-610	132	103	126	93	96	99	91	102	106	948	105	36.2%
At I-610	15	37	33	23	18	13	8	21	22	190	21	7.2%
Outside I-610	163	165	173	160	143	106	173	189	175	1447	161	55.2%
Unknown	1	2	6	7	7	4	0	3	7	37	4	1.4%

The *time of day* that the incidents were occurring was an important factor in determining the effect that each has on delay. The ideal method of obtaining the delay from each incident would be to simulate the incidents at the exact time that each actually occurred. This is considered impossible because of the large number of time slices and number of simulations that would have to be evaluated to calculate delay for each incident.

To accommodate for the variation in delay over time, the incidents occurring in the peak directions (inbound AM peak and outbound PM peak) were grouped into mostly two hour and some three hour time periods. Shoulder and one lane blockages were simulated for each time period to represent an average condition for each group of incidents. The off-peak directions did not have enough volume fluctuation over the periods to justify grouping the data; therefore one set of simulations were assumed feasible for the six hour period. Figure 2 shows the distribution of incidents over time for both directions.

The *incident blockage* or lateral location of the incidents was important in determining the impact they had on the overall delay. Shoulder and one-lane blockages were the two categories used in this analysis. Table 8 shows that over a nine month period almost 70% of the incidents were blocking the shoulder and only 4.5% of these were on the left shoulder. This is explained by the removal of most of the left shoulders in the construction zone. The remaining 30% are minor incidents that block one lane.

Table 8. Incident Blockage Location

Location	Aug 91	Sept 91	Oct 91	Nov 91	Dec 91	Jan 92	Feb 92	Mar 92	Apr 92	Total	Avg	%-age
Lft Shoulder	16	10	14	8	15	12	9	18	13	115	12.8	4.5%
Mainlane	88	97	83	66	92	64	93	93	109	785	87.2	30.4%
Rt Shoulder	207	189	233	200	152	143	168	201	185	1678	186.4	65.1%

Accidents with major freeway blockages were not included because MAP does not have the authority to institute quick removal policies. It was infeasible to compute the effect MAP may have had on major accidents since they only represent about 4% of the total incidents.

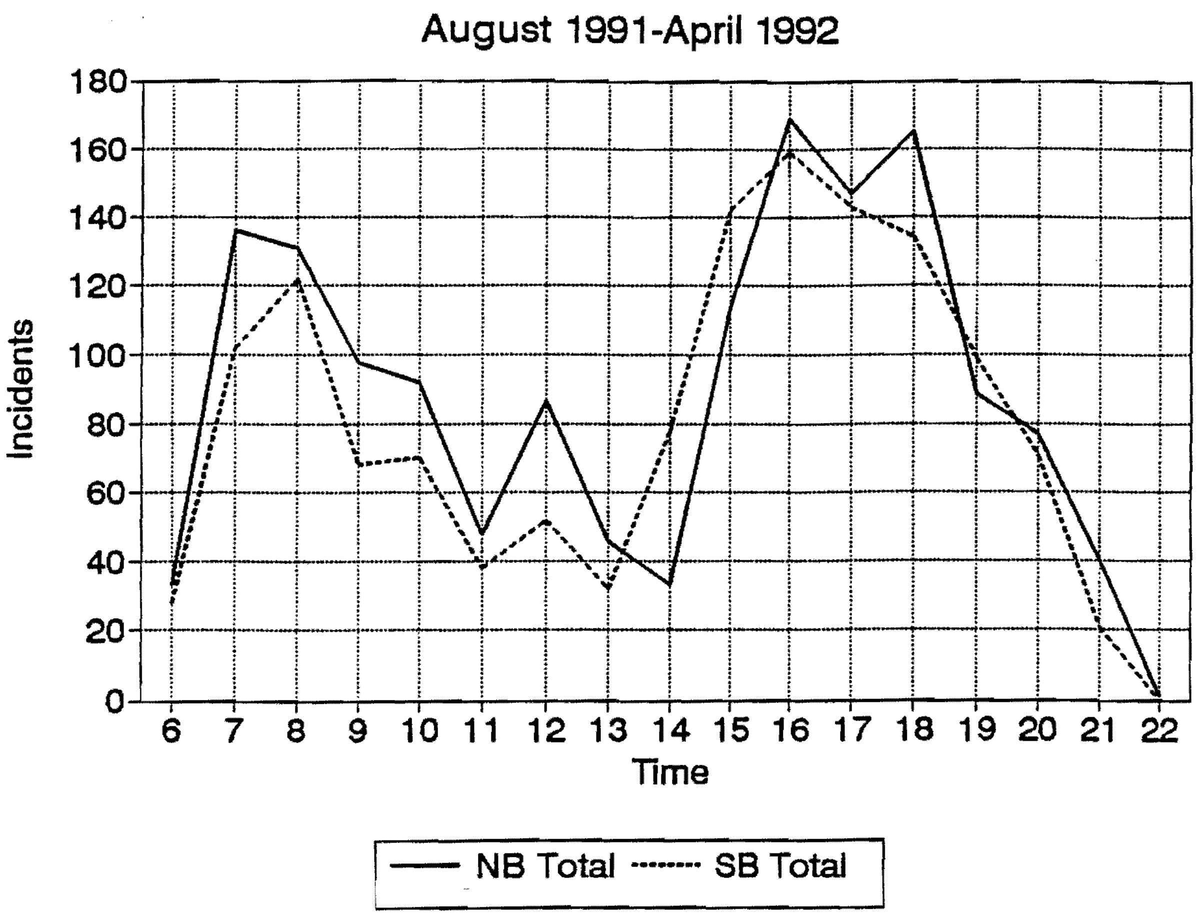

Figure 2. Incidents by Time of Day

The percentage breakdown of incidents was completed for both directions by location along the freeway, by time period when they occurred, and by the lateral location of the incidents. The procedure was completed using the following equation:

No. of Incidents (in any section) = Total Incidents * Percent by Direction * Percent by Period * Percent by Location * Percent by Blockage

DELAY CALCULATIONS

The four directional models were used to calculate the total delay by simulating incidents in each of the three sections (inside, within, and outside I-610). Normal freeway conditions with no incidents were simulated in each of the four models to obtain a base line delay. The base line delay represents the normal or recurrent delay that is experienced on the Southwest Freeway with no incidents. Incidents were then simulated for shoulder and one-lane blockages by reducing the capacity at the correct location and time by the amount determined previously in the "Capacity Reduction" section of this report.

The FREQ program reduces the capacity by inputting capacity reduction factors in each time slice. Each time slice is fifteen minutes, therefore, the average duration of an incident without MAP (46.5 minutes) could not be simulated. A delay curve was developed for each simulation by calculating the delay as a function of the duration of the simulated incident. The incidents were simulated for a duration of 15, 30, 45, and 60 minutes and the delays were plotted at each time. From these curves, the delay was determined for operations without MAP (average incident duration = 46.5 min) and with MAP (average incident duration = 30.0 min). The difference between the two delays calculated at 46.5 minutes and 30 minutes represents an estimate of how much delay savings was experienced by other motorists on the freeway.

This difference in delay calculation is shown for each simulation model in Table 9, except for the outbound off-peak period. This period did not have enough traffic volumes for the capacity reductions to create additional delay during a shoulder or one-lane incident. Table 9 also shows the calculations for the total benefits experienced by motorists by the following equation:

Benefit in Dollars = Difference in Delay * Total No of Incidents * Average Vehicle Occupancy * Value of Time

Table 9. Benefits for Southwest Freeway MAP

Location on Freeway	Time of Incident	Delay			Total No. of Incidents	Benefit to Motorists ($)	Delay			Total No. of Incidents	Benefit to Motorists ($)
		w/out MAP (veh-hr)	w/ MAP (veh-hr)	Difference (veh-hr)			w/out MAP (veh-hr)	w/ MAP (veh-hr)	Difference (veh-hr)		
Inbound AM Period — Shoulder Blocked							**Inbound AM Period — One Lane Blocked**				
Inside I-610	6:30 am	1068	1068	0	62	$0	3546	2591	955	27	$296,966
At I-610		3127	2406	721	12	$99,645	6082	3331	2751	5	$158,439
Outside I-610		809	853	-45	94	($48,392)	1692	1106	587	41	$277,085
Inside I-610	8:30 am	1068	1068	0	84	$0	1465	1158	308	37	$131,052
At I-610		1514	1272	242	17	$47,292	3982	2854	1128	7	$90,933
Outside I-610		1086	1083	3	127	$4,414	2401	1829	573	56	$369,355
Inside I-610	10:30 am	1068	1068	0	83	$0	1244	1167	77	36	$31,743
At I-610		1069	1069	0	17	$0	1958	1692	266	7	$21,409
Outside I-610		1068	1068	0	126	$0	1624	1423	200	55	$126,833
					@6:30 =	$51,253				@6:30 =	$723,490
					@8:30 =	$51,707				@8:30 =	$591,341
					@10:30 =	$0				@10:30 =	$179,985
					TOTAL =	$102,960				TOTAL	$1,503,816
Inbound PM Period — Shoulder Blocked							**Inbound PM Period — One Lane Blocked**				
Inside I-610	4:00 pm	765	765	0	279	$0	995	886	109	122	$152,778
At I-610		823	803	20	56	$13,093	2493	1671	822	24	$227,200
Outside I-610		774	771	3	425	$15,213	1140	749	391	186	$836.797
					TOTAL =	$28,306				TOTAL =	$1,216,775
Outbound PM Period — Shoulder Blocked							**Outbound PM Period — One Lane Blocked**				
Inside I-610	1:30 pm	2757	2757	0	35	$0	2757	2757	0	16	$0
At I-610		2757	2757	0	7	$0	2892	2819	73	3	$2,527
Outside I-610		2757	2757	0	54	$0	2830	2777	52	24	$14,451
Inside I-610	4:00 pm	2762	2756	6	97	$6,510	2831	2764	67	43	$33,382
At I-610		2716	2739	-23	19	($5,133)	2152	2011	141	9	$14,600
Outside I-610		2872	2789	83	148	$141,524	3846	3248	598	65	$448,015
Inside I-610	5:30 pm	2729	2739	-9	89	$9,717	2412	2630	-218	39	($97,891)
At I-610		2407	2721	-314	18	$65,090	2574	2342	232	8	$21,373
Outside I-610		2887	2822	65	136	$102,171	3517	3185	331	60	$228,997
					@1:30 =	$0				@1:30 =	$16,978
					@4:00 =	$142,901				@4:00 =	$495,996
					@5:30 =	$27,363				@5:30 =	$152,479
					TOTAL =	$170,264				TOTAL =	$665,454

Table 9. Benefits for Southwest Freeway MAP (continued)

$125,013	=	Cost Savings to Assisted Motorists
$301,530	=	One Year Benefit from Shoulder Incidents
$3,386,044	=	One Year Benefit from One Lane Incidents
$3,812,587	=	Total Benefit of Southwest Freeway MAP
$17,075	=	Annual Cost per Van with Three-Year Depreciation (includes purchase, maintenance, and equipment cost)
$146,000	=	Labor Paid by TxDOT and METRO (Four Deputies)
$16,333	=	TxDOT Administrative Costs (salaries, radio, lens, and phone)
$196,483	=	TOTAL COSTS
19	=	ESTIMATED B/C RATIO

Some incidents, depending on location and traffic volumes, actually decreased the overall delay and are shown in Table 9 as negative numbers. This occurs because some incidents upstream of the I-610 entrance ramps metered or restricted the Southwest Freeway traffic which improved I-610 entrance ramp operations enough to offset the delay of traffic queuing behind the incident. This decrease in benefits as a result of removing these incidents was included in the benefit calculations.

The value of time in this equation was determined from a TTI report (9) which derives the value of time using a speed choice model which assumes a rational driver chooses a speed so that the total driving costs are minimized. The total driving costs include value of time and operating cost, accident costs, and traffic violation costs. The study recommends a value of time of $10.47 for 1992, which is adjusted using the current Consumer Price Index value.

BENEFIT-COST ANALYSIS

Benefits

The calculations of total benefits to other motorists are shown in Table 9. This total benefit is divided into the benefits of clearing incidents blocking the shoulder and one lane, which are $301,530 and $3,386,044, respectively. Including the $125,013 saved by assisted motorists, a total benefit of $3,812,587 was assigned to motorists who drove in the Southwest Freeway construction zone during a one-year period between August 1991 and July 1992.

Costs

The total cost to operate two MAP vehicles on the Southwest Freeway for one year is approximately $196,500. The MAP costs were divided into labor, vehicle, and administrative costs. The labor costs include the gross earnings and fringe benefits for four Harris County Sheriff's deputies and part of the services of a clerk. The vehicle costs include the cost of two mini-vans, the equipment for each van, and the maintenance for each van. The administrative costs include the costs of managing the Southwest Freeway portion of MAP by TxDOT.

The total labor costs, which included nineteen deputies and one clerk, were calculated for the entire MAP operations and were paid from TxDOT and METRO funding. These costs were totaled for one year and were averaged on a per deputy basis. The labor costs for the

Southwest Freeway MAP operations were calculated to be $146,000 for one year for the four deputies and 4/19 of the clerk. It was assumed that since four of the nineteen deputies were patrolling the Southwest Freeway then 4/19 of the clerk's time went to working with these deputies.

The purchase price of each MAP vehicle is $16,300 unequipped and approximately $23,450 fully equipped. The annual maintenance as reported by HCSD is an average of $8,400 per MAP vehicle. Maintenance includes gas, oil, parts, and labor needed to keep the vans in good operating condition. Assuming a salvage value of $2,500 and a three year depreciation period, the yearly cost to purchase and operate the vehicles is $17,075 per vehicle per year.

TxDOT estimated the administrative costs for managing the Southwest Freeway portion of MAP at $16,333. These costs include the salaries for the management and other dispatch personnel, office lease, and other necessary amenities.

Benefit-Cost Ratio

A benefit-cost ratio of 19 was calculated for the Southwest Freeway MAP. The total benefit of 3.8 million dollars includes the benefit of travel time savings that motorists experienced when capacity reducing incidents are removed from the freeway ($3,687,574) and the savings of assisted motorists ($125,013). The total costs of $196,500 represents the costs to operate MAP on the Southwest Freeway for one year.

RESULTS

The Houston Motorists Assistance Program (MAP) on the Southwest Freeway during reconstruction has proven to be a cost effective method of managing traffic in a construction zone. This study estimates a benefit-cost ratio of the program at 19. A cost benefit of $3.8 million was experienced by Southwest Freeway motorists for one year because MAP reduced the average duration of incidents by about 16.5 minutes and because the assisted motorists received free services. Costs were estimated at $196,500, which includes Harris County Sheriff's labor costs, MAP vehicle purchase and maintenance costs, and TxDOT administrative costs. Patrolling two MAP vans on congested freeways that are being reconstructed is a proven, cost efficient method of managing traffic.

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