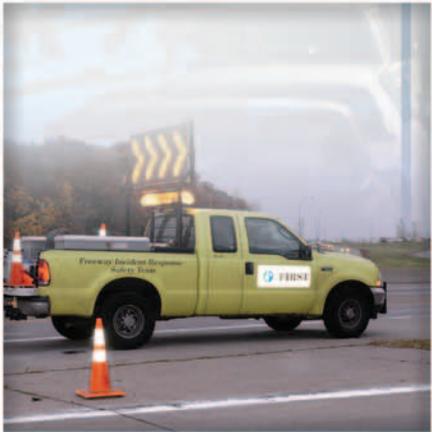


# Minnesota Department of Transportation FIRST Program Evaluation

November 2004



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## Executive Summary

The Freeway Incident Response Safety Team (FIRST) is an incident management measure designed to assist disabled vehicles along congested freeway segments and relieve peak period non-recurrent congestion through quick detection, verification, and removal of freeway incidents. The primary purpose of the FIRST Program is to alleviate congestion and to prevent secondary crashes.

This report evaluates the activities of Mn/DOT's FIRST Program to determine the cost effectiveness of the program. This was done by researching similar programs and evaluating congestion reduction environmental impacts and improved safety through secondary crash reduction.

To evaluate the program, information and data was collected and researched by the following methods:

- Interviewing FIRST staff and the Minnesota State Patrol
- Review of operations of other freeway service patrols around the United States
- Observation of operations at the FIRST Dispatch Center located at the Regional Transportation Management Center (RTMC)
- "Ride Alongs" with FIRST personnel throughout the FIRST coverage area
- Simulation modeling
- Review of crash data
- Development of a benefit/cost (B/C) analysis

From this data, analysis was done to determine the monetary benefits of the FIRST Program.

The previous benefit estimate in 2000 was \$2.73 million, which consisted only of delay and fuel consumption. The total program benefit in 2003 is estimated at \$16.62 million. This increase is due to several factors, including the addition of emissions measures and the general expansion of the program, but most of the increase is due to the inclusion of the secondary crash reduction benefit.

Mn/DOT expenditure and budget data provides an estimate of the annual cost of the FIRST Program. The cost items include staff, vehicles (including annualized depreciation), associated equipment, operating and maintenance costs, facilities, supplies, utilities, computers, communications, and other equipment.

The following table shows the total of the benefits and costs for the operation of the FIRST Program in 2003.

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**Benefit/Cost Summary (2003)**

Total Costs	\$1,052,242
Total Benefits	\$16,624,875
Net Benefits	\$15,572,633
Benefit/Cost Ratio	15.8:1

This evaluation found the FIRST Program benefit cost ratio of 15.8:1 to be mid-range of other areas' ratios across the nation, which nation from 3.4:1 to 36:1.

In addition to determining the monetary benefit of the FIRST Program, the "ride alongs" provided the opportunity to identify changes for consideration in improving the operation of FIRST. As part of this project, we recommend that the following changes in FIRST operation be discussed and reviewed for incorporation into this program.

- Improve communications between FIRST and State Patrol units by providing text messaging between vehicles or allowing access to State Patrol station talk groups.
- Add additional vehicle lighting on FIRST trucks to improve visibility and improve effectiveness of working in traffic. Improvements include adding additional rear facing lights, adding blue lights, and adding flashing lights to the vehicle grill.
- Develop "quick clearance" legislation that will allow the FIRST Program, Mn/DOT, and State Patrol to quickly remove incident without being held liable for additional damages caused to vehicles and goods.
- Develop legislation that would give "towing authority" to Mn/DOT including the FIRST Program. This would allow for the quicker removal of abandoned vehicles that cause additional congestion and are a potential safety hazard to passing motorists.

# Minnesota Department of Transportation

## FIRST Program Evaluation

Prepared by Short Elliott Hendrickson Inc.

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### 1.0 Introduction

The Freeway Incident Response Safety Team (FIRST) is an incident management measure designed to assist disabled vehicles along congested freeway segments and relieve peak period non-recurrent congestion through quick detection, verification, and removal of freeway incidents. The primary purpose of the FIRST Program is to alleviate congestion and to prevent secondary crashes.

This report evaluates the activities of Mn/DOT's FIRST Program to determine the cost effectiveness of the program. This was done by researching similar programs and evaluating congestion reduction environmental impacts and improved safety through secondary crash reduction.

### 1.1 Background

The objectives of the FIRST Program Evaluation are to evaluate the effectiveness of the FIRST on the 160-mile freeway system in the Minneapolis-St. Paul metropolitan area. Specifically, an evaluation methodology has been developed to estimate the effectiveness of reducing congestion and secondary crashes, and to develop a benefit/cost (B/C) analysis based on the findings of the evaluation.

Information and data was collected and researched by the following methods:

- Interviewing FIRST staff and the Minnesota State Patrol
- Review of operations of other freeway service patrols around the United States

- 
- Observation of operations at the FIRST Dispatch Center located at the Regional Transportation Management Center (RTMC)
  - “Ride Alongs” with FIRST personnel throughout the FIRST coverage area
  - Simulation modeling
  - Review of crash data
  - Development of a Benefit/Cost (B/C) analysis

An evaluation study conducted in 1991 determined the Highway Helper Program should be transferred to the Mn/DOT Metro Division’s Freeway Operations section. Prior to 1991, the Highway Helper Program was under the Mn/DOT Metro Division Maintenance System. The Highway Helper Program move to the Freeway Operations has allowed the program to be more fully integrated with other traffic management initiatives. This move was completed in 1993.

Under the Freeway Operations Section management section, drivers were reclassified to “Highway Helper”, which allowed the program to hire individuals with skills specifically related to motorist assistance.

The name was changed from Highway Helper to FIRST in 2003 to reflect the role FIRST plays in removing incidents on the freeway.

The FIRST Program role includes the following:

- Detect freeway incidents by patrolling metro freeways
- Quickly respond and remove incidents
- Provide traffic control and scene security at crashes by activating the large arrow board on top of the FIRST truck
- Assist State Patrol with first aid at crash sites
- Open and close the I-394 HOV lane gate arms several times a day

## **2.0 FIRST Operations**

### **2.1 FIRST Incident Management Program Coverage**

The FIRST Program covers critical freeway segments utilizing a route structure to optimize response times. In 1987, the Highway Helper Program began operation with three routes in the Twin Cities metro area covering approximately 40 miles. Highway Helpers patrolled the three routes during AM and PM peak

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periods. In January 1990, the Highway Helper program was expanded from three to six routes covering approximately 75 miles of freeway. In 1996, an additional route was added using Congestion Mitigation and Air Quality (CMAQ) funding. Currently, there are eight routes that cover approximately 160 miles or 53% of the 300 mile metro area freeway system.

The FIRST Program has eight routes that are driven from 5:30 a.m. to 7:30 p.m., Monday through Friday. Specific routes are also covered on weekends as required for events. Each route is driven by one specially marked and equipped pickup truck, occupied only by the driver.

The routes driven are in the Minneapolis-St. Paul metropolitan area and include portions of the following roadways: I-35E, I-35W, I-94, I-394, I-494, I-694, TH 36, TH 62, TH 77, TH 100, and TH 169. A map of the FIRST routes is located on the following page.

## **2.2 FIRST Unit Field Operations**

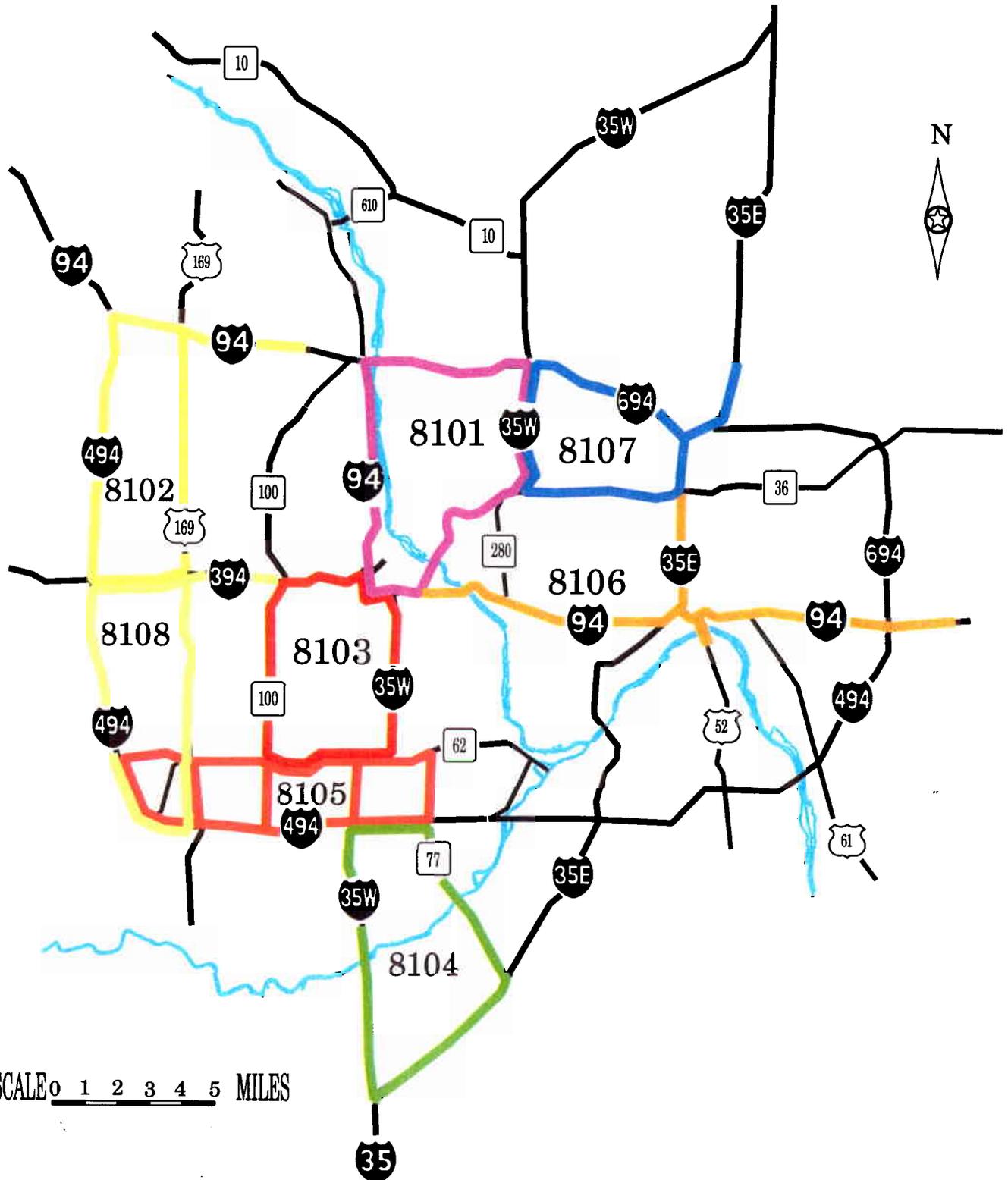
The operation of FIRST vehicles in the field is controlled by the following policies and procedures, which are contained in the Appendix.

- Mn/DOT Highway Helper Procedures
- Highway Helper & TMC Dispatcher Joint Operating Policies and Procedures
- Highway Helper Mobile 2-Line Message Sign

Each FIRST truck is equipped with the following equipment:

- Equipment to change a tire
- Air compressor
- Tow strap
- Gasoline containers
- Material to soak up spills
- First aid kit
- Amber light warning system
- Changeable message sign
- Air horn, speaker
- Cell phone
- Automatic Vehicle Locating (AVL) system

# FIRST ROUTES



NOVEMBER 13, 2002

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Observations were made of FIRST field operations by accompanying three separate drivers on their routes. This was done on:

- Route 8105  
Wednesday, June 16, 2004  
1:30 p.m. – 5:30 p.m.
- Route 8103  
Wednesday, June 16, 2004  
3:30 p.m. – 7:00 p.m.
- Route 8106  
Thursday, June 17, 2004  
6:30 a.m. – 9:00 a.m.

The 8105 “ride along” came across six incidents during the four-hour observation period and provided assistance for two of the incidents. In both instances where assistance was rendered, the FIRST vehicle, using its large sign board and lights, provided room for the vehicles involved in the incident to merge back into traffic flow or move from the left interior lane to the outside shoulder lane.

On the Route 8103 “ride along”, the driver stopped for six incidents and provided assistance for four of the incidents. Assistance was provided for a crash scene, overheated vehicle, stalled vehicle, and a vehicle with a flat tire. The assistance included providing lane closures, cleaning up crash debris, instructing driver to move vehicle out of the roadway, allowing driver to use cell phone, providing room for driver to merge into traffic, and changing a tire.

The Route 8106 “ride along” encountered six incidents. Assistance was provided for two of these incidents. The assistance included providing room for driver to merge into traffic and changing a tire.

These observations found the FIRST drivers to be very observant, safe, and courteous drivers. Also, very evident was the hazardous situations that these drivers are often exposed to, due to the nearness to moving traffic, and the speed of that traffic.

The “ride alongs” provided the opportunity to identify changes for consideration in improving the operation of FIRST. As part of this project, we recommend that the following changes in FIRST operation be discussed and reviewed for incorporation into this program.

- 
- Improve communications between FIRST and State Patrol units by providing text messaging between vehicles or allowing access to State Patrol station talk groups.
  - Add additional vehicle lighting on FIRST trucks to improve visibility and improve effectiveness of working in traffic. Improvements include adding additional rear facing lights, adding blue lights, and adding flashing lights to the vehicle grill.
  - Develop “quick clearance” legislation that will allow the FIRST Program, Mn/DOT, and State Patrol to quickly remove incident without being held liable for additional damages caused to vehicles and goods.
  - Develop legislation that would give “towing authority” to Mn/DOT including the FIRST Program. This would allow for the quicker removal of abandoned vehicles that cause additional congestion and are a potential safety hazard to passing motorists.

### **2.3 Application of FIRST Resources to Incident Management**

The efficiency of the FIRST Program or any freeway service program is reflected in the following critical aspects of its operations.

- How long it takes a FIRST unit to reach the reported incident site after the being contacted by the RTMC.
- What is the average travel distance for FIRST units to reach the incident site?
- How long it takes the FIRST unit to clear various types of accidents.
- What is the approximate reduction in the incident blockage time due to the operations of FIRST Program?

Understanding the above aspects is important for determining the efficiency and B/C from the time the incident report is received to the complete removal of any resulting blockage.

#### **2.3.1 Incident Detection and Management**

Incidents on the FIRST Program roadway network can be detected by RTMC surveillance cameras, by the State Patrol, and other emergency responders, by roadway users calling from cell phones, and by FIRST units themselves.

The FIRST Program manages freeway traffic flows with the goal of greater efficiency and safety. A key component to achieving this

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goal is the presence of the FIRST Dispatch Center, which operates within Mn/DOT's RTMC. The metropolitan area freeway system is equipped with cameras, which are connected to monitors in the RTMC. The cameras scan the freeway system for problems and incidents, which affect traffic flow on the freeway system.

This Center also receives phone calls informing them of incidents. Phone calls and two-way radio contact are also received from Mn/DOT maintenance vehicles and the State Patrol.

The Dispatch Center relays information on incidents to the nearest FIRST field unit.

Observation of the operations of the FIRST Dispatch Center was conducted on June 7, 2004. The operators in the Dispatch Center have many demands. They are required to:

- Complete a log of incidents.
- Observe monitors.
- Communicate with the FIRST drivers.
- Listen to audio scanners from Mn/DOT Maintenance and State Patrol.
- Communicate with RTMC, Mn/DOT Maintenance, and State Patrol.

A copy of the log and applicable policies and procedures are included in Appendix A.

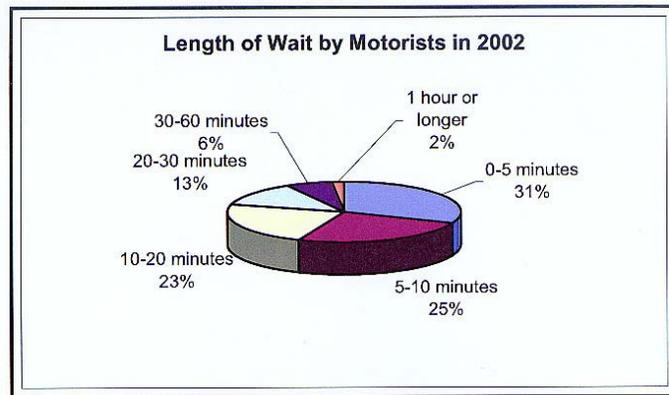
Overall, effective management of the FIRST Program relies on communication, coordination, and cooperation from Mn/DOT law enforcement agencies and roadway users.

### **2.3.2 Response**

The FIRST Program covers critical freeway segments using route structure to optimize response times. The FIRST routes have been selected based on the potential for incident created congestion. Factors Mn/DOT used in this determination included roadway characteristics, extent and severity of daily congestion, number of incidents, and the presence or absence of an on line ramp metering system with video surveillance.

The FIRST unit routes are approximately 13 miles in length, and the same routes are used for a.m. and p.m., Monday through Friday. The most recent data obtained from roadway users is displayed in Figure 1.

Figure 1



Compiled from motorist comment cards

Minnesota Department of Transportation, Highway Helper 2002 Summary Report

The ability of the FIRST unit to respond to an incident is best described as the timeframe from the moment the FIRST dispatcher has received a reported incident to the arrival of the FIRST unit at the incident site. In 2002, approximately 79% of disabled vehicles were responded to in less than 20 minutes. Market research has shown that after 20 minutes have passed, drivers are more likely to leave vehicles in search of assistance. Most drivers realize they are safer in their vehicles; however, they tend to have a patience threshold, which if exceeded, results in drivers making poor choices.

When an incident is detected, either surveillance cameras or the FIRST unit verify the incident and determine what assets are required to deal with the situation. This may include calling for the State Patrol, ambulance, fire truck, a tow truck/wrecker, a hazardous materials units, and/or traffic control support.

### 3.0 Research

As part of this evaluation, available data from throughout the United States identifying effective methods for reducing congestion and secondary crashes was gathered. The primary purpose of this endeavor is to determine whether the FIRST Program is as good as it can be.

#### 3.1 Secondary Crashes

Freeway service patrols throughout the United States report a wide variation in observed secondary crash rates. Estimates range from 1.5% on Los Angeles freeways to 35% on an expressway near Gary, Indiana. This variation is due to several factors.

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First, there is no consensus on the definition of a secondary crash. A recent study reported:

“[r]educations in secondary accidents are a very important kind of benefit of urban ITS deployments. Reliable data, however, are virtually nonexistent. Accident records frequently have no place to indicate that an accident was a secondary accident except in a field for general comments. As a result, some records may show no indication that an accident was caused by backup from a previous accident rather than some other cause...Consideration is still being given to the identification of secondary accidents, but to date no means of reliably distinguishing secondary accidents from primary accidents has been identified.”<sup>1</sup>

Clearly, researchers using different definitions of a secondary crash will arrive at different conclusions concerning the incidence of secondary crashes.

Researchers use two basic methods to define a secondary crash. The most common method used archived data and simply assumes that any crash occurring in close proximity (i.e., within x miles and within y minutes) to a primary incident must be a secondary crash. Although researchers agree that “close proximity” comprises closeness in both time and space, they differ in preparing these concepts. How close in time (½ hour, 1 hour, 2 hours)? How close in space (½-mile, 1-mile, 2 miles)? Should crashes in the opposite direction (due to gawkers) be included?

The second approach videotapes the crashes and then relies on traffic control operators to watch the film and categorize each observed crash as either primary or secondary.

Both approaches have drawbacks. Using an algorithmic definition of proximity will lead to both false alarms and missed targets. On the other hand, filming the crashes is subjective inasmuch as it relies on human judgment to decide whether a given crash is really due, in whole or in part, to a primary incident (i.e., two different operators may classify the same crash differently => repeat validity is questionable).

In short, unless researchers develop a universal and operational definition of a secondary crash, we will continue to observe wide variations in reported secondary crash rates.

The second reason for the wide variation in observed secondary crash rates is that studies differ with respect to the scope of

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<sup>1</sup>Meyer, E. and C. Sun, August 2003, “Using Reidentification to Evaluate the SCOUT Traffic Management System,” Proceedings of the 2003 Mid-Continent Research Symposium, Iowa State University, Ames, Iowa.

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primary incidents considered. That is, some studies consider secondary crashes that are caused by crashes only, while other studies consider secondary crashes caused by all types of primary incidents (crashes, vehicle disablements, debris, etc.). Obviously, the latter approach should identify more secondary crashes and result in a higher secondary crash rate, all else being equal.

Third, the specific roadways being evaluated vary across the studies with respect to safety-related features. Highways with a freeway management system or a motorist assistance patrol, for example, should have a lower secondary crash rate than highways without such programs. Similarly, highways with fewer horizontal and vertical curves should have a lower secondary crash rate than their curvier counterparts.

Appendix B provides an annotated bibliography of secondary crashes, which are grouped into two categories:

- Internet sources
- Studies

The internet sources appear on the Web without supporting documentation, while studies are more serious endeavors. In some cases, it is likely the internet sources can be traced to formal reports or studies.

### **3.2 Benefit/Cost Studies of Freeway Service Patrols (FSPs)**

This section examines nine benefit/cost studies of FSPs in: Boston, Massachusetts; Chicago, Illinois; Denver, Colorado; Gary, Indiana; Houston, Texas (both regular and special programs); Los Angeles, California; San Francisco, California; and the Twin Cities, Minnesota. Key facts and findings from these studies are summarized in the FSP Summary and the annotated bibliography in Appendix C.

The literature reports a wide variation in B/C ratios of FSPs. Estimates range from 3.4:1 in San Francisco, California to 36:1 in Houston, Texas. Even within studies, estimates vary considerably. In one of the Houston studies, for example, the B/C ratio ranges from 7:1 to 36:1, depending on the assumed impact of the FSP on incident durations.

Although a complete account of all sources of variation in B/C ratios is beyond the scope of this project, it is clear that most of the variation is due to several key factors. Primary sources of variation that are evident from the studies include:

- Specific categories of benefits and costs included in the analyses

- 
- Critical assumptions about the effectiveness of the programs
  - Critical assumptions about the value of the estimated benefits

Other sources of variation that are not as easily discerned from the studies include:

- Program operating characteristics
- Prevailing traffic conditions in the study areas.

Each of these sources of variation is discussed below.

### **3.2.1 Categories of Benefits**

Freeway service patrols provide society with many types of benefits, including travel time savings, fuel savings, emissions reductions, crash avoidance, and increased security to motorists. However, many of these benefits are difficult to quantify and monetize. As a result, B/C studies tend to consider only one or two types of benefits.

All nine studies monetize the travel time savings (i.e., reductions in delay) associated with a FSP. Boston, Gary, Los Angeles, San Francisco, and the Twin Cities also monetize fuel savings. Boston, Los Angeles, San Francisco, and the Twin Cities quantify emissions reductions, although only Boston takes the next step and monetizes the emissions reductions. Gary is the only study to include avoided crashes. Finally, one of the Houston studies includes aid to stranded motorists. No study includes all of the benefit types.

Travel time savings account for the majority (and in some cases all) of the benefits reported in each of the studies reviewed. Fuel savings, when included, account for 4% to 8% of total benefits. Emissions reductions account for 1% of the total benefits in the Boston study (note that valuing emissions reductions is somewhat controversial, especially in areas that are in full compliance with the Clean Air Act). Avoided crashes account for 27% to 32% of the total benefits in the Gary study; however, the authors used very conservative values of avoided crashes, so it is likely this category should have accounted for a much higher percentage of total benefits. Finally, it seems inappropriate to include “aid to stranded motorists” as a benefit category simply because most of this is a transfer from one segment of society to another (i.e., there is no efficiency gain or economic benefit to society if a FSP tows a stranded motorist “for free” as opposed to the motorist calling a private tow truck operator and paying out of pocket; the only

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difference is who pays and who benefits...society as a whole is not better off either way).

In summary, it appears that the most important benefit categories are delay savings and crash avoidance.

### **3.2.2 Categories of Costs**

Although the studies use different terminologies, it appears that they all include personnel salaries and benefits, equipment costs, supplies, operating costs, and maintenance. However, some of the studies do not appear to include administrative overhead (e.g., costs of administrative personnel, leasing/maintaining facilities, utilities, etc.). These omissions are likely due to differences in stakeholder perspectives adopted by the studies. That is, some studies (e.g., Chicago) adopt a societal perspective and include the economic value of all resources used by the program, including resources (e.g., buildings/facilities, equipment) that were donated to the program or paid by other public entities, while other studies adopt a narrower perspective and include only costs that are paid by the program directly.

### **3.2.3 Assumptions about Program Effectiveness**

Perhaps the largest source of variation in B/C ratios is the estimated/assumed impact of the FSPs on incident durations. Because delay is a quadratic function of incident duration, program effectiveness (with respect to delay savings) is primarily dependent to the impact of the FSP on incident duration. As seen in the FSP Summary Table in Appendix C, programs with relatively large B/C ratios tend to estimate/assume that their FSPs have relatively large impacts on incident durations. For example, Boston has a B/C ratio of 19:1 and assumes its Motorist Assistance Program (MAPs) reduce incident durations by 15 minutes to 30 minutes; Chicago has a B/C ratio of 17:1 and assumes its Emergency Traffic Patrols (ETPs) reduce incident durations by 20 minutes to 40 minutes. In contrast, the Twin Cities have a B/C ratio of 4.4:1 and assume the FIRST units reduce incident durations by only 0 minutes to 8 minutes.<sup>2</sup> Similarly, the Houston B/C ratio varies from 7:1 to 36:1 as the assumed impact of the FSPs on incident duration increases from 5 minutes to 20 minutes.

Given that the B/C ratio depends strongly on the impact of the program on incident durations, it is natural to question whether these estimated/assumed impacts are accurate. In practice,

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<sup>2</sup> The B/C ratio of the Twin Cities program is relatively small. This is most likely due to: (1) the assumption that Highway Helper reduces incident duration by a relatively low 0 minutes to 8 minutes, (2) the assumption of a relatively low \$10/veh-hr for delay savings, (3) excluding the benefits of assisting crashes, debris incidents, and “other” incidents, and (4) excluding the benefits of avoided crashes.

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estimating the impact on incident duration requires data both before and after implementation of the FSP. While “after” data are readily available in most cases (e.g., program logs), “before” data can be difficult to obtain. Therefore, many studies are forced to either: (1) assume the impact on incident durations, or (2) do a sensitivity analysis whereby they calculate the B/C ratio for a range of assumed impacts.

Moreover, the impact on incident duration is a function of regional incident management practices both before and after implementation of the FSP. All else being equal, FSPs probably have a smaller impact on incident durations in regions that have a freeway management system (or traffic operations center), a rotational tow truck program, quick-clearance legislation, accident investigation sites, a toll-free number to report incidents, etc. In short, regions with relatively few or undeveloped incident management procedures will probably benefit more from a FSP than their more sophisticated counterparts. This also suggests that B/C studies conducted in the early 1990s should be redone, as the impact of the FSPs on incident duration is probably smaller today than it was 10+ years ago when cell phones and toll-free incident numbers were much less popular.

#### **3.2.4 Assumptions about Valuing the Benefits**

The B/C ratios of the FSPs vary also because the studies assume different real values for the same measures of effectiveness. For example, all of the studies monetize the value of delay savings. However, one of the Houston studies assumes \$12.20/veh-hr in 1991, while the Twin Cities study assumes \$10/veh-hr in 2000. These are very different assumptions in real terms. The B/C ratio of the Houston program will be much higher than the B/C ratio of the Twin Cities program (even if there is no real difference in effectiveness between the two programs).

Differences in assumptions about fuel costs and the value of emissions reductions are less important, inasmuch as these benefit categories account for a relatively small portion of total benefits. However, assumptions about the value of avoided crashes are very important, inasmuch as this category has the potential to account for a relatively large portion of total benefits.

#### **3.2.5 Program Operating Characteristics**

Other factors that affect the B/C ratio of a FSP include the number and type of patrol vehicles, training provided to drivers, hours of operation, and dispatching strategy (e.g., priority versus first-encountered-first-served). Since additional vehicles, better driver training, and extended hours of operation all can be expected to increase both benefits and costs of the program, the impact of these

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factors on the B/C ratio is unclear without further analysis. It seems clear, however, that patrols should be dispatched to handle severe incidents before minor incidents (as is done in Chicago), as opposed to being required to stop and assist every stranded motorist in the order in which they are encountered on the freeway, even if more severe incidents exist elsewhere on the route (as is done in Boston). Note that priority-dispatch is more feasible when the program is funded through public revenues (taxes), as opposed to when it is funded by private sponsors who do not want to develop ill-will by ignoring stranded motorists (even if it is to get to a more severe incident downstream).

### **3.2.6 Prevailing Traffic Conditions**

Although information about prevailing traffic conditions is not typically included in the studies, it makes sense that total benefits would be a function of the number and types of incidents assisted, traffic demand, and roadway characteristics. For example, routes that experience more incidents (or a larger proportion of severe incidents) or that have a higher traffic demand should produce higher B/C ratios. Road characteristics (e.g., lane widths, capacities, presence of shoulders) affect the delay associated with a given incident, which in turn, affects the delay savings attributable to a FSP. For example, roads without shoulders will experience greater delays (and greater delay savings due to a FSP) when incidents occur. Furthermore, if road capacity far exceeds demand at the time of the incident, delay (and delay savings) will be relatively small.

## **4.0 Benefit/Cost Evaluation**

The objective of the economic portion of the Mn/DOT FIRST Program Evaluation is to quantify the benefits and costs associated with the program. The January 2000 Mn/DOT Highway Helper Summary Report lists the following benefits of the incident response program:

- Aid to stranded motorists
- Decreased delay
- Fuel and emissions reduction
- Improved safety for those involved in incidents
- Safe clearance of blocking incidents
- Improved resource allocation
- Improved public perception

However, only two measures were quantified and included in the total benefits: delay and fuel consumption. The two critical benefits this evaluation adds are reductions in emissions and

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secondary crashes. Many measures are not easily quantifiable (e.g., motorist security) and will not be included in the benefit estimate.

For this study, a combination of empirical analysis and microsimulation is used to determine the various benefits. A body of empirical research already exists to aid in estimating the benefits based on current data. Microsimulation is employed to determine the congestion extent, severity, and duration caused by an incident. Changes in congestion are used to estimate the different benefits of the FIRST Program.

Modeling incidents is a rare application, and few software programs do it. The program used for this study is Paramics, an advanced microsimulation package developed in the United Kingdom. With this program, hundreds of scenarios are modeled with varying parameters including road geometry, location (lane) of incident, traffic demand, and duration of the incident. Each model results in an area of congestion emanating upstream from the incident, and generally persisting beyond the time the incident is cleared.

Many variables affect the extent and duration of congestion caused by an incident. Due to lack of data and scope limitations, most of these are not included (e.g., road grade, ramp and weaving areas, weather, special event traffic, light conditions, severity of an incident, etc.). To further define the range of conditions, the simulation portion focuses on a typical three-lane (each direction) freeway section in the Twin Cities area.

A limitation of the microsimulation used for this study is the inability to model incidents on the shoulder of the freeway. Examples of this include a stalled vehicle, a vehicle with a flat tire, substantial debris, or median maintenance. Rather than rely on simulation, an analytical approach is used. The Federal Highway Administration (FHWA) Traffic Incident Management Handbook shows that typical shoulder incidents result in an overall capacity reduction of about 5%.

If the current traffic demand is less than the reduced capacity of the road, no queuing is assumed to occur, thus no influence on secondary crashes. If the current traffic demand is greater than the reduced capacity from the shoulder incident, then congestion is assumed to occur in accordance with deterministic queuing theory.

The range of results from the simulation models and the shoulder blocking are then applied to actual incidents the FIRST personnel respond to. This in turn provides benefit estimates for reduction of delay, fuel consumption, emissions, and secondary crashes. The following subsections are the key benefits to be quantified.

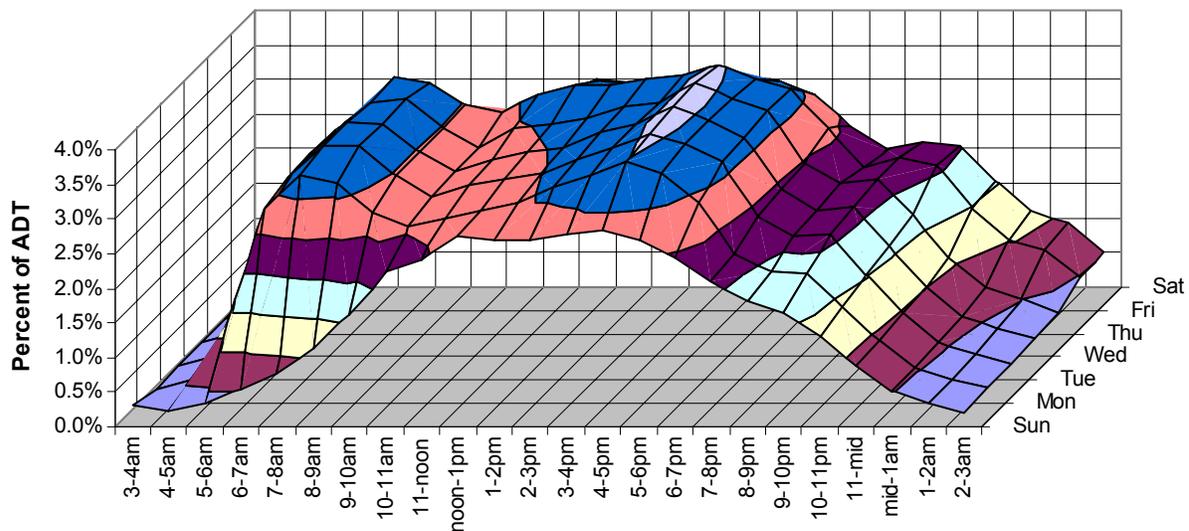
#### 4.1 Congestion Reduction

Debris in the road, disabled vehicles on the shoulder, crashes, and other incidents all increase travel time. This delay depends on the severity and location of the incident, how long the incident persists, and other factors. An objective of the FIRST Program is to expedite the clearance of incidents to reduce delay to motorists.

The benefit from reducing delay or congestion is a function of the traffic demand, the capacity of the road, the duration and location of the incident, and other factors.

The database used in this analysis contained 2,036 incidents that the FIRST Program responded to in May 2003. An average daily traffic (ADT) volume was determined for each of these incidents based on its location. Then for each incident, the traffic demand at the time of the incident was estimated by multiplying the ADT at that location by a factor representing the day of the week and the hour of the day. That factor is calculated from automatic traffic recorder (ATR) data on freeways in Minneapolis (I-35W and I-94). Figure 2 graphically depicts the 168 factors (7 days x 24 hours) for each hour of a typical week in the Twin Cities.

**Figure 2 – Day and Hour Volume Factors from Twin Cities ATR Data**



Previous FIRST estimates of time reductions for various incident durations were used in this analysis.<sup>3</sup> Table 1 summarizes the

<sup>3</sup> Minnesota Department of Transportation Metropolitan Division. Highway Helper Summary Report, January 2000 and Highway Helper 2002 Summary Report, February 2003.

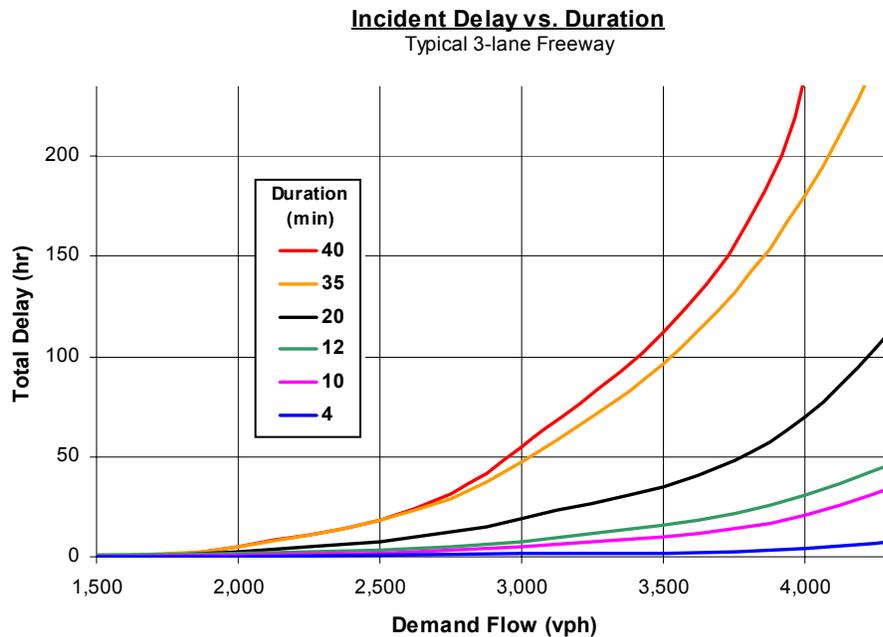
typical incident durations and the estimates of time saved with the FIRST Program.

**Table 1**  
**Average Blocking Incidents**

Blocking Duration	Percent of All Incidents	Average Blocking Time without FIRST	Average Blocking Reduction with FIRST
Less than 27 minutes	88.3%	12 minutes	8 minutes
27 to 57 minutes	8.9%	40 minutes	5 minutes
Greater than 57 minutes	2.8%	Greater than 57	0 minutes

With the aid of customized Excel VBA programming, a database was built from over 100,000 output files comprising data for hundreds of model runs in the Paramics simulation program. These covered a range of incident durations from 0 (no incident) to 40 minutes and locations in the left, center, and right lanes. Figure 3 summarizes the delay results of the simulation analysis.

**Figure 3 – Incident Delay vs. Duration**

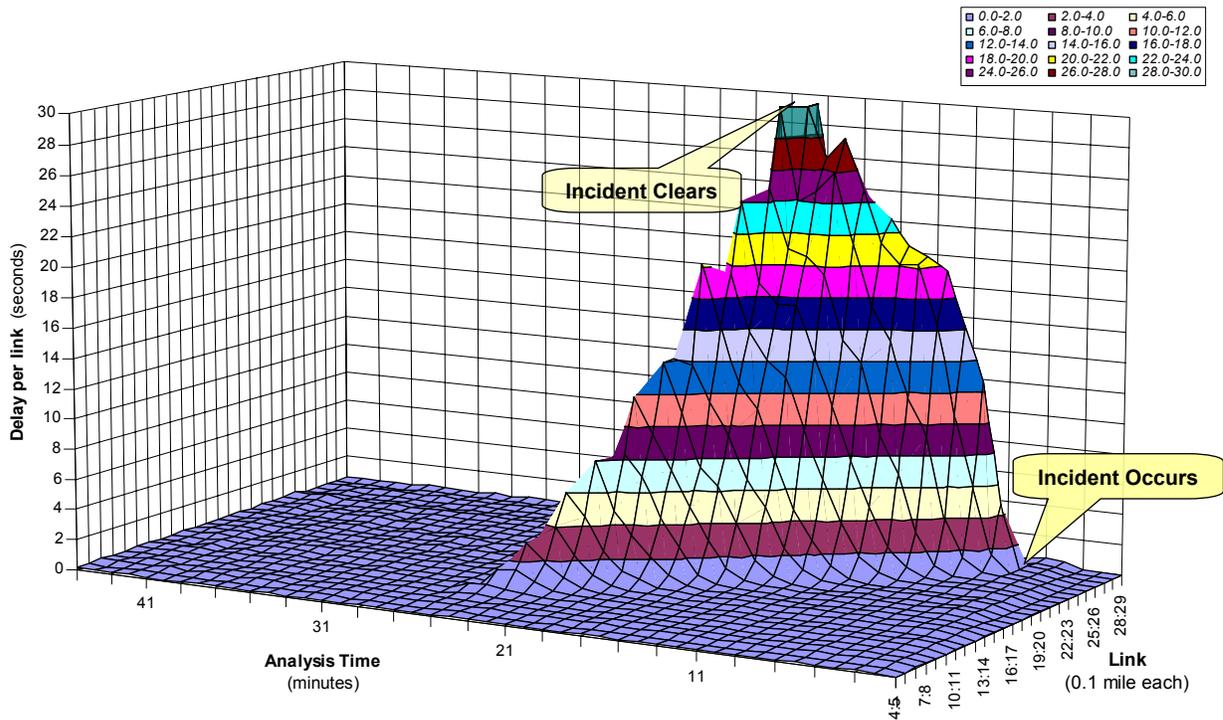


The X-axis shows the demand flow in vehicles per hour (vph) on a typical three-lane freeway section in the Twin Cities. The Y-axis shows total delay (in hours) and each line on the graph represents a blocking incident of different durations (from 4 minutes to 40 minutes). The delay shown is only the delay due to the blocking incident (non-recurring) and is in addition to delay due to congestion resulting only from higher demand flows (i.e., the recurring congestion is removed from this plot).

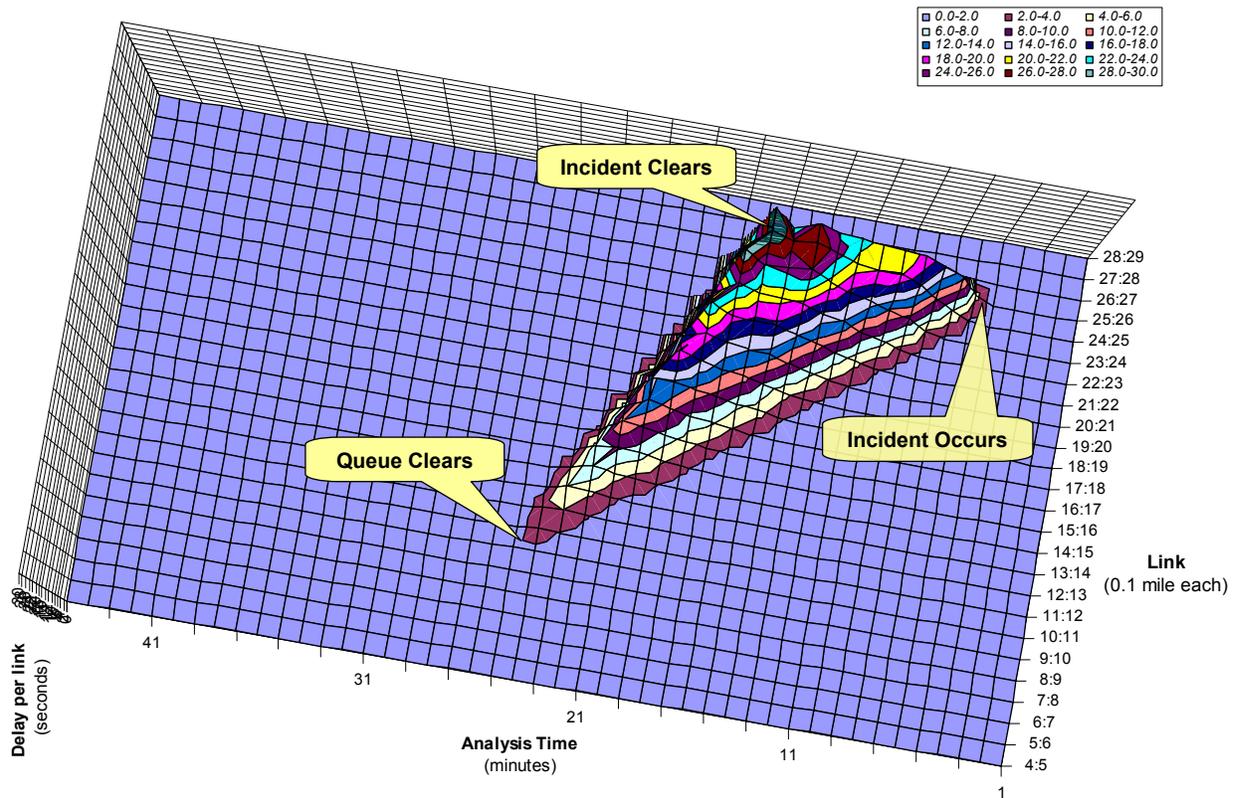
So for example, if the FIRST Program reduces a blocking incident duration from 12 minutes to 4 minutes while the demand flow is 4,000 vph, then the total delay savings for all travelers is about 27 hours. Converting to dollars based on values of time, this saves \$300 to \$400. The details of this conversion are discussed below.

Figures 4 and 5 illustrate the simulation results for one of the modeled scenarios, specifically a blocking incident with a 10-minute duration during a demand flow of 4,000 vph on a typical three-lane freeway section. The front axis on the horizontal plane shows elapsed time; the right axis on the horizontal plane shows the distance along the freeway (upstream in front, downstream in back); and the vertical axis is a representation of delay. Each graph is a separate view of the same data – the first is a front view, the second is a top view. The blocking incident occurs at the location labeled “25:26” and remains blocking from time equal 5 minutes to 15 minutes. This is a classic representation of a queue propagating upstream and then persisting beyond the time the blocking incident clears.

**Figure 4 – Delay from Blocking Incident**



**Figure 5 – Delay from Blocking Incident**



Applying the changes in resulting delay to the actual incidents provides an estimate of delay reduction. The 2,036 incidents in May 2003 include information on whether each was blocking a lane or if it was on the shoulder. While shoulder incidents are technically not blocking incidents, they do reduce the capacity of the roadway. The FHWA<sup>4</sup> showed that shoulder incidents still cause slightly over half the capacity reduction that a blocking incident has, on average. Earlier estimates showed less than this, so to remain conservative, this analysis assumes incidents on the shoulder to cause one-fifth the delay of an incident in a travel lane.

Delay is calculated for both an incident reduction from 12 minutes to 4 minutes and for an incident reduction from 40 minutes to 35 minutes, based on the estimated demand volume at the time of the incident. An average of these two results, weighted by the frequency of occurrence (see Table 2), is then determined for any incident shown to block a lane or occur on the shoulder.

Based on this methodology, about 82% of the incidents in May 2003 resulted in some delay savings, from less than a minute to 288 hours, the former for a mid-day stall on the shoulder, the latter from an injury crash on I-94 in downtown Minneapolis that

<sup>4</sup> FHWA Freeway Management and Operations Handbook, 2003.

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occurred at 3:50 p.m. on a Thursday. The total delay savings from the FIRST Program estimated for May 2003 is 24,818 hours.

This delay reduction is converted to dollars based on values of time recommended by Mn/DOT.<sup>5</sup> These values are based on USDOT guidance and were published November 2003. They are \$10.04 per person per hour of auto time and \$18.61 per truck. The estimates also incorporate characteristic auto occupancies and truck percentages, 1.2 persons and 5.0%, respectively. For example, the value of 1 hour of delay is:

$$1 \times [(\$10.04 \times 1.2 \times 95\%) + (\$18.61 \times 5\%)] = \$12.40$$

Applying this to the May 2003 data results in a annual benefit estimate of \$3.69 million. A summary of all the benefit figures is shown in Table 4 at the end of this section.

This estimate is \$1.14 million or 45% greater than the delay estimate in the January 2000 Highway Helper Summary Report. This is expected because the coverage of the FIRST routes is greater, and traffic volumes and congestion continues to increase. The delay benefit estimate is about 43,000 hours or 17% greater. Also, the value of time in the 2000 estimate did not include a factor for vehicle occupancy or for commercial vehicles. The value of time used previously was \$10/hour, while the aggregate value of time used in this estimate is \$12.38/hour.

#### **4.2 Environmental Factors**

The 2000 Highway Helper Summary Report includes three environmental measures: fuel consumption, hydrocarbon emissions, and carbon monoxide (CO) emissions. The economic portion, however, only applied a value to fuel consumption. The environmental factors in this analysis also include fuel consumption and emissions, the latter comprising CO, hydrocarbons (HC), and nitrogen oxides (NOx). These measures vary a great deal with vehicle speed and acceleration, which depend heavily on traveling conditions and congestion.

The associated benefit estimate, in dollars, is the reduction in these environmental factors due to the Mn/DOT FIRST Program. The environmental model used in this analysis is one maintained by FHWA and embedded into their popular simulation program, CORSIM. The embedded tables base the measures on vehicle speed and acceleration. The same model runs performed in Paramics were duplicated in CORSIM, in part for validation, and in part to provide the necessary environmental measures.

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<sup>5</sup> Mn/DOT Office of Investment Management, <http://www.oim.dot.state.mn.us>, 2003.

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The resulting savings estimates for May 2003 are as follows:

- Fuel (gasoline): 55,149 gallons
- Carbon Monoxide (CO): 22.54 tons
- Hydrocarbons (HC): 0.4340 tons
- Nitrogen Oxides (NOx): 1.226 tons

The monetary conversions for these are those used in the Mn/DOT Ramp Meter Evaluation.<sup>6</sup> The second route is to use the more comprehensive values that were used by Mn/DOT and Cambridge Systematics in the ramp meter evaluation work. The conversions are:

- Fuel (gasoline): \$1.56/gallon<sup>7</sup>
- Carbon Monoxide (CO): \$3,371/ton
- Hydrocarbons (HC): \$1,774/ton
- Nitrogen Oxides (NOx): \$3,625/ton

These four items amount to a total of \$2.01 million in benefits for 2003. Fuel consumption and CO benefits are much greater than the other two.

Although the year 2000 estimate did not monetize these items other than fuel, there are some differences to note. The fuel consumption savings is substantially higher – chiefly a result of the expanded FIRST Program, increasing traffic, and different methodologies rather than increased fuel prices (\$1.15 in 2000 versus \$1.56 in 2003). The CO savings shows a slight increase from the 2000 estimate. The HC savings is substantially less than what was estimated in 2000. NOx was not previously estimated. Overall, the previous environmental benefit (fuel consumption only) was estimated at \$0.18 million versus \$2.01 million in this analysis.

#### **4.3 Improved Safety**

A key component of the benefits estimation is the reduction of secondary crashes. Agencies and other evaluation studies generally agree that incident management reduces secondary crashes, but most also agree that this is a very difficult benefit to quantify. At the least, it had involved a subjective judgment by an emergency responder or a traffic control center operator. Another study defined all crashes occurring within 2 hours after a major incident and within 2 miles as a secondary crash.

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<sup>6</sup> Prepared by Cambridge Systematics, 2002. The conversion values therein are based on the ITS Deployment Analysis System (IDAS), FHWA.

<sup>7</sup> 2003 US Average Retail Price, Energy Information Administration, Washington, DC.

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Defining the influence area with the 2-hour/2-mile approach underestimates some secondary crashes, but likely overestimates most secondary crashes as the majority of incidents do not cause congestion of that magnitude. And the subjective approach is not amenable to estimating influence areas and secondary crashes within a large database containing thousands of crashes.

Traffic simulation is another approach that may yet show promise for determining the influence area of a primary crash. Very few programs model incidents and those that do would require thousands of runs to develop an adequate range of conditions. Many variables affect the extent and duration of congestion caused by an incident, but due to lack of available data, most of these cannot be modeled in an efficient manner (e.g., road grade, ramp and weaving areas, weather, special event traffic, light conditions, incident severity, etc.). The remaining variables that can be easily modeled include certain road geometry, number of lanes, location (lane) of the incident, traffic flow, and duration of the incident.

Prior research<sup>8</sup> shows that programs similar to the Mn/DOT FIRST result in an approximately 14% reduction in crashes on the covered road segments, chiefly attributed to the less severe crashes. This research is empirically based, thus more reliable than attempting to comb through a crash database arbitrarily guessing which crashes may be secondary crashes.

The FIRST Program reduces the incidence of secondary crashes, not necessarily primary crashes or other incidents. The secondary crash types are generally possible injury crashes and property damage crashes. Therefore, the crash reduction figure will be applied to these two types of crashes, while more severe crashes are assumed to be unaffected.

The 2003 crash data used for this analysis is supplied by Mn/DOT for the corridors covered by the FIRST Program. The two types of crashes affected are monetized using the Mn/DOT Office of Investment Management recommend values: Type C – possible injury is \$29,000 and Type N – property damage only is valued at \$4,200 per instance.

There were 662 crashes on the segments covered by the FIRST Program in May 2003. Factoring the Type C and N crashes up by 14% returns 763 crashes that would have occurred without the FIRST Program. Upon monetizing this difference, the total estimated crash reduction benefit for 2003 is \$10.93 million. This

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<sup>8</sup> Olmstead, T. *The Effects of Freeway Management Systems and Motorist Assistance Patrols on the Frequency of Reported Motor Vehicle Crashes*. Doctoral Thesis. Cambridge, MA. 2000.

benefit is approximately five times greater than the environmental benefits and three times greater than the delay benefit.

The previous benefit estimate in 2000 was \$2.73 million, which consisted only of delay and fuel consumption. The total program benefit in 2003 is estimated at \$16.62 million. This increase is due to several factors, including the addition of emissions measures and the general expansion of the program, but most of the increase is due to the inclusion of the secondary crash reduction benefit. Table 2 summarizes the economic benefits in this analysis.

**Table 2  
Total Economic Benefit Summary (2003)**

<b>Delay Benefit</b>		<b>Carbon Monoxide (CO)</b>	
Delay Avoided (Hours, May 2003)	24,818	CO Saved (tons, May 2003)	22.54
Delay Avoided (Hours, 2003)	297,816	CO Saved (tons, 2003)	270.4
Value of time per person	\$10.04	Cost per ton of CO	\$3,371
Average Vehicle Occupancy	1.2	<b>Annual CO Savings</b>	<b>\$911,609</b>
Value of time per commercial vehicle	\$18.61	<b>Hydrocarbons (HC)</b>	
Heavy Vehicle percent	5.0%	HC Saved (tons, May 2003)	0.4340
<b>Total Delay Savings (2003)</b>	<b>\$3,685,801</b>	HC Saved (tons, 2003)	5.207
		Cost per ton of HC	\$1,774
		<b>Annual HC Savings</b>	<b>\$9,238</b>
<b>Crash Benefit</b>		<b>Nitrogen Oxides (NOx)</b>	
Type K	\$0	NOx Saved (tons, May 2003)	1.226
Type A	\$0	NOx Saved (tons, 2003)	14.71
Type B	\$0	Cost per ton of NOx	\$3,625
Type C	\$571,233	<b>Annual NOx Savings</b>	<b>\$53,339</b>
Type N	\$339,809		
Total (May 2003)	\$911,042		
<b>Crash Savings (2003)</b>	<b>\$10,932,502</b>		
<b>Fuel</b>		<b>Total Economic Benefit</b>	
Fuel Saved (gallons, May 2003)	55,149	<b>Annual Savings (2003)</b>	<b>\$16,624,875</b>
Fuel Saved (gallons, 2003)	661,785		
User price per gallon	\$1.56		
<b>Annual Fuel Savings</b>	<b>\$1,032,385</b>		

#### 4.4 Program Costs

Mn/DOT expenditure and budget data provides an estimate of the annual cost of the FIRST Program. The cost items include staff, vehicles (including annualized depreciation), associated equipment, operating and maintenance costs, facilities, supplies, utilities, computers, communications, and other equipment. A summary is shown in Table 3.

**Table 3  
Total Cost Summary (2003)**

<b>FY 2003</b>	
<b>Staffing Costs</b>	
Salary and Benefits	825,327
<b>Subtotal Staffing Costs</b>	<b>825,327</b>
<b>Vehicle Costs</b>	
Maintenance	69,261
Fuel	57,729
Depreciation*	50,000
<i>*10 trucks – depreciation cost of \$5000 per year per truck</i>	
<b>Subtotal Vehicle Costs</b>	<b>176,990</b>
<b>Supplies/Equipment/Building Operations</b>	
AVL and Nextel Equipment	24,512
Uniforms, Supplies, Tools, Etc.	5,798
Building Operating Costs (Garbage, Etc.)	3,945
Employee Training*	300
AVL Systems Maintenance	7,674
<i>*Defensive Driving Course in 2002</i>	
<b>Subtotal Other Operating Costs</b>	<b>42,229</b>
<b>Communications Costs</b>	
Nextel Service	7,696
<b>Subtotal Communications</b>	<b>7,696</b>
<b>Total Annual Program Costs</b>	<b>1,052,242</b>

The cost components are much the same as the data used in the January 2000 analysis. From fiscal year (FY) 1999 to FY 2003, the annual cost of the FIRST Program increased by \$428,515 or 69% to \$1,052,242. The greatest contributors to this increase were a program expansion and increased coverage area.

#### **4.5 Benefit/Cost**

This evaluation of the Mn/DOT FIRST Program begins with gathering information from program personnel via meetings, observations, and ride alongs. The economic component builds on previous evaluations by researching new methodologies and reviewing the economic evaluations performed by other jurisdictions. The two key components to be added to the benefit tabulation are safety (secondary crash reduction) and environmental (emissions reduction). Table 4 shows the summary of findings from this analysis.

**Table 4  
Benefit/Cost Summary (2003)**

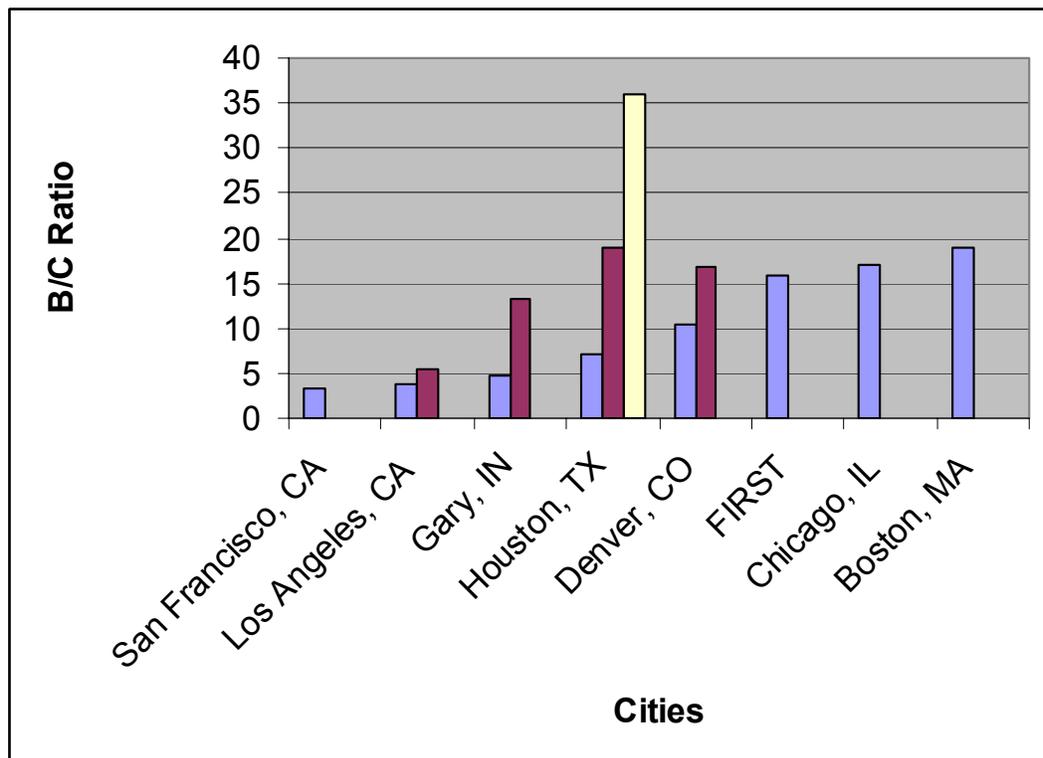
Total Costs	\$1,052,242
Total Benefits	\$16,624,875
Net Benefits	\$15,572,633
Benefit/Cost Ratio	15.8:1

While the total costs increased by 69% compared to the FY 99 estimate, the benefit estimation included additional factors and increased by six times for this FY 03 analysis. The net benefits are, therefore, seven times greater; the benefit cost ratio is revised up from 4:1 to 16:1.

**5.0 Findings and Conclusions**

Nationwide, there is a large variation in B/C ratios for FSPs. The analysis done in this study combines analytical and empirical analyses to arrive at the monetary benefits of the FIRST Program. The benefits come from reduced traffic delays, fewer secondary crashes, less fuel consumption, and lower emissions. Comparing the overall benefits to the program costs yields a B/C ratio of 15.8:1. A ratio of this magnitude reflects a significant public benefit for the investment. Figure 6 shows a comparison of the FIRST Program benefit cost ratio to others across the country.

**Figure 6 – Benefit Cost Ratio Comparison**



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While the benefit of the FIRST Program is significant, it may be understated. The assumptions made in this evaluation in the development of the benefit cost ratio were conservative. Specifically, the secondary crashes were not considered to be severe, while there have been cases of severe secondary crashes. Additionally, the FIRST Program provides traffic control and protection at crash scenes for responders and affected motorists. This safety benefit was not quantified.

While there is great benefit to the program, the study revealed operational changes that should be considered, which could further enhance the program.

The “ride alongs” provided the opportunity to identify changes for consideration in improving the operation of FIRST. As part of this project, we recommend that the following changes in FIRST operation be discussed and reviewed for incorporation into this program.

- Improve communications between FIRST and State Patrol units by providing text messaging between vehicles or allowing access to State Patrol station talk groups.
- Add additional vehicle lighting on FIRST trucks to improve visibility and improve effectiveness of working in traffic. Improvements include adding additional rear facing lights, adding blue lights, and adding flashing lights to the vehicle grill.
- Develop “quick clearance” legislation that will allow the FIRST Program, Mn/DOT, and State Patrol to quickly remove incident without being held liable for additional damages caused to vehicles and goods.
- Develop legislation that would give “towing authority” to Mn/DOT including the FIRST Program. This would allow for the quicker removal of abandoned vehicles that cause additional congestion and are a potential safety hazard to passing motorists.

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## **Appendix A**

FIRST Daily Log

FIRST Policies and Procedures

Route # \_\_\_\_\_  
 Begin Mileage \_\_\_\_\_  
 End Mileage \_\_\_\_\_

### FIRST Daily Log

Road Condition (Dry Wet Snow/Ice)  
 Shift (AM / PM)

Date \_\_\_\_\_  
 Page \_\_\_\_\_ of \_\_\_\_\_  
 Driver ID \_\_\_\_\_

<b>Detection Method</b> F FIRST T TMC Control Rm R Radio (Mn/DOT) P Patrol Radio O Other	<b>Lane Code</b> 0 - Right Shoulder 1 - Lane 1 2 - Lane 2 3 - Lane 3 4 - Lane 4 5 - Lane 5 6 - Left Shoulder 7 - Median	<b>Incident Type</b> 8 - Auxiliary Lane 9 - Entrance Ramp E - Exit Ramp H - HOV Lane F - Off Roadway	<b>Incident Type</b> A Accident S Stall D Debris on Road O Other	<b>Assist Type</b> A Coolant/Overheat B Battery C Telephone D Directions F Fuel G Tag L Lane clear (verbal) M Mechanical	<b>Other Assist Requested</b> A Ambulance C City Police F Fire Truck P State Patrol T Tow Truck O Other
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Assist	Not enter on MDT	Method of Detection	Incident Type	Road ID	Direction (N,S,E,W)	Lanes Involved	Milepoint	Arrival Time	Depart. Time	Assist Types	Vehicle License	Other Asst. Required	Assist Notify Time
1													
2													
3													
4													
5													

**Comments**

Assist 1 \_\_\_\_\_

Assist 2 \_\_\_\_\_

Assist 3 \_\_\_\_\_

Assist 4 \_\_\_\_\_

Assist 5 \_\_\_\_\_

## **GUIDELINES FOR COMPLETING THE HIGHWAY HELPER DAILY LOG**

In order to assure consistency and quality of the Highway Helper Daily Log, it is useful to point out some helpful guidelines. The following items are considered some of the more important things to keep in mind while completing the daily log. Each place on the log where information is required is listed below:

**Route #**

Ex: 8101, 8102, etc.

Only one route should be entered on each log sheet. The 8100 route is a weekend route and should only be used when the HH is covering the entire metro area on a weekend day.

**Begin/End Mileage, Shift, Road Condition**

Write in the mileage and circle the proper shift and road condition.

**Date**

Any format is fine as long as it includes the month, day, and year.

**Page**

This only needs to be marked if there is more than one page. When there is more than one page, please staple them together.

**Driver ID**

Use the ID that was given to you.

**Method of Detection**

There are four codes listed on the top of the log sheet for this field: Highway Helper, TMC, Radio, and Other.

**Incident Type**

There are four codes listed at the top of the log sheet for this field. Please be sure that you are recording the correct code; this is a critical field.

**Road ID**

Record the mainline roadway that the incident is located.

**Direction**

Simply E, W, N, or S.

**Lanes Involved**

Refer to the lane codes at the top of the log sheet. If there is more than one lane effected, separate the lane codes with slashes. (Ex. 0/1/2)

**Milepoint**

Get this information from the milepoints list located in the truck. If there isn't a milepoint that corresponds to the location of the incident because it is farther away, write in the name of the cross street.

**Arrival & Depart Times**

Use military time in these boxes. If you forget to record this information at the time of the incident, please estimate what they were.

Assist Types

The codes for assist types are found at the top of the log sheet. Most of the codes are straightforward in that the code letter is the first letter of the assist type. This is not always the case, so make sure the right one is being recorded. A common mistake is to use "D" for debris when the correct code is "V." Also, be specific with the code usage.

Vehicle License

Record the license plate number on the first line. Put the state on the next line or in parenthesis after the plate number if the vehicle is from a state other than MN. The assumed state will be MN if no other state is written. When more than one vehicle needs to be recorded, write the plate number with the state in parenthesis following it. There are only three lines and if more space is needed, group them in a way that maintains legibility.

Other Assistance Requested

This field has codes listed on the top of the log sheet and includes: ambulance, city police, fire truck, state patrol, and other. With most entries this is not applicable, but if the Helper requests assistance, it needs to be recorded.

Assist Notify Time

Record in military time the time that the assistance was notified/requested.

Patrol Radio

If the Patrol Radio was used, write a "Y" in this box. Most incidents don't include using the Patrol Radio, so in this case, leave the box blank.

Remarks

There is a line corresponding to each incident. If any important details of the incident are relevant to the log, please record them in this space. Most incidents probably don't require more information; use your judgement. This is where you should clarify the use of "other" used anywhere on the log sheet.

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General Guidelines:

1. Write neatly – messy log data is difficult to interpret and sometimes useless
  2. Be careful to use the correct codes.
  3. Staple multiple pages.
  4. Turn the logs into the HH Supervisor in a timely manner.
  5. Use specific assist type codes.
  6. Try to record up to only five incidents on one log sheet.
- 
- 

<b>Camera No</b> 854	<b>Date</b> 5/1/2004	<b>Time</b> 12:21	<b>Incident Type</b> Crash	<b>Locations</b>	<b>Responder</b>	<b>Notified</b>	<b>Response</b>
<b>Dir</b> NB	<b>Mainline Road</b> 52 (TH)	<b>Cross Street</b> Lafayette	<b>Vehicles</b> 2	<input type="checkbox"/> Right Shoulder	State Patrol		12:35
<b>Source</b> CAD	<b>Entered by</b> Hals, Denise	<b>Lanes clear</b>	<b>All clear</b> 13:00	<input checked="" type="checkbox"/> Lane 1	Highway Helper		
<b>Truck Type</b>	<b>Lanes clear</b>	<b>Incident ID</b> 232520	<b>KBEM?</b>	<input type="checkbox"/> Lane 2	Tow		
<b>Impact</b> 1 Mile or less	<b>Tape?</b>	<b>Time that a Custody Tow was Requested at</b>	<b>Notes</b>	<input type="checkbox"/> Lane 3	Motorist Assist		
				<input type="checkbox"/> Lane 4	Ambulance		12:25
				<input type="checkbox"/> Lane 5	City Police		
				<input type="checkbox"/> Left Shoulder	C. V. I.		
				<input type="checkbox"/> Auxiliary Lane	Coroner		
				<input type="checkbox"/> Collector/Distributor	ESS		
				<input type="checkbox"/> Entrance Ramp	Fire Truck		12:24
				<input type="checkbox"/> Exit Ramp	Helicopter		
				<input type="checkbox"/> HOV Lane	Maintenance		
				<input type="checkbox"/> Median	Media		
				<input type="checkbox"/> Off Roadway	Sheriff		

Close Form

Animal
Crash
Crash - Road Closed
Debris
Fire, Other
Fire, Vehicle
Flooding
Law Enforcement
Maintenance Activity
Medical
Meter Activated
OTHER
Pedestrian
Rollover
Spinout
Stall
Unoccupied Stall
Vehicle Off Road

- Aircraft
- CAD (Patrol)
- Camera
- Clear Channel (Media)
- FIRST
- FIRST Phone Line
- Maintenance
- Metro Networks (Media)
- Overheard (Maint or SP Disp)
- Patrol Phone Line (Patrol)
- Person in the Field
- Scanner
- Trooper (Patrol)
- Wakota Service Patrol
- Other

**Highway Helper  
&  
TMC Dispatcher  
Joint Operating Policies and Procedures**

**January 2, 2002**  
Updated

## **I. Communication – How to Communicate**

### **A. Helpers to TMC**

- Use 2-way radio, attempt to contact at least twice.
- If no response, use Nextel (private channel) with the alert function. If unsuccessful, call 612-349-2604.
- If no response on radio after several attempts, document specifics in the communication log sheet, and submit to the Highway Helper Supervisor.

### **B. TMC to Helpers**

- Use 2-way radio, attempt to contact at least twice.
- If no response, use Nextel (private channel) with the alert function. If informational only, send message via AVL.
- If no response on radio and Nextel after several attempts, document specifics in the communication log sheet, and submit to the Operations Manager (Nick).
- Dispatcher should expect an acknowledgement (such as “10-4”) from the HH, even for information calls.

### **C. Everyone**

- All communication should be concise and to the point. This includes both radio communications and Nextel communications.
- Communicate just the facts. Plan what is to be said before the communication takes place.
- Keep volume levels up on primary channels.

## **II. When/What to Communicate**

### **A. Helpers Notify TMC - Incident**

Helpers shall notify TMC about **ALL Incident** stops and stalls:

- When arriving at an accident or responding to an accident that they located on their own.
- When locating a stall in a hazardous area including outside of the tunnel, whether occupied or unoccupied, whether or not they are stopping to assist.
- When arriving at a stall blocking (whether occupied or unoccupied) state “stall blocking.”
- The Dispatcher shall respond according to the severity of the incident. Information calls may be asked to stand by if the Dispatcher is dealing with other emergency calls.

The following calls are examples of emergency calls:

- Crash Blocking
- Stall Blocking
- Debris in Lane
- Crash on Shoulder

## A. Helpers Notify TMC – Incident (continued)

The following are examples of information calls:

- Stall on Shoulder
- Debris on Shoulder
- Reporting Maintenance

Example of emergency call:

“8101 to TMC, Crash, Blocking.” When TMC responds, give location. This is the highest priority call.

Example of information call,

“8101 to TMC, Information for Maintenance.”

Helpers shall notify TMC about **ALL Incident** stops and stalls (continued):

- When they arrive at an incident to which TMC has dispatched them.
- When the status of an incident to which they responded changes (i.e. tow enroute, clear to shoulder), and when they clear an incident.
- When they arrive at an unoccupied stalled vehicle (10-6 at 10-73)
- When leaving an unoccupied stall, Helper will give location and brief description. ~~The Dispatcher will log the information in the incident database.~~
- When they transport someone off the roadway (location, beginning mileage, arriving at destination, end mileage). ~~The Dispatcher will log this information in the incident database.~~
- When there is an incident that TMC cannot see that is affecting traffic (update as status changes), and additional traveler information as requested.

## B. Helpers notify TMC – Non-Incident

- When they are going to be out of service and unavailable for anything other than a short “pit stop” (1-2 minutes) break (i.e. up at the valley, Jiffy Lube, or off his/her route for any reason including 15 minute breaks). HH shall notify the TMC with that information. The Helper should also change his/her status to “out of service” on the AVL system.
- When they are leaving before their normal scheduled shift change, whether pre-planned or unplanned.
- When they have completed their normal shift and will not be returning to their route. Helpers should use 10-7.
- If the Helper would like TMC to notify patrol for any reason, they should specifically ask them to. Do not assume TMC is notifying patrol.
- If a Helper needs to leave early because of an emergency during the peak period, that Helper should contact the lower priority route to cover the higher priority route.

- If the Helper leaves early, s/he will let the Dispatcher know which route is covered, and which phone will be used by the Helper covering his/her route. The Highway Helper Route Priority List should be followed during the peak period.
- Helper shall notify TMC of traveler information (including that out of camera range) such as downed ramp meters, etc.

## **B. TMC Notifies Highway Helper**

- When they begin and end a shift and who is working the shift.
- When they need a Highway Helper to respond to an incident (either verified or non-verified). This should be done on the TMC radio initially, not on the Nextel.
- When an incident the Helper was dispatched to clears before they arrive.
- When the status of an incident changes (i.e. lane blocking to shoulder or patrol arrives).
- When there is an **ANYTHING** that is affecting their route (accident, stall, and debris, grass fire, medical) even if they are not to take action or respond. TMC should state "FYI" to ensure that patrol understands that TMC is not dispatching the Helper.

## **III. Nextel Phones**

- Helpers shall turn their Nextel phones on and wear them for their entire shift (i.e. 4:30 AM to 12:30 PM).
- Helpers are expected to answer all calls except if they are impeded by the situation. This includes wearing them while assisting motorists, taking a break, or attending a meeting.
- The Nextel phones should be used to communicate more detailed information.
- The Highway Helper's phone should correspond to the correct Helper route. (Example: The HH on the 8101 route shall have the 8101 phone with him/her.)
- The "Alert" function should be used when contacting HH or TMC.

## **IV. Use of AVL**

- All Highway Helpers should logon to the AVL system.
- If there is a problem with the AVL logon, the Highway Helpers should troubleshoot the problem with the Dispatcher; if necessary, call the AVL technical support person XXXXXXXXXX
- Log all incidents.
- All Highway Helpers should change their status to "out of service" whenever they are on a break. This includes a short stretch break or a regular 15-minute break.
- The Dispatcher will know the password and understand the database.

## **V. Use of Scanner**

- Highway Helpers shall listen to the State Patrol scanner, and;

- The Dispatcher shall also listen to the State Patrol scanner.

## VI. Additional Radio Codes

- **10-88** (Helper needs help immediately) (**location, direction, nature of situation**)
  - The Highway Helper should try to give TMC as much information as possible.
  - TMC should contact MSP dispatch immediately.
  - TMC should try to get more information from Helper if possible and locate Helper via AVL.
- **10-38** (Helper is concerned about possible physical confrontation/personal safety.). TMC should locate Highway Helper via camera, monitor situation and take appropriate action.
- **10-73** (abandoned vehicle).
- **10-7** (done for the day).

## VII. Off Route Situation

- During peak hours, HH will go off route only **if requested by trooper and at HH discretion.**
- Off-peak Dispatcher will put out info; Helper will decide whether or not to go to incident.

## VIII. Procedure for dispatching

- TMC should put out incidents to all Helpers (by number) within the vicinity.
- HHs covering overlapping route will inform TMC as to who will respond to incident.

## IX. HOV Gates

HOV gates are a priority:

- HH shall notify TMC when gates are open and closed. (This includes weekends.)
- ~~The Dispatcher shall log this information in the incident database.~~

## X. Transports

- HH shall notify TMC when transporting someone off the roadway (location, beginning mileage, arrival at destination, ending mileage.)
- ~~The Dispatcher shall log this information in the incident database.~~

## **XI. Towing**

- HH calls private towing companies directly.
- HH will communicate information to TMC; TMC will relay info to State Patrol.

## **XII. Debris**

- When safety will allow, Helper can be dispatched to pick up small debris, depending on traffic locations, and situations.
- DOT Maintenance is responsible for all types of removal.

## **XIII. Verification**

- It is not necessary for the Dispatcher to verify by camera when HH requests action; the Dispatcher will take action first, verify second. (Example: stall in tunnel, accident.)

## **XIV. Suspicious Abandoned Vehicles**

- If in the process of tagging an abandoned vehicle, the Helper notices that the vehicle looks “tampered with”, the Helper should radio TMC to request that a Trooper check the vehicle out. Be specific about what looks suspicious so this can be relayed to the trooper.

## General Guidelines

### Highway Helper Mobile 2-Line Message Sign (August, 2001 Update)

The following are guidelines developed for the proper use of the Highway Helper mobile 2-line changeable message sign purchased for field testing:

- The sign shall be used to *supplement* the current Highway Helper warning lights (i.e. rotating beacons and emergency four-way flasher) not replace them.
- The sign shall only be used for *emergency* incident situations.
- When it is determined an incident will last for more than one hour, Mn/DOT Maintenance should deploy the appropriate traffic control devices.
- The sign may be used as a flashing arrowboard to direct traffic away from a lane blocking stall or accident when a Highway Helper is protecting the incident scene. This is for emergency situations only and should not replace the deployment of the appropriate traffic control devices.
- When the Highway Helper is working on the shoulder in a potentially hazardous situation (i.e. changing a tire on the traffic side of the vehicle) the sign may display the Mn/MUTCD flashing caution symbol (all four corners flashing yellow dot). If the incident is partially blocking a lane the sign should display a flashing arrow.
- When an overhead CMS/VMS is not positioned correctly to communicate the appropriate warning information to travelers, the Highway Helper may use the sign to display this information under the following guidelines:

One panel shall be used to provide driver information for the following messages:

- RIGHT LN CLOSED
  - LEFT LN CLOSED
  - CNTR LN CLOSED
  - ROAD CLOSED
  - CRASH AHEAD
  - RAMP CLOSED
  - TUNNEL CLOSED
- The Traffic Engineering office is trying to get Federal Approval of the following guideline... Until that time, the Highway Helpers should only use one panel messages.

*If an incident has sufficiently decreased vehicle speeds (less than 30 MPH) at the location of the Highway Helper vehicle, two panels may be used such as RIGHT TWO : LANES CLOSED at the discretion of the Highway Helper. The Highway Helper shall document the situation, message used and overall effect on traffic for evaluation purposes.*

# **Mn/DOT HIGHWAY HELPER PROCEDURES**

**Revised 8/8/01**

The following document outlines the procedures used by the Highway Helpers when performing their jobs. It is recognized that working on the Metro area freeways can be very dangerous. These procedures were developed to assist in creating a safer working environment for the employees as well as the public they are serving. Safety must be always be the number one priority.

## **Getting off and on the roadway**

When a Highway Helper spots a stranded motorist, consideration should be given to the location of the stalled motorist in regard to the location of the Highway Helper. If Highway Helper can not reach the stall safely, they should go to the next exit and circle back to reach the stranded motorist.

When approaching the stall, the Highway Helper should consider getting back into the flow of traffic when deciding where they should park their vehicle. If the flow of traffic is heavy and they would not be able to go around the vehicle if they were unable to get it started, they should consider parking their vehicle in front of the stall. If the traffic is light or they would be able to go around the stall they should park their vehicle behind the stall. Parking behind the stall would be the preferred parking place as it allows some added protection when working on the vehicle and it is less disruptive to the flow of traffic when pulling off onto the shoulder.

## **Approaching vehicle passenger**

If possible, the Highway Helper should approach the stalled motorist from the passenger side of the vehicle for safety reasons.

## **Determining what is wrong**

When trying to determine what is wrong with the vehicle try to get as much information from the driver as possible. Ask the driver if they have ever had this problem with the car before, how did the car act when it died on them, ask them to be as specific as possible. Also, inquire as to any recent work that may have been done on the vehicle, related or not.

## **Fuel**

One of the first things to check for in a stalled vehicle is fuel. Motorist do not always know, or

are afraid to admit that they may have run out of fuel. Sometimes you may have to convince them that they need fuel. You can do this by pouring some gas into the carburetor. If it starts, the problem is fuel related and you should start by giving the motorist a gallon of fuel.

If the motorist was out of fuel, the Highway Helper should politely inform the driver that running out of fuel on the freeway is considered unlawful stopping on the freeway and they may receive a citation for having done so. Encourage them to keep plenty of fuel in the tank to avoid taking such risks in the future.

## **Overheating**

Another common reason for a motorist to be stranded is if their vehicle has overheated. You should never remove a radiator cap of a vehicle that is extremely overheated. When removing the radiator cap you should tell the motorist to stand back just in case hot coolant should spray from the radiator. Remove the cap by first turning the cap only part way to release any pressure that may be in the system. After you are sure there is no pressure, you may remove the cap the rest of the way to check the coolant.

Before adding coolant to the radiator, the Highway Helper should check belts, hoses and look for leaks in the cooling system. If a heater hose is leaking it may be possible to cut off the end of the hose and put it back on the fitting. If the belt that runs the water pump is broken, you should tell the driver they should not drive the vehicle because they may ruin their engine by overheating it.

Oil should also be checked before adding any coolant. A vehicle that is low on oil will also cause an engine to overheat. Check the oil dipstick for water, if there is water on the dipstick it is possible the engine block or heads may be cracked. If water is found on the dipstick tell the driver and note it on your log sheet.

Coolant should only be added after the vehicle has had sufficient time to cool (usually at least 30 minutes, depending on ambient temperature) and the vehicle is running. When adding coolant, you should pour the coolant in slowly, allowing time for the added coolant to mix with the existing coolant in the system. This will help reduce any thermal shock to the engine block and cooling system.

If you find a vehicle shortly after it has overheated and has not had sufficient time to have cooled down, you may leave the driver some coolant and tell them that you will check back on them later on. This should be done only if the driver is in a safe location and wants to wait with their vehicle.

## **Tire changing**

Tire changes should be done only where it is reasonably safe to do so. If a vehicle is found on a narrow shoulder and the flat tire is on the traffic side, you should ask the driver to move their vehicle to where the shoulder is wider. If it is not possible to move the vehicle to a safe place, the Highway Helper should inform the driver that they will have to be towed to a safer location. When calling for a tow, make sure to let the towing company know if the vehicle has a rear flat. This is so they will send out a flat bed to tow the vehicle off.

When changing the tire make sure to block the vehicle if there is any chance the vehicle may roll. Break all the lug nuts loose, but do not remove before jacking up the vehicle. Before jacking up the vehicle, make sure emergency brake is engaged and vehicle is in park. Jack up the vehicle and remove lug nuts and tire. Put the spare tire on the vehicle and replace lug nuts. Never crawl beneath the vehicle unless it has additional support from blocks; do not rely on the jack alone to provide adequate safety. Let the vehicle down and check lug nuts for tightness. Tightening lug nuts should be done in a criss-cross pattern.

## **Batteries**

To determine if the battery is discharged, ask the driver to turn on their headlights and try to turn over their car engine. If you hear a steady clicking sound and / or the headlights go dim when they try to start their car, the problem is probably a discharged battery or poor battery connections. Safety glasses must be worn when performing any work on the battery.

Before deciding to jump the battery an inspection should be made of the battery post and connections. It may be necessary to clean and tighten the battery post and connections. If you decide that cleaning the battery post must be done, first disconnect the ground cable, then the positive cable. When reconnecting the battery the positive cable should be connected first, then the ground cable.

When making connections to jump the battery, the discharged battery should always be connected first. First connect the positive post of the discharged battery using the red clamp, then connect the negative post using the black clamp. When making connections to the good battery, connect the positive post first using the red clamp then the negative post using the black clamp.

If after charging the discharged battery for a few minutes, the car does still not turn over very well, check your jumper cable connections. If the connections are okay and you have a volt meter available, check the battery voltage as the driver tries to start their car. If the voltage remains above 9.5 volt as the engine is turning over, the car's starter is probably faulty.

If the vehicle died because of a faulty charging system the vehicles driver should be informed they will only be able to drive a few miles (depending on the condition of the battery and how long you let it charge) before their car will kill on them again. This of course does not apply if the battery went dead trying to restart the vehicle.

## **Miscellaneous Automobile Problems**

Other things to check for are fuses for the electric fuel pump, any loose or broken wire connections, blown fusible links, and coil wire.

If the vehicle has an overhead cam engine you can remove the oil filler cap and see if the valves are moving. If they are not, the timing belt is bad. Some overhead cam engines also have an inspection hole that allows you to see the belt. You can get a pretty good idea if the timing belt is gone by just listening to the engine as it is being turned over. There won't be the sound of compression as the engine turns over.

If the car starts and runs for a short time and there is a strong sulfur smell this could mean the catalytic converter is plugged. Sometimes it is possible to knock loose some of the clogged material by tapping gently on the converter with a hammer.

After making any repair you should instruct the driver that it is only a "band-aid" fix to allow them to get safely off the freeway and they should have their vehicle checked out as soon as possible.

## **Cellular phone usage**

Phone usage should be kept to a minimum and used only when other forms of communication are not available or practical.

When a motorist needs to use the phone, ask them to keep it short and inform them no long distance calls are allowed, however 800 numbers are permitted. The Highway Helper should remain in their vehicle when the motorist is making their calls. This is to insure they are not making any long distance calls and that they are keeping their conversation limited to the problem at hand. Also, make sure that if arrangements are made for a friend to meet the motorist, that it is done at a location off of the freeway.

Cellular phone numbers should not be given out to anyone. When arranging for a tow through a towing service they will ask you for the phone number you are calling from. Explain you are calling from a cellular phone and the number will not do them any good in locating the nearest towing company.

## **Accidents**

When arriving on the scene of an accident, the Highway Helper should park their vehicle in such

a manner as to protect the accident scene and prevent further damage.

The Highway Helpers shall report all accidents to the TMC so they can relay information to the State Patrol. Give TMC dispatcher your location, direction of travel, the lanes that are involved and if there are any injuries. It is not necessary to give the license plate # of the vehicles involved. However the Highway Helper should make every effort to record all license plate # s' of all the vehicles involved. This should be done just in case someone tries to leave the accident scene.

The Highway Helper should ask every individual involved if they are injured. If no injuries, the Highway Helper should ask the parties involved to move their vehicles to the shoulder. If there are injuries, the Highway Helper should not move the vehicles. First aid may be rendered to the injured. Make sure you stay within the realm of your training and never move a seriously injured person, unless an immediately life threatening situation exists.

The Highway Helper should encourage the parties involved and any witnesses to remain until the patrol arrives. The Highway Helper should stay on the scene until the patrol arrives. The Highway Helper is there to secure the accident scene, move the vehicles if possible, give guidance, and render any first aid that is within the realm of their training. Remember that the trooper is in charge. Leave the scene once you are no longer needed.

If property damage is over \$1000 total for all vehicles involved, the drivers of all vehicles must file a report with the state. Highway Helpers should not distribute accident report forms. The parties involved in the accident should obtain the forms directly from the State Patrol or another authorized source. If no injuries were involved, the damage to the vehicles was minor and all parties involved agree, the motorist may exchange information and leave. However, Highway Helper should notify patrol that the people involved are going to exchange information and leave.

If the motorist do not want to wait for a trooper to arrive, the Highway Helper cannot stop them from leaving. The Highway Helper should explain that in light of insurance fraud and numerous lawsuits being filed, it would be in their best interest to wait for the trooper to arrive.

### **Unattended Vehicle Check/Paint**

When checking an unattended vehicle look for anything that may be of a suspicious nature, (i.e. a punched ignition or door lock, a broken window with the glass still inside the vehicle, etc.). If anything is found that seems out of the ordinary, the patrol should be notified so that they may check the vehicle.

Place a large check mark in yellow marking paint on the traffic-side window and the date and time on the back windshield. This alerts others (State Patrol, motorists, etc.) that the vehicle has been checked.

If the Highway Helper gives a ride to a stranded motorist make sure they are aware they only have 2 hours to remove the vehicle or it may be towed and taken into custody. If they return and find their vehicle gone, they may call the State Patrol to find out the location of where the vehicle was towed.

If a vehicle is found in a "legal" but unsafe spot,(i.e. narrow left shoulder, blind spot in a curve, etc.) the Highway Helper should check the vehicle and call the TMC to inform them that the abandoned vehicle is in an unsafe location and ask them to send a trooper to remove it. **Remain with the vehicle until a trooper arrives to issue a custody tow** or follow the instructions of the dispatcher. (i.e. they may request you wait for the tow company to respond)

### **Transporting Motorist**

When a Highway Helper transports a motorist they should contact TMC and give their current location, destination and mileage. Once they have reached their destination, they should notify TMC and give their ending mileage.

If a Highway Helper should see a pedestrian on the freeway they should notify the TMC. If the Highway Helper feels that the pedestrian is in immediate danger, (i.e. someone walking in a bad location or a person trying to cross the freeway) they may stop and ask the person to leave the freeway or offer a ride off the freeway system.

A Highway Helper is not required to transport any individual they do not feel comfortable with and should make other arrangements for the persons safe transportation off the freeway system.

If a Highway Helper should run into trouble while transporting a individual, the Highway Helper should inform the person it is time to check in and at that time give TMC a code 10-88 to let them know they are in need of assistance from the State Patrol.

Highway Helpers should not be transporting motorists to destinations far off their routes, especially during the peak rush hour. Instead bring them to a place where they can wait for their own assistance and have a phone available if they should need one. (i.e. fast food restaurant, gas station, etc.)

### **Towing**

Highway Helpers may allow the motorist to call directly for a tow. If a motorist does not have a preference for a particular towing service, call the State Patrol and request a rotational/zone tow.

When requesting a tow, give the MSP dispatcher the location, direction of travel, which shoulder the vehicle is located on, make, color, and license plate number of the vehicle. If the vehicle is located on the left shoulder, a flat bed should be requested. Also mention any other information that may be required to dispatch the correct equipment to the stall (i.e. if the vehicle is a large truck and has a heavy load or if the vehicle has a rear flat tire).

Keep in mind that if the response of the motorist's chosen towing company is slow and the vehicle is considered a hazard, the State Patrol may insist on using a rotational/zone tow. If the response of the rotational/zone tow is longer than 20 minutes, the Highway Helper can call MSP dispatch and request an ETA for the tow. Ongoing problems with tow response time should be documented and reported to the supervisor.

If a vehicle is abandoned and must be removed immediately because it is a hazard, the Highway Helper should call the TMC. Tell the TMC dispatcher that you have an unoccupied vehicle that is blocking (partly blocking) and would like a trooper to respond. If a trooper is not available you may request to start a custody tow.

When requesting a custody tow, give the TMC dispatcher the location, direction of travel, which lane it is blocking, make, color and license number of the vehicle. Also mention any other information that may be needed, (i.e. if it is a large truck and if it has a heavy load, or if the vehicle has a rear flat tire). This information is needed so the correct type of equipment is dispatched to the scene.

If the weather is bad or the motorist seems uneasy, the Highway Helper may remain with the vehicle until the tow arrives. This is a judgement call and should be considered on a case by case basis.

### **Use of Flashing Lights and Truck Mounted CMS**

When stopping on the freeway the Highway Helper should only use what lights are necessary for safety. Excessive flashing lights attract attention, thus slowing down the flow of traffic. Here are some guidelines:

#### *On a ramp:*

If the vehicle is located on an entrance or exit ramp, the location of the vehicle on the ramp, if the metering lights are on and how much the vehicle is blocking should be taken into consideration. If the vehicle is located on the ramp where the flow of traffic is slow and the vehicle is only slightly blocking, then only the light bar and four-way flashers should be used. If the vehicle is located where it is blocking a good portion of the lane and the flow of traffic is closer to the rate of the main line, then the light bar and beacon lights should be used.

#### *On the shoulder:*

Use flashing lights on arrow stick and/or flashing lights on the light bar along with the 4-way

hazard flashers (truck's turn signal 4-way flashers) as a minimum.

*On the shoulder – hazard:*

Move the disabled vehicle further down the shoulder to a safer location (or up a ramp and off the freeway) either under its own power or by pushing with the HH truck's push bumper if possible. If this is not possible, use all the lights discussed in the "on the shoulder" case, plus rotating beacons. Consider using orange cones from the HH truck and set them up a distance behind the truck. Depending on situation and availability, ask another Helper for backup at/prior to your location. That Helper could use the sequential arrow (chevron) on the truck-mounted CMS to provide traffic control. This would all depend on the conditions at your location, time of day, traffic conditions, weather, etc. Notify TMC of the hazardous stall immediately.

*Vehicle stalled in traffic lane / debris in traffic lane / crash blocking traffic lane:*

Use all the lights described in the "on the shoulder – hazard" case, plus use the truck-mounted CMS with the sequential arrow (chevron). If possible, move the vehicle out of the traffic lane to the shoulder or a safer spot. Notify TMC, request additional help from another Helper, State Trooper, tow, etc.

### **Pushing Vehicles from Hazardous location**

The purpose of relocating vehicles from a hazardous location is for safety and not to save the driver the expense of a tow.

Carefully instruct the motorist before you push them.

Tell them:

- 1) Exactly where you want them to go.
- 2) To turn on the key.
- 3) Put the car in neutral.
- 4) That the car will steer and brake very hard.
- 5) To leave their window down. (so you can talk to them over the load speaker if necessary.)
- 6) Again tell them where you want them to go.

When pushing vehicles don't follow them through the turn, back off and push again once the vehicle has completed the turn.

### **Automatic Towing Procedure**

In an effort to reduce the response time of tow trucks to the accident scene, the State Patrol may automatically send a tow before the Trooper responds.

If the tow truck driver arrives first at the accident, they are not to disturb the accident scene, but wait for instructions from the patrol.

If a Highway Helper arrives first at the accident, they may inform the TMC that a tow is not needed only if they are 100% sure that is the case. It is up to the State Patrol dispatcher to decide if they want to continue the tow.

When the trooper arrives at the accident scene and determines that a tow is not required they will call their dispatcher to cancel the tow.

### **When to stop if Patrol is Present**

A Highway Helper is not to stop at an incident if the State Patrol is already on the scene unless they are signaled by the trooper that their assistance is requested. Always consult with the trooper on scene first and never approach the motorist unless the trooper asks for help.

### **Use of Shoulder, Turn Arouds and HOV Bypasses**

Refer to policy entitled, "Guidelines for Use of Roadway Areas Other than Normal Traffic Lanes by Highway Helper Vehicles."

### **Vehicle Maintenance:**

Vehicle maintenance is the responsibility of both parties assigned to that vehicle.

Before taking the vehicle at the beginning of your shift, you will check out the vehicle according to the daily operator check-list.

A clean vehicle is necessary to provide a good public image for the Highway Helper program and to prevent the stranded motorist from getting their clothes soiled from road grime.

At the end of each shift the driver will do the following maintenance:

- Fuel the vehicle and replace any gas, coolant or anything else you may have used (i.e. WD 40, starting fluid, etc.).
- Clean the inside of the cab and remove any debris that may be in the truck box.
- Weather permitting, wash the truck with a brush and soap.

If you are unable to perform any of the above tasks due to unusual circumstances, leave a note of explanation for the next driver and inform the lead worker on duty.

You should also communicate to the other driver any problems that you may be having with the vehicle that you will have to make an appointment to be looked at.

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## **Appendix B**

### Annotated Bibliography-Secondary Crashes

The internet sources are presented to give a sense of what the “popular press” thinks about secondary crashes. The studies contain more information and are worthy of more attention. Within each group, results are presented in descending order of estimated/reported secondary crash rates (in bold).

### Internet Sources

1. Trans4mation, The Evolution of Transportation in Central Florida. January 26, 2004. “I-4 Receives Help to Reduce the Highest Secondary Crash Rate in the Country,”

[http://www.trans4mation.org/g5/media/newsreleases/20040126-highest\\_2nd\\_crashrate.html](http://www.trans4mation.org/g5/media/newsreleases/20040126-highest_2nd_crashrate.html).

- “Approximately **1/3** of all crashes on Interstate 4 in Orange County, a higher percentage than any other Interstate in Central Florida or the entire nation, are attributed to secondary incidents, or accidents caused by other accidents.”

2. Chester, R., and Gresham, Smith & Partners. Fall 2003. “Tennessee Department of Transportation Plans Intelligent Transportation System for Memphis Region,” *Roadtalk* 17 (3): 3-5, Tennessee Transportation Assistance Program, The University of Tennessee,

<http://ctr.utk.edu/ttap/graphics/roadtalk/pdf%20file/fall03.pdf>

- “Research shows that up to **30%** of all accidents are secondary accidents that happen because of another accident that occurred downstream.”

3. North Carolina Department of Transportation. December 29, 2003. “NCDOT and CCPS Join Forces to Educate Motorists on Legislation to Improve Highway Safety and Efficiency,”

[http://www.ncdot.org/news/hwysafetyeducate12\\_03.html](http://www.ncdot.org/news/hwysafetyeducate12_03.html).

- “Studies show that for every minute a freeway lane is closed, it takes four minutes for traffic to recover. They further show that during these backups nearly **30%** of all highway crashes occur.”

4. FHWA, USDOT. June 2002. “Proceedings of the National Conference on Traffic Incident Management: A Road Map to the Future,” Sponsored by AASHTO, FHWA, ITS America, and TRB,

<http://ops.fhwa.dot.gov/Travel/IncidentMgmt/timconf/TIMCnfPr.htm>

- “Crashes that result from other incidents make up **14-18% of all crashes**. These secondary crashes are estimated to cause **18% of all deaths** on freeways.”

5. Mn/DOT, Office of Traffic, Security, and Operations, Regional Transportation Management Center. “Incident Management Program,” <http://www.dot.state.mn.us/tmc/incmgmt.html>.

- “Exact figures on the number of secondary crashes are difficult to calculate, however two studies estimate that around **15%** of crashes are the result of an earlier incident.”

6. ASFA (Federation of French Motorway and Toll Facility Companies). October 2003. “The French Toll Road Operators: 2002,” [http://www.autoroutes.fr/pdf/RA\\_Chapitre5\\_gb.pdf](http://www.autoroutes.fr/pdf/RA_Chapitre5_gb.pdf).

- **1 in 7 fatal accidents** is a secondary accident (14.3%)

7. Lari, A., D. Christianson, and S. Porter. January 1982. “I-35 Incident Management and the Impact of Incidents on Freeway Operation,” Mn/DOT, FHWA TE-82/04, as cited in “Ohio Quickclear: Best Practices Guide,” <http://www.dot.state.oh.us/quickclear/Best%20Practices/qcbpa.pdf>.

- **13%** of all peak-period crashes are secondary crashes resulting from incident-related congestion

8. Jernigan, J. July 1998. “Expected Safety Benefits of Implementing Intelligent Transportation Systems in Virginia: A Synthesis of the Literature,” Virginia Transportation Research Council, FHWA/VTRC 99-R2.

- In the event of a crash, the risk of a secondary crash increases from 300% to 600% because once a crash occurs, congestion, speed variance, and traffic stops increase, thereby increasing crash risk

- the 300% estimate comes from a 1988 study by Sullivan and Hsu (Berkeley's Institute of Transportation Studies)
- the 600% estimate comes from a 1993 study by Tedesco, Alexiadis, Loudon, Margiotta, and Skinner (I'm pretty sure these are Cambridge Systematics folks)

#### 9. FHWA, US DOT. "ITS Benefits and Costs Database,"

[http://www.benefitcost.its.dot.gov/ITS/benecost.nsf/images/Reports/\\$File/deskref.pdf](http://www.benefitcost.its.dot.gov/ITS/benecost.nsf/images/Reports/$File/deskref.pdf)

<http://www.benefitcost.its.dot.gov/ITS/benecost.nsf/ID/908E1267499C4322852569610051E27E>

<http://www.benefitcost.its.dot.gov/ITS/benecost.nsf/ID/6653718EFFE52A5C852569610051E27F>

- In Pennsylvania, TIMS (Traffic and Incident Management Systems) decreased secondary crashes on highways by 40% between 1993-1997
- In San Antonio, TransGuide (comprising VMS, lane control signs, loop detectors, CCTV, and a communication network covering 26 instrumented miles) reduced secondary crashes by 30% in 1995
- In Amsterdam, a traffic management system comprising detection (loops and video cameras), lane control, VMS, and variable speed limits decreased crash rates by 23%, serious crashes by 35%, and secondary crashes by 46%

#### Studies

1. Karlaftis, M., N. Richards, S. Latoski, and K. Sinha. 1998. "An Empirical Analysis of Secondary Crash Causes," Proceedings of the 77<sup>th</sup> Annual Meeting of the Transportation Research Board, Washington, DC, Paper 980017

- **35%** of all crashes occurring on 24 miles of the Borman Expressway (Gary, Indiana) between 1992-1995 are secondary
  - a secondary crash is defined to occur within 15 minutes of the clearance time and 1.5 km upstream of the primary crash (though a later report published in the Journal of Transportation Engineering by some of the same authors claims within 3 miles upstream of the primary crash)
  - crashes are the only type of primary incident considered
- The study also identified and quantified the effect of primary crash descriptors on the likelihood of a secondary crash occurrence
  - significant factors include: clearance time, type of vehicle involved (car, van, semi-, truck), weekday, season, and lane location
    - factors that increase the likelihood: clearance time, weekday, and car or semi
    - factors that decrease the likelihood: winter, location at the ramp or median/shoulder
- Each minute increase in clearance time increases the likelihood of a secondary crash by 2.8%
  - in winter, the increase is 1.85%
  - in all other seasons, the increase is 3.63%
- Since Hoosier Helper decreases clearance time by an assumed 10 minutes => HH reduces probability of secondary crash by 18.5% during the winter and 36.3% during the other 3 seasons
- Crash cost savings due to Hoosier Helper exceed costs of the program (B/C ratio is 1.38 for crash benefits alone...and these are probably conservative inasmuch as they appear to underestimate the value of avoiding a given crash by not including pain & suffering, lost workplace productivity, etc.)

2. Owens, D. 1978. "Traffic Incidents on the M1 Motorway in Hertfordshire," Crowthorne, Berkshire, Great Britain: Transportation Road Research Laboratory, as cited in Raub (#4 below).

- Out of 75 crashes viewed on film, 13, or **17%**, were considered secondary
- The study filmed the effect of incidents on traffic delay along a British motorway

3. Delcan Corporation. January 1994. "Evaluation of the Highway 401 COMPASS Freeway Traffic Management System (Renforth Drive to Warden Avenue): Summary Report," Prepared for Ministry of Transportation of Ontario, Ontario, Canada

- The study evaluated the effect of COMPASS's changeable message signs (CMS) on the incidence of secondary crashes on Highway 401 (Toronto)
  - Without the CMSs, the secondary crash rate was **16.8%** (i.e., 32 secondary crashes out of 191 total crashes)
  - With the CMSs, the secondary crash rate was **5.2%** (i.e., 12 secondary crashes out of 229 total crashes)
- secondary crashes were determined by TOC (traffic operations center) system operators viewing CCTVs (they filled out a form for each observed crash). That is, operators were instructed to classify a crash as secondary if it was "caused as the result of a primary incident."
- COMPASS comprises loop detectors, CCTVs, CMS, communications system, traffic operations center, etc. (but CMS were inoperational during "before" phase of study)
- The "without CMS" period comprised 18 weeks from September 1990 – January 1991; the "with CMS" period comprised 12 weeks from November 1991 – February 1992.

4. Raub, R. 1997. "Secondary Crashes: An Important Component of Roadway Incident Management," *Transportation Quarterly*, 51 (3): 93-104.

- **15%** of crashes reported to police on urban arterial roadways (NOT FREEWAYS) are likely to be secondary
  - A secondary crash is defined to occur within 1.6 km of the primary incident and within the clearance time + 15 minutes of the primary incident
    - Although the study does not explicitly state so, I'm pretty sure it assumes the distance is limited to upstream in the same direction as the primary incident
  - data were collected on urban arterial roadways in seven contiguous communities in Northern Chicago suburbs during January 1995
- crashes represent 60% of the primary incidents that have an associated secondary crash (but only 35% of all events in the database)
- 13% of those primary incidents that have an associated secondary crash actually cause 2 or more secondary crashes

5. COMSIS Corporation. May 1996. "Incident Response Evaluation: Final Report," Prepared for State Highway Administration of Maryland, Office of Traffic and Safety.

- secondary crash rates on highways near DC and Baltimore ranged from **5.0%** to **14.3%** in 1991 and 1992
  - highways studied included: US 50, I-95 (from I-495 to I-695), I-495 Capital Beltway in Maryland, I-695 Baltimore Beltway
  - a secondary crash is defined to occur within one hour after the onset of the primary crash and 3 miles upstream of the primary crash
  - crashes are the only type of primary incident considered
- The freeway service patrol of Maryland's Coordinated Highways Action Response Team (CHART) was estimated to reduce system-wide delay by 5% => assumed to reduce secondary crashes by 5% as well
  - CHART includes freeway service patrol, traffic operations centers, CCTVs, etc.
- Subsequent CHART evaluations in 1997 and 2000 changed the definition of a secondary crash
  - in 1997, secondary crash was defined to occur within 2 hours after a primary incident and within the range of two miles
  - in 2000, the definition was expanded to include rubbernecking in the opposite direction => secondary crash was defined to occur within 2 hours from the onset of a primary incident and within two miles upstream of the primary incident; or occurring in the opposite direction and within half hour from the onset of the primary and within half mile either upstream or downstream of the primary

- in 1997, CHART was assumed to reduce average incident duration (and therefore secondary crashes) by 35%
- in 2000, CHART was assumed to reduce average incident duration (and therefore secondary crashes) by 57%

6. Ran, B., R. Sonntag, A. Drakopoulos, B. Barrett, P. Sattayhatewa, B. Nemeth, S. Leight, and T. Miller. September 2000. "Evaluation of the Southeastern Wisconsin Traffic Incident Management Enhancement (TIME) Program – Phase 1," prepared for Wisconsin Department of Transportation.

- The secondary crash rate on I-94 in Racine and Kenosha counties (Wisconsin) was **9.36%** during 1997 prior to implementation of "crash investigation sites" (CIS); the CIS reduced the secondary crash rate in 1998 to **6.19%**
  - a secondary crash is defined to occur within 1 hour after onset of primary crash and within 2 miles upstream of primary crash
- WisDOT implemented two different motorist assistance patrols along portions of I-94
  - "Gateway Patrol" comprises 4 tow trucks operated by private towing contractors under contract with WisDOT
    - *a 14% decrease in the number of secondary crashes associated with a downstream collision was measured in the period following implementation*
  - "Enhanced Freeway Patrol" is operated by the Milwaukee County Sheriff's Department and comprises 4 utility-type vehicles (equipped with push-bumpers, markings identifying them as part of Sheriff's Dept patrol squad, etc.)
    - *an 8% decrease in the number of secondary crashes associated with downstream incidents was measured in the period following implementation*
  - These two results (14% vs. 8%) make intuitive sense inasmuch as tow trucks should have a stronger impact than utility vehicles on secondary crashes because they can clear more incidents more completely
  - Nearly half (46%) of the primary incidents associated with secondary crashes were crashes and one-third (33%) involved disabled vehicles

7. Moore, J., G. Giuliano, and S. Cho. May/June 2004. "Secondary Accident Rates on Los Angeles Freeways," *Journal of Transportation Engineering* 130 (3): 280-285.

- The secondary crash rate on LA freeways ranges from **1.47% to 2.9%** (i.e., the number of secondary crashes per crash is 0.015 to 0.030)
  - The number of secondary crashes per incident (including crashes) ranges from 0.007 to 0.013 => 0.69% - 1.28% of total incidents
- secondary crashes are defined using 4 successively restrictive filters
  - Filter 1: on the same freeway, in either direction, occurring within 2 miles and 2 hours of each other
  - Filter 2: excludes incidents that can't be secondary crashes b/c (1) their location is on the wrong side of the primary incident (e.g., downstream in same direction), (2) they aren't crashes, or (3) they are clearly chain reaction crashes (i.e., occur within seconds of the primary incident and so aren't amenable to treatment)
  - Filter 3: excludes duplicate records (crashes tend to be over-represented in the study database due to their severity and duration)
  - Filter 4: excludes if crash is not in or approaching the shockwave generated by primary incident (this is debatable: don't really need a shockwave to be distracted by an incident)
- Study used data from LA freeways during March, May, and July 1999
- Note that the proportion of crashes that made it through filter #1 (43.9%) is considerably higher than found in other studies (4.9%, 6.4%)
  - this may explain the low secondary crash rate (i.e., if we lower the total number of crashes, the secondary crash rate will increase)

- on the other hand, since filter #1 excludes some crashes, it's possible that the total number of crashes should really be higher => secondary crash rate is actually lower

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## **Appendix C**

Annotated Bibliography-Benefit/Cost Studies of Freeway Service Patrols

FSP Summary Table

Note: all program descriptions should be taken to mean at the time of the study. Programs may be different today.

## **Boston, Worcester, and Springfield, Massachusetts**

Stamatiadis, C., Gartner, N. and J. Winn. 1997. "Evaluation of the Massachusetts Motorist Assistance Program: An Assessment of the Impacts of this Project on Congestion and Air Quality." University of Massachusetts Transportation Center (sponsored by Massachusetts Highway Department), Report No. UMTC-96-4

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### **Program Description**

- The Massachusetts Motorist Assistance Program (MAP) operates 21 routes along 488 freeway miles in the metro areas of Boston, Worcester, and Springfield, MA
- Vehicles are ¾-ton and 1-ton vans, equipped with push bumpers
  - If assistance cannot be provided, operators contact State Police for tow
- Operating hours are weekdays only: 6:30am-9:30am and 3:30pm – 6:30pm
- At time of study, there did not exist a state-wide, multi-agency incident management program in MA (i.e., does not appear to be a FMS or TOC in operation during the study period)

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### **Study Description**

- The study was conducted by the University of Massachusetts Transportation Center (faculty who did the work were at UMASS-Lowell) and sponsored by the Massachusetts Highway Department
- The data are from 1995
- Delays are estimated using FREQ11, a macroscopic simulation model of freeway operations
  - Outputs of FREQ11 include total delay, fuel consumption, and emissions of HC, CO, and NOx
- In absence of MAP, incidents are assumed to be handled by State Police
- Reductions in incident duration due to MAP:
  - Minor incident = 15 minutes
  - Vehicle disablement = 25 minutes
  - Accident on lane moved to shoulder = 25 minutes
  - Roadway debris = 30 minutes
  - Accident on lane = 20 minutes
- Shoulder incidents are assumed to reduce capacity by 15% if MAP responds and 19% if State Police responds (police may be causing a larger gawking effect than MAPs)
- Monetary values are taken from the ITE Transportation Planning Handbook
  - \$10 per vehicle-hr of delay
  - \$1.50 per gallon of fuel

- \$0.23/kg of HC; \$.02/kg of CO; and \$0.76/kg of NO<sub>x</sub>
  - Average B/C ratio across all twenty-one routes = 19
    - B/C ratios on specific routes range from 3 to 58
  - Total benefits = \$40.7M
    - Delay = \$37.8M
    - Fuel = \$2.5M
    - Emissions = \$0.37M
      - HC = \$.028M
      - CO = \$.025M
      - NO<sub>x</sub> = \$.32M
  - Total costs = \$2.1M
    - \$100,000 per van (1 van per route X 21 routes) = \$2.1M
    - no further breakdown of costs provided
- 

## Study Strengths and Weaknesses

- Strengths
  - Very thorough study
    - incidents analyzed by location, time, and type
    - estimates of reduction in incident durations were based, in part, on field data
    - quantified and monetized reductions in delay, fuel consumption, and emissions of HC, CO, and NO<sub>x</sub>
- Weaknesses
  - Cost information is very high level => difficult to know whether everything is captured, although \$100,000 per route seems reasonable
  - Excludes benefit of avoided crashes

## Chicago, Illinois

ATA Foundation. 1997. "Incident Management: Challenges, Strategies, and Solutions for Advancing Safety and Roadway Efficiency." Prepared for the National Incident Management Coalition in association with Cambridge Systematics, Inc.

Fenno, D. 1997. "Technical Support for Traffic Management, Traveler Information, and ITS Initiatives; Incident Management Support Materials; Freeway Service Patrols: A Nationwide Assessment." PB Farradyne Inc. in association with Texas Transportation Institute (sponsored by FHWA), DTFH61-96-00048

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## Program Description

- Chicago's Emergency Traffic Patrol (ETP) operates 12 routes along 79 centerline miles using the following vehicles:
  - 35 medium tow trucks
  - 4 heavy duty tow trucks
  - 11 4x4s (for shift supervisors)
- Hours of operation are 24 hours a day, 7 days a week
- ETP operates in the presence of a "model freeway traffic management program" comprising a traffic systems center and a communications center

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## Study Description

- The original study was conducted by Cambridge Systematics for the Trucking Research Institute/ATA Foundation, Inc (published in 1990). Detailed summaries of the original study are included in the two documents cited above.
- Dollar values are in 1989\$
- Delays estimated using "routines developed by FHWA" => almost certainly based on a deterministic queuing model (DQM)
- Although the ETP operates 24/7, only incidents occurring during the am/pm peak and midday periods were included in the analysis
- Reductions in incident durations due to the ETP are based on conversations with program managers and the literature:
  - Shoulders = 20 minutes
  - 1-lane blocked = 35 minutes
  - 2 or more lanes blocked = 40 minutes
- \$10 per vehicle hour, based on:
  - 80% of vehicle-hours due to auto drivers at \$7.70/hr
  - 20% of vehicle-hours due to truck drivers at \$20.62/hr

- averages \$10.68 => rounded down to be conservative (1989\$)
- acknowledges that average vehicle occupancy of 1.2 would raise \$/veh-hr (but doesn't incorporate this)
- B/C ratio = 17
- Total benefits = \$95M (this is entirely delay savings)
- Total costs = \$5.5M
  - Personnel = \$2.5M
  - Patrol vehicles (equip, maint, other) = .6M
  - Heavy wreckers (heavy duty tows) = .07M
  - Other (sand, salt, etc.) = .3
  - Building (construction, maintenance) = .8
  - Overhead (insurance, management, etc.) = 1.2

## Study Strengths and Weaknesses

- Strengths
  - With one notable exception, the costs are very thorough (e.g., this is one of the few studies to include building costs)
    - The exception is that it appears that nothing is included for the eleven (11) 4x4 vehicles that the supervisors drive
- Weaknesses
  - Benefits exclude fuel savings, emissions reductions, and avoided crashes
  - \$10/veh-hr seems rather high for 1989 (or maybe it's just that subsequent studies—Twin Cities (2000) and LA (1998)—that also assume \$10/veh-hr are being too conservative)
  - Reductions in incident duration seem very high...maybe too high
    - The ETP operates in the presence of a traffic systems center and a communications center, so it's hard to imagine that the roving ETP tow trucks really save that much time as compared to TSC operators (or state police) simply calling AAA whenever an incident is observed or detected...unless the time savings also include the benefit of the TSC and communications center, in which case the estimated B/C ratio is too high for the ETP alone (although the study makes it clear that the B/C ratio applies to the ETP alone)
    - Cell phones were much less popular in 1989 compared to today => savings in detection time due to roving ETP patrols likely would be smaller if study were conducted today (because motorists now use cell phones to report many/most incidents shortly after occurrence)
  - A separate (but very confusing) B/C analysis of the ETP program without the 4 heavy wreckers = 11:1; but it's hard to believe that 4 wreckers can make that much difference...plus there are several inconsistencies in the tables for the "partial program" analysis

## Denver, Colorado

Cuciti, P., and B. Janson. 1995. "Incident Management Via Courtesy Patrol: Evaluation of a Pilot Program in Colorado." Presented at 74<sup>th</sup> Annual Meeting of the Transportation Research Board

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### Program Description

- This courtesy patrol was a pilot program that operated 3 routes along 27 centerline miles in Denver, CO
  - Operating hours were weekdays only: 6am-9am and 3:30pm-6:30pm
  - Two types of courtesy patrols were used:
    - Colorado State Patrol
      - Two (2) 4-wheel drive vehicles equipped with push bumpers
      - 12 centerline miles
      - operated by off-duty, uniformed state patrol officers
    - AAA
      - Four (4) Class A tow trucks
      - 15 centerline miles
      - operated by regular AAA tow truck drivers
  - No freeway management system (or traffic operations center, etc.) was in operation during the study period
  - The pilot program included taxi companies (to provide rides for occupants of disabled vehicles if there were too many people to fit in patrol vehicles) and private businesses that agreed to allow their parking lots to be used as "safe havens" for disabled vehicles moved by AAA from the interstate
- 

### Study Description

- The study was conducted by researchers at the University of Colorado, Denver and funded by the Colorado Department of Transportation
- Data are from 1992-1993
- Delays are estimated using a deterministic queuing model
- Reductions in incident durations due to the courtesy patrols:
  - Lane-blockers = 10.5 minutes
  - Non-lane-blockers = 8.6 minutes
- The evaluation excluded assists to abandoned vehicles
- \$10 per veh-hr
- B/C ratio = 10.4 – 16.9

- Total benefits = \$1,750,000 - \$2,030,000 (this is all delay savings)
    - Range is due to different assumptions about capacity reduction due to incidents occurring on the right shoulder
  - Total costs = \$120,000 - \$168,000
    - Includes equipment and personnel, but does not disaggregate
    - Range is due to different assumptions about hourly cost of AAA vs. state patrol operators
- 

## Study Strengths and Weaknesses

- Strengths
  - Estimates of reductions in incident duration are based, in part, on field data
- Weaknesses
  - Benefits are underestimated inasmuch as the study:
    - excludes fuel savings, emissions reductions, and avoided crashes
    - excludes assists to abandoned vehicles
    - underestimates capacity reductions due to incidents
  - Costs appear to exclude overhead (bldg, utilities), maintenance on equipment, and salaries of administrative personnel
  - Does not disaggregate benefits by state patrol vs. AAA operators

## Gary, Indiana

Latoski, S., Pal, R., and K. Sinha. 1999. "Cost-Effectiveness Evaluation of Hoosier Helper Freeway Service Patrol." *Journal of Transportation Engineering-ASCE* 125 (5): 429-438

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### Program Description

- The Hoosier Helper freeway service patrol (FSP) operates along 24 miles of highways in Northwest Indiana (near Gary, IN)
  - Hours of operation:
    - Prior to May 1996: 7 days a week, 6am – 8:30pm
    - After May 1996: 7 days a week, 24 hrs a day (at least 2 vehicles in service at all times)
  - Vehicles are 3 vans and 3 pickup trucks
- 

### Study Description

- The study was conducted by researchers at Purdue University (School of Civil Engineering) and Dunn Engineering Associates
- B/C ratios were estimated both before and after the FSP expanded to 24 hours in May 1996
  - Before May 1996 is referred to as "daytime program"
  - After May 1996 is referred to as "24-hr program"
- Data for daytime program are Jan-Dec 1995; data for 24-hr program are June-Dec 1996
- The daytime program uses 1995\$ and the 24-hr program uses 1996\$
- Delay savings are estimated using the traffic simulation model XXEXQ
  - Macroscopic model developed specifically for the study of incidents
  - Accommodates freeways and arterial streets (a network approach) to allow motorists to divert around incidents
- Reductions in incident durations due to FSP assumed to be:
  - Crashes and in-lane assists = 10 minutes
  - All other assists = 15 minutes
- Reduction in secondary crashes were calculated in an earlier study by same authors
  - 2ary crash defined to occur within 3 miles upstream and within the clearance time plus 15 minutes of a primary crash (note that primary incidents are limited to crashes only)
  - Assumed that a 10-minute reduction in crash duration (due to FSP) reduces likelihood of a secondary crash by 18.5% in winter and 36.3% in all other seasons
  - Two components of benefits by reducing secondary crashes are (1) delay savings and (2) crash cost savings
- Valuation assumptions:

	<b>Daytime Program</b>	<b>24-Hr Program</b>
\$/veh-hr on weekdays	\$14.88	\$15.02
\$/veh-hr on weekends	\$11.76	\$12.14
\$/crash	\$2000	\$2073
\$/gallon of unleaded fuel	\$1.04	\$1.14
	\$1.02	\$1.14

- \$/veh-hr for daytime program based on weighted average of \$8.03/hour for autos, \$27.26/hour for single-unit trucks, and \$30.38/hour for combination trucks (weights determined by % traffic on weekdays vs. weekends); 24-hr values were calculated similarly using 1996 prices
- B/C ratios are:
  - 4.7 for daytime program
  - 13.3 for 24-hr program
- Benefits are:

<b>Benefits</b>	<b>Daytime Program</b>	<b>24-Hr Program</b>
Delay reduction	\$1,241,300	\$3,708,100
Secondary crash reduction	\$618,200	\$1,539,100
Fuel savings	\$78,300	\$249,400
	<b>\$1,937,800</b>	<b>\$5,496,600</b>

#### **Total Benefits**

- Benefit of 2ary crash reduction disaggregated as follows:
  - Delay savings
    - \$99,500 for daytime program
    - \$817,500 for 24-hr program
  - Crash costs savings
    - \$518,700 for daytime program
    - \$721,600 for 24-hr program
- Costs are:

<b>Costs</b>	<b>Daytime Program</b>	<b>24-Hr Program</b>
Vehicles/equipment	\$58,700	\$35,600
Overhead (phone charges)	\$39,000	\$45,700
Maintenance (parts and repairs, gas)	\$35,200	\$39,700
Salaries and benefits	\$278,300	\$292,900
<b>Total Costs</b>	<b>\$411,200</b>	<b>\$413,900</b>

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## **Study Strengths and Weaknesses**

- Strengths
  - Very thorough study that goes into detail (sometimes more than necessary) in disaggregating costs and benefits
  - Benefits include delay savings, fuel savings, and avoided secondary crashes
  - Sensitivity analyses performed on assumptions about discount rate, value of travel time, and vehicle crash costs => results did not change appreciably

- Weaknesses
  - Relative costs of daytime and 24-hr programs do not pass the “sniff test” => how can the 24-hr program cost approximately the same as the daytime program (although there should be economies of scale once the daytime program is in place, I’d still expect the 24-hr program to raise total costs appreciably due to extra salaries for drivers and increased wear and tear on vehicles)?
  - Costs do not appear to include buildings/lease
  - \$/crash is very low and assumes property damage only (i.e., excludes insurance administration costs, household productivity losses, workplace losses, pain and suffering, etc.)

## Houston, Texas (regular program)

Siegfried, R., and W. McCasland. 1991. "Houston Motorist Assistance Program Annual Report: August 1990-July 1991." Texas Transportation Institute, sponsored by Texas Department of Transportation and Metropolitan Transit Authority of Harris County (in cooperation with Houston Automobile Dealers Association, Harris County Sheriff's Department, and Houston Cellular Telephone Company)

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### Program Description

- The Houston Motorist Assistance Program (MAP) operates 7 routes along 140 centerline miles in the Houston metro area
- The MAP uses 9 vans operated by deputies from the Harris County Sheriff Department
- Operating hours are weekdays only: 6am – 10pm
- There does not appear to be a FMS or TOC present during the study period

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### Study Description

- The study was conducted by researchers at TTI (Texas Transportation Institute) and sponsored by the Texas Department of Transportation and the Metropolitan Transit Authority of Harris County (in cooperation with the Houston Automobile Dealers Association, Harris County Sheriff's Department, and Houston Cellular Telephone Company)
  - The study period is August 1990 – July 1991
  - Delays are estimated using "routines and calculations" developed by the FHWA => almost certainly deterministic queuing models (though the study doesn't explicitly say so)
  - Study authors did not know by how much the MAP would affect incident durations, so they did a sensitivity analysis assuming incident durations without the MAP would increase by 5, 10, 15, and 20 minutes
  - \$12.20 per veh-hr
    - \$9.76 per person-hr X average vehicle occupancy of 1.25
  - B/C ratio ranges from 7 to 36, depending on assumption about the impact of the MAP on incident durations:

<b>Increase in incident durations without the MAP</b>	<b>B/C ratio</b>
5 minutes	7
10 minutes	15
15 minutes	25
20 minutes	36

- A previous study estimated the reduction in incident durations due to the MAP at 17.7 minutes => B/C ratio would be approximately 30:1
  - Total benefits (all delay savings) are \$7.4M, \$16.2M, \$26.3M, or \$37.9M, assuming that without the MAP, incidents would last an additional 5, 10, 15, or 20 minutes, respectively
  - Total costs = \$1,064,748
    - Labor (salaries and fringe) = \$918,825
    - Equipment (vehicles, 3-year life) = \$145,923
- 

## Study Strengths and Weaknesses

- Strengths
  - This is one of the first B/C studies of a MAP/FSP; as such, it can be forgiven somewhat for the following weaknesses
- Weaknesses
  - Overall evaluation hampered by lack of data => only 60% of MAP assist forms completely filled out => biased results?
  - Benefits excluded fuel savings, emissions reductions, and crashes avoided
  - Very high B/C ratio likely due to:
    - Relatively high value of \$12.20/veh-hr (especially for 1990-91)
    - Costs appear to be underestimated => nothing appears to be included for facilities (bldgs, utilities/overhead)

## Houston, Texas (special program)

Hawkins, P. 1993. "Evaluation of the Southwest Freeway Motorist Assistance Program in Houston." Texas Transportation Institute, sponsored by Texas Department of Transportation, Report No. 1922-1F

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### Program Description

- The Houston Motorist Assistance Program (MAP) assigned two vans to patrol US59 (Southwest Freeway) during reconstruction projects from July 1991 through September 1992
  - Two (2) vans were operated by deputies from the Harris County Sheriff Department
  - There does not appear to have been a FMS or TOC in operation during the study period
- 

### Study Description

- The study was conducted by a researcher at TTI (Texas Transportation Institute) and sponsored by the Texas Department of Transportation
- Study period was August 1991 to August 1992
- Delays are estimated using FREQ10, a macroscopic simulation model of freeway operation
  - Incidents modeled by type, location, time, and blockage (shoulder vs. mainline)
  - FREQ10 allows user to reduce the capacity of the freeway at a specific time and location
- Study included minor incidents only => excluded major incidents (e.g., multi-vehicle crashes, crashes involving injury or death, large trucks, etc.) because these incident types are responded to by other police agencies
- Reduction in average incident duration due to the MAP = 16.6 minutes
- \$11.50 per veh-hr
  - \$10.47 per person-hr and average vehicle occupancy = 1.1
- B/C ratio = 19.4
- Total benefits = \$3,812,587
  - Delay = \$3,687,574
  - Aid to stranded motorists = \$125,000
- Total costs = \$196,483
  - Labor (salaries and fringe) for 4 drivers and clerk = \$146,000
  - Admin (salaries and fringe for TxDOT, radio, phone, office lease) = \$16,333
  - Equipment (vans, maintenance, other equipment) = \$34,150

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## Study Strengths and Weaknesses

- Strengths
  - Costs include office lease (most studies ignore costs for buildings/facilities)
- Weaknesses
  - Because the program patrolled a freeway undergoing reconstruction, results may not be generalizable to “regular programs”
  - Benefits exclude fuel savings, emissions reductions, and crashes avoided
  - The assumed reduction in average incident duration due to the MAP is probably too high
    - Although the “after data” (with the MAP) of incident durations are based on MAP field records (a good thing), the before data (i.e., without the MAP) are based on earlier studies dating to 1969 and are probably too long (i.e., incident durations without the MAP likely would be shorter at the time of this study than in 1969...and much shorter today)
  - Most of the benefit category “aid to stranded motorists” comprises transfers from one segment of Houston’s population to another (e.g., value of providing gas to a stranded motorist = \$57; value of pushing a disabled car off the freeway = \$57, etc.). Because transfers do not represent efficiency gains they should not be included in the total benefits (i.e., it doesn’t make a difference to the societal B/C ratio whether the motorist pays a tow truck driver or taxpayers pay for the MAP—the only thing that changes is the distribution of the costs and benefits) => if “aid to stranded motorists” is excluded from the analysis, the B/C ratio drops from 19.4 to 18.8

## Los Angeles, California

Skabardonis, A., Petty, K., Varaiya, P., and R. Bertini. 1998. "Evaluation of the Freeway Service Patrol (FSP) in Los Angeles." Institute of Transportation Studies, University of California—Berkeley (in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the US DOT, FHWA), California PATH Research Report No. UCB-ITS-PRR-98-31

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### Program Description

- A single route of the Los Angeles Freeway Service Patrol (FSP) was evaluated in this study
    - The route under study was a 7.8-mile section of the I-10 freeway in LA
    - The overall Los Angeles FSP comprises 149 tow trucks from 20 towing contractors patrolling 40 beats covering 404 centerline miles
  - 3 tow trucks are used to patrol the route under study
    - Service is provided by private tow truck companies selected through a competitive bid process, under contract to the local transportation planning agencies
  - Hours of operation are weekdays only: 6am-10am and 3pm-7pm
  - The FSP operates in the presence of a traffic operations center
- 

### Study Description

- The study was conducted by researchers at UC-Berkeley's Institute of Transportation Studies, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the US DOT, FHWA. A similar study was conducted of San Francisco's FSP program.
- The data are from 32 weekdays during 1996
- Delays are estimated using a deterministic queuing model
  - Field data from loop detectors and probe vehicles are used to model incident scenarios (e.g., demand, highway capacity, capacity reduction due to incidents, etc.) with and without the FSP
- Because authors did not have good "before" data (i.e., without the FSP) with respect to incident durations, they did a sensitivity analysis assuming the FSP would reduce incident durations by 10, 12.5, or 15 minutes
- Study ignores incidents of short duration, abandoned vehicles, and off-mainline incidents
- \$10 per veh-hr
- \$1.10 per gallon of fuel
- B/C ratio ranges from 3.75 to 5.5, depending on assumption about impact of FSP on incident durations:

**Decrease in incident durations with FSP**

	<b>B/C ratio</b>
10 minutes	3.75
12.5 minutes	4.5
15 minutes	5.5

- Benefits include delay reduction and fuel savings and depend on assumption about impact of FSP on incident durations:

<b>Decrease in incident durations with FSP</b>	<b>Total Benefit (\$M)</b>	<b>Delay Benefit (\$M)</b>	<b>Fuel Savings (\$M)</b>
10 minutes	1.24	1.14	.10
12.5 minutes	1.49	1.36	.13
15 minutes	1.83	1.68	.15

- Total cost = \$.33M (assumes the study route accounts for 2% of total FSP budget because the route uses 2% of total truck hours)
  - Tow truck contract = \$.25M
  - Operations (pagers, cell phones, etc.) = \$.01M
  - Administration (salaries & overhead, travel/training, supplies) = \$.03M
  - Capital (telecomm equipment, radio frequency equipment, bldg) = \$.04M

## Study Strengths and Weaknesses

- Strengths
  - One of only two studies reviewed that uses field data for demand, highway capacity, capacity reductions, etc. at time of incidents (SF is the other)
  - Quantified savings of emissions, but did not monetize
- Weaknesses
  - Study focused on a single route within the overall LA FSP program => results may not generalize to other LA routes
  - Benefits are underestimated because (1) they exclude value of crashes avoided and emissions reductions (emissions reductions were quantified but not monetized), and (2) delay and fuel benefits exclude incidents of short duration, abandoned vehicles, and off-mainline incidents

## San Francisco, California

Skabardonis, A., Noeimi, H., Petty, K., Rydzewski, D., Varaiya, P., and H. Al-Deek 1995. "Freeway Service Patrol Evaluation." Institute of Transportation Studies, University of California—Berkeley (in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the US DOT, FHWA), California PATH Research Report No. UCB-ITS-PRR-95-5

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### Program Description

- A single route of the San Francisco Freeway Service Patrol (FSP) was evaluated in this study
    - The route under study was a 9-mile section of the I-880 freeway in Hayward, Alameda County
    - The overall San Francisco FSP comprised 17 beats covering 110 centerline miles of freeway in the Bay Area
  - 2 tow trucks are used to patrol the route under study
    - Service is provided by private tow truck companies selected through a competitive bid process, under contract to the local transportation planning agencies
  - Hours of operation are weekdays only: 6am-10am and 3pm-7pm
  - It appears that there is a FMC or TOC in operation during the study period
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### Study Description

- The study was conducted by researchers at UC-Berkeley's Institute of Transportation Studies, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the US DOT, FHWA. A similar study was conducted of LA's FSP program.
- The data are from 1993 (24 weekdays before the FSP and 22 weekdays after the FSP)
- Estimates of incident delay are based on the difference in average travel speeds under normal and incident conditions using data from loop detectors and instrumented (probe) vehicles
- Study examined breakdowns only (i.e., excluded crashes, short duration incidents and abandoned vehicles)
- Reductions in incident duration due to the FSP were obtained using "before and after" data from loops and probe vehicles
  - Breakdowns = 16.5 minutes
  - Crashes = 12.6 minutes
- Delay savings were measured at 42.36 veh-hrs per assisted breakdown using "before and after" data obtained from loops and probe vehicles
- \$10 per veh-hr
  - 92% cars at \$8 per person-hr and average vehicle occupancy = 1.15, and 8% trucks @ \$25/veh-hr

- \$1.15 per gallon of fuel
  - B/C ratio = 3.4
  - Total benefits = \$.99M
    - Delay = \$.91M
    - Fuel = \$.08M
  - Total cost = \$.30M (assumes the study route accounts for 7.4% of total FSP budget because the route uses 7.4% of total truck hours)
    - Tow truck contract = \$.21M
    - Operations (pagers, cell phones, etc.) = \$.01M
    - Administration (salaries & overhead, travel/training, supplies) = \$.06M
    - Capital (telecomm equipment, radio frequency equipment, bldg) = \$.02M
- 

## Study Strengths and Weaknesses

- Strengths
  - Only study reviewed that uses field data for all components of estimates of delay reduction (LA study uses field data for most of the components, but must make assumptions about impact of FSP on incident duration)
  - Quantifies emissions reductions (but does not monetize)
- Weaknesses
  - Study focused on a single route within the overall SF FSP program; in fact, the study route had a very high frequency of crashes and other incidents relative to other SF routes => results probably not generalizable to other routes within the program (i.e., other routes probably have lower B/C ratios)
  - Benefits are underestimated because (1) they exclude the value of crashes avoided and emissions reductions (emissions reductions were quantified but not monetized), and (2) delay and fuel benefits exclude incidents of short duration, abandoned vehicles, and crashes
    - If all incidents are included in the analysis, B/C ratio increases to 9:1 (but considerable uncertainty due to sketchy crash data)
  - Although using “before & after” field data to estimate delay savings due to the FSP is commendable, it does not appear that the study controlled for any potential confounding factors that may have changed between the before and after study periods (e.g., traffic demand, weather) => some uncertainty around the estimated delay savings

## Twin Cities, Minnesota

Minnesota Department of Transportation. 2000. "Highway Helper Summary Report." Freeway Operations Section, Office of Traffic and Maintenance Operations

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### Program Description

- The Twin Cities Highway Helper (HH) program operates 7 routes along 85 centerline miles in the metro Twin Cities area
  - Vehicles include 8 pickup trucks (1/2-ton) equipped w/push bumpers
    - 7 pickups cover the routes and 1 is a backup
  - Hours of operation are:
    - Weekdays: 4:30am – 8:15pm
    - Weekends: limited coverage 9am – 9pm
  - At time of study, there was a TMC in operation
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### Study Description

- The study was conducted by Mn/DOT's Freeway Operations Section
- Data are from 1998 (benefits) and 1999 (costs)
- Study uses a "freeway modeling technique" to simulate identical stalled vehicle incidents and their effects on delay, fuel, and emissions; estimated amount of delay avoided, fuel saved, and emissions reduced were then applied to the actual number of stalls assisted by HH in 1998 across all sections of roadway, times of day, and durations.
  - No details provided about freeway modeling technique...probably a macroscopic simulation model similar to FREQ11 or XXEXQ
- Study considers only stall incidents (86% of all assists)
  - Excludes crashes (7%), debris (4%), and other incidents (3%)
- Reductions in incident duration due to Highway Helper are based on data collected by the Highway Helper program and the TMC control room in 1994 and 1995:
  - 8 minutes if incident duration < 27 minutes
  - 5 minutes if incident duration is between 27 minutes & 57 minutes
  - 0 minutes if incident duration > 57 minutes
- \$10 per veh-hr
- \$1.15 per gallon of fuel
- B/C ratio = 4.4
- Total benefits = \$2,730,648
  - Delay = \$2,548,726

- Fuel = \$181,922
  - Total costs = \$623,727
    - Salaries and benefits = \$463,285
    - Vehicles and maintenance = \$59,692
    - Supplies, equipment = \$101,410
- 

## **Study Strengths and Weaknesses**

- Strengths
  - Estimates of reduction in incident durations were based, in part, on field data
  - Study quantified emissions reductions in HC and CO (but did not monetize)
- Weaknesses
  - Benefits are underestimated because (1) they exclude the value of crashes avoided and emissions reductions (emissions reductions were quantified but not monetized), and (2) delay and fuel benefits exclude debris incidents, crashes, and “other” incidents
  - Costs do not appear to include anything for building/facilities (lease or mortgage)
  - Costs include only 7 vehicles, even though 8 are in fleet (1 is a backup)
  - Although not a problem in this study, potential problem in future B/C studies due to incorrect belief that CMAQ funds used to pay program costs do not need to be “counted” (incorrect because if delay/fuel savings to taxpayers are going to be counted as benefits, then so should cost to taxpayers of funding CMAQ projects)

**FREEWAY SERVICE PATROLS – SUMMARY TABLE**

Program Location (year of study)	B/C Ratio	Total Benefits (\$Million)	Total Costs (\$Million)	Miles	Patrol Vehicles (# and type)	Hours of Operation	Assumptions				
							FSP Effectiveness		Valuation		
							Reduction in Incident Duration (minutes)	Crash Re-duction (%)	Time (\$ per veh-hr)	Fuel (\$/gal)	Other (\$)
Boston, MA (1997)	19	40.7 Delay = 37.8 Fuel = 2.5 Emissions = 0.37	2.1 0.1 per route	488	21 vans w/push bumpers (3/4-ton or 1-ton)	Weekdays am/pm peaks (6 hrs/day)	15 – minor incident 25 – veh disable 25 – crash to shldr 30 – debris 20 – crash in lane  Also, shldr incidents reduce capacity by 15% if MAP vs. 19% if state police		10	1.50	CO = .02/kg  HC = .23/kg  NOx = .76/kg
Chicago, IL (1990)	17	95 (all delay)	5.5 Personnel = 2.5 Vehs/equip = 1.0 Building = .8 Overhead = 1.2	79	35 medium tow trucks  4 heavy tow trucks  11 4x4s	24/7 (study limited to am/pm peaks and mid- day)	20 – shoulder 35 – 1-lane blocked 40 – 2+ lanes blocked		10		
Denver, CO (1995)	10.4 to 16.9	1.75 - 2.03 (all delay)	0.12 - 0.17	27	2 four-wheel drive vehicles w/push bumpers  4 tow trucks	Weekdays am/pm peaks (6 hrs/day)	10.5 – lane-blocker 8.6 – non-lane-blckr		10		
Gary, IN (1999) daytime program	4.7	1.9 Delay = 1.2 Crash reduction = .6 Fuel = .08	0.4 Vehs/equip = .06 Overhead = .04 Maintenance = .04 Salaries = .27	24	3 vans  3 pickup trucks	7 days 6am–8:30pm	10 – crashes and inlane assists 15 – all others	18.5 in winter  36.3 in spring, summer fall	14.88 M-F  11.76 SaSu	1.02 diesel  1.04 unld	2,000 per crash

**FREEWAY SERVICE PATROLS – SUMMARY TABLE**

Program Location (year of study)	B/C Ratio	Total Benefits (\$Million)	Total Costs (\$Million)	Miles	Patrol Vehicles (# and type)	Hours of Operation	Assumptions				
							FSP Effectiveness		Valuation		
							Reduction in Incident Duration (minutes)	Crash Re-duction (%)	Time (\$ per veh-hr)	Fuel (\$/gal)	Other (\$)
Gary, IN (1999) 24-hour program	13.3	5.5 Delay = 3.7 Crash reduction = 1.5 Fuel = .25	0.4 Vehs/equip = .04 Overhead = .05 Maintenance = .04 Salaries = .29	24	3 vans  3 pickup trucks	24/7	10 – crashes and inlane assists 15 – all others	18.5 in winter  36.3 in spring, summer fall	15.02 M-F SaSu	1.14 diesel and unld	2,073 per crash
Houston, TX (1991) regular program	7 to 36	7.4 – 37.9 (all delay)	1.06 Labor = .92 Equipment = .14	140	9 vans	Weekdays 6am – 10pm	5 – 20 per incident (sensitivity analysis)		12.20		
Houston, TX (1993) special program	19	3.8 Delay = 3.68 Aid to stranded motorists = .12	0.2 Labor = .15 Admin = .02 Equipment = .03	?	2 vans	?	16.6 per incident		11.50		
Los Angeles, CA (1998)*	3.8 to 5.5	1.24 – 1.83 Delay = 1.14 – 1.68 Fuel = 0.10 – 0.15	0.33 Tow contract = .25 Operations = .01 Admin = .03 Capital = .04	7.8	3 tow trucks	Weekdays am/pm peaks (8 hrs/day)	10 - 15 per incident (sensitivity analysis)		10	1.10	
San Francisco, CA (1995)**	3.4	0.99 Delay = .91 Fuel = .08	.30 Tow contract = .21 Operations = .01 Admin = .06 Capital = .02	9	2 tow trucks	Weekdays am/pm peaks (8 hrs/day)	16.5 – breakdown 12.6 – crash		10	1.15	

**FREEWAY SERVICE PATROLS – SUMMARY TABLE**

Program Location (year of study)	B/C Ratio	Total Benefits (\$Million)	Total Costs (\$Million)	Miles	Patrol Vehicles (# and type)	Hours of Operation	Assumptions					
							FSP Effectiveness		Crash Re- duction (%)	Valuation		
							Reduction in Incident Duration (minutes)			Time (\$ per veh-hr)	Fuel (\$/gal)	Other (\$)
Twin Cities, MN (2000)	4.4	2.7 Delay = 2.5 Fuel = .2	0.6 Salaries = .45 Veh/maint = .06 Supplies/equip = .1	85	7 pickup trucks w/push bumpers (½-ton)	M-F 4:30am – 8:15pm  SaSu 9am – 9pm (limited coverage)	8 – duration < 27 min 5 – 27 < duration < 57 0 – duration > 57 min	10	1.15			