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16. Abstract

This report documents the general procedures and results associated with a before-and-after analysis of Phase I of the San Antonio TransGuide System. This analysis focuses on the issues of: 1) safety; 2) incident management; and 3) driver understanding and utilization of the system. The first phase of the TransGuide System became operational July 26, 1995, and includes 26 miles of freeway in the downtown San Antonio area.

An improvement in safety has been observed in association with TransGuide System implementation. This improvement includes a 15 percent reduction in injury accident rate within the limits of the TransGuide System. Over the same time frame, injury accident rate increased 4.3 percent on freeways not included within the TransGuide System (i.e., control freeways). The benefits associated with these improvements translate into an annual savings of $4.3 million.

Review of video data has indicated an average reduction in response time of 20 percent. These results have further been used as input to the FREFLO freeway simulation model to quantify the impacts of reduced response time on delay and fuel consumption during major incidents. The results of the analysis indicate an average delay savings of 700 vehicle-hours and reduction in fuel consumption of 2,600 gallons per major incident. Based upon accident frequency for freeways included within Phase I of TransGuide, these figures translate to an annual savings of $1.65 million.

A series of fifteen (15) before-and-after surveys have also been distributed to a panel of over 600 downtown employees. The results of these surveys indicate excellent driver understanding, compliance, and confidence in the system.

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BEFORE-AND-AFTER ANALYSIS OF ADVANCED TRANSPORTATION MANAGEMENT SYSTEMS

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IMPLEMENTATION STATEMENT

The Texas Department of Transportation sponsored this report as part of an overall research effort (entitled "Highway Operations Research and Implementation") geared toward the assessment of means to enhance the operation and management of surface transportation systems. The primary objective of this particular research study was to collect, analyze, and interpret data to assess the effectiveness of committed Advanced Transportation Management Systems (ATMSs) in Texas.

The first major ATMS in Texas opened in San Antonio on July 26, 1995. The first phase of this facility (referred to as TransGuide) covers 26 center-line miles of freeway in the downtown area of San Antonio. TransGuide is planned to eventually encompass 191 center-line miles of freeway in the San Antonio area.

This report presents data and analyses relating to Phase I of the TransGuide facility through August of 1996. This report specifically focuses on the effectiveness of TransGuide in the areas of safety, incident management, and driver understanding/utilization. The results of this research study are already aiding implementing agencies in the areas of justifying ATMSs and realistic expectations of benefits to the motoring public.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation, nor is it meant for construction, bidding, or permit purposes. This report was prepared by Mariano E. Molina, Steven P. Venglar, and Russell H. Henk (Texas P.E. certification number 74460).

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I. INTRODUCTION

BACKGROUND

Although the United States has one of the best transportation systems in the world, our system is experiencing increasing congestion due to continued growth in travel. The level of mobility upon which we have come to depend can no longer be taken for granted. The nation's annual cost of congestion in lost productivity alone is over $100 billion. In addition, there are more than 30,000 fatalities and another five million injuries each year resulting from traffic accidents (1).

Intelligent Transportation Systems (ITS) refers to a group of technologies including information processing, communications, control, and other electronic technologies to reduce highway congestion and improve safety. It is one of the most promising approaches to addressing today's surface transportation problems. The national ITS program identifies, analyzes, tests, and implements new and existing technologies and services. The objective of this program is to improve the quality and range of transportation choices in the United States, which can be achieved through safer, better-informed travelers (2).

Congestion and highway accidents are two major focal points of the ITS program. To reduce the high costs of fatalities, injuries, property damage, and lost time, the ITS program is being expedited. The array of projects currently underway or planned reflect these efforts (3).

Many of these planned projects are in the form of Federal Highway Administration (FHWA) ITS Operational Tests, which are being conducted around the country. These tests are conducted in an operational highway environment and are used to evaluate advanced systems in real-world situations to ensure public benefits, to determine whether the expected benefits can be achieved at the expected cost, and to heighten awareness and educate the public about the potential of ITS. Operational Tests emphasize private-public partnership through a cooperative venture between the United States Department of Transportation (U.S. DOT) and one or more partners. The mission of the Operational Tests is to bridge the gap between research and development and full-scale deployment of ITS services, evaluate user service benefits and costs under real operating conditions, test all aspects of deployment, and add to corporate knowledge.

An FHWA Operational Test is currently underway in San Antonio, Texas. The Texas Department of Transportation (TxDOT) has installed the first phase of an advanced traffic management system (ATMS) at an estimated cost of $32 million. The three-story control center and 26 miles of the 191-mile proposed ATMS are now operational. This ATMS encompasses a complete digital communication network with field equipment consisting of changeable message signs, lane control signals, loop detectors, and surveillance cameras. The goal for incident detection and verification is two minutes, with a system response goal of under one minute after detection. The Operational Test will document the San Antonio ATMS design rationale and goals, evaluate the system's success in meeting the design goals, and evaluate the digital communication network for cost effectiveness and benefits versus "traditional" transportation data communication systems.

STUDY OBJECTIVE

The Texas Transportation Institute (TTI) teamed with TxDOT to conduct a research study which evaluated the effectiveness of the San Antonio ATMS through a series of "before" and "after" analyses. The overall research effort through which this "before-and-after Analysis" has been funded centers around improved highway operations through a coordinated program of research and implementation. This report documents the procedures and results associated with "before-and-after" study activities through the 1996 fiscal year.

DEFINITION OF ATMS

According to ITS America, "ATMS employs innovative technologies and integrates new and existing traffic management and control systems in order to be responsive to dynamic traffic conditions while servicing all modes of transportation." Key features of an ATMS are subsystem integration and real-time control adjustments that account for traffic fluctuations (3) . Put more simply, an ATMS detects traffic conditions over a wide geographic area and transmits the information to a traffic management center. The information is processed and then used to advise drivers about traffic conditions (i.e., how to avoid incidents) manage incidents, and adjust signal timings on impacted frontage road intersections.

SAN ANTONIO ATMS

The San Antonio ATMS is referred to as TransGuide (short for Transportation Guidance System). The San Antonio District of TxDOT developed the system to be the most advanced in the nation. A map of Phase I of TransGuide, which includes 26 center-line miles of freeway around downtown, is shown in Figure 1. This first phase of the system was implemented July 26, 1995. The second phase will increase the total center-line miles of coverage to approximately 55 and will include the freeways highlighted in Figure 2. The expected completion horizon is late 1997/early 1998.

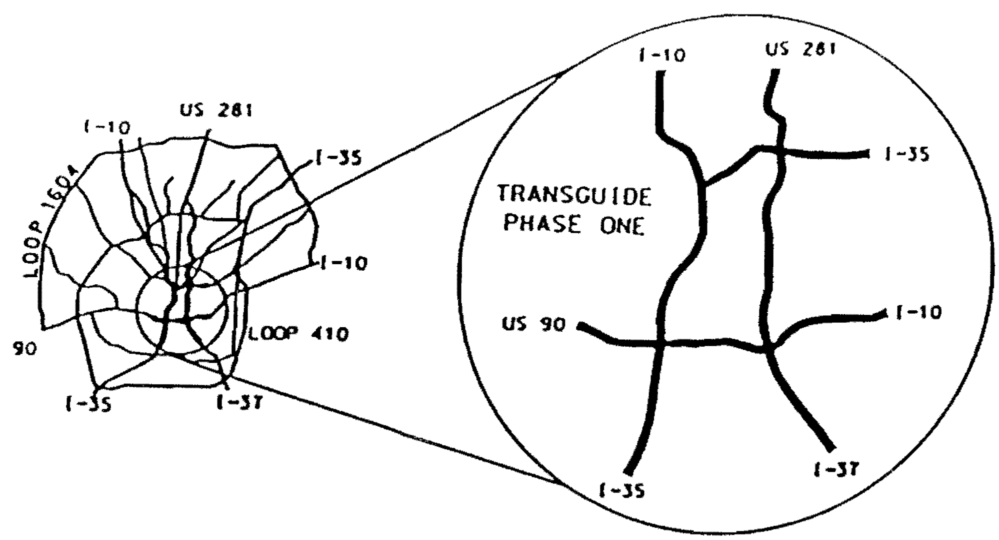


Figure 1. Phase I of TransGuide System

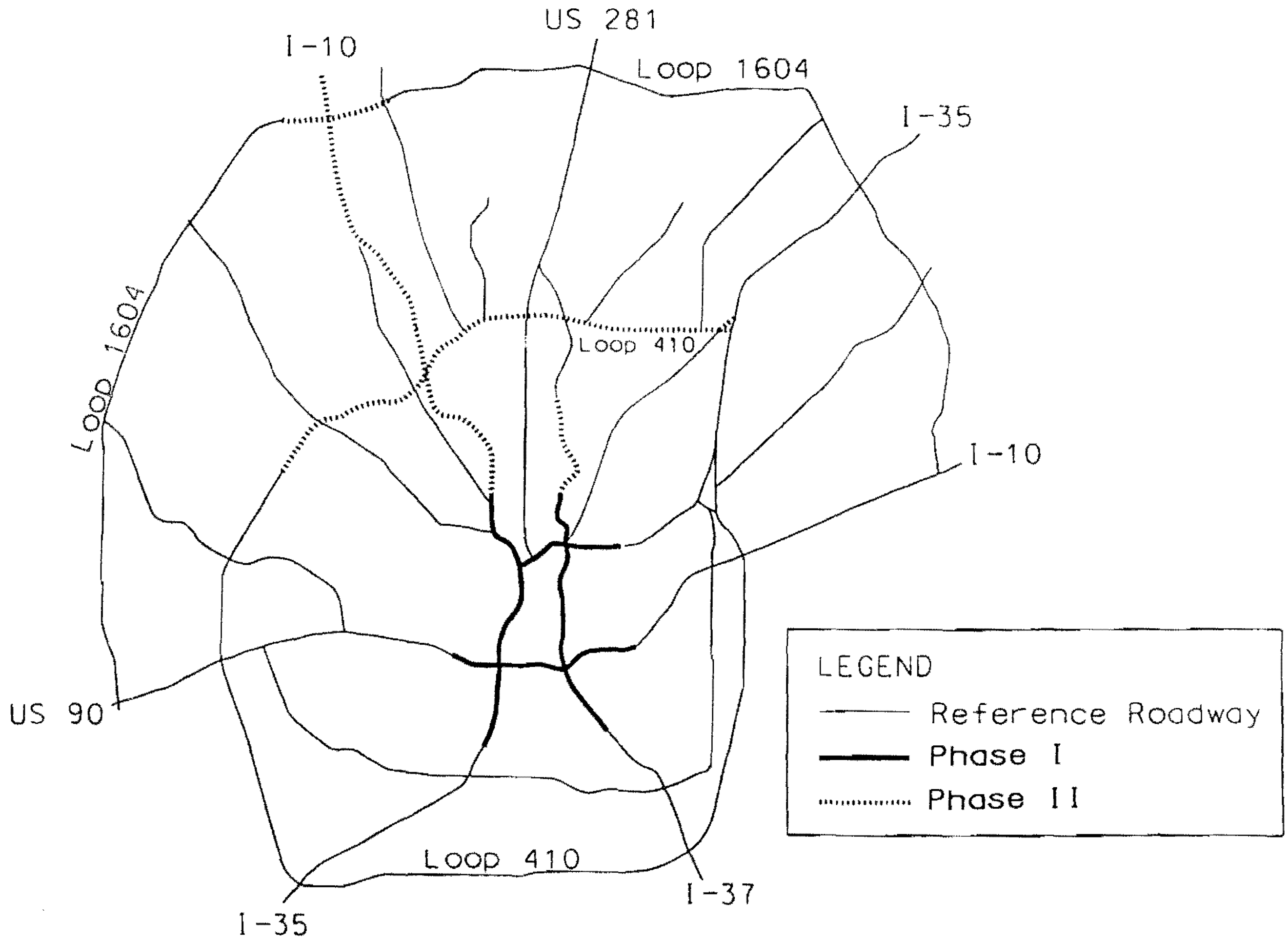


Figure 2. Existing and Future (1996/1997) Components of TransGuide System

II. EVALUATION ELEMENTS AND RESULTS

The evaluation upon which this study is based consists of a series of "before" and "after" analyses conducted to determine the general effectiveness of the TransGuide System. These analyses were designed to address major components of the system (e.g., incident detection and management, visual display information, etc.). The following list contains the "before" and "after" study elements included as part of this study:

- Safety;
- Incident Management; and
- Driver Understanding and Utilization.

For each of these study areas, data were collected, reduced and analyzed both before and after TransGuide became operational. An explanation of each of the "before" and "after" study area methodologies is documented subsequently. Results associated with each of these study areas follow each study methodology explanation.

SAFETY

The purpose of this portion of the analysis was to quantify any changes in overall injury accident rate (injury defined as a non-incapacitating injury or greater in severity) and injury accident frequency that might be associated with implementation of the TransGuide System. Due to changes in accident data reporting and documentation procedures during 1995, property-damage-only (PDO) accidents were not included in this analysis. Anticipated benefits of ATMSs include improvement in these areas of transportation system safety. Accident data for all roadways included in Phase I (before and after TransGuide implementation) have been examined as a part of this particular analysis. Texas Department of Transportation traffic records databases were used to summarize the frequency and characteristics of accidents.

Operations for the TransGuide System officially began July 26, 1995. Injury accident data for the time period of August 1 through December 31 for the years 1992 through 1994 were categorized by type of incident, location, time of day, day of week, and weather conditions. A similar search and categorization of injury accidents was completed for August 1 through December 31, 1995 data. During the time period within which this study was conducted, accident data for 1996 were not yet available. The formula used to calculate the accident rate is shown in Equation 1 (below).

$$\frac{\text{Number of Injury Accidents}^1}{\text{Vehicle Kilometers of Travel}^1} \times \frac{1 \text{ Million veh-km}}{\text{Veh-km of travel}^1} = \frac{\text{Injury Accident Rate per Million}}{\text{vehicle kilometers of travel}} \quad \text{Eq. 1}$$

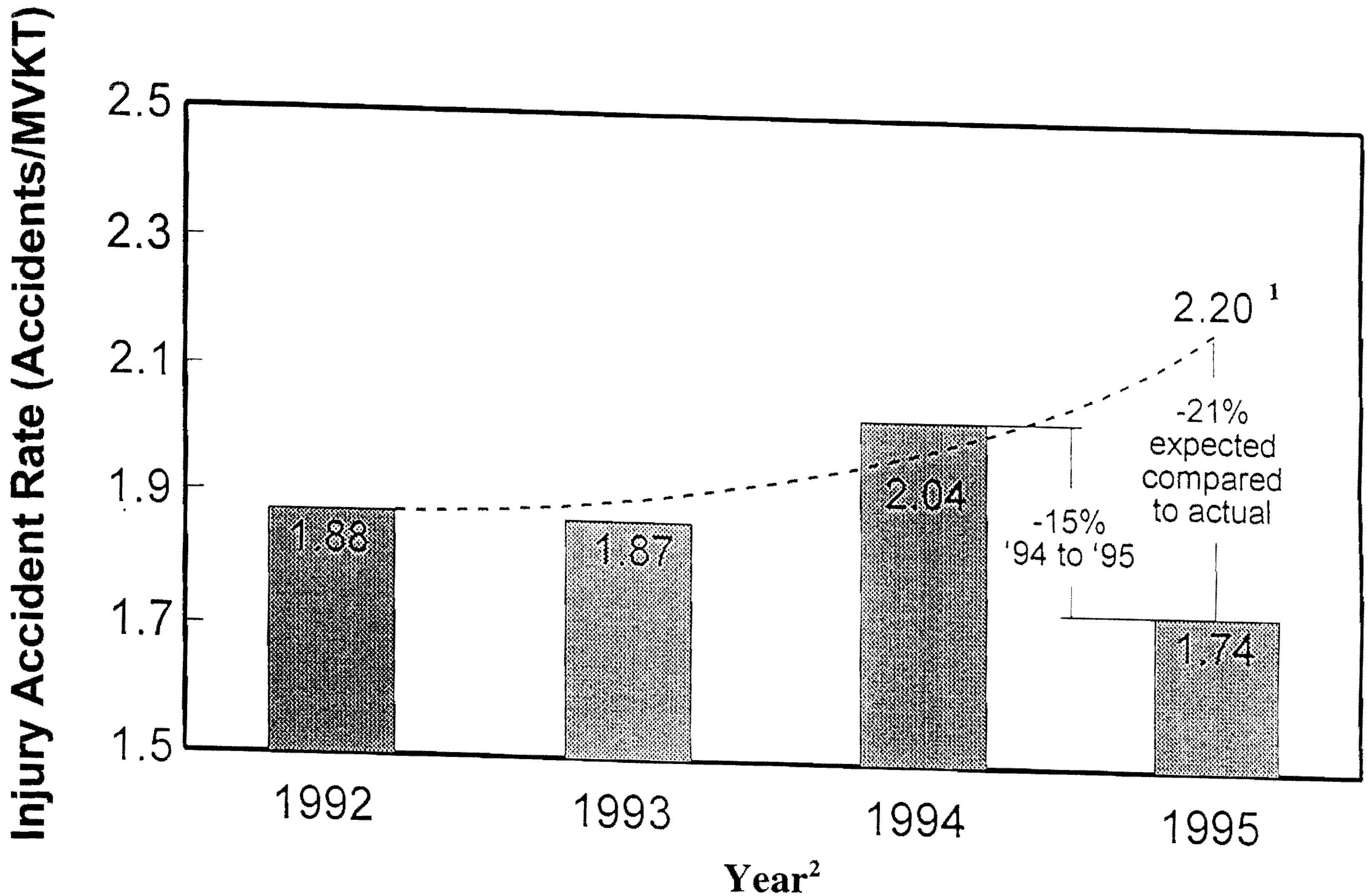
[1]For a specific section of freeway.

Table 1 provides a summary of "before-and-after" injury accident data. As indicated in Table 1, improvements in safety subsequent to TransGuide System implementation have been demonstrated with an overall injury accident rate decrease of 15 percent and a projected (relative to trend line data illustrated in Figure 3) accident rate decrease of 21 percent. The projected injury accident rate reflects an assessment (best estimate) of what the injury accident rate would have been had TransGuide not been implemented and was determined using a curvilinear best-fit line.

Table 1. Summary of Before-and-After Injury Accident Data

Injury Accidents	Accident Frequency/Rate		Percent Change
	Before[1]	After[2]	
Within TransGuide Limits:			
Total injury accidents	133	112	-16%
Injury accident rate, per mvk (per mvm)[3]	2.04 (3.28)	1.74 (2.80)	-15%
Projected injury accident rate, per mvk (per mvm)[3,4]	2.20 (3.54)	1.74 (2.80)	-21%
Control Freeway Sections[5]:			
Total injury accidents	77	83	+7.8%
Injury accident rate, per mvk (per mvm)[3]	2.33 (3.75)	2.43 (3.91)	+4.3%

[1]Average for the time period of August 1 through December 31 of 1992-1994.
[2]Total and/or average for the time period of August 1 through December 31, 1995.
[3]Total accidents per million vehicle-kilometers of travel, with a million vehicle-miles of travel indicated in parentheses ().
[4]Projected accident rates based upon trends in historical data. Projection based upon curvilinear best-fit line.
[5]Control data utilized from San Antonio freeways with similar geometric conditions and traffic congestion levels (see Figure 4).



[1]Curvilinear best-fit line used to estimate projected accident rate assuming no TransGuide implementation
[2]The time period of August 1 through December 31 for the respective year indicated

Figure 3. Injury Accidents per Million Vehicle-Kilometers of Travel

Analysis of freeways not covered by the TransGuide System (i.e., control freeways) for this same time period of comparison indicated a 7.8 percent increase in total accidents and a 4.3 percent increase in overall accident rate. The control freeways utilized in this analysis were limited to those characterized by similar geometric conditions and traffic congestion levels and are illustrated in Figure 4. This part of the analysis specifically consisted of identifying sections of freeway with similar total traffic conditions (average daily traffic (ADT)) and similar levels of congestion (ADT per lane). Assuming a cost of $32,200 per non-fatal evident injury accident, the aforementioned reduction in accidents (15 percent) translates into an annual benefit of $4.3 million (4).

INCIDENT MANAGEMENT

An important element of TransGuide is the effectiveness with which the system is able to promptly identify accident/incident locations. With timely and accurate detection, incidents can be more efficiently managed and cleared. Using the TransGuide field cameras, various locations were videotaped on a daily basis from 7:00 a.m. to 7:00 p.m. "Before" data collection began in early 1995 and continued until Phase I of TransGuide became operational. All incidents captured on video were reviewed to determine incident response, physical incident clearance times, and queue dissipation. Furthermore, data on accident response times were obtained from the San Antonio Police Department (S.A.P.D).

Several accidents were captured on videotape during the incident response study. Table 2 presents a summary of the data obtained regarding incidents that occurred both prior to and after the implementation of TransGuide. Average response time improved 19 percent for minor accidents and 21 percent for major incidents

Table 2. Response Time to Incidents, Before-and-After TransGuide System Implementation

Type of Accident	Total Response Time (minutes)[1]		Percent Change
	Before[2]	After[3]	
Minor	26	20	-19%
Major	24	19	-21%

[1]Total response time includes the time expired between police dispatch receiving the call and an officer arriving at the scene.
[2]The average total response time prior to TransGuide implementation (on July 26, 1995) during 1995.
[3]Total response time as measured from video surveillance between August 1, 1995 and December 31, 1995.

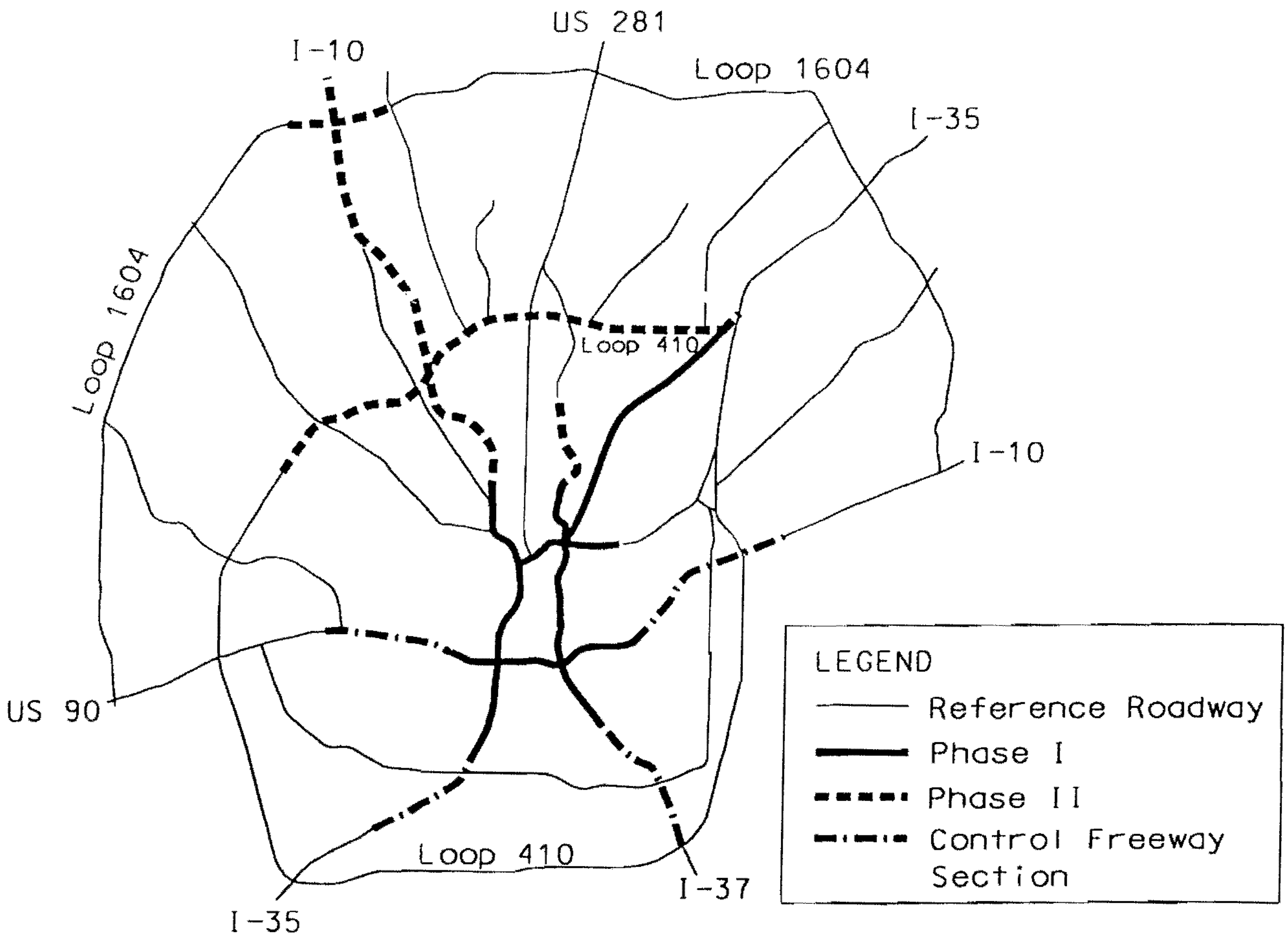


Figure 4. Control Freeways Utilized in Accident Analysis

The results of this analysis were used as a basis for simulating traffic operations (during incidents) before and after TransGuide implementation for the freeway segments indicated in Figure 1. The FREFLO freeway simulation model was used to estimate impacts of improved response time on total delay and fuel consumption. These simulations indicated that average delay savings and reduction in fuel consumption amounted to 700 vehicle-hours and 9,840 liters (2,600 gallons) of fuel, respectively, for major incidents. Based upon the frequency of major incidents for freeways included within Phase I of TransGuide, these delay savings translate into an estimated annual savings of $1.65 million.

DRIVER UNDERSTANDING AND UTILIZATION

An additional key component to the TransGuide System is the visual information displayed to the drivers, which conveys valuable traffic information (e.g., via changeable message signs and lane control signals). The changeable message signs and lane control signals warn motorists of incident and traffic congestion and/or tell motorists what to do in response to an incident. It is, therefore, integral to the success of the ATMS that the motorists see, understand, and respond appropriately to the displayed messages.

A panel of more than 600 downtown employees was developed. A series of travel questionnaires was (and continues to be) sent to the panel members to determine current travel patterns and habits. Questions regarding commuter routes and alternative routes were asked prior to the active implementation of TransGuide. After TransGuide became fully operational, questions were posed to these same panel members relative to specific travel patterns in response to messages that were displayed in order to determine motorists' recollection/understanding of the messages, message response rate, perception of traffic conditions on alternative routes, and motorists' general utilization and impression of the system.

The first questionnaire sent to the panel members was used to obtain information about the panel members' current driving habits. The results of this questionnaire showed that the majority of the panel members listen for traffic reports (via local radio stations) on a daily basis. In response to the questions regarding alternate routes, more than half of the panel members reported that they generally use alternate routes to avoid traffic incidents.

General results of the "before" questionnaires showed that most of the panel members encountering incidents were subjected to at least moderate delays (2 to 10 minutes), with an average of 25 percent indicating significant delays (i.e., greater than 10 minutes). Thirty-seven percent reported that they were previously notified of the incident conditions through radio and/or television. Of those previously notified, 47 percent reported taking an alternate route (either the frontage road or a different roadway altogether) to avoid the incident. A significant portion of the panel members taking an alternate route (an average of 45 percent) felt that the alternate route saved them time. When asked if they felt current methods of notifying motorists of traffic incidents are efficient (prior to TransGuide implementation), 60 percent said "no" or that systems "could be improved."

As of August 1996, a total of 15 surveys had been conducted. Eight (8) of these questionnaires were distributed "before" TransGuide implementation and seven (7) "after." The average response rate has been 72 percent over the course of this study. Highlights of survey results are provided below:

- "Before" surveys indicated only 40 percent of motorists felt current methods for notifying motorists and managing traffic congestion were efficient; "after" surveys indicate 86 percent feel means are efficient--a significant improvement in motorist confidence in the traffic management system.

- "Before" surveys indicated that an average of 58 percent of people using alternate routes (during incidents) felt they saved time; "after" surveys indicate this figure has improved to 71 percent, likely from more accurate information provided by TransGuide.

- The number of respondents who indicated they had seen specific instructions during incidents and subsequently followed the instructions has improved from a level of 33 percent (for the first incident-related survey distributed six (6) days after system implementation) to a current level of 80 percent--indicating a significant improvement in driver confidence and a high level of system compliance.

- "After" surveys indicate that 88 percent feel messages are "very easy" to understand--illustrating excellent motorist comprehension.

III. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, Phase I of the TransGuide System is demonstrating quantifiable benefits in the areas of safety, incident management, and driver understanding/utilization. The benefits observed to date can be considered conservative, as the freeways included within Phase I are characterized by little-to-no recurrent congestion. Future phases of the system will encompass freeways with significant recurrent congestion and should, therefore, exhibit even a greater relative magnitude of benefits.

Annual benefits associated with the observed improvements total $5.95 million. Assuming a constant stream of these annual benefits over a 20-year project life and a four (4) percent discount rate, the net present worth of these benefits totals approximately $80 million. These benefits compare favorably with the initial capital investment of $32 million in the TransGuide System, which also included construction of the Operations Control Center (OCC).

It is important to note that conclusions drawn thus far are largely based upon performance of the TransGuide System over a six- to nine-month time period. While preliminary analyses have been consistently positive, long-term analysis of TransGuide (and similar ATMSs) will be necessary in order to develop statistically significant databases upon which sound conclusions regarding ATMS performance/effectiveness can be drawn. Future efforts to identify cost and benefit issues should more thoroughly address additional benefits, as well as quantify operations and maintenance costs (life-cycle costs).

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