

Chapter 1 – Introduction

1.1 The Problem – Need for Advanced Traveler Information System (ATIS)

For decades, the United States has been investing in its transportation infrastructure to keep up with the nation's ever-growing transportation needs. Beginning in the mid-1950's, the construction of the National Interstate System served as the centerpiece of America's transportation infrastructure focus. As the \$130 billion program neared completion, however, academics and federal and state transportation leaders, both public and private, began to look ahead to the future needs of the United States' surface transportation system. In 1986, the first series of meetings took place between those stakeholders. This group recognized that, while the National Interstate System had positively impacted the mobility and efficiency of interstate travel and commerce, significant transportation problems still existed. Of specific interest was the desire to improve traffic safety while reducing congestion, particularly in urban interstate areas. In too many cities, rush-hour traffic was extending throughout the day, creating congestion on interstates well beyond the familiar morning and evening peaks. This group also noted that the construction of additional transportation facilities in the form of new highway lanes and overpasses was becoming both financially and physically impossible (Sussman, 1996). The proliferation of overpasses in the country's metropolitan areas was a testimony to the lack of space available for future highway construction.

Additionally, America was beginning to understand the economic detriment caused by the increased congestion. A 1991 study by General Motors estimated that highway congestion was causing a loss of \$93 billion in productivity each year along with an estimated cost of \$70 billion in traffic accidents. Americans were spending over 1.6 billion hours in traffic jams each year, burning up 4 percent in fuel. 1991 projections estimated that by the year 2005, those numbers would rise to 8.1 billion hours lost and 20 percent of fuel consumed (Gose, 1993).

At the same time, the world was receiving its first glimpses of the information technology (IT) age. Personal computers were beginning to make their way onto desktops in businesses as well as into American households. Business productivity increased with the benefits provided by these small, powerful machines. In light of this IT boom, the solution to America's surface

transportation dilemma seemed unavoidable. America's conventional surface transportation infrastructure would have to be merged with the explosive IT industry. The use of IT could serve as the engine for acquiring, storing and distributing traffic information in such a way as to improve the congested conditions on the nation's highways while improving highway safety.

The United States government took its first step toward merging its highway infrastructure with information technology in 1987 with the enactment of the Surface Transportation Assistance Act of 1987. Through this act, additional research and technology (R&T) funding was provided to address highway problems under the direction of the Strategic Highway Research Program (SHRP). R&T funding had previously been provided at moderate and fairly constant levels. The SHRP initiative preceded the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, a more powerful act of legislation which authorized the provision of approximately \$660 million over a six-year period for research, development and testing of Intelligent Vehicle Highway System (IVHS) innovations. Among the specific goals of the IVHS initiative of ISTEA was the reduction of the societal, economic and environmental costs of traffic congestion. The accelerated use of advanced technology to reduce traffic congestion was an additional goal of the IVHS program (Miller, 1992).

In time, the term "Intelligent Transportation Systems" (ITS) replaced IVHS as the proper name for the use of IT to enhance surface transportation. On January 10, 1996, Secretary of Transportation Federico Pena announced a plan to implement a national intelligent transportation infrastructure (ITI) as part of an initiative called Operation Timesaver. The objective of Operation Timesaver would be to reduce overall travel times by 15% by the year 2006, whether the mode be car, bus, train or subway. The implementation of ITI's in America's 75 largest metropolitan areas would be the method for achieving that objective. Included in the components of the standard ITI were Traveler Information Systems, which could provide travelers with comprehensive travel information from which to make informed travel decisions. Sussman divides the ITS components that would make up the ITI into six categories: Advanced Traffic Management Systems; Advanced Traveler Information Systems; Advanced Vehicle Control Systems, Commercial Vehicle Operations; Advanced Public Transportation Systems; and, Advanced Rural Transportation Systems (1996).

1.2 The Development of Automated Vehicle Identification in San Antonio, Texas

As part of Operation Timesaver, the USDOT solicited bids from cities around the nation to receive funding as part of an ITI deployment initiative. This initiative, labeled the Metropolitan Model Deployment Initiative (MMDI), would help fund the development of fully-integrated ITI's in selected US cities. San Antonio, TX, was one of four cities chosen to participate in MMDI (New York City, Phoenix and Seattle were the other three selected).

As part the of San Antonio MMDI, ten projects were identified for evaluation:

- Medical Center Corridor
- Freeway Surveillance Expansion (ATMS)
- LifeLink
- Bus Incident Management System (BIMS)
- Advanced Warning to Avoid Railroad Delays (AWARD)
- Traveler Information Kiosks
- In-Vehicle Navigation Device (IVN)
- Web Page
- Paratransit Vehicles w/IVN (PIVN)
- Travel Speed Database

In the San Antonio case, the Travel Speed Database forms an integral part of the city's ATIS program. This database is served in part by data collected from freeways and major arterials instrumented with Automated Vehicle Identification (AVI) equipment. ATIS data is then made available to users to allow them to make informed travel decisions. Because a portion of San Antonio's freeways were already instrumented with loop detection equipment, the AVI system would not provide complete coverage of the city's freeways. After evaluating available funding and desired areas of AVI coverage, a total of 53 AVI antenna sites containing 93 readers were selected and constructed in San Antonio, as shown in Figure 1.1. The 53-site array covers approximately 100 center-lane miles of highways and arterials.

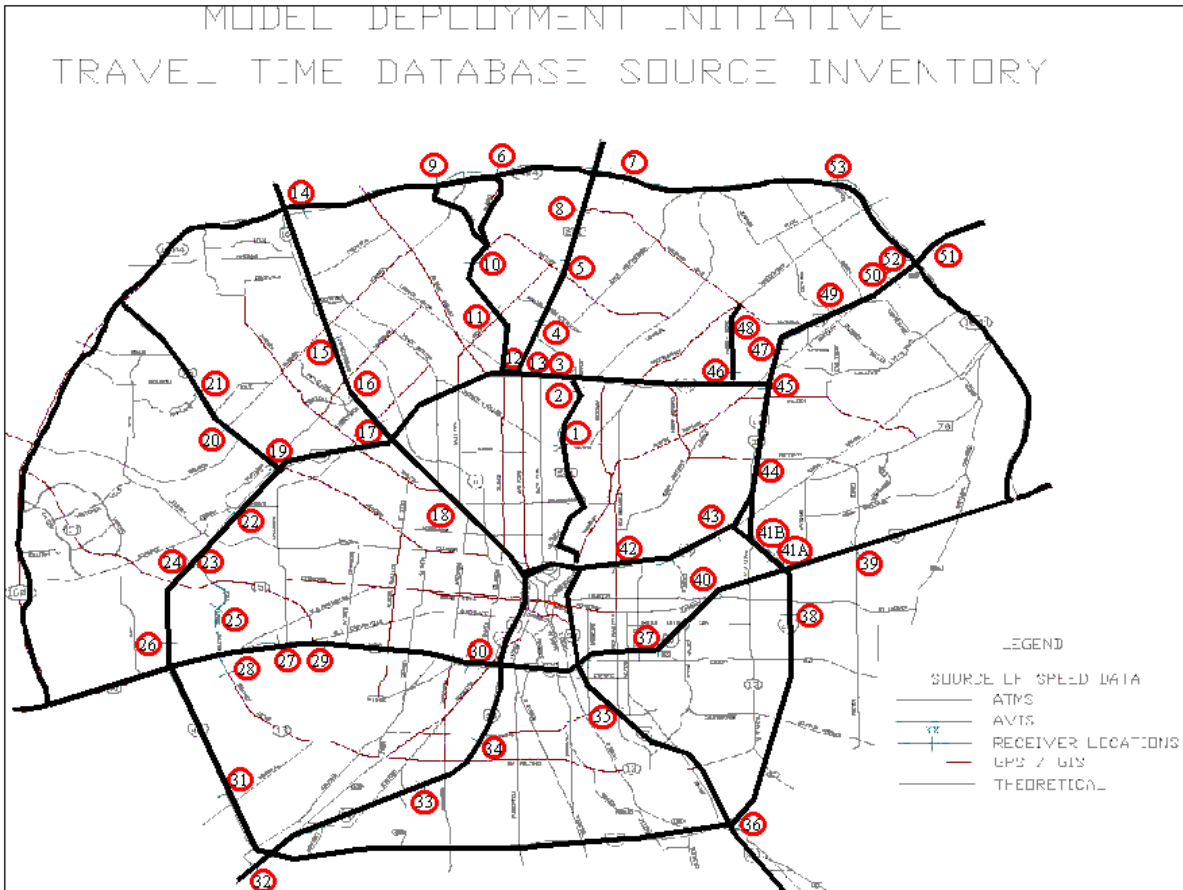


Figure 1.1 – San Antonio AVI System Antenna Site Map

AVI technology utilizes Radio Frequency Identification (RFID) to identify vehicles equipped with transponder tags. RF energy is broadcast into traffic lanes from overhead antennas. This energy is then reflected by the windshield-mounted AVI tags, and a modified signal containing the tag's unique ID is sent back to the antenna and transmitted to a central computer system. Upon passing another antenna, the vehicle's tag is again identified. The central computer system processes all tag reads recorded by the AVI system and matches like tag ID's to calculate antenna-to-antenna travel times of tag-equipped vehicles. Using a five-minute rolling average algorithm, aggregated travel times are averaged for every link defined by the AVI system. A more detailed explanation of the San Antonio AVI system is provided in Chapter 5 of this thesis.

1.3 Thesis Objectives

ATIS applications rely heavily on the reliability, accuracy and quality of travel time data to allow users to make informed decisions regarding route choice. In the San Antonio case, city residents can make travel decisions based on ATIS information that is provided through the Internet, In-Vehicle Navigation (IVN) units and traveler information kiosks.

The main objective of this thesis is to assess the reliability and accuracy of the AVI system used for ATIS in San Antonio, TX. In doing so, this research helps evaluate the quality of data being provided to San Antonio travelers via the Internet, IVN and traveler information kiosks. In addition, this assessment is performed to develop a database of field parameters from which computer modeling of AVI systems can be performed.

To achieve this objective, this thesis addresses the following relevant issues:

- Validation of GPS units for use as a benchmark measurement tool
- Analysis of the reliability and accuracy of individual AVI Reader Sites
- Analysis of and commentary on San Antonio AVI transponder tag distribution
- Analysis of the relationship between single-vehicle link travel times and aggregated AVI link travel times

It should be noted that this field study does not attempt to quantify the benefits gained from the use of AVI-generated travel time data.

1.4 Thesis Organization

This thesis is organized into 7 chapters including this introductory chapter.

Chapter 2 provides a literature review which discusses traffic surveillance research efforts and the potential benefits offered by AVI technology. Specifically, this chapter identifies the demand for improved traffic surveillance techniques as evidenced by the extensive research performed in this field. The status of AVI in current research as well as its advantages over other traffic surveillance technologies such as loop detectors is also discussed.

In analyzing the functionality of San Antonio's AVI system, a suitable baseline of measurement was necessary. Global Positioning System (GPS) units were chosen for this task based upon the ability of GPS to accurately capture location, speed and time data. Chapter 3 provides an evaluation and discussion of the suitability of the GPS units for use as a benchmark for measuring AVI system performance in this study.

The level of market penetration (LMP) of travel tags in San Antonio's traffic flow is an important reference parameter for the aggregate travel time study as well as for modeling efforts stemming from the accuracy and reliability studies. In chapter 4, a LMP value is estimated from daily tag reads and loop detector volume counts near a San Antonio tag reader. In addition, chapter 4 provides an analysis of the tag distribution efforts in San Antonio as revealed by the increase in tag reads over time at individual AVI antenna sites. The influence of out-of-town transponder tags on the AVI system is also discussed.

Chapter 5 focuses on the reliability and accuracy of the AVI antennas. The reliability of the system as a whole is discussed based upon a one-month data set of daily AVI tag files. In addition, antenna reliability and accuracy are quantified based on a data set generated by a series of controlled test runs performed during the summer of 1998.

Chapter 6 gives a detailed analysis of single probe vehicle travel times as compared to aggregated travel time values. Variances are observed between a floating test vehicle's travel time and averaged travel times of tag-equipped vehicles traversing the same link within 2-min, 5-min and 15-min time windows. This evaluation

Chapter 7 provides a conclusion and summary of the results found in the previous chapters of this work. In addition, it provides suggestions for further research.