

CHAPTER 1

INTRODUCTION

1.1 - Introduction

The United States has been investing in its transportation infrastructure to keep up with the nation's ever-growing transportation needs for decades. In the mid-1950's, the construction of the National Interstate System served as the greatest public works projects in history (President Clinton, 1997). As the \$130 billion program completed, it has been greatly improving the nation's surface transportation system and shaping America's economic, social and cultural life over the last four decades. 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.

Between 1980 and 1995, the number of vehicle miles traveled annually in the United States increased by 58%, from 1.53 trillion to 2.42 trillion miles. During the same period the capacity of the public road system only increased by about 1%, from 3.86 million to 3.91 million miles. In 50 of the Nation's urban areas, congestion nearly doubled from 7.3 million daily person-hours in 1982 to 14.2 million daily person-hours in 1993. Travel patterns have also changed, with enormous growth in travel outside of the central cities and between the suburbs of our metropolitan areas. All of this adds up to increased traffic on highways, arterials and local roads. People spend more time driving than ever, with an *average driving time per day for all drivers of one hour and 13 minutes*. Increases in traffic also impacts commercial vehicles which are experiencing increased delays in transporting goods and services, thus adding to their costs. In addition, congestion and stop-and-go traffic can cause frustration among drivers and compromise safety. Growth in travel and changes in travel patterns also present new challenges to transit agencies.

The America policy-makers also noted that financial, environmental, safety, and other policy and political considerations make expanding the size of the transportation system almost impossible (sussman,1996). Particularly in the Nation's metropolitan areas with the worst air quality, there are a host of barriers to adding new transportation capacity through construction or expansion of highways or roads. Even if adding new capacity weren't a problem, there is growing consensus that we can't build our way out of congestion.

Additionally, America was beginning to understand the economic detriment and environmental pollution caused by the increased congestion. A 1991 study by General Motors estimated that highway congestion was causing a loss of \$96 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). Air pollution from automobile emissions increases the incidence of heart and lung disease, and the Environmental Protection Agency estimated that 56 percent of cancer risk associated with air pollution results from motor vehicle emissions. In addition to causing region air pollution, motor vehicle emissions and the transportation infrastructure also damage ecosystems and deplete natural resources. There may be global impact as well, as the transportation sector is responsible for roughly 30 percent of global greenhouse gas emissions, which may contribute to global warming. In all, estimates of the external cost of the US transportation system (measured in the cost associated with damage to human health, damage to agriculture, and extinction of plants and animals) range from \$10 to \$200 billion/year (Daniel, 1996).

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.

Thus, operating the existing system better and smarter is a priority and is a principal tenet of contemporary Federal transportation policy. 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.

After 1992, the term "Intelligent Transportation Systems" (ITS) replaced IVHS as the proper name for the use of advanced IT to enhance surface transportation system. 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 "*generate an overall benefit-cost ratio of 5.7 to 1 for the group of nearly 300 metropolitan areas examined, with even stronger returns to the top 75 most congested metropolitan areas (8.8 to 1)*". In addition, the study estimated economic consequences of direct investment of ITS in seventy-five metropolitan areas over the twenty year period (1996-2015). According to this estimate, the outcomes of ITS investment will include between \$300 and \$350 billion in direct economic impacts and the creation of nearly 600,000 jobs. The implementation of ITI's in America's 75 largest metropolitan areas would be the method for achieving that objective. The components of the standard ITI included 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 (sussman, 1996). Of which, Automatic

Vehicle identification (AVI) system and travel time information is playing an increasingly important role.

1.2 - Background of AVI System and San Antonio Projects

Automated Vehicle Identification (AVI) is the process and technology by which individual vehicles are uniquely identified as they pass specific points in the road network, without any action being required of the driver or wayside observer. Potential benefits of the AVI technology are in the fields of measuring traffic parameters in real time, traffic operations and control, reduction of traffic congestion at transportation facilities (toll plaza facilities), transportation planning (O-D studies), fleet management, information and control, electronic toll collection, security purpose, vehicle weighting and classification, etc. The basic output of the AVI technologies is accurate traffic information which can help in making appropriate decisions.

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), funded 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 projects, 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.

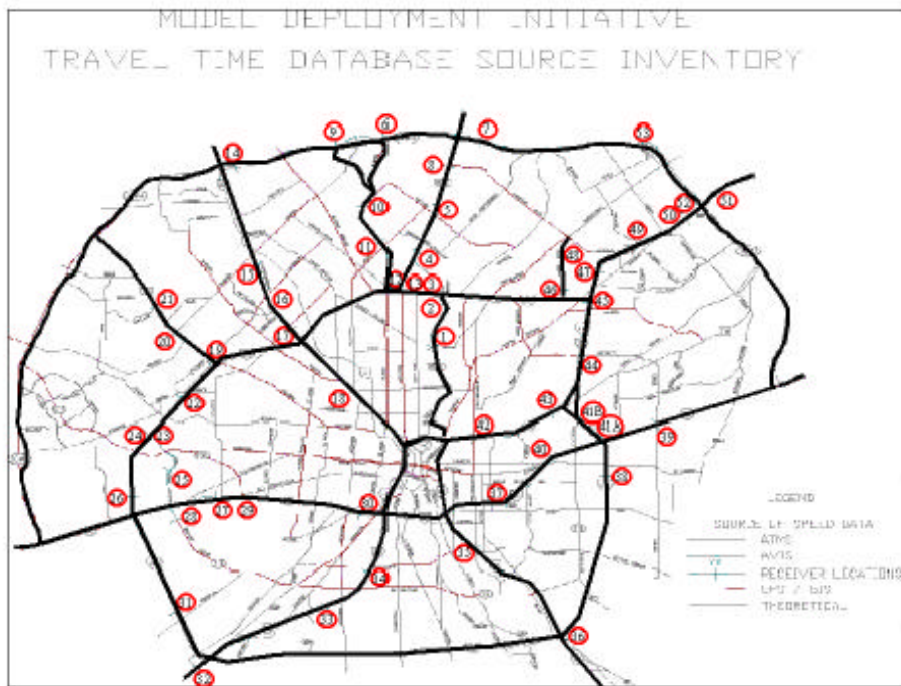


Figure 1.1 – AVI Antenna Site Map in San Antonio, Texas

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. This process is characterized as one "reading". 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.

1.3 - Objectives of the Thesis

The ITS applications rely heavily on the reliability, accuracy and quality of travel time data (include collected travel time data and forecasted 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 further model and optimize the AVI system in San Antonio, TX, specially to improve the coverage of travel time data collection and the accuracy of travel time forecasting using advanced technology. In addition, the neural network technology will be compared with other travel time prediction technologies.

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

- Optimization problem of AVI site locations using genetic algorithms approach,
- Analysis of the reliability and accuracy of individual AVI site,
- Forecasting of travel time using the neural network technology,
- Comparisons of Neural Network models with other travel time prediction technologies.

It should be noted that the travel time data used to be trained in neural network is directly from San Antonio Tag database which has been in continuing updated.

1.4 -Thesis Organization

This thesis is organized into 6 chapters including this *introductory chapter*.

Chapter 2 provides a summary of the available literature in the area of traffic surveillance research efforts and the potential benefits offered by AVI technology. Specifically, The status of

AVI in current research as well as its advantages over other traffic surveillance technologies such as Global Positioning System (GPS) and loop detectors is also discussed. Then a review of neural network technology is performed.

Chapter 3 describes several advanced techniques for travel time data collection has been used by transportation planner and operator in the past years and its advantages and disadvantages. A summary overview of the San Antonio AVI system functionality is also presented and the reader reliability and accuracy is addressed. In addition, this chapter describes and presents the results of two studies that evaluate the reliability and accuracy of the AVI data collection.

Chapter 4 develops a model for optimal locations of AVI site location. The proposed model is tested in the case of relatively small hypothetical transportation network. The heuristic algorithm is developed based on the genetic algorithms.

Chapter 5 focuses on the travel time forecasting. MATLAB (Version 4.0, Math Works, Inc., 1992) and the accompanying Neural Network Toolbox (Version 2.0, Math Works, Inc., 1994) is applied to the San Antonio AVI Tag database to forecast the travel time in the future time intervals. Two ANN models are designed and tested with AVI travel time data. The forecasted travel time is compared with the observed travel time values based on the mean absolute percentage error (MAPE). Finally, the comparison of Neural Network models with other travel time prediction technologies is performed.

Chapter 6 provides a conclusion and summary of the results found in the previous chapters of this work. In addition, it provides suggestions for further research.