

CHAPTER 3

AVI TRAVEL TIME DATA COLLECTION

3.1 - Introduction

Travel time information is becoming more important for applications ranging from congestion measurement to real-time travel information. Several advanced techniques for travel time data collection has been used by transportation planner and operator in the past years, include electronic distance-measuring instruments (DMIs), computerized and video license plate matching, cellular phone tracking, automatic vehicle location (AVL), video imaging and automatic vehicle identification (AVI) et al. In this chapter, the various advanced techniques are described, and the advantages and disadvantages are summarized to support the study of AVI travel time data collection system in San Antonio, Texas.

A summary overview of the San Antonio AVI system functionality was presented and the reader reliability and accuracy was addressed according to Mr. John Riley 's study in his MS thesis: "Evaluation of Travel Time Estimates Derived From Automatic Vehicle Identification Tags in San Antonio, TX". In addition, the evaluation of San Antonio AVI system was performed in this chapter.

3.2 – Various Advanced Techniques for Travel Time Data Collection

A recently completed NCHRP study, *Quantifying Congestion*, concluded that travel time – base measures are most useful for the wide of congestion measurement needs (Lomax and et al.). The NCHRP study indicated that travel time measures are compatible with multimodal analyses and are understood by nontechnical audiences, yet are rigorous enough for technical analyses. Many transportation agencies have already adopted travel time measures for congestion measurement. Travel time information also is becoming important for on-board vehicle navigation/guidance system and real-time traveler information systems.

The increasing reliance on travel time information indicates a need to measure travel times accurately and cost-effectively. The traditional method for measuring travel times over the past

40 years has been the “test vehicle” or “floating car” technique. Several other travel time measurement techniques have emerged with the incorporation of portable computers and other electronic technology; AVI is one of these:

- Electronic distance-measuring instruments (DMIs)
- License plate matching (Via portable computer or video),
- Cellular phone tracking
- Video imaging
- Global Position System (GPS)
- Automatic vehicle location(AVL) and automatic vehicle identification (AVI)

In this chapter, the functionality of these advanced techniques are described and the advantages and disadvantages of each data collection also are summarized. AVI system used in San Antonio will be described and discussed in detail as part of San Antonio MMDI then.

3.2.1 – Electronic Distance-Measuring Instruments

The integration of an electronic DMI with the floating car technique provides an easier, safer way to collect detailed travel time information (compared with traditional methods for floating car studies). The sensor of the electronic DMI is attached to the test vehicle’s transmission, and the DMI receives consecutive pulses from the vehicle transmission while the vehicle is moving. A DMI typically can provide instantaneous speeds up to every 0.5-sec. This detailed travel time information can be downloaded automatically to a portable computer in an easy-to-use data format.

The major advantages of electronic DMIs include the following:

- Technique improves cost-effectiveness and safety of data collection relative to traditional (i.e. al, manual) floating car studies.
- Automatic recording to portable computer decreases data reduction and analysis time.
- Detailed travel time and delay information can be used to identify bottlenecks and areas of extensive delay.

- Acceleration and deceleration characteristics can be calculated, potentially a valuable source of input data for fuel consumption and mobile source emission analysis.

The disadvantages include the following:

- The floating car technique is still somewhat labor-intensive and is usually limited to a few measurements per day per staff member.
- Travel times are only as accurate as the driver's judgment of traffic conditions.
- Floating car technique on arterial streets may not measure the delay of cross street turning onto the study route.

3.2.2 - Electronic License Plate Matching

License plate matching was used as early as the 1950s for travel time studies but has more commonly been used for tracking or identifying vehicle in origin-destination surveys. Early methods relied on observers to note the license plates of passing vehicles and corresponding times on paper or into a tape recorder. License plates were manually matched later in the office, and travel times computed. Recent advances have substantially improved the ease and accuracy of this technique.

The major advantages of license plate matching are that it

- Can provide large sample sizes during the data collection period;
- Can provide a representative estimate of travel times through random sampling;
- Provide travel time at small time intervals, giving a speed profile for the study section throughout the peak period; and
- Uses a portable computer technique that is considered more cost-effective per travel time run than floating car.

Some of the disadvantages are the following:

- Data quality concerns from incorrectly reading or matching license plates;
- Collection of only overall travel times(no stopped delay)
- Less practical for high-speed traffic or long road sections with low through traffic; and
- Moderate initial cost for equipment purchase.

3.2.3 – Cellular Phone Tracking

With the increasing popularity of cellular phones among motorists, their application for traffic monitoring is becoming more widely utilized. Some cities have a dedicated number for cellular phone users to report their position at designated checkpoints, allowing a traffic operations center to estimate travel times on the basis of several cellular phone reports. Cellular phones in use can also be tracked using geolocation techniques.

According to the cellular phone demonstration project in Houston, TX and several other tracking projects, cellular phone tracking has the following advantages:

- Minimal costs are involved with instrumenting vehicles because of the popularity of cellular phone, and
- Cellular network and control centers are also able to handle incident and emergency calls.

Its disadvantages include:

- Large investment in control center for tracking phone calls;
- Cellular phones must be in use to track, thereby limiting sample size and coverage; and
- Potential public disapproval because of privacy concerns.

3.2.4 – Video Imaging

Several video-based systems are being developed to measure overall travel times; however, these systems are somewhat less developed than other techniques. Video systems capture vehicle images and attempt to match images from different camera locations.

Video imaging has the following advantages:

- Operating costs could be low relative to equipping probe vehicles, and
- Video could also be used to verify and respond to incident.

The disadvantages include the following:

- Technology is not extensively tested,
- Video quality is limited by ambient conditions, and
- There is potential public disapproval because of privacy concerns.

3.3 – San Antonio Automatic Vehicle Identification (AVI) System

Automatic Vehicle Identification (AVI) System is a technology that has emerged recently in various traffic management and toll collection applications. An AVI system basically consists of an in vehicle transponder (tag), a roadside reading unit, and a central computer system. When a vehicle containing a transponder (tag) passes a roadside reader unit, the information on the transponder is transferred to the reader unit. The transferable information can range from a simple vehicle identification number to toll account balances or trip information.

3.3.1 - Functionality of the San Antonio System

The hardware architecture of the San Antonio AVI system consists of three principal components: the AVI Data Processing System, the AVI Reader Field Site System and the AVI Tags. The AVI Data Processing System is located in the Transguide building, TxDOT's San

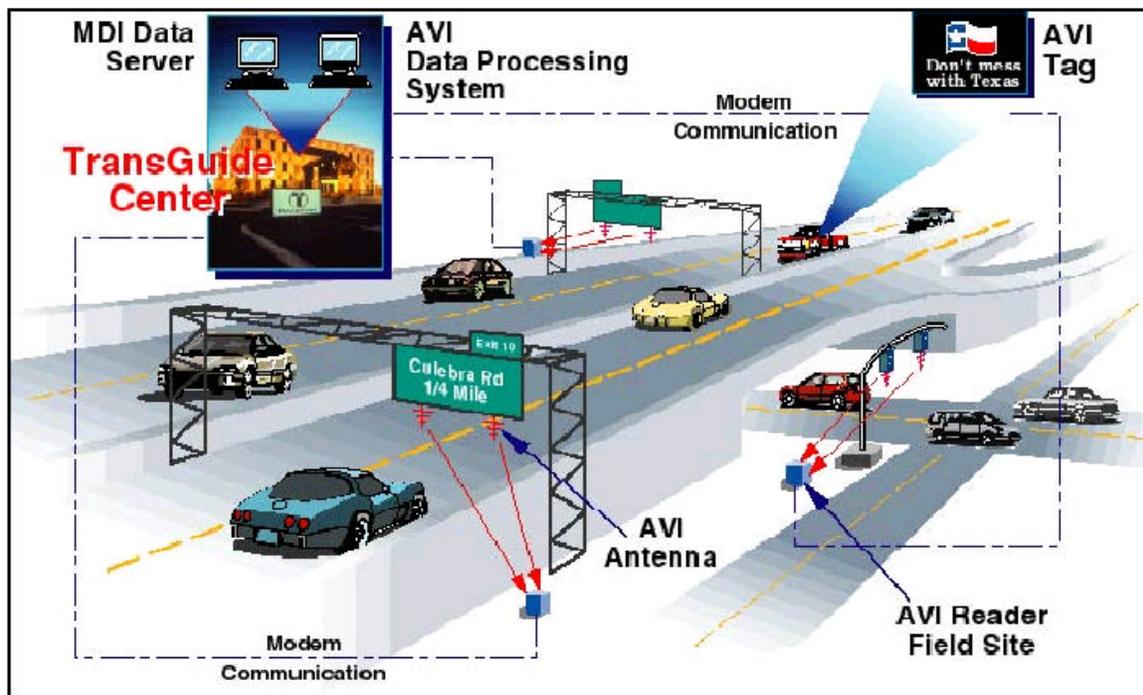


Figure 3.1 – Graphical Schematic of San Antonio AVI System Hardware Architecture

(Source: <http://www.transguide.dot.state.tx.us/>)

Antonio Traffic Management Center. This system consists of the AVI master computer, a modem server and a set of modems. The AVI Data Processing System is designed to be in constant contact with the AVI Reader Field Site System via telephone line connection. In the

field, the AVI Reader Field Site sends a RF signal into the desired lanes of coverage to ‘read’ AVI tags of passing tag-equipped vehicles. The AVI Reader Field Site sends the tag identification data back to the AVI Data Processing System where tag reads are stored and matched. All tag identification numbers for the San Antonio system are unique. A tag matching algorithm constantly searches for tag matches at adjacent AVI sites and performs five-minute rolling average travel time calculations for each AVI link. Link travel time data derived from the rolling average travel time algorithm is then provided to a data server master computer for use in ATIS services (in chapter 5, the travel time forecasting will be improved using neural networks technology). A graphical schematic of the San Antonio AVI hardware architecture is shown in Figure 3.1.

3.3.2 – San Antonio Passive Tags

San Antonio AVI tags are passive tags that communicate with the AVI Reader Field Site equipment via modulated backscatter of RF energy (Figure 3.2). The term ‘passive’ is given to these tags because they do not emit a signal on their own power. Each AVI tag is energized by the RF frequency broadcast by the field antennas. This RF energy is then modified and reflected by the tag. The modified, reflected signal contains the unique tag identification data required for tag matching to occur.

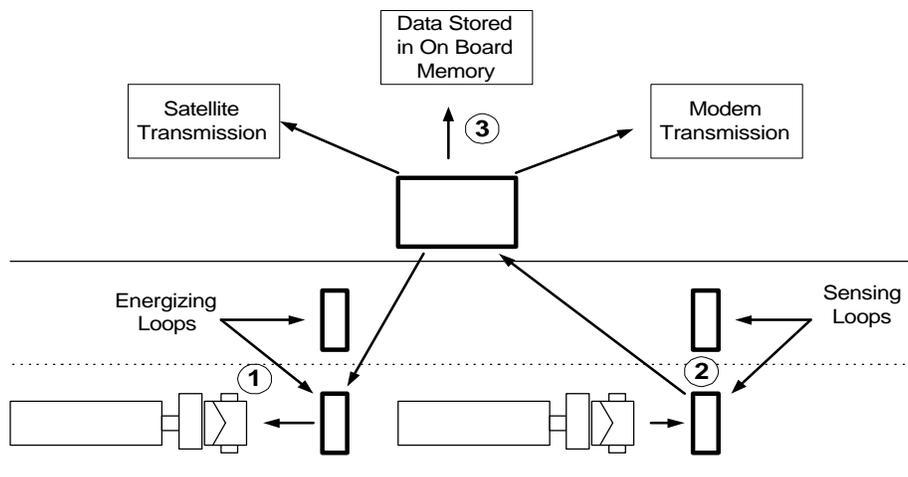


Figure 3.2 – San Antonio Passive Tags

(Time lapse 1-3: 1, Vehicle approaches AVI site equipment, energizing loop energizes tag; 2, tag transfers data to sensing loop; and 3, AVI equipment receives code, store or transfers data.)

The system design capture rate for passive San Antonio AVI tags is 80%. For comparative purposes, electronic toll collection (ETC) facilities in the United States utilize a design capture rate of 99.95%. The extremely high reliability is necessary given that toll revenues depend directly upon the successful capture of each toll tag by AVI antenna equipment. For this reason, ETC tags most often are designed to be 'active' tags (Figure 3.3) containing a frequency-emitting battery that is more readily detected by AVI antennas. The original intent of the San Antonio AVI system design was to develop a system that was cost-effective and that produced useful and accurate travel time data. In addressing the cost constraint, the designers of the system ultimately decided that it would not be necessary to have an antenna covering every lane of the 53 AVI sites. This decision allowed the designers to utilize existing infrastructure (overhead sign bridges, traffic bridges, span wires, et al.) for the mounting of AVI antennas, which significantly reduced the initial capital costs of bringing the AVI system on-line. Furthermore, by establishing a minimum design capture rate of 80%, the designers felt that the AVI equipment could effectively record tag data at a satisfactory cost to the city of San Antonio.

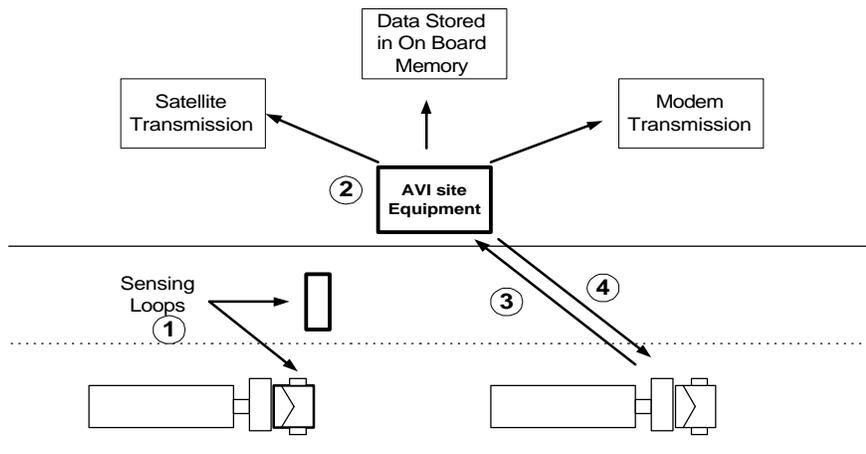


Figure 3.3 – Active Tags

(Time lapse 1-4: 1,Vehicle approaches AVI site equipment, triggers sensing loop (tag continuously transmitting); 2,AVI site equipment power up, ready to receive; 3, AVI equipment receives code, store or transfers data; 4, AVI site equipment transmits data to truck (if system equipped for read/write).)

3.3.3 - Communication from Readers to Operating System

To evaluate the reliability of the AVI system, it is important to understand how the Amtech AVI

system handles tag reads under various situations. When an AVI Reader Site antenna receives a signal from an AVI tag, the reader records the tag's unique identification number along with the time-of-day. The reader then attempts to send that information via modem to the central computer where tag reads are stored and tag matches are performed. In some instances, the AVI readers experience a timeout situation when their attempt to communicate with the server via modem is blocked. If the reader does not receive a response from the server in a certain amount of time, it will attempt to send the tag data repeatedly until it receives an acknowledgement within the correct amount of time. In such an instance, the system may record the singular passage of a tag more than once (The AVI tag data proved this). Tag reads that are recorded multiple times show identical time stamps. Under normal operating conditions, however, the tag is read once and recorded once by the master computer.

3.3.4 - Estimation of Link Travel Times

AVI link travel times are calculated by a rolling average travel time algorithm. To provide more accurate travel time information, this algorithm filters travel times that exceed user-defined threshold link travel time values. A complete description of the San Antonio AVI rolling travel time algorithm can be found in AVI MDI System Design Document. The travel time data which calculated by rolling average algorithm will be treated as input data of the neural networks which examined in chapter 5 to perform travel time forecasting studies.

3.4 - System Reliability Study

The AVI System Reliability Study consists of two parts: AVI antenna *system* functionality and AVI antenna *site* functionality. In the first analysis, the AVI system functionality is observed for a one-month period to determine the frequency of antenna non-functionality. In the second analysis, individual AVI sites are analyzed to observe their ability to correctly capture a passing tag-equipped vehicle.

According to Mr. John Riley 's study in his MS thesis: "Evaluation of Travel Time Estimates Derived From Automatic Vehicle Identification Tags in San Antonio, TX", the AVI system demonstrated a level of functionality consistently above 90%. With a percentage of downtime days of 5.47%, the system during this study period experienced an average of 2.9 (out of 53)

readers down per day. The freeway AVI readers yielded a higher reliability percentage (86% correct reads) than the arterial section (75% correct reads). In the study of AVI accuracy, it was found that the AVI system is highly accurate in calculating travel times. The level of travel time accuracy generated by the AVI system was found to exceed those often reported for loop detectors.

3.5 – Summary

In this chapter, a description of various advanced techniques and its advantages and disadvantages is given. Also the summary overview of San Antonio AVI system functionality was presented and the reader reliability and accuracy was addressed. The study results indicate that AVI system is highly accurate in calculating travel times. The mean difference between AVI- and GPS-calculated travel times was found to be 0.04 seconds, with a standard deviation of 0.99 seconds. The level of travel time accuracy generated by the AVI system was found to exceed those often reported for loop detectors (John Riley, 1999). The highly accuracy of AVI tag data provides highly accurate data source and improve the accuracy and reliability of travel time forecasting in chapter 5 using neural network technology.