3.0 Automated Vehicle Identification

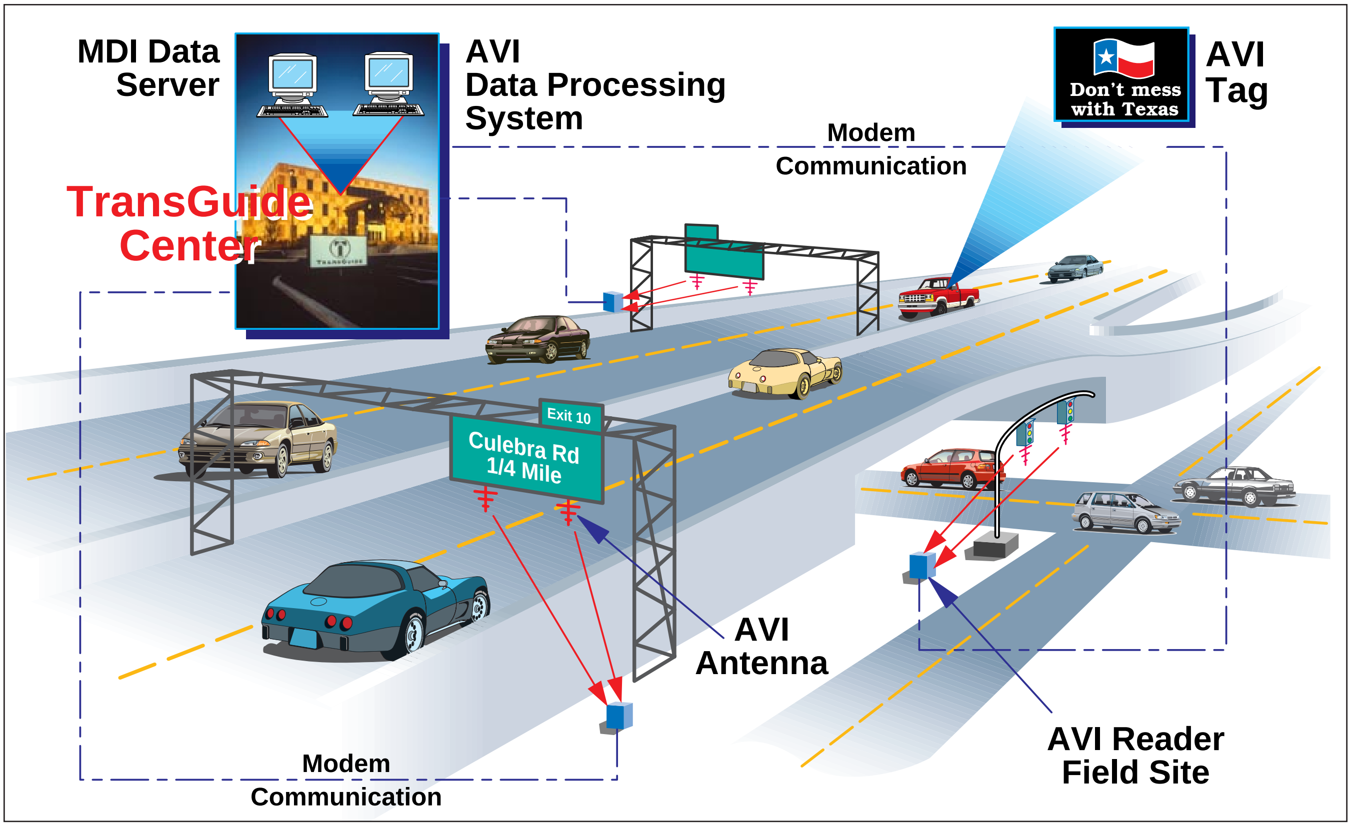

Figure 7. Automated Vehicle Identification Conceptual View

The Automated Vehicle Identification (AVI) System is an important source of real-time traffic data for other MDI systems as well as the TransGuide ATMS and the TransGuide Advanced Traveler Information System (ATIS).

3.1 Overview

The AVI System is an important source of real-time traffic data for other MDI systems as well as the TransGuide ATMS and the TransGuide Advanced Traveler Information System.

ATMS systems rely on real-time traffic data to detect incidents, monitor traffic flow, and inform the public. Data are traditionally collected by using roadside sensors to measure the number and speed of vehicles as they travel past the sensor. While these point speed data are useful in determining traffic conditions at a particular point, they cannot evaluate the traffic conditions between the points at which the sensors are located.

A more sophisticated measurement would be the determination of travel time between two instrumented points. Unlike the point speed data, travel time data contains information about traffic delays that occur between two points. These delays can be caused by accidents, traffic signals, or construction.

The AVI System addresses the shortcoming of point speed detection methods by determining travel times between specific locations throughout the city. These data can then be used as a source of real-time traffic data in the TransGuide ATMS System, the TransGuide ATIS System, and other MDI systems such as the IVN System and Traveler Information Kiosk System.

The AVI System consists of several thousand vehicle tags (AVI Tags), several AVI Reader Field Sites, and a collection of computer hardware and software designated as the AVI Data Processing System. Figure 7 shows a conceptual view of the AVI System with each of these components.

3.2 Design Information

The system design is presented in two forms: system architecture and software design. The system architecture defines the framework of the major hardware and software components of the AVI System and the methods used to communicate between the components.

Two views of the AVI System architecture are presented: the hardware architecture and the software architecture. Both views use block diagrams to illustrate the components of the architecture and the methods of communication between the components.

3.2.1 Hardware Architecture

The hardware architecture of the AVI System is presented in Figure 8. This figure shows the three main components of the AVI System: the AVI Data Processing System, the AVI Reader Field Site Systems, and the AVI Tags.

The AVI Data Processing System is connected to the Data Server Master Computer via the TransGuide Ethernet network, which consists of a collection of cables, routers, and bridges that serve many computer systems, including the AVI Master Computer and the Data Server Master Computer.

The AVI Data Processing System is connected to the AVI Reader Field Sites via Plain Old Telephone System (POTS) lines. Phone lines are required at two locations—the AVI Reader Field Site and the AVI Master Computer. One POTS line is installed in the field for each AVI Reader Field Site; however, to minimize monthly phone costs, fewer POTS lines are installed at the AVI Master Computer. A ratio of two AVI Master Computer POTS lines for every three AVI Reader Field Site POTS lines was selected. The AVI Reader Field Sites are designed to connect when they have tag data to transfer. After the transfer is successfully completed, the field sites disconnect from the AVI Master Computer. It is the responsibility of the AVI Reader Field Sites to initiate communication with the AVI Data Processing System.

The AVI Reader Field Sites communicate with the AVI Tags via a radio frequency (RF) signal that is emitted by the AVI Reader Field Site. This signal excites the transponder of a passing AVI Tag, causing the tag to emit a RF signal. The AVI Reader Field Site reads the signal emitted by the AVI Tag, which contains the unique AVI Tag identifier.

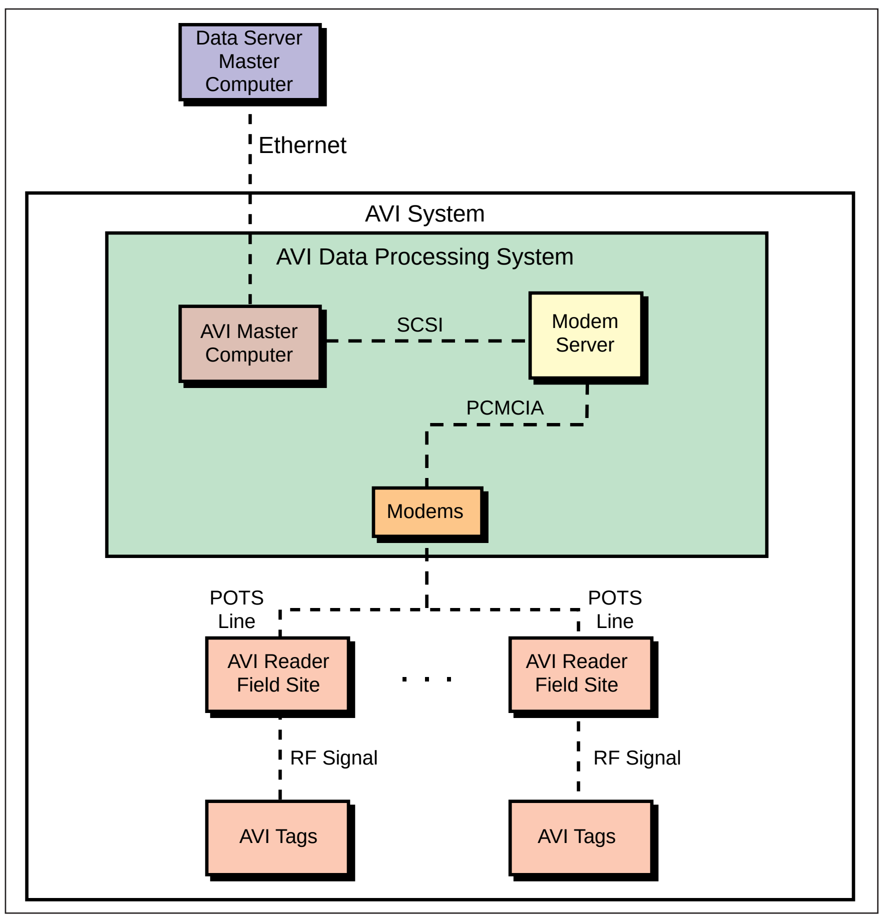

Figure 8. Hardware Architecture of the AVI System

The three major components of the AVI System are discussed in more detail in the following sections.

3.2.1.1 Automated Vehicle Identification Data Processing System

Three major components comprise the AVI Data Processing System—the AVI Master Computer, the AVI Modem Server, and several PCMCIA modems (Figure 8).

The AVI Master Computer communicates with the AVI Modem Server via a Small Computer System Interface (SCSI). A special vendor-supplied software driver executes on the AVI Master Computer to allow the master computer to access the AVI Modem Server serial ports through the SCSI. This software driver creates one logical serial port for each of the available modem slots in the AVI Modem Server.

The AVI Modem Server contains slots for PCMCIA modems. These modems contain connection points where POTS lines can be attached. The number of PCMCIA modems installed in the AVI Modem Server is equal to the number of telephone lines installed for communicating with the AVI Reader Field Sites.

The AVI System telephone lines are installed in a *hunt* configuration. Each of the AVI Reader Field Sites uses the same base telephone number to access the AVI Data Processing System. The telephone service provider assigns incoming calls to the next available line in the system. Therefore, the POTS line to which the call is assigned determines which modem and serial port will service an incoming call.

3.2.1.2 Automated Vehicle Identification Reader Field Site System

The AVI Reader Field Site Systems were supplied by Amtech Systems Corporation. The reader field sites consist of a number of components including an Automatic Data Processor (ADP), reader modules, RF modules, antennas, a cabinet, and a modem. A block diagram of the AVI Reader Field Site System is shown in Figure 9, and the components of the system are described below.

The ADP, the central processing unit of the AVI Reader Field Site System, initializes the system, controls the reader modules, and communicates via the modem with the AVI Data Processing System. The ADP can contain up to four Reader Modules.

The Reader Modules are connected via specialized cable to the RF Modules and can accommodate up to two RF Modules. The Reader Module controls the RF Module and receives the data that are read by the module in response to the RF Module signal.

The field modem is connected to a POTS line and is controlled by the ADP unit, which initiates communication with the AVI Data Processing System. The ADP is programmed to dial the AVI Data Processing System base telephone number to initiate communication. The modem communication can be configured in one of two ways. The default configuration, shown in Figure 9 in black (to the right of the ADP), is to connect the ADP directly to the field modem. The second configuration, shown in Figure 9 in gray (to the left of the ADP), is to connect the ADP to a wireless modem

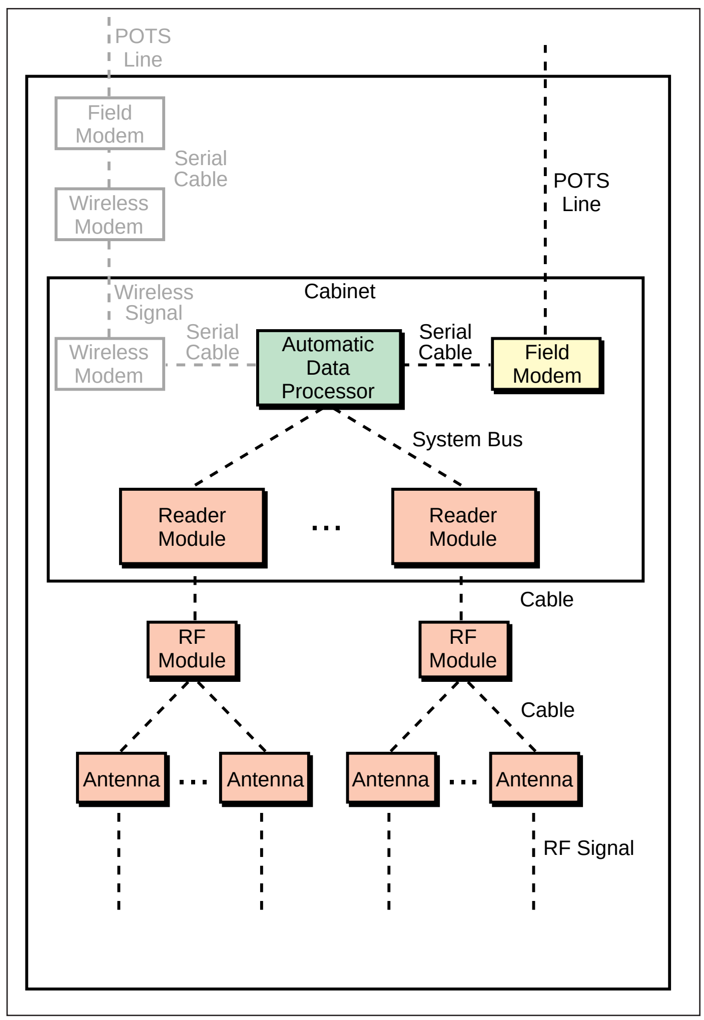

Figure 9. AVI Reader Field Site System Block Diagram

that communicates with another wireless modem to pass the information along to the field modem. This configuration is used in locations where telephone service cannot be supplied directly to the ADP cabinet. Example AVI field sites are shown in Figures 10, 11, and 12.

3.2.1.3 Automated Vehicle Identification Tags

The AVI Tags, supplied by Amtech Systems Corporation, are passive beam-powered tags used in Electronic Toll Collection Systems. These tags contain a transponder that emits an RF signal containing a tag identifier whenever the Reader Module energizes the transponder. This tag identifier uniquely identifies the tag. An example tag placement on a vehicle is shown in Figure 13.

Figure 10. Bridge-Mounted AVI Field Reader Site

Figure 11. Overhead Sign-Mounted AVI Reader Site

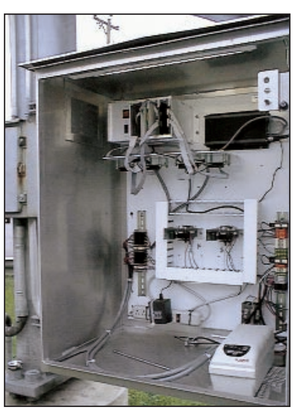

Figure 12. Automatic Data Processing Cabinet Installation

3.2.2 Software Architecture

The software architecture is presented in Figure 14 and shows the major software components of the AVI System and the method of communication between them. This diagram corresponds very closely to the hardware architecture diagram presented in Section 3.2.1. The software architecture shows two main components: the AVI Data Processing Software and the AVI Reader Field Site Software. Each AVI Data Processing System component shown in the diagram represents a UNIX process.

The AVI Data Processing Software communicates with the Data Server at the network layer using the TCP/IP protocol. This protocol provides a standardized mechanism for two software applications running on two different host computers to communicate with each other. At the application layer, the two applications communicate using a proprietary protocol defined by the Data Server itself.

The AVI Data Processing Software communicates with the AVI Reader Field Site Software at the network layer using the RS-232 protocol, which is a standard protocol for serial devices. At the application layer, the applications communicate using a proprietary protocol defined by Amtech Systems Corporation. This protocol defines the data messages and the sequencing of the messages between the reader and the host software.

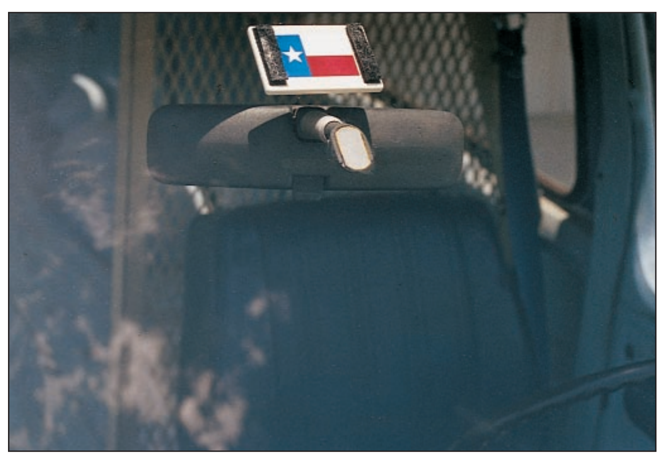

Figure 13. AVI Tag Placement

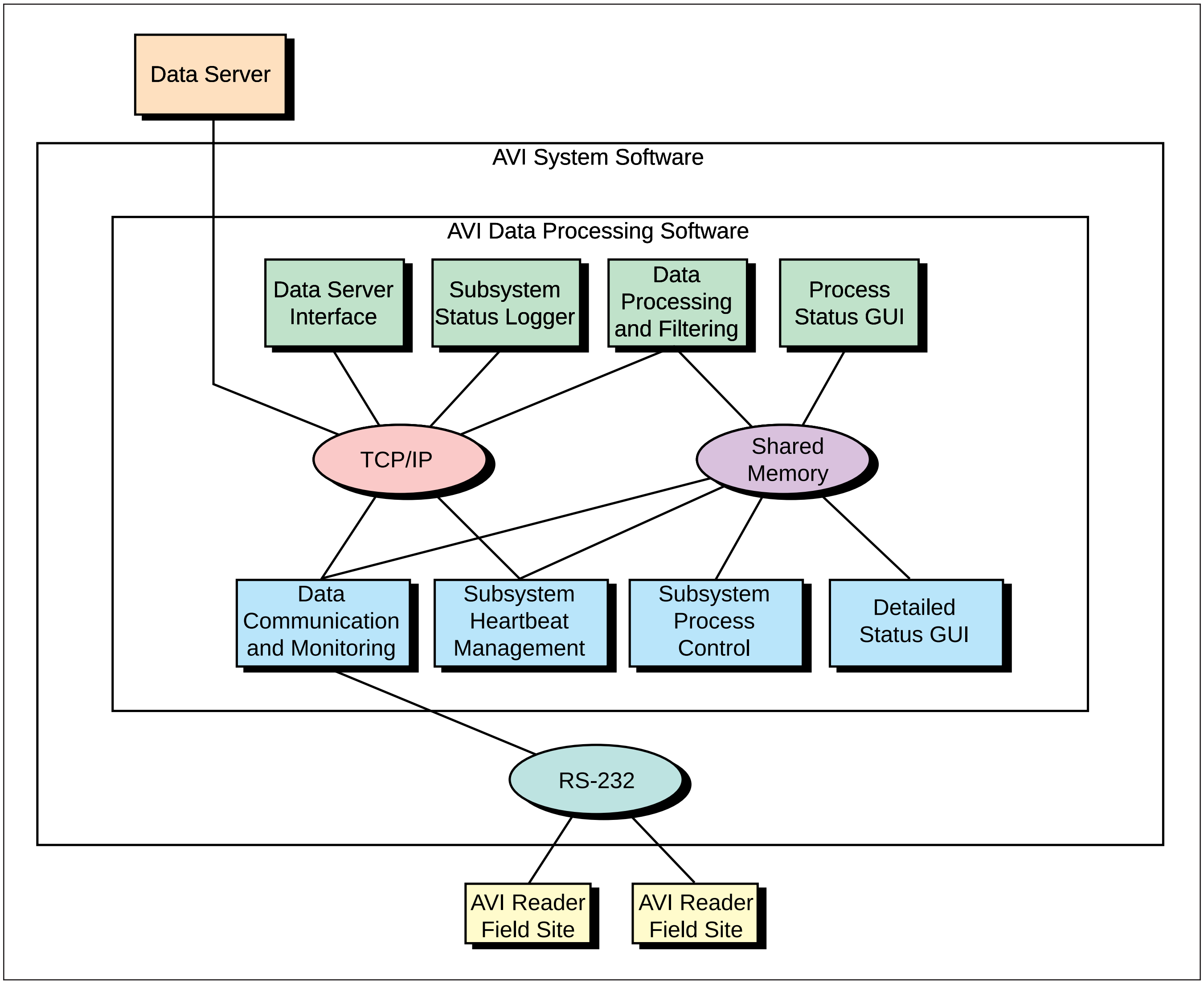

Figure 14. AVI Software Block Diagram

Several components are within the AVI Data Processing Software. These components communicate using one of two methods: TCP/IP or shared memory. The use of one method over the other is based primarily on ease of implementation and the potential for software components to be distributed to other host systems.

3.2.3 Travel Time Algorithm

The AVI System calculates travel times and travel speeds when an AVI site reports a tag read. The AVI System stores the tag reads in an internal database organized by site. When a new tag is received, the AVI System searches the internal database to see if other sites have previously read the tag. Only the sites adjacent to the site that reported the tag are searched.

If the AVI System determines that an adjacent site has read the tag, a *tag match* is generated and stored in a tag match table associated with the two readers. The tag match tables contain the tag matches associated with the two readers along with the time the match occurred and the travel time and travel speed indicated by the match.

Periodically, the AVI System calculates the current average travel time and travel speed for each roadway segment in the network. These averages are calculated as *rolling averages* and are based on the tag matches that are stored in the tag match tables. Additional details about the travel-time algorithm can be found in the *Automated Vehicle*

Identification Model Deployment Initiative System Design document.

3.3 Automated Vehicle Identification Site Selection

The Texas Transportation Institute conducted a study to determine the best locations for the AVI sites in the city of San Antonio. For this analysis, the Texas Transportation Institute consulted several data sources including: *Quantifying Congestion User's Guide*, produced by the Texas Transportation Institute; *Travel Rate Study Technical Memorandum*, produced by the San Antonio Metropolitan Planning Organization; and *Review of ITS Benefits: Emerging Successes*, produced by Mitretek Systems.

The Mitretek report indicated that the majority of AVI System benefits could be obtained by locating sites in the most congested locations in an urban area. Specifically, this report concluded that reporting travel times for the most congested links provides 90 percent of the system benefit at a lower cost. The *Travel Rate Study Technical Report* was used as an initial guideline for the determination of San Antonio's most congested roadways.

After noting the sites mentioned in the *Travel Rate Study Technical Memorandum*, traffic volumes from the TxDOT 1995 District Highway Traffic Map of the San Antonio area were correlated with the proposed AVI site locations. A determination of relative congestion was made based on the ratio of peak hour traffic volume of the roadway versus capacity of the roadway. Capacity was estimated for each AVI site using information on the total number of lanes in the roadway and the occurrence of traffic signals, if any. As the peak hour volume approaches hourly capacity, the volume-to-capacity ratio (V/C) approaches one, signifying congestion. The resultant V/C ratios represent a macroscopic view showing relative estimates of congestion in the San Antonio area.

Although V/C ratios were the primary factor in placing the AVI sites, other factors were considered. To maximize the ability of the TransGuide system to collect data, the AVI sites were not placed in areas that were served by the TransGuide ATMS. Also, consideration was given to place sites in all parts of the city. Site cost, which was influenced by the availability of existing infrastructure (e.g., mechanical structure, telephone service, and electrical service), was also considered.

Lastly, the *Quantifying Congestion User's Guide* was used to determine the appropriate linear spacing of the sites. Table 3 shows the spacing guidelines that were applied based on road classification (i.e., expressway/arterial) and volume (i.e., high/low access).

Table 3. AVI Site Spacing Guidelines

	Expressways	Arterials
High Access	1-3 miles	1-2 miles
Low Access	3-5 miles	2-3 miles

3.4 Tradeoff Decisions

During the design phase of the AVI program, available tag technologies were evaluated because cost and implementation constraints prohibited the original concept of an Intelligent Vehicle Registration Tag (IVRT), a tag that was combined with the annual registration of the vehicle. The features of the various tags surveyed are shown in Table 4.

As the site selection process was completed, communication alternatives were investigated to determine the most cost-effective solution to transmit the tag reads from the field to the AVI Master Computer. The original plan was to use leased lines, but during the evaluation, the use of POTS lines proved to be more cost effective. Table 5 presents the evaluation information about communication alternatives for the AVI program.

3.5 Summary

AVI reader equipment was successfully installed at 54 locations around the city of San Antonio. The AVI computer software collects data from each of these sites and broadcasts the data for display on the Traveler Information Kiosks, IVN Systems, and TransGuide WWW page. The sites are collecting data from local vehicles equipped with TransGuide travel tags, as well as vehicles from surrounding areas such as Houston, Dallas, and Oklahoma that are equipped with toll tags.

Some minor adjustments were necessary in the display of arterial data on the TransGuide WWW page to account for additional delays caused by traffic signals on the arterials. The system has shown susceptibility to a lack of data (i.e., not enough probe vehicles passing through reader sites) during off-peak hours. However, this susceptibility is expected to improve as distribution of TransGuide travel tags progresses.

The AVI System accurately measures travel times and speeds along the instrumented highways and arterial streets during peak travel periods. The system, which covers approximately 98 miles of roadway, has proven an excellent source of real-time traffic data for the traveling public and historical traffic data for transportation researchers.

Table 4. AVI Tag Comparisons
(Selected tag is highlighted in yellow)

Characteristic	Priority	IVRT	Toll	Beam
Shelf Life	High, recurring cost very important.	Battery powered, 2 to 5 years	Battery powered, 5 years	Beam-powered, unlimited
Minimum Quantity	Medium, did not want to order more tags than could be distributed.	High, large quantities were required to initiate an order.	Low.	Low.
Cost	Medium, initial cost less important than recurring cost.	Low, tags contain no intelligence or protective packaging.	High, tags contain intelligence to support toll-collection transactions.	Medium, tags are passive and contain no intelligence.
Adhesion Method	Low.	Sticker with adhesive backing attached to windshield.	Velcro backing attached to Velcro on windshield.	Velcro backing attached to Velcro on windshield.
Distribution Method	Medium, some methods faced institutional issues.	Combined with Texas vehicle registration sticker that is renewed every year.	Voluntary.	Voluntary.

Table 5. AVI Communications Tradeoffs
(Selected communication method is highlighted in yellow.)

Characteristic	Priority	ISDN B-channel	ISDN D-channel	Leased Telephone	Dial-up Telephone
Communications Protocol	Low. Each type of protocol requires different hardware and software, but level of difficulty is similar.	RS-232	X.25	RS-232	RS-232
Data Rate	Low. Small data packages are being transmitted.	56K	9.6K	33K	33K
Initial Cost	Medium. Initial budget was limited, but recurring costs are the driving factor.	High. Requires expensive equipment at control center to manage the channels.	High. Requires expensive equipment at control center to manage the channels, plus additional ISDN Pad in the field.	Low. Requires inexpensive modems.	Low. Requires inexpensive modems.
Cost per Month	High. Recurring costs are the highest priority.	High. Requires 106 B-channels	Low. Requires 53 D-channels and one B-channel.	High. Dedicated lines have higher monthly charges.	Medium. Dial-up lines are less expensive than leased lines.
Cost per Byte	High. Recurring costs are the highest priority.	None.	High. A tariff is assessed for each byte transmitted on the network.	None.	None.