Chapter 5 - Market Penetration Study

5.1 Introduction

In establishing the San Antonio AVI program, it was a goal to distribute a sufficient number of tags in such a manner as to generate sufficient traffic data on as many AVI-equipped links as possible at each hour of the day. The best-case scenario for gathering real-time traffic data would be to have every vehicle traveling on San Antonio's roads to be equipped with an AVI tag. This scenario would represent 100% market penetration of tags in San Antonio's traffic. Relative to this ideal, Transguide MMDI officials instead set an initial goal of distributing 78,000 tags to San Antonio drivers. Efforts were made to distribute tags at automotive shows and transportation expos, along with soliciting the participation of large companies and the general public. To address the potential public suspicions related to privacy issues associated with the use of tags carrying unique identification numbers, Transguide issued tags to the public in pairs so that it would not know which tag would be installed on an individual's vehicle. In addition, an encryption program was written to encrypt all tag reads so that even San Antonio's Transguide officials would not know the true tag identification numbers read by the AVI system.

This chapter will first summarize the tag distribution efforts of Transguide. It will then also provide an analysis of the behavior of the time series of tag reads at several of San Antonio's AVI sites. Finally, results from the level of market penetration analysis will be presented. The LMP serves as a useful reference parameter for the accuracy and reliability analysis to follow.

5.2 Tag Distribution

The distribution of AVI tags in San Antonio began in November of 1997. A total of 1,080 tags were distributed during the first month of the program. From that point forward, tag distribution increased dramatically to nearly 10,000 tags being distributed in March of 1998. That March distribution figure would prove to be the peak of AVI tag distribution, as the distribution rate fell off steadily to an average of 1,350 per month from April 1998 through December 1998. This average ranged from a high of 2,234 in April and a low of 216 tags distributed in November. The monthly and cumulative tag distribution figures are shown in below in Figure 5.1 from the

program's inception in November 1997 to the end of December 1998, which marked the close of this market penetration study. Table 5.1 shows the specific tag distribution counts illustrated by Figure 5.1.

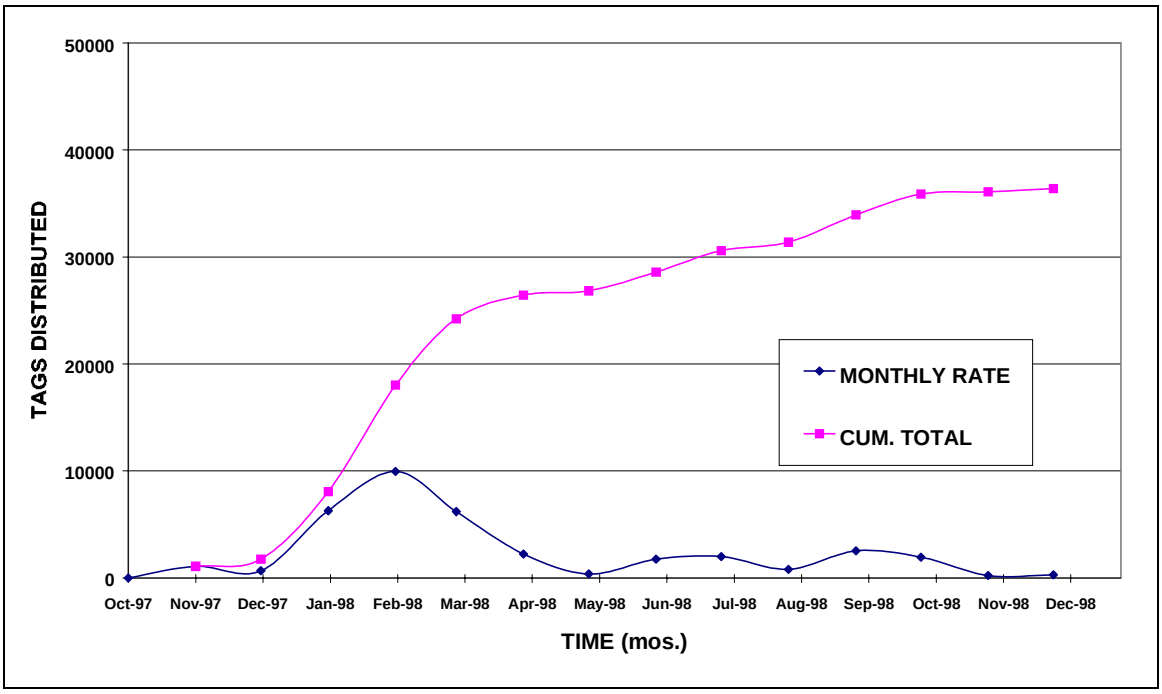

Figure 5.1 – San Antonio AVI Tag Distribution Statistics

Table 5.1 – San Antonio Monthly Tag Distribution Statistics

Month	# Tags Distributed	Accumulated Total # Tags Distributed
November 1997	1,080	1,080
December 1997	680	1,760
January 1998	6,293	8,053
February 1998	9,955	18,008
March 1998	6,204	24,212
April 1998	2,234	26,446
May 1998	385	26,831
June 1998	1,754	28,585
July 1998	1,999	30,584
August 1998	802	31,386
September 1998	2,537	33,923
October 1998	1,952	35,875
November 1998	216	36,091
December 1998	299	36,390

5.2.1 Analysis of Tag Distribution Statistics

Tag read statistics for San Antonio were collected by Southwest Research Institute (SwRI) as part of the AVI program during the first ten months of the tag distribution campaign (Nov. '97 through Aug. '98). The numbers that were accumulated revealed not only how effective the tag distribution program was, but also identified a substantial number of non-San Antonio or 'foreign' Amtech tags that were being recorded by the AVI system.

5.2.1.1 San Antonio Tag Distribution Efforts

As Figure 5.1 illustrates, by August of 1998, over 30,500 tags had been distributed to San Antonio drivers. However, as of July 16, 1998, only 11,000 different San Antonio tags had been recorded at least once by the AVI system. Several reasons exist for the relatively large discrepancy in the number of unique tags distributed versus the number of unique tags read. First, it should be noted that for tags distributed in bulk to companies, there most likely existed some lag time before they were in turn distributed to that company's employees and finally installed in a vehicle. Second, there also exists a subset of AVI-equipped vehicles that, during the course of normal, every-day travel, never pass beneath an AVI reader. The large majority of

the city's center lane-miles are not equipped with AVI antennas. San Antonio's AVI system coverage is limited to approximately 100 center lane-miles, equating to just 2.4% of the San Antonio district's 4,166 total state-maintained center lane-miles (excludes city streets and county roads, as of end of year, 1997) (http://www.dot.state.tx.us). A third reason that may contribute to the lower-than-expected number of unique reads might be that individuals receiving two tags may have installed both tags in the same vehicle. Because every tag operates on the same frequency, two tags being read simultaneously by an AVI antenna cancel one another's signals, rendering them both unreadable. AVI signal attenuation due to metallic treatment in windshields is a fourth cause for reduced unique tag reads. Certain U.S. and foreign car models are manufactured with a special metallic windshield treatment that reduces AVI signal strength, decreasing the likelihood of a properly-installed AVI tag being read (North Texas Tollway Authority Web Page, http://www.ntta.dst.tx.us). Lastly, there is likely a small subset of tags that are either incorrectly installed and hence unable to be read, or that are defective and unresponsive to the AVI antenna signals.

5.2.1.2 Influence of Out-of-Town Tag-Equipped Vehicles

Of the 3,300,000 tag reads recorded by the system through August 31 of 1998, 51.26% of those tag reads were generated by Amtech tags from out-of-town drivers. AVI administrators from SwRI noted that numerous 'hits' were received from Amtech-manufactured toll tags distributed by toll authorities in Houston, Dallas, Oklahoma and Kansas, in order of decreasing frequency. It should be noted that such toll tags function slightly differently from the AVI tags distributed under San Antonio's ATIS program. Because toll tags require an extremely high reliability (> 99%), they contain small batteries that actively emit a signal. Such 'active' tags are more visible to AVI equipment because of the signal emitted, and hence they are extremely readable. San Antonio's tags, on the other hand, do not contain a signal-emitting battery. Instead they are passive, which reduces tag manufacturing and maintenance costs. A summary of San Antonio AVI tag distribution along with the toll tag distributions in Houston, Dallas, Oklahoma and Kansas is given in Table 5.2 for reference.

Table 5.2 – Regional Amtech AVI Tag Distribution Statistics

LOCATION	PROGRAM NAME	ETC / INCIDENT MGMT/ATIS	TAGS DISTRIBUTED THROUGH 1998
San Antonio, TX	Transguide	ATIS	36,000
Houston, TX	Transtar	ETC & Incident Management	250,000
Dallas / Ft. Worth, TX	North TX Tollway Authority	ETC	214,203
Kansas	K-TAG	ETC	99,113
Oklahoma	PIKEPASS	ETC	360,000

The out-of-town tag-equipped vehicles are actually quite helpful to the ATIS program in San Antonio as such tags create a 'background' level of tag reads that provides substantial data to transportation management officials at Transguide at no additional tag distribution cost.

5.3 AVI Tag Read Trends

Given the gradual distribution efforts in San Antonio, it is possible to compare the steady increase in tag-equipped vehicles with a similar increase over time of the number of tag reads registered at individual AVI sites. Such an evaluation is necessary to ensure that the AVI tag distribution program is yielding expected field results. In investigating this hypothesis, two AVI sites were chosen for analysis: Site # 12 and Site # 47. Site # 12 is located on Blanco Rd., an arterial route in the north-central section of San Antonio, just north of Loop I-410 (see arrow in Figure 5.2).

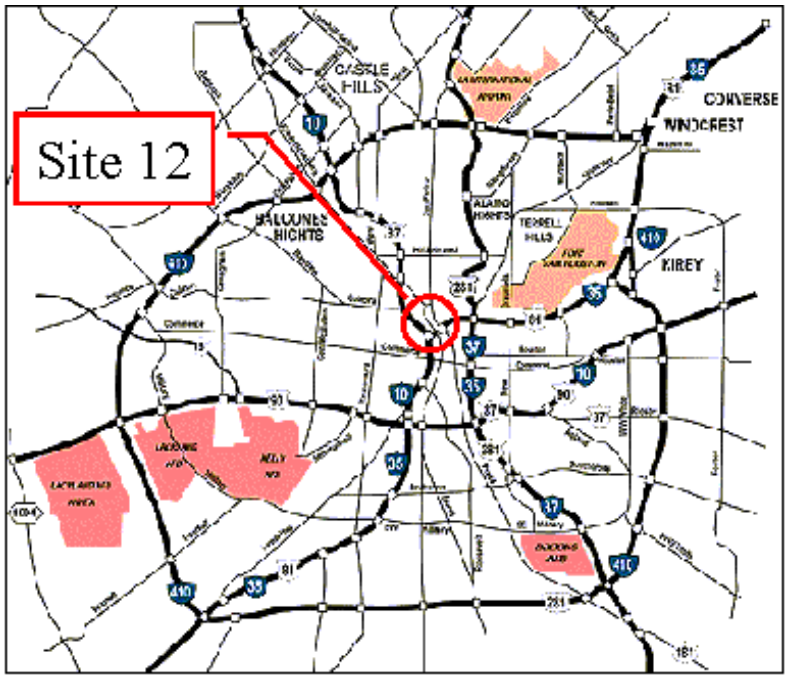

Figure 5.2 – AVI Site # 12 at Blanco Road

Site # 47, meanwhile, is located on I-35 in the northeast portion of San Antonio, as shown in Figure 5.3.

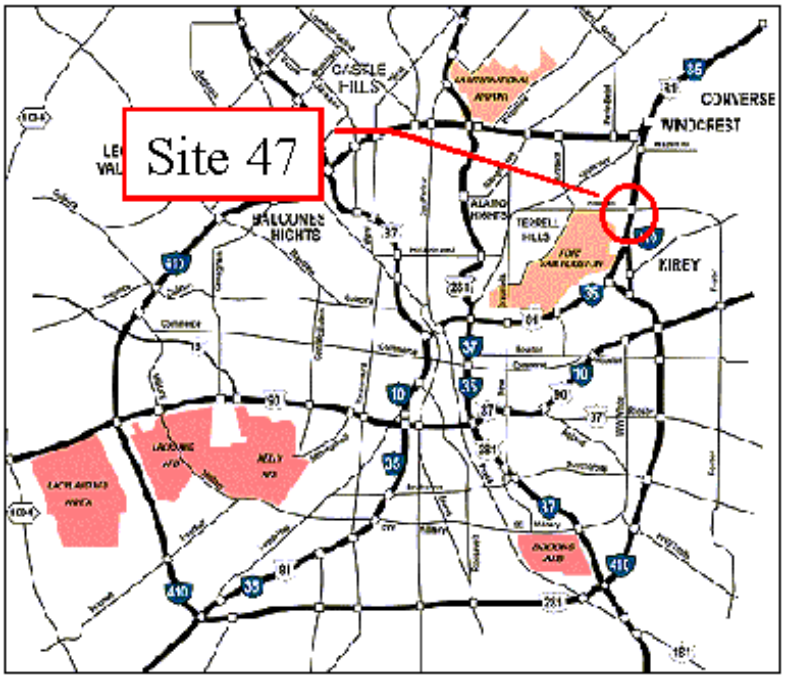

Figure 5.3 – AVI Site # 47 at I-35

These sites were chosen since they are representative of both arterial and freeway AVI sites.

5.3.1 Tag Read Trends – Arterial Facility

Site 12 came on-line in mid-April of 1998, and a one-month analysis of tag reads at this site was performed for the observations between April 14 and May 10, 1998. The graphical representation of this data, including weekday and weekend tag read trendlines, is given in Figure 5.4.

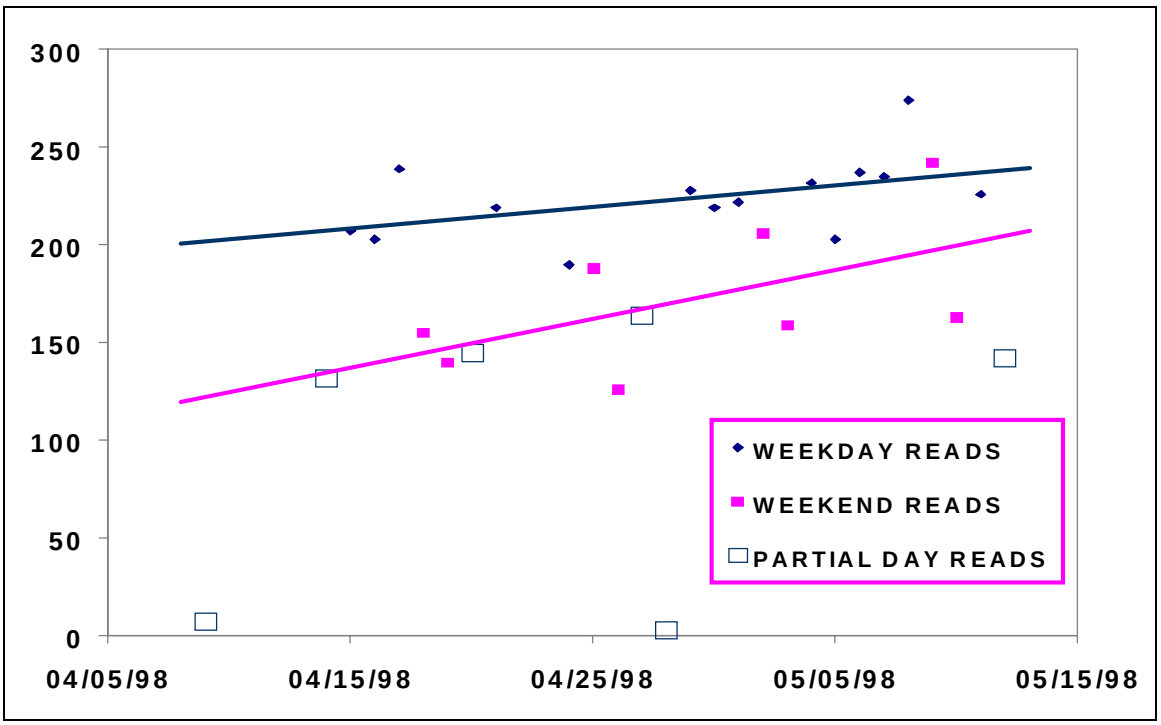

Figure 5.4 – AVI Site # 12 Tag Read Trend

As shown, both weekday and weekend tag reads per day show a steady increase during the 28 days that were surveyed. Weekday tag reads increased from 207 reads on 4/15/98 to 242 reads on 5/09/98 (17% increase), the last weekday of this analysis. Saturday tag reads, meanwhile, climbed from approximately 155 to 242 reads during a similar interval of time (56% increase), while Sunday tag reads increased from 140 to 163 (16% increase). Of particular note is that, since it is an arterial, Blanco Rd. is less likely to be influenced by out-of-town tags as it is by native San Antonio tags.

5.3.2 Tag Read Trends – Freeway Facility

Site 47 was brought on-line in mid-February of 1998. It yielded similar results as those for the data provided by Site 12 (Figure 5.5). Site 47, which was subject to much higher traffic volumes than its arterial counterpart, produced weekday reads averaging 1308 reads per day during the week of 02/09/98 thru 02/13/98 and rising to an average of 2606 reads per day during the week of May 4 thru 8, 1998, an increase of 99%. Weekend reads also rose significantly during that time period from approximately 2700 reads/weekend (02/21 – 02/22/98) to 4200 reads/weekend (05/09/98 – 05/10/98), for an increase of 56%.

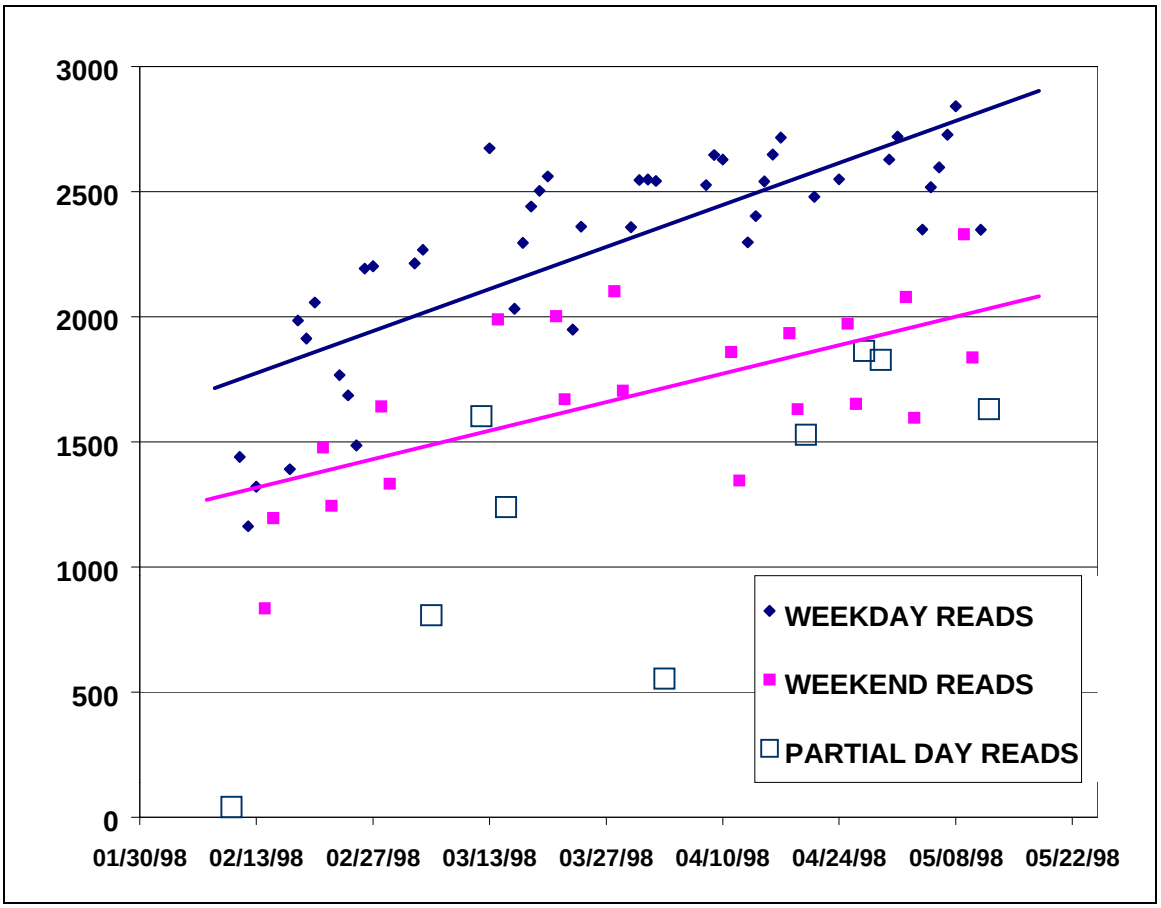

Figure 5.5 – AVI Site # 47 Tag Read Trend

5.4 Level of Market Penetration

Given what is known about the tag distribution statistics and tag read trends in San Antonio, it is desirable to obtain a working definition for the Level of Market Penetration (LMP) of AVI tags

in San Antonio. This definition is a prerequisite before attempting to quantify that LMP figure. In considering a working definition of LMP, two definitions were proposed:

- Definition 1: LMP = (number of tags distributed in San Antonio) / (number of registered vehicles in San Antonio)

- Definition 2: LMP = (number of tags read at a site) / (number of vehicles counted at that site)

In calculating the Definition 1 LMP value, the most recent count of registered vehicles in San Antonio in August 1998 was 1,375,133 (http://www.dot.state.tx.us/). The number of tags distributed at that time was 31,386, which yields a Definition 1 LMP equal to: (31,386 / 1,375,133) = 2.28 %.

Obtaining a Definition 2 LMP required the collection of additional data. This research effort did not include the use of traffic counting equipment. Therefore, the existing San Antonio traffic-counting infrastructure was used. Because San Antonio's ATIS program features the unique combination of both inductance loop detection and AVI technologies, the San Antonio freeway network could be surveyed to find an AVI site that was located adjacent to a loop detector station. This allowed both AVI tag read and traffic volume data to be obtained. A suitable scenario was identified just southwest of the inner loop around downtown San Antonio on U.S. 90. U.S. 90 has loop detector stations in the east- and westbound lanes at milepost 571.113. AVI site # 30, meanwhile, is located on U.S. 90 approximately half a mile to the west of loop station 571.113. Loop data collected by San Antonio servers was obtained and filtered to remove all loop data sets that were less than 95% complete for a given day. In addition, since only five of the six loops were working in each direction, the daily volume counts were scaled up by a factor of 6/5, or 1.2. Assumed in this analysis is conservative traffic flow between the loop station and the AVI site. In reality, there exist 2 westbound exits, 1 eastbound exit and 2 eastbound entrance ramps on this section of U.S. 90. Loop detector data acquisition and filtering was performed using the Translink Data Management System Web-based Database (http://vixen.cs.tamu.edu/).

5.4.1 Single-Day Market Penetration

Single-day as well as multi-day market penetration plots were created to analyze these data. Loop data from station 571.113 for June 11, 1998, were collected in 5-min aggregates along with 5-minute-aggregated tag read data from AVI site 30. These data are presented in Figure 5.6 below.

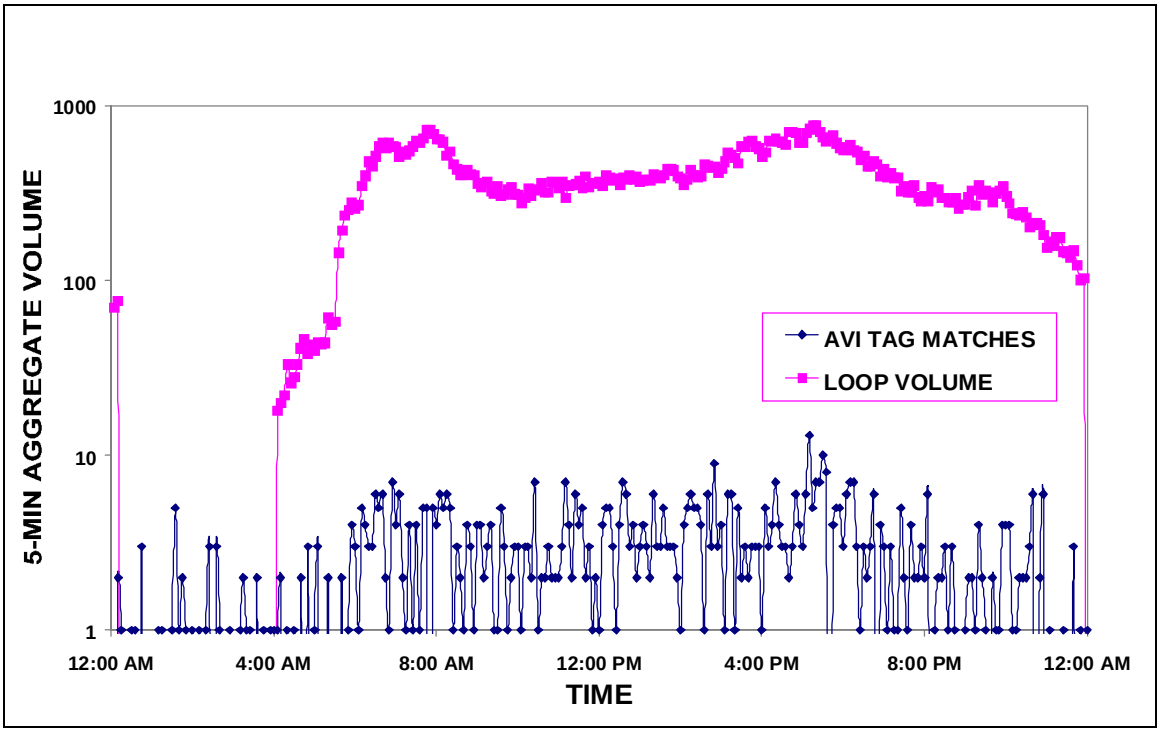

Figure 5.6 – Estimated Single-day Market Penetration at AVI Site # 30

Because the loop station was not functioning between shortly after midnight and 4 a.m., no loop data were available for that time period. However, the rest of the chart provides significant information regarding the number of tag reads per 5-min interval compared to the estimated overall traffic volume at site # 30. Tag reads appear to fluctuate between 4 or 5 reads per 5 minutes, while the traffic volume ranges from a peak of 771 vehicles/aggregation during the evening rush hour period to only 70 vehicles/aggregation at 12:05 a.m. To calculate the Definition 2 LMP, the AVI aggregated reads were divided by their respective loop aggregated volumes to obtain a percentage LMP plot in 5-min aggregations (see Figure 5.7 below).

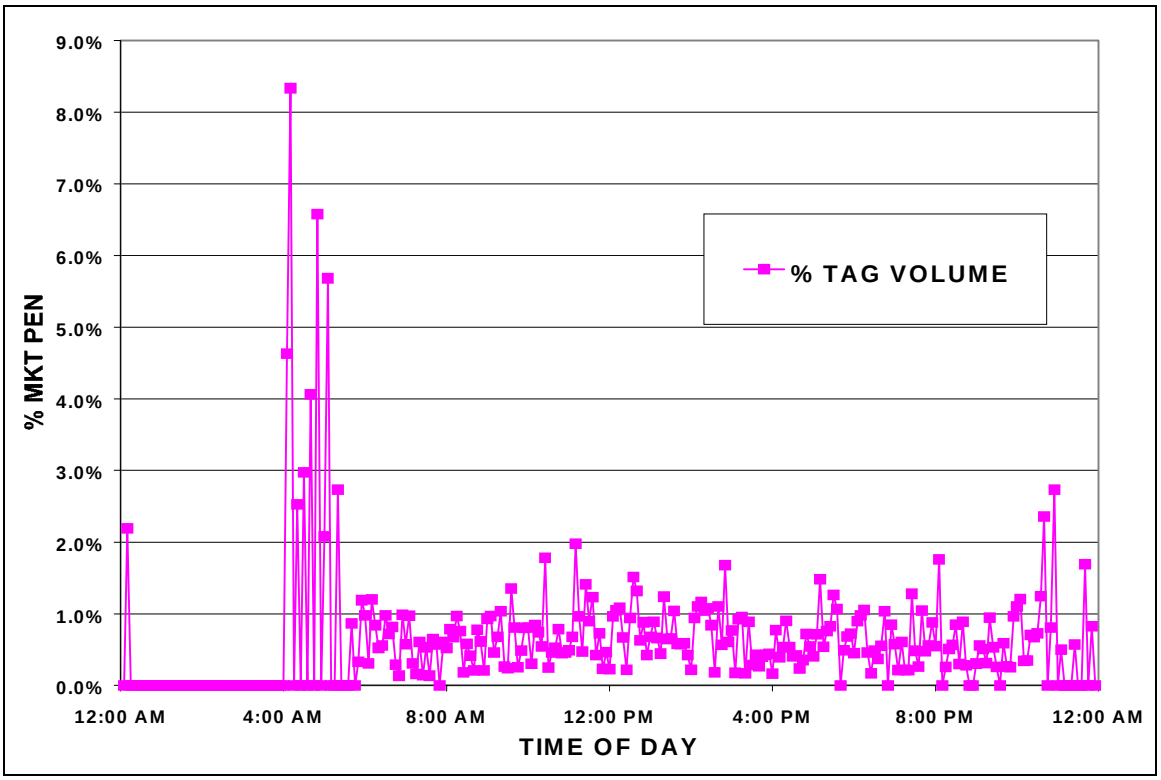

Figure 5.7 – Estimated Single-day Market Penetration Percentages at AVI Site # 30

This chart shows that the actual LMP percentage is close to 0.5 %. The unusual spikes during the early morning hours are likely due to the high commercial vehicle volume relative to the low overall traffic flow. It is surmised that commercial vehicles are more likely to carry AVI transponders, hence the early-morning spikes.

5.4.2 Multi-Day Market Penetration

On a more macroscopic level, daily tag read volumes at AVI site 30 were compared with daily traffic volumes for loop station 571.113 from mid-February to mid-May. Linear trendlines were fitted to the data, which was plotted on a logarithmic scale for clarity in Figure 5.8.

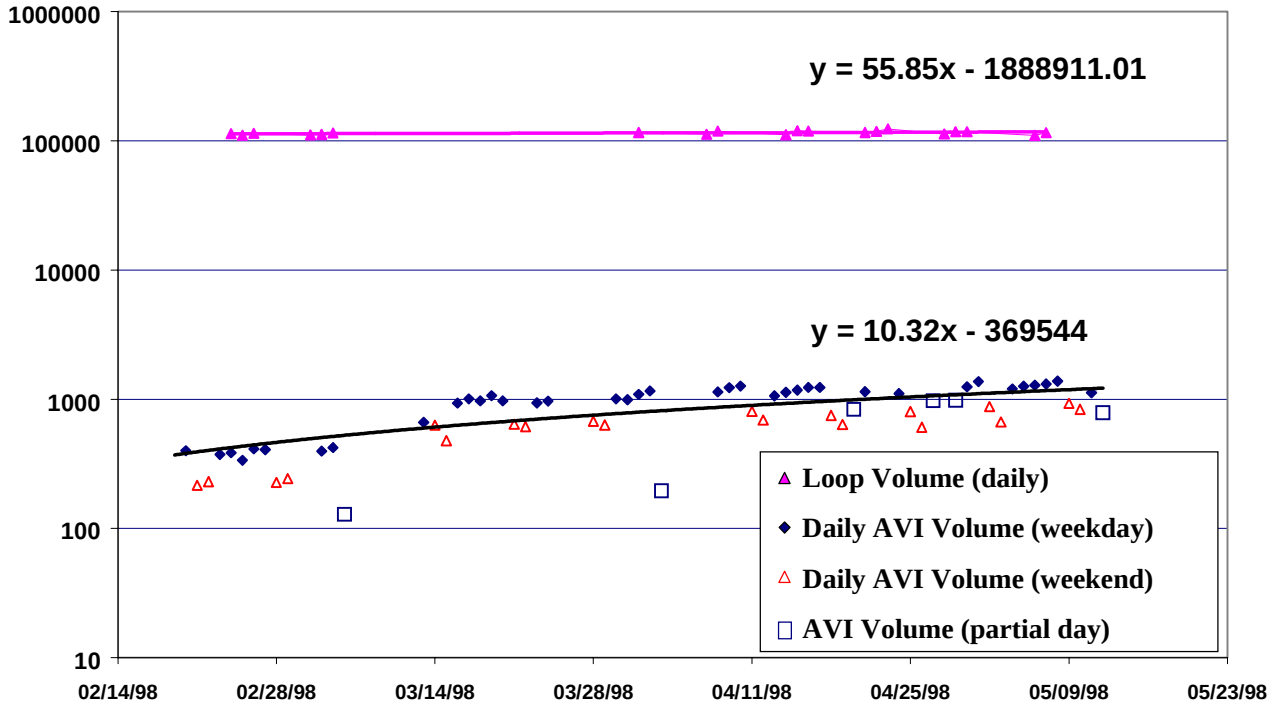

Figure 5.8 – Multi-day Market Penetration Data at AVI Site # 30

The quantitative results from the above chart are found in the equations of each trendline. This chart and equations were generated in an MS Excel spreadsheet, which assigns numerical values to dates, beginning with January 1, 1900. These equations can be used to forecast future market penetration levels, although caution must be used since tag distribution rates in both San Antonio and surrounding toll-tag authorities are highly variable (particularly San Antonio's). Forecasted LMP data were generated through the end of the summer of 1998, and the results are given provided in Figure 5.9.

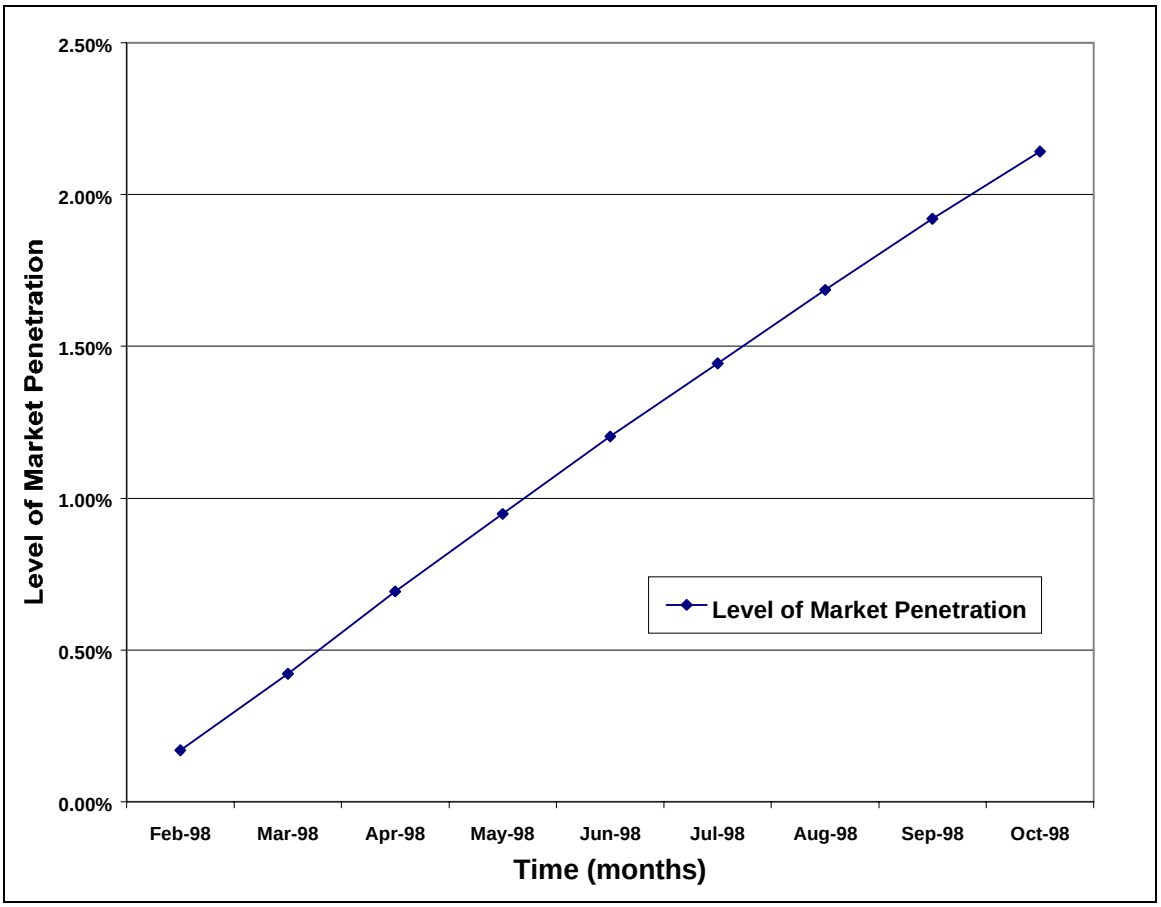

Figure 5.9 – LMP Forecasting at AVI Site # 30

It should be note that the trend in Figure 5.9 provides a rough-estimate prediction of actual market penetration levels in San Antonio.

5.5 Summary

This chapter began with a summary of the tag distribution efforts of San Antonio's transportation management officials. Over 36,000 travel tags were distributed in San Antonio from the program's inception in November 1997 through December 1998. An analysis of Amtech tag distribution statistics in the San Antonio region included statistics from toll programs in Houston, Dallas, Oklahoma and Kansas. It was found that over 900,000 Amtech tags had been distributed in the surrounding regions of San Antonio by the end of 1998. These out-of-town tags were found to be an important provider for travel time information, accounting for over 50% of San Antonio's tag reads.

Tag read trend analyses performed at individual AVI reader sites reflected San Antonio's tag distribution efforts. Daily tag reads increased over 15% (including 56% on Saturdays) during a one-month period at site 12 on Blanco Rd. (an arterial facility). At site 47, located in I-35, daily tag reads were observed over a 4-month period. Tag reads at this freeway facility were found to increase by 99% on weekdays.

Using volume counts from a loop detector stationed near AVI reader site 30, market penetration estimates were calculated for 5-minute aggregation periods. Figure 4.7 shows the level of market penetration of travel tags (includes tags from San Antonio and out-of-town) to be approximately equal to 0.5% from the morning peak to approximately 10 pm. During early morning hours, the LMP ranges as high as 8%. This increased LMP is likely due to an increased percentage of trucks on the freeways. It is believed that trucks are more likely to be equipped with AVI tags. It should be noted that this thesis does not attempt to recommend a travel tag LMP suitable for providing adequate real-time travel time information. Instead, this LMP calculation serves as a reference parameter for the following chapter, which compares aggregate travel times with travel times from a single probe vehicle.