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CALIFORNIA CENTER FOR INNOVATIVE TRANSPORTATION
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY

Travel Times on Changeable Message Signs Volume II – Evaluation of Transit

Ali Mortazavi et. al, Senior Development Engineer

**CCIT Research Report
UCB-ITS-CWP-2009-2**

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CCIT TO1009 Final Report Volume II Sep. 2009

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Travel Times on Changeable Message Signs Volume II – Evaluation of Transit signs

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CCIT Research Report
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This work was performed by the California Center for Innovative Transportation, a research group at the University of California, Berkeley, in cooperation with the State of California Business, Transportation, and Housing Agency's Department of Transportation, and the United States Department of Transportation's Federal Highway Administration.

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September 2009

CCIT TO1009 Final Report Volume II Sep. 2009

Executive Summary

Real time traffic information on Changeable Message Signs (CMS) has gained popularity in urban areas where congestion and incidents frequently affect vehicle travel. CMS have been used to broadcast information about corridor downstream delays, traffic incidents and estimated travel times. Displaying accurate travel times on CMS helps commuters assess traffic, alleviates driver's stress, and allows drivers to make better route decisions. Knowing the driving times to popular destinations, travelers may be able to map their driving to the less congested route or chose a different form of transportation. Moreover, signs are the most effective means to communicate real-time, relevant information to motorists. Unlike a radio broadcast, signs target drivers passing a given location. Hence, the message is highly likely to be of interest to those drivers.

For the past four years, CCIT has helped Caltrans implement and deploy an automated system nicknamed MITTENS (Messaging Infrastructure for Travel Time Estimates to a Network of Signs) to display travel times on CMS in the Bay Area. MITTENS relies on MTC's 511 for travel time predictions. These predictions are based on real-time traffic data collected by toll tag readers (FasTrak program), by Caltrans' embedded loop traffic detectors, and by speed radar data. Predictions are updated every minute and are reported on the signs accordingly.

Task Order 1009 is the continuation of Task Order 13 in which CCIT could successfully deploy the first version of MITTENS in the Bay area. MITTENS 1.0, was a successful step in delivering travel time messages to a "network of signs" in the Bay Area.

After deploying the first version, new requirements to enhance the functionality of the system emerged. As a result, a new version of the software, MITTENS 2.0, was developed during this project. The new system is flexible in using different data sources other than 511 data to calculate travel time. In addition, MITTENS 2.0 is able to handle smart message display by dynamically generating highway travel times, transit times, and destinations. Furthermore, it is capable of comparing transit travel time and highway travel time. This feature enables the system to display the transit travel time when there is an advantage in using trains during peak hours. The objective was to provide comparative information for commuters and encourage motorists to use transit system in the rush hours. The evaluation study on the transit signs showed positive effect of commuter behavior.

For this version, the administrator Graphical User Interface (GUI) was deployed and CCIT continued enhancing the GUI. The new enhancements consisted of adding features to define different templates for the CMS display. The CCIT team also provided on-going support and incrementally enhancing functionality of MITTENS.

The travel time system is fully operational in the Bay Area and covers more than 30 signs. In addition, the system is successfully displaying comparison of transit trip and highway driving time for Millbrae and Redwood City stations. The system received the California Transportation Foundation TRANNY award for the best traffic operation project and was nominated for Best of ITS Awards for best innovative practice.

CCIT also upgraded MITTENS to allow deployment in other Caltrans districts. We also conducted a feasibility study on disseminating travel time information on other districts, i.e. D3, D5 and D10.

This report consists of the following documents:

Volume I – MITTENS Documentation:

- MITTENS Manual. This section provides detail information on:
 - a. System Overview
 - b. Operating Manual
 - c. User Interface
 - d. System Architecture and Database
- Deployment of MITTENS in District 10

Volume II – Evaluation of Transit Signs:

- Evaluation of Displaying Transit Information on Changeable Message Signs

Volume III – Travel Time Studies:

- Travel time study along US-101 and CA-154 in District 5
- Data analysis for travel time estimation on US-50 and I-80 in District 3

PROJECT FACT SHEET

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Evaluation of Displaying Transit Information on Changeable Message Signs

Final Report – September, 2009

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

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1. Introduction and Problem Statement

People are frustrated by the increasing amount of time they spend delayed in highway traffic and welcome alternatives that offer reliable solutions to their commute problems. Recently, the public has become more aware of commuter trains and values them as green, viable, and safe commuting options. Positive perception toward public transportation can be utilized to enhance transit usage in congested areas.

Disseminating transit and traffic information to motorists is a winning proposition to encourage mode shift and reduce traffic congestion on highways. Drivers can benefit greatly as real-time information provides current freeway and transit conditions while they are commuting. This information helps drivers create a form of self-management to make informed decisions about their mode of transportation. As a result, various benefits can be achieved, including improved safety, time savings, increased throughput, cost savings, reduced emissions, and reduced fuel consumption.

As an effective tool that shares real-time traffic information with the traveling public, the Changeable Message Sign (CMS) has gained popularity in urban areas due to its benefits of mitigating congestion and improving safety. For the past four years, as a part of Task Order (T.O.) 1009, the California Center for Innovative Transportation (CCIT) has helped California Department of Transportation (Caltrans) District 4 deploy an automated system called MITTENS¹ to display driving times on Changeable Message Signs in the Bay Area. With successful deployment and operation of MITTENS in the Bay Area since 2005, CCIT — in collaboration with Caltrans District 4, Caltrain, and BART — initiated a pilot project in July 2007 to display public transit information (i.e., Caltrain Baby Bullet²) on the signs. MITTENS is now also capable of comparing commute times by driving and by riding trains along the US-101 corridor.

There are three signs designated to displaying transit information along 101 for two major Caltrain stations — Millbrae and Redwood City. Each sign displays three types of information (Figure 1-1):

- Highway travel time
- Caltrain travel time
- Next train departure time

During rush hours, a comparison between driving time vs. station-to-station train trip time is displayed. This comparison can help motorists avoid highway congestion and use public transportation, encouraging motorists to switch their travel mode immediately and to make more educated decisions for future travel plans.

¹ Messaging Infrastructure for Travel Time Estimates to a Network of Signs

² Caltrain commute-hour express service

Figure 1-2 shows the locations of the transit information signs. The signs are installed before highway exits for the Millbrae and Redwood City Caltrain stations. Table 1-1 lists the location information of the three transit signs in Caltrans District 4.

The operating schedule of these signs was initially designed according to the schedule of the Baby Bullet train, which covers the morning and afternoon peak hours from Monday to Friday. Generally, the signs operate weekdays around 5:00-9:00 am and 3:30-7:00 pm. Table 1-2 shows detailed operating schedules of each transit sign. Operation time of CMS 122, 123, and 012 is 318, 392, and 301 minutes per weekday, respectively. However, the signs are not designed to continuously display transit messages during the operating schedule, only when there is a travel time saving because of riding Caltrain compared to highway driving. The operating scheme will be further discussed in the following sections.

After implementation of the system, no assessment was conducted about the effect of the signs on commuter behavior. In this project, CCIT aims to evaluate the benefits of the system and assess the effect of the transit messages on mode shift. This report investigates user satisfaction and feedback regarding the operation of three Changeable Message Signs (CMS) along US-101 — located next to Millbrae and Redwood City stations.



Figure 1-1: Transit sign message

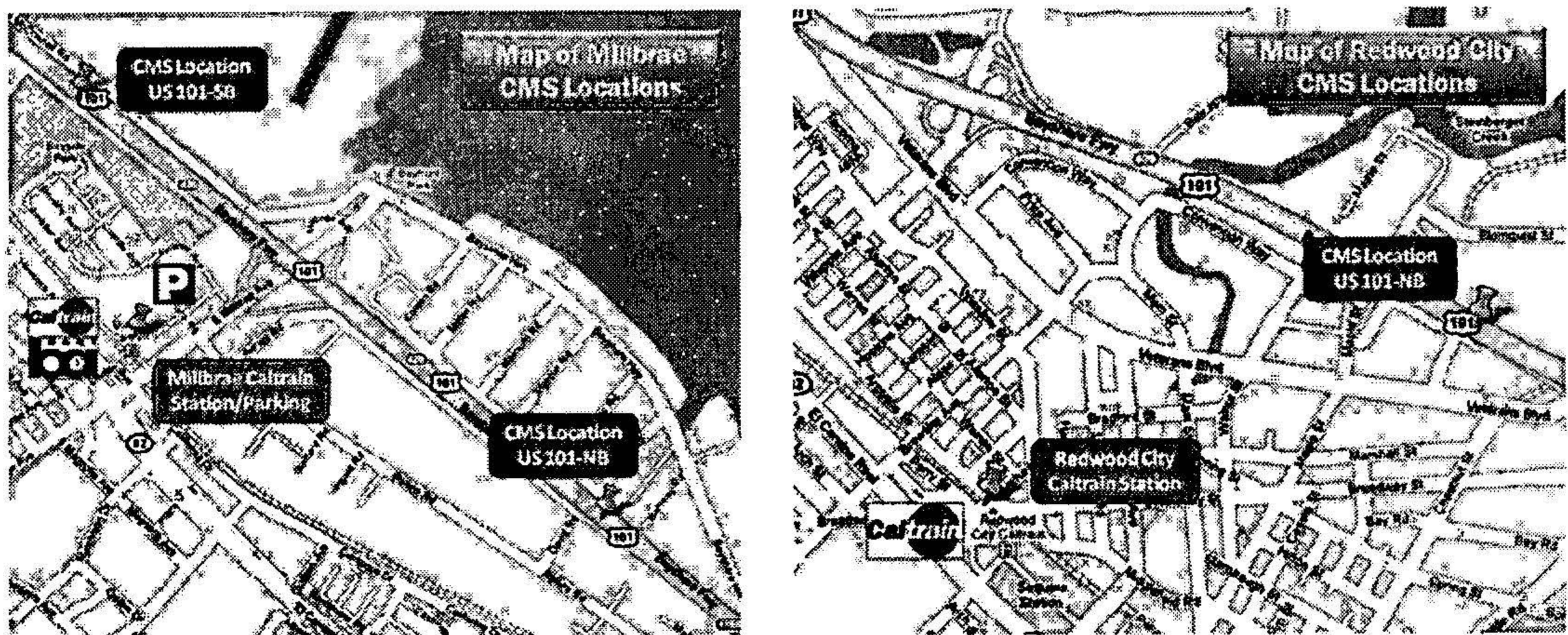


Figure 1-2: CMS locations

Table 1-1: Location information of transit-related CMSs

CMS ID	Highway	Direction	Origin	Destination	Approximate Distance (miles)	Travel Time with Average Free-flow Speed (min)
CMS 122	US-101	South	San Bruno (near Millbrae Caltrain/BART station)	San Jose	31.8	~30
CMS 123	US-101	North	Redwood City (near Redwood City Caltrain station)	San Francisco	26.1	~24
CMS 012	US-101	North	San Mateo (near Millbrae Caltrain/BART station)	San Francisco	16.0	~15

Table 1-2: Operating schedules of transit-related CMSs

CMS ID	Operating Schedule	Daily Operation Time (in minutes)		
		Morning	Afternoon	Total
CMS 122	Monday to Friday 06:50 – 09:07 and 15:45 – 18:46	137	181	318
CMS 123	Monday to Friday 05:33 – 08:33 and 15:35 – 19:07	180	212	392
CMS 012	Monday to Friday 06:14 – 08:47 and 15:04 – 19:31	153	267	420

2. Technical Approach

This evaluation considers both the tangible and intangible benefits associated with displaying transit information along with highway traffic information. To assess both types of benefits, the team conducted a qualitative (user satisfaction) analysis and quantitative analysis to assess the effect of the signs on commuter behavior. The user satisfaction survey is a major element to identify traveler perception regarding transit-related messages, e.g., discovering the percentage of commuters who have changed or are willing to change their travel mode from car to transit. In addition, quantitative analysis helps researchers measure the tangible benefits of the signs.

The study will emphasize the significant impact of disseminating real-time traveler information on CMS to help commuters make informed decisions. It can also initiate a statewide support for deployment of the system.

2.1. User Satisfaction Analysis

CCIT successfully conducted a user/commuter survey through two major channels:

1. **Station survey.** To obtain samples from transit commuters, paper questionnaires (See Appendix II) were distributed in the Millbrae and Redwood City stations. The targeted population was Baby Bullet commuters in the two stations. The objectives were to examine:
 - Number of people that actually switched from driving to using transit
 - Problems/challenges regarding commuting with Baby Bullet trains
 - General perception/suggestions about the signs
 - Factors affecting modal shift
2. **Online survey.** We conducted an online survey through the Bay Area 511 website (www.511.org) to target regular commuting public. The survey aimed to look into:
 - Number of people that actually switched from driving to using the transit
 - Challenges/issues that keep motorists from using the train
 - General perception/suggestions about the signs
 - Potential commuters that may switch from driving a car to taking a train
 - Factors affecting modal shift

2.2. Quantitative Analysis

The team performed the following quantitative evaluations:

Measurement of increase in train ridership

In collaboration with Caltrans and Caltrain, CCIT collected and analyzed parking counts and passenger counts data as metrics for ridership-increase assessment. The analysis tries to identify possible deviations from baselines and correlate any instantaneous spikes to the performance of the transit signs.

Comparison of Baby Bullet trip time and highway travel time

The difference between highway driving time and transit trip time is a viable measurement to quantify benefits obtained by taking the train vs. driving and to evaluate the effectiveness of disseminating transit information. A detailed analysis of this measurement, estimated based on MITTENS message log data, can help practitioners:

- Demonstrate/showcase time savings associated with using transit
- Improve system operational performance
- Estimate number of highway commuters who may potentially switch to transit

3. User Satisfaction Analysis

As one of the major elements of the evaluation, a survey regarding the traveler information signs was developed and distributed to collect and analyze travelers' perceptions of the transit-related messages. The primary goal of the survey was to obtain insights about how the pilot transit-related CMS project was perceived. In particular, the survey examined general perception/suggestions about the signs, percentage of commuters who have changed or are willing to change their travel mode from car to transit, factors affecting modal shift, and challenges/issues that keep motorists from using the train. The survey results can help Caltrans practitioners better understand the impacts of using CMSs to disseminate transit-related traveler information and provide practical suggestions to the current and future CMS operations statewide.

3.1. Survey Methodology

3.1.1. Survey Time

The time to conduct the survey was initially set for the middle of September 2008, following the evaluation project schedule. However, this time needed to be carefully examined, since it could have significantly altered the survey results. Seasonal traffic data were evaluated to test if the proposed survey time (in the traffic-data time period of July, August, and September) fell within an appropriate window to conduct the survey. Results indicated that, for the proposed survey traffic-data time period, there was no remarkable difference in traffic flow compared to other times of the year, which implied that mid September was a feasible time to conduct the survey. Detailed seasonal traffic analysis is presented in Appendix I.

3.1.2. Survey Design

A 27-question survey was developed that covered respondent demographics and a mix of general and specific questions in multiple-choice and open-ended formats. Questions were broken into three parts to address different objectives of the survey. First, in order to understand respondents' commuting attributes, questions such as commute frequency, commute origin/destination, commute mode, and commute time were asked. The second part of the questionnaire explored general perceptions about the signs, whether people actually switched from driving to using transit, people's willingness to switch modes in the future, factors affecting modal shift, and so on. The third section asked socioeconomic-related questions to uncover additional factors that might affect travelers' modal choice and thus further influence the effectiveness of transit-related messages. The survey was posted online on the Bay

Area 511.org website, and paper copies were printed for direct distribution. A printout of the questionnaire is presented in Appendix II³.

3.1.3. Survey Distribution

There were many discussions and considerations on possible distribution channel(s) of the survey. Ideally, the team hoped to randomly select traveling commuters in the area affected by transit-related CMSs, regardless of whether commuters had seen or used the signs in their travel and regardless of what travel mode they typically use. After eliminating non-feasible and non-practical approaches, the team contacted the Bay Area 511.org for the advertisement of the online survey and the Caltrain/BART station for onsite direct survey distribution.

The online survey was advertised on the 511.org homepage, which is hosted by San Francisco Bay Area Metropolitan Transportation Commission (MTC), to encourage website visitors to take the survey. The online survey was operational for approximately one month, from late September 2008 to the end of October 2008. The targeted population for the online survey was commuters in the Bay Area.

Paper questionnaires, with prepaid mail-in envelopes, were distributed in the Redwood City Caltrain station and Millbrae Caltrain/BART station on September 23, 2008 from 7:30 – 10:00 am and in the from 2:30 – 5:00 pm. Approximately 1,189 paper surveys were distributed over the entire survey period. The targeted population was typical and occasional Baby Bullet Caltrain commuters in the two stations that are currently covered by the signs.

3.2. Survey Response

Mail-in survey responses were gathered from mid-October until late December 2008. Three hundred and seventy one (371) paper surveys were returned, for a return rate of 31.2%. Nine (9) surveys were removed from the data analysis due to incomplete responses and inconsistencies. Overall, 362 paper surveys were analyzed, for a total yield of 30.4% (see Table 3-1 for more details). As a reference, a sample size of 362 produces a margin of error of roughly 5% at the 95% confidence level. This means that the 95% confidence interval of a 50/50 split response to a yes/no question is $\pm 5\%$. Eighty-point-nine percent (80.9%) of station survey respondents reported that they had seen the transit signs.

Table 3-1: Total number of responses

Survey Channel	Total Solicitation	Total Responses	Total Analyzed	Total Yield
Millbrae (station survey)	800	242	238	30%

³ The format and question numbers of the online survey are slightly different to the paper printout due to the predefined features of the online survey tool selected (i.e., Survey Monkey – www.surveymonkey.com).

Redwood City (station survey)	389	129	124	32%
511.org (online survey)		157	117	

Online survey responses were gathered for approximately one month, from late September 2008 to late October 2008. One hundred and fifty seven (157) online surveys were collected in total. Forty (40) surveys were removed from the data analysis due to incomplete responses and inconsistencies. Overall, 117 online surveys were analyzed (see Table 3-1 for more details). As a reference, a sample size of 117 produces a margin of error of roughly 9% at the 95% confidence level. This means that the 95% confidence interval of a 50/50 split response to a yes/no question is $\pm 9\%$. The online survey reached a more diverse population of commuters than the paper survey, as more than half of online respondents (55.6%) reported that they do not commute between San Jose and San Francisco and 44.4% reported that they were unfamiliar with transit signs located on US-101.

Aside from a few very distant zip codes, most of the survey respondents lived in the Bay Area. The highest concentration of survey responses was located near the active signs along US-101 (see Table 3-2 for more details). This is desirable because it is likely that these survey respondents read the messages frequently and that their responses reflect the target population.

Table 3-2: Top 10 commute origins and destinations

Rank	Origin		Destination	
	City	Frequency	City	Frequency
1	San Francisco	68	San Francisco	104
2	Redwood City	66	Redwood City	59
3	Millbrae	37	South San Francisco	49
4	Burlingame	32	Palo Alto	26
5	San Mateo	27	Millbrae	25
6	San Jose	18	Mountain View	25
7	Sunnyvale	18	San Jose	23
8	South San Francisco	17	Burlingame	14
9	Mountain View	15	San Mateo	12
10	Palo Alto	15	Menlo Park	11

Income results in the CMS survey roughly corresponds to the census survey for the SF Bay Area (San Francisco – Oakland – San Jose); however, the survey respondents are slightly skewed towards wealthier households. A possible explanation for this disparity is that commuters tend to be higher income earners. There was also a large non-response rate of 7.1% on the income question, which may hide further upwards bias. Figure 3-1 compares income between the survey respondents and general population.

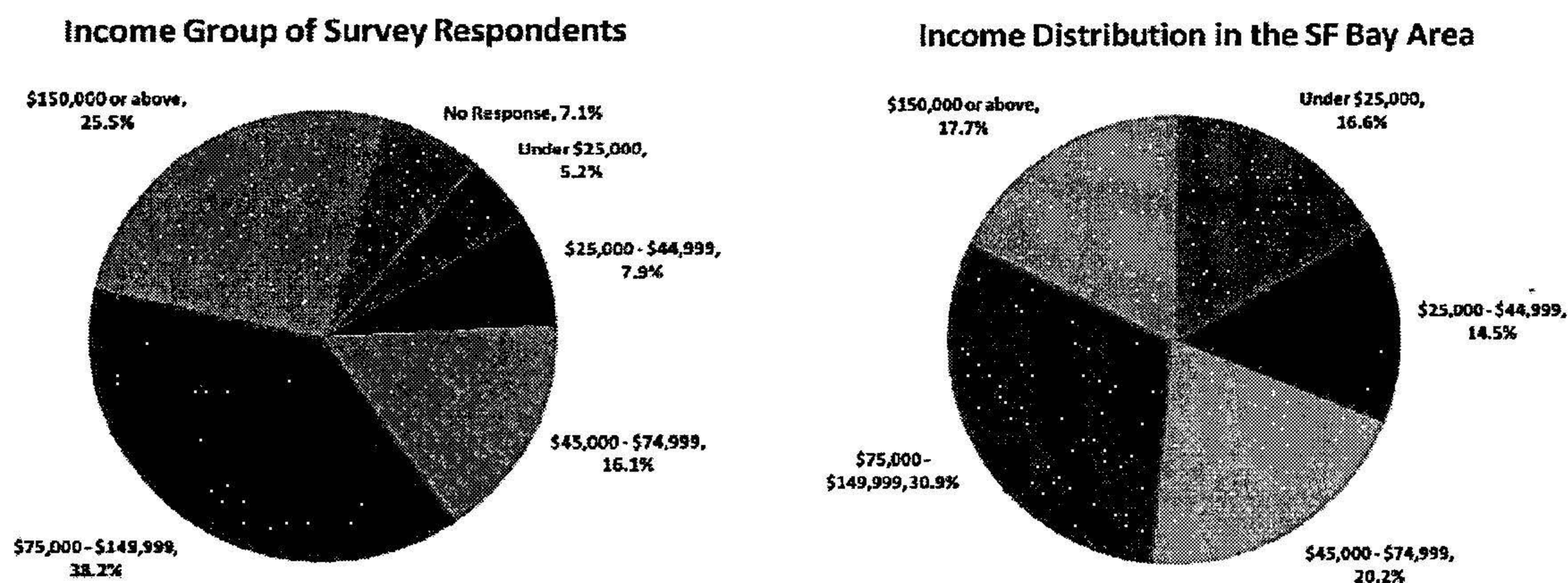


Figure 3-1: Income comparison between sample and population

Source: 2005-2007 American Community Survey 3-Year Estimates

Most respondents were between the ages of 25 and 49 (63.4%). None of the online respondents were 65 or above. Survey respondents under the age of 18 were removed from the analysis. Compared to the age distribution in the SF Bay Area (San Francisco – Oakland – San Jose), middle-aged respondents are overrepresented in the survey sample; however, this is the most common age range for commuters, the target population.

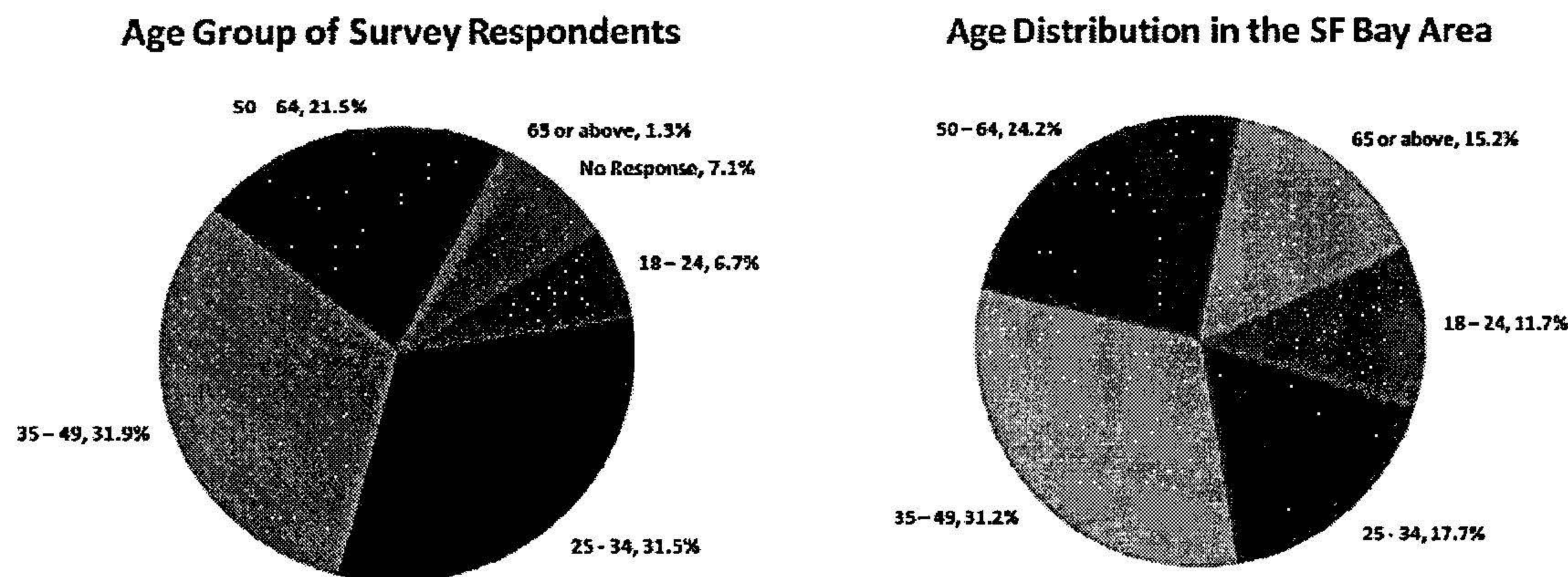


Figure 3-2: Age comparison between sample and population

Source: 2005-2007 American Community Survey 3-Year Estimates

3.3. Survey Results

3.3.1. Demographics and Commuting Attributes

Overall, more males (n=255) than females (n=209) participated in the survey, resulting in a sample population of 53.2% males and 43.6% females, with 3.1% not reporting gender. Most respondents were between the ages of 25 and 49 (63.4%). Respondents had a high average household income, with 63.7% reporting their household income to be \$75,000 or above. Most survey respondents had completed college, graduate school, or higher (87.5%).

The majority of survey respondents commute 5 times or more per week (56.2%). The station surveys were successful at targeting Caltrain users, with 83.1% of station survey respondents commuting by Caltrain. Overall, 64.5% of respondents were Caltrain users. The second most popular commute mode was driving alone (24.8%), followed by BART (18.2%) and local buses (16.1%).

Major factors influencing commute mode are shown to be different between online and station survey respondents. Train commuters believe that gas price and environmental concerns are the most important factors, which complements the increasing trend in gas price for the last year. Train commuters also consider the uncertainty of parking availability, which can keep them from using the train. However, respondents who took the online survey gave more importance to travel time to as a major factor. In general, both groups think that parking availability at their destination and cost are factors that affect their commuting choices.

Please see Appendix III for more survey results on respondents' demographic information and their commuting attributes.

3.3.2. About Traveler Information Signs

The majority of respondents have seen the transit signs. The online survey shows a lower ratio (55.6%) since population coverage for online survey includes non-US 101 commuters.

Respondents from the Redwood City station survey were more likely to have seen the sign around Redwood City heading north on US-101; similarly, respondents from the Millbrae station survey were more likely to have seen the signs near the Millbrae station. Online survey respondents were more likely to have seen the sign around Redwood City heading north on US-101 and around San Bruno heading south on US-101. Of respondents who have seen the transit signs, most reported that they noticed one sign (54.5%); 25.7% were familiar with all three of the transit sign locations.

In general, message content and accuracy is deemed to be very good. Most commuters trust the accuracy of the signs and report that the message display is easy to understand and read while driving. For instance, on a scale of 1 to 5 (5 being the highest), 77% of the respondents answered with 4 or 5 in agreement with the statement, "The travel information displayed on the information sign is easy to understand." Only 10% of respondents gave the transit signs a negative rating in respect to accuracy.

For those who have seen the signs, fewer train commuters agree that the signs help them decide whether to drive or take the train (8% for Caltrain users; 17% for respondents who do not commute with Caltrain), which is logical because these respondents were already train users. 22% of respondents who took online survey indicate that the information helps with their travel decisions.

For both survey instruments, distance from the train station to their final destination and convenience were the most frequent reasons reported by respondents for deciding not to take Caltrain even when the train was faster. Parking fees and a parking availability were also provided as reasons not to take Caltrain.

Please see Appendix III for more survey results on responses about traveler information signs.

3.3.3. Modal Shift Resulting from Transit Signs

The results indicate a rate of modal shift due to travel information shown on the signs (511: 9%; Redwood City: 2%; Millbrae: 4%). However, the percentage of those who would consider changing modes in the future is significantly higher for both the station and online survey (31%-52%). This is a great representation of positive public attitude toward dissemination of transit information.

Of those who have switched to taking the train, most reported that they switched when they could save 20 minutes or more due to traffic (68.8%). Of those who had not seen the transit signs but believed the sign message could influence their decision to take the train, 60.0% reported that they would switch if there were a time savings of 20 minutes or more.

By comparing survey respondents who tend to drive alone for their commuting and who typically use other travel modes, it is found that a slightly greater percentage of drivers had switched their travel mode because of the signs (5.3% vs. 4.7%); but solo drivers are less likely to switch travel mode in the future (36.4% vs. 41.3%).

Online respondents who reported that they had switched to taking the train were more likely to commute between San Jose and San Francisco. However, online respondents who had not seen the signs were more likely to report that they would switch modes if they did not currently commute between San Jose and San Francisco (35.6%). This suggests that commuters in other regions of the Bay Area could benefit from increased travel information related to modal choice.

More males switched modes due to seeing the transit signs (Males: 5.6%; Females: 3.4%). However, females were more likely to report that they would switch if the train were faster (Males: 31.5%; Females: 50.9%).

Age and education do not appear to be significant factors in determining the likelihood of a commuter switching modes due to the transit signs. However, commuters over the age of 50 who had not seen the transit signs were more likely to report that they would change modes in the future (56.5%), especially compared to commuters between the ages of 35 and 49 (24.1%).

Low-income drivers or high-income drivers were more likely to have switched modes (11.8% and 6.3%, respectively) compared to those reporting an average income (2.5%).

Please see Appendix III for more survey results on modal shift resulting from transit signs.

3.3.4. Write-in Comments

The final write-in question called for general comments and suggestions. Many respondents offered praise for Caltrain and the traveler information signs with 44 occurrences; however, respondents also identified areas for improvement. The most popular comment, with 65 occurrences, reflected frustration over delays, scheduling, and transfers from Caltrain to Muni and BART. More reliable service, frequent express trains, and coordinated schedules with other transit providers were suggested as ways to increase the convenience of using Caltrain. With sixteen occurrences, broken validation machines, and high fares were frequent remarks regarding ticketing. Fifteen (15) respondents commented they have already made the decision to drive when they pass the road signs and would like the information to be accessible before they leave the house, either online or through their cell phones. Ten (10) respondents requested additional bike storage on the trains or near the stations.

Please see Appendix III for detailed write-in comments.

4. System Operating Performance Analysis

This task aims to examine the operating performance of transit-related CMSs by looking into MITTENS log data. The objectives of this task are as follows:

- **Demonstrate and quantify time advantages of using transit.** How much time highway commuters can potentially save by switching to transit is calculated based on historical data.
- **Assess the system operation and performance.** Log data during operating time (rush hours) are assessed to check whether the system operates under the optimized schedule. This task will help Caltrans and Caltrain with future CMS operational planning to effectively disseminate traffic information in the region.
- **Link CMS survey data results with current CMS operating performance data.** This analysis will identify possible benefits of posting transit information via CMS (i.e. % of motorists who tend to potentially switch to using trains) and also provide more practical recommendations to the current and planned CMS operations.

4.1. Methodology

The team used the distribution of Δt as a metric for the performance analysis. Δt is defined as the time difference between highway travel time and Caltrain station-to-station trip time, which is shown as Equation 4-1.

$$\Delta t = TT_{\text{Highway}} - TT_{\text{Transit}}$$

Equation 4-1

This measure can be easily calculated by using available highway and transit/Caltrain travel time obtained from MITTENS log data. Therefore, taking Caltrain has an advantage in terms of travel time saving if Δt is greater than zero. As briefly mentioned in the previous section, transit-related CMSs are designed to display messages only when Caltrain trip time is less than highway travel time. Checking the frequency, sign, and magnitude of Δt can be used to:

- Evaluate the system performance
- Quantify time savings of switching to transit
- Optimize the operation schedule
- Predict the number of commuters who potentially choose to ride the train

This evaluation looks into the frequency of occurrence of each Δt range based on percentage of total operating time. In addition, the Δt distribution data are filtered based on different Δt ranges. (The Δt preference ranges outlined in the survey were the basis for this selection.) To achieve the aforementioned objectives, the analysis looks into the Δt distribution at three different levels:

- Overall distribution. All the collected data for each sign (station) are combined and analyzed together.
- Day-to-day distribution of Δt . Daily distribution of Δt is analyzed from Monday to Friday.
- Within-day distribution of Δt . Hourly Δt data are assessed.

The distributions are presented as histograms in which the Y-axis is the normalized counts. The following sections give details about the analysis results.

4.2. Data Collection

In order to examine the operating performance of the transit-related signs, the MITTENS' log data were analyzed. MITTENS is capable of archiving historical data of the actual messages displayed on the CMSs. Four months (January – April 2008) of daily/hourly log data were collected for the analysis during, a period which all three signs were in use. Periods with fully or partially missing operating records due to system failure or overhaul are excluded from the analysis. Only weekday data with proper operating information are included in the final data analysis (please see Table 4-1 for more details).

Table 4-1: Period of data analysis and operation time information of transit-related CMSs

CMS ID	Selected Dates for Analysis	Total Days (weekdays)	Operation Time (in minutes)	
			Daily	Total
CMS 122	1/24~25, 1/28~2/1, 3/3~7, 3/24~28, 3/31~4/4, and 4/21~25	27 days	318	8,586
CMS 123	1/24~25, 1/28~2/1, 3/3~7, 3/24~28, 3/31~4/4, and 4/21~25	27 days	392	10,584
CMS 012	3/3~7, 3/24~28, 3/31~4/4, and 4/21~25	20 days	420	8,400

4.3. Results and Findings

4.3.1. Overall Distribution of Δt

Figure 4-1 shows the distribution (histogram) of Δt for three transit signs aggregated over weekdays. The X-axis is the magnitude of Δt (in minutes); and the Y-axis is the normalized count. Since highway drivers will be more likely to change their travel mode to transit when there is more time saving by riding the train, the magnitude and frequency of occurrence for a specific Δt range can be used to estimate the expected number of drivers who may switch their travel mode from car to train. Table 4-2 demonstrates these statistical values. The initial assessment of the Δt ranges (X-axis) and normalized count (Y-axis) in Figure 4-1 and Table 4-2 implies that:

- There is a time saving (positive Δt) in taking the train. (Average: 11-13 minutes)

- Highway commuters along 101 can save a great deal of time (larger values of Δt) during heavy traffic congestion by switching to transit. (Standard deviation: 9-12 minutes)
- Normalized count of Δt decreases as the magnitude of Δt increases.

Detailed graphs of frequency and magnitude of Δt for the three transit CMSs are presented in Appendix IV.

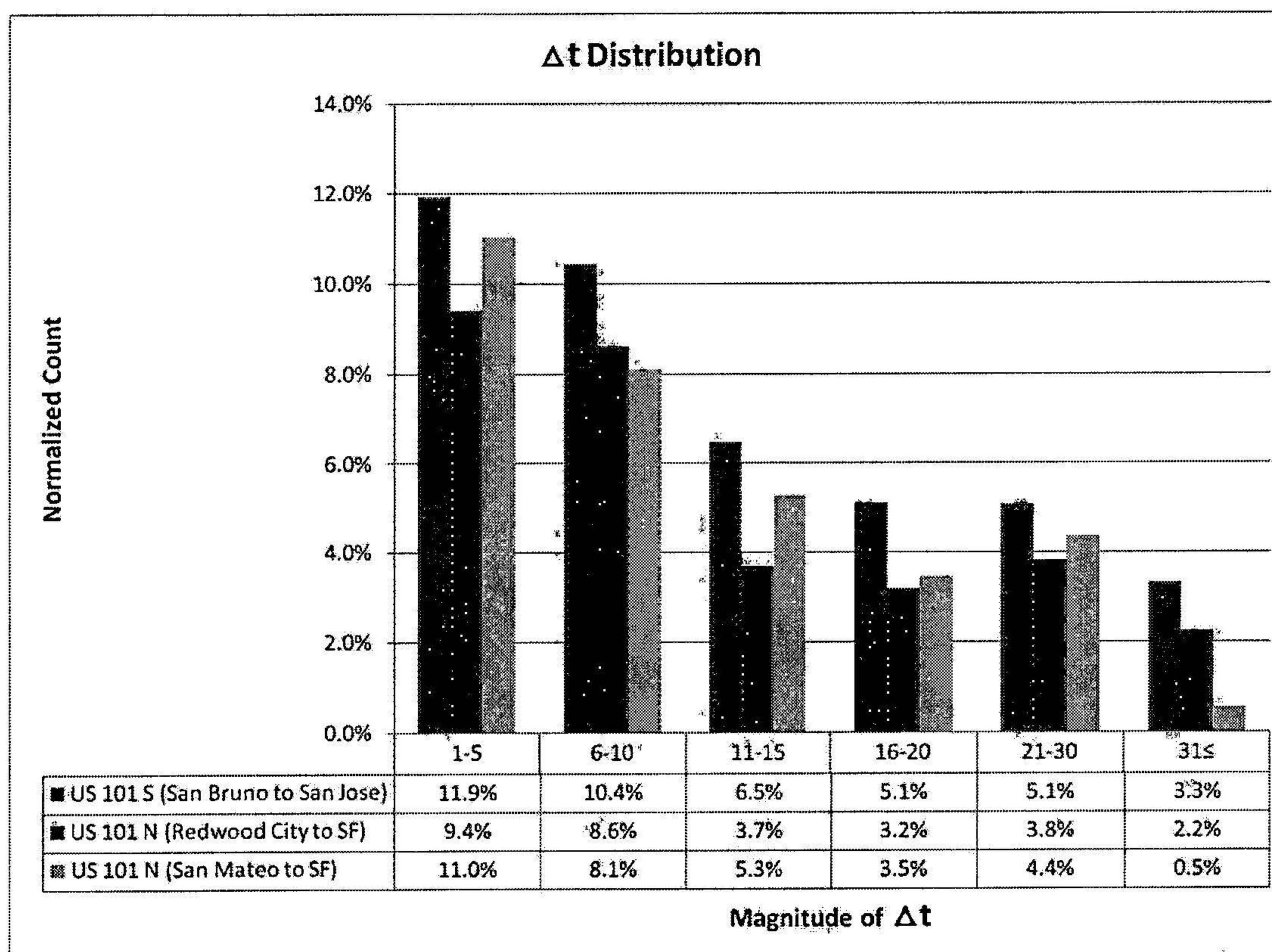


Figure 4-1: Frequency and magnitude of Δt

Table 4-2: Statistical values

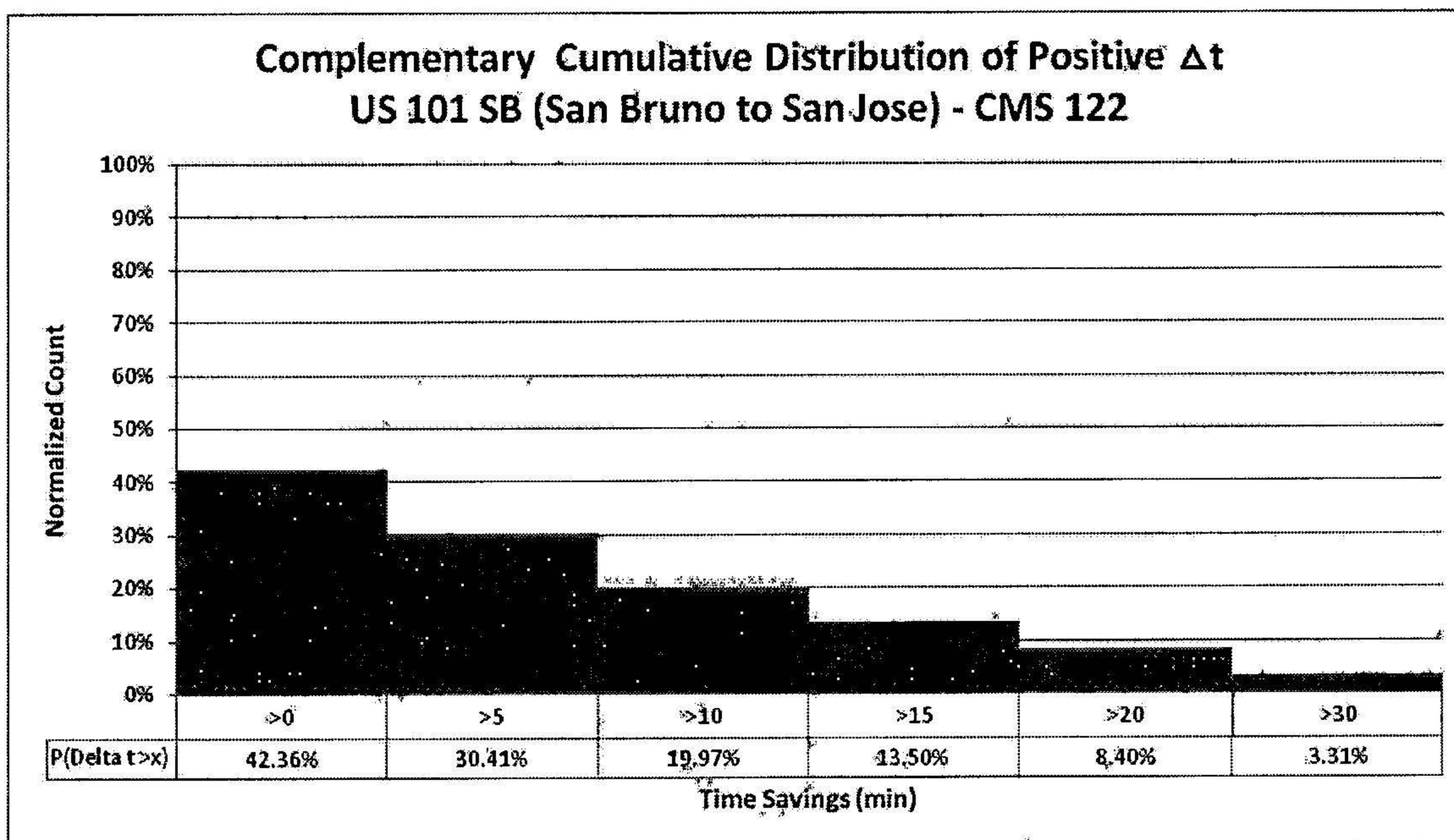
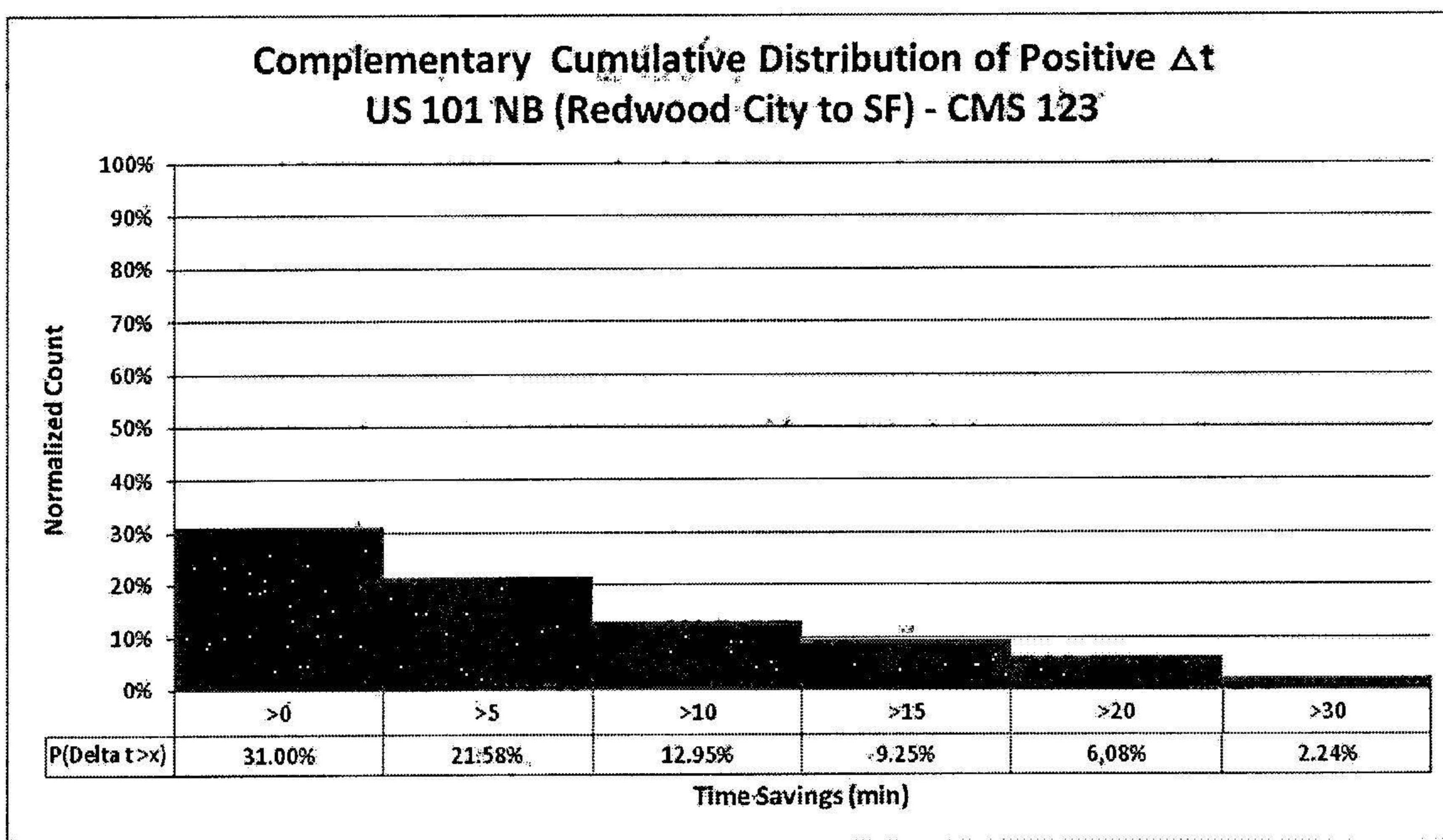
	Mean	Median	Variance	Standard Deviation
CMS 122				
US 101 S (San Bruno to San Jose)	12.84	10	117.76	10.85
CMS 123				
US 101 N (Redwood City to SF)	12.71	9	146.81	12.12
CMS012				
US 101 N (San Mateo to SF)	10.78	9	76.86	8.77

Table 4-3 presents the normalized count of positive Δt during the operation time. This table indicates the frequency of situations in which commuters could save time by riding the train when compared to the highway driving time. The analysis unit is minutes. As listed in the table, the normalized count of positive Δt (during operation schedule) is 42.4%, 31.0%, and 32.8% for CMS 122 (Millbrae - SB), 123 (Redwood City - NB), and 012 (Millbrae - NB), respectively. It is found that the value is decreasing as the magnitude of Δt increases; however, the normalized counts for all Δt ranges are meaningful values to express potential travel mode changes.

Table 4-3: Percentage of occurrence time of positive Δt during total operation time

	CMS ID/Study Sections	Total Operation Time	Total Positive Δt	Magnitude Categories of Δt					
				1-5	6-10	11-15	16-20	21-30	30-
Frequency (in minutes)	CMS 122	8,586	3,637	1,026	896	556	438	437	284
	US 101 S (San Bruno to San Jose)								
	CMS 123	10,584	3,281	997	913	392	336	406	237
	US 101 N (Redwood City to SF)								
	CMS012	8,400	2,753	926	681	444	290	367	45
	US 101 N (San Mateo to SF)								
Total Positive Delta t / Total Operation Time (%)	CMS 122	-	42.4%	11.9%	10.4%	6.5%	5.1%	5.1%	3.3%
	US 101 S (San Bruno to San Jose)								
	CMS 123	-	31.0%	9.4%	8.6%	3.7%	3.2%	3.8%	2.2%
	US 101 N (Redwood City to SF)								
	CMS 012	-	32.8%	11.0%	8.1%	5.3%	3.5%	4.4%	0.5%
	US 101 N (San Mateo to SF)								

Figure 4-2 to Figure 4-4 display the complementary cumulative distribution of Δt . As an example, Figure 4-2 shows that southbound commuters can save more than 10 minutes by switching to Caltrain about 20% of the time. The graphs also show a potential time saving of more than 20 minutes for Redwood City to SF and San Mateo to San Jose commuters approximately 6.1% and 4.9% of the time, respectively.

Figure 4-2: Complimentary cumulative distribution of Δt for CMS 122Figure 4-3: Complimentary cumulative distribution of Δt for CMS 123

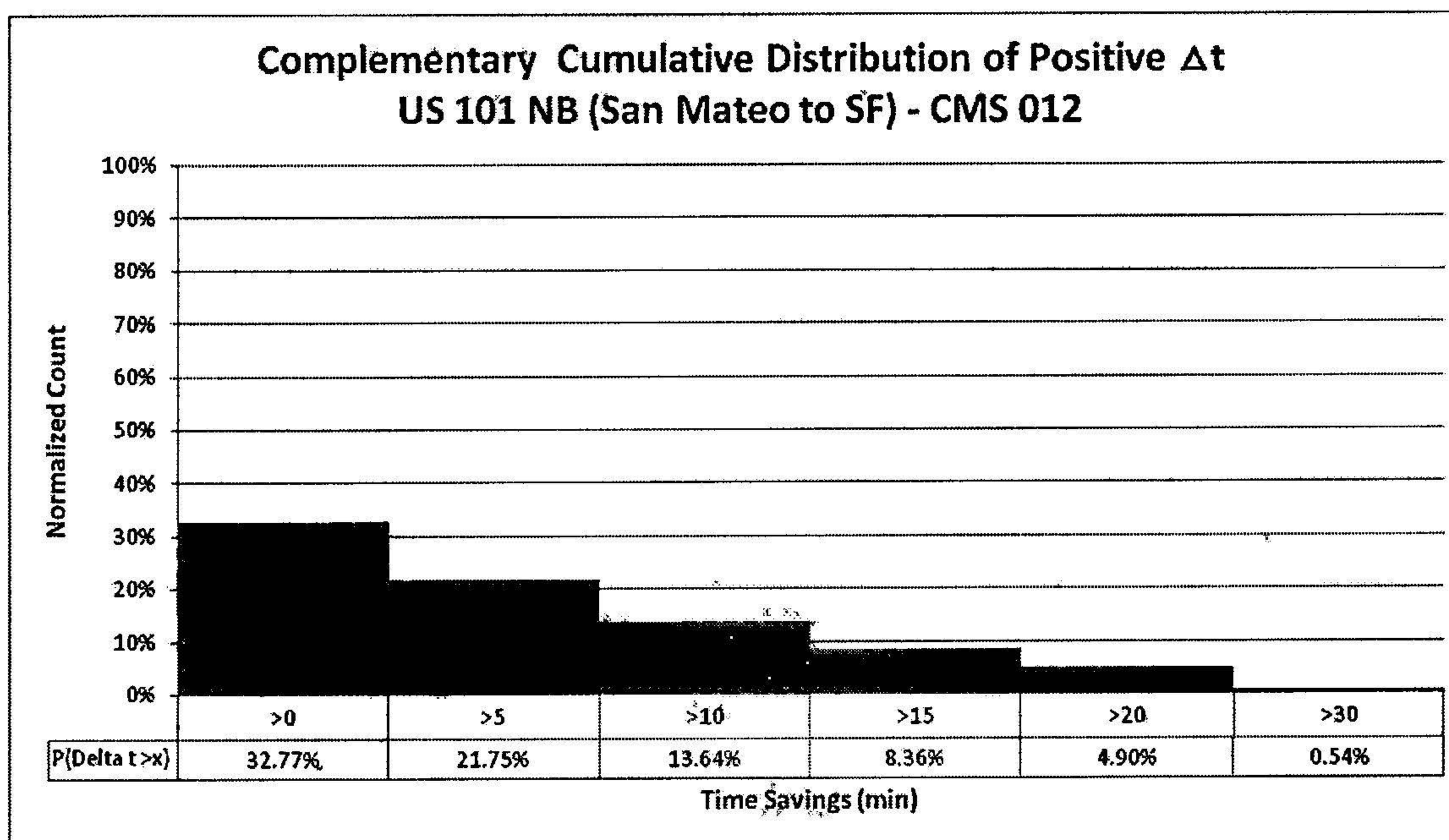


Figure 4-4: Complimentary cumulative distribution of Δt for CMS 012

4.3.2. Day-to-day Distribution of Δt

Figure 4-5 to Figure 4-7 show the day-to-day variation of Δt when each station's log data are arranged by weekday. In general, for a low magnitude of Δt ($1 \leq \Delta t \leq 15$), the normalized count increases from Monday to Wednesday and then slightly decreases on Thursday to Friday, indicating that low to moderate traffic congestion incidents occur more often during the early part of the week. However, normalized counts for a large magnitude Δt (≥ 16) continue to grow from Monday to Friday, although the overall frequency is lower compared to low or moderate traffic delays. Because northbound heavy traffic congestion occurred more frequently from Wednesday to Friday, it follows that transit CMS may induce more mode change from highway driving to train riding in the latter half of the week. Figure 4-5 also shows that southbound travel has larger Δt variation, specifically for early weekdays (Monday and Tuesday). Therefore, southbound commuters can save more time on Mondays and Tuesdays relative to northbound drivers. Please see Appendix IV for a detailed analysis.

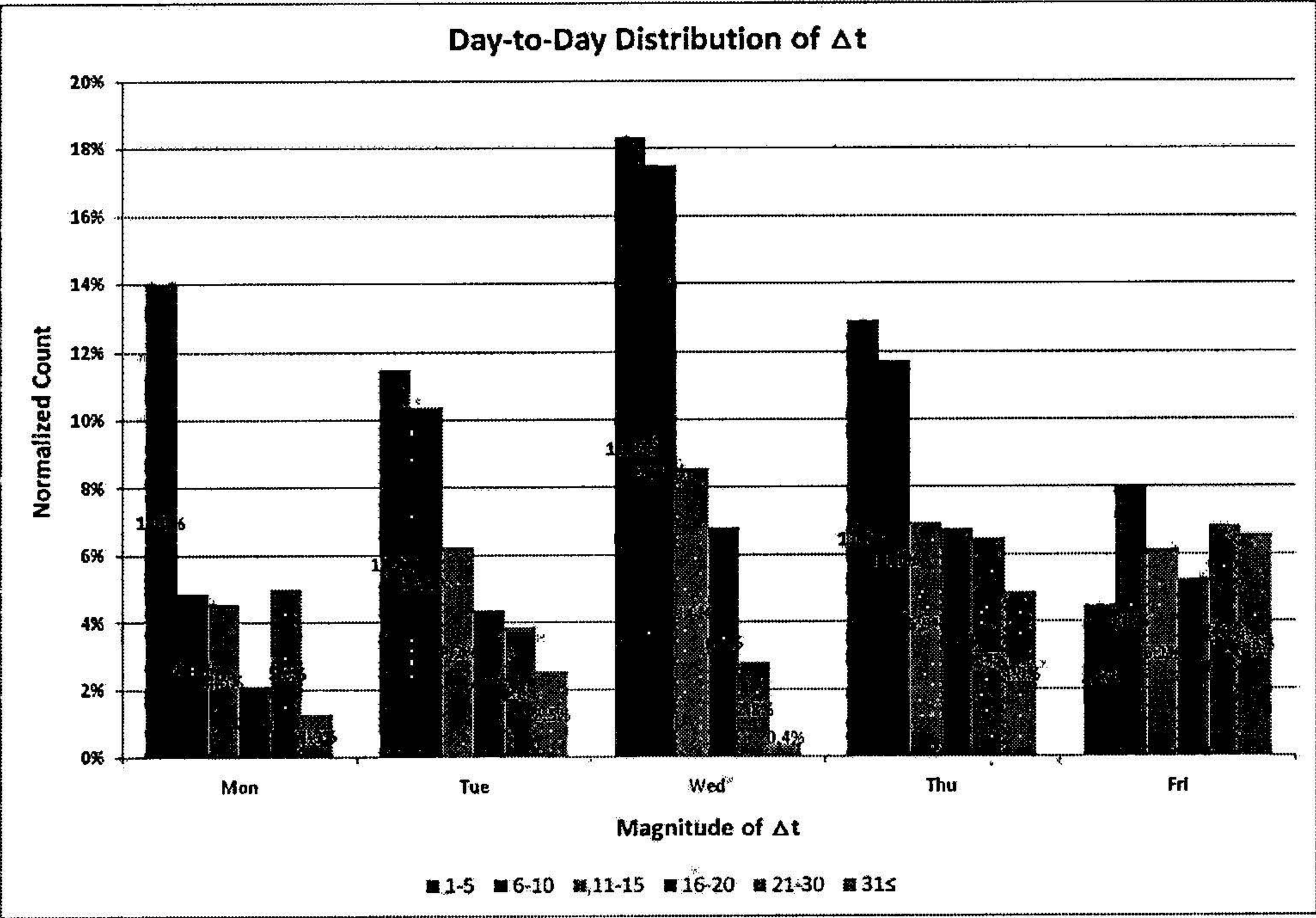


Figure 4-5: Day-to-day distribution of Δt (CMS 122/US 101 SB San Bruno to San Jose)

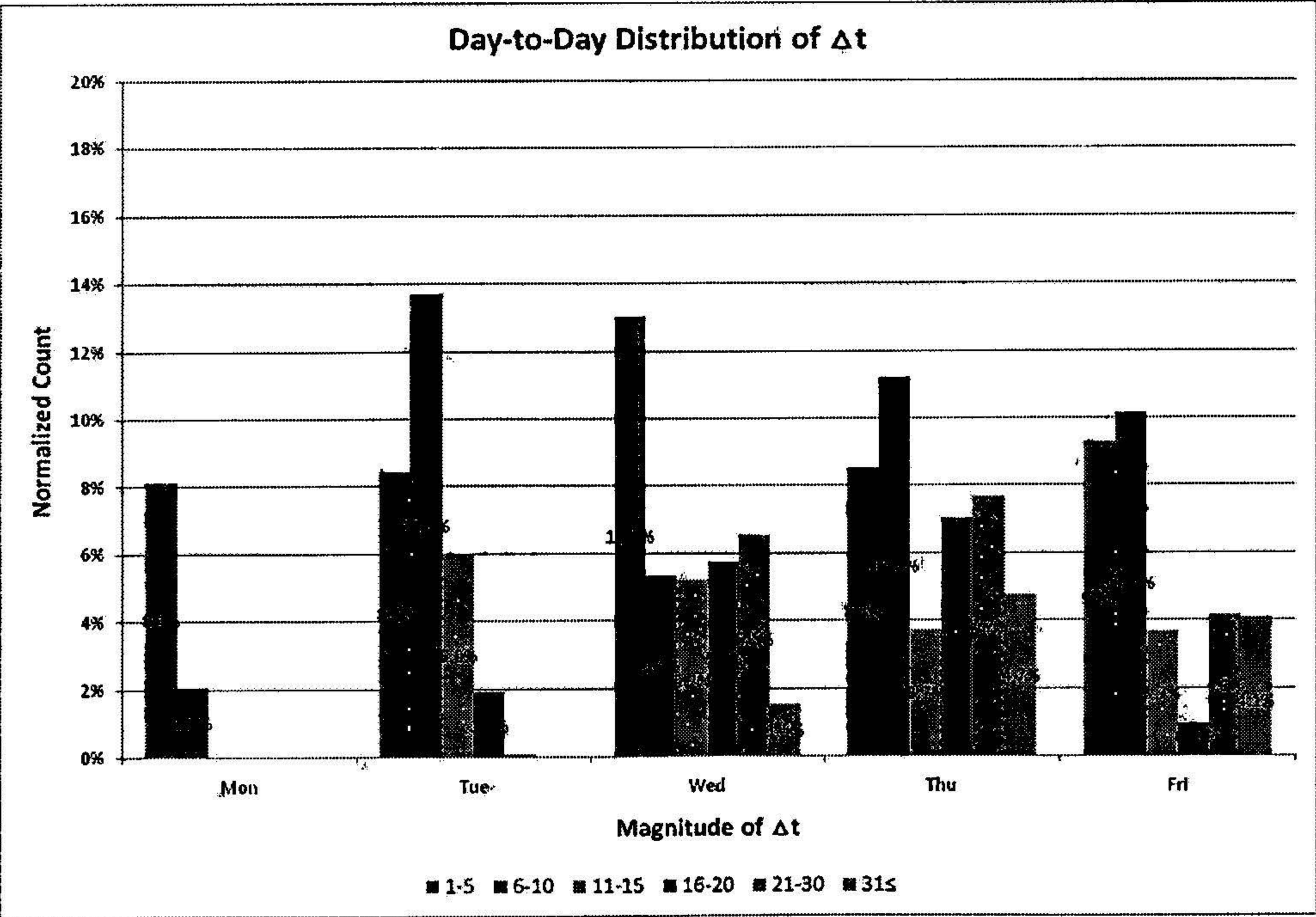


Figure 4-6: Day-to-day distribution of Δt (CMS 123/US 101 NB Redwood City to SF)

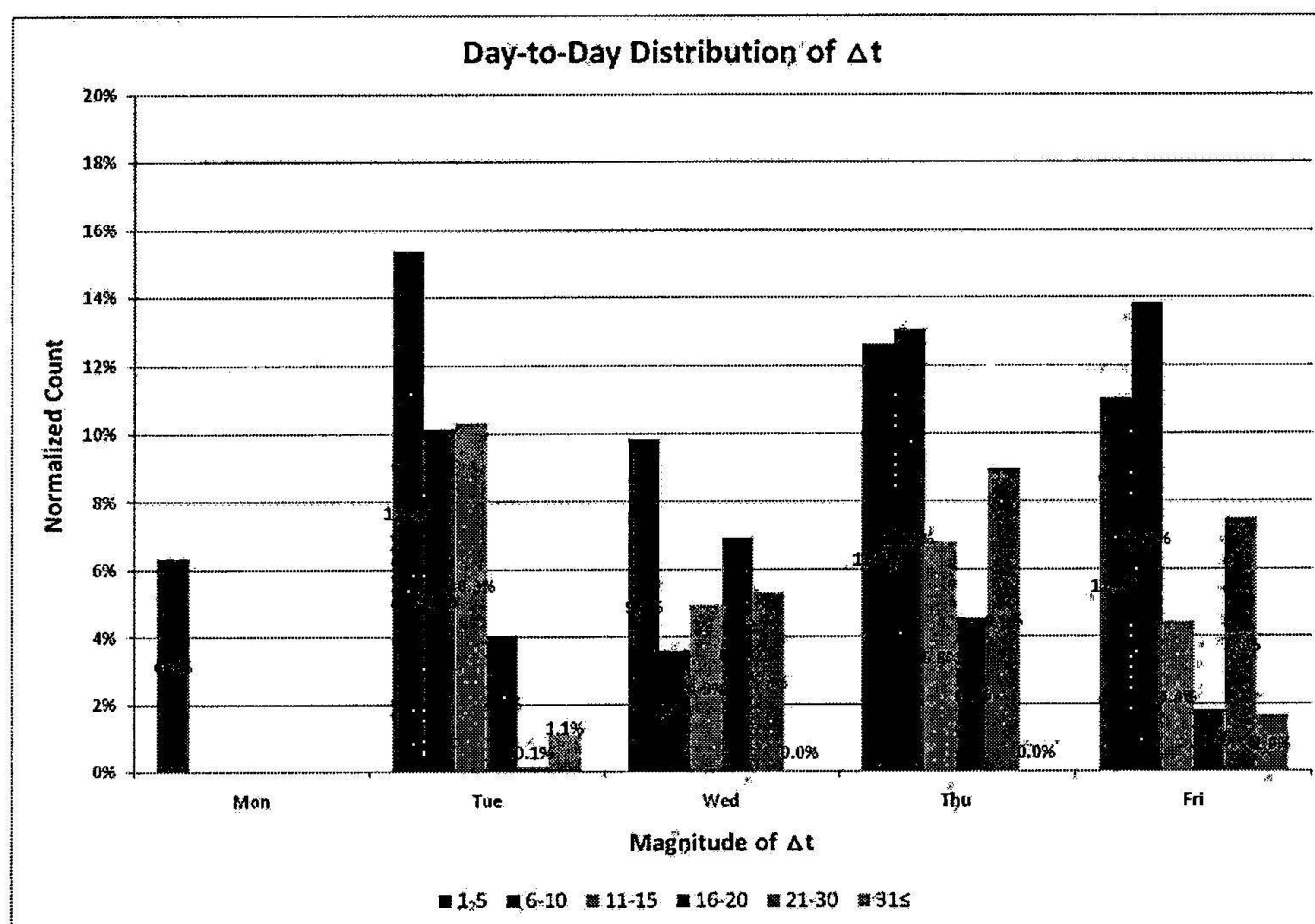


Figure 4-7: Day-to-day distribution of Δt (CMS 012/US 101 NB San Mateo to SF)

1.1.1.1 Operation Schedule

Figures 4-8 to 4-10 present the hourly distribution of positive Δt for the three transit signs. In general, the southbound sign (Figure 4-8) shows more positive Δt incidents compared to the northbound signs (Figure 4-9 to Figure 4-10). During morning peak hours, the longer the distance covered by the CMS, the wider the distribution of Δt observed, as indicated by the narrow distribution of the Millbrae northbound sign (Figure 4-10). For each CMS, positive Δt occurred more frequently during afternoon peak hours. Overall, the graphs show that the occurrences of traffic congestion in the afternoon peak hours are relatively more severe, especially for longer travel distances.

Figures 4-8 to 4-10 are used to propose a new operation schedule. The graphs show that the concentration of positive Δt distribution is between 7:30 am and 9:00 am while there is no time advantage (positive Δt) for early morning hours (5:00 am to 7:30 am). The afternoon data indicate that all three of the signs were operating over 10% of the time, indicating an advantage simultaneously at each location. Therefore, to optimize the system performance, the team suggests revising only the start time for the morning peak hours as shown in Table 4-4. The revised schedule limits the sign operation to the periods when commuters can potentially save time more than 5% of time by switching to the train. Table 4-5 presents the percentage of occurrences for a positive Δt during the proposed schedule.

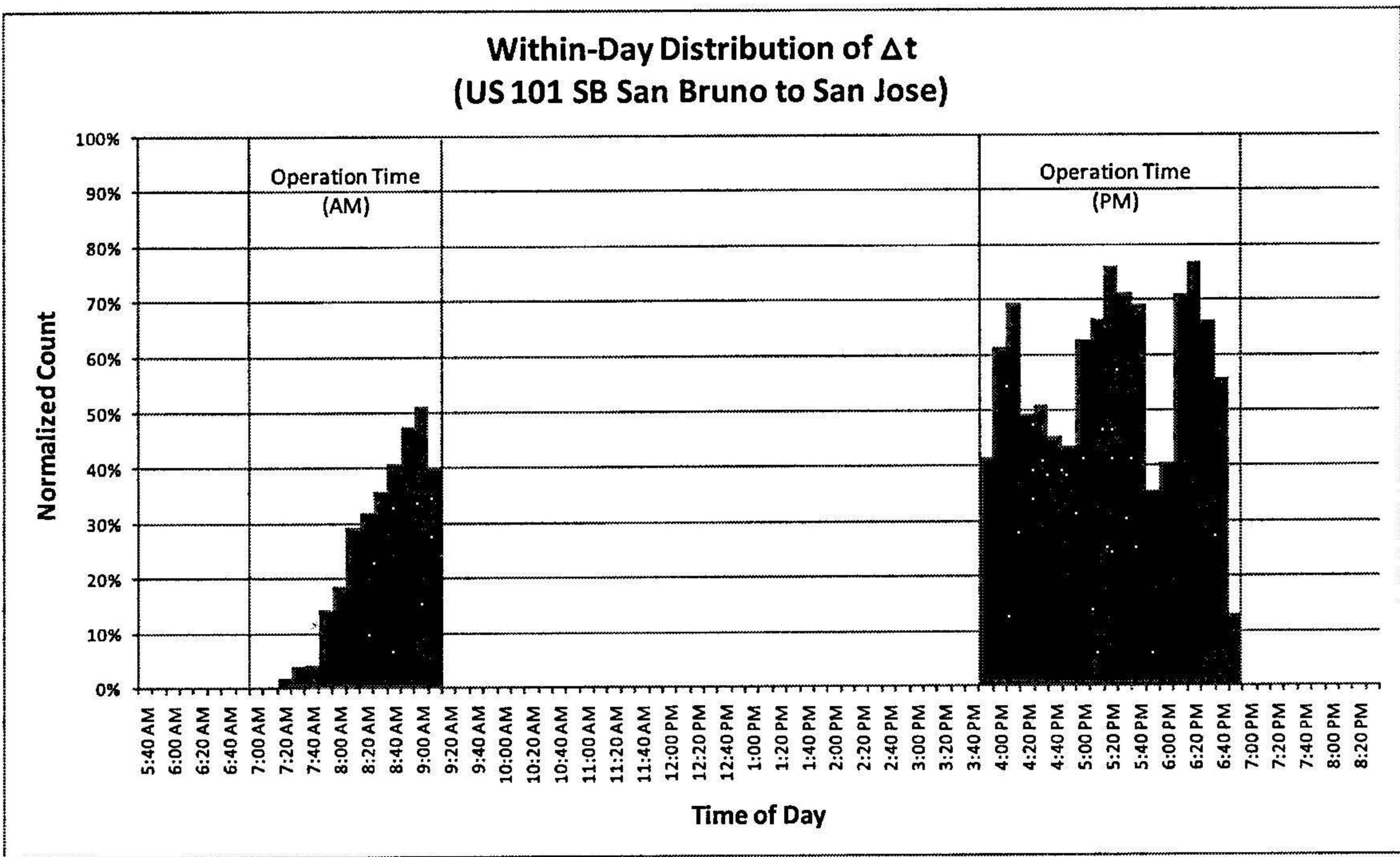


Figure 4-8: Within-day distribution of Δt (CMS 122/US 101 SB San Bruno to San Jose)

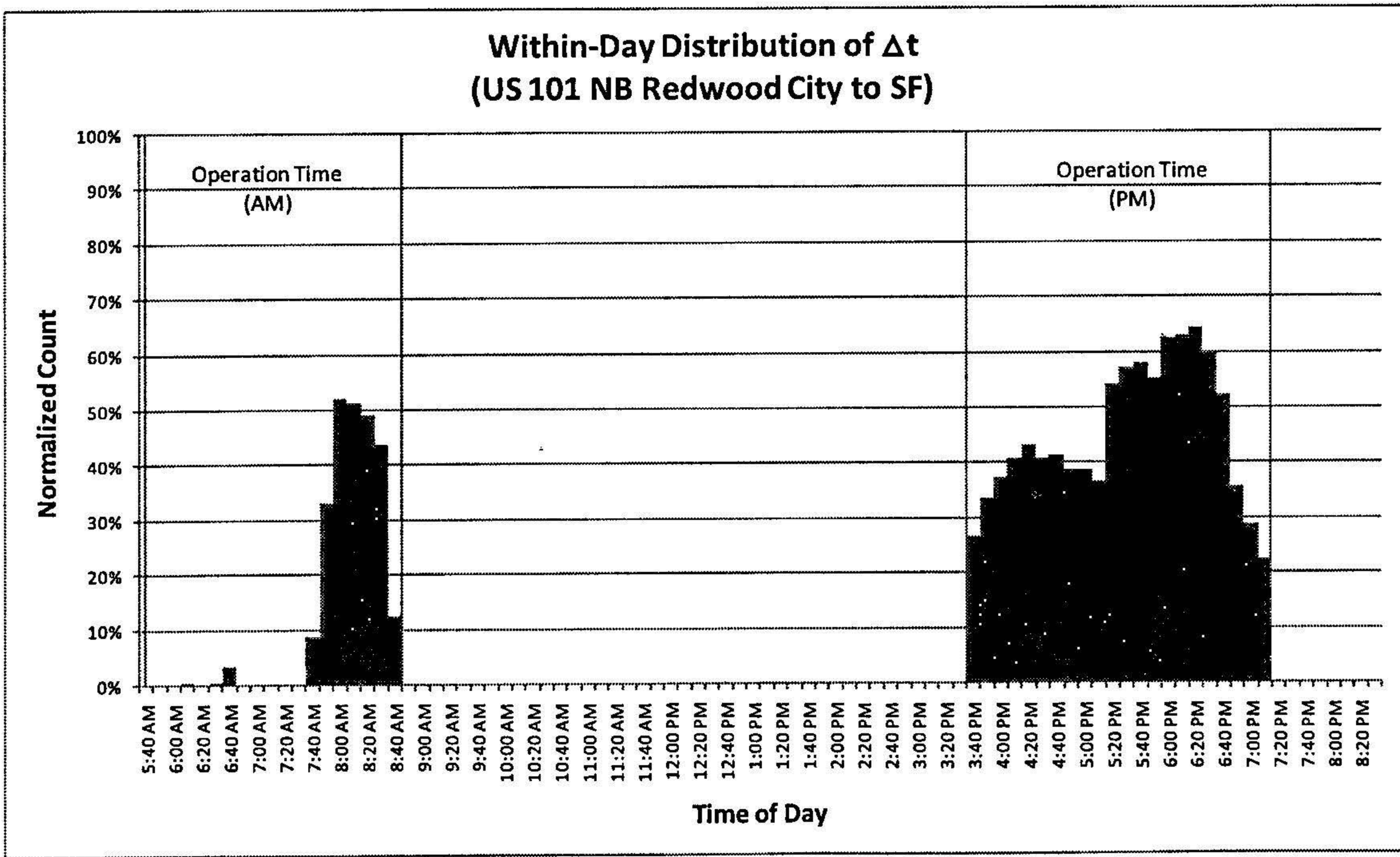


Figure 4-9: Within-day distribution of Δt (CMS123/US 101 NB Redwood City to SF)

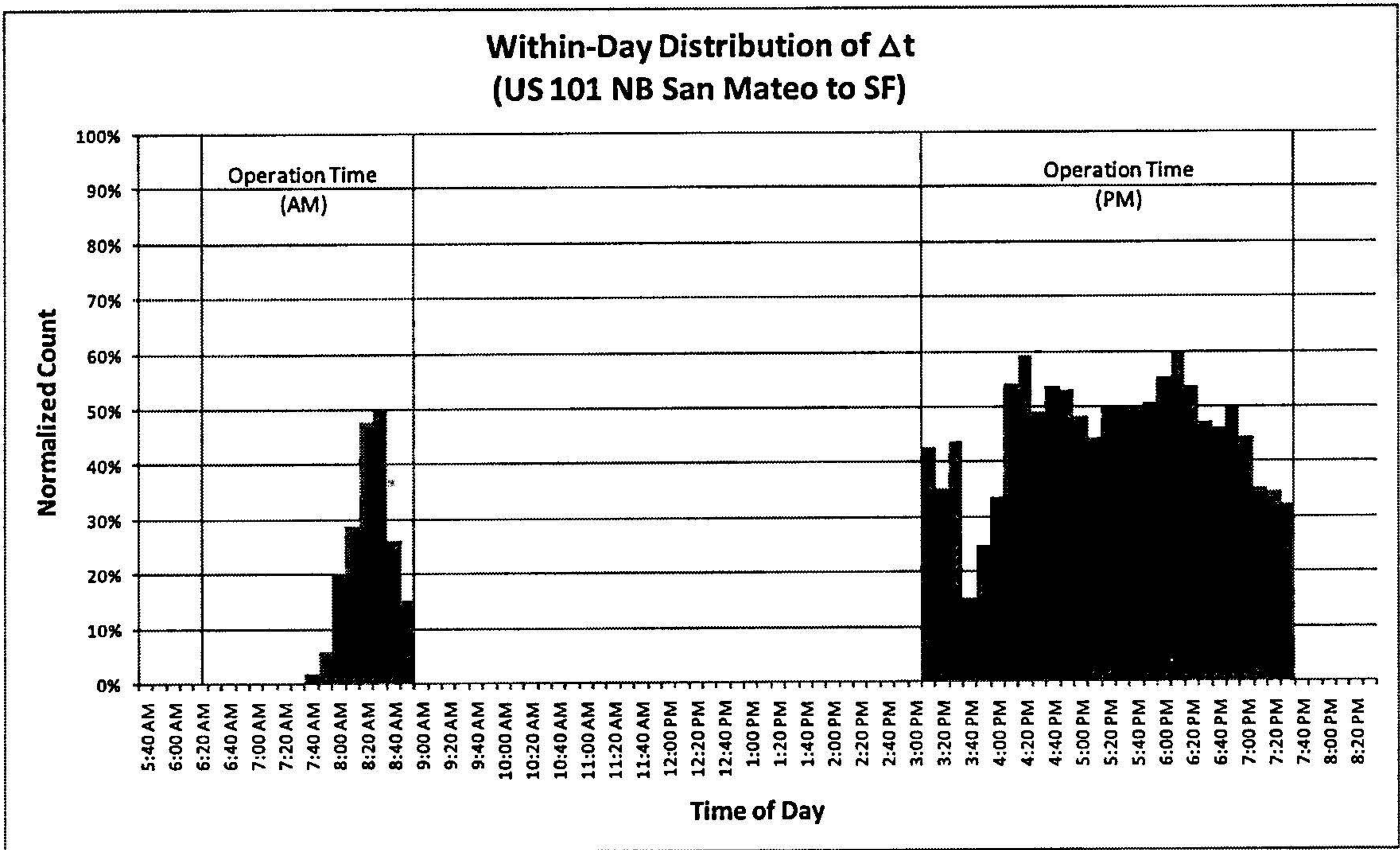


Figure 4-10: Within-day distribution of Δt (CMS012/US 101 NB San Mateo to SF)

Table 4-4: Proposed schedule

	Original Operating Schedule	Proposed Operating Schedule
CMS122	06:50-09:07 AM and 15:45-18:46 PM	07:40-09:07 AM and 15:45-18:46 PM
CMS123	05:33-08:33 AM and 15:35-19:07 PM	07:30-08:33 AM and 15:35-19:07 PM
CMS012	06:14-08:47 AM and 15:04-19:31 PM	07:50-08:47 AM and 15:04-19:31 PM

Table 4-5: Percentage of occurrence of positive Δt for the adjusted schedule

	CMS Sections	ID/Study	Total Adjusted Operation Time	Total Positive Δt	Magnitude Categories of Δt (in minutes)					
					1-5	6-10	11-15	16-20	21-30	30-
Frequency (in minutes)	CMS 122		7,236	3,612	1,014	883	556	438	437	284
	US 101 S (San Bruno)									

		to San Jose)							
		CMS 123							
		US 101 N (Redwood 7,425	3,270	986	913	392	336	406	237
		City to SF)							
		CMS012							
		US 101 N (San Mateo 6,480	2,739	912	681	444	290	367	45
		to SF)							
Total Δt/Total Operation Time (%)	Positive	CMS 122							
		US 101 S (San Bruno -	49.9%	14.0%	12.2%	7.7%	6.1%	6.0%	3.9%
		to San Jose)							
		CMS 123							
		US 101 N (Redwood -	44.0%	13.3%	12.3%	5.3%	4.5%	5.5%	3.2%
		City to SF)							
		CMS 012							
		US 101 N (San Mateo -	42.3%	14.1%	10.5%	6.9%	4.5%	5.7%	0.7%
		to SF)							

4.3.3. Within-day Distribution of Δt

Figures 4-11 to 4-13 show the within-day variation of positive Δt during weekdays. It is notable that the normalized counts of Δt maintain a gradually decreasing pattern from Monday to Friday in the morning peak hours for northbound signs; however, conversely, a gradually increasing pattern appears from Monday to Friday for the afternoon peak hours. The latter trend exists for all three transit signs regardless of direction. This trend implies that, during operation of the transit signs, commuter would benefit from paying more attention to the signs during the morning peaks hours for the first half of the week and to the afternoon peak hours for the second half of the week.

Figures 4-14 to 4-16 demonstrate within-day variations of Δt in different ranges for positive Δt values. Morning southbound data show larger variation of Δt ($\sigma = 6.91$ minutes) than northbound signs ($\sigma = 3.76$ minutes). During afternoon peak-hours, southbound US-101 commuters experience longer delays (i.e., larger Δt values) comparing to northbound motorists. In addition, normalized counts of the southbound Δt distribution is higher than for the northbound data, suggesting that there are more occasions in which southbound commuters can save time by switching to transit. The comparison of Figure 4-15 and Figure 4-16 indicates greater time savings for Redwood City transit commuters due to the longer travel distance to San Francisco.

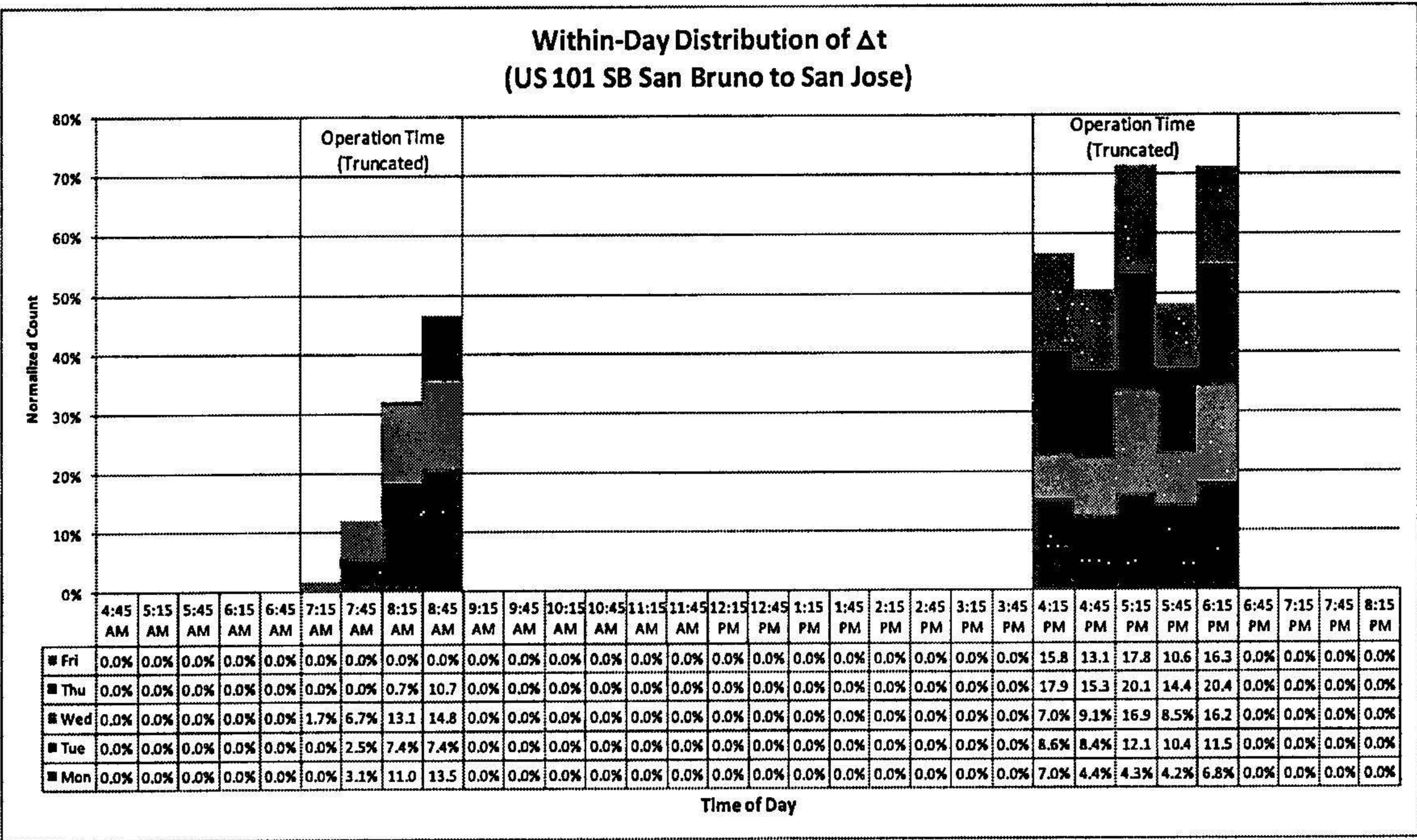


Figure 4-11: Within-day distribution of Δt for weekdays (CMS 122/US 101 SB San Bruno to San Jose)

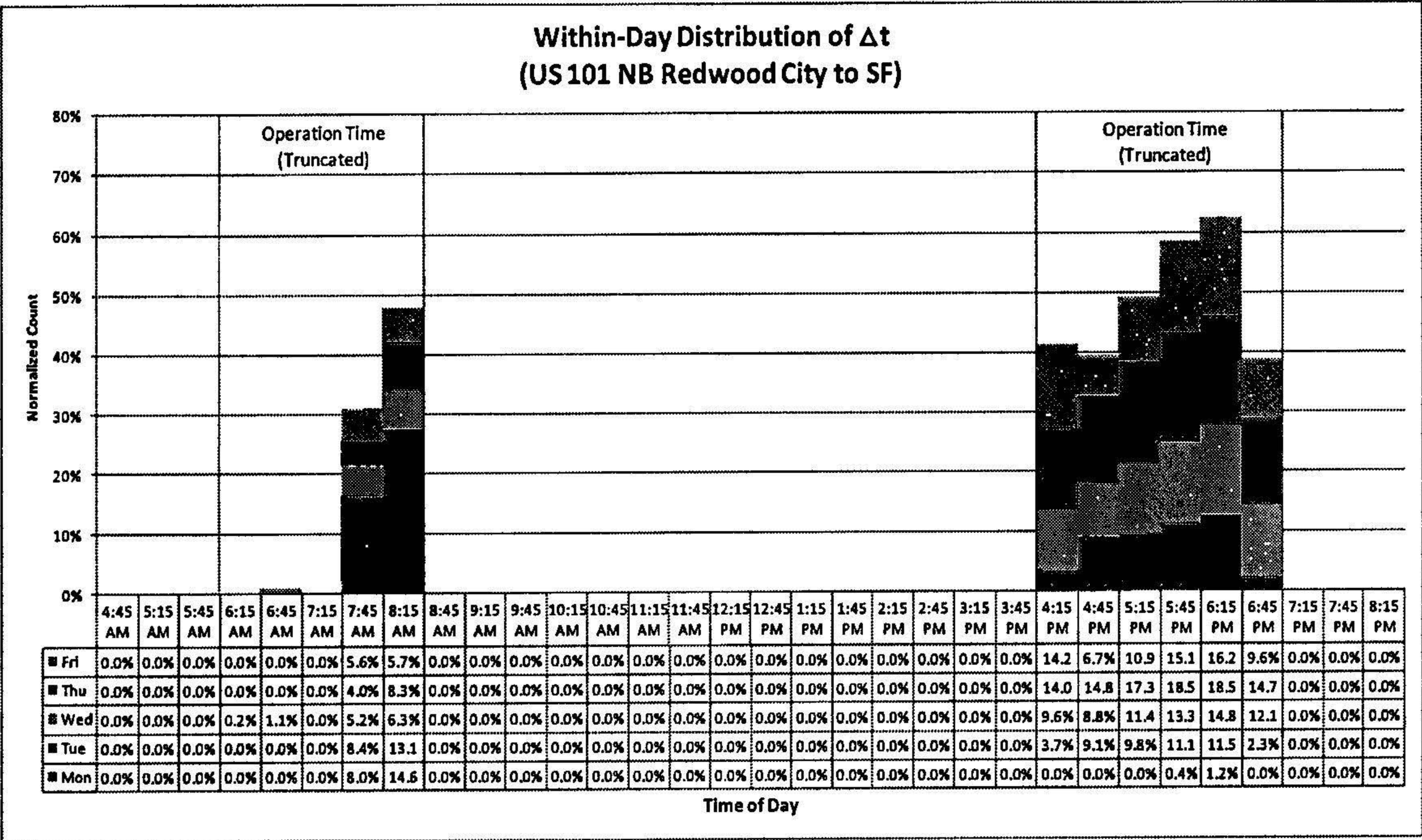


Figure 4-12: Within-day distribution of Δt for weekdays (CMS 123/US 101 NB Redwood City to SF)

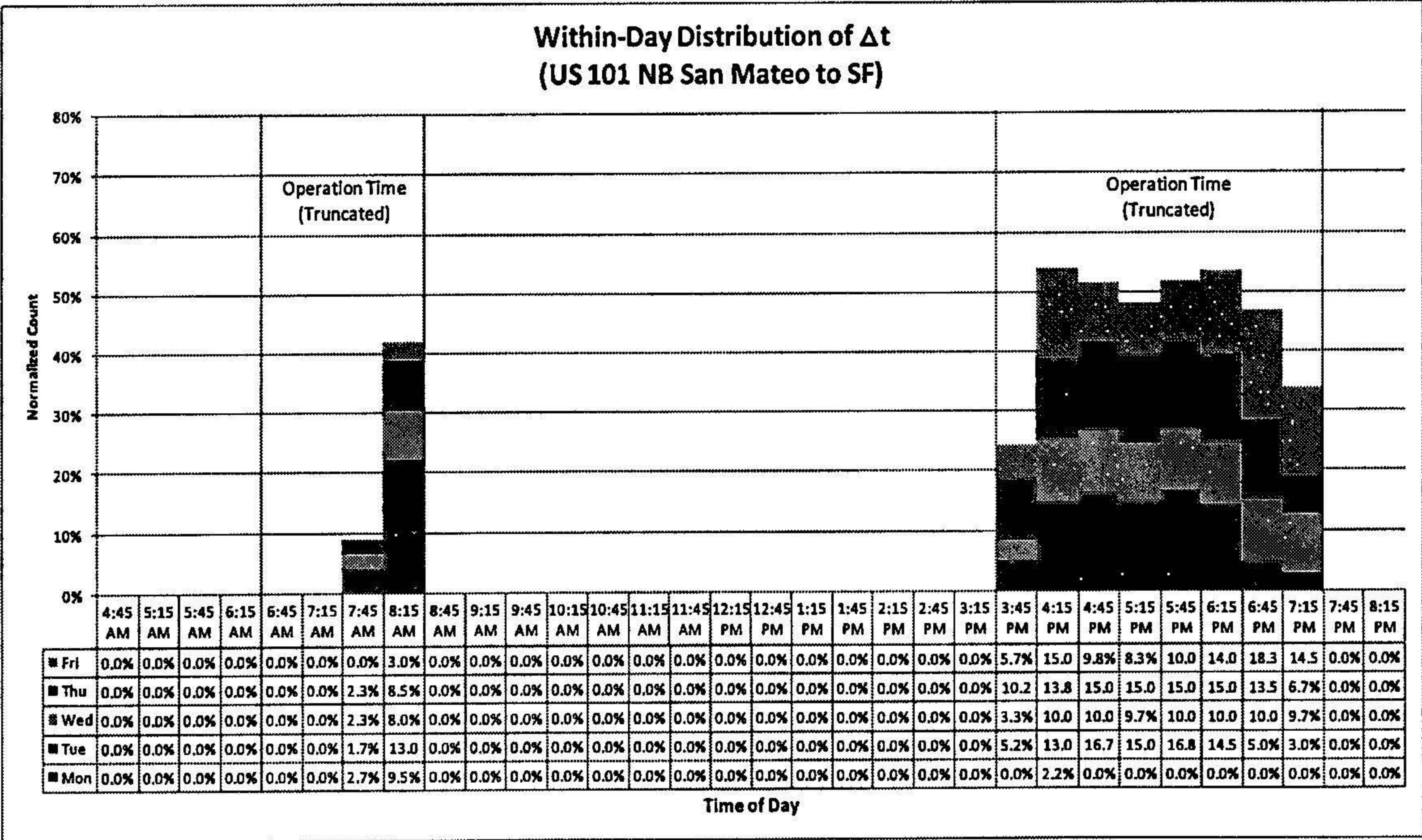


Figure 4-13: Within-day distribution of Δt for weekdays (CMS 012/US 101 NB San Mateo to SF)

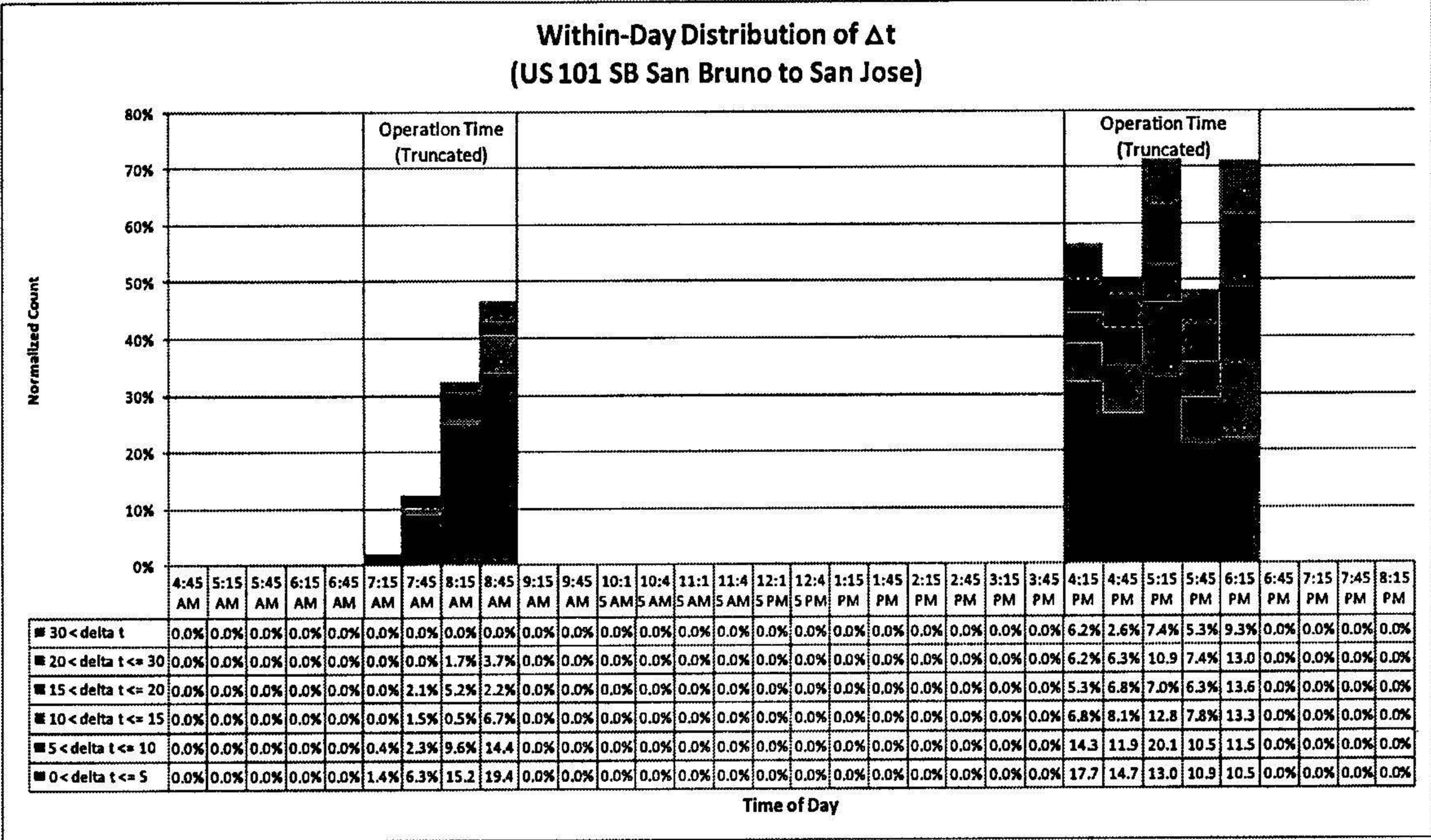


Figure 4-14: Within-day Δt distribution grouped by ranges of Δt
(CMS 122/US 101 SB San Bruno to San Jose)

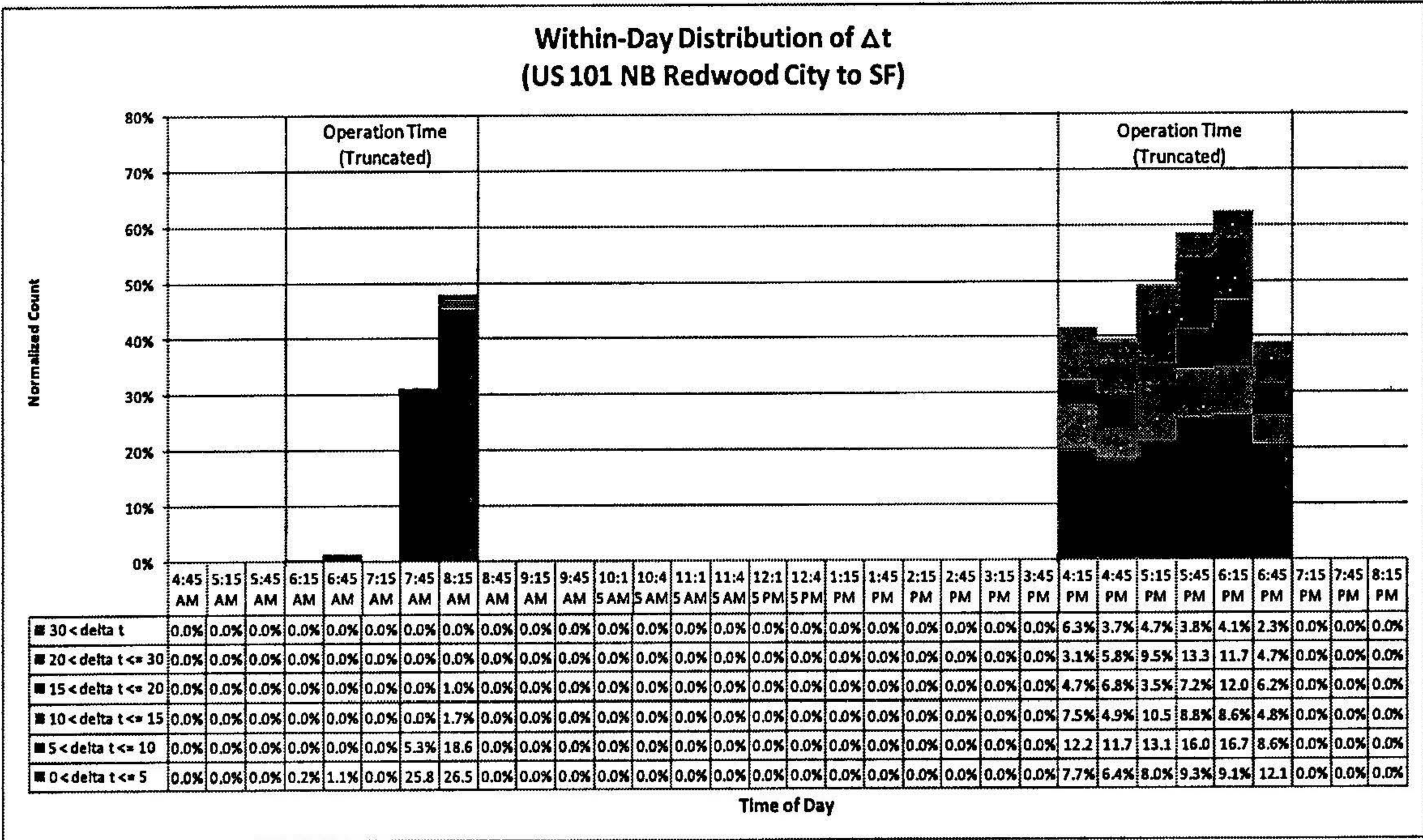


Figure 4-15: Within-day Δt distribution grouped by ranges of Δt
(CMS 123/US 101 NB Redwood City to SF)

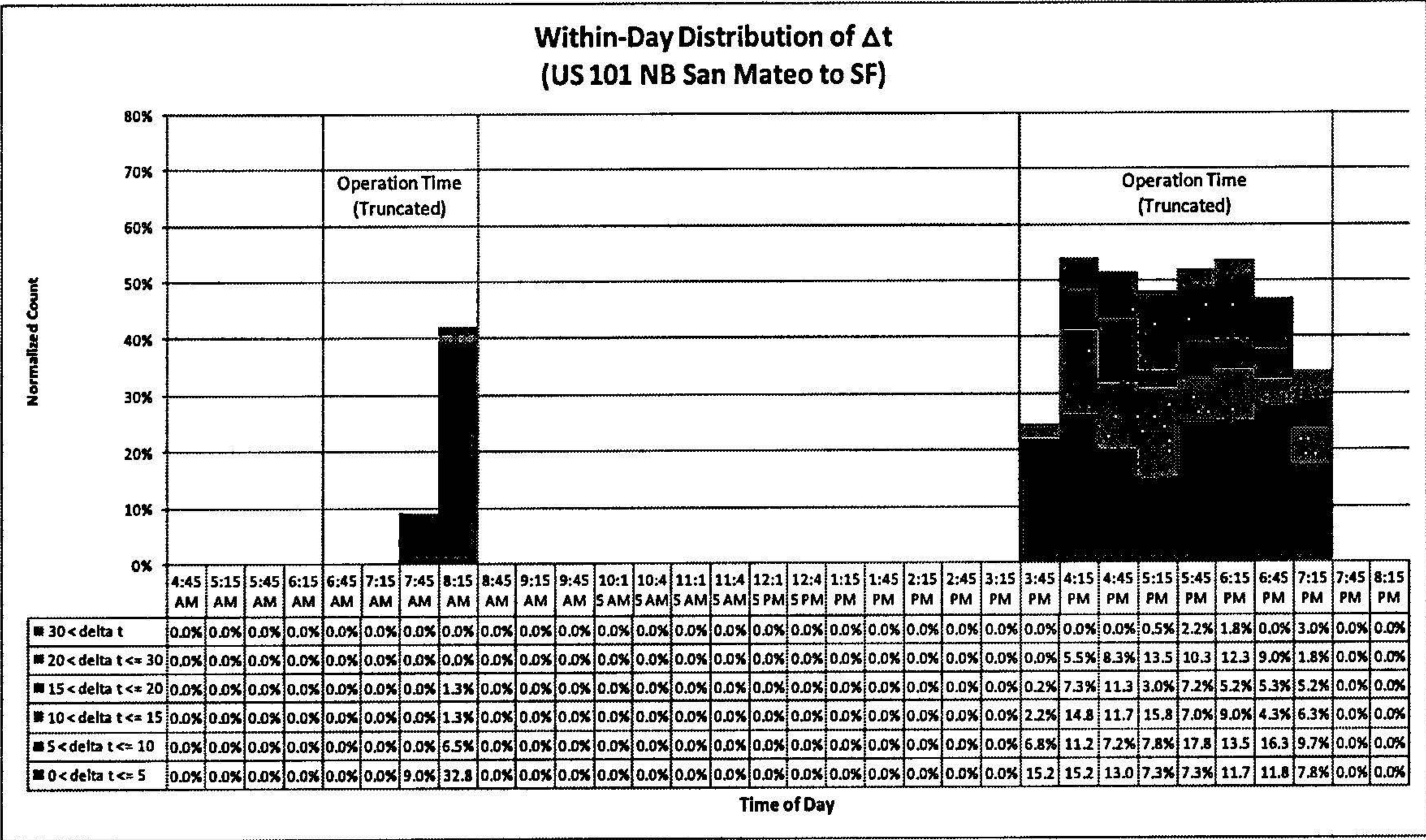


Figure 4-16: Within-day Δt distribution grouped by ranges of Δt
(CMS 012/US 101 NB San Mateo to SF)

4.3.4. Transit Time Advantage Factor (TTAF)

The objective of this section is to define a metric to quantify the time advantage for transit trips, called the Transit Time Advantage Factor (TTAF) and to identify the operation scenarios that are more likely to trigger a modal shift among highway commuters.

The analysis uses Δt as a basis for determining whether taking a train saves time (i.e., riding Baby Bullet has an advantage/benefit over driving along US-101). Comparing Δt histograms for different weekdays shows that the advantage is dependent on two factors: the Δt range and frequency (normalized count). For incidents in which the signs display higher Δt values over longer periods, there is more possibility of modal switch among commuters.

The simple approach is to use the distribution integral to quantify time advantage. The higher values state more occurrence of positive Δt . Based on the Δt analysis, we have defined six Δt ranges (0-5 minutes, 5-10 minutes, etc.). For a specific range, Δt_i , we define:

- n_i : Frequency (or normalized count)

- Δt_{imin} : Minimum of the range
- Δt_{imax} : Maximum of the range

As an example, for the 5 to 10 minute range:

$\Delta t_i = \Delta t_2$, $\Delta t_{imin} = 5$ and $\Delta t_{imax} = 10$.

Then Transit Time Advantage Factor (TTAF) can be defined as:

$$TTAF = \sum_{i=1}^6 n_i \quad TTAF = \sum_{i=1}^6 n_i \quad (\text{We assume the width of each bin is 1.})$$

The area underneath the distribution curve is a sufficient method to represent only positive Δt values. However, this approach is not appropriate to compare two scenarios that have equal areas with different Δt ranges.

As explained previously, one of the objectives is to find a feature that reflects the possibility of modal shift. The team is interested in defining a parameter in which the higher values signify more switches. As a result, including commuters' feedback about their Δt preferences is essential in the definition of TTAF.

Instead of calculating the area underneath the histogram, the team suggests calculating the weighted summation of n_i 's. The weights are estimated using Δt preference data collected from the commuter survey described in the User Satisfaction Analysis. The TTAF parameter is now defined as:

$$TTAF = \sum_{i=1}^6 w_i \cdot n_i$$

Where:

- n_i : Frequency of occurrence for a specific Δt_i
- w_i : Percentage of people who indicated that their preferred Δt to switch is $\geq \Delta t_{imin}$.

This parameter defines the modal shift rate; therefore, the values are presented as a percentage. Table 4-6 shows weekdays TTAF values for different ranges defined in the survey questionnaire. Online survey data, isolated in Table 4-7, show slightly higher TTAF values because 511 respondents reported more willingness for modal switch (See the User Satisfaction Analysis). Because the parameter considers both the likelihood of a time advantage and the percentage of respondents willing to switch to transit, in order to result in a high TTAF, a Δt range must be both frequent in the traffic data and great enough to compel drivers to change modes; therefore the range 21-30 most often predicts the greatest modal switch rate. The southbound sign (CMS 122) has the highest TTAF value, meaning more time advantage and the highest possibility of modal shift. In addition, larger TTAF values during Thursdays and Fridays indicate that highway commuters can save even more time by switching to the train on these days, which consequently results in more people diverting from the highway to the stations.

Table 4-6: TTAF values for each sign using station and online survey results

Delta t	CMS 122 US 101 S (San Bruno to San Jose)						CMS 123 US 101 N (Redwood City to SF)						CMS 012 US 101 N (San Mateo to SF)					
	Mon	Tue	Wed	Thu	Fri	Average	Mon	Tue	Wed	Thu	Fri	Average	Mon	Tue	Wed	Thu	Fri	Average
1-5	0.69%	0.56%	0.90%	0.63%	0.22%	0.60%	0.40%	0.41%	0.64%	0.42%	0.46%	0.47%	0.31%	0.76%	0.48%	0.62%	0.54%	0.31%
6-10	0.32%	0.68%	1.15%	0.77%	0.53%	0.69%	0.13%	0.90%	0.35%	0.73%	0.66%	0.56%	0.00%	0.66%	0.23%	0.85%	0.91%	0.30%
11-15	0.59%	0.82%	1.12%	0.91%	0.80%	0.85%	0.00%	0.78%	0.68%	0.49%	0.48%	0.49%	0.00%	1.35%	0.65%	0.89%	0.58%	0.40%
16-20	0.78%	1.64%	2.56%	2.53%	1.98%	1.90%	0.00%	0.71%	2.15%	2.65%	0.35%	1.17%	0.00%	1.53%	2.60%	1.71%	0.67%	0.74%
21-30	3.10%	2.39%	1.72%	4.02%	4.24%	3.09%	0.00%	0.03%	4.07%	4.77%	2.57%	2.29%	0.00%	0.07%	3.30%	5.56%	4.67%	1.56%
31-	1.26%	2.52%	0.38%	4.87%	6.55%	3.12%	0.00%	0.00%	1.53%	4.72%	4.08%	2.07%	0.00%	1.07%	0.00%	0.00%	1.61%	0.31%
Total	6.73%	8.60%	7.83%	13.73%	14.32%	10.24%	0.53%	2.84%	9.42%	13.77%	8.60%	7.03%	0.31%	5.44%	7.27%	9.63%	8.98%	3.61%

Table 4-7: TTAF values for each sign using only online survey results

Delta t	CMS 122 US 101 S (San Bruno to San Jose)						CMS 123 US 101 N (Redwood City to SF)						CMS 012 US 101 N (San Mateo to SF)					
	Mon	Tue	Wed	Thu	Fri	Average	Mon	Tue	Wed	Thu	Fri	Average	Mon	Tue	Wed	Thu	Fri	Average
1-5	0.63%	0.52%	0.83%	0.59%	0.20%	0.56%	0.37%	0.38%	0.59%	0.39%	0.42%	0.43%	0.29%	0.70%	0.45%	0.57%	0.50%	0.50%
6-10	0.44%	0.94%	1.59%	1.06%	0.73%	0.95%	0.19%	1.24%	0.48%	1.02%	0.92%	0.77%	0.00%	0.92%	0.32%	1.19%	1.26%	0.74%
11-15	0.62%	0.85%	1.17%	0.94%	0.84%	0.88%	0.00%	0.81%	0.71%	0.50%	0.50%	0.51%	0.00%	1.40%	0.67%	0.93%	0.60%	0.72%
16-20	0.85%	1.78%	2.78%	2.74%	2.14%	2.06%	0.00%	0.77%	2.34%	2.87%	0.38%	1.27%	0.00%	1.66%	2.82%	1.85%	0.73%	1.41%
21-30	3.61%	2.79%	2.01%	4.69%	4.96%	3.61%	0.00%	0.04%	4.75%	5.57%	3.00%	2.67%	0.00%	0.09%	3.85%	6.49%	5.45%	3.18%
31-	1.26%	2.52%	0.38%	4.87%	6.55%	3.12%	0.00%	0.00%	1.53%	4.72%	4.08%	2.07%	0.00%	1.07%	0.00%	0.00%	1.61%	0.54%
Total	7.41%	9.39%	8.76%	14.90%	15.42%	11.18%	0.55%	3.25%	10.40%	15.06%	9.30%	7.71%	0.29%	5.84%	8.12%	11.03%	10.15%	7.08%

4.3.5. Link Survey Results to Δt Analysis

Table 4-8 summarizes the survey results on the percentage of people who have switched or are willing to switch their travel mode from highway driving to train riding based on the different levels of travel time saving (i.e., Δt) they acquire from the transit-related CMSs. Typical transit users are not included in this analysis. Although the mode switch magnitude is relatively moderate, transit-related CMSs do influence travelers' mode choice, especially when the travel time saving of taking Caltrain is greater than 20 minutes. In addition, the percentage of willingness to switch mode is significantly higher than the percentage of commuters who have currently switched. Overall, the effect is considerably stronger for higher magnitude level of Δt than lower Δt . For instance, the mode changing rate for a situation with more than 20 minutes time saving in transit is about 7.9% and 21.2% for the current and future conditions, respectively; while lower Δt (<15 minutes) only contributes an additional 1.6%, and 3.8% of travelers who have switched or are willing to switch their travel mode.

Table 4-8: Survey result on modal change rate under different Δt

Δt (in minutes)		>0	>5	>10	>15	>20	>30
Percentage (%)	Have Switched Mode	0.0	1.6	1.6	4.8	7.9	9.5
	Willing to Switch Mode	1.9	1.9	3.8	11.5	21.2	30.8

Combining the survey results with the percentage of occurrence time of positive Δt during the designed operating time (Table 4-7) determines the existing and potential mode switch rates due to the information disseminated via transit-related CMSs. The results, shown in Table 4-9, indicated that, based on the survey data, current mode switch rate due to transit-related CMSs is fairly low; however, there are considerably more highway travelers who are willing to switch modes in the future.

Table 4-9: Existing and potential mode switch rates during transit-related CMS operating time

Δt (in minutes)	Have Switched Mode			Willing to Switch Mode		
	CMS122	CMS123	CMS012	CMS122	CMS123	CMS012
>30	0.37%	0.30%	0.07%	1.20%	0.98%	0.22%
>20	0.79%	0.69%	0.51%	2.09%	1.84%	1.35%
>15	0.76%	0.63%	0.52%	1.85%	1.52%	1.26%
>10	0.38%	0.29%	0.28%	0.91%	0.71%	0.68%
>5	0.57%	0.49%	0.45%	0.69%	0.59%	0.54%
>0	0.00%	0.00%	0.00%	0.96%	0.85%	0.82%

The typical hourly traffic flow during transit-related CMS operating time has also been examined. By multiplying the existing and potential mode switch rates and hourly traffic flow for each sign, the number of possible mode switching travelers per hour is calculated. The results are presented in Table 4-10. The results show that the number of travelers who switch their travel mode due to the signs increases with the magnitude of Δt . Derived from the survey results, the potential number of switching travelers in the future is notably higher than the current situation. Furthermore, it is believed that the mode switch rate, as well as number of mode switching travelers, will continue increasing if there is

worsening traffic congestion on the highway, with more awareness of the transit-related CMSs, and if there are more available and convenient travel alternatives.

Table 4-10: Hourly existing and potential mode switch traffic during transit-related CMS operating time

Δt (in minutes)	Have Switched Mode			Willing to Switch Mode		
	CMS122	CMS123	CMS012	CMS122	CMS123	CMS012
>30	23	15	4	74	48	14
>20	48	34	34	129	90	90
>15	47	31	35	113	74	84
>10	23	14	19	56	35	46
>5	35	24	30	42	29	36
>0	0	0	0	59	41	54

Next, the analysis specifically looks at the distribution of Δt values greater than 15 minutes. This focused evaluation is conducted because, based on the survey results, CMSs displaying such information are expected to induce more travel mode switch from highway driving to transit, possibly reducing traffic congestion on highways. As shown in Figure 4-14 to Figure 4-16, it is observed that larger Δt (> 15 minutes) occur more frequently in the case of longer travel distances for both morning and afternoon peaks. In the morning peaks, the frequency of Δt greater than 15 minutes is relatively low and only exists in a narrow time window. Moreover, Δt is never more than 30 minutes in the morning peaks. However, on the contrary, there is a significant amount of time and frequency of Δt greater than 15 minutes in the afternoon peaks. It is reasonable to conclude that a stronger mode switching effect of transit-related CMSs can be expected in the afternoon peak hours.

4.4. Summary of Results

In summary, the analysis of transit-related CMS operating performance shows that:

- The total percentage of operating time that the CMSs display travel information (i.e., when Δt is greater than zero) are 32.7%, 23.9%, and 18.7% for CMS122, CMS123, and CMS012, respectively. One of the possible reasons that CMS122 has a higher message display rate, especially in the afternoon peak hours, is that it corresponds to a southbound segment on US-101 with a higher VMT than the northbound segments of US-101 corresponding to CMS123 and CMS012. Another possible reason is the higher delay found along the southbound segment of US-101 corresponding to CMS122 than that of the northbound segment on US-101 corresponding to CMS123 and CMS012. Nevertheless, the message display rates are all considerably effective to induce potential travel mode changes.
- When looking at specific hours of a day, the time interval of displaying transit information in the morning tends to start later than the operating schedule of the signs, which usually reaches a significant display rate after 7:00 am to 7:30 am. However, the display interval in the afternoon

is active during the entire operating interval. This indicates that reducing the operating time in the early morning might increase the overall operating performance of transit-related CMSs while the afternoon operating schedule is appropriate and should not be altered.

- Overall, traffic conditions result in fewer occurrences of Δt with a higher magnitude compared to a low or moderate Δt value ($\Delta t \leq 15$ minutes). However, the condition of heavy traffic congestion occurred more frequently in the second half of the week, which implies that the effect of transit-related CMSs might induce more frequent mode change from highway driving to riding the train in the latter half of the week than in the beginning of the week. To be more specific, when transit-related CMSs are operating, commuters can benefit from paying more attention to the morning peak hours on Monday, Tuesday, and Wednesday and to the afternoon peak hours on Thursday and Friday.
- Positive Δt occurs in a wider time window with longer travel distances in the morning peaks, while in the afternoon peak hours, positive Δt has a narrower distribution but higher frequency as the travel distance increases. This observation indicates that traffic congestion in the afternoon peak hours is more concentrated or severe, especially in the case of greater travel distance. Therefore, it is believed that the mode switching effect of transit-related CMSs is stronger in the afternoon peak hours.
- According to the survey results, transit-related CMSs do affect travels' mode choice, especially when the travel time saving of taking Caltrain is greater than 15 minutes. The significance of this effect will increase if highway traffic congestion worsens in the future, commuters become more aware of the transit-related CMSs, and more convenient travel alternatives are made available.

5. Ridership Count Analysis

Train ridership is affected by many factors under many kinds of circumstance. For example, changes in gas price can significantly influence people's choices on public transportation vs. auto travel. Nevertheless, it is worthwhile to attempt linking train ridership data to the effect of transit-related CMSs, since ridership changes in Caltrain (i.e., Baby Bullet trains) could be a direct performance measure of the effectiveness of transit-related signs.

5.1. Data Collection

In order to identify if there were any increase in ridership associated with the operation of the transit-related signs, the team explored available ridership data along the Caltrain corridor between San Jose and San Francisco. However, Caltrain typically collects ridership data during the month of February each year, which significantly constrains this analysis since detailed ridership data before and after the CMSs took effect, especially during the designed CMS operating time, are not available. Therefore, the team conducted a descriptive analysis using the most available ridership count data. In the future, this ridership count analysis can be extended by collecting more detailed ridership count data while trying to control different factors affecting ridership changes.

5.2. Results

By reviewing Caltrain 2007 and 2008 ridership data, major findings related to our study are generated as follows:

- Compared to February 2007, the total average weekday ridership (AWR) in February 2008 has increased 9.3 percent. At the same time, Caltrain service has operated in a "steady state" (no service or schedule changes) from 2007 to 2008. These observations imply that the ridership increase is induced by outside factors and not Caltrain operations. This supports the assumption that implementing transit-related CMSs may result in an increase of train ridership. Figure 5-1 illustrates this comparison in Caltrain ridership.

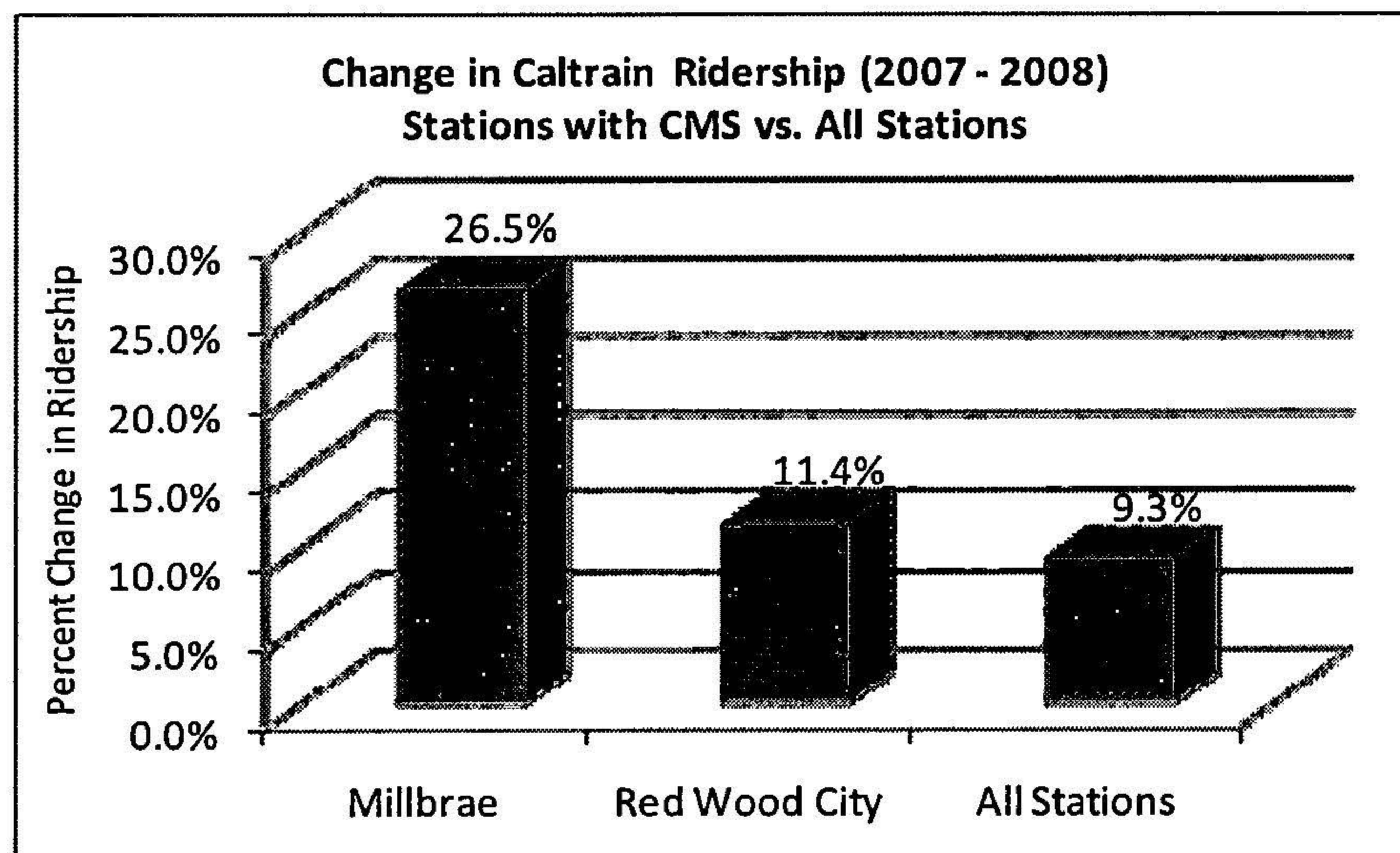


Figure 5-1: Caltrain ridership comparison between stations with CMS and all stations

- Both Millbrae and Redwood City are among the stations with the greatest percent increase in ridership. Millbrae station has a 26.5 percent ridership increase, ranked as 2nd; while Redwood City station has a 11.4 percent ridership increase, ranked as 6th. A portion of the increase in ridership at Millbrae is due to the re-routing of South San Francisco shuttle. In general, these significant increases match with existing locations of transit-related signs.
- Within peak hours (start of service – 9 am in the morning and 3 – 7 pm in the afternoon), an overall increase in ridership for all types of service is found from 2007 to 2008. Baby Bullet trains have a 12.9 percent ridership increase rate, which is higher than other services offered during peak hours as well as overall AWR for whole day services. In other words, there are more people riding the train during peak hours, possibly due to the operation of the transit-related CMSs during these hours.
- The February ridership data also shows that Baby Bullet trains as well as some other peak hour trains have the highest loads, which can reach approximately 90 percent of seated capacity. This is about a 10 percent increase from 2007. Therefore, the number of riders would be reaching or exceeding seated capacity, especially for peak months, which is an important aspect to consider in further development and deployment of transit-related CMSs.
- Caltrain services typically have two types of commute patterns: the traditional peak (northbound morning and southbound evening) and the reverse peak (southbound morning and northbound evening) commute. Both commute markets showed growth from 2007 to 2008, with the reverse peak market experiencing stronger growth than the traditional peak. The ratio of those traveling north in the morning to those traveling south in the morning

continues to remain at approximately 60/40. This might be another piece of useful information for further improvements to transit-related CMSs.

6. Parking Count Analysis

Parking availability at the train station is one of the crucial concerns for people using public transportation, especially for those considering shifting their travel mode from driving a personal vehicle. Therefore, when analyzing the effectiveness of the transit-related CMSs, it is necessary to evaluate the Caltrain parking facilities and parking capacity/occupancy.

6.1. Data Collection

In search of possible changes in parking count due to the transit-related signs, the team contacted Caltrain, BART, and Caltrans District 4 for all available parking count data before and after the CMSs took effect. Although there is no detailed parking count data corresponding to the designed CMS operating time, a descriptive analysis is performed on the most available data. For each transit-related CMS, the Transit Time Advantage Factor (TTAF) defined in the System Operating Performance Analysis is linked with the corresponding daily parking counts. Summary results and findings are presented in the section.

6.2. Results

By examining the available parking counts data for the Millbrae and Redwood City stations, the following facts and issues related to this study were found:

- Overall, the parking occupancy has increased from 2007 to 2008 for both the Millbrae and Redwood City Caltrain stations, although Redwood City experienced a more significant increase as compared to Millbrae (see Figure 6-1 and Figure 6-2 for more details). One possible reason is that parking at Millbrae tends to be more flexible because of the nearby BART parking facilities.

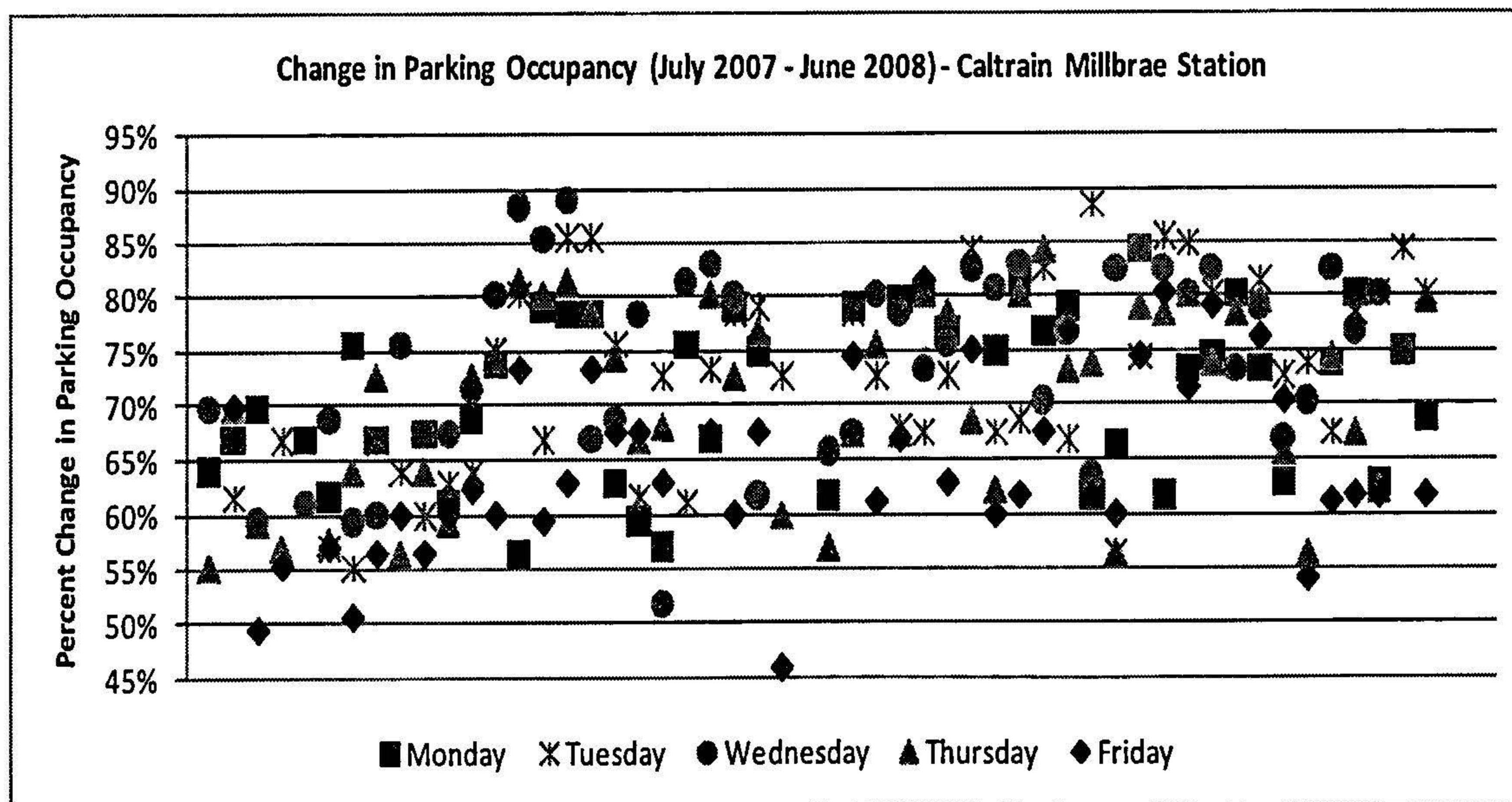


Figure 6-1: Change in parking occupancy – Caltrain Millbrae Station

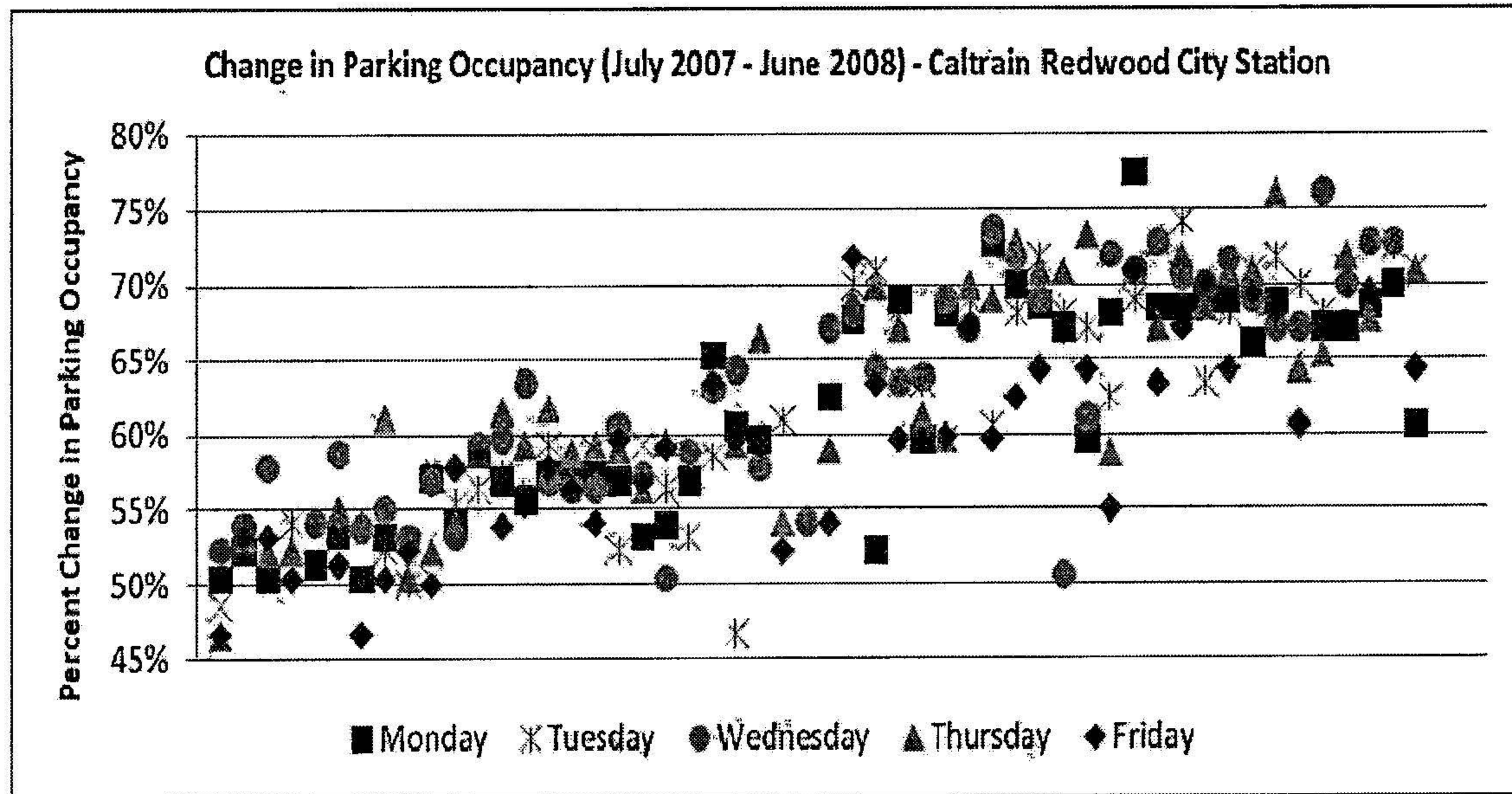


Figure 6-2: Change in parking occupancy – Caltrain Redwood City Station

- For different weekdays, Millbrae station has more variation in parking occupancy, while Redwood City shows a more stable trend across different weekdays.
- The parking capacities are 172 and 536 for Millbrae and Redwood City, respectively. Both stations appear to be able to accommodate the current parking loads. However, since the occupied parking spaces are reaching 70-80 percent of the capacity, and are occasionally even higher, future improvements to transit-related signs need to consider this issue.
- Additionally, the daily parking occupancy and TTAF are compared, as shown in Figure 6-3 to Figure 6-5. The dates selected in this comparison are the same as Table 4-1 in the System Operating Performance Analysis. TTAF of CMS122 and CMS012 is compared with the parking occupancy for the Millbrae station, and TTAF of CMS123 is compared with the Redwood City station. Based on these Figures, it is difficult to tell if the parking occupancy and TTAF have a positive relationship. The correlation coefficients are also calculated to identify the relationship between parking occupancy and TTAF in more detail; however, no statistically significant positive relationship is found for any of the three transit-related signs.

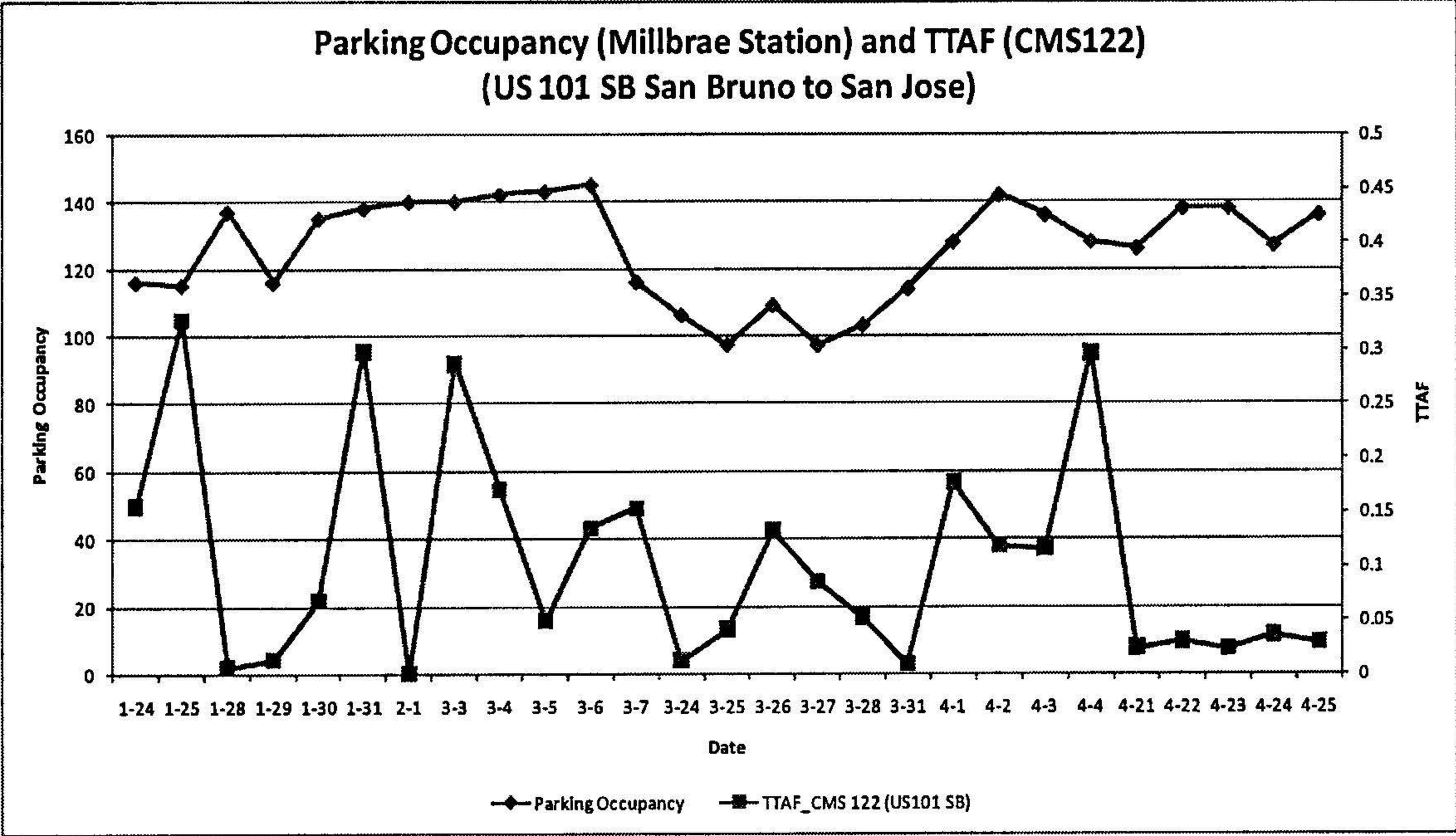


Figure 6-3: Parking occupancy (Millbrae Station) and TTAF (CMS122)

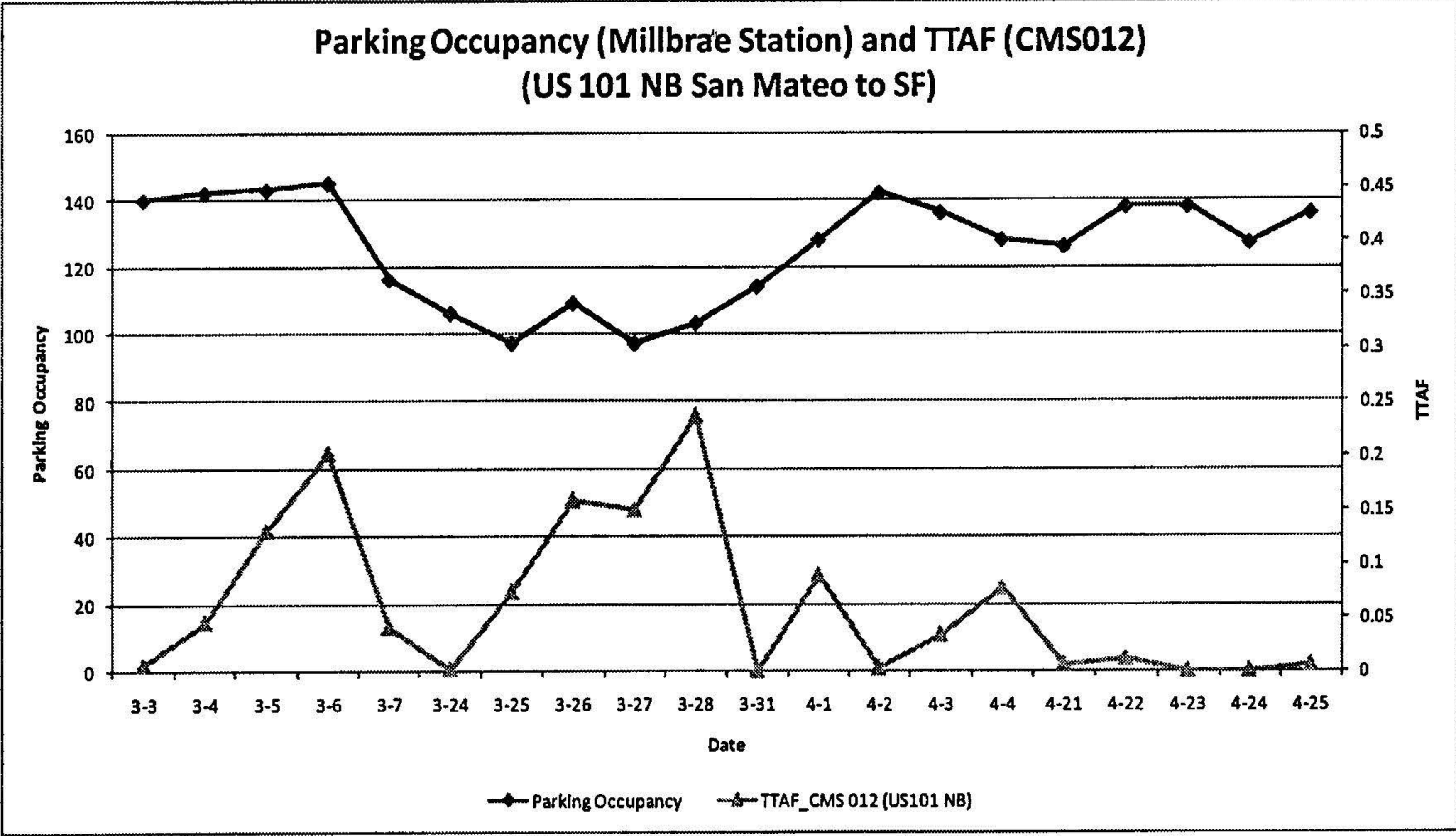


Figure 6-4: Parking occupancy (Millbrae Station) and TTAF (CMS012)

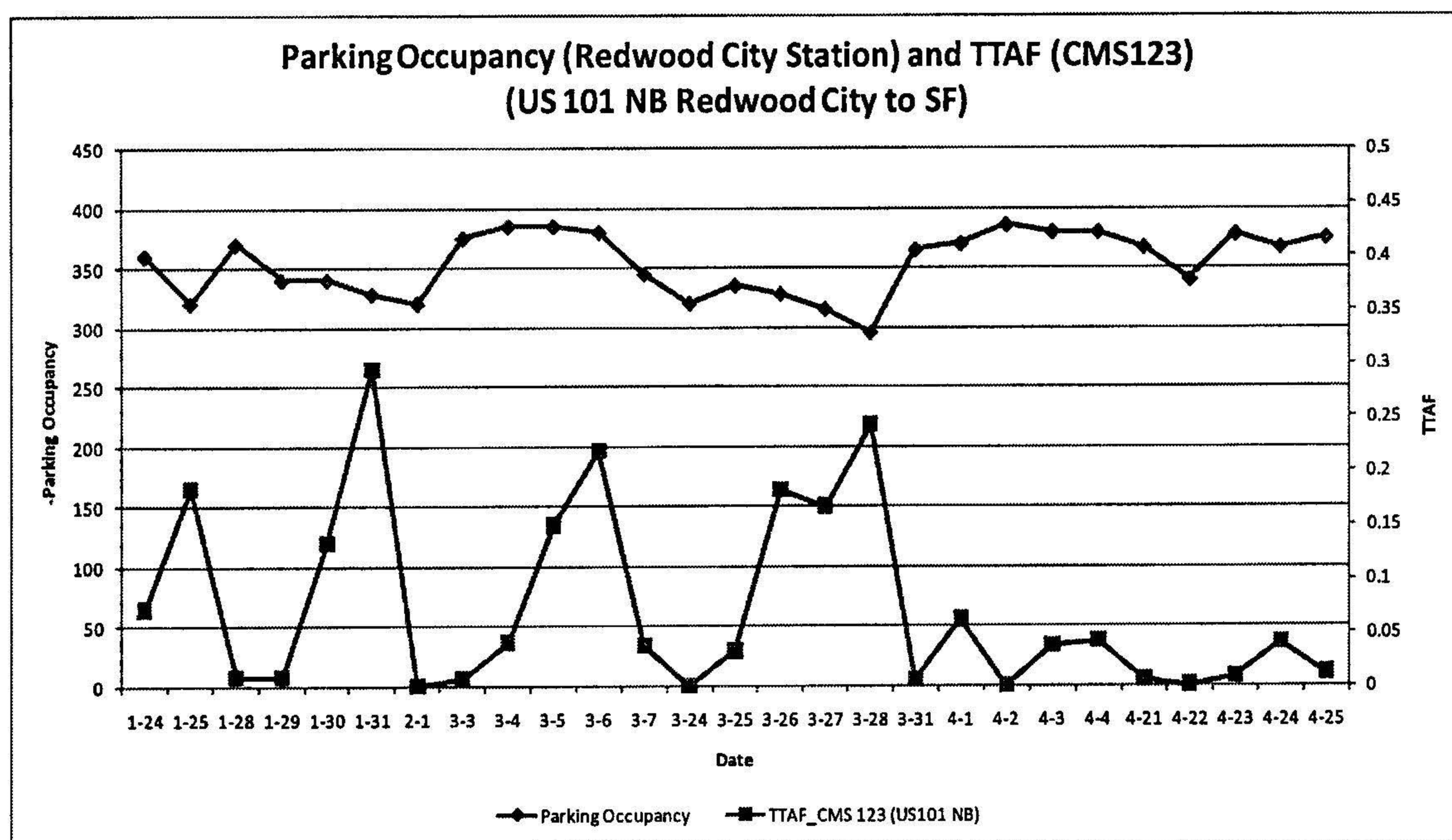


Figure 6-5: Parking occupancy (Redwood City Station) and TTAF (CMS123)

In summary, parking occupancy is affected by many aspects and conditions, such as existing parking capacity, gas price, service level of public transportation itself, etc. Although a general increasing pattern is found from both Caltrain stations, it is not feasible to determine how much is due to the transit-related signs based on current available data. In the future, this part of analysis can be extended by collecting more detailed parking counts and traffic data while possibly controlling for different factors affecting parking count changes.

7. Conclusion

This report describes the efforts of the California Center for Innovative Transportation (CCIT), in collaboration with California Department of Transportation (Caltrans) District 4, to deploy three Changeable Message Signs displaying transit information in addition to highway travel time. Three transit-related CMSs were implemented along the US 101 corridor, displaying travel time and schedule information for the Caltrain Baby Bullet commuter line departing from the Millbrae and Redwood City stations. The signs were active for a limited period during the peak commute times and only displayed the travel time comparison between the train and driving when transit had an advantage.

To evaluate the design and success of the project, the team conducted both qualitative and quantitative analyses. The qualitative analysis consists of a user satisfaction survey distributed through two channels: a paper questionnaire at two Caltrain stations and an online questionnaire on the Bay Area 511.org website. The quantitative analysis compared train and highway travel time to determine the possible time savings obtained by riding the Baby Bullet Caltrain service and to estimate the potential modal shift resulting from the information displayed by the transit-related CMSs. In addition, ridership and parking counts were analyzed to identify possible relationships with the operation period of the signs.

The user satisfaction analysis indicated positive support for the transit-related CMSs and the general objective of sharing travel information with commuters. Overall, 362 paper surveys (238 distributed at the Millbrae station; 124 distributed at the Redwood City station) and 117 online responses were analyzed. Most commuters, particularly those traveling daily along the US-101 corridor, reported that they had seen the transit signs and trust the accuracy of the information displayed. While a small percentage of respondents said they had changed modes to taking the train due to the travel time information (approximately 5%), an even greater percentage (approximately 41%) indicated that they would consider switching modes in the future, a compelling show of support for public dissemination of transit information. However, respondents named several barriers to taking the train, such as distance from the train station to their final destination, convenience, and parking availability.

The system operating performance analysis showed that the transit signs were operating effectively and that there often is a significant advantage in taking the train. Overall, the CMSs displayed the time savings message 32.7% of time during peak hours for the southbound direction, 23.9% for the northbound direction near Redwood City, and 18.7% for the northbound direction near Millbrae station. In general, traffic in the afternoon peak hours proved more severe, suggesting a greater potential transit advantage than during the morning commute. However, this may diminish the mode switching effect since commuters may be less likely to leave their car near their workplace to make the return trip by train. Nevertheless, when combined with the reported time savings that would induce a mode switch from the survey results, the time advantage analysis suggests the potential for a significant change in travel behavior due to the transit-related CMSs.

To determine a relationship between ridership and the transit-related CMSs, ridership and station parking data were compared with the operating times of the CMSs. While Caltrain ridership has increased steadily over the past year, the two focus stations for the CMS implementation, Redwood City and Millbrae, have experienced some of the highest increases. Parking availability, an important factor in commuter decision-making as reported in the survey, was found to be sufficient but nearing occupancy levels greater than 85%. To extend this study and to draw further conclusions regarding a relationship between these counts and the times when the CMSs are active, a more detailed level of data (e.g., counts per minute) must be collected and analyzed.

Integrating transit travel time with highway CMSs is an exciting next step in the dissemination of real-time travel information. By comparing highway driving with train travel times, transit-related CMSs help commuters make informed decisions regarding their travel behavior. On a day-to-day basis, these signs inform drivers of a faster option when faced with heavy congestion or a severe traffic incident. Under these circumstances, encouraging some drivers to change modes to a convenient commuter train will reduce the lingering effects of a traffic bottleneck. Over time, transit-related CMSs could increase awareness of transit options and reinforce positive perceptions of transit services by displaying transit's time advantage. Overall, these effects could lead to significant time savings, increased throughput, reduced fuel consumption, and lower emissions for the areas served by transit-related CMSs.

8. Acknowledgements

The project team wishes to thank the many contributors to this project. Success was only made possible by the active participation of all the stockholders. With great apologies to anyone who may be forgotten, the team particularly recognized the following individuals:

Ron Moriguchi, Division of Project Management South, California Department of Transportation - District 4

Becky Frank, Office of Transit and Community Planning, California Department of Transportation - District 4

David M Cortez, Office of Transit and Community Planning, California Department of Transportation - District 4

Alan Chow, Traffic Systems, California Department of Transportation - District 4

Charles Price, Electrical Systems, California Department of Transportation - District 4

Robert Tam, Caltrain

I.1. Methodology and Data

In order to determine whether the proposed survey time was feasible, the team utilized historical traffic data archived by the Freeway Performance Measurement System (PeMS) to test whether there are any remarkable variances in traffic attributes between the proposed survey time (July-Aug-Sep) and other months. Traffic data from the year of 2007 were analyzed in the study. To correspond to the three transit-related CMSs, three highway segments on US-101 were selected:

- Segment 1 – US-101S, from SM Terminal Access Rd, San Mateo (CAPM⁴: 18.75, AbsPM⁵: 420.974) to Airport Pkwy, San Jose (CAPM: 39.655, AbsPM: 389.329) – corresponding to CMS 122
- Segment 2 – US-101N, from Woodside/Seaport, Redwood City (CAPM: 5.5, AbsPM: 407.687) to I-80E, San Francisco (CAPM: R4.241, AbsPM: 432.535) – corresponding to CMS 123
- Segment 3 – US-101N, from Broadway, San Mateo (CAPM: 16.75, AbsPM: 418.937) to I-80E, San Francisco (CAPM: R4.241, AbsPM: 432.535) – corresponding to CMS 012

Three types of metrics were used in the seasonal traffic data analysis: Vehicle Miles Traveled (VMT)⁶, Vehicle Hours Traveled (VHT)⁷, and delay.

I.2. Summary Results

I.2.1. For Segment 1 (CMS122):

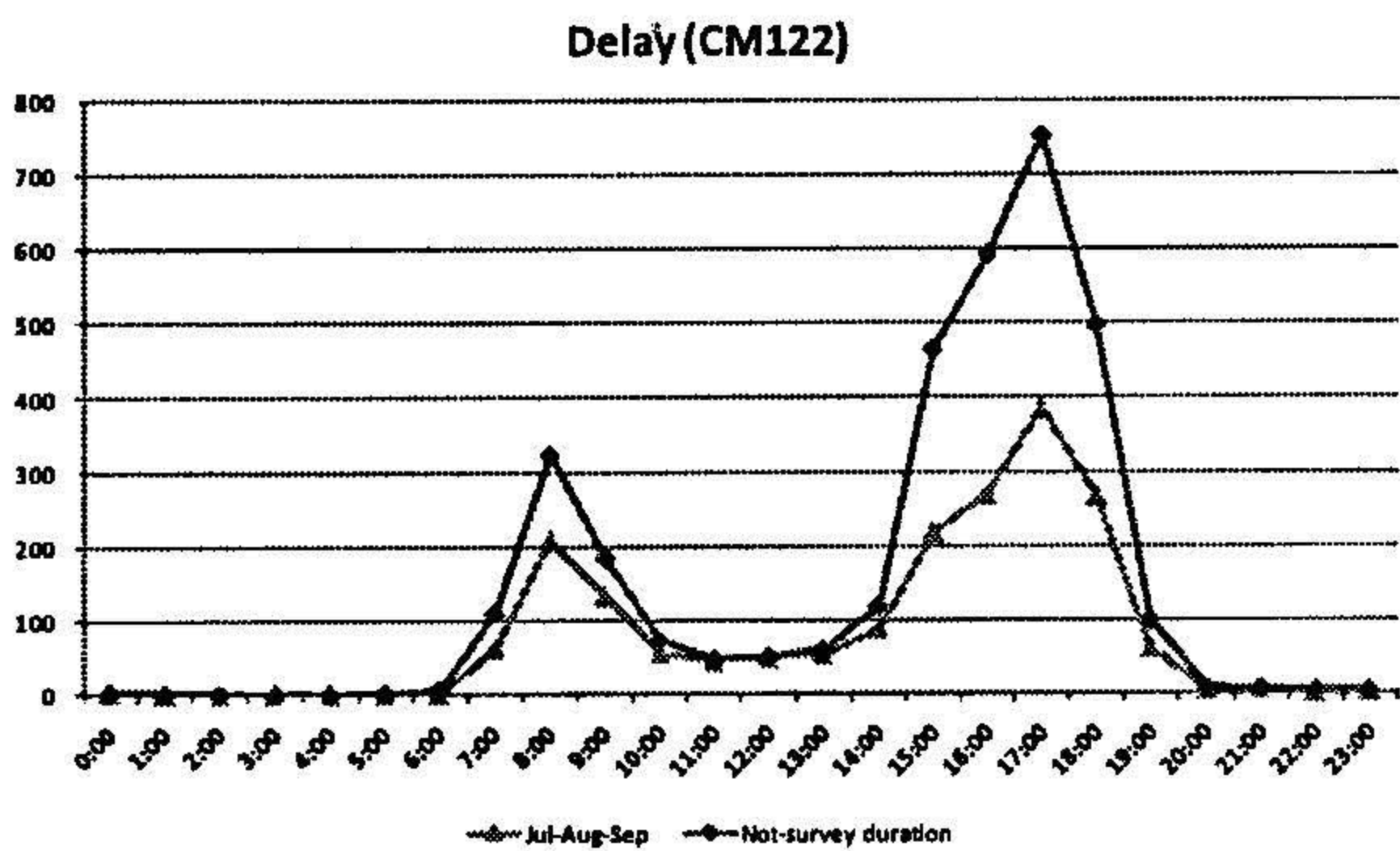
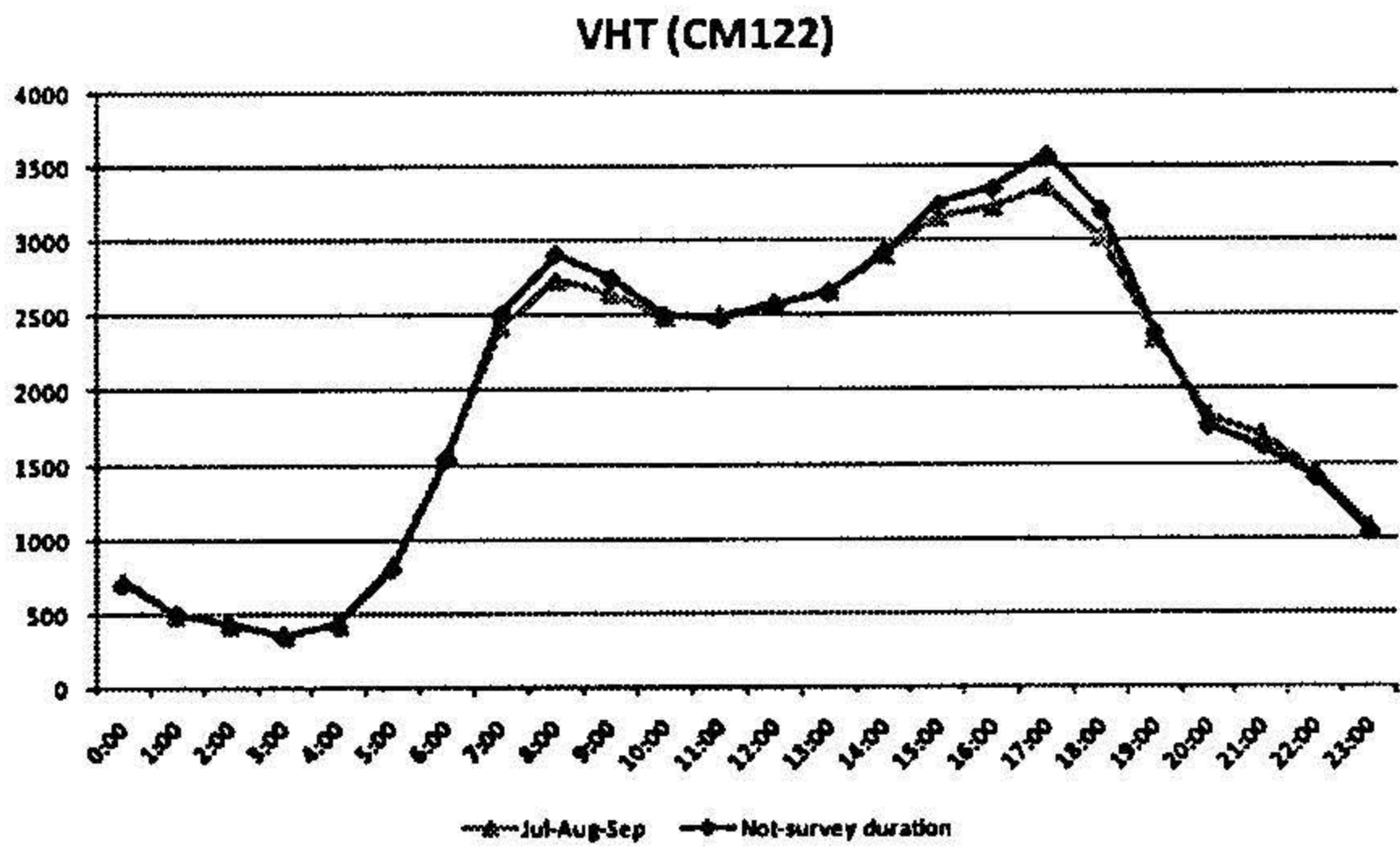
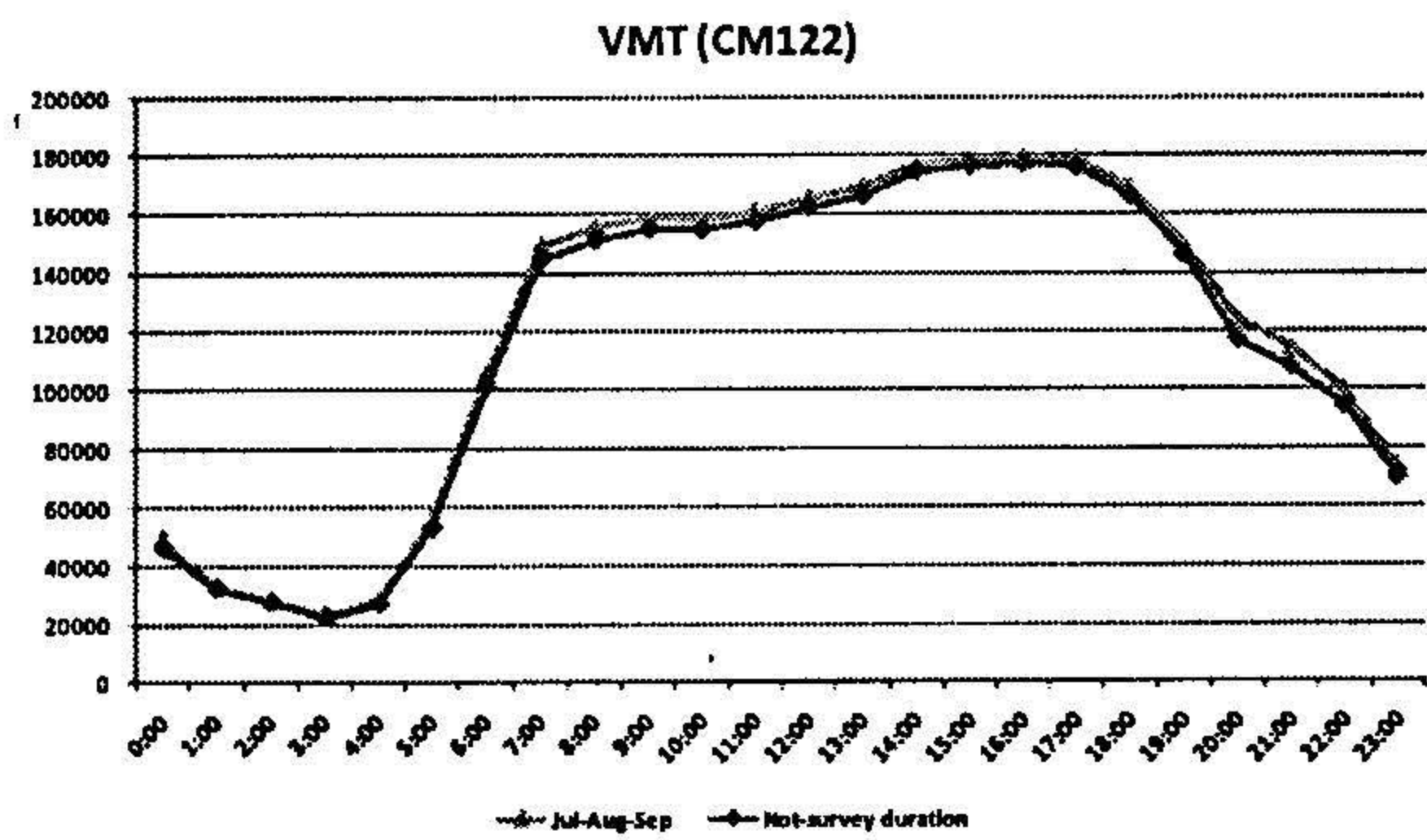
- Daily traffic profile

⁴ CAPM refers to jurisdictional postmile, which is assigned to physical boxes and geometric features on a freeway when the freeway is built.

⁵ AbsPM is the actual centerline distance down the freeway from the district boundary.

⁶ VMT is a good indicator showing how many vehicle miles were traveled within a given section. An hourly VMT is almost equal to the average flow multiplied by average speed and time span (1 hour).

⁷ VHT indicates how much total time vehicles spent within a given section.



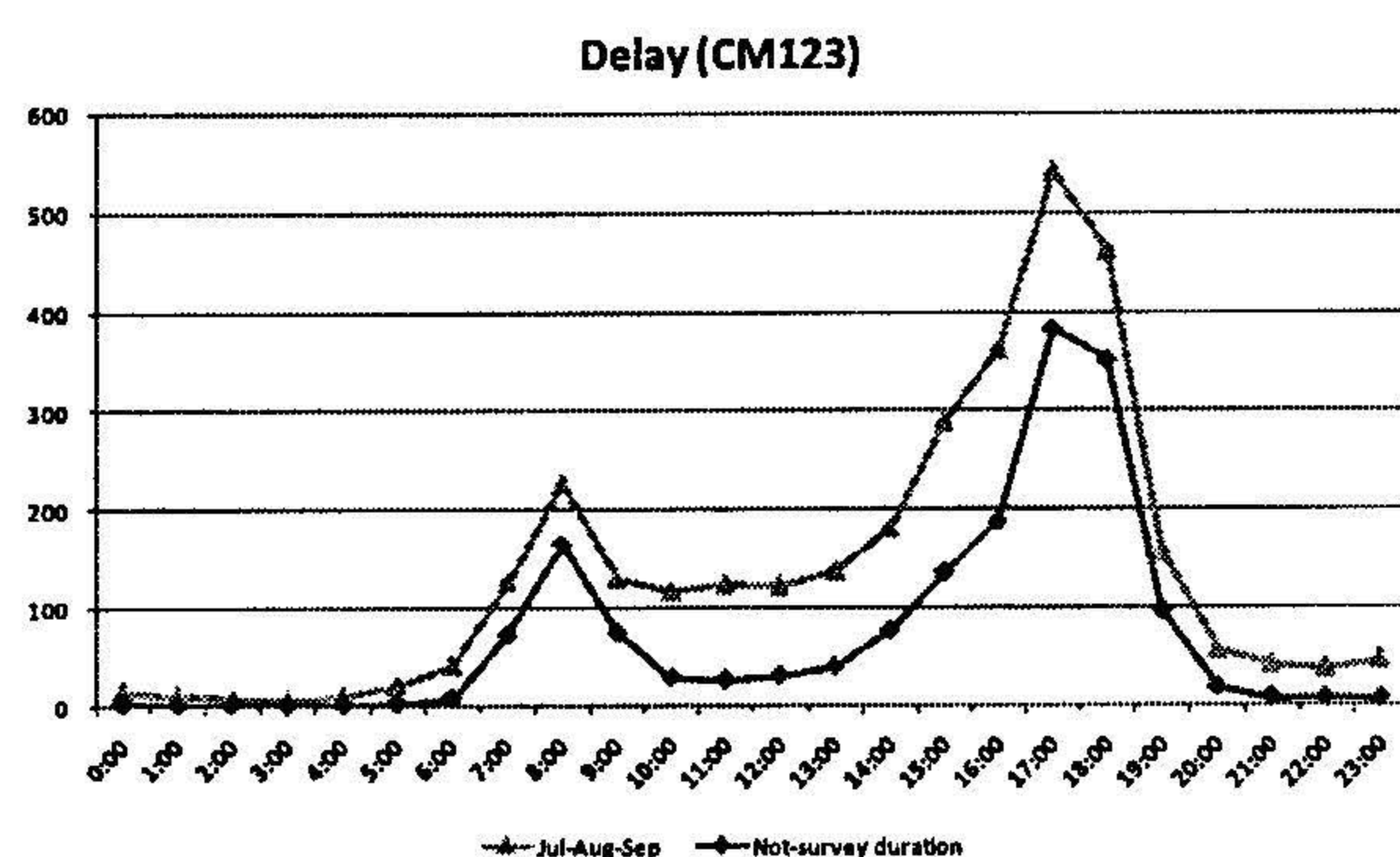
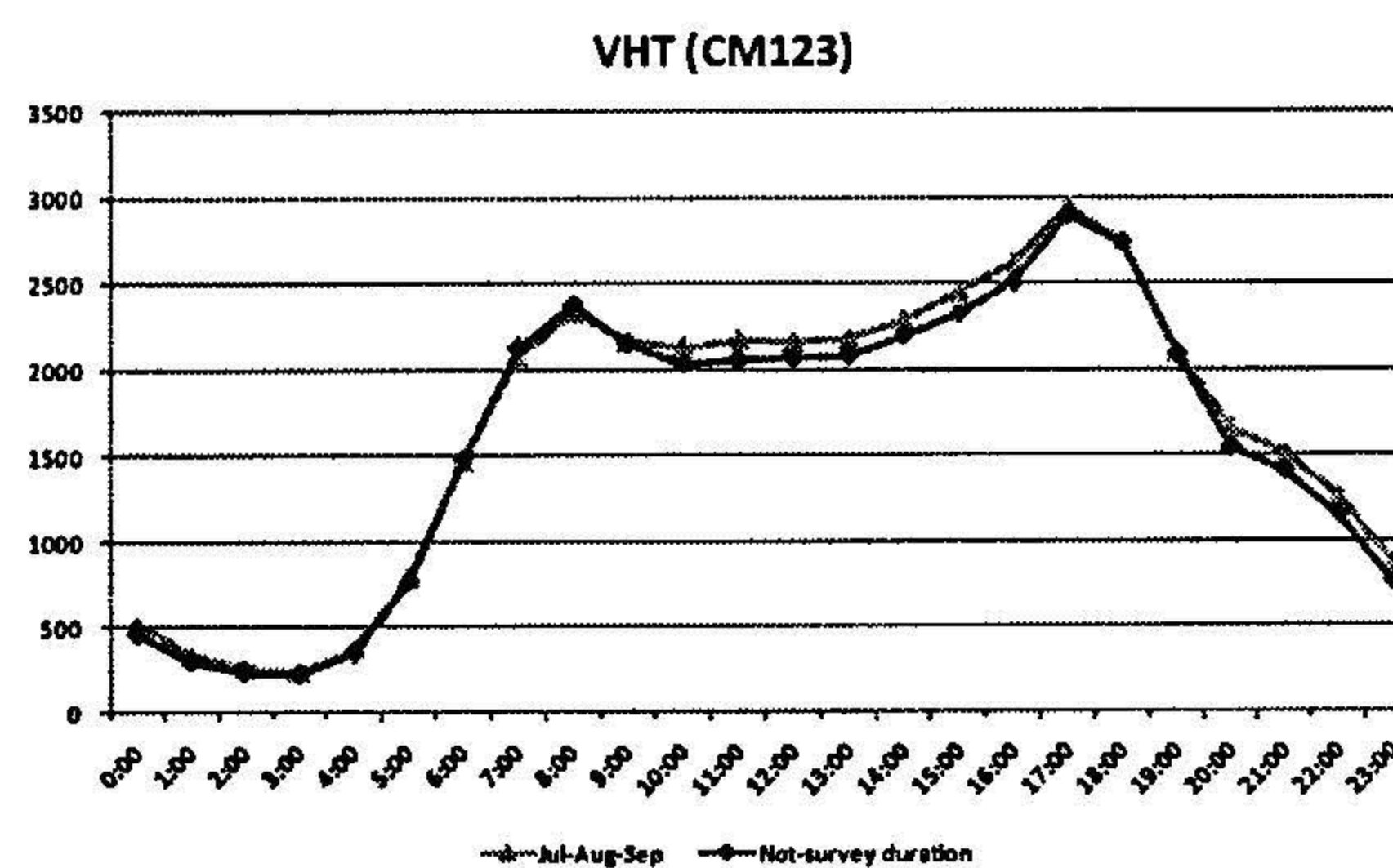
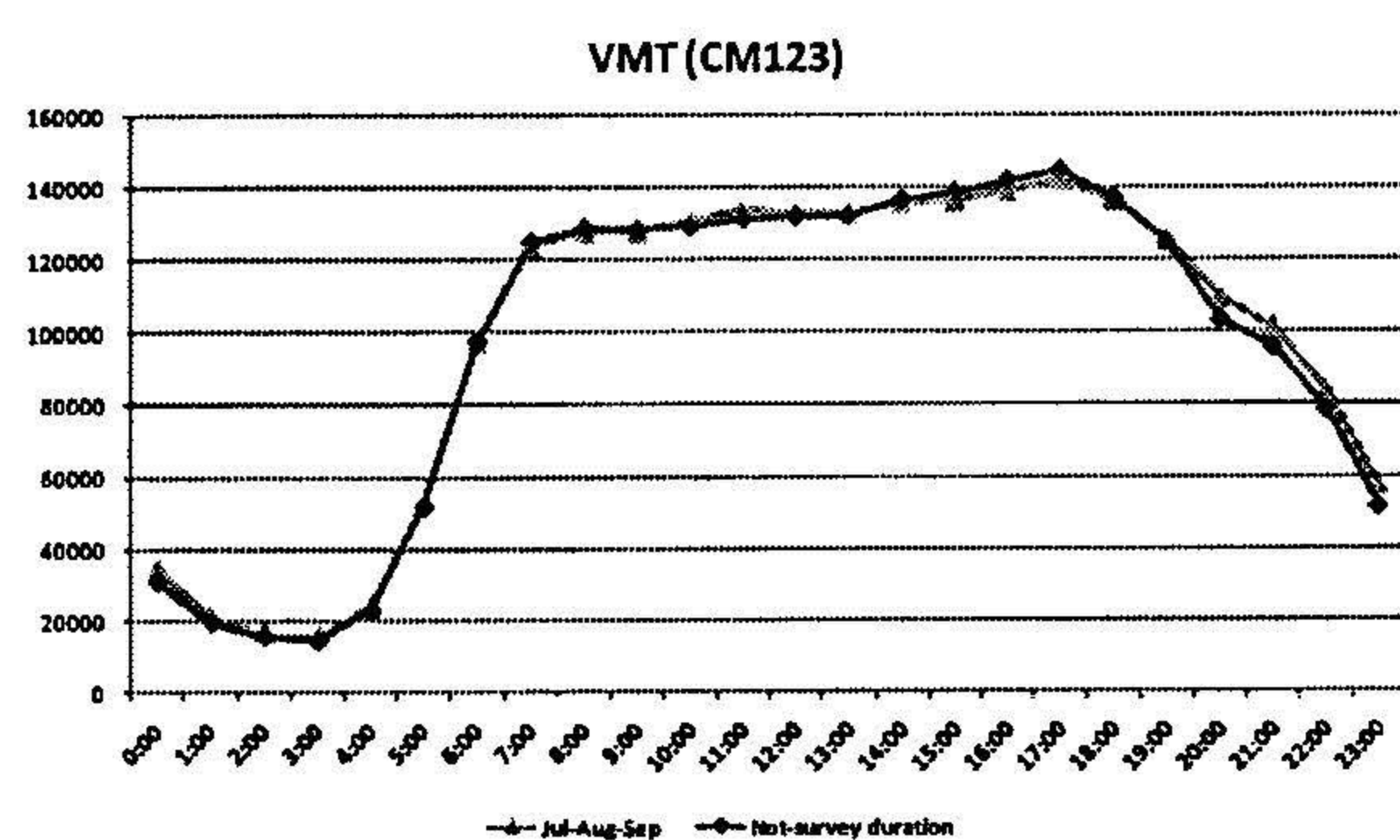
■ Variance

Measure	Season	Morning Peak	Afternoon Peak
VMT	Annual Avg. (a)	137,910	173,898
	Survey Time (b)	141,777	175,918
	Difference (c=b-a)	3,867	2,020
	% Change (c/a)	2.80%	1.16%
VHT	Annual Avg. (a)	2,426	3,339
	Survey Time (b)	2,337	3,185
	Difference (c=b-a)	(89)	(154)
	% Change (c/a)	-3.69%	-4.62%
Delay	Annual Avg. (a)	156	577
	Survey Time (b)	100	285
	Difference (c=b-a)	(56)	(292)
	% Change (c/a)	-35.78%	-50.65%

Notes: Survey time refers to July, August, and September; annual average excludes the survey time.

I.2.2. For Segment 2 (CMS123)

■ Daily traffic profile



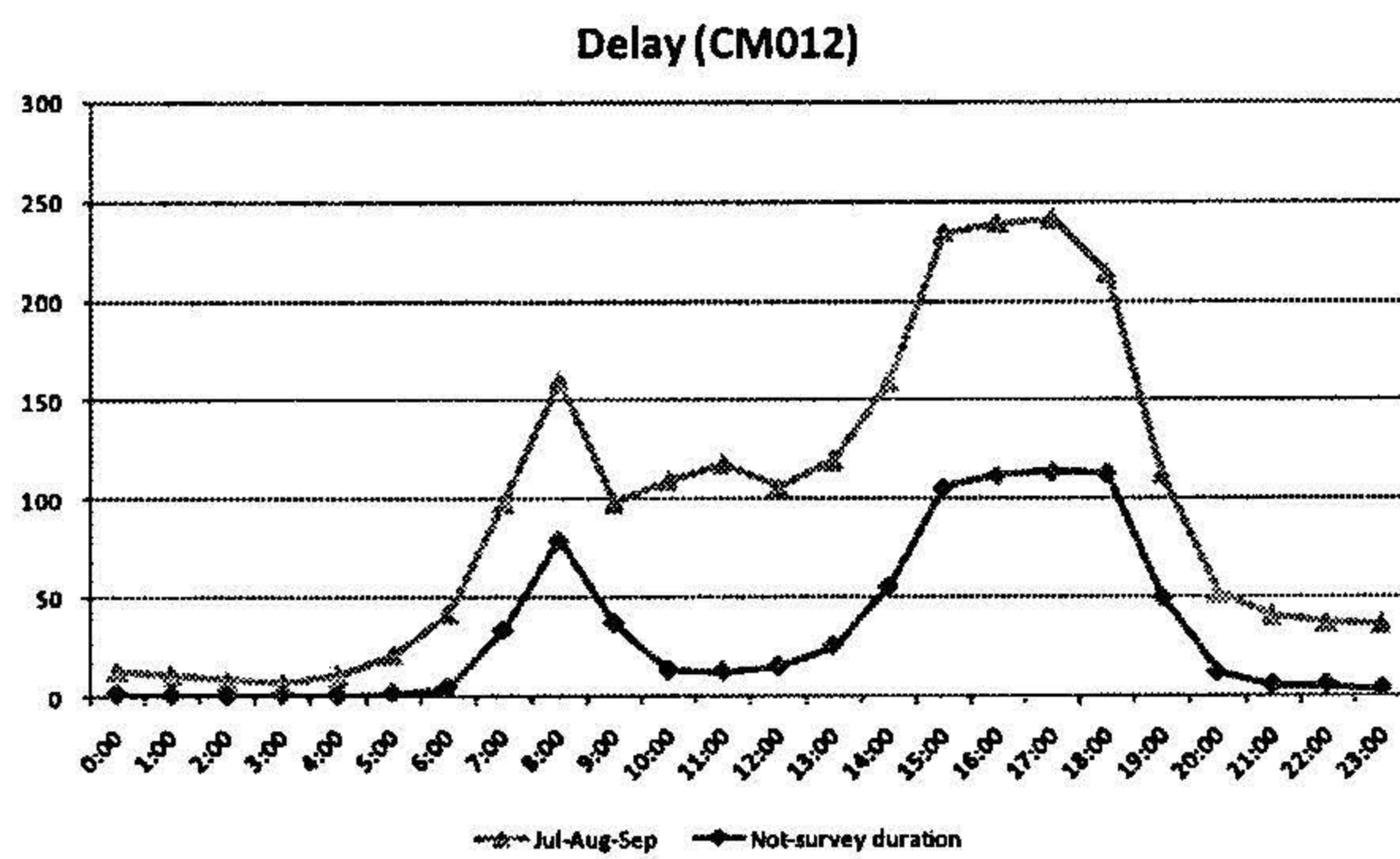
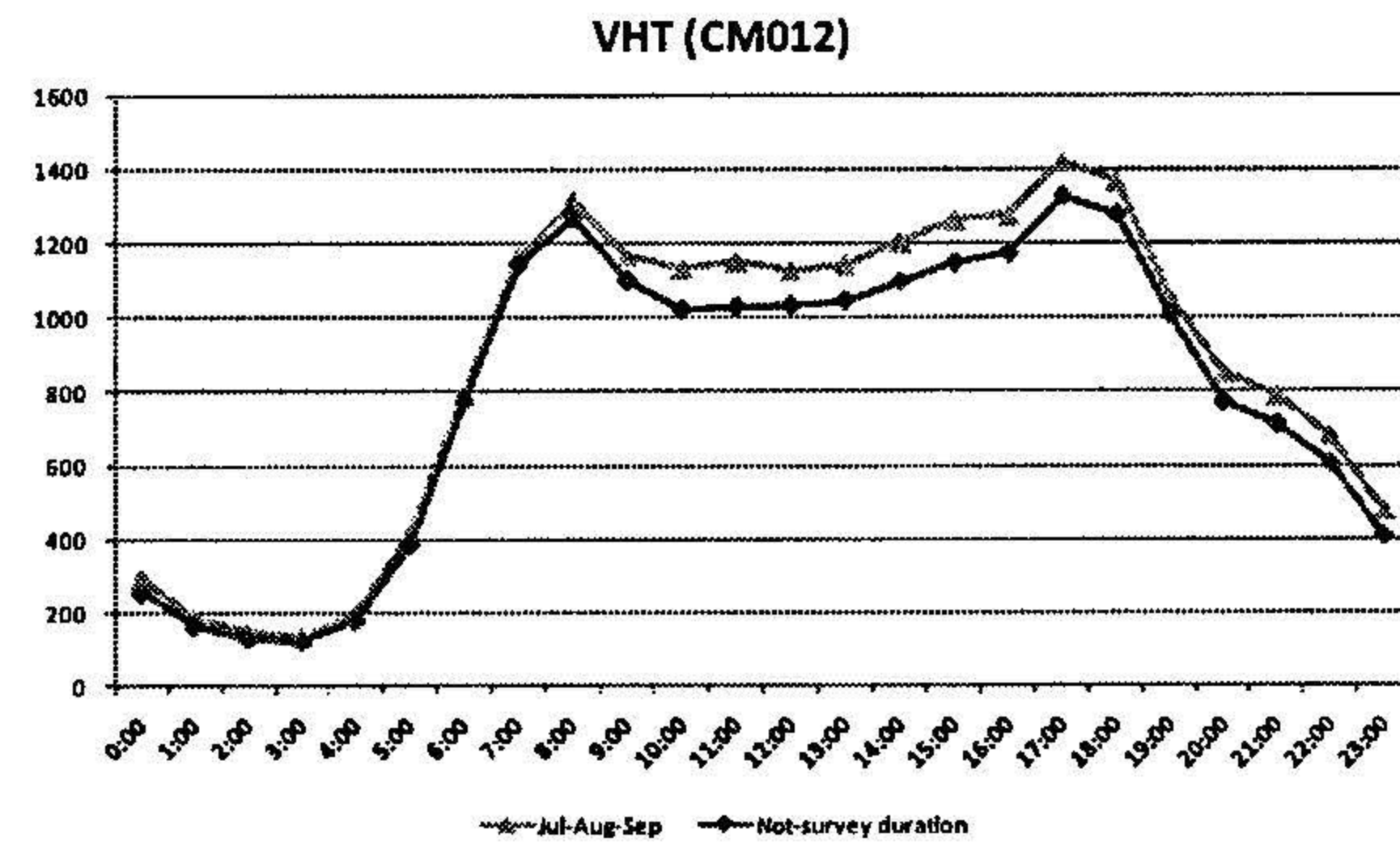
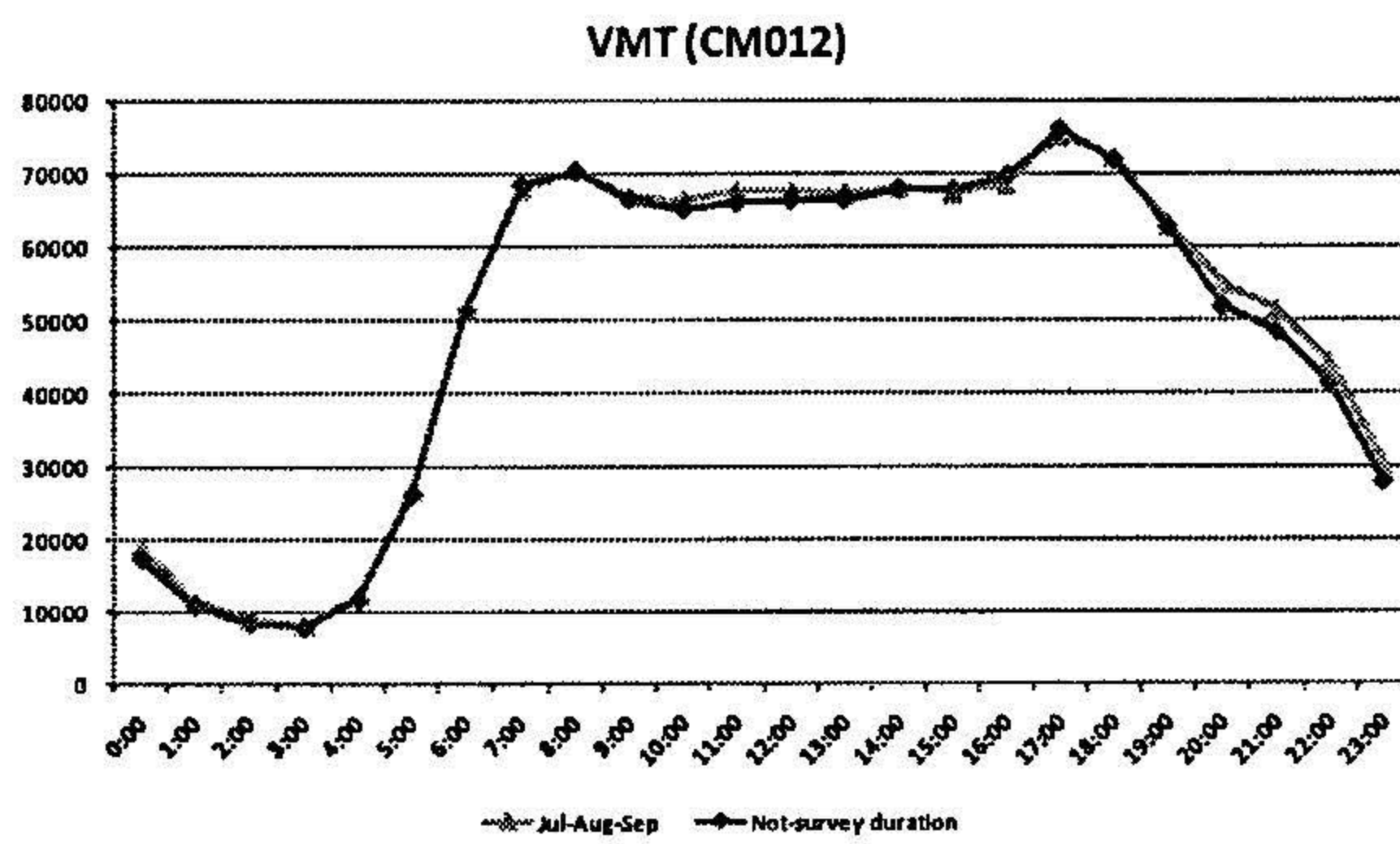
■ Variance

Measure	Season	Morning Peak	Afternoon Peak
VMT	Annual Avg. (a)	119,862	140,493
	Survey Time (b)	118,827	138,168
	Difference (c=b-a)	(1,035)	(2,325)
	% Change (c/a)	-0.86%	-1.66%
VHT	Annual Avg. (a)	2,031	2,608
	Survey Time (b)	2,010	2,684
	Difference (c=b-a)	(20)	77
	% Change (c/a)	-1.00%	2.93%
Delay	Annual Avg. (a)	80	264
	Survey Time (b)	131	413
	Difference (c=b-a)	51	149
	% Change (c/a)	63.58%	56.22%

Notes: Survey time refers to July, August, and September; annual average excludes the survey time.

I.2.3. For Segment 3 (CMS012)

■ Daily traffic profile



■ Variance

Measure	Season	Morning Peak	Afternoon Peak
VMT	Annual Avg. (a)	64,102	71,333
	Survey Time (b)	64,016	70,753
	Difference (c=b-a)	(86)	(580)
	% Change (c/a)	-0.13%	-0.81%
VHT	Annual Avg. (a)	1,070	1,231
	Survey Time (b)	1,108	1,329
	Difference (c=b-a)	38	98
	% Change (c/a)	3.57%	7.98%
Delay	Annual Avg. (a)	39	111
	Survey Time (b)	100	232
	Difference (c=b-a)	61	121
	% Change (c/a)	157.57%	108.72%

Notes: Survey time refers to July, August, and September; annual average excludes the survey time.

I.3. Summary Findings

The following findings were discovered through the analysis of seasonal traffic data on selected US-101 highway segments:

- For all of three segments, there were no remarkable differences in VMT and VHT between planned survey time and other seasons, although significant differences in delay can be found.
- For Segment 1 (CMS122, US-101 southbound), the delay in planned survey time was less than the other seasons (about 35% for morning peak and 50% for afternoon peak).
- Conversely, for Segments 2 and 3 (CMS123 & 012, US-101 northbound), the delay in planned survey time was much higher than the other seasons. There were over 50% and 100% peak-hour delay increases for CMS123 and CMS012, respectively.
- The results also show that a large variation in delay exists not only for peak hours but also for non-peak hours within the planned survey time.

These findings indicate that, for the proposed survey time, there was no remarkable difference in traffic flow compared to other times of the year, which implied that it was a feasible time window to conduct the survey. Furthermore, it was also found that there was a significant delay increase for the US-101 northbound, which implied that the planned survey time might be a better time to conduct the survey and to advocate the usage of transit-related Changeable Message Signs.

YOU ARE INVITED TO PARTICIPATE IN A TRAVELER INFORMATION SIGN SURVEY!

Dear Travelers,

The California Center for Innovative Transportation (CCIT) at University of California, Berkeley, is conducting a Traveler Information Survey regarding your commute and the usage of the travel time estimates on information signs along US-101 between San Jose and San Francisco. An example of a traveler information sign is provided in the picture to the right.

Your assistance is very important to us and will help California Department of Transportation for future planning and operation strategies to disseminate traffic information in your region.

The survey will take about five (5) minutes to complete. You should only complete the survey if you are 18 years of age or older. Your participation is voluntary and you are free to refuse, discontinue, or skip any questions.

Once you have completed the survey, please fold it and place it in the envelope provided and drop it in the mail. Postage is already paid.

If you have any questions, please contact Dr. Ali Mortazavi, lead investigator for this study at 510-642-4059 (ali@calccit.org). You may also contact the Committee for Protection of Human Subjects (CPHS) at University of California, Berkeley at 510-642-7461 (subjects@berkeley.edu).

Sincerely,

California Center for Innovative Transportation

Traveler Information Sign



COMMUTING ATTRIBUTES

1. How often do you commute between San Jose and San Francisco (i.e., daily travel between home and work/school)?

- ☐ 5 times or more
- ☐ 3 - 4 times per week
- ☐ 1 - 2 times per week
- ☐ A couple of times per month
- ☐ I do not commute

If you checked this box, please skip to Question 9

2. Where does your commute usually begin?

(Zip Code or Neighborhood) and (City Name)

3. Where does your commute usually end?

(Zip Code or Neighborhood) and (City Name)

4. How long have you experienced this commute?

- ☐ More than 5 years
- ☐ 2 - 5 years
- ☐ 1 - 2 years
- ☐ Less than 1 year

5. What is an acceptable amount of time you can be late to work/school?

(Minutes)

6. What is your typical commuting travel mode?

- ☐ Auto
 - ☐ Drive Alone
 - ☐ Carpool
- ☐ Public Transportation (select all that apply)
 - ☐ Caltrain
 - ☐ BART
 - ☐ Local buses (including MUNI)
- How do you access public transportation?
 - ☐ Walk
 - ☐ Bike
 - ☐ Drive and Park
 - ☐ Dropped off by car

☐ Other (please specify): _____

7. What factors influence your commuting choice? (select all that apply)

- ☐ Gasoline prices
- ☐ Environmental concerns
- ☐ Travel time
- ☐ Convenience
- ☐ Transit fare
- ☐ Parking availability at train station
- ☐ Parking availability at work/school
- ☐ Parking cost
- ☐ Comfort
- ☐ Other (please specify): _____

8. What is your average one-way commute time?

- ☐ 80 minutes or more
- ☐ 60 - 79 minutes
- ☐ 40 - 59 minutes
- ☐ 20 - 39 minutes
- ☐ Less than 20 minutes

TRAVELER INFORMATION SIGNS

There are three traveler information signs that display both highway and Caltrain travel estimates (see picture above). They are located along US-HWY 101 between San Jose and San Francisco.

9. Have you seen any of these signs in the following locations? (select all that apply)

- ☐ Around Redwood City heading US-101 north
- ☐ Around Burlingame heading US-101 north
- ☐ Around San Bruno heading US-101 south
- ☐ No, I haven't seen any of the traveler information signs before

If you checked this box, please skip to Question 11

10. In general, the travel times displayed via the information signs helps me decide whether to drive or take the train.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

11. The travel time information signs are easy to read while I am driving.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

(Continued)

12. The travel time estimates displayed on the information signs are accurate.

- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

13. The travel information displayed on the information sign (example at the bottom center of this page) is easy to understand.

- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

14. When the information sign does not display any information I generally assume:

- ☐ The sign only displays information when needed (e.g. taking train is faster)
☐ The sign is not working
☐ The sign only displays emergency travel information
☐ I thought the sign always displayed information

15. Have you switched from driving a car to taking a train because of the travel information on the signs?

☐ Yes, when time saved by taking a train is

- ☐ more than 30 minutes
☐ more than 20 minutes
☐ more than 15 minutes
☐ more than 10 minutes
☐ more than 5 minutes
☐ between 0 and 5 minutes

☐ No

16. What keeps you from using Caltrain, if anything, even when taking Caltrain is faster? (select all that apply)

- ☐ Parking space
☐ Parking fee
☐ Transit fare
☐ Level of convenience of taking a train
☐ Level of comfort using public transportation
☐ Distance from train station to your destination
☐ Other (please specify): _____

Please Skip to Question 21

Please look at the picture of the information sign display at the bottom center of this page.

17. I find the information displayed on the sign easy to understand.

- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

18. In general, I would use the information sign to help me decide whether to drive or take the train.

- ☐ Strongly agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly disagree

19. Would you switch from driving a car to taking a train because of the travel information on the signs?

☐ Yes, when time saved by taking a train is

- ☐ more than 30 minutes
☐ more than 20 minutes
☐ more than 15 minutes
☐ more than 10 minutes
☐ more than 5 minutes
☐ between 0 and 5 minutes

☐ No

20. What would keep you from using Caltrain, if anything, even when taking Caltrain is faster? (select all that apply)

- ☐ Parking space
☐ Parking fee
☐ Transit fare
☐ Level of convenience of taking a train
☐ Level of comfort using transit
☐ Distance from train station to your destination
☐ Other (please specify): _____

21. Please look at the picture of the information sign below. Pretend that you are driving from Redwood City to San Francisco; it is now 8:00am. If you were to take the next Caltrain, as displayed on the sign, what time would you arrive in San Francisco?

: am

FWY - SF	70 MIN
CALTRAIN	45 MIN
TRAIN AT	8:15

22. Please provide any additional comments related to the information signs (optional):

GENERAL INFORMATION

23. Your gender:

- ☐ Female
☐ Male

24. Your age group:

- ☐ Under 18
☐ 18 - 24
☐ 25 - 34
☐ 35 - 49
☐ 50 - 64
☐ 65 or above

25. Your approximate household income:

- ☐ Under \$25,000
☐ \$25,000 - \$44,999
☐ \$45,000 - \$74,999
☐ \$75,000 - \$149,999
☐ \$150,000 or above

26. What is the highest level of education you have completed?

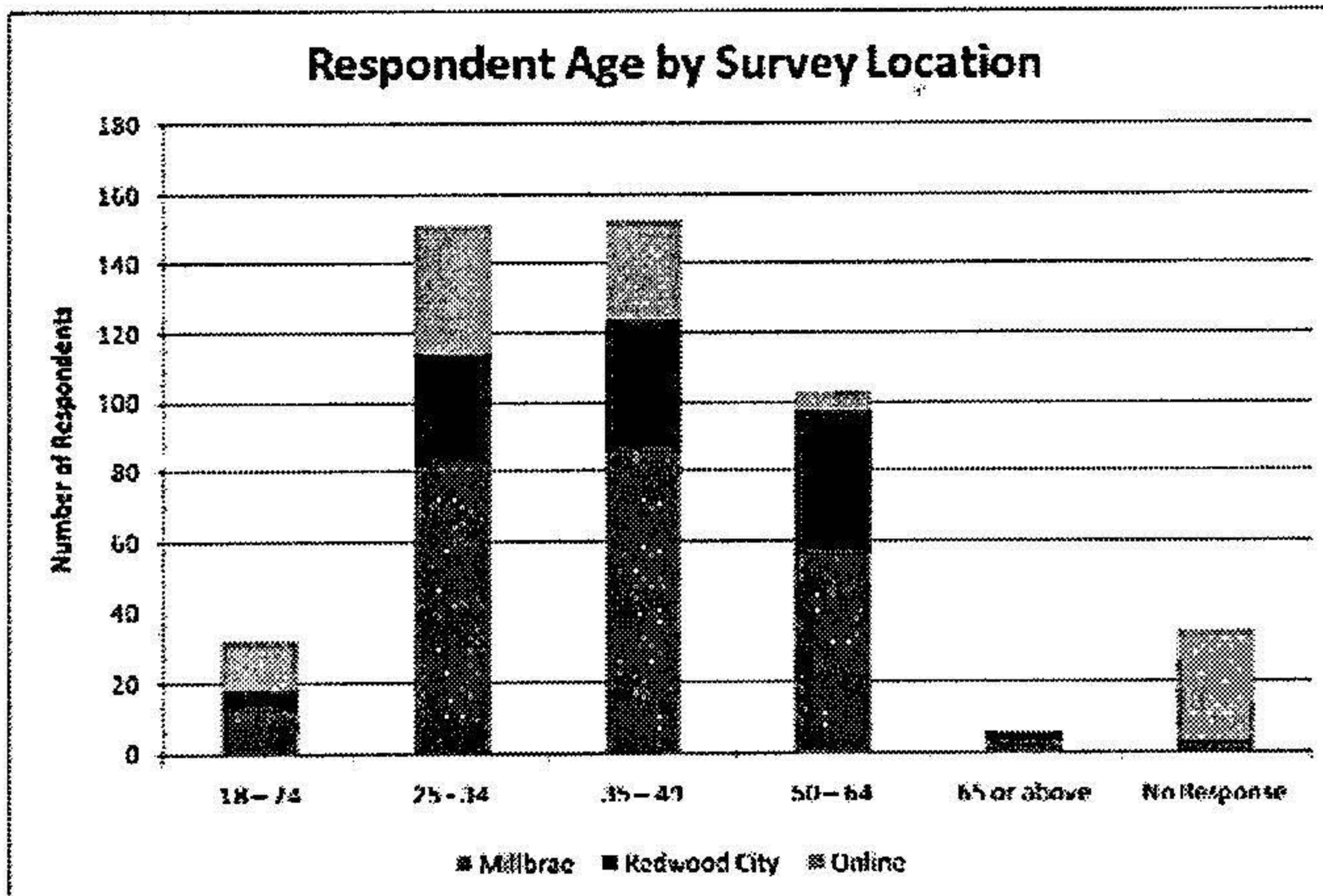
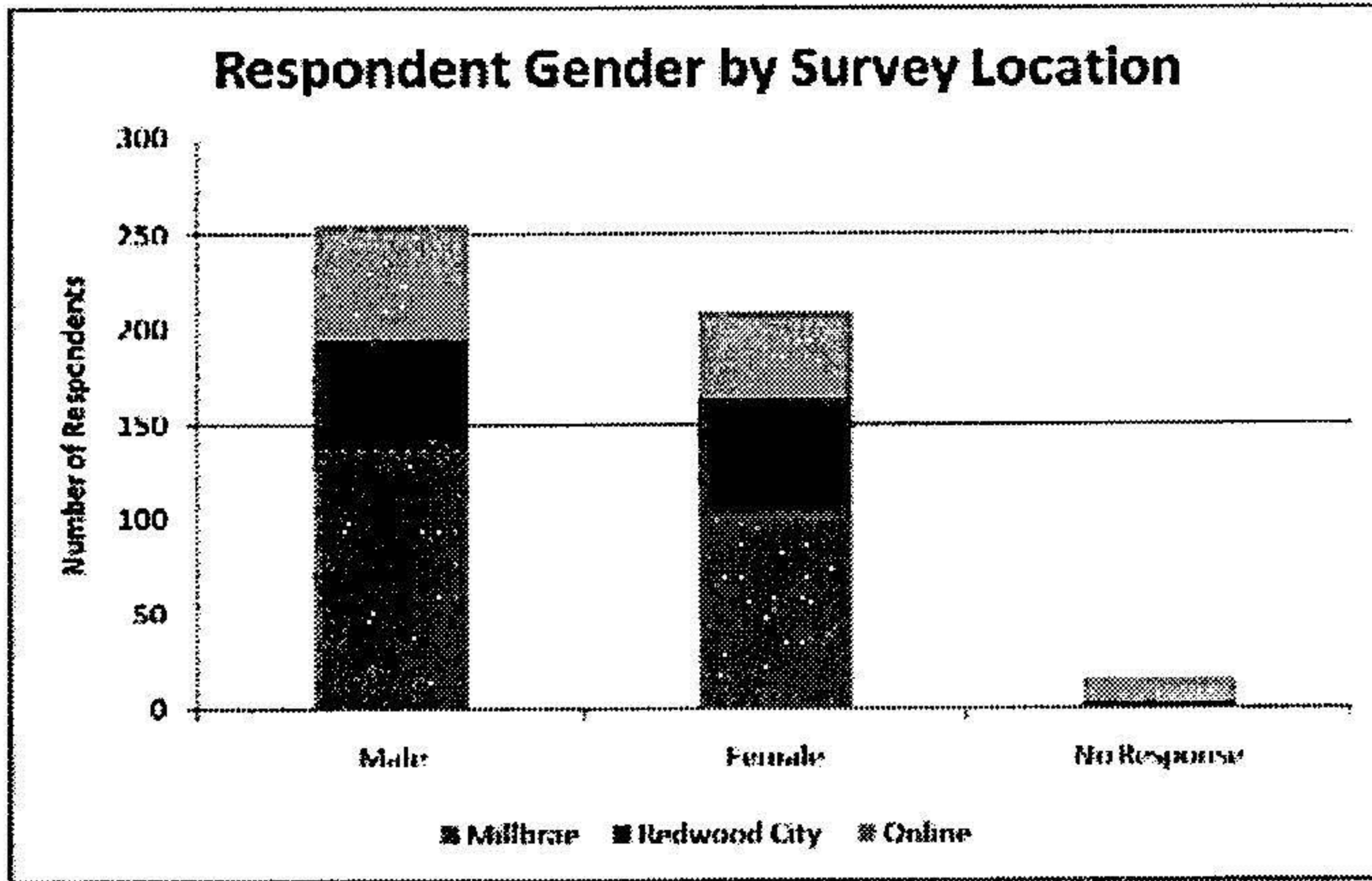
- ☐ High school
☐ College
☐ Graduate school or higher
☐ Other (please specify): _____

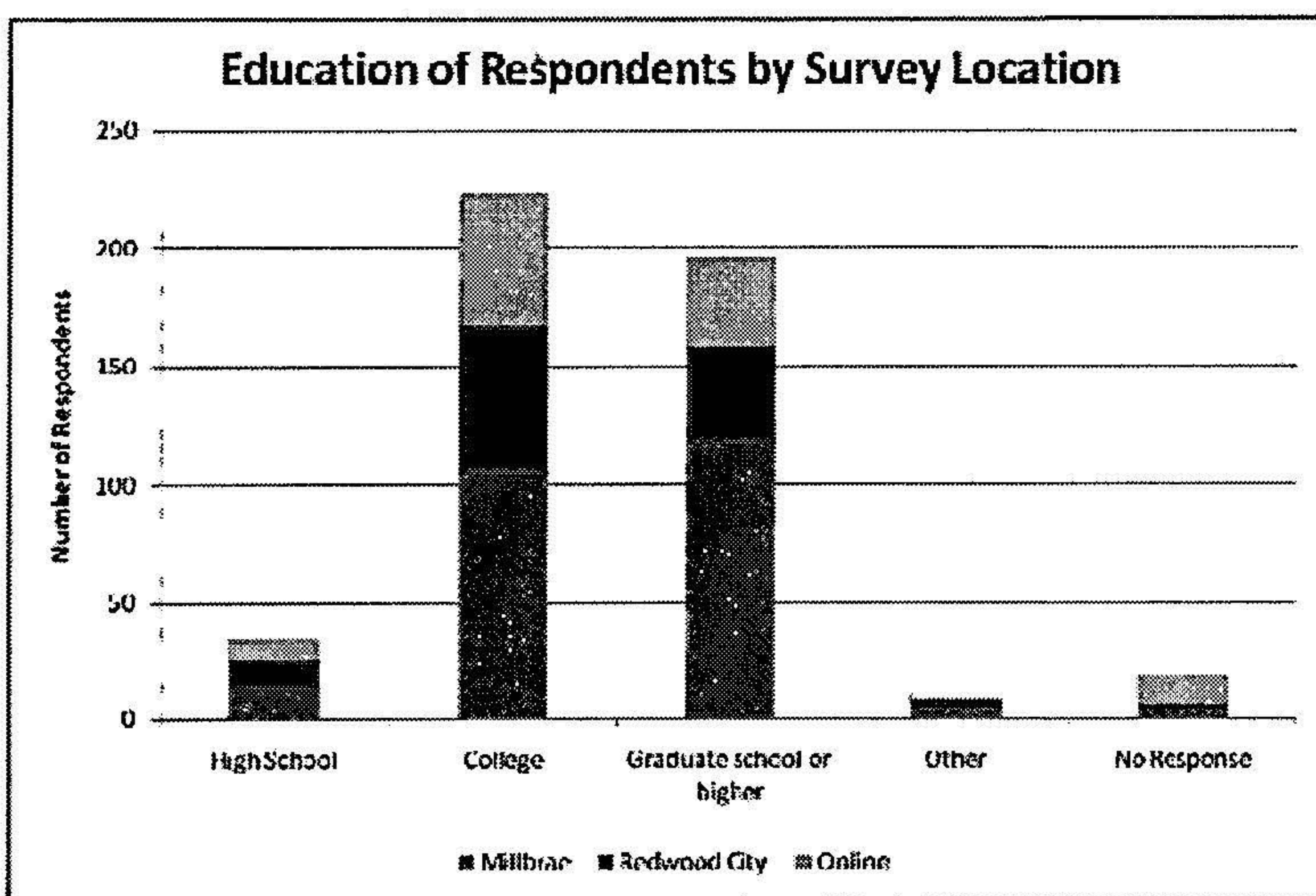
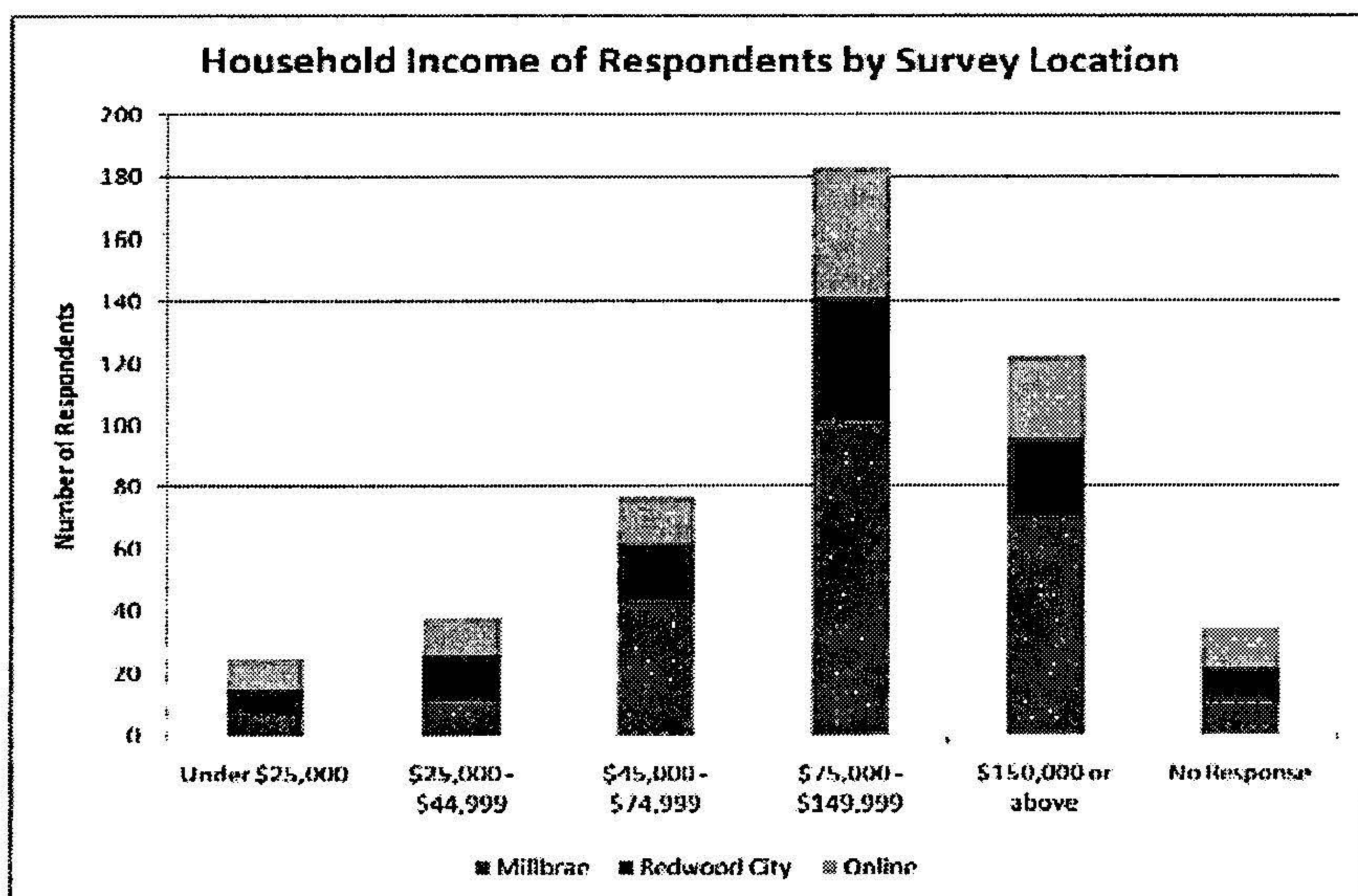
27. We would appreciate any of your general comments (optional):

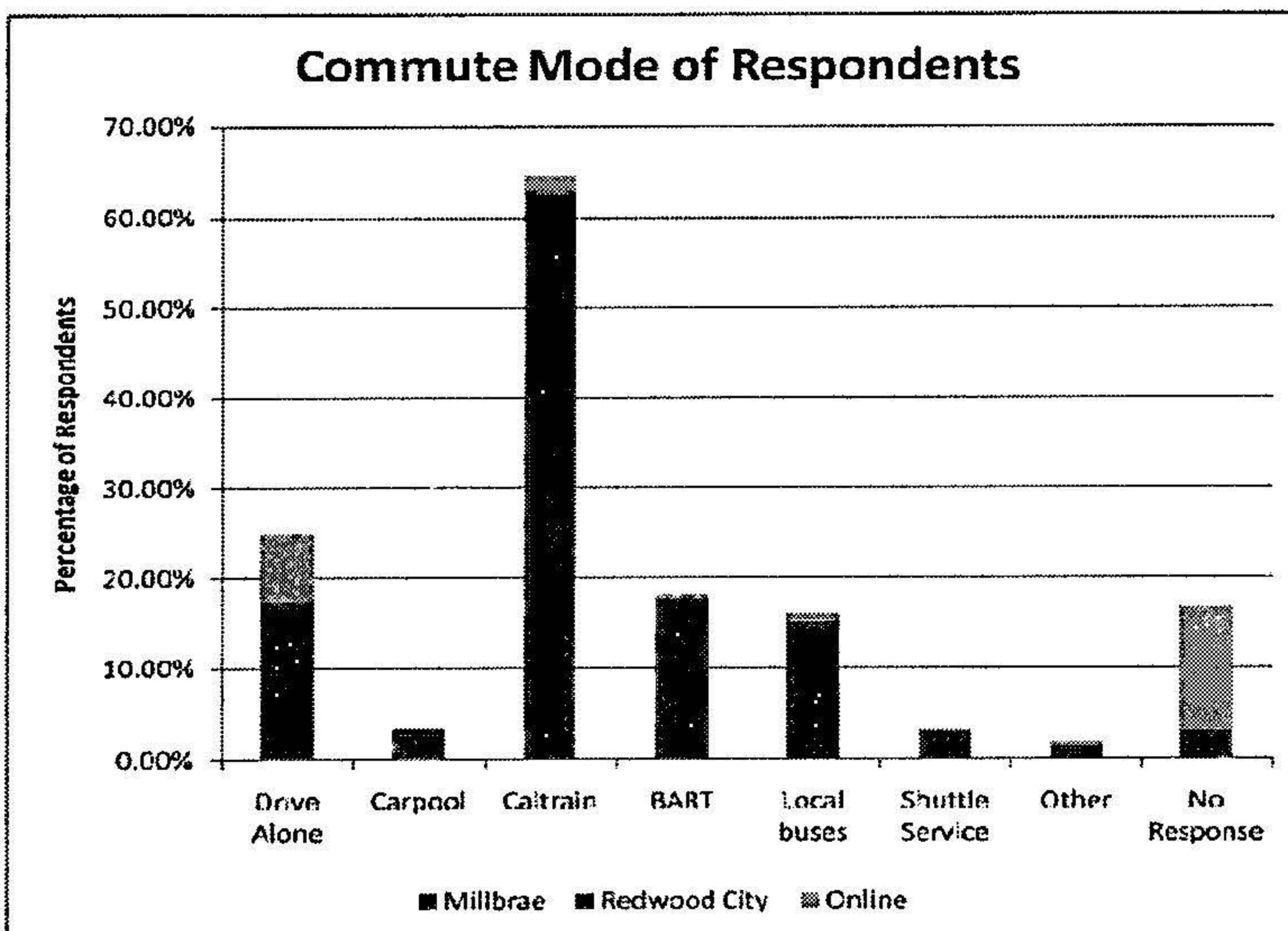
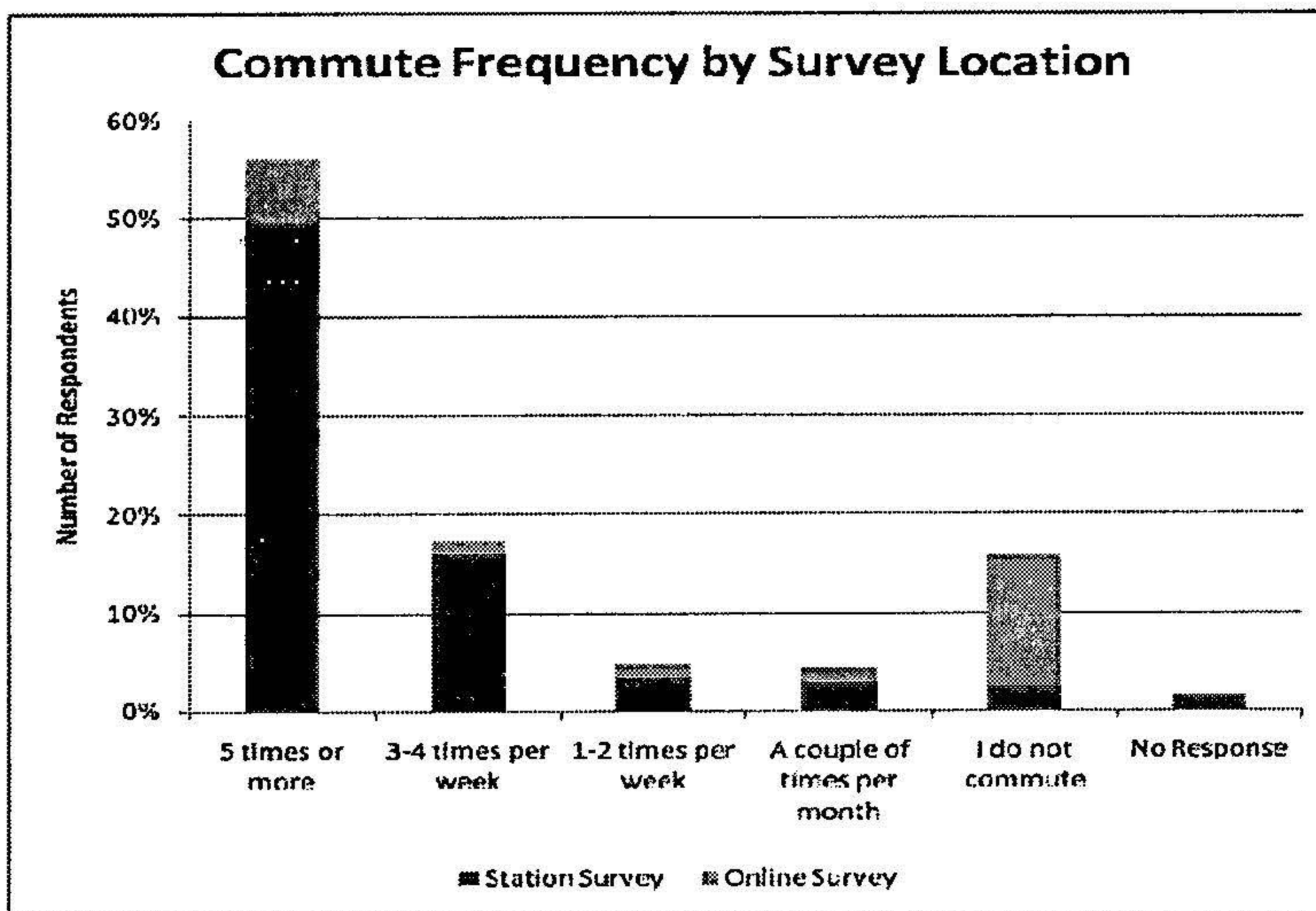
**THANK YOU
 VERY MUCH FOR
 PARTICIPATING!**

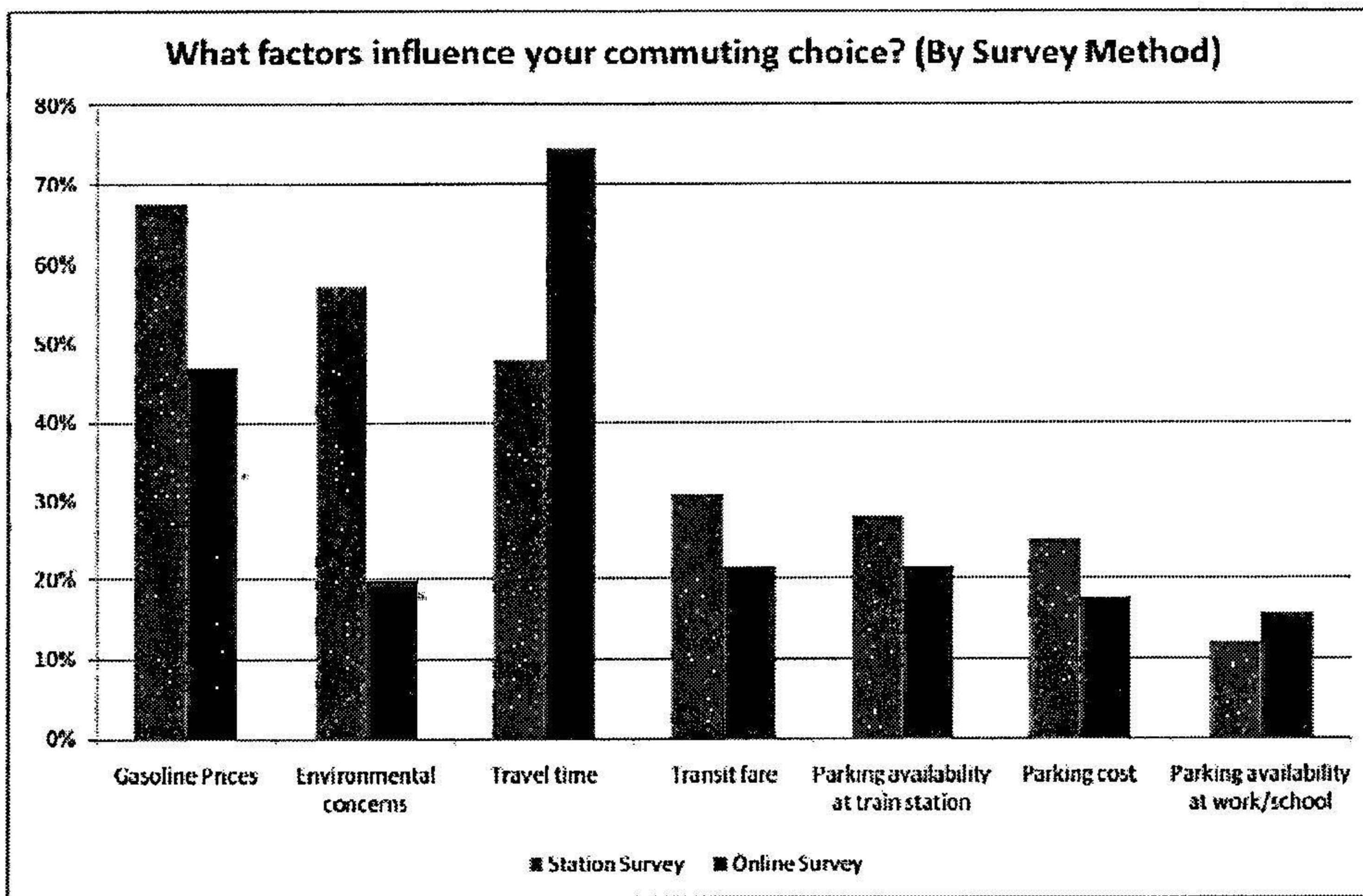
Your input will help to improve the commute for you and others!

III.1. Demographics

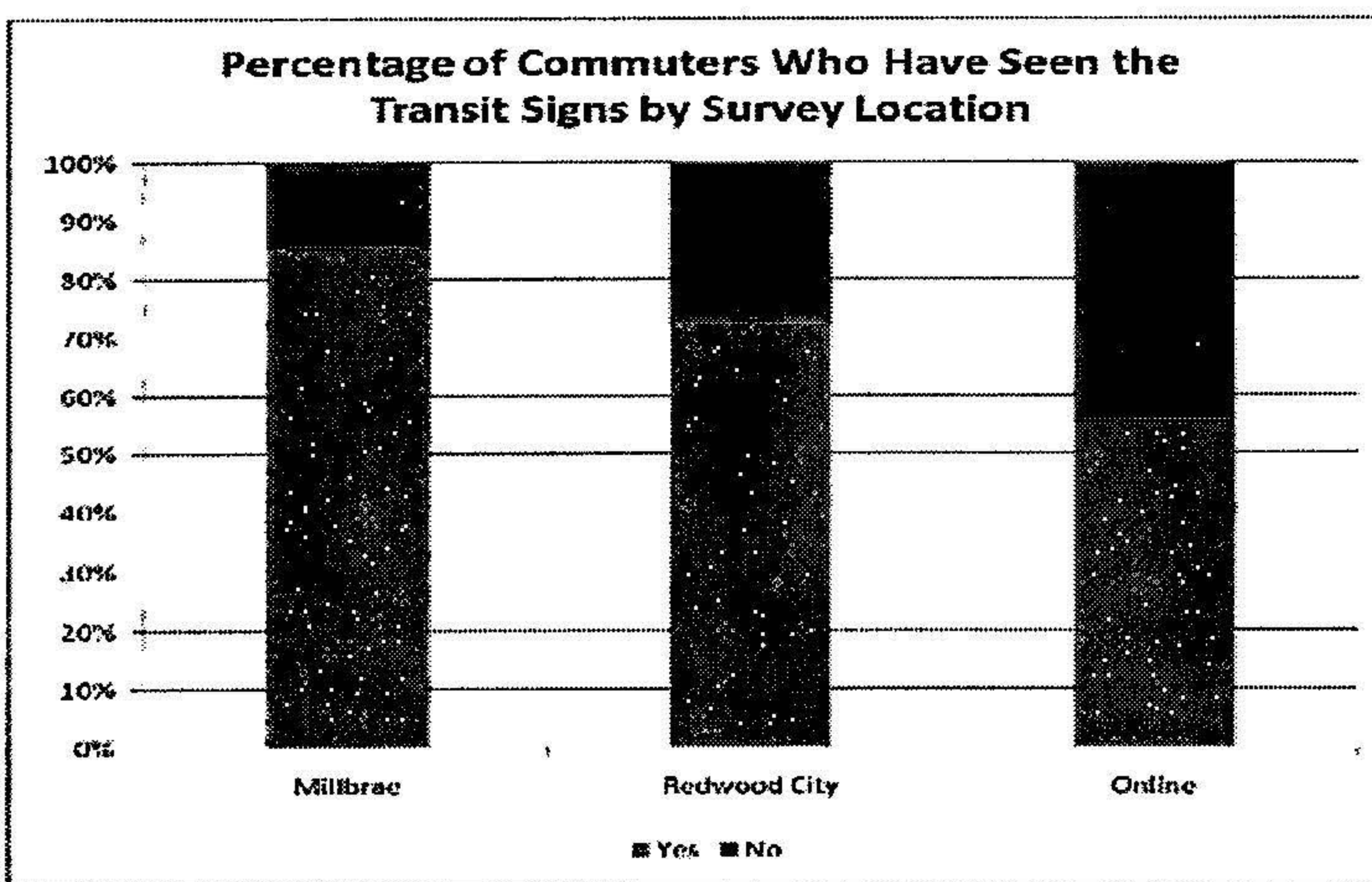


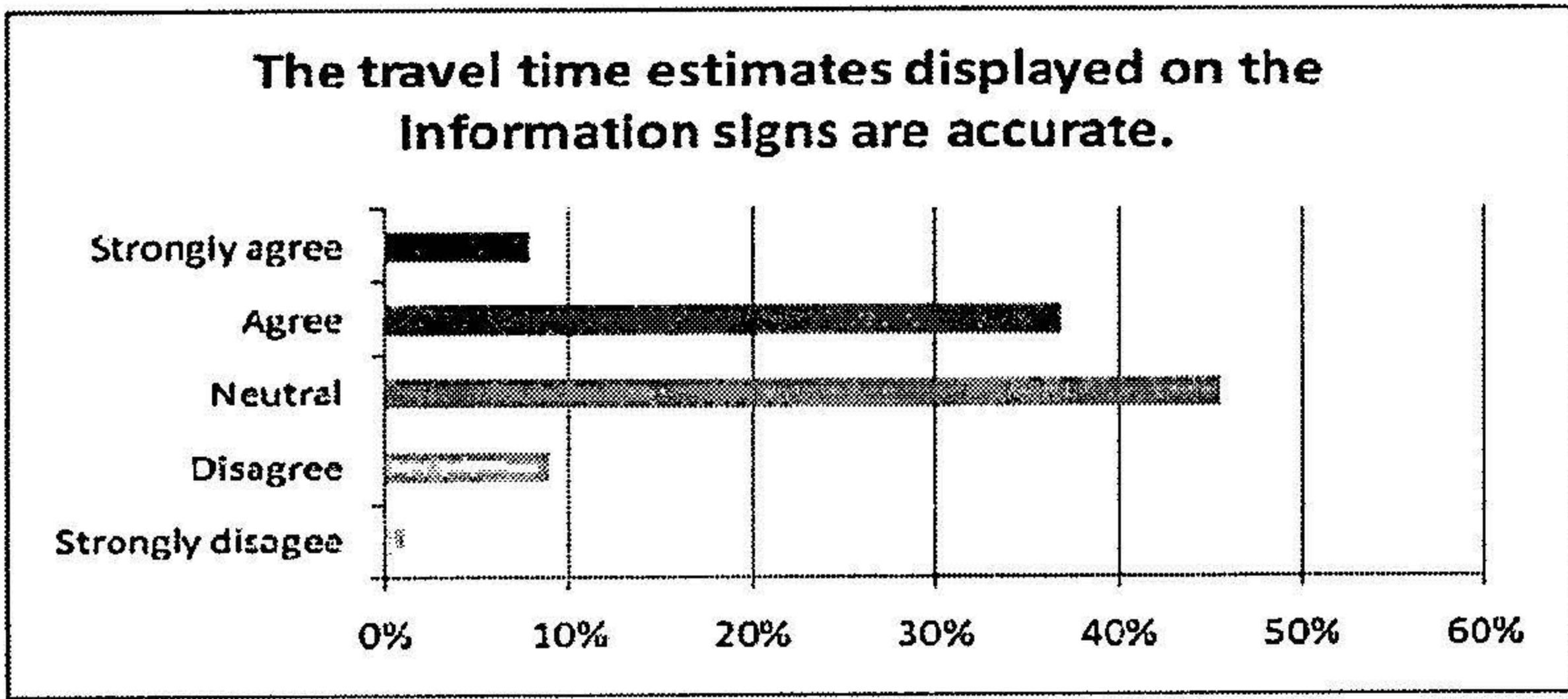
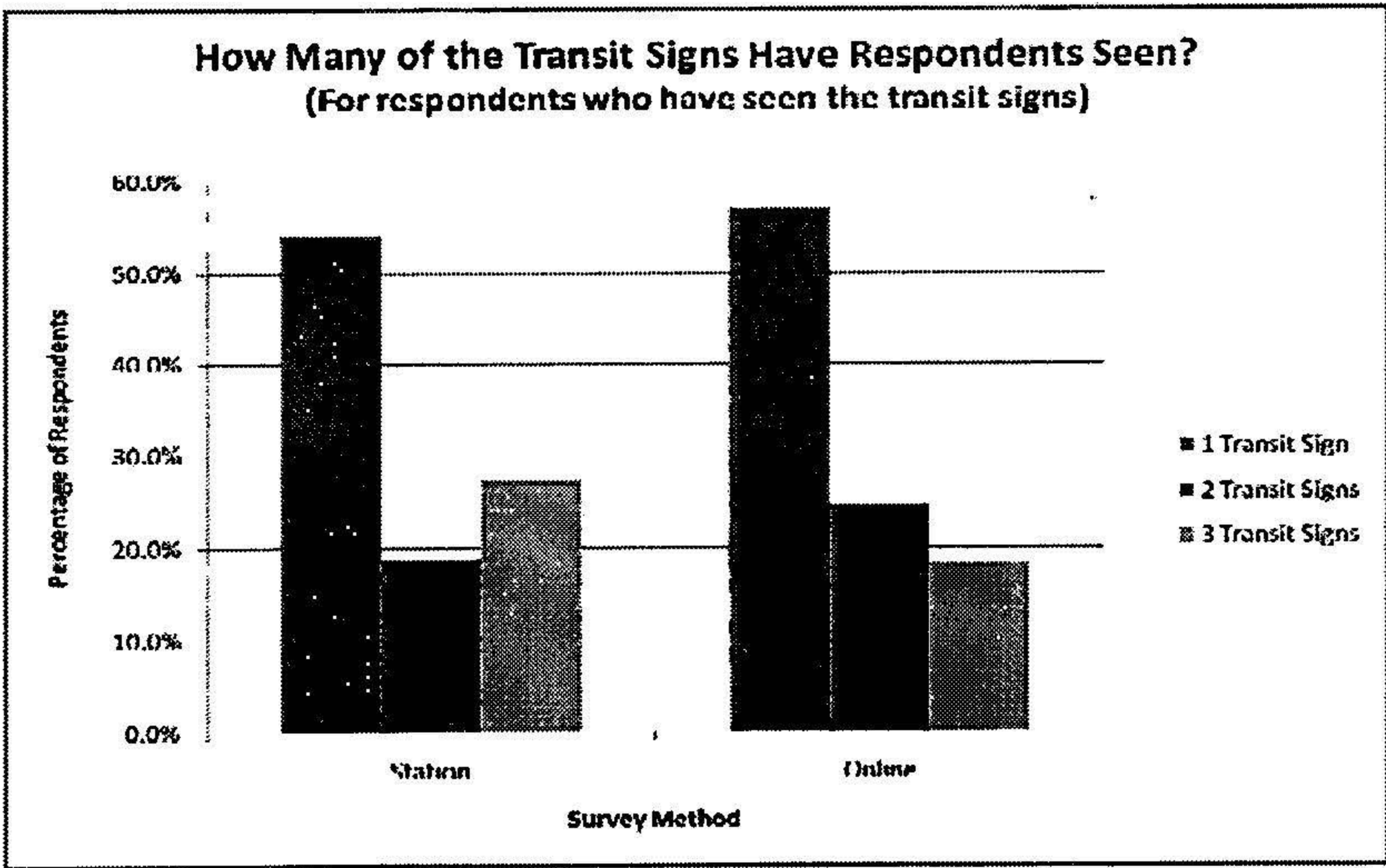
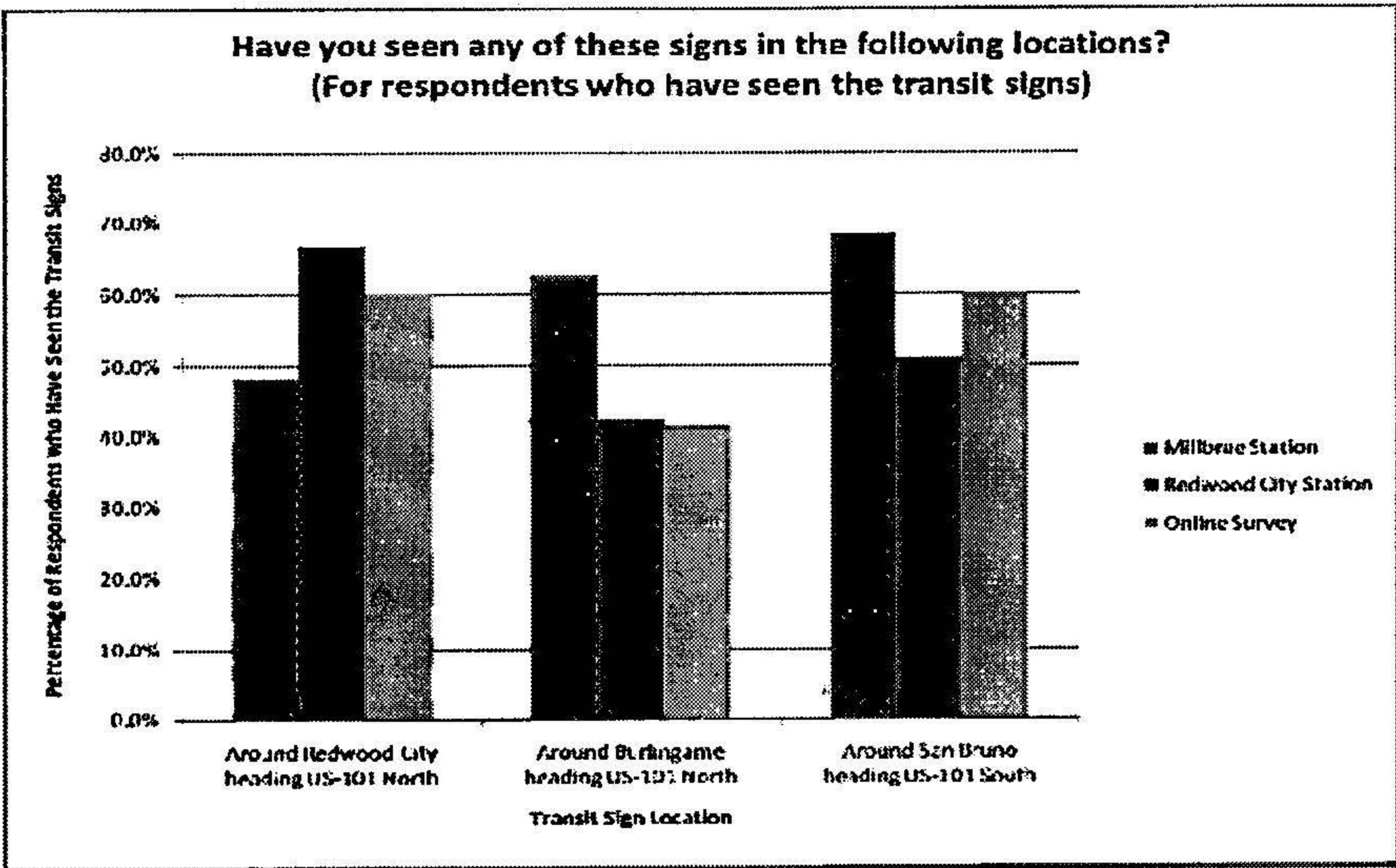


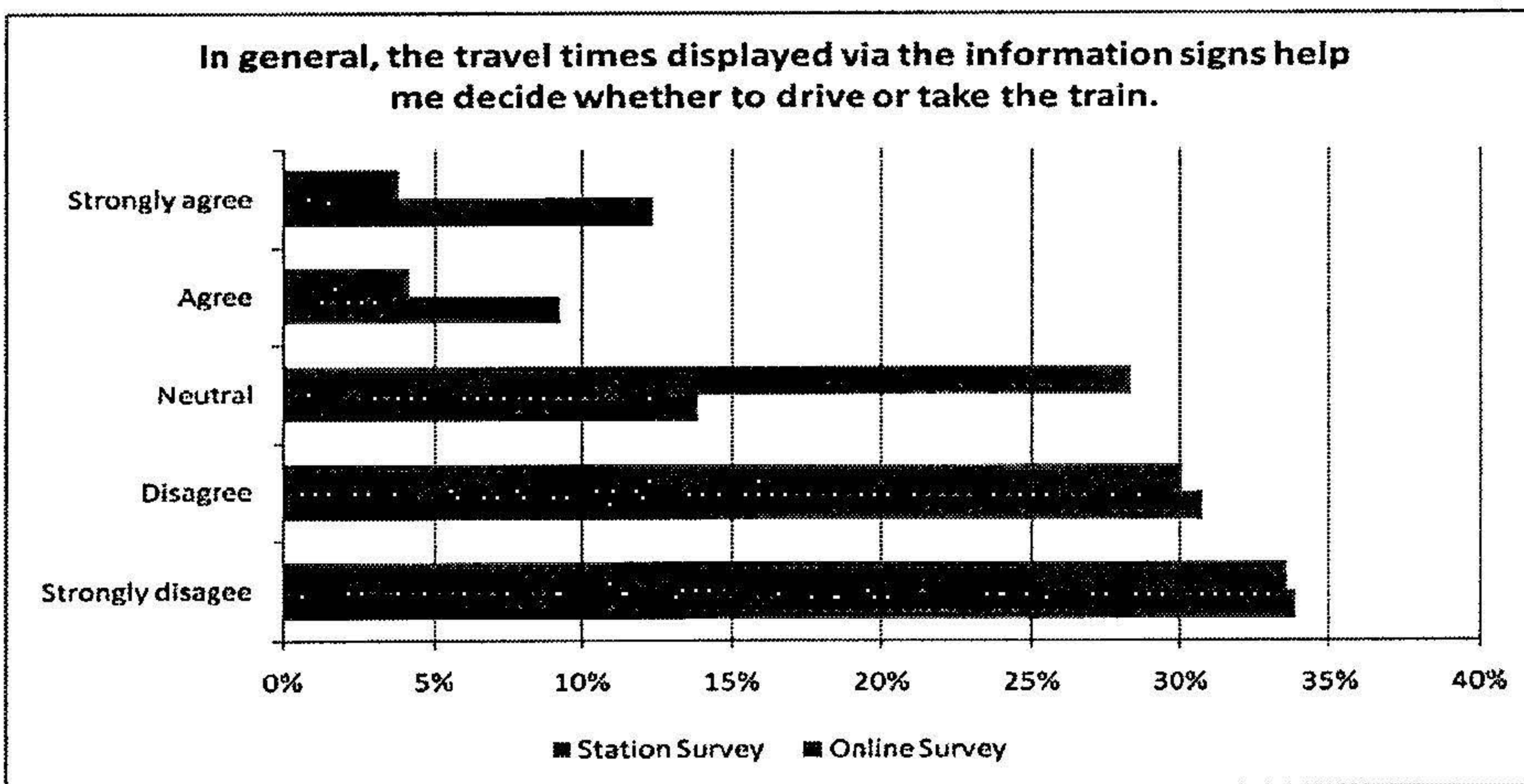
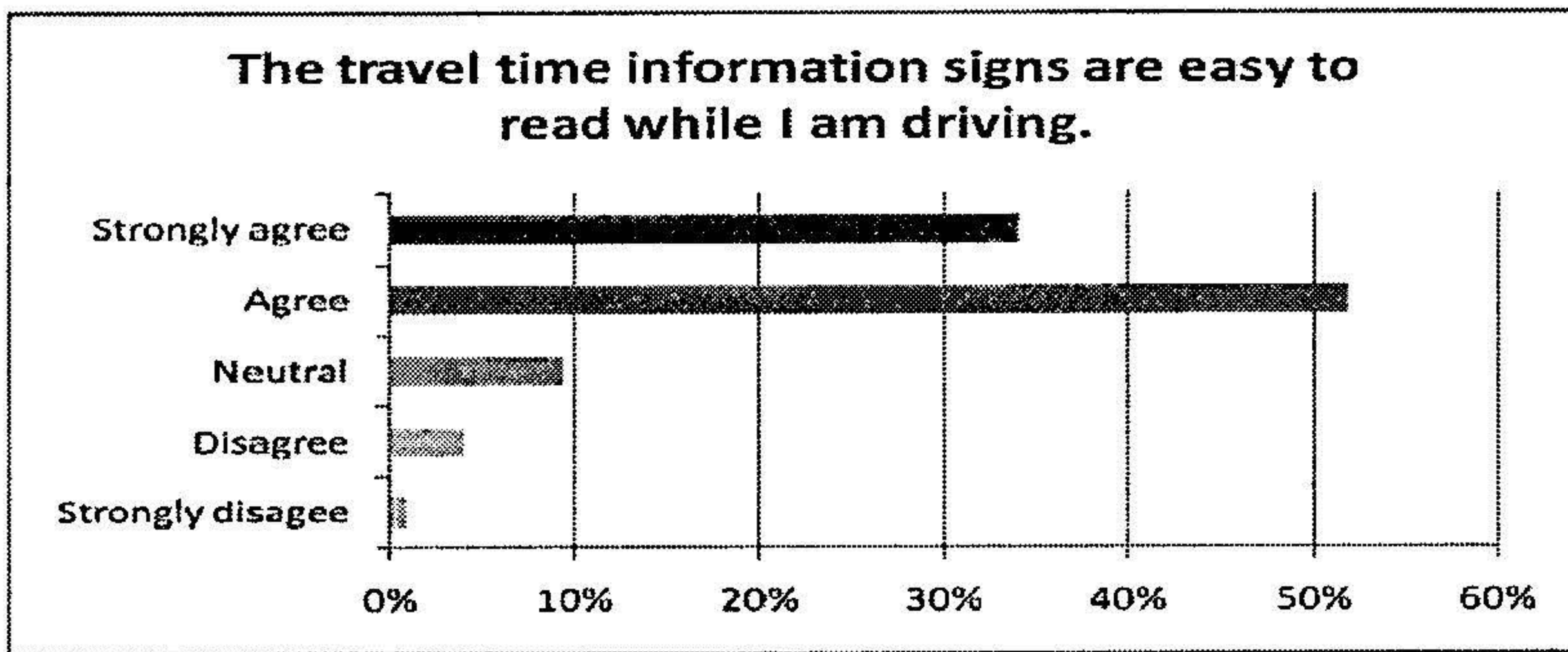
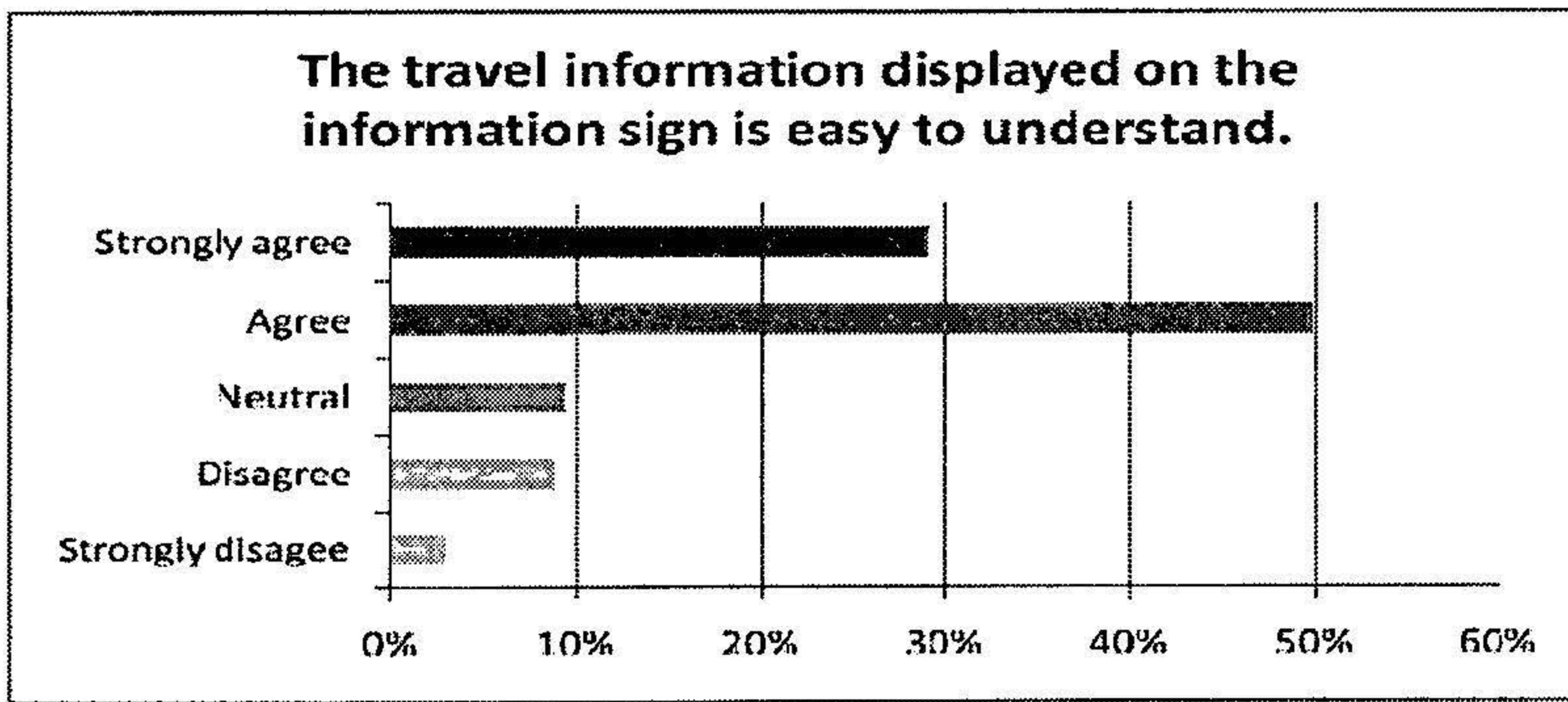


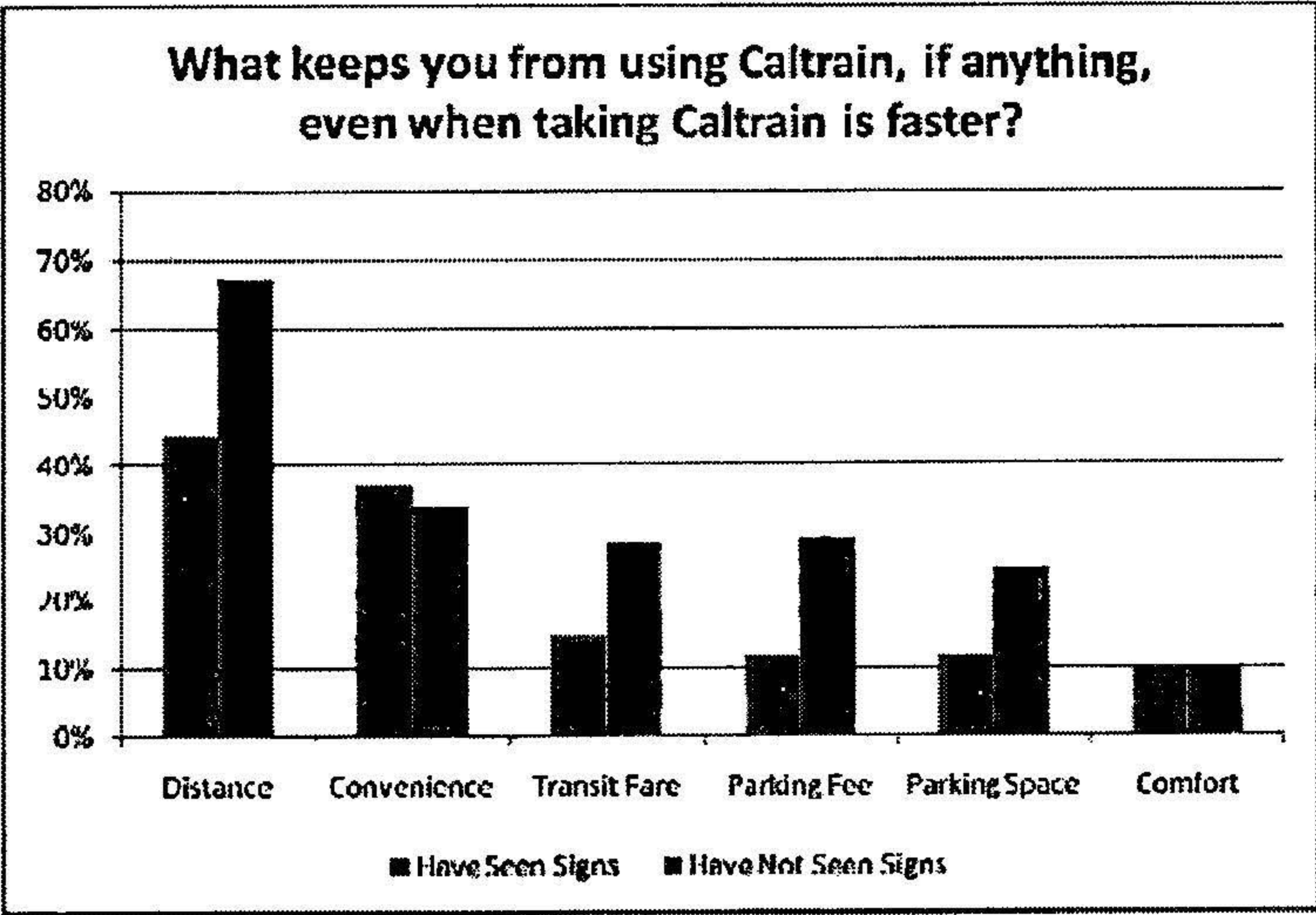


III.2. About Traveler Information Signs

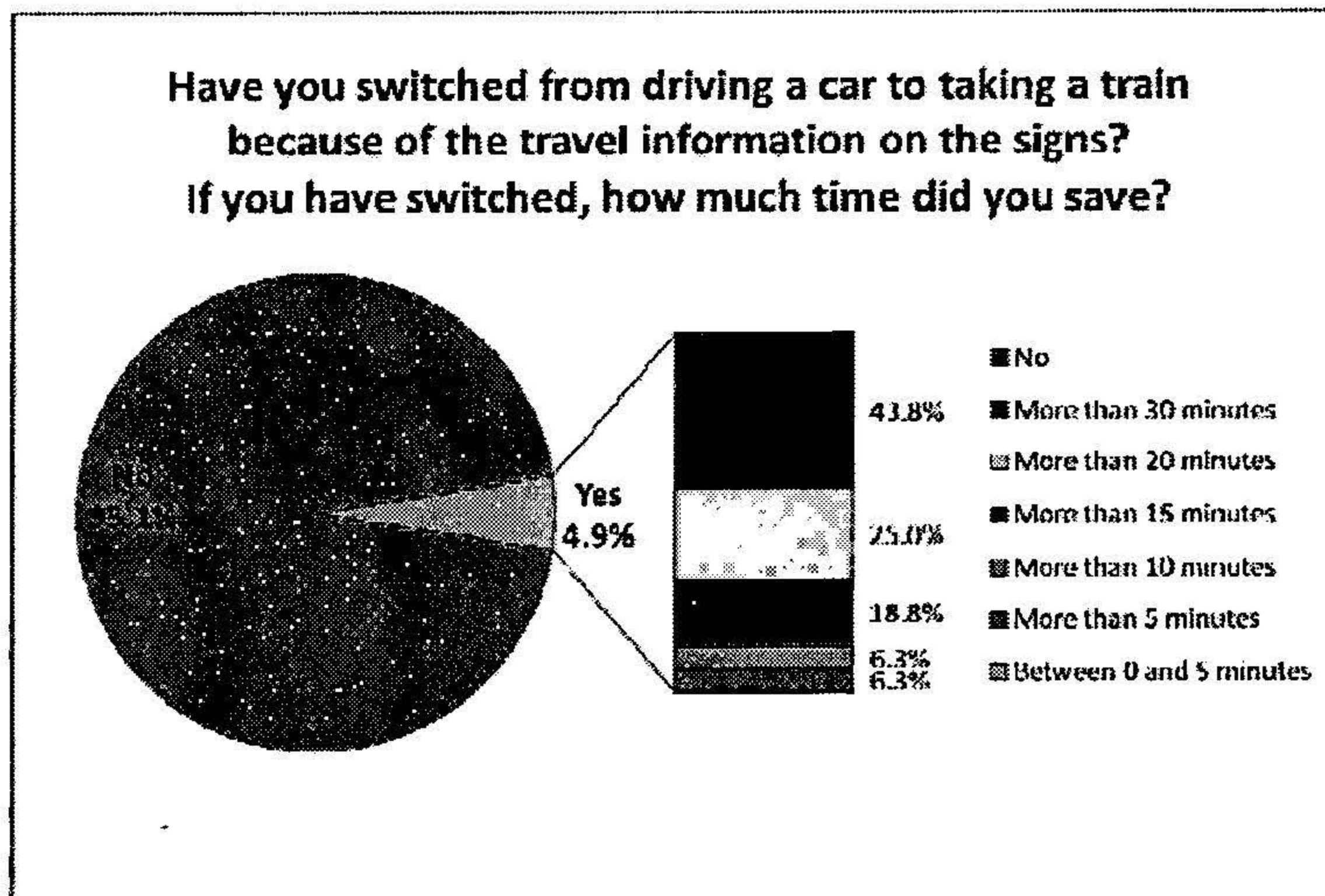
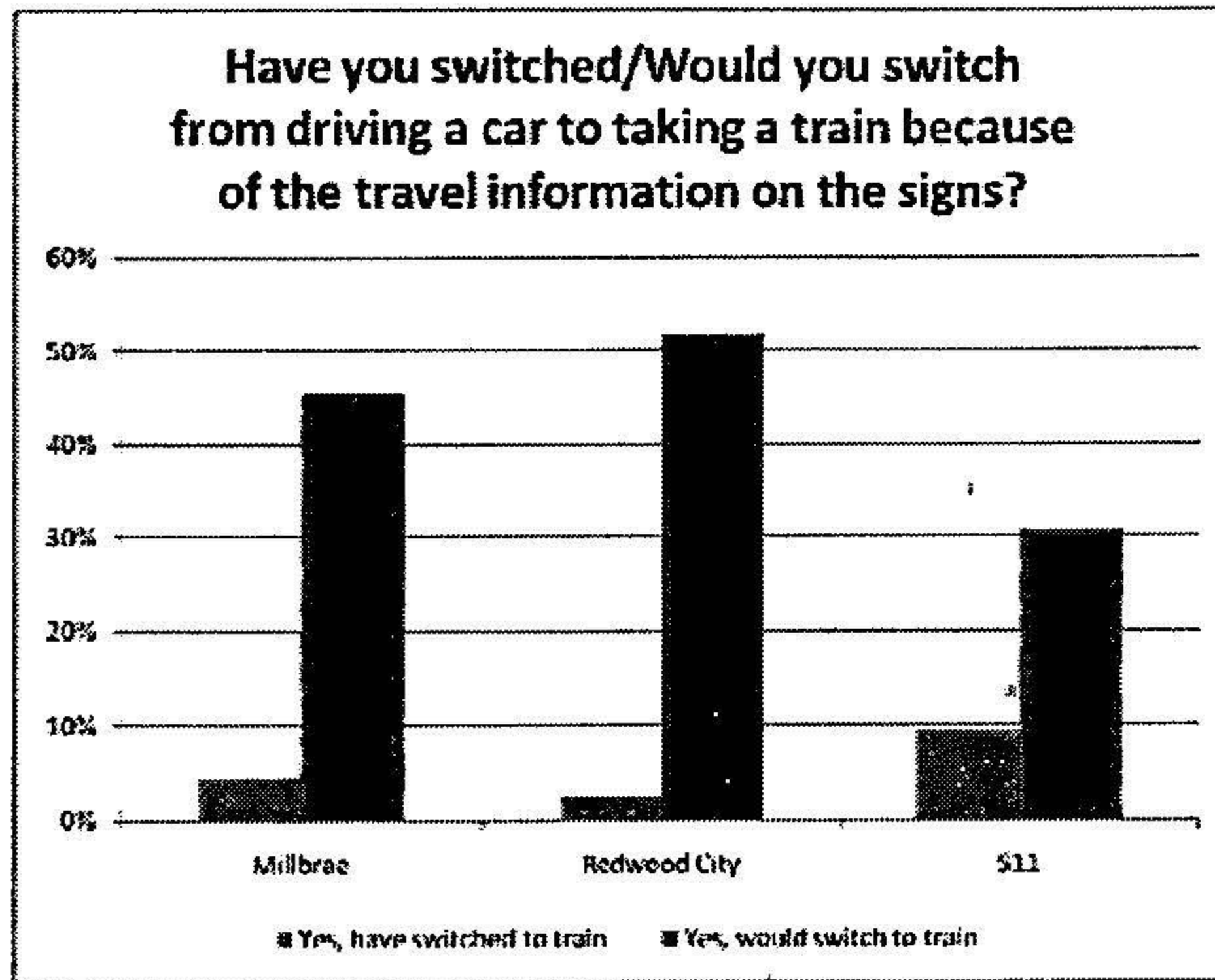


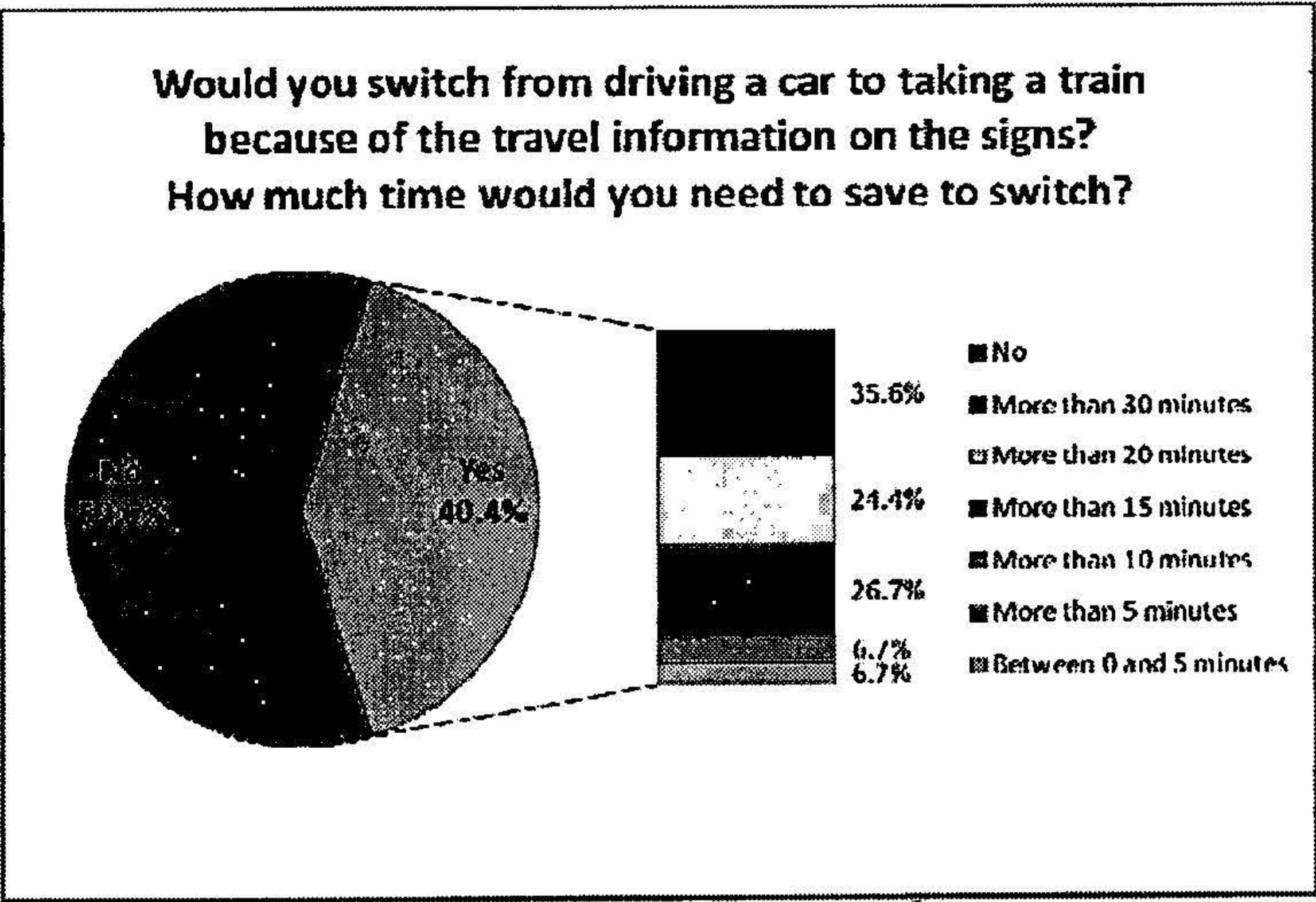


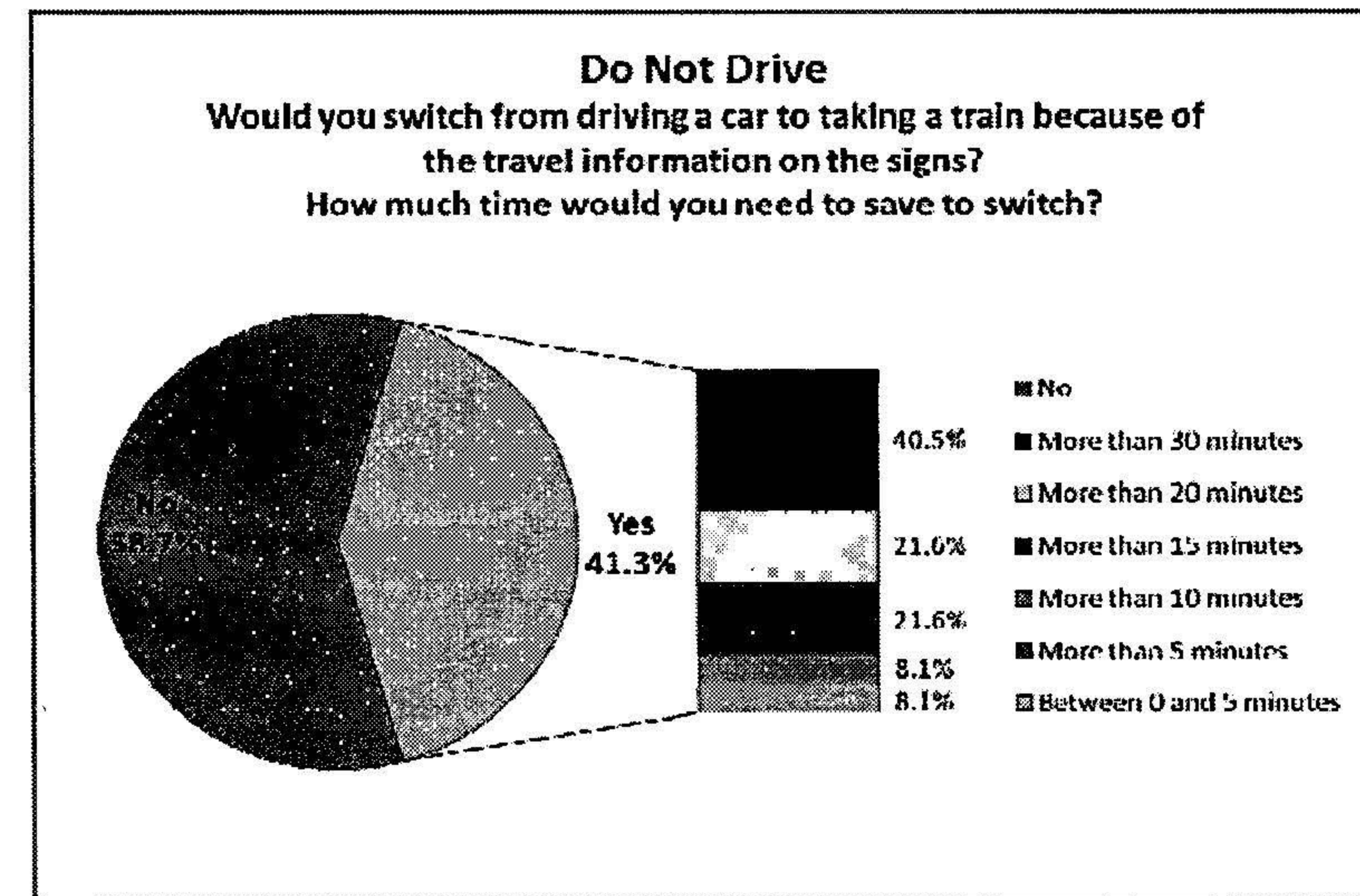
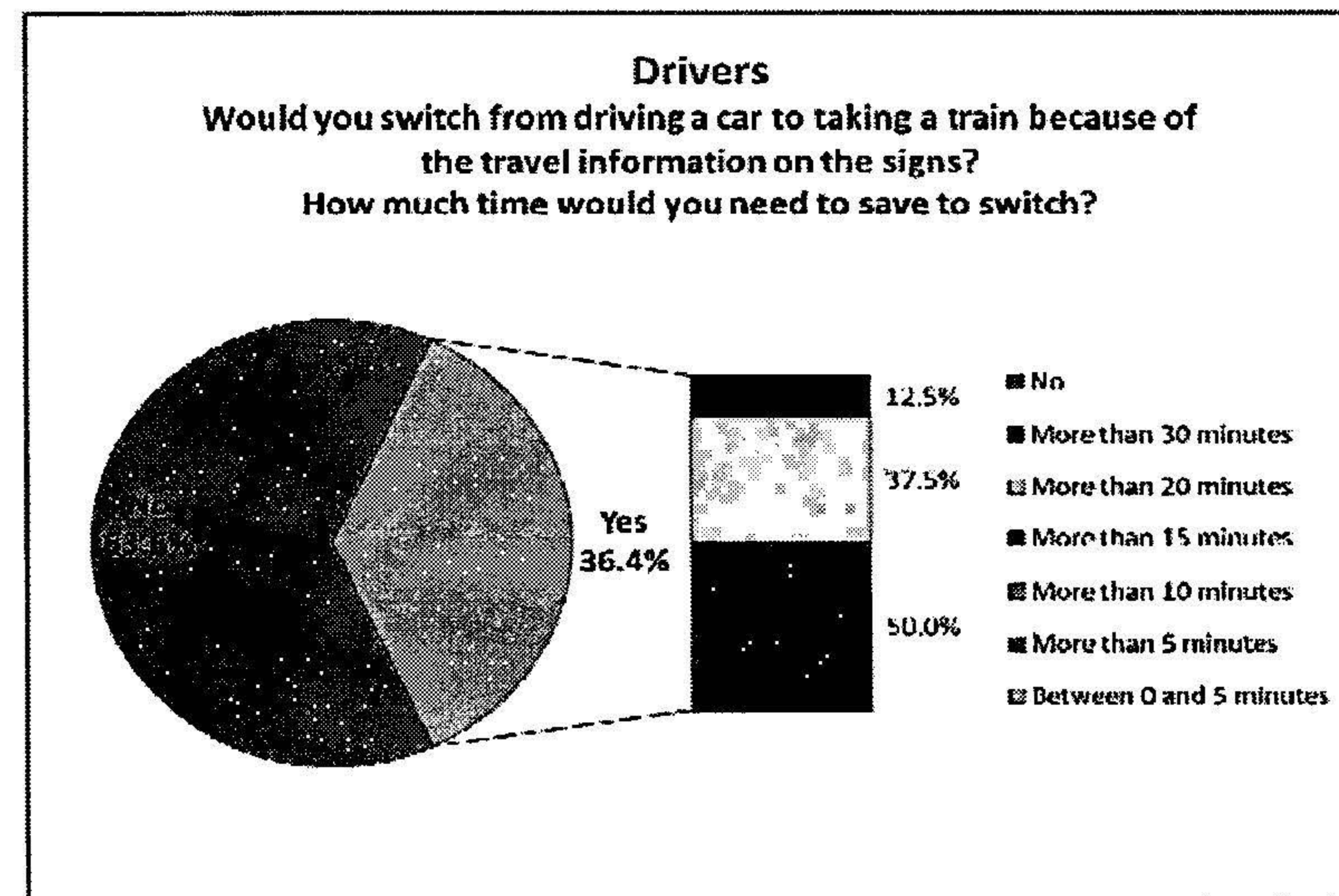
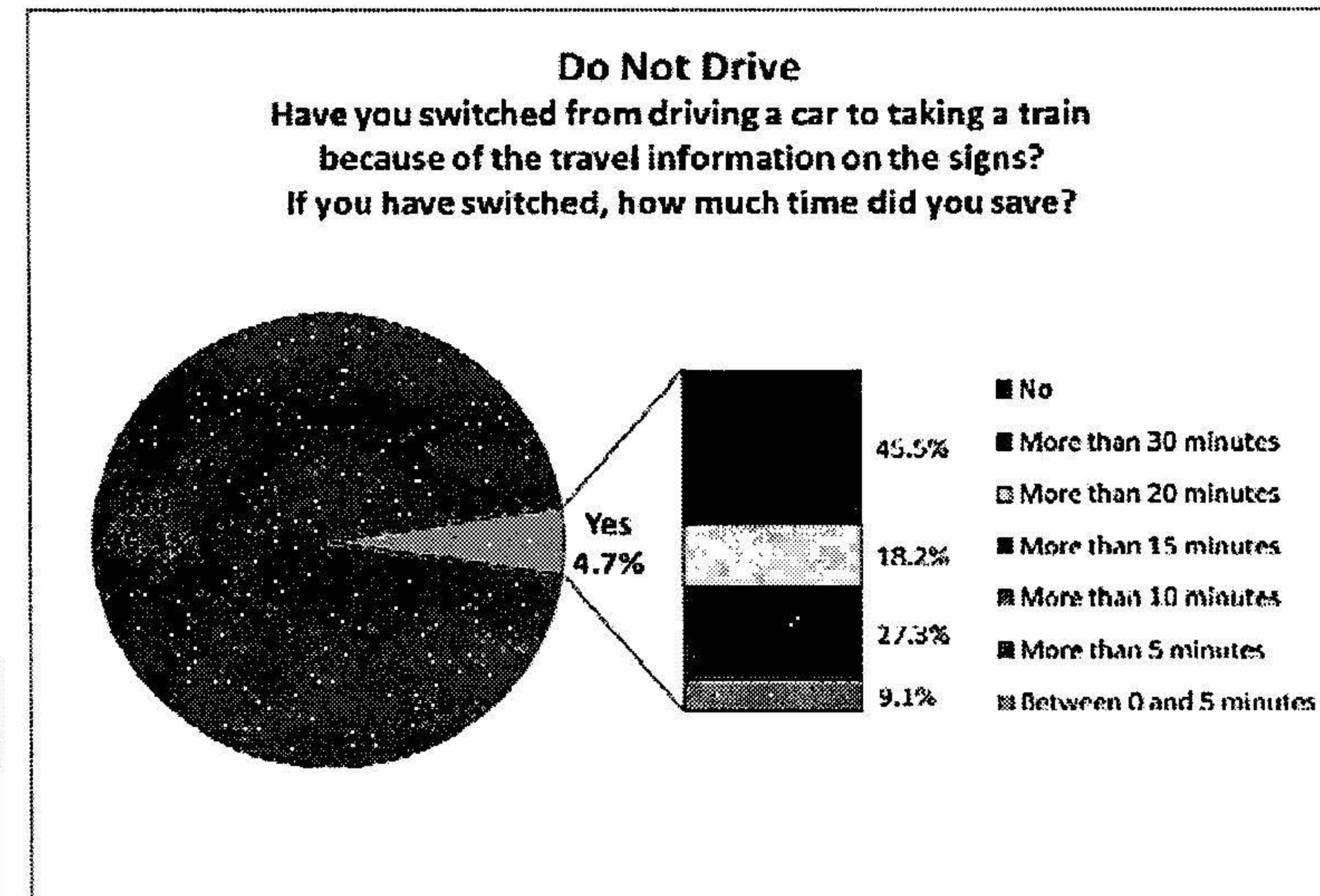
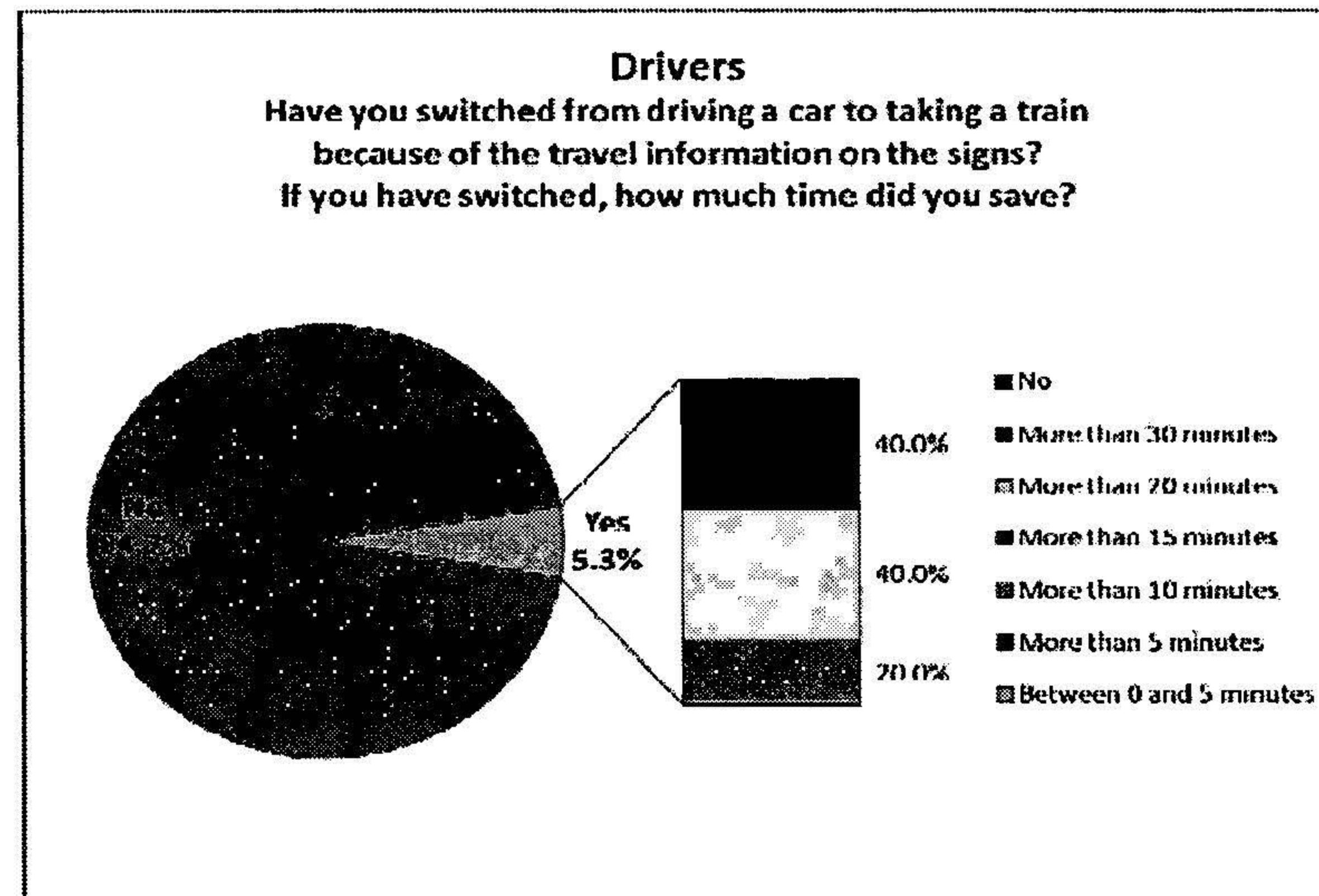




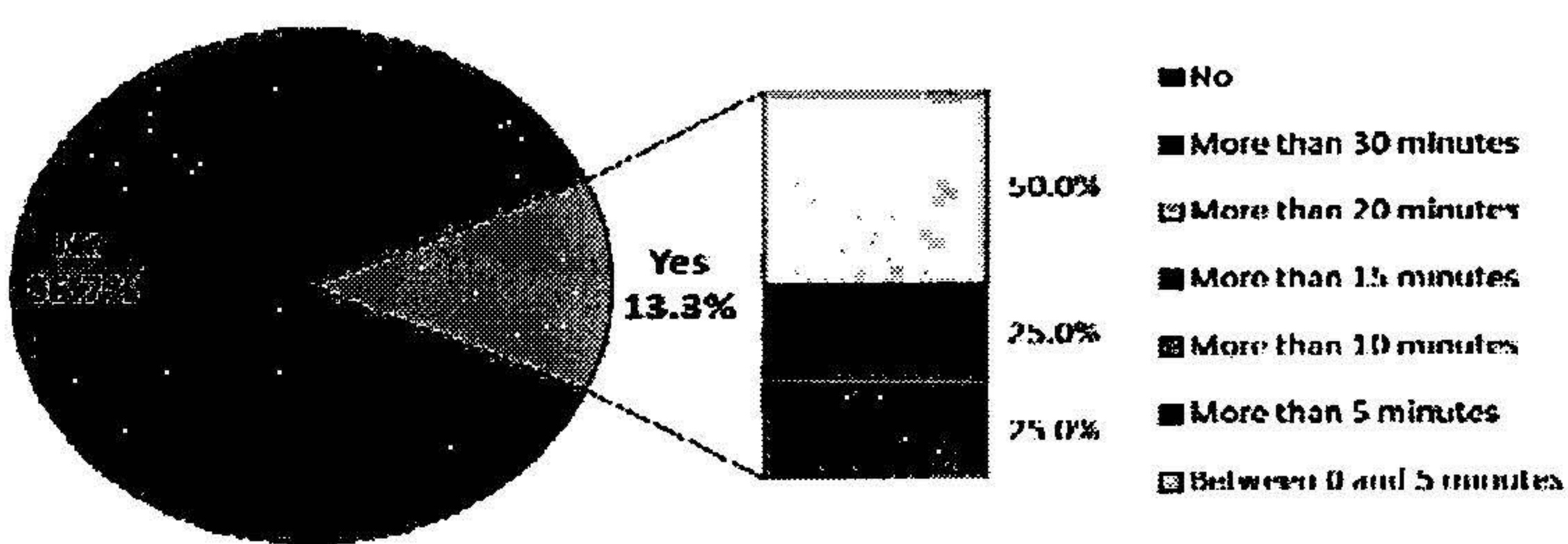
III.3. Modal Shift Resulting from Transit Signs



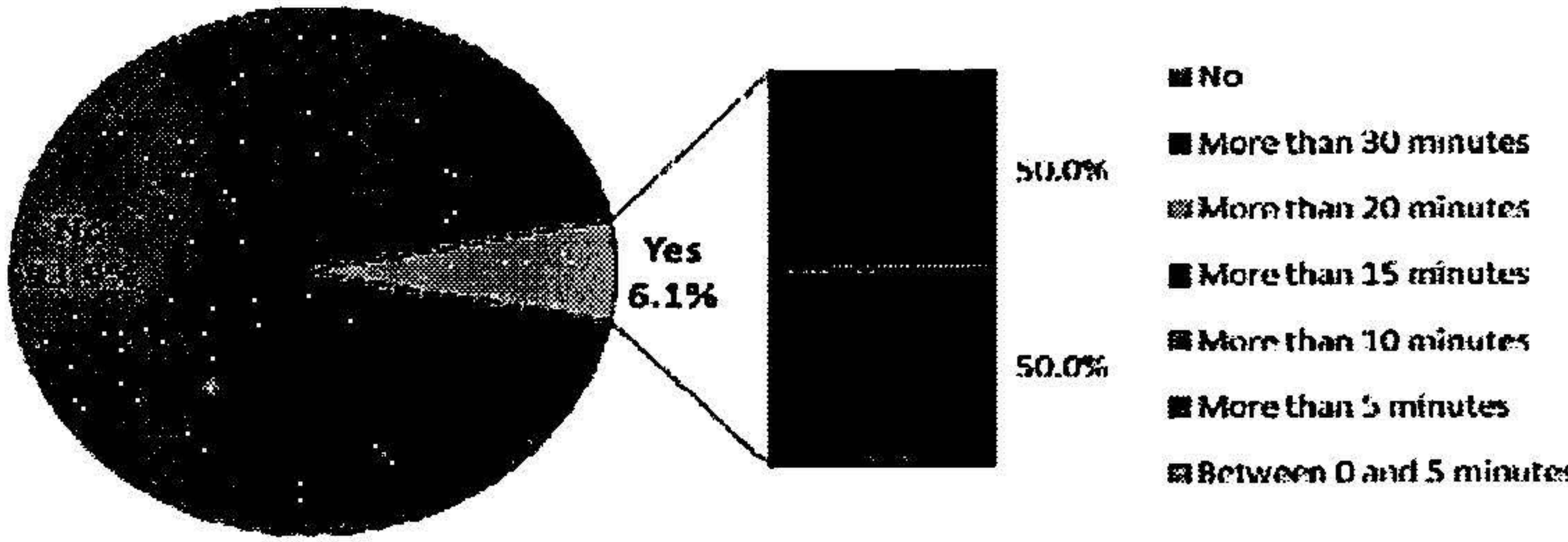


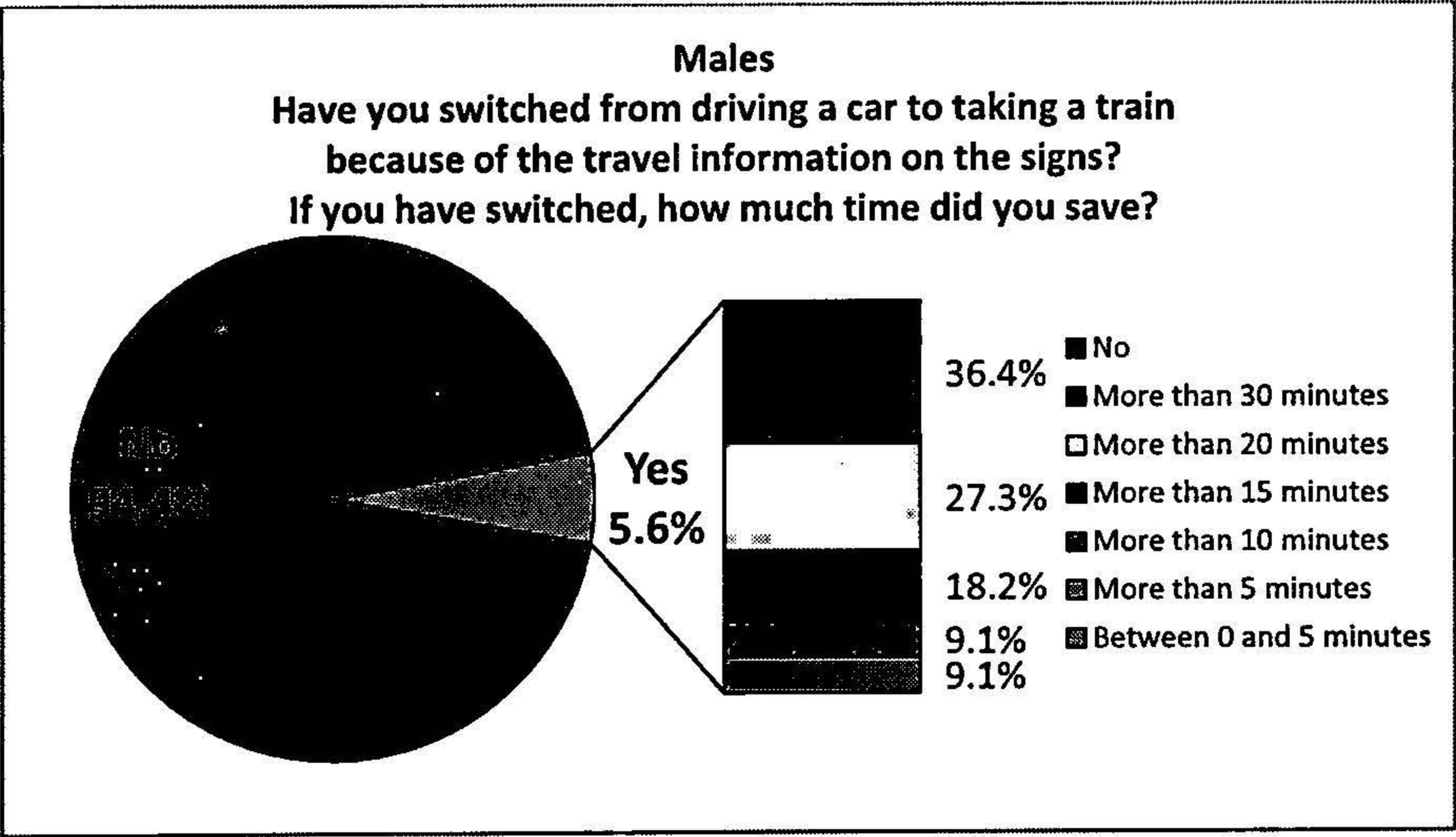
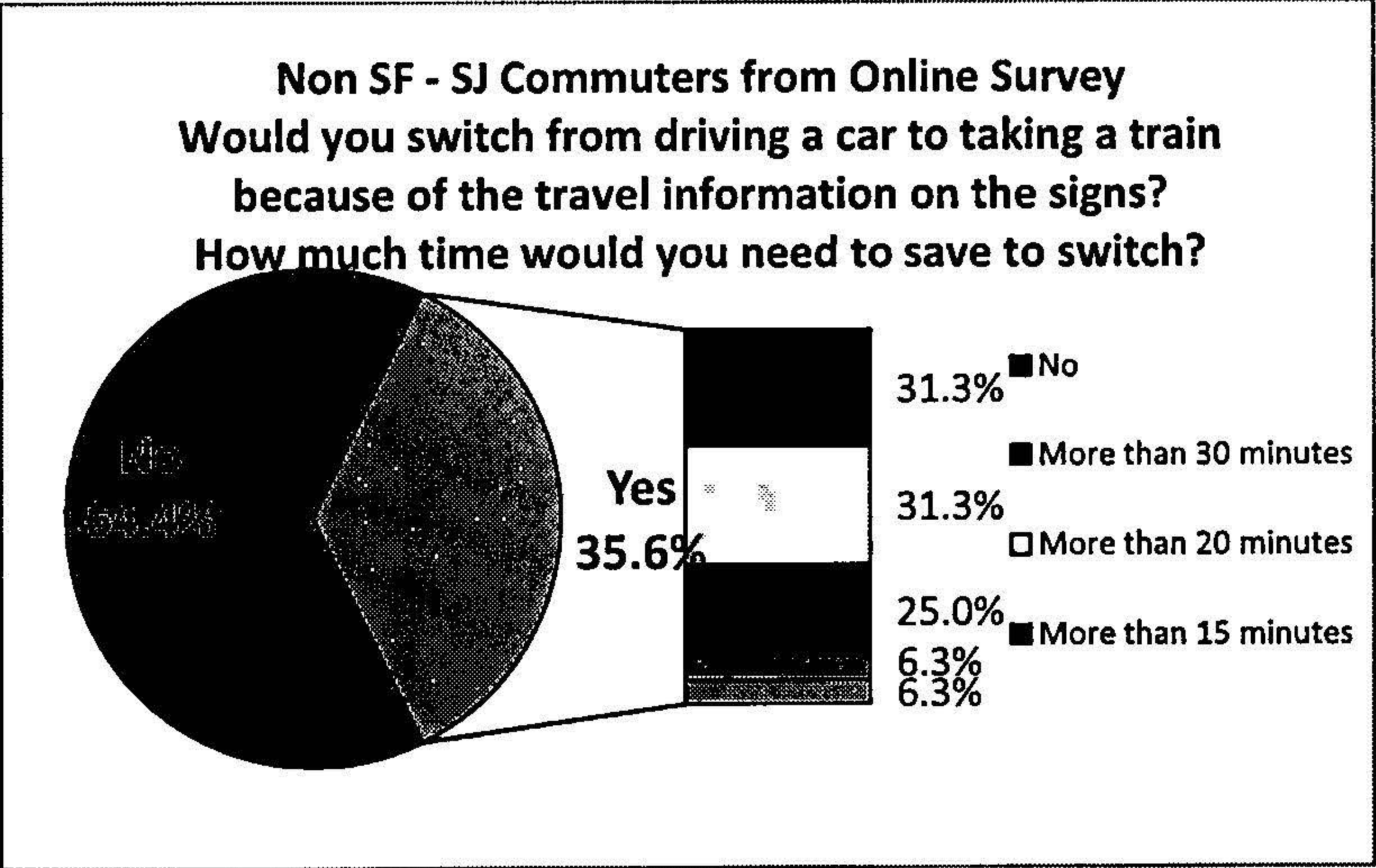


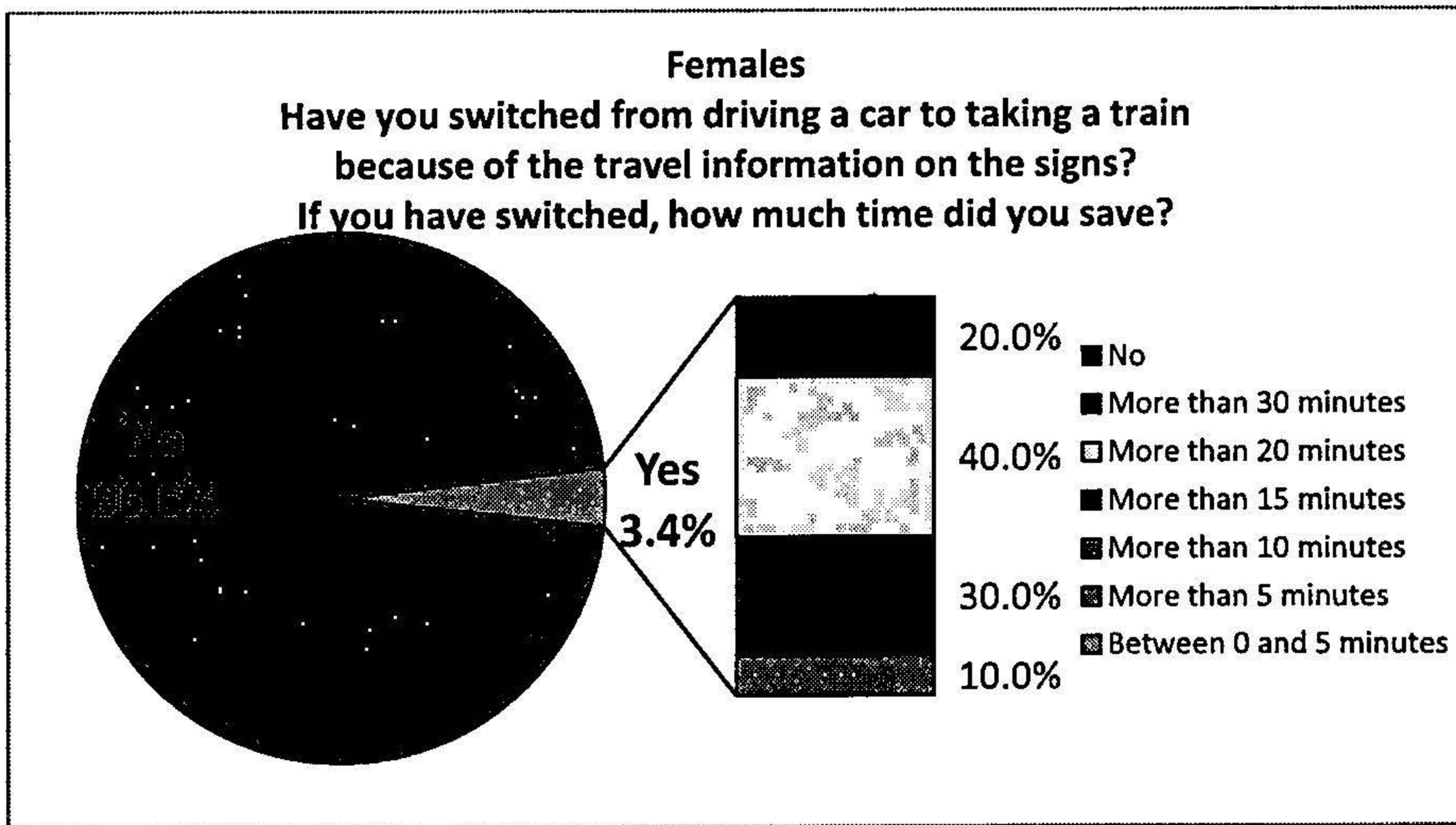
SF - SJ Commuters from Online Survey
Have you switched from driving a car to taking a train
because of the travel information on the signs?
If you have switched, how much time did you save?



Non SF - SJ Commuters from Online Survey
Have you switched from driving a car to taking a train
because of the travel information on the signs?
If you have switched, how much time did you save?







III.4. Write-in Comments

III.4.1. Redwood City Station Survey

Please fix the ticket validation system! Those ticket validators don't work a lot of the time. It was not working in SM. I boarded the train at 2:20, finally found a seat. When conductor came by I gave him my ticket and advised the validator not working in SM gave me a bad time about not seeking out a conductor. Poor customer relations!

Thanks Caltrain for continuing to be a good transportation choice.

Signs for emergency info + travel time. No train info needed. Also don't add unnecessary info.

I'm glad we have public transport here, but it could be better timed for people having to use both modes. Car=50min commute 1 way; [Caltrain] + Bart=1.5 to 2 hrs - which would you choose if you had a family?

I start at the California Ave station. They have increased parking fees here, but the lighting and water drainage is bad. They should spend the money to improve the lot.

I would always rather take the train if I need to go to SF (besides for work) so I only drive if my destination is not convenient (i.e. sunset or Marina) or I don't want to be at the SF train station late at night. Therefore the signs have little impact on me. I do use the driving times, though.

I love Caltrain. It is convenient, fast and saves me gas money.

I need to choose a travel method before leaving the house. Give me the info on a web page.

Broken validating machines, infrequently schedule.

Ticketing service should be on train. Closer to entrances of train station.

Traveler information signs have minimal impact to commute decision making as people are already on the road. Find ways to engage and incentivize the commuter before the decision is made.

Is it possible to receive the information on the sign on my cell phone, so that I could check it before I leave my home by car?

I'm all for public transportation and think the more we educate people the better.

I would like to use my bike on Caltrain but am afraid there won't be room. Please consider increasing space for bikes

Caltrain takes you only to South SF. If you take MUNI after, you have another 20-30 minutes.

Caltrain should notify of late trains using twitter!

It is nice to take the train when needed-It is relaxing

They need bullet trains on weekends and one for weekday late nights!

Would really appreciate it [if] Caltrain and Muni Worked together for better connections - seems like Muni oblivious to Caltrain schedule and doesn't really care about service.

The MUNI is strongly affecting my decision to keep using Caltrain because I connect to MUNI in SF. MUNI is not a reliable mode. There is a consistent lack of communication on delays causing me to miss the Caltrain.

Need more frequent stops at some stations during commute hours. Greater accommodation for bicycles.

Give more breaks to Monday pass holders.

Appreciate the great conduction. They are very service oriented. Wish you would add more cars to trains to all have seats.

Trains are getting crowded. Add more cars to rush hour trains.

People already taking trains don't care [about] signs on the freeway. Think before you survey.

You might [try] simplifying the sign to something like take CATRAIN + Save \$200/day 15 minutes + 1 polar bear.

More bike cars. More new train. Cars old train. Cars are awful.

Need more cars on the trains

I love taking the train to Giants Games & It is convenient and efficient

I would be happy if there was more space for bikes on the train

More alternative commuter surveys please.

I choose to live in Redwood City because Caltrain services are frequent.

Have a 24/7 AM&FM radio station with traffic

Need the train to be on time more frequently because that is the way I get to work

I believe it was not mentioned but sometimes Caltrain is running late & it really kills time. Most of all makes me late to school.

Have only a regional pass, more express trains to main transportation hubs, better radio info, lower rates for commuters, access time 24/7 for public transportation

I hope you get more comments.

Trains are crowded

Please have more trains going south bound (morning & evening) & northbound (at 4:15). Thanks.

Caltrain is only good Mon-Fri during rush/commute hours. Otherwise car move convenient + faster.

Not sure if Caltrain does commuter checks but it should. I pay taxes on my transit subsidy but commuter check is tax-free. If Caltrain does take commute check, it should work w/ the county (San Mateo Co.) government to use them instead of lame transit subsidy, the county currently which pays for only 6 rides/mo.

Better paper on 10 day passes. Conductors-BADGE#423 needs to have more trust, faith in passengers who have problems with validators that don't work.

Don't understand sign

My walk to the train station about 1 mile so not only am I saving gas I am also getting exercise. The train is very convenient and dependable.

So San Francisco station is the pits. The message is don't come or come at your own risk!

Make sure that train sticks to schedule.

I would like the Redwood City (Pacific Shores) Shuttle to arrive earlier so I could take the South bound baby bullet trains. Put more bike cars on the train.

We don't want to raise the fare.

III.4.2. Millbrae Station Survey

I live in the Mission. I love Caltrain but I take the Muni 48 s to the Caltrain or from my school Muni 44 - Muni and Caltrain are not in sync - it is not convenient. SDUSD teacher so I travel to Burlingame dentist on Caltrain

While I use Caltrain 90% of the time, it's beginning to be hard to accept demands for fare increases when ridership is up, crowding more common, delays the norm. Don't even get me started re Bart.

Caltrain is unreliable

Doesn't the 101 have signs near Bay Bridge?

The TV commercial ad "go to the ballpark (SF Giants) by Caltrain" is really good. It helped me switch from driving to taking the train.

Keep trying! The first steps (learning how is hardest part) - my commute time is almost double but 'no stress' time to read the paper etc. makes it worth it. I'm filling this out on the train. I know what the signs are trying to communicate, yet find them unclear.

This sign is rarely on, so I have stopped looking for it. Would not help me decide to take the train with the present info. Sign not working 80% of the time.

Trying to move office near a Caltrain

Caltrain passes by a lot of stations including the one which is the closest to my home. And parking is not shaded. All of these are inconvenient.

I have a local commute, but always take the train or BART to the city for meetings.

I love taking Caltrain! More signs indicating north and south are needed. Inexperienced riders ask several times per week. No smoking on platform needs to be enforced in Millbrae, please.

Give more room for bikes. I do not ride one but if my friends who do get bumped they are late for work. Not good.

Thank you for making an effort to help us. Larger letters on signs is helpful for elderly.

I would always factor the time to look for parking and walking time from Caltrain

Lower fares, cheaper for people with low income

Caltrain rocks!

The sign is confusing because it looks like "45 min" is when the next train will arrive. Also, how do I know if the train will stop where I want to get off, at say Bayshore or San Bruno?

Run Caltrain on time, keep fare at this level

The new Caltrain cars do not provide space for feet or legs at seats. Patrons frequently must stand.

It would also be nice to have Bart and Caltrain synchronize schedules. At Millbrae for example BART arrives 9:53. South Caltrain leaves 9:55, not much time in between.

How about express Muni buses in SF that go directly to 4th and Townsend in AM and PM??

I believe driving times are unrealistic - too short relative to real traffic on 101.

Faster bullet trains...better connection with VTA. Fare by zone sucks. Caltrain can be late, slow or after Caltrain I miss the light train VTA in Mountain View.

Normally, if my destination to SF on weekends are not near the train station (Civic Center) then the info signs are not useful re: train usage

Keep fares low!

I don't have a car so I am not sure how useful my opinions are to you. I always take the train.

The 6:29am southbound from Millbrae is 90% on time - so I have not used the sign

This is a good effort to get more people off the road.

Reliability is an issue with Caltrain. Dated trains and poor maintenance have led to frequent breakdown-causing delays.

Check validator machines and have them fixed and clean toilet seats more often.

I love Caltrain!

I rarely drive. If I see the signs, it means I'm driving to and from work that day.

I've lived in several public transit-heavy towns - London, Paris - and find SF has a lot of work to do to live up to the promise transit-wise. Sign wouldn't help because decision would already be made.

Please keep Caltrain and Bart affordable to all. Please consider more bullet trains.

I generally decide whether to drive or take Caltrain before I leave the house.

Improve your safety record.

Transit fare is free from my job!

Caltrain staff are so mean, not always on time, the seats are dirty

Only thing that might make people able to easily change their mind to take the train when they are driving is signs from the freeway directing people to the location of the train station, as well as parking. Otherwise you're only reaching people who know the Caltrain system well.

The single thing that Caltrain can do is smaller trains more often with ticketing machines that aren't so slow to use.

I did not pay attention to the sign. I was not aware that there were these signs about traffic and train times.

Please keep the Hillsdale-Belmont bus SVC working after the pilot! It's great!

I wish the signs in the Caltrain stations were as informative as the freeway signs. When trains are late they range from no info to cryptic info

Good intent but I doubt it changes anybody's decision GOING south - there are not enough travel options on the other end; north more practical - but still people who take BART will take BART plus the wait factor.

I've never taken the train - schedule of trains? Costs vs. Bart? How to get to work from train? These keep me on Bart!

Too few express trains

If Muni could be made more reliable, I'd switch to Caltrain despite the higher expense. I tend to take BART to avoid Muni connection.

Gilroy should get more trains (both directions) trains should have Wi-Fi

Please coordinate Caltrain and Bart schedules! The project of taking Caltrain downtown is very much needed.

Fares high, trains crowded, parking should not cost, always late and crowded. Signs are confusing and vague

I noticed that at Millbrae station, Bart arrived from SF to Millbrae the passengers usually don't catch the Caltrain from Millbrae to San Jose because they have to go upstairs and go back down to catch the train. Also the Bart and Caltrain time schedule doesn't coordinate

There is no local bus to get me to work in less than 1 hr, car takes 15-20 min

I never realized the signs were intended to show us the difference in time between driving and train. I will use and pay better attention in the future.

It would be great if Caltrain schedule can be synchronized with VTA light rail schedule at Diridon and Tamien stations.

Public transit is great and I'm hoping that more people will take advantage of it! Thanks!

It's also important to show if there are train or Bart delays as well.

Some conductors on Caltrain are rude.

Signs should also be near on ramps save entering onto freeway.

The major reason I don't take Caltrain is it doesn't end/stop near Financial District. Mission District on Colen Park. Distance most important. (I commute to SF for pleasure and doctor appointments - not work.)

Where is the station? Chances of making train low!

Use Caltrain instead of Bart because Bart is filthy

The people you need to survey are on 101 - not on Bart/Caltrain

Scheduled SF Giants home game, 2 blocks from park vs. drive, parking expensive

Caltrain almost always slower on the southbound commute than by car

I didn't know until this survey that these signs are to encourage the use of public transportation. I thought they are just informing drivers about traffic conditions.

Caltrain should keep bathrooms cleaner. Some conductors are too loud and verbose. Access to BART garage in Millbrae is deficient and causes lost time and missed trains.

Have pertinent information on the electronic signs in the Caltrain station, especially when there is a delay.

The sign is good but it is too late to change while driving on the freeway.

I want to stab Muni in the eye

Either I am consciously making a choice to drive my car or am doing it because the Caltrain times do not sync up with my schedule. Thus, those signs rarely affect my commute.

The Caltrain is a great alternative.

Use solar power

This survey seems to be targeted towards people who drive to/from work. I've taken Caltrain for over 10 years and use a monthly pass.

We need more bicycle access to Caltrain! More safe routes to the stations and more bike cars on the trains.

Signs are a good idea when they work.

Keep the signs on - encourages mindfulness real time savings of taking Caltrain

Overall, I am satisfied. There are frequent Caltrain delays that can be overly frustrating.

I always take Caltrain unless I get a ride from a neighbor. Is the sign not used during a non-rush hour or it is not needed at that time?

Because I never would be able to find a parking space at Mountain View Caltrain Station

Overall Caltrain agents have been very courteous and helpful. Thanks! Caltrain carts could be and should be cleaned more often.

Until there is fast, reliable bus connection to the train, I will drive when my destination is not near the train station

Love the idea of the signs (now that I get it!) Would be wise to educate commuters as to their purpose. Maybe a billboard campaign? Or TV ads. Picture of stressed driver stuck in traffic seeing sign and a picture of same driver as she relaxes on the train.

For the distance I travel Caltrain is never faster

The signs cause traffic to move slower than it can since people slow down to see what it is saying. I do not know if it helps or causes more delay!

Clean the trains inside & out. Seats are very nasty.

I take Caltrain 6:15am to 8:00am arrival SSF almost every day 101-85-280, cross at San Bruno to 101 and if I take a car. Saw one (traveler info sign) on 280 but recognized not displaying transit info

I like taking the train to and from work. It takes planning to get used to the schedule and know options. I hate 101 and the dangers during commute hours.

The signs are helpful - it would be great if the sign indicated when it was last updated with info.

Train should be on time; Online train timing and arrival info daily; Increase frequency of trains; Improved public announcements

I've missed the SV train, drove to Mountain View, no parking drove to work. Parking car is always a concern, also finding station.

To be improved: seats are really dirty and should be cleaned, most conductors are rude 90% of ticket validators don't work, reclining tables and Wi-Fi would attract more commuters

Website with real time Caltrain information will be useful

My main gripe is that the VTA train at mountain view does not wait for the Caltrain when Caltrain is late by ~ 5 minutes

III.4.3. Online Survey

I'd use Caltrain if (1) the Transbay AC Transit bus stopped at a Caltrain station, and (2) Caltrain ran with greater frequency outside of commute hours.

I would prefer that the signs listed length of time from your current position to other cities. I see these signs on 101N going towards the Bay Bridge (example - Berkeley 15 minutes). I do not think that people will pull off the freeway and go to a Caltrain station to save 10 minutes on their commute because this info was posted on your signs.

The sign causes traffic jams from people slowing down to read it.

Easily displaying which exits along HWY 101 lead to Caltrain might help. I like what you are doing, and good luck!

If I am in Redwood City I use the signs decide if I take the San Mateo [Bridge] or continue on 101N to get to the east bay. Or if I'm already in San Francisco it just tells me how long it will take me from SF to get to Treasure Island/Oakland.

All of my questions were answer in this survey, so no comments at this time. Thank you.

Need vanpools/Wi-Fi busses/trains/whatever from Napa county to/from Bay area!!!!

More than Caltrain I would really like to see BART come to south bay

If I commuted in this direction, I would likely take the train as my commute by default anyway. I would likely use this resource to keep me informed.

Generally take 280 rather than 101 so don't see the signs mentioned. Live near Bayshore but I don't trust parking my car in the area nor do I want to be in that neighborhood late at night. Consequently I drive from the Balboa Park area to San Bruno then take the Caltrain to Palo Alto. Making the Bayshore and 22nd St. Caltrain stations safer would be wonderful!

California has ridiculous public transport system in the whole world. Rather because there are so many private operators offering halfway service to public, it is expensive & useless. Even developing countries have better, faster networks. The car companies targeting their own profits never let it improve. You have your own interest of putting up signs. How/where am I going to drop my car and travel by Caltrain just because some sign is telling me I can reach faster? And what after reaching particular train station? Walk down again? And be late for work? What about on the way back? How am I going to reach the station?

I no longer commute on Hwy 101, but when I did, I loved taking Caltrain.

Didn't read the intro. I commute from East Bay.

Looking for more off peak frequencies on Caltrain headed NORTH...after 9 P.M. Otherwise I think Caltrain RULES. It is way better than BART.

Don't charge for parking, it'll definitely be more appealing to take the train if I don't have to pay for parking...

I have seen similar signs in the Oakland area and sometimes they are difficult to read because the contrast between the letters and the background isn't very good.

It'd be nice to say what station the train leaves from.

I really don't like the idea of putting ads on this signs

Public transportation is unreliable & there are not enough express trains. Also, the transportation from the station is too limiting.

I don't think signs can influence someone to pull off the freeway and take transit instead. Consider the things you have to do if you change your plans and switch from the freeway to the train: 1. Get over to the exit lane in time to make the exit. 2. Locate the train station. 3. Find a parking spot. 4. Possibly pay for parking. 5. Buy a train ticket. 6. Figure out how to get to your office from the destination train station. 7. Figure out how to get back to the train station for the return trip. There are just too many variables involved. For a lot of people just getting from the station to the office will be enough of a deal-breaker. If the Bay Area had more ubiquitous transit options -- in terms of both reach and frequency -- it'd be easy to ditch your car mid-commute. Taking transit really is still a premeditated decision and can't be made impromptu. And once you have transit that's ubiquitous enough that you don't have to think so hard about whether you should use it, it'll be convenient enough that most people will probably opt to use transit rather than drive!

The commute between San Mateo and Millbrae is horrendous. The road is terrible, uneven, and has a lot of pot holes. Mostly northbound 101 just north of 3rd avenue and southbound from Broadway Avenue to poplar Avenue.

I've noticed these signs (at least the one southbound on 101) and have always been confused as to what exactly they mean. There needs to be more explanation--which I admit is incredibly hard in this scenario. Initially, I thought it was trying to convince drivers to exit NOW, take Caltrain, and arrive at their destination earlier. But this survey leads me to believe it is just convincing drivers to ditch their cars on a regular basis (i.e. the next day) and take Caltrain then as an alternative.

I wish it was easy to find fellow carpoolers to Palo Alto

The information signs are excellent, but they could be used far more widely and relate to info other than just Caltrain. Travel times are a great idea, but what about more Bay Bridge exit closures for example? It would seem that the signs should never be dark; there is a lot of info!

I love Caltrain, but getting from 4th and King to my apartment takes longer than driving the entire distance. Getting from San Carlos station on the shuttle to my office in Redwood Shores takes about the same time as driving the entire distance. So 2 hours and 5 minutes each way on Caltrain versus 45 minutes each way driving. I don't have enough time in the day to take Caltrain.

I wouldn't mind being contacted- this is the most AWFUL commute ever. The strip from Burlingame/Millbrae/San Bruno to San Mateo/92 and then to Redwood City is a NIGHTMARE in the morning. Drivers are absolutely insane. If it wasn't for my clients, I would not be driving or even working in San Mateo county. Caltrain is great, but it's hard to get from place to place and not close to my work near Hillsdale. It's awesome when I work in Redwood City though, but I have had a lot of problems parking near 22nd Street in SF.

I take Caltrain as often as possible, but only when I have time. The number of schedule options (times & stations), as well as the distance to the stations, result in a trip that takes much longer than traveling by car. Also, the arrival times don't fit well with my work schedule - I either arrive earlier than I'd like, or later. The last point that keeps me from taking the train is cost. For medium length trips, the cost of a ticket is just as expensive as the cost of gas consumed. Of course this doesn't factor in insurance or maintenance, but those don't count if you need to have a car for other reasons.

I hate the bay bridge! I have no idea why it is so much worse than other commutes or so unpredictable. The 880 route is particularly bad with only 1 fastrak lane when everyone tries to merge into that one lane causing it to be very slow around the bus lane split when the fastrak lanes from the maze are flying through!

I would like to be able to purchase 3 months of mass transit at a discount.

The sign should say when was it last updated at the Top Right corner

The electronic signs are very helpful. I actually found out about 511.org and the carpool/vanpool information via these signs. I am now looking into carpooling opportunities in my region.

Most South Bay work locations are a long distance from Caltrain stations and shuttles, when available are slow. The best way to increase ridership from SF to south bay is to reduce the time it takes to get from the station to work. e.g. 1) Provide more secure bike storage at stations 2) Provide timed transfers with VTA bus system 3) Work with local employers to improve efficiency of shuttle services. 4) Provide secure overnight car parking, so people can leave cars and get Caltrain home.

The signs for the train along the highway are way too late to influence a decision about taking the train vs. driving. I have already committed to the drive once I am that far in my commute that I see the signs.

Please expand your train or Bart or bus routes. There is a bus terminal several blocks north of my office but they don't have a stop at the terminal. I would have to get off a mile away, walk pass the terminal on my way to work. We need public transportation to reach SFO North Cargo Area.

The signs are a good idea, but I was confused the first time I saw it. I'm still a bit baffled if I scan it quickly -- doing the math while driving in traffic is almost "too hard", although I'm loath to admit it. It's such a good idea!

We generally like Caltrain, but ssf is not a bullet stop, so even if there is a Caltrain close by, we still commute to Millbrae. Also, the shuttles meeting the train in mtn. view are not reliable. If the train is delayed, there is also no shuttle to get to work. The train station in ssf is a joke (unsafe, dusty, not a major stop). But, it's nice to be able to go to Millbrae for the free parking and bullet trains.

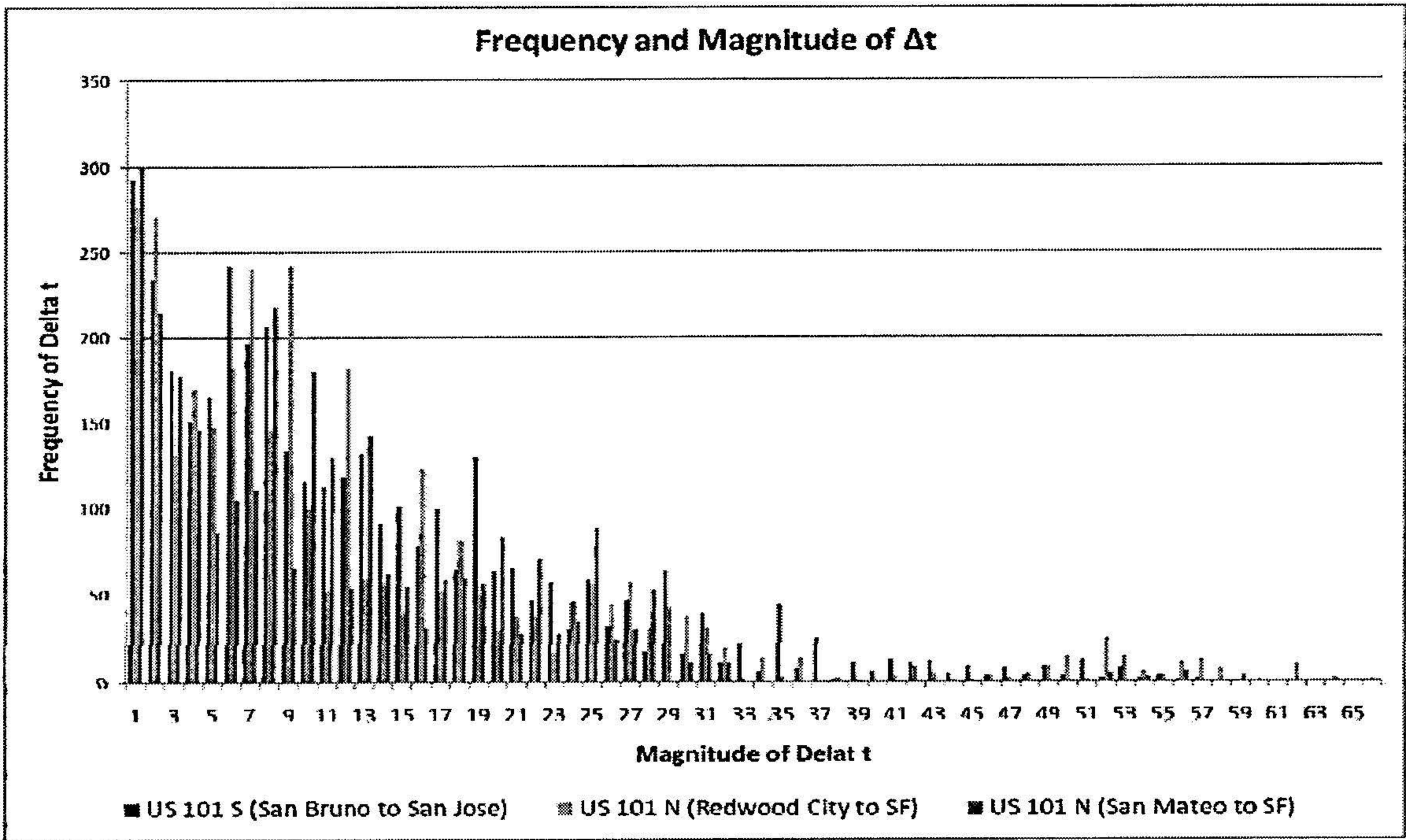


Figure IV-1. Frequency and magnitude of Δt

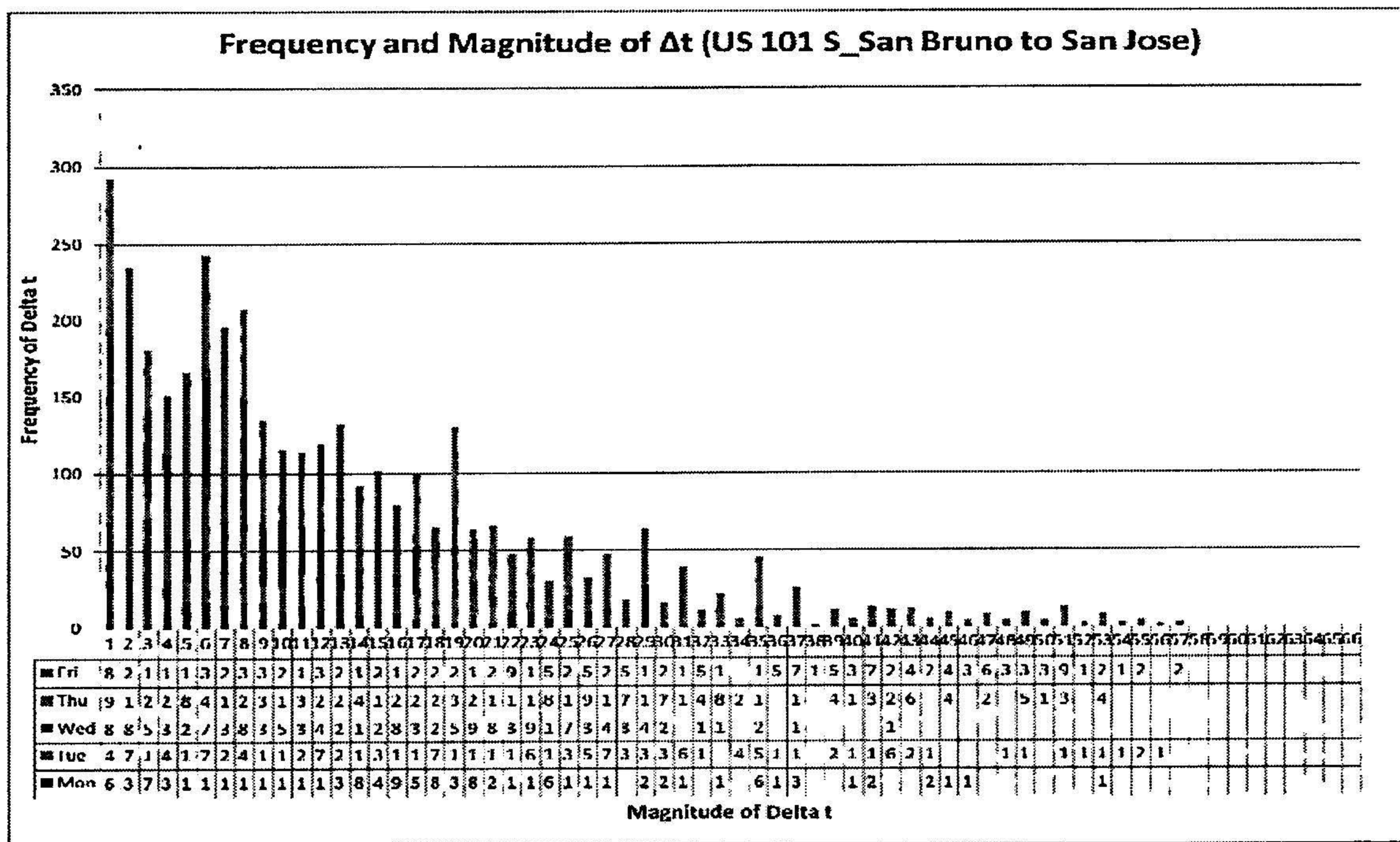


Figure IV-2. Frequency and magnitude of Δt on weekdays (CMS 122/US 101 S San Bruno to San Jose)

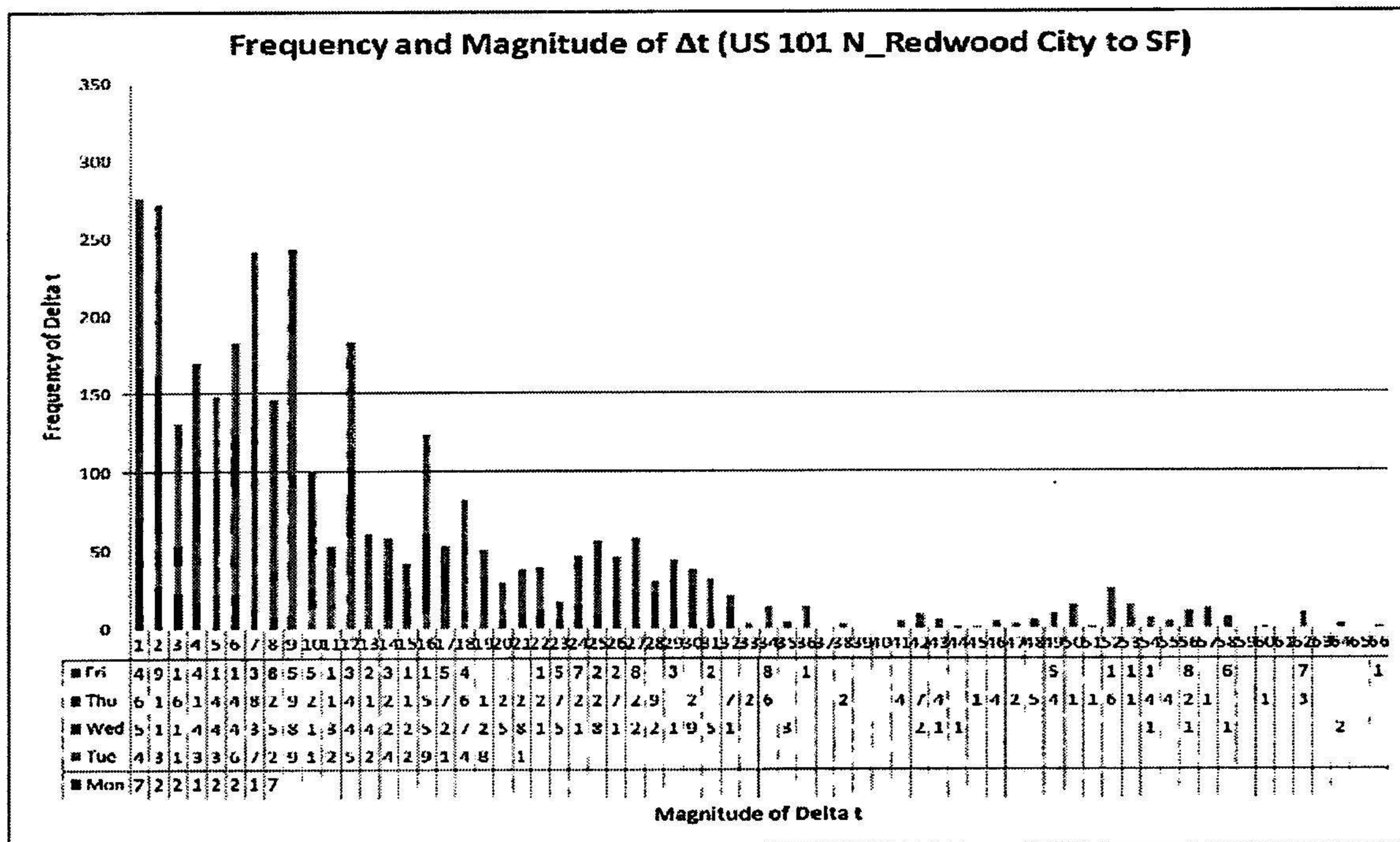


Figure IV-3. Frequency and magnitude of Δt on weekdays (CMS 123/US 101 N Redwood City to SF)

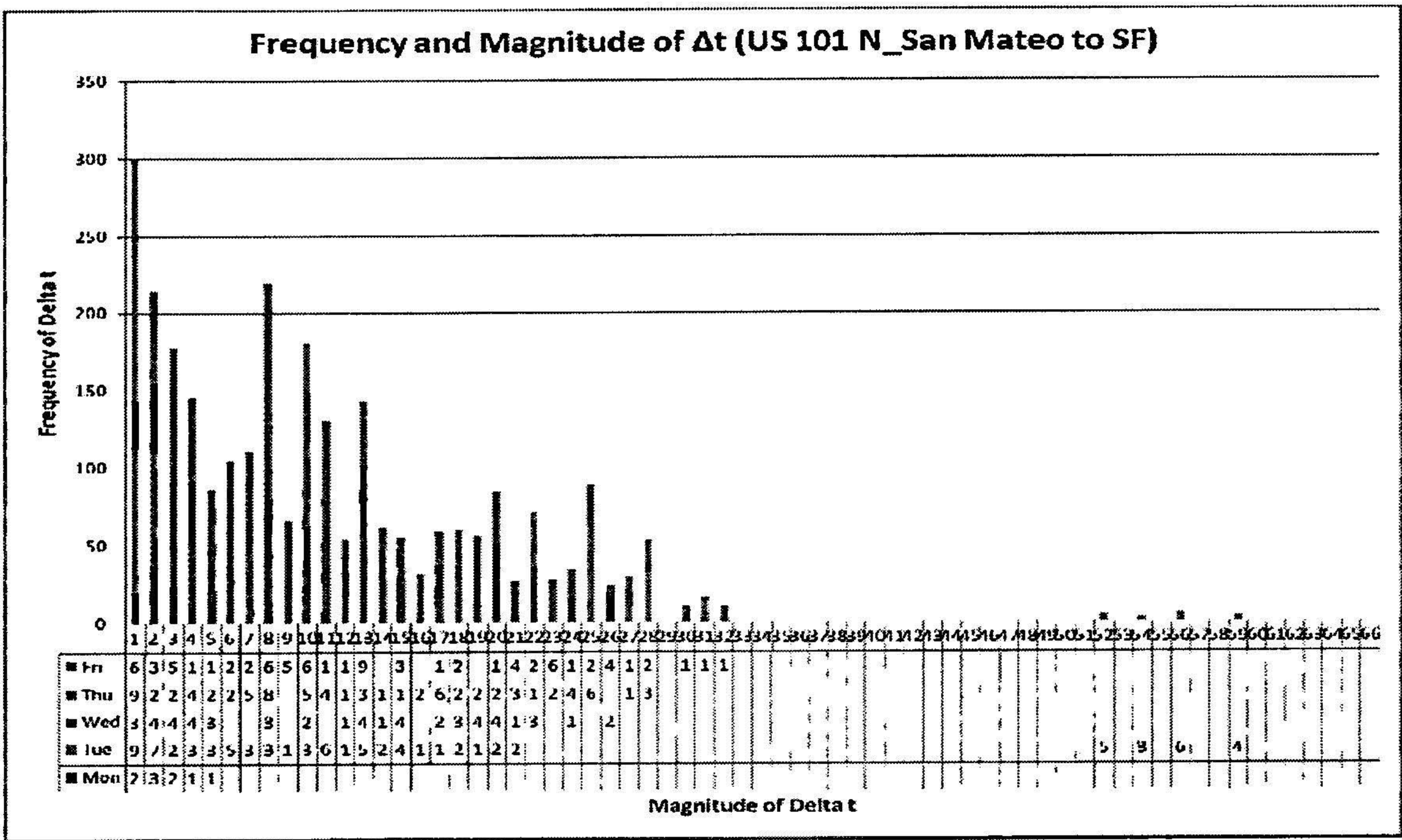


Figure IV-4. Frequency and magnitude of Δt on weekdays (CMS 012/US 101 N San Mateo to SF)