Oregon Regional Intelligent Transportation Systems (ITS) Integration Program

Final Phase III Report:

I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project

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16. Abstract This report presents the results of the evaluation of the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project, a cooperative project between the Oregon Department of Transportation (ODOT) and the City of Portland to integrate incident management along a high-volume freeway-arterial corridor south of downtown Portland (defined as the "Study Area"). The evaluation approach was to collect data to assess the impact of the traffic/incident management system on customer satisfaction, system efficiency, and traveler mobility in the corridor during incident conditions. A panel survey of drivers who commute northbound in the Study Area was established to which to administer a series of "incident" surveys to gain perspective on their perceptions of and satisfaction with traffic conditions in the corridor during incidents. To assess system efficiency and traveler mobility, ODOT provided volume, speed data, and secondary incident information for I-5, and TriMet (the public transit provider in Portland) provided speed data from bus probes along Barbur Boulevard.

The results of the customer satisfaction study showed that although customer satisfaction ratings of traffic conditions in the corridor during incidents have not significantly improved since the incident management system was deployed, reported commute times during the "After" incident were shorter than reported commute times during the "Before" incident. This response occurred despite the fact that the "After" incident was a much more serious crash, blocked more lanes, and lasted longer than the "Before" incident. In addition, reported commute times of those who took Barbur Boulevard as an alternate route during the incidents were shorter than commute times reported by those who stayed on I-5, indicating that the incident management system was effective at getting commuters around the incidents (on Barbur Boulevard) and to their destination more quickly that staying on I-5.

Results of the mobility and efficiency study showed that even during major incidents, when capacity on I-5 was severely reduced (as evidenced by low volumes on I-5 during the incidents); speeds were significantly lower than normal; speed variability was significantly higher than normal; and that traffic performance on Barbur Boulevard was only moderately impacted by the incident, with speeds operating at 81 percent of "normal" or better. Moreover, average speeds on Barbur Boulevard during the two major "After" incidents fully recovered by the second 30-minute time period following clearance of the incidents, while average speeds on Barbur Boulevard had not fully recovered during the relatively minor "Before" incident, indicating that the Barbur Boulevard incident management plan was effective at moving traffic along Barbur Boulevard.

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ABBREVIATIONS

ATMS	Advanced Traffic Management System
CBD	Central Business District
CCTV	Closed-Circuit Television
I-	Interstate
ITS	Intelligent Transportation Systems
mph	Miles Per Hour
MOEs	Measures of Effectiveness
ODOT	Oregon Department of Transportation
SAIC	Science Applications International Corporation
TriMet	Tri-County Metropolitan Transportation District
USDOT	United States Department of Transportation
VMSs	Variable Message Signs
VMT	Vehicle Miles Traveled
vphpl	Vehicles Per Hour Per Lane

EXECUTIVE SUMMARY

INTRODUCTION

This document presents the evaluation strategies and objectives, the data collection methodologies, and the results of the evaluation of the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project in Portland, Oregon.

System Description

The City of Portland and Oregon Department of Transportation (ODOT) implemented cooperative strategies to deploy Intelligent Transportation Systems (ITS) on a parallel freeway/arterial corridor. As part of the regional advanced traffic management system (ATMS) program, this incident management system integrates traffic surveillance and control devices along a high-volume stretch of Interstate 5 (I-5) and a parallel arterial street, Barbur Boulevard, south of downtown Portland. The I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project integrates and facilitates cooperative use of various ITS devices, including variable message signs (VMSs), closed circuit television cameras (CCTV), ramp meters, and traffic signals to help minimize delay when incidents occur on either roadway. The project allows ODOT and the City of Portland to better exchange information and use various ITS devices to provide improved information and mobility to motorists. This integration also allows for multi-agency traffic-responsive corridor management that includes emergency pre-emption and transit priority treatments.

Hypotheses

The following hypotheses were developed for testing in the evaluation of the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project:

- Improved integration with multi-jurisdictional signal systems will increase corridor efficiency without expanding existing roadways.
- The project will reduce delay and travel times in the corridor during incident conditions, thereby improving traveler mobility.
- Through improved incident management, the project will reduce accident risk during incident conditions.
- Increased travel time reliability and decreased delays during incident conditions will improve customer satisfaction.

Evaluation Objectives

The purpose of the evaluation of the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project is to collect and analyze data related to a change in system efficiency, traveler mobility, safety, and customer satisfaction as a result of the project. The objectives of the evaluation are as follows:

- Assess customer satisfaction in the corridor during incidents.

- Assess corridor efficiency during incidents.

- Assess traveler mobility in the corridor during incidents.
- Assess traveler safety in the corridor during incidents.

Evaluation Approach

The approach to the I-5/Barbur Boulevard evaluation was three-fold and involved the following elements:

- Administration and analysis of “Before” and “After” incident questionnaires to survey panel members.
- Analysis of traffic volumes, speeds, and travel times along I-5 and Barbur Boulevard during incidents.
- Analysis of secondary incidents in the corridor.

SUMMARY OF FINDINGS

The findings of this evaluation are summarized here according to each of the four evaluation objectives:

- Assess customer satisfaction in the corridor during incidents.
- Assess corridor efficiency during incidents.
- Assess traveler mobility in the corridor during incidents.
- Assess traveler safety in the corridor during incidents.

Assess Customer Satisfaction in the Corridor During Incidents

Customer satisfaction was assessed through the use of a panel survey. Three “incident” surveys were administered throughout the course of the evaluation: (1) for an incident that occurred before system deployment (i.e., Incident 1); (2) for an incident that occurred around the time of system deployment (i.e., Incident 2); and (3) for an incident that occurred after system deployment (i.e., Incident 3). The responses to the three surveys were compared to determine if the system had any impacts of customer satisfaction during incident conditions.

While the characteristics of Incident 1 and Incident 2 were very similar, the characteristics of Incident 3 were very different. Incidents 1 and 2 were multi-vehicle crashes (one injury, one non-injury) that occurred around 7 a.m. and lasted for about 30 minutes. Incident 3 involved a pedestrian fatality, occurred before the morning peak period, and lasted through most of the morning peak. Therefore, while the responses to the incident questionnaires may reflect a change in customer perceptions and satisfaction as a result of the system, the responses may also reflect the differences in the types of incidents that occurred.

Driver Behavior During Incidents

While the large majority of respondents reported learning about Incidents 1 and 2 after leaving home, the majority of respondents reported learning of Incident 3 before leaving home. This may be a result of the magnitude of Incident 3 as compared to Incidents 1 and 2. In addition, the early occurrence of Incident 3 (5:30 a.m.) may have given the media more time to broadcast information related to the incident.

More respondents reported taking alternate routes when they learned of the Incident 3 as compared to the other two incidents. At the same time, fewer respondents reported doing the "same as usual" during Incident 3 as compared to the other two incidents (results were significantly different for those learning of the incidents after leaving home, but not for those learning of the incidents before leaving home). When asked specifically about their use of Barbur Boulevard to avoid the incidents, more respondents reported using Barbur Boulevard as an alternate route during Incident 3 than did during Incident 1; and likewise, fewer respondents reported staying on I-5 during Incident 3 than did during Incident 1.

All of these results could indicate that the VMSs were effective at getting commuters to take alternate routes (including Barbur Boulevard); however, the result could also be due to more commuters being aware of Barbur Boulevard as an alternate, as well as a result of the timing and nature of Incident 3.

Driver Perception of and Satisfaction with Traffic Operations During Incidents

As a whole, respondents perceived their commute times to be shorter during Incident 3 than during Incident 1, despite the dramatic difference in the magnitude and scope of Incident 3 as compared to Incident 1. Further, respondents who took Barbur Boulevard as an alternate route tended to perceive less additional time needed to commute than those respondents who stayed on I-5 during Incident 3 as compared to during Incident 1. These results suggest that the system was efficient in moving motorists around the incident and to their destination more quickly.

Respondents' ratings of traffic conditions along Barbur Boulevard during incidents varied only slightly across the three incident surveys. It did appear that the ratings for traffic signal operations tended to increase across the three surveys. However, pair-wise t-tests of the average ratings showed no significant differences between average ratings for Incident 1 as compared to Incident 2, for Incident 1 as compared to Incident 3, or for Incident 2 as compared to Incident 3.

For those respondents who stayed on I-5 during the incidents, the same result was found. There were only slight variation in the distribution of ratings across the three surveys, and a pair-wise comparison of the average ratings showed no significant difference in average ratings between any of the surveys.

Driver Use of Traffic Information to Make Commute Decisions During Incidents

Respondents' reported use of information varied only slightly across the three incident surveys. While more respondents tended to report receiving some sort of information across the three surveys, the distributions of responses were not significantly different.

The large majority of respondents who learned of the incidents before leaving home had heard about the incident on television or radio reports. While most of those respondents who learned of the incidents after leaving home heard about the incidents on radio reports, many never received any information about the incidents (although their commute was affected). Interestingly, many fewer respondents had no information about Incident 3 (28 percent had no information) than did for Incident 1 (60 percent had no information – a significant result).

Assess Corridor Efficiency During Incidents

Corridor efficiency, or throughput, was measured using freeway volumes. Originally, the Evaluation Team had hoped to use traffic counts from road tubes placed along Barbur Boulevard, but no incidents warranting use of the incident management system occurred during the month-long period in which the road tubes were in the field. Therefore, no volume data from Barbur Boulevard were available for use in the evaluation.

Assess Traveler Mobility in the Corridor During Incidents

Traveler mobility was assessed through traffic volumes and speeds along I-5 and through speeds from bus probes along Barbur Boulevard. The results showed that, even during major incidents, when capacity on I-5 was severely reduced (as evidenced by low volumes on I-5 during the incidents), speeds were significantly lower than normal, and speed variability was significantly higher than normal, yet traffic performance on Barbur Boulevard was only moderately impacted by the incidents, with speeds operating at 81 percent of "normal" or better. Moreover, average speeds on Barbur Boulevard during the two major "After" incidents fully recovered by the second 30-minute time period following clearance of the incidents, while average speeds on Barbur Boulevard had not fully recovered during the relatively minor "Before" incident, indicating that the Barbur Boulevard incident management plan was effective at moving traffic along Barbur Boulevard.

This result is in line with the results of the customer satisfaction study. The mobility data show that traffic conditions on I-5 during the incidents were severely degraded, while traffic conditions on Barbur Boulevard were only moderately degraded during the incidents. Interestingly, drivers' perceptions of the traffic conditions reflected this, as drivers on I-5 were less satisfied with traffic conditions during incidents than drivers traveling on Barbur Boulevard during the incidents.

Assess Traveler Safety in the Corridor During Incidents

There were insufficient data to support an analysis of traveler safety in the corridor. First, there were too few incidents that occurred in the Study Area during the evaluation period. Second, there were no secondary incidents that occurred during the incidents used for the evaluation. To support an analysis of secondary incidents, there would need to be many incidents with which to analyze (both before and after system deployment).

CONCLUSIONS

Based on the evaluation results, the following conclusions are made:

- More respondents used Barbur Boulevard as an alternate route after implementation of the incident management system:
  - More respondents tended to use Barbur Boulevard (or other alternate routes) during Incident 2 as compared to Incident 1, and during Incident 3 as compared to Incident 2. Likewise, fewer respondents reported staying on I-5 during Incident 2 as compared to Incident 1, and during Incident 3 and compared to Incident 2.
  - More respondents, who learned of the incidents *after* leaving home, tended to take alternate routes to avoid Incident 3 than did to avoid Incident 1 (60 percent took alternate routes during Incident 3 as compared to 40 percent during Incident 1). Further, fewer respondents, who learned of the incidents *after* leaving home, tended to do the "same as usual" (in terms of their commute) during Incident 3 than during Incident 1 (only 36 percent did the "same as usual" during Incident 3 as compared to 58 percent during Incident 1).
- It appears that the incident management system was effective at getting some commuters around the incident and to their destination more quickly than without:

  - More respondents reported additional commute times of more than 15 minutes during Incident 1 than during incident 3; likewise, fewer respondents reported the shortest additional commute times (up to 10 minutes) during Incident 1 than during Incident 3. As a whole more respondents perceived their commute times to be shorter after the incident management system was implemented, despite the magnitude of Incident 3 as compared to Incident 1.
  - During Incident 3, more respondents who stayed on I-5 reported the longest additional commute times (more than 15 minutes) as a result of the incident as compared to those who took Barbur Boulevard as an alternate route (63 percent for those on I-5 versus only 25 percent for those on Barbur); likewise, more respondents who took Barbur Boulevard as an alternate route reported the shortest additional commute times (up to 10 minutes) as a result of the incident as compared to those who stayed on I-5 (58 percent for those who took Barbur versus 21 percent for those who stayed on I-5). Many more respondents who took Barbur Boulevard to avoid the Incident 3 (after implementation of the incident management system) reported shorter commute times than those who stayed on I-5, while many more respondents who stayed on I-5 during Incident 3 reported the longest commute times.

- Satisfaction ratings for traffic conditions on I-5 and Barbur Boulevard were not significantly different across the three incident surveys. However, response trends tended to suggest that respondents' satisfaction ratings for Barbur Boulevard had increased across the three surveys. This was especially true for the satisfaction ratings of *traffic signal operations*, which indicated that commuters may perceive the positive impacts of the incident management signal timing "flush" plan. More surveys during more incidents would be needed to further test for the significance of this result.
- Respondents' ratings of the timeliness, accuracy, and usefulness of the traveler information they received regarding the incidents were not significantly different across the three incident surveys.
- The results of the mobility analysis suggest that the incident management system was successful at moving assumed large volumes of traffic along Barbur Boulevard during the After incidents:
  - While traffic conditions on I-5 were severely degraded during the After incidents (significantly reduced capacity and speeds, with significantly higher speed variabilities), traffic conditions on Barbur Boulevard were only moderately degraded during these major incidents, with speeds operating at 81 percent or "normal" or better.
  - In addition, speed variabilities on I-5 and Barbur Boulevard during the incidents indicated that traffic flow on Barbur Boulevard was much less variable than that on I-5.
- The customer satisfaction data support the mobility data in that drivers on I-5 during the incidents were far less satisfied with traffic conditions during the incidents than drivers traveling on Barbur Boulevard. This result further supports the idea that the incident management system was efficient at moving drivers down Barbur Boulevard during the incidents when freeway traffic was moving at significantly slower rates.

Based on the results of this evaluation and the conclusions drawn, the hypotheses stated up front have either been supported by the results of the evaluation, have not been supported by the results of the evaluation, or are inconclusive at this time:

- **Hypothesis: Improved integration with multi-jurisdictional signal systems will increase corridor efficiency without expanding existing roadways.** *The hypothesis is inconclusive due to insufficient volume data on Barbur Boulevard.*
- **Hypothesis: The project will reduce delay and travel times in the corridor during incident conditions, thereby improving traveler mobility.** *The hypothesis is supported through the customer satisfaction surveys; more respondents who took Barbur Boulevard reported a shorter additional commute time during the incidents than those who stayed on I-5, and more respondents who stayed on I-5 reported the longest additional commute times than those who took Barbur Boulevard. In addition, the hypothesis is supported through the mobility analysis – while traffic conditions were significantly degraded along I-5 during all incidents, traffic conditions on Barbur Boulevard were only moderately degraded. In addition, the traffic conditions on Barbur Boulevard recovered at a rate faster during the major "After" incidents than during the relatively minor "Before" incident.*
- **Hypothesis: Through improved incident management, the project will reduce accident risk during incident conditions.** *This hypothesis is inconclusive. There were not enough data available for the analysis.*
- **Hypothesis: Increased travel time reliability and decreased delays during incident conditions will improve customer satisfaction.** *The hypothesis is inconclusive with the current data; while the response trends appear to show an increase in satisfaction with traffic volume, speed, and traffic signal operations on Barbur Boulevard across the three incidents, the changes were not significantly different. More surveys of more incidents would be needed to determine the impact of the system on customer satisfaction ratings.*

1. INTRODUCTION

This report describes the evaluation of the Interstate 5 (I-5)/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project, a cooperative project between the Oregon Department of Transportation (ODOT) and the City of Portland Department of Transportation. This report describes the evaluation approach, findings, and conclusions of the evaluation.

1.1 BACKGROUND

The Portland metropolitan region has a long history of investing in multi-modal transportation solutions to enhance mobility and maintain the region's livability standards and reputation.[1] As a complementary means to enhance the efficiency and safety of travel, the Portland region has been actively involved in the planning and deployment of Intelligent Transportation Systems (ITS) infrastructure since the early 1990s. Considering a forecast regional population increase of nearly 500,000 residents by the year 2040, and a related increase of 55 percent in vehicle miles traveled (VMT) on regional transportation facilities in the next 20 years, integrated ITS deployment is considered critical in meeting future transportation demands.[2]

Portland's commitment to ITS as a solution to transportation problems is evidenced by *TransPort 2000*, a regional ITS plan consisting of 16 integrated and interoperable projects.[2] *Transport 2000* includes significant bi-state, urban-rural, and multi-modal components. This project plan represents the joint planning efforts of a regional committee consistent with statewide and regional planning processes in Oregon and Washington. The *TransPort 2000* projects build on the region's significant existing ITS infrastructure investment and fill current gaps in planning, emergency management, traveler information, and parking subsystems. When deployed, the projects will complete the region's core ITS infrastructure, consistent with the U.S. Department of Transportation's (USDOT's) national ITS goals for safety, efficiency, productivity, mobility, and environmental improvements.[2]

1.2 PROBLEM STATEMENT

I-5 is the major north-south freeway corridor on the West Coast. In Portland, I-5 is also a major commuter route into and out of the central city. Barbur Boulevard is a major arterial that parallels I-5 from downtown Portland to the City of Tigard. I-5, between I-405 to the north and the Portland city limits to the south, carries 120,000 to 140,000 vehicles daily. Barbur Boulevard carries 25,000 to 35,000 vehicles per day and serves nine bus lines along certain sections.[3]

The I-5/Barbur Boulevard corridor is a vital link between the City of Portland Central Business District (CBD) and suburban areas to the south. This corridor serves heavy commuter travel, interstate travel, and has key transit connections between the CBD and suburban areas to the south, with a transit park-and-ride station at Capitol Highway. The I-5 corridor currently experiences significant congestion, especially during the peak travel periods, and has been the site of numerous incidents. In 2000, there were 201 collisions on I-5 in the Study Area with 27

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[1] Tri-Met 5-Year Intelligent Transportation System Plan Final Report, published by PB Farradyne and Battelle, February 2000.

[2] *TransPort 2000*, A FY 2000 Federal Transportation Appropriations Bill Project Request, June 15, 2001.

[3] William C. Kloos, P.E., Dennis J. Mitchell, P.E., James M. Peters, P.E., Willie K. Rotich, P.E., Creating a Freeway/Arterial Concept of Operations Plan in Portland, **http://ite.org/Conference/papers/CB05B0603.pdf**.

occurring during the AM peak and 16 during the PM peak. During incidents that occur on I-5, travelers frequently use Barbur Boulevard as a diversion route. Implementation and integration of the traffic management field devices in the corridor will allow the City of Portland and ODOT to coordinate their response to incidents and better manage traffic that ends up diverting to Barbur Boulevard during incidents.

1.3 DESCRIPTION OF PROJECT

The City of Portland and ODOT implemented cooperative strategies to deploy ITS on a parallel freeway/arterial corridor. As part of the regional advanced traffic management system (ATMS) program, this incident management system integrates traffic surveillance (Figure 1-1) and control devices along a high-volume stretch of I-5 and a parallel arterial street, Barbur Boulevard, south of downtown Portland.

During an incident on I-5, freeway traffic tends to divert to Barbur Boulevard in an attempt to bypass the resulting congestion. The project goal is to better manage this diverting traffic and maximize the vehicle throughput on Barbur Boulevard.[4]

Figure 1-1. CCTV View of I-5 at Barbur Boulevard.

The I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project integrates and facilitates cooperative use of various ITS devices, including variable message signs (VMSs), closed circuit television cameras (CCTV), ramp meters, and traffic signals to help minimize delay when incidents occur on either roadway. The project allows ODOT and the City of Portland to better exchange information and use various ITS devices to provide improved information and mobility to motorists. This integration also allows for multi-agency traffic-responsive corridor management that includes emergency pre-emption and transit priority treatments.

Even with the implementation of incident management strategies in this corridor, other freeways are still the preferred alternate routes because the arterial routes cannot carry the same traffic volumes as the freeways. Message signs in advance of this corridor on I-5 northbound and southbound, I-84 westbound, and US 26 eastbound recommend other freeways as alternate routes to I-5 during an incident on this section of I-5. Even with these messages, Barbur Boulevard may be the most viable route for some motorists, and they will take Barbur to avoid the incident on I-5. By integrating with the I-5/Barbur Boulevard Parallel Corridor Traffic Management Project, ODOT and the City of Portland can coordinate their responses by cooperatively adjusting signal timing, managing the response, and providing information to motorists.[4]

[4] I-5/Barbur Boulevard Incident Management Plan: Users Manual Version 1. DKS Associates, Oregon Department of Transportation, City of Portland, Portland, Oregon, October 2002.

The project limits are Interstate 405 (I-405) junction to the north and the Portland/Tigard city limits on the south (near Exit #294). A map of the area just south of downtown Portland is shown in Figure 1-2 (the Study Area is designated by the box).

The incident management system on the I-5/Barbur Boulevard Corridor includes two operation centers – one at ODOT and one at the City of Portland. In addition, the Tri-County Metropolitan Transportation District (TriMet) transit buses act as traffic probes for congestion information on Barbur Boulevard.

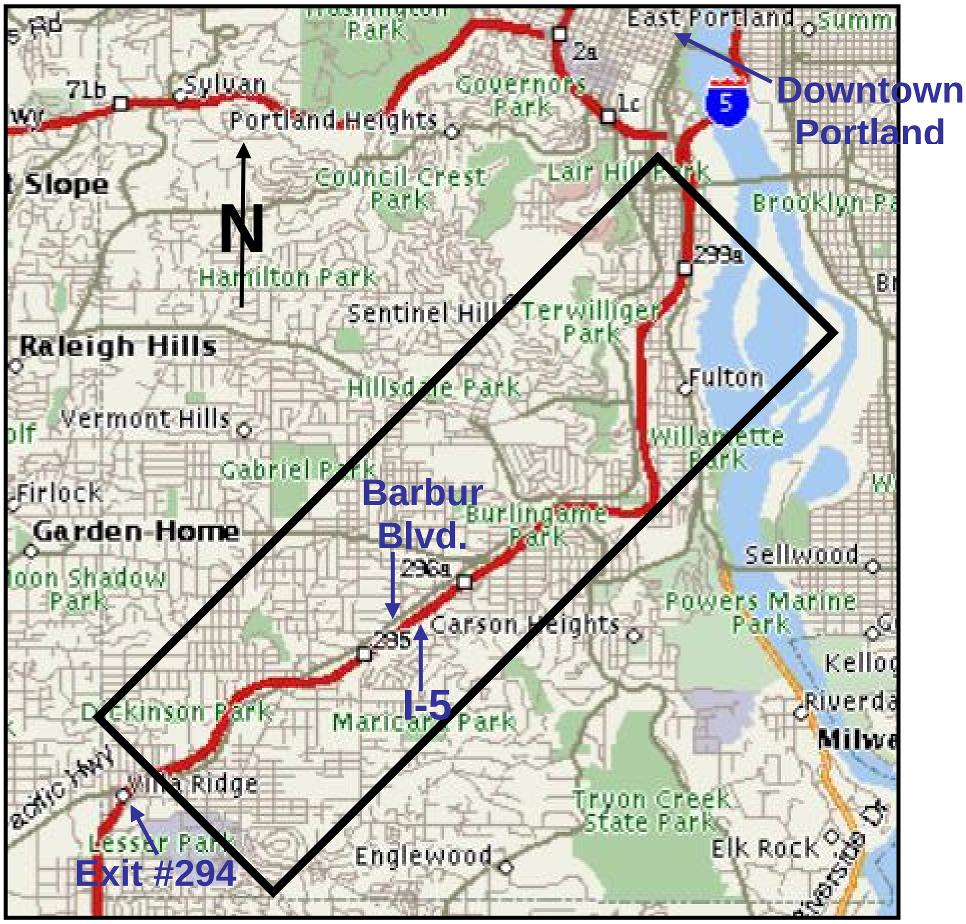


Figure 1-2. Map of I-5/Barbur Boulevard Study Area.

1.4 EVALUATION OBJECTIVES

The purpose of the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project evaluation is to collect and analyze data related to a change in system efficiency, traveler mobility, safety, and customer satisfaction as a result of the project. The objectives of the evaluation are as follows:

- Assess customer satisfaction in the corridor during incidents.
- Assess corridor efficiency during incidents.

- Assess traveler mobility in the corridor during incidents.
- Assess traveler safety in the corridor during incidents.

1.5 HYPOTHESES AND MEASURES OF EFFECTIVENESS

For each evaluation objective, a corresponding hypothesis was developed. To test the hypotheses, measures of effectiveness (MOEs) were identified. The objectives, associated hypotheses, and corresponding MOEs are listed in Table 1-1.

Table 1-1. Hypotheses and MOEs for the Evaluation of I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project

Objective	Hypothesis	MOE
Assess customer satisfaction in the corridor during incidents.	Increased travel time reliability and decreased delays during incident conditions will improve customer satisfaction.	• Traveler perceptions during incident conditions. • Customer satisfaction ratings during incident conditions.
Assess corridor efficiency during incidents.	Improved integration with multi-jurisdictional signal systems will increase corridor efficiency during incidents without expanding existing roadways.	• Vehicle throughput during incident conditions.
Assess traveler mobility in the corridor during incidents.	The project will reduce delay and travel times in the corridor during incident conditions, thereby improving traveler mobility.	• Travel time for main-line vehicles during incident conditions. • Travel time reliability for mainline vehicles during incident conditions.
Assess traveler safety in the corridor during incidents.	Through improved incident management, the project will reduce accident risk during incident conditions.	• Secondary incidents in the corridor.

1.6 GENERAL EVALUATION APPROACH

The approach to the I-5/Barbur Boulevard evaluation was three-fold and involved the following elements:

- Administration and analysis of “Before” and “After” incident questionnaires to survey panel members.
- Analysis of traffic volumes, speeds, and travel times along I-5 and Barbur Boulevard during incidents.
- Analysis of secondary incidents in the corridor.

The results of the customer satisfaction analysis are discussed in Section 2 and the results of the efficiency and mobility analysis are discussed in Section 3.

Please note, there is no safety analysis presented due to insufficient data for the analysis. (There were too few primary incidents that occurred during the course of the evaluation, and there were no secondary incidents that occurred during the incidents analyzed for this evaluation.)

2. CUSTOMER SATISFACTION ANALYSIS

It was hypothesized that the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project would increase corridor efficiency and travel time reliability during incident conditions, thereby resulting in an improvement in customer satisfaction. The objectives of the customer satisfaction study were to:

- Assess driver behavior during incidents.
- Assess driver perception of and satisfaction with traffic operations during incidents.
- Assess driver use of traffic information to make commute decisions during incidents.

This section describes the survey approach, respondent characteristics, and the findings from the "Before" and "After" incident surveys. This section is organized as follows:

- 3.1 Survey Approach
- 3.2 Findings
- 3.3 Summary

2.1 SURVEY APPROACH

The approach to surveying customers regarding the I-5/Barbur Boulevard Parallel Corridor Traffic Management Project was a panel survey. A survey panel of downtown Portland commuters was established in Phase II of this evaluation. Survey panel members were recruited through their employers. Ten employers (including private companies, universities, and public agencies) agreed to allow their employees to participate. Overall, 1,334 individuals (about 4 percent of the employees that could have potentially responded to the initial survey) responded by going to the designated Website and answering the qualifying questions. Of these, 573 (43 percent) qualified to participate in the panel survey based on their commute patterns. Of those who qualified, 460 (80 percent) completed the initial "baseline" questionnaire. The results of this baseline questionnaire are presented in the Phase II report.[5]

After administering the baseline questionnaire, three subsequent questionnaires were administered to the panel. These questionnaires were administered immediately following a major incident on northbound I-5 that occurred during the morning commute in the I-5/Barbur Boulevard Study Area. These questionnaires, referred to as "incident" questionnaires, are defined as follows:

- Incident 1: Northbound I-5 at Taylors Ferry
- Incident 2: Northbound I-5 at Terwilliger
- Incident 3: Northbound I-5 at Macadam

[5] Oregon Regional Intelligent Transportation System (ITS) Integration Program Final Phase II Report, Federal Highway Administration, U.S. Department of Transportation, July 12, 2002.

The objective of the incident questionnaires was to gain insight into the commute patterns of drivers during incidents based on their stated response following the incidents (as opposed to asking them what they generally do during incidents). The responses from incidents occurring before system deployment could then be compared to responses from incidents occurring post deployment to determine whether or not the system had an impact on driver behavior, perceptions, and satisfaction. Table 2-1 summarizes the characteristics of the three incidents. The details of each incident are discussed in Sections 2.1.1 through 2.1.3.

Table 2-1. Summary of Incidents Occurring in Study Area

Incident #	Date	Type	# Lanes Blocked	Time	Duration	Survey Period
1	Tuesday Dec 3, 2002	3-vehicle Non-injury crash	1 left	7:05 a.m.	37 min	Dec 4-6
2	Tuesday Apr 8, 2003	4-vehicle Injury crash	2 left	7:02 a.m.	31 min	Apr 8-11
3	Tuesday Aug 26, 2003	Vehicle-pedestrian Fatal crash	2 right	5:26 a.m.	2 hrs 34 min	Aug 26-29

2.1.1 Incident 1: Northbound I-5 at Taylors Ferry

Incident 1 occurred on Tuesday, December 3, 2002 at 7:05 a.m. The incident was classified as a three-vehicle non-injury accident, which closed the left travel lane until 7:42 a.m. Two VMSs were used to convey incident information to motorists on I-5. One VMS displayed the following message: "ACCIDENT I-5 NB 3 MI N OF HWY 217. LEFT LANE CLOSED." The media were notified of the crash. This incident occurred before the incident management system was installed.

The Evaluation Team received notification of the incident the afternoon of December 3. Incident questionnaire emails were sent to panel members first thing Wednesday morning, December 4. The questionnaire was available for panel members to complete through Friday, December 6.

Emails were sent to 421 panel members to notify them about the online incident questionnaire. Of the 421 emails, two were returned, indicating that the email address was no longer valid. Four members responded that they had moved and no longer commuted in the Study Area. Overall, 292 panel members (72 percent) accessed the survey, of which 283 (97 percent) completed it. Of the 283 respondents who completed a questionnaire, 268 (95 percent) reported that they still traveled in the Study Area. Of these 268, 8 (3 percent) reported that they were riding the bus the morning of the incident, 39 (14 percent) knew of the incident, but their commute was not impacted, and 131(46 percent) were not aware of the incident. Only 90 (32 percent) reported that their commute was impacted by this incident.

2.1.2 Incident 2: Northbound I-5 at Terwilliger

Incident 2 occurred on Tuesday, April 8, 2003 at 7:02 a.m. The incident was classified as a four-vehicle injury accident, which closed the two left travel lanes until 7:33 a.m. Two VMSs were used to convey incident information to motorists on I-5. The following message was displayed on the VMSs: "ACCIDENT I-5 NB NEAR TERWILLIGER. LEFT LANE CLOSED." The media were notified of the crash. While this incident occurred after the incident management system was installed, the system was not activated until late in the incident, and the only system component activated was the signal “flush plan” on Barbur Boulevard.

The Evaluation Team received notification of the incident on the afternoon of April 8. Incident questionnaire emails were sent to panel members immediately that afternoon. The questionnaire was available for panel members to complete through Friday, April 11.

Emails were sent to 399 panel members to notify them about the online incident questionnaire. Of the 399 emails, 23 (6 percent) were returned, indicating that the email address was no longer valid. Four members responded that they had moved and no longer commuted in the Study Area. Overall, 242 panel members (65 percent) accessed the survey, of which 238 (99 percent) completed it. Of the 238 respondents who completed a questionnaire, 221 (93 percent) reported that they still traveled in the Study Area. Of these, 6 (3 percent) reported that they were riding the bus the morning of the incident, 31 (13 percent) knew of the incident, but it did not impact their commute, 72 (30 percent) were not aware of the incident, and 29 (12 percent) did not make their normal commute that day. Only 83 (35 percent) reported that their commute was impacted by this incident.

2.1.3 Incident 3: Northbound I-5 at Macadam

Incident 3 occurred on Tuesday, August 26, 2003 at 5:26 a.m. The incident was classified as a pedestrian-vehicle fatal crash, which closed the two right travel lanes until 8:00 a.m. Several VMSs were used to convey incident information to motorists on I-5. The message on the VMSs specified the location of the crash and advised drivers to take alternate routes. The media were notified of the crash. This incident occurred after installation of the incident management system, and the system was fully activated during the incident.

The Evaluation Team received notification of the incident on the afternoon of August 26. Incident questionnaire emails were sent to panel members immediately that afternoon. The questionnaire was available for panel members to complete through Friday, August 29.

Emails were sent to 344 panel members to notify them about the online incident questionnaire. Of the 344 emails, 6 (2 percent) were returned, indicating that the email address was no longer valid. Additionally, 13 (4 percent) sent auto-replies indicating that the potential respondents were out of the office. Four (12 percent) members responded that they had moved and no longer commuted in the Study Area. Overall, 216 panel members (68 percent) accessed the survey, of which 214 (99 percent) completed it. Of the 214 respondents who completed a questionnaire, 201 (94 percent) reported that they still traveled in the Study Area. Of these, 55 (27 percent) reported that they were not riding in a car, vanpool, carpool, or on a motorcycle in the Study Area on the morning of the incident, 22 (11 percent) knew of the incident, but it did not impact their commute, and 16 (8 percent) were not aware of the incident. Only 108 (54 percent) reported that their commute was impacted by this incident.

2.1.4 Summary of Incidents

Each of the three incidents occurred on a Tuesday morning. While Incidents 1 and 2 were very similar in nature (e.g., timing, duration, lanes blocked), Incident 3 was far worse in that it occurred early, lasted through most of the morning commute, and involved a pedestrian fatality. The findings, based on the responses of 90, 83, and 108 panel members to Incidents 1, 2, and 3, respectively, are discussed in detail in Section 2.2.

2.2 FINDINGS

For each questionnaire, the driver characteristics, including gender, age, and years of driving in Portland were compared to the driver characteristics of the overall panel. This comparison was made to determine if the respondents to each incident questionnaire were representative of the overall panel. These comparisons are discussed in more detail in Sections 2.2.1 through 2.2.3.

2.2.1 Gender

Figure 2-1 shows the percentage of respondents for each questionnaire that were male and female. Overall, there is little difference between the respondents' gender across the four questionnaires. A statistical comparison showed no significant difference in respondents' gender across the four questionnaires (chi-squared statistic of 1.295, significance of 0.730). Therefore, the panel members sampled during incident questionnaires appear to be representative of the original survey panel in terms of their gender.

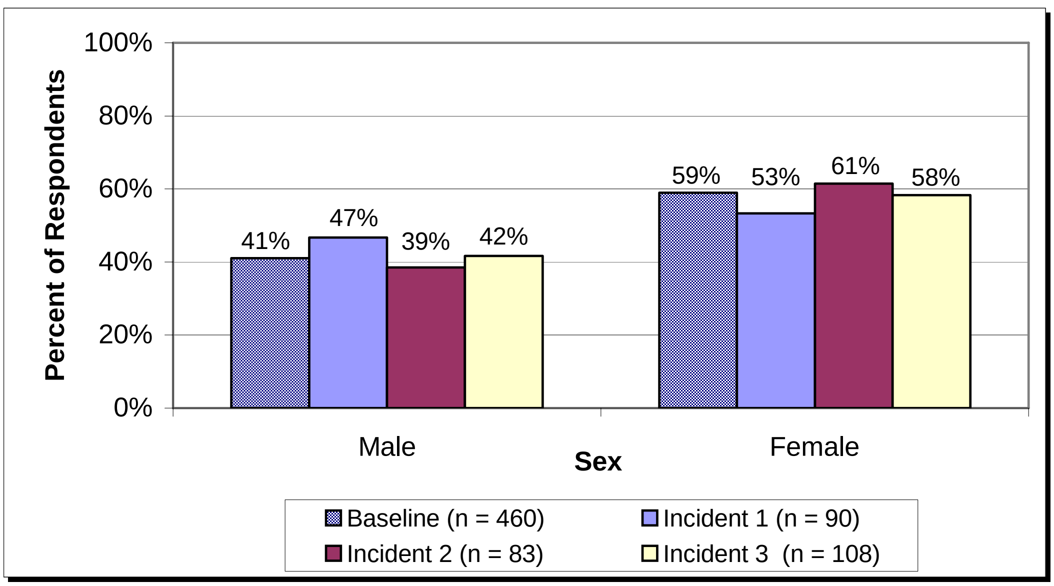


Figure 2-1. Comparison of Respondents Based on Gender for Each Questionnaire.

2.2.2 Age

Figure 2-2 shows the age distribution of respondents for each questionnaire. The age distribution of respondents to the baseline questionnaire and the Incident 1 questionnaire are nearly identical. Likewise, the age distributions of the respondents for the Incident 2 and 3 questionnaires are nearly identical.

Comparing the age distribution for the baseline and Incident 1 questionnaires to the response distributions for the Incident 2 and 3 questionnaires, the 41 – 50 year age group is somewhat overrepresented in the Incident 2 and 3 questionnaires, while the younger age groups are somewhat underrepresented. A statistical comparison, however, showed no significant difference in respondents' age across the four questionnaires (chi-squared statistic of 15.007, significance of 0.451). Therefore, the panel members sampled during incident questionnaires appear to be representative of the original survey panel in terms of their age.

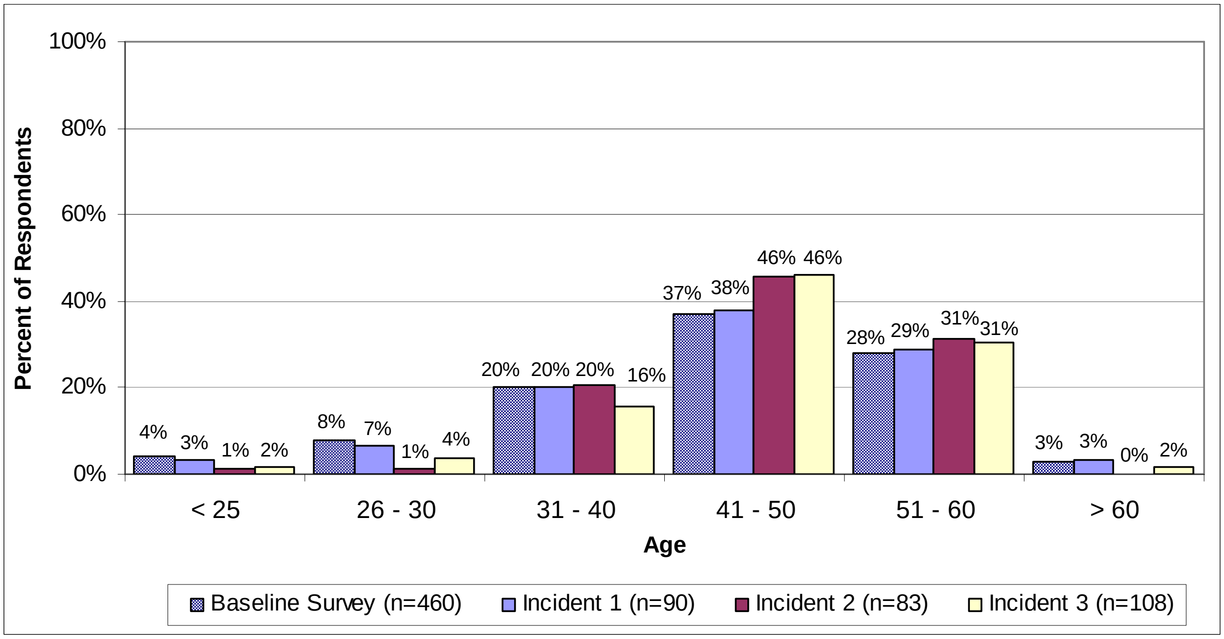


Figure 2-2. Age Distribution of Respondents for Each Questionnaire.

2.2.3 Years Commuting in Portland

Figure 2-3 shows the distribution for respondents' years driving in Portland for each questionnaire. The distribution of years driving in Portland for the baseline questionnaire, the Incident 2 questionnaire, and the Incident 3 questionnaire are nearly identical. For the Incident 1 questionnaire, there are somewhat fewer "seasoned" Portland drivers (11 – 20 years) and somewhat more drivers with less experience driving in Portland (2 – 5 years). A statistical comparison, however, showed no significant difference in respondents' years of driving in Portland across the four questionnaires (chi-squared statistic of 4.339, significance of 0.977). Therefore, the panel members sampled during incident questionnaires appear to be representative of the original survey panel in terms of their years driving in Portland.

It should be noted that the small sample of drivers surveyed during each incident is not a large enough sample to be representative of the population of commuters on northbound I-5 in the morning. In addition, the method of survey administration (i.e., Internet) limits the applicability of the results to the population. Essentially, the opinions of the sample of I-5 commuters who work in an office setting and have access to a computer/Internet may not be representative of other types of commuters and therefore, the results cannot be generalized to the population as a whole. However, the information gained from the surveys can provide valuable information about the behaviors and perceptions of some commuters during incidents and how their responses differ before and after the integrated incident management system was deployed on Barbur Boulevard and I-5.

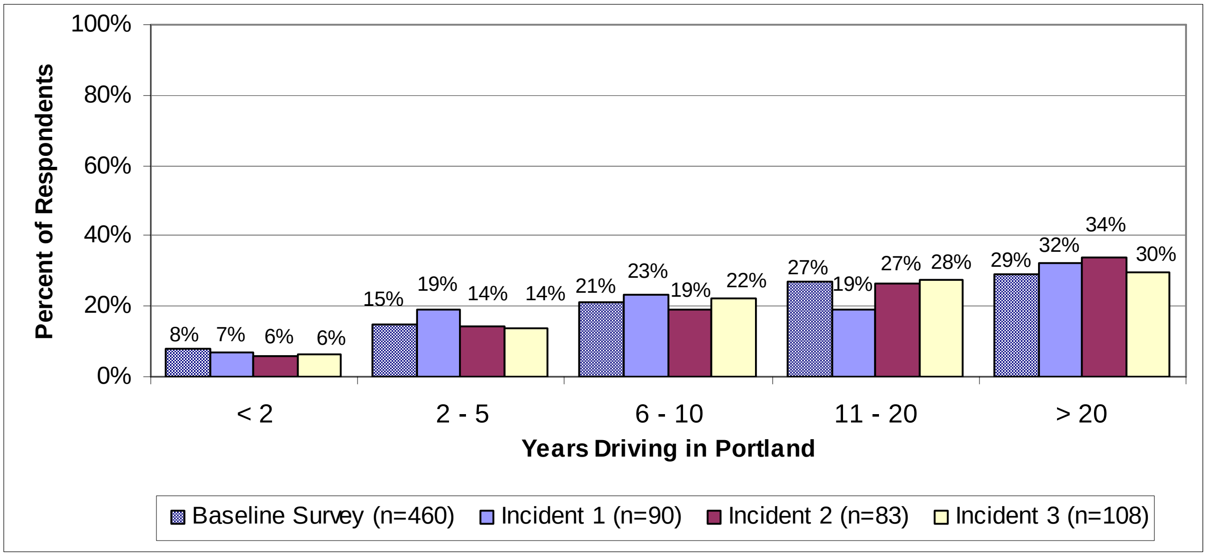


Figure 2-3. Distribution of Driving Experience of Respondents for Each Questionnaire.

The findings of the surveys are presented in terms of the three objectives of the customer satisfaction survey:

1. Determine driver behavior during incidents.

2. Determine driver perception of and satisfaction with traffic operations during incident.

3. Assess driver use of traffic information to make commute decisions during incidents.

2.2.4 Driver Behavior During Incidents

The first objective of the customer satisfaction survey was to determine driver behavior during incidents. To do this, drivers' behaviors across the three incident surveys were compared to determine if the incident management system had an impact on commute decisions during incidents. Drivers' commute decisions are discussed in terms of when they learned about the incidents (i.e., before or after they left home). These findings are discussed in Sections 2.2.4.1 and 2.2.4.2.

2.2.4.1 When and How Drivers Learned of the Incidents

Respondents were asked to indicate when they first learned of the incidents, and they were presented with different response choices depending on when they learned of the incident. The premise here was that if individuals learned of the incident in advance, they could make changes to their commute time and might have more options for alternate routes, than if they learned of the incident once they were already on the road.

The response distribution for each incident is shown in Figure 2-4. The response frequencies in Figure 2-4 show that very few respondents learned about Incident 1 and Incident 2 (11 percent and 14 percent, respectively) before leaving home. During Incident 3, nearly 46 percent of respondents learned of the incident before leaving home.

A chi-squared test was performed to test for significant differences between the response distribution for Incidents 1 and 3. The results showed a chi-squared statistic of 28.775 with a significance of 0.000, indicating a significant difference between the two distributions.

This change, as significant as it may be, is not a result of the incident management system per se, as there is no component of the system that provides more information to travelers about incidents before leaving home. This result is likely due to the type and magnitude of Incident 3. Incident 3 not only involved a pedestrian fatality, but it also lasted for 2.5 hours, spanning much of the morning commute. This was a “major” incident as compared to Incidents 1 and 2, which did not involve pedestrians or fatalities, and lasted for only about 30 minutes each. Also, because Incident 3 occurred early in the morning, before the morning commute, the media had more time to report on what had happened before many potential respondents left for work.

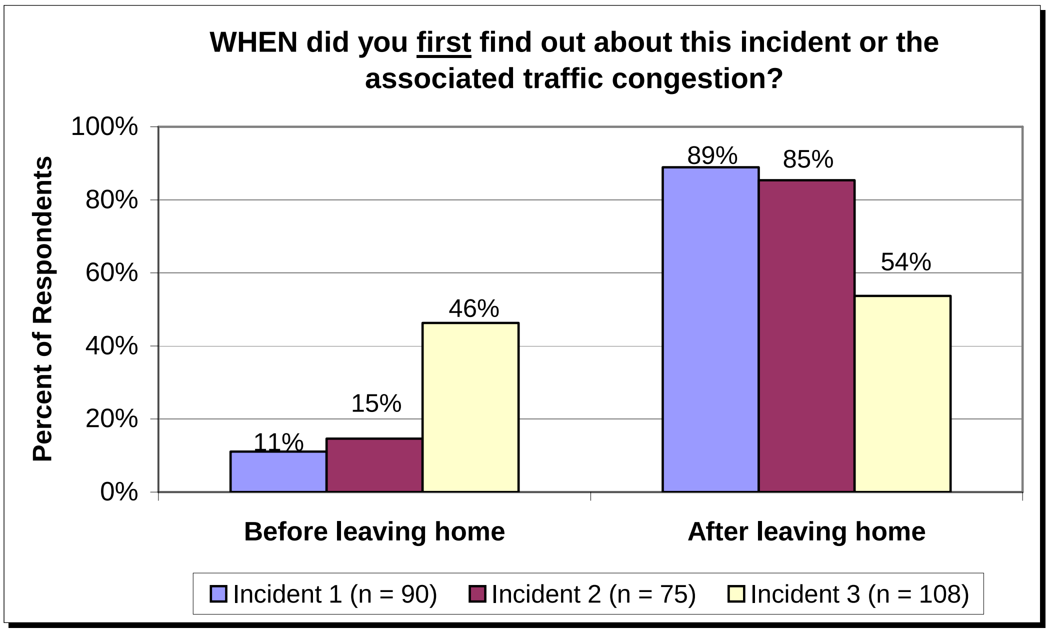


Figure 2-4. Distribution of When Respondents Learned About the Incidents.

Respondents were also asked to indicate how they first learned of the incident. The response distribution for each incident is shown in Figure 2-5. The top portion shows the information sources used by those respondents who learned about the incidents before leaving home. The bottom portion shows the information sources used by those respondents who learned about the incident after leaving home.

For those who learned of the incidents after leaving home, more respondents learned of Incident 3 than the other two incidents. In fact, only 28 percent of respondents had no information about Incident 3, as opposed to the 60 percent that had no information about Incident 1, and the 47 percent that had no information about Incident 2.

Figure 2-6 shows the distribution for how respondents learned about Incidents 1 and 3. (The distributions include both those respondents who learned about the incidents before and after leaving home).

A chi-squared test was used to compare the two distributions. The results showed a chi-squared statistic of 43.09 with a significance level of 0.000, indicating a significant difference between the two distributions. These results suggests that more respondents had some type of information about Incident 3 than did for Incident 1, and support the theory that Incident 3 was more publicized due to its early morning occurrence and its magnitude.

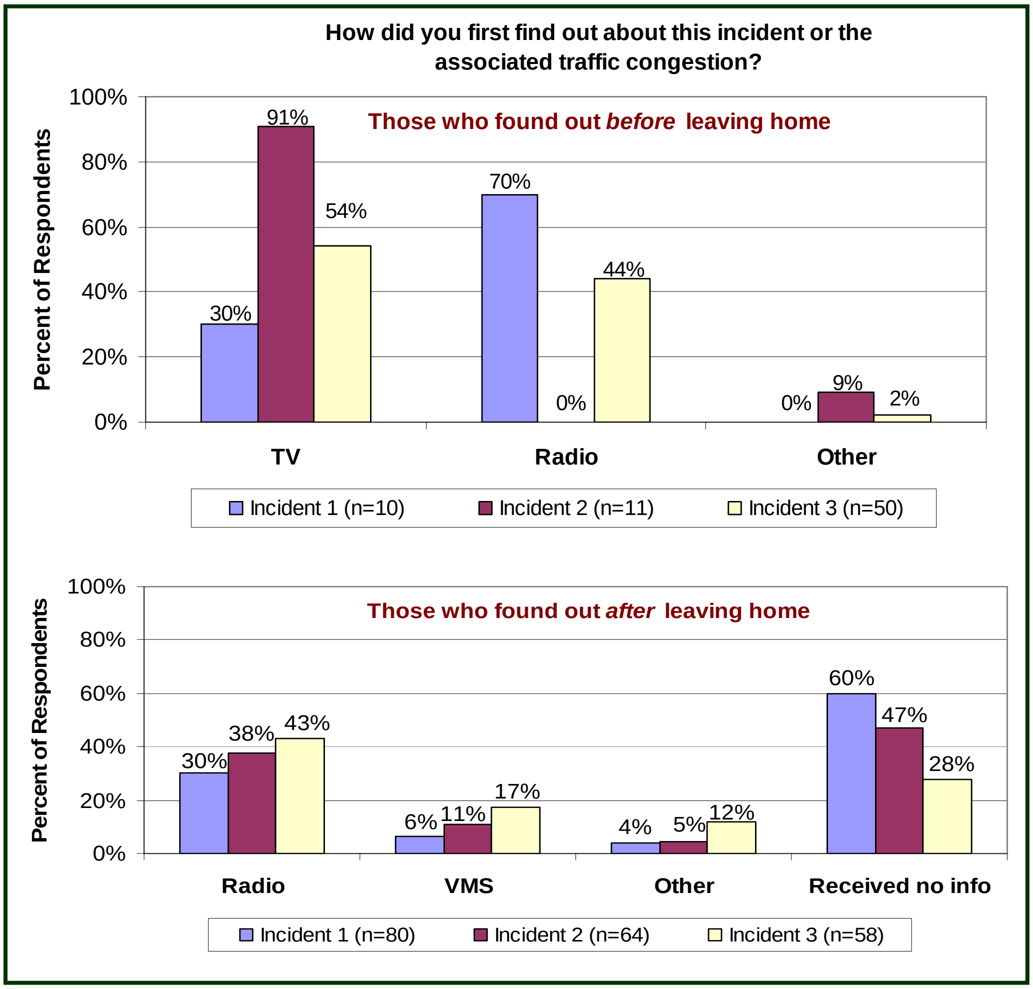


Figure 2-5. Distribution of How Respondents Found Out About the Incidents.

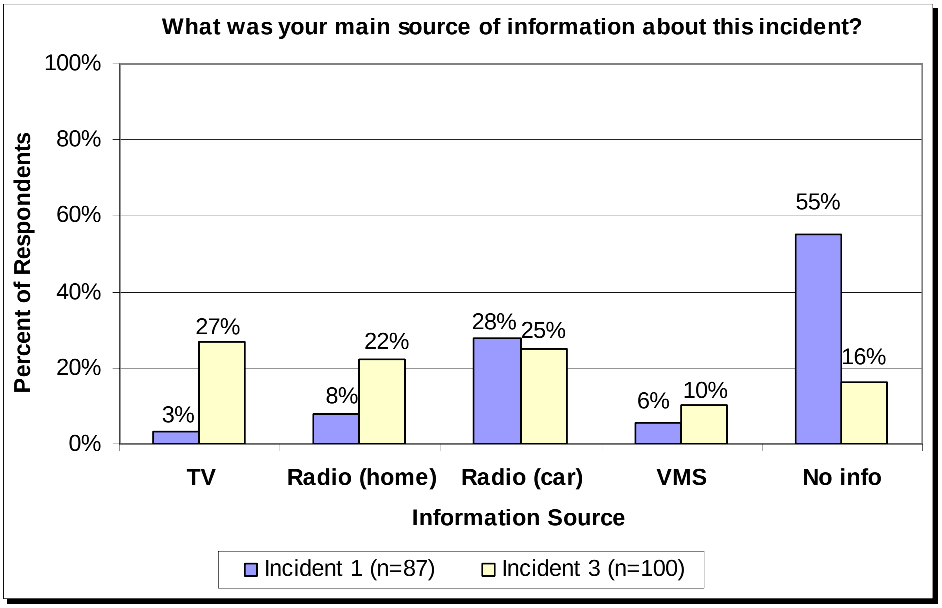


Figure 2-6. How Respondents Learned About Incidents 1 and 3.

2.2.4.2 Actions Drivers Took During the Incidents

After reporting when and how they learned about the incidents, respondents were asked to indicate what they did when they learned about the incidents. Their response choices were as follows:

- I left home earlier or later than normal.
- I used an alternate route that included a freeway.
- I used an alternate route that did not include a freeway.
- I did the same as usual – I left at my normal time and used my normal route.

Figure 2-7 shows the response distributions for what drivers did when they learned about the incidents. For those who learned of the incident before leaving home,
Figure 2-7 shows that almost twice as many respondents reported taking an alternate route that included an arterial street during Incident 3 than during the other two incidents. Fewer respondents (only 10 percent) reported that they did the same as usual during Incident 3 than for the other two incidents.

For those who learned of the incident after leaving home,
Figure 2-7 shows that during Incident 3, more respondents reported using an alternate route that includes a freeway, more respondents reported using an alternate route that did not include a freeway, and fewer respondents reported doing the "same as usual".

This finding could be a result of the incident management system, especially for those who learned about the incidents after leaving home, as the VMS on I-5 did suggest that motorists take alternate routes. The results could also be due to the timing and nature of Incident 3 (i.e., due to the early occurrence of the incident, drivers had more time to make a decision about an alternate route, and due to the magnitude, had more incentive to do so). Most likely the finding is a result of a combination of both the VMS incident management system and the nature of Incident 3.

A chi-squared test was performed to test for differences between the response distributions for Incidents 1 and 3 for those who learned of the incidents before leaving home. The results were a chi-squared statistic of 5.676 with a significance level of 0.128, indicating no significant difference between the two distributions.

A chi-squared test was also performed to test for differences between the response distributions for Incidents 1 and 3 for those who learned of the incidents after leaving home. The results were a chi-squared statistic of 6.042 with a significance level of 0.049, indicating a significant difference between the two distributions. Essentially, for those respondents who learned of the incidents after leaving home, more tended to take alternate routes during Incident 3 than during Incident 1, and fewer tended to do the same as usual during Incident 3 than did during Incident 1.

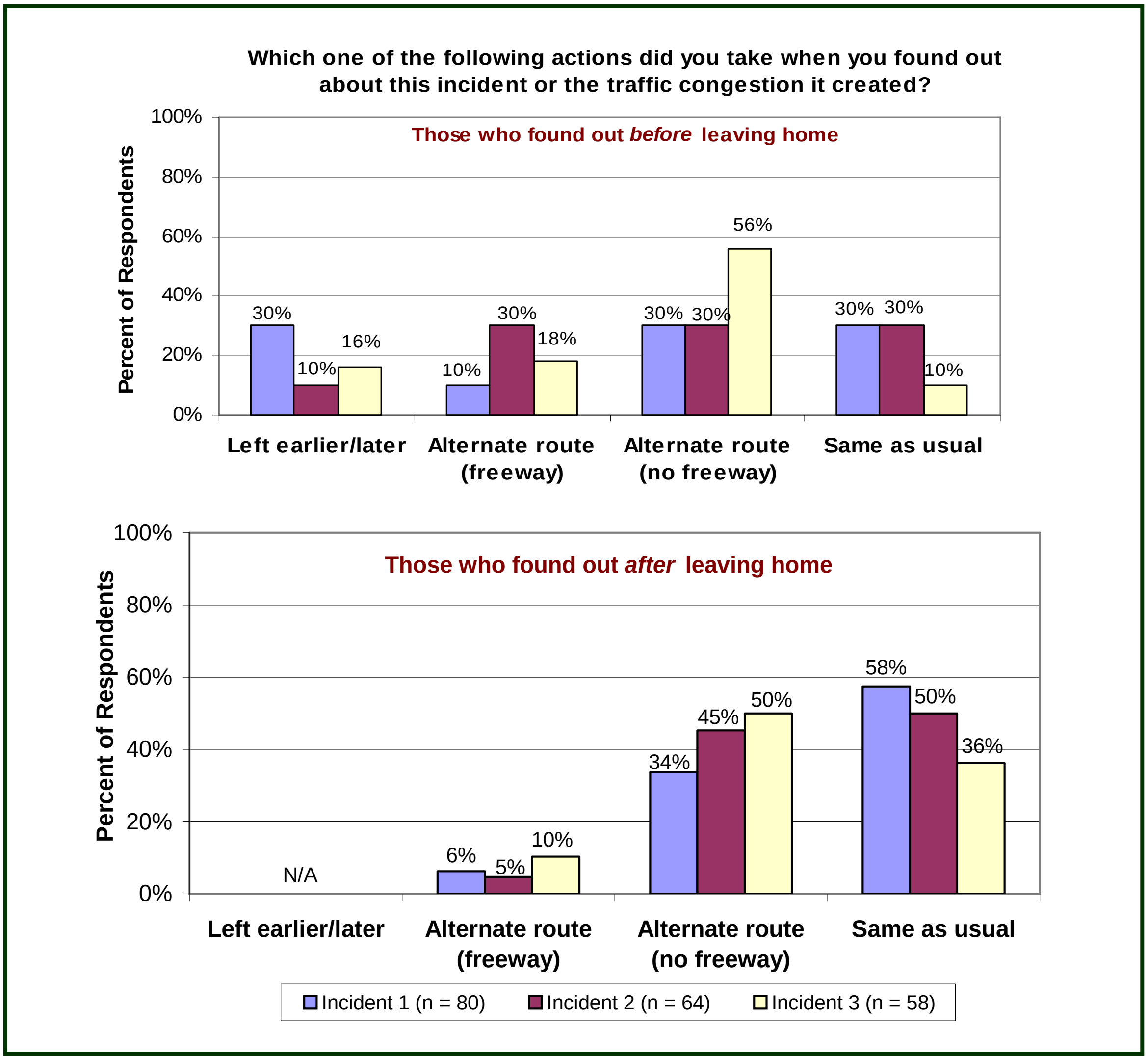


Figure 2-7. What Respondents Did in Response to Incidents.

Respondents were also asked if they had used Barbur Boulevard to avoid the incidents. The response choices were as follows:

- Yes, I took Barbur in an attempt to avoid the incident.
- Yes, I usually take Barbur instead of I-5.
- No, I took a different alternate route in an attempt to avoid the incident.
- No, I stayed on I-5.

Figure 2-8 shows the responses distributions to this question for the three incident questionnaires. By observing the response distributions, it can be seen that more respondents reported using Barbur Boulevard to avoid Incident 2 than used it to avoid Incident 1. Likewise, slightly more respondents reported using Barbur to avoid Incident 3 than used it to avoid Incident 2. Fewer respondents reported staying on I-5 during Incident 3 than during the other two incidents.

In addition, for the third incident, more respondents reported that they used a different alternate route than for the first and second incidents. It is more likely that more respondents would have used Barbur during Incident 3 than the other two incidents because the VMS advised drivers to use alternate routes. However, the result of more respondents who reported using Barbur during Incident 2 than during Incident 1 may be due to some respondents not realizing that Barbur was a viable alternative to I-5. It became apparent that by participating in the panel survey, some respondents may have become aware of Barbur and started using it as an alternate route.

A chi-squared test was performed to compare the response distributions across the three incidents. The result was a chi-squared value of 20.76, with 6 degrees of freedom, and a significance level of 0.002, indicating a significant difference between the responses across the three incidents.

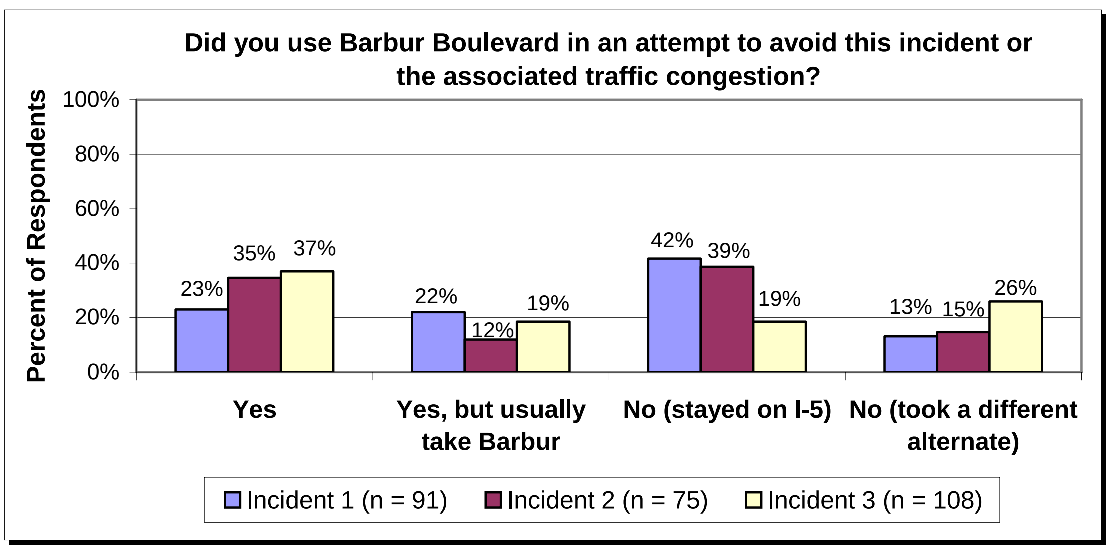


Figure 2-8. Respondents' Choice of Route in Response to Incidents.

Figure 2-9 shows only the responses for the "Before" incident (Incident 1) and the "After" incident (Incident 3), and shows only those respondents who either took Barbur to avoid the incident or who stayed on I-5. A chi-squared test was performed to compare the responses before and after system implementation. The result was a chi-squared value of 11.50, with 1 degree of freedom, and a significance level of 0.001, indicating a significant difference between the percentage of respondents who used Barbur (versus staying on I-5) before and after implementation of the incident management system. Again, this change could be a result of the incident management system and/or more respondents being aware of Barbur as an alternate route, or it could be a result of the magnitude of Incident 3. For example, many drivers have a threshold of how much traffic/ delay they are willing to accept before finding an alternate route. Because Incident 3 blocked two lanes of I-5 for most of the morning commute (as opposed to Incidents 1 and 2, which each lasted only 30 minutes), the nature of this incident might have forced some respondents to seek an alternate route.

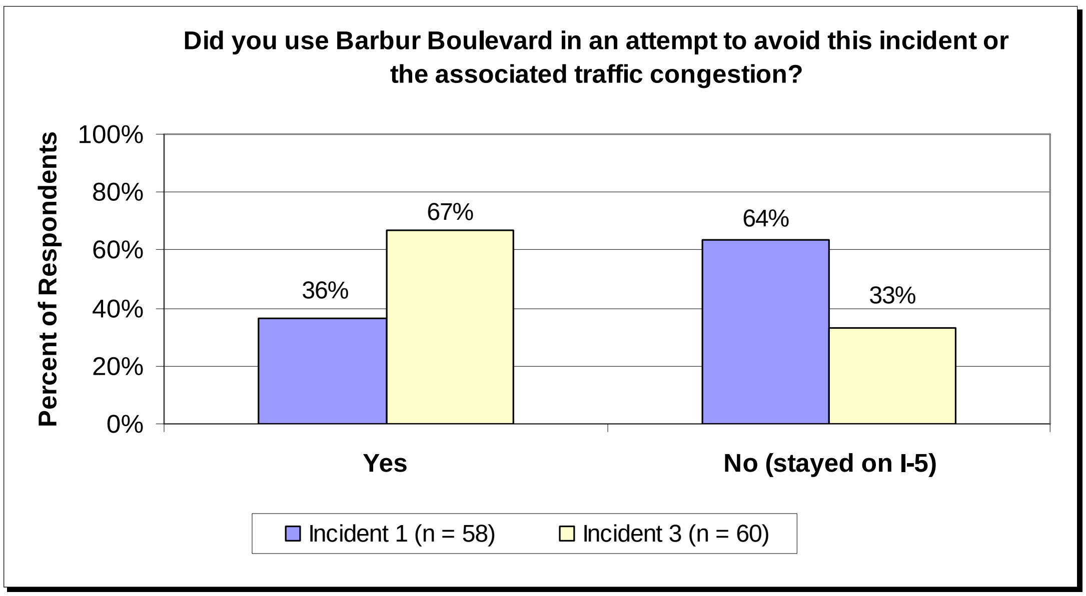


Figure 2-9. Respondents' Choice in Using/Not Using Barbur Boulevard as an Alternate Route During Incidents 1 and 3.

2.2.5 Driver Perception of and Satisfaction with Traffic Operations During Incidents

The second objective of the evaluation was to determine if the system had an impact on drivers' perceptions of and satisfaction with traffic operations in the corridor during incidents. These findings are discussed in Sections 2.2.5.1 and 2.2.5.2.

2.2.5.1 Perception of Commute Time During Incidents

Respondents were asked to indicate how much longer it took them to get to their destinations during the three incidents, as compared to their "normal" commutes. Figure 2-10 shows the response distributions for the three incident questionnaires. More respondents reported shorter commute times (up to 10 minutes) for Incident 3 than the other two incidents. Likewise, fewer respondents reported commute times between 11 and 15 minutes and over 15 minutes during Incident 3, as compared to the other two incidents. This is a somewhat counterintuitive result when considering the magnitude of Incident 3. Intuitively, one might think that for an incident that spanned most of the morning commute, drivers would experience significantly more delays than for incidents that lasted only 30 minutes. This result could be an indication that the incident management system was effective at moving drivers around the incident.

To test for significant differences, a chi-squared test was performed to compare the responses between the “Before” and “After” incidents (Incident 1 and 3, respectively). Figure 2-11 shows the response distributions for Incidents 1 and 3. The results were a chi-square statistic of 5.825, with 2 degrees of freedom, and a significance level of 0.054. These results indicate a significant difference between the two response distributions for Incidents 1 and 3 at the 94 percent significance level, with respondents perceiving their commute times to be shorter during Incident 3 than during Incident 1.

The responses shown in Figure 2-10 and Figure 2-11 could be indicative of improved corridor efficiency during Incident 3 as a result of the incident management system. Knowing that more respondents used Barbur Boulevard during Incident 3 than during Incident 1, this result could indicate that the incident management system was effective at moving drivers around the incident and to their destination faster during a major incident than during more minor incidents before the incident management system was deployed.

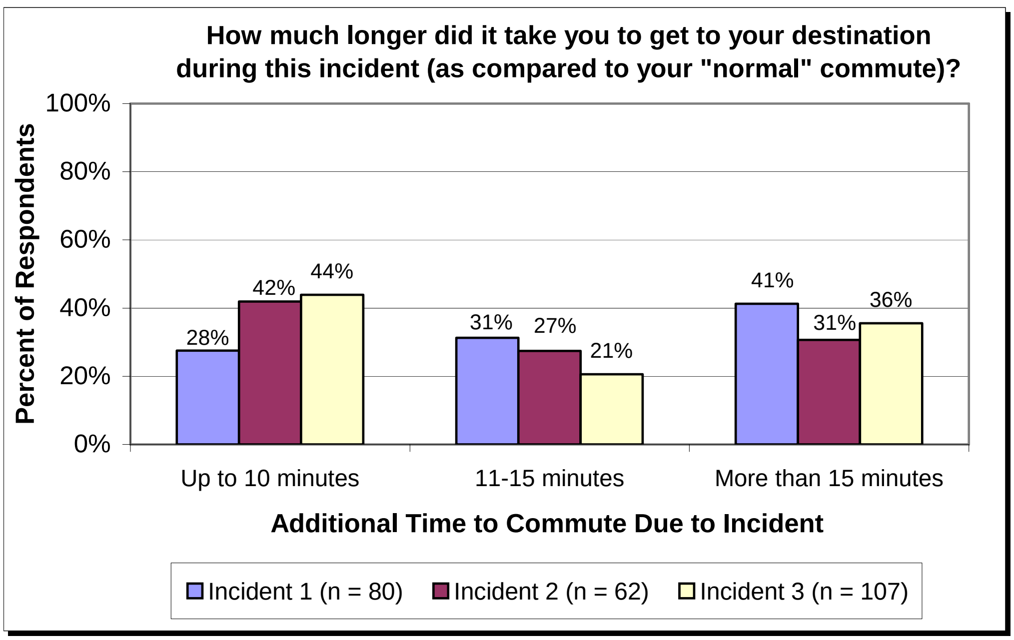


Figure 2-10. Reported Time Added to Commute During Incidents.

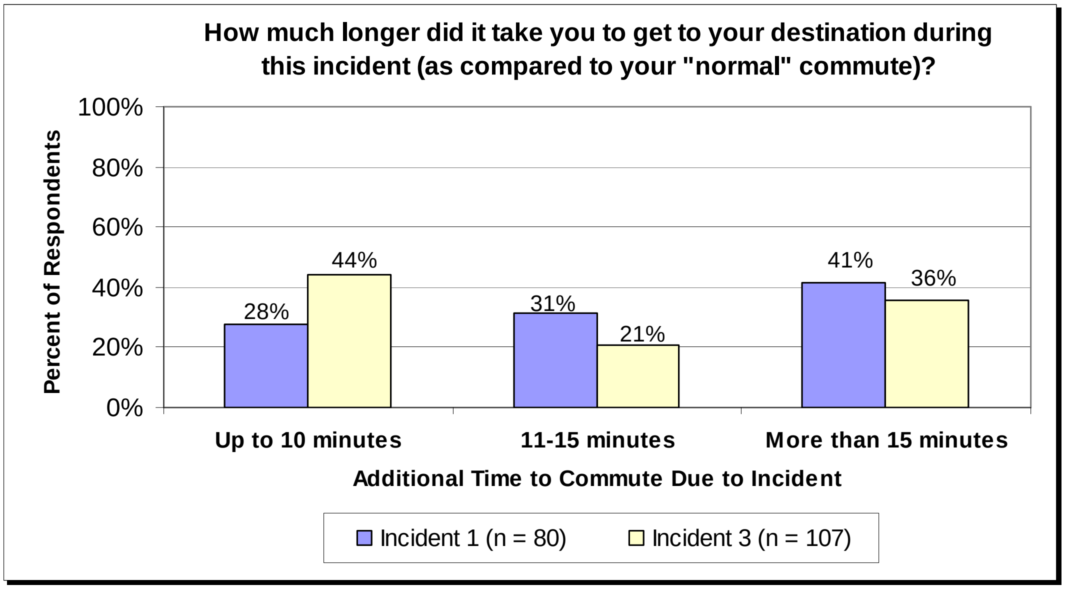


Figure 2-11. Reported Commute Times – Incident 1 Versus Incident 3.

To investigate this theory, a closer look was taken at the additional commute time reported by respondents during the incidents depending on which roadway they took. Specifically, a comparison was made between the responses of those who took Barbur Boulevard to avoid the incident and those who stayed on I-5. Figure 2-12 shows the additional commute times reported by these respondents across the three incidents.

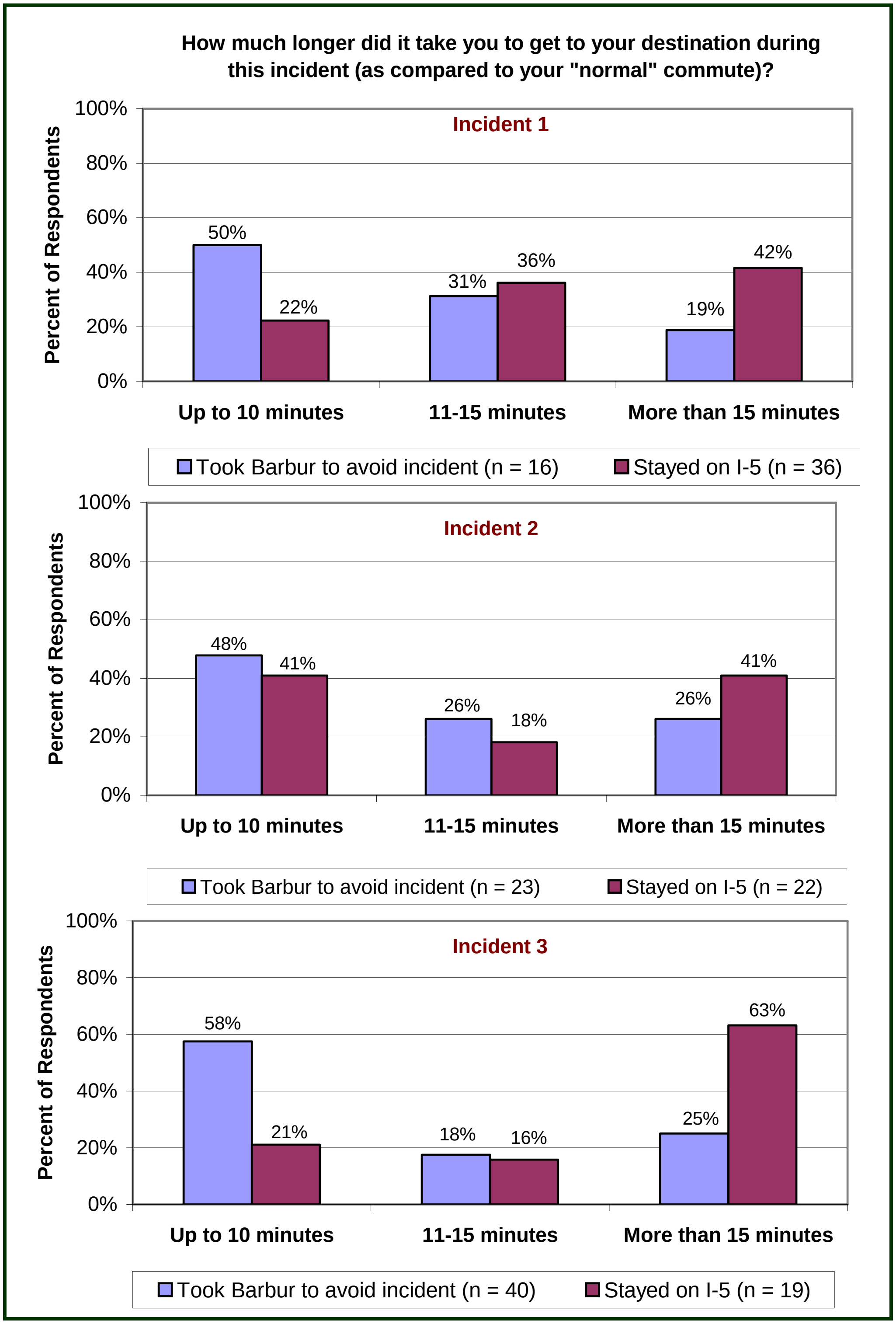


Figure 2-12. Reported Additional Time to Commute Due to Incidents.

Based on the frequency distributions in Figure 2-12, respondents who took Barbur Boulevard tended to perceive less additional time needed to commute during each incident than those respondents who stayed on I-5. This difference appears to be the most pronounced during Incident 3.

Chi-squared test were performed to compare the response distributions between the Barbur Boulevard and I-5 commuters. The results are shown in Table 2-2. The responses for Barbur versus I-5 commuters are not significantly different for Incidents 1 or 2; however, the responses for Barbur versus I-5 commuters are significantly different for Incident 3.

Because Incidents 1 and 2 were very similar in nature, it is not surprising that the response distributions for this question are similar. For Incident 3, it does appear that those respondents who took Barbur to avoid the incident were able to get around the incident and to their destinations much more quickly than those who stayed on I-5. This result further supports the theory that the system was efficient in getting motorists around the incident and to their destination more quickly.

Table 2-2. Chi-Squared Test Results for Reported Commute Times Versus Commute Route

Incident #	Chi-squared Statistic	Degrees of Freedom	Alpha	Result
1	4.534	2	0.104	Not significantly different
2	1.178	2	0.555	Not significantly different
3	8.791	2	0.012	Significantly different

Figure 2-13 illustrates how the response distributions changed for Barbur Boulevard commuters and for I-5 commuters between Incidents 1 and 3. A visual inspection of the responses of the Barbur Boulevard commuters shows that a few more commuters reported shorter commute times (*up to 10 minutes* longer than normal) during Incident 3 than during Incident 1. At the same time, fewer commuters reported longer commute times (11 to 15 minutes longer than normal) during Incident 3 than during Incident 1. However, a few more Barbur commuters reported the longest commute times (more than 15 minutes longer than normal) during Incident 3 than during Incident 1. A chi-squared test showed no significant difference between the response distributions between the two incidents (chi-squared statistic of 1.317, significance of 0.518).

Comparing these results with those for the I-5 commuters, it can be seen that many more of the I-5 commuters reported the longest commutes (more than 15 minutes longer than normal) during Incident 3 than during Incident 1. A chi-squared test showed no significant difference between the response distributions for the two incidents (chi-squared statistic of 2.943, significance of 0.230). Where one might expect significantly more commuters to have longer commutes (during Incident 3), the theory does not hold. This could be a result of more drivers using Barbur and spreading the traffic volumes between I-5 and Barbur, decreasing the overall demand on I-5.

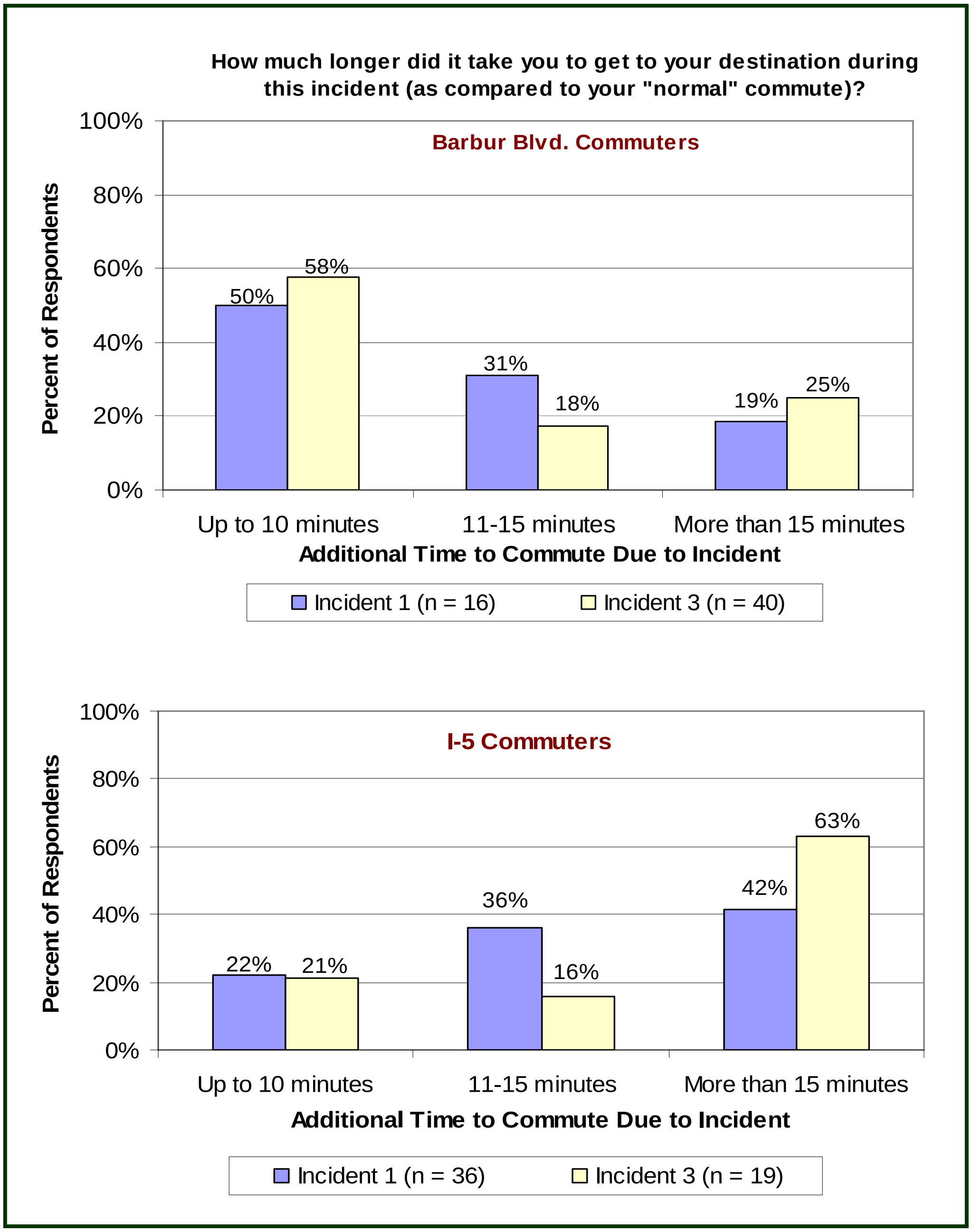


Figure 2-13. Reported Additional Time to Commute – Barbur Boulevard Versus I-5.

2.2.5.2 Satisfaction with Traffic Operations During Incidents

Next, respondents were asked to indicate their satisfaction with traffic operations in the corridor during incidents. Those commuters who took Barbur were asked to rate their satisfaction with three aspects of the traffic operations along Barbur: volume of traffic, travel speed, and traffic signal operations. The distributions of respondents' satisfaction ratings for each of the three incidents are shown in Figure 2-14.

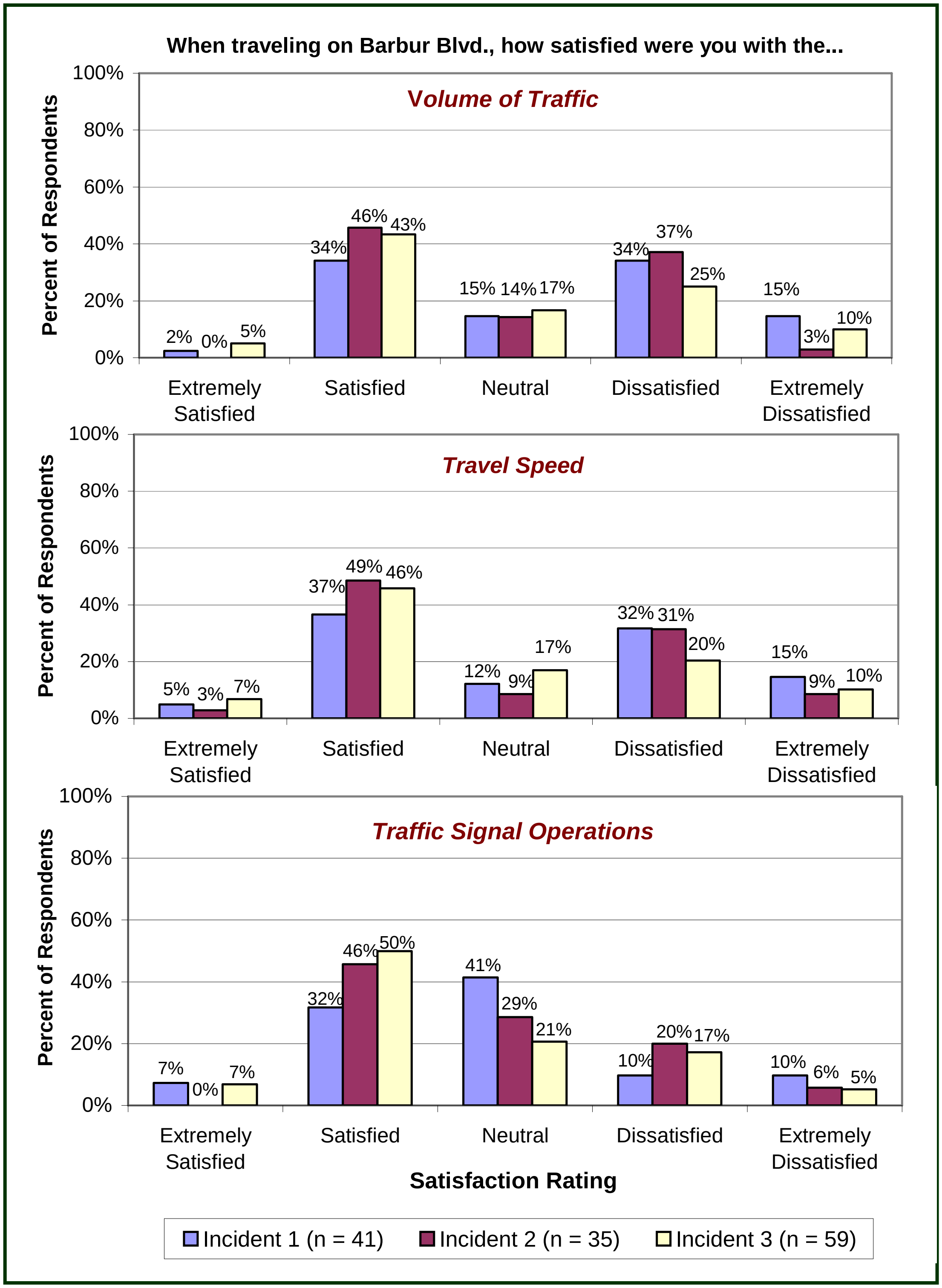


Figure 2-14. Respondents' Perceptions of Incident Conditions on Barbur Boulevard.

Figure 2-14 shows that there are only slight differences in the response distributions of satisfaction ratings across the three incidents. There appears to be slightly higher satisfaction ratings for traffic volume and travel speed during Incident 2, as compared to the other two incidents, and slightly higher satisfaction ratings for traffic volume and travel speed for Incident 3 over Incident 1. Interestingly, it does appear that more respondents were satisfied with the traffic signal operations during Incident 2 than during Incident 1 and more respondents were satisfied with the traffic signal operations during Incident 3 than during Incident 2 (i.e., increased satisfaction over the three incidents). These results could reflect the improved operations resulting from the signal flush plans implemented during both Incidents 2 and 3. Pairwise t-tests of mean ratings showed no significant differences between Barbur satisfaction ratings among any of the three incident questionnaires (Table 2-3).

Table 2-3. Results of Pairwise Comparisons of Barbur Boulevard Satisfaction Ratings

Comparison		Difference Between Mean Ratings	Degrees of Freedom	t-statistic	Result
Incident 2 versus Incident 1	Volume	0.2725	74	1.095	Not significant
	Speed	0.2035	74	0.749	Not significant
	Signal operations	-0.0279	74	-0.121	Not significant
Incident 3 versus Incident 2	Volume	0.1094	91	0.478	Not significant
	Speed	0.1670	91	0.691	Not significant
	Signal operations	0.2192	91	1.032	Not significant
Incident 3 versus Incident 1	Volume	0.3818	97	1.652	Not significant
	Speed	0.3705	97	1.561	Not significant
	Signal operations	0.1913	97	0.909	Not significant

I-5 commuters were asked to rate their satisfaction with "traffic conditions" on I-5 during the incidents. The response distributions of the respondents' satisfaction ratings are shown in Figure 2-15. While there are only slight differences among the response distributions, more respondents appear to be extremely dissatisfied during Incident 3 than the other two incidents. This result is not surprising, especially when considering the magnitude of Incident 3. In Table 2-4, pair-wise t-tests of mean satisfaction ratings showed no significant differences between the ratings on any of the three incident questionnaires.

Table 2-4. Results of Pair-Wise Comparisons of I-5 Satisfaction Ratings

Comparison		Difference Between Mean Ratings	Degrees of Freedom	t-statistic	Result
Incident 2 versus Incident 1	Traffic conditions	0.3831	63	1.586	Not significant
Incident 3 versus Incident 2	Traffic conditions	0.5776	47	1.856	Not significant
Incident 3 versus Incident 1	Traffic conditions	-0.1944	54	-0.767	Not significant

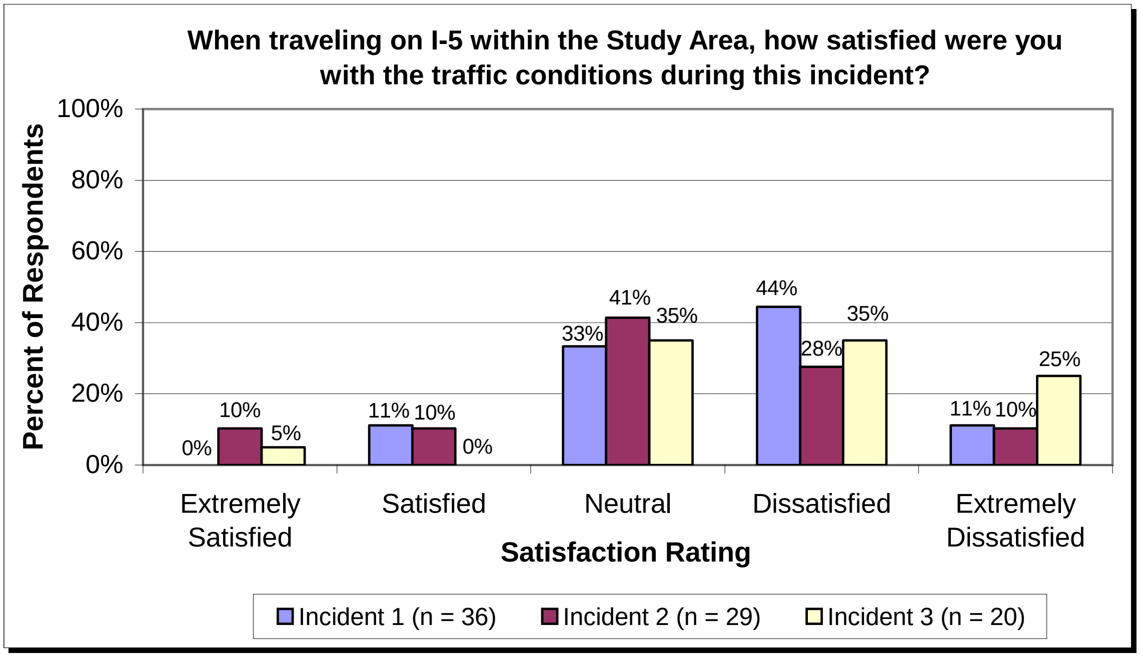


Figure 2-15. Respondents' Perceptions of Incident Conditions on I-5 in Study Area.

2.2.6 Driver Use of Traffic Information to Make Commute Decisions During Incidents

The last objective was to assess drivers' use of traffic information to make commute decisions during incidents. Respondents were asked to report their main source of information about the incidents and to rate the timeliness, usefulness, and accuracy of the information for making important decisions about their commutes. Respondents were also asked specifically if they had seen the VMS in the Study Area, and if so, to rate the timeliness, usefulness, and accuracy of the VMS message for making important decisions about their commutes. The results of these questions are discussed in Sections 2.2.6.1 and 2.2.6.2.

2.2.6.1 Main Source of Information

Respondents were first asked to indicate their main source of information regarding each incident. Figure 2-16 shows the response distributions for the three incidents. The results are shown separately for those respondents who learned of the incidents before leaving home and for those respondents who learned of the incidents after leaving home.

For those who learned of the incident before leaving home, more respondents tended to learn about the incidents from TV reports across the three incidents, and fewer respondents tended to learn about the incidents from radio reports across the three incidents.

For those respondents who learned of the incidents after leaving home, more tended to learn about the incidents from radio reports, VMS, and other sources across the three incidents. Interestingly, many fewer respondents reported receiving no information about Incident 3 than the other two incidents. Again, this could be a result of the early occurrence and magnitude of Incident 3.

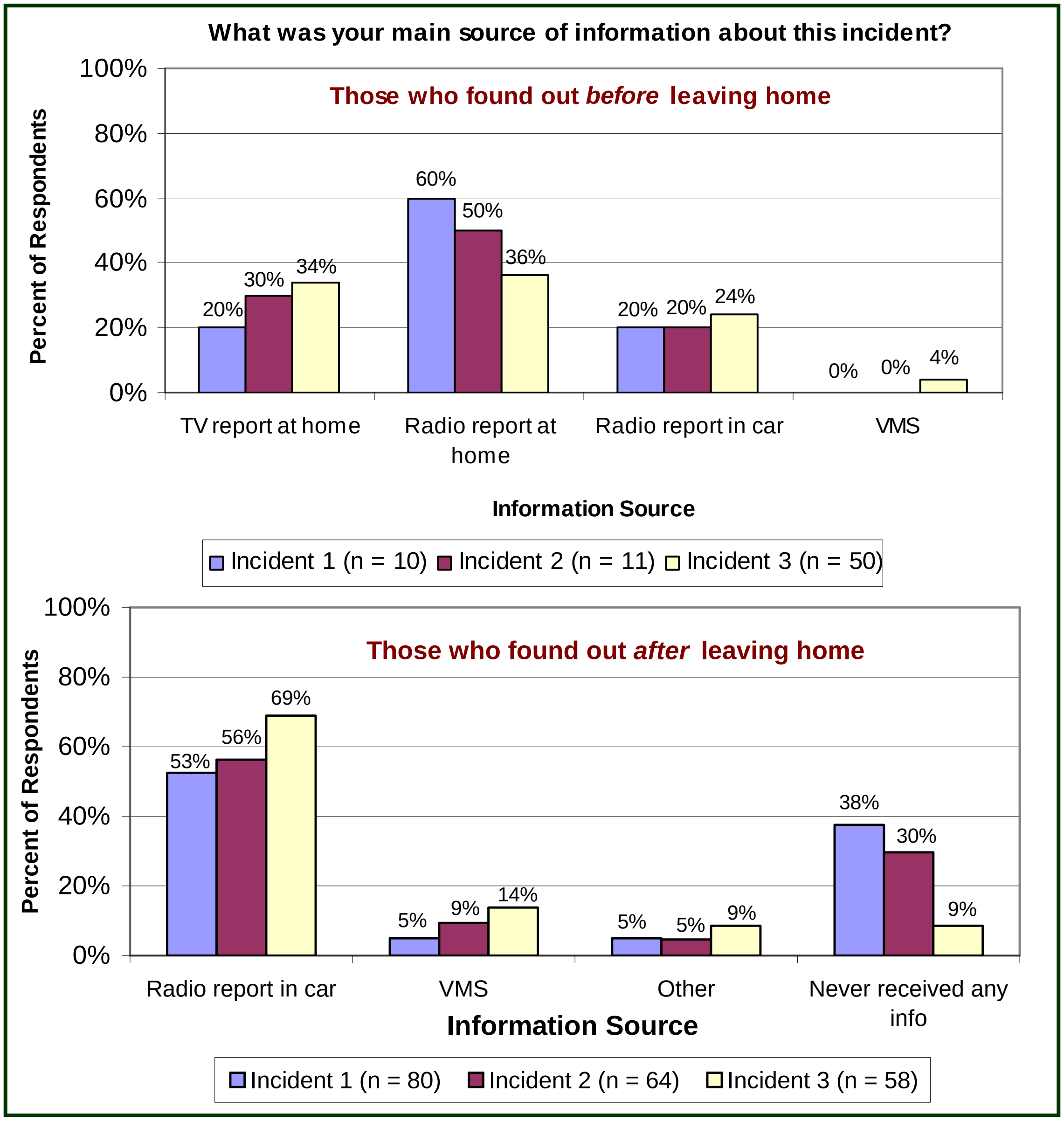


Figure 2-16. Respondents' Main Source of Information About the Incidents.

Next, respondents were asked to rate how timely, useful, and accurate their main source of information was when making important decisions about their commute time and route during the incidents. The response distributions are shown in Figure 2-17.

Overall, respondents tended to rate the timeliness, accuracy, and usefulness of their main source of information more favorably across the three incidents, and overall, there were fewer negative ratings across the three incidents. Chi-squared tests comparing the information ratings for Incidents 1 and 3 are shown in Table 2-5. The results show no significant differences among the ratings for the three incidents.

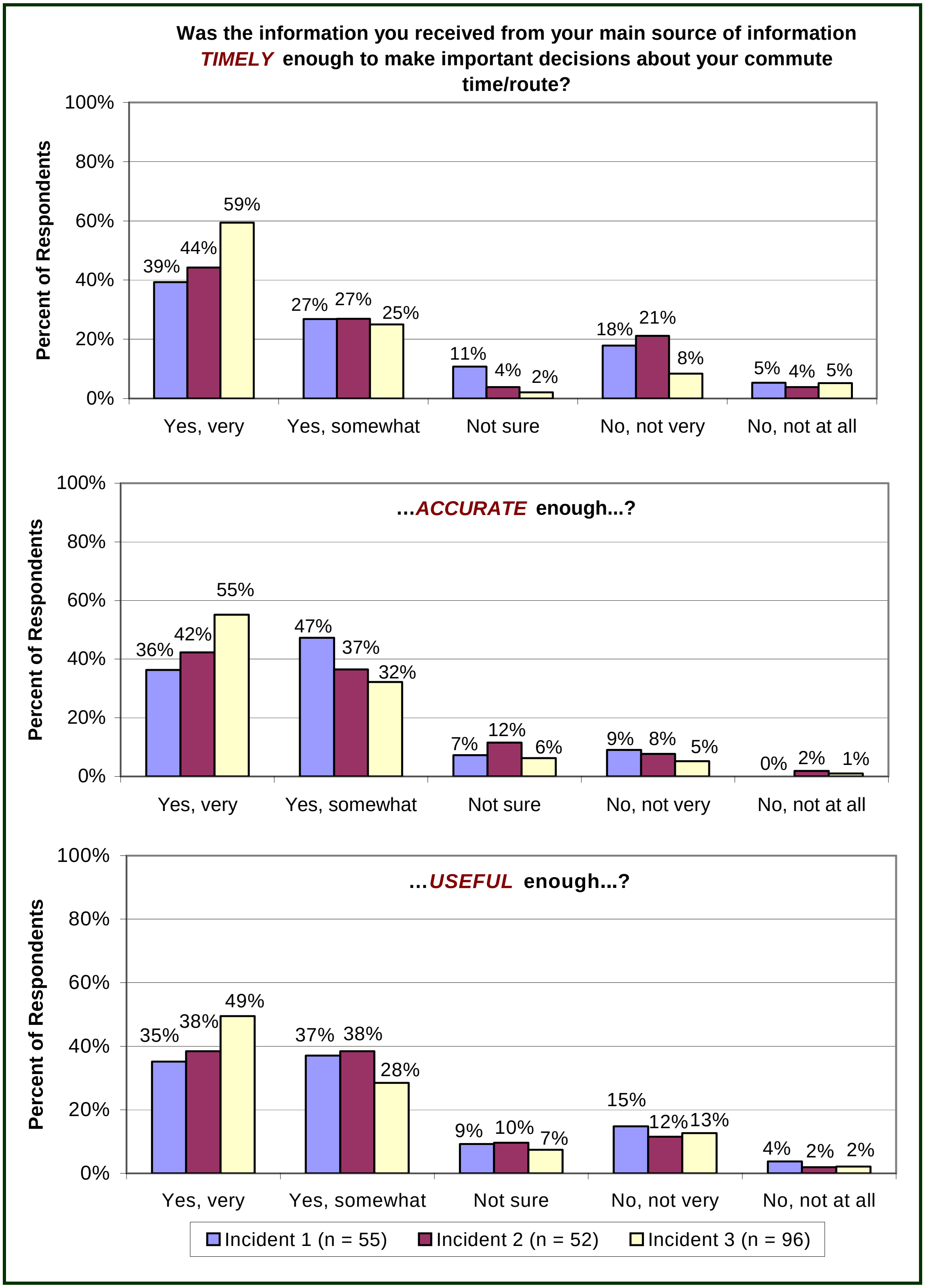


Figure 2-17. Respondents' Perceptions of Main Source of Information.

Table 2-5. Results of Comparisons of Information Ratings for Incidents 1 and 3

Rating Factor	Chi-squared Statistic	Degrees of Freedom	Significance	Result
Timeliness	9.731	3	0.021	Not significant
Accuracy	5.090	3	0.165	Not significant
Usefulness	2.856	3	0.414	Not significant

2.2.6.2 Variable Message Signs

In addition to enquiring about respondents' main source of information, the incident questionnaires asked respondents if they saw a VMS posting a message related to the incidents. The responses are shown in Figure 2-18. Slightly more respondents reported that they saw a VMS with a message related to the incident during Incident 3 than during the other two incidents. A chi-squared test indicated no significant differences in the response distributions for Incidents 1 and 3 (chi-squared statistic of 1.467, significance of 0.226).

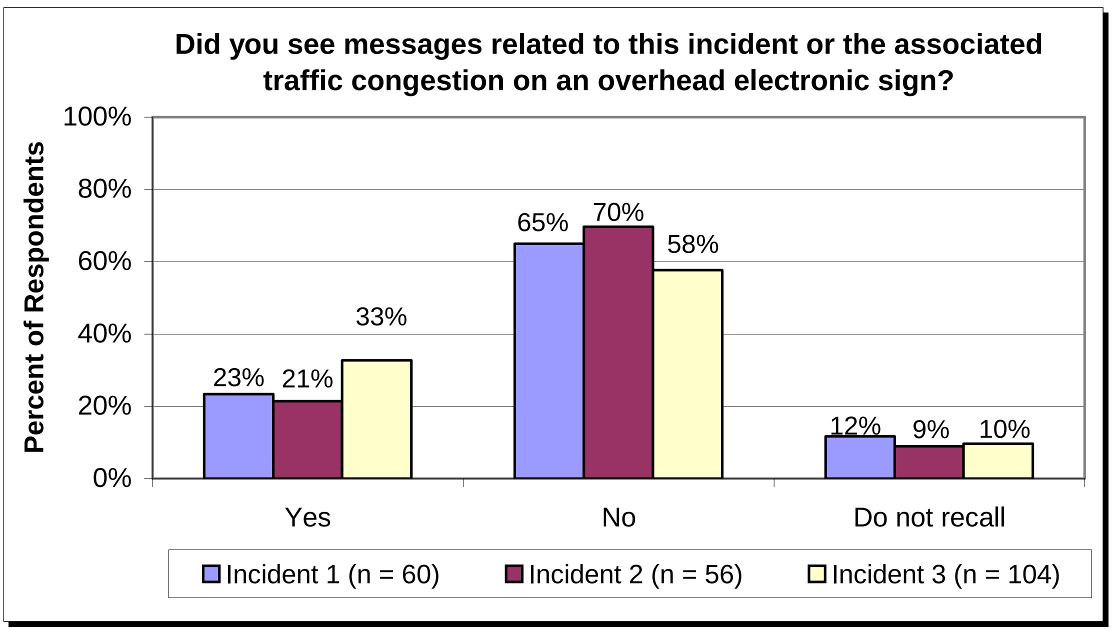


Figure 2-18. Whether or Not Respondents Saw VMS.

Respondents who saw a VMS were then asked to rate the timeliness, accuracy, and usefulness of the VMS messages in terms of using the posted information to make important decisions about their commute time and route. The ratings for the three incidents are shown in Figure 2-19.

In general, the ratings for timeliness, accuracy, and usefulness of the VMS messages for the three incidents were favorable, and there were only slight differences in ratings across the three incidents. The ratings tended to be a little lower for Incident 3 than for the other two incidents. In general, the accuracy of the information was rated more favorably than the timeliness of the information, and the timeliness of the information was rated more favorably than the usefulness of the information.

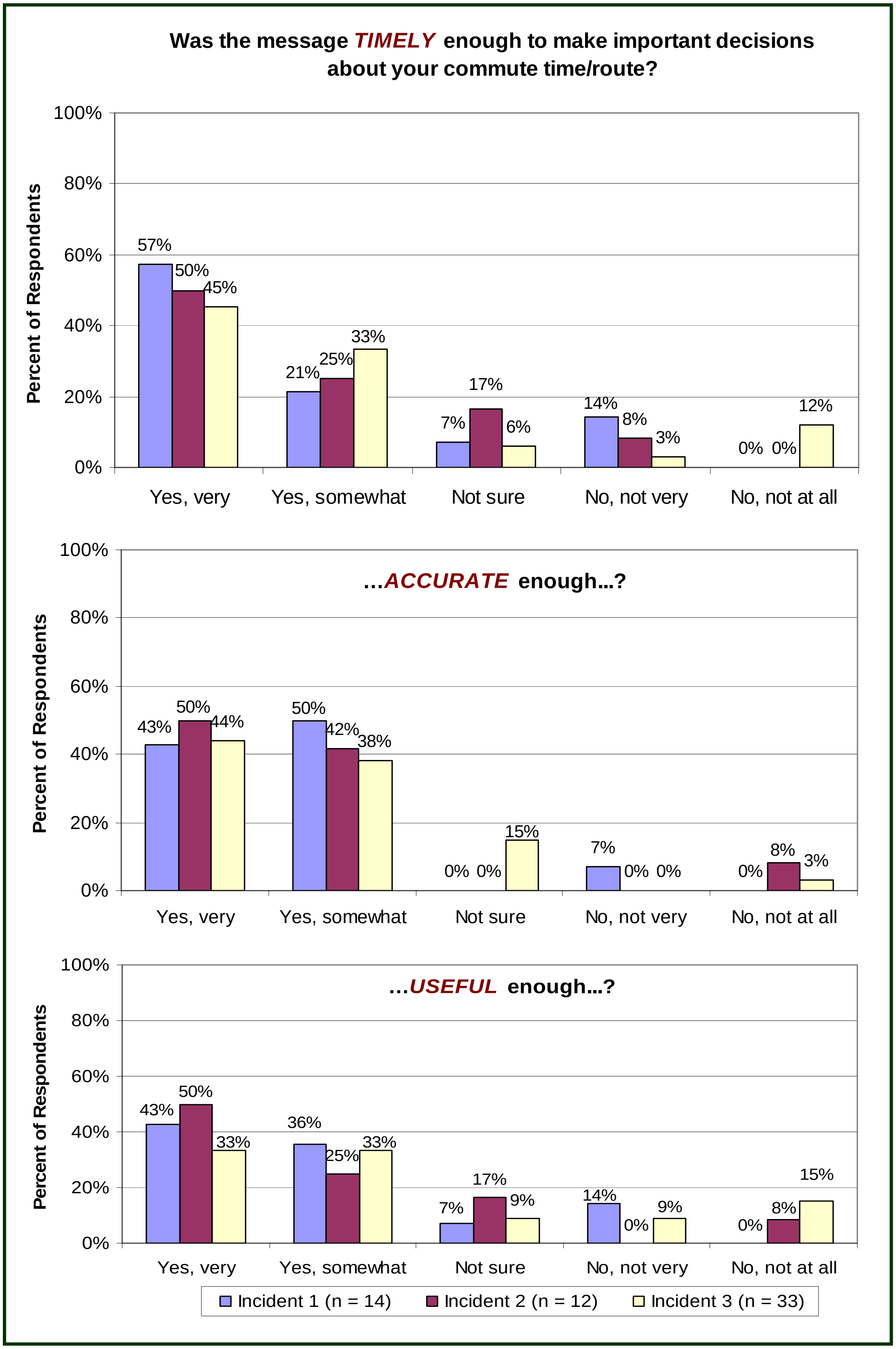


Figure 2-19. Respondents' Perceptions of the VMS.

Respondents who reported using Barbur Boulevard in an attempt to avoid Incident 3 were asked if they saw the electronic “detour” or trailblazer signs along Barbur directing them back to I-5. Of the 60 respondents who took Barbur to avoid the incident, half (30) reported that they did see the trailblazer signs. Those 30 respondents were asked if they followed the directions to I-5 posted on the signs. The responses are shown in Figure 2-20.

The majority of respondents reported that they did not follow the signs because they were almost at their destination (some of the panel members worked along Barbur Boulevard just south of downtown Portland). Six respondents (67 percent) said they decided not to use the signs, 3 respondents (10 percent) reported that they did not understand the signs, and only 1 respondent (3 percent) reported that he/she followed the directions on the signs. When asked if following the directions on the trailblazer signs saved time, the one respondent reported that it did not. When asked if he/she would follow the signs again, the respondent reported affirmatively.

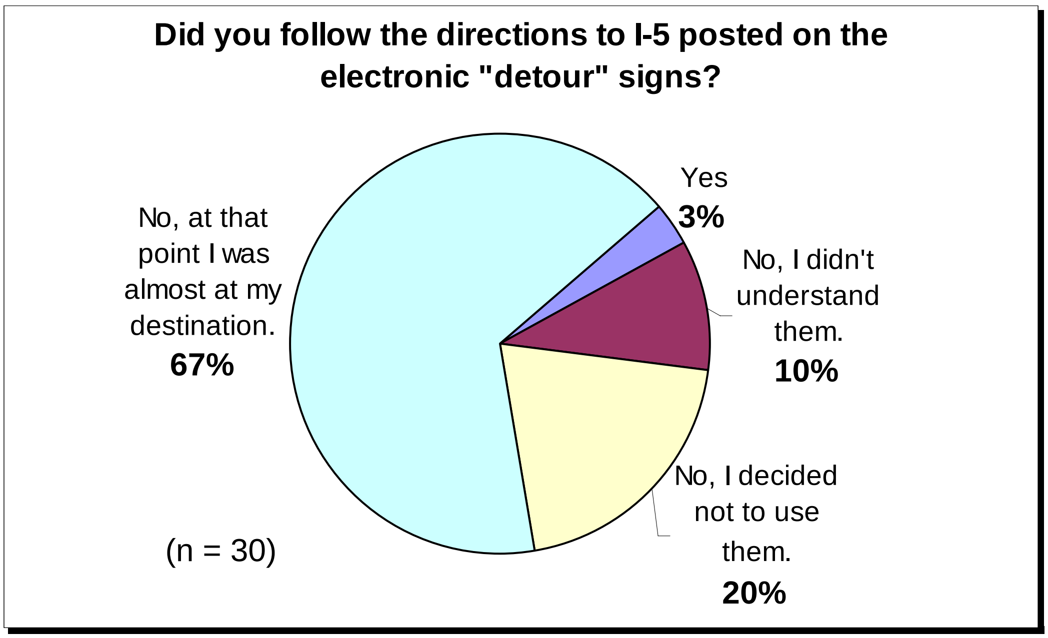


Figure 2-20. Whether or Not Respondents Followed Trailblazer Signs on Barbur Boulevard.

2.3 SUMMARY

While the results of the incident surveys suggest that there may be improvements in terms of reduced commute times, the satisfaction ratings during the incidents showed no significant improvements. The results from the individual incident surveys are difficult to compare directly due to the nature of the incidents for which the surveys were administered. Ideally, the surveys would have been administered for incidents that were very similar in terms of time of occurrence, magnitude, and duration.

The results have revealed interesting behaviors that do suggest changes in the way some drivers commute during incidents and possible positive consequences for these behaviors. For example, more respondents appeared to be using alternate routes during Incident 3 than the other two incidents, rather than waiting on I-5 in the congestion. Further, the results showed that those respondents who took alternate routes (including Barbur Boulevard) reported shorter additional commute times (less than 5 additional minutes) during Incident 3 than during Incident 1. Slightly fewer respondents reported the longest additional commute times (more than 15 additional minutes) during Incident 3 than during Incident 1.

Because of the magnitude of Incident 3, as compared to Incident 1 (Incident 3 involved a fatality, blocked two lanes, and lasted through the entire morning commute; Incident 1 was a non-injury incident that blocked one lane and lasted only 37 minutes), it could be expected that even with the incident management system, the sheer magnitude of Incident 3 could have caused much longer commute times. However, this finding suggests that those commuters who took Barbur Boulevard were able to move around the incident and on to their destination more quickly than those who stayed on I-5 during Incident 3 as compared to Incident 1, despite the much greater magnitude of Incident 3. This is probably the most significant finding of the incident surveys.

3. EFFICIENCY AND MOBILITY ANALYSIS

This section describes the efficiency and mobility analysis conducted as part of the evaluation of the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project. The objective of the efficiency and mobility analysis on I-5 and Barbur Boulevard was to quantitatively document the changes in traffic flow during incidents on I-5 as a result of the technology deployment, and to determine the impacts of the corridor-arterial integration on system efficiency and traveler mobility.

In the Phase II portion of this study, several measures of effectiveness were selected to test the impact of the technology project on system efficiency and traveler mobility:

- Vehicle volume (vehicles/hour/lane) in the primary direction during incident conditions (efficiency).
- Speed (in miles per hour [mph]) in the primary direction during incident conditions (mobility).
- Speed variability (mph) in the primary direction during incident conditions (mobility).

To test the impacts of the corridor traffic management project on system efficiency and traveler mobility, the Phase II baseline results of operations and safety were compared to results extracted from the post-deployment data.

3.1 DATA COLLECTION APPROACH

The data needed for the efficiency/mobility study came from two primary sources: (1) ODOT I-5 loop detector volume and speed data and (2) speed probes from buses on transit routes along the Barbur Boulevard arterial (from TriMet).

The data collection methods employed in this study were driven by the need to analyze and compare traffic conditions during (1) non-incident conditions (i.e., background conditions); (2) incident conditions without the system activated (i.e., baseline incident conditions); and (3) incident conditions with the system activated (i.e., post-deployment incident conditions).

Since incidents occur at random, no manual data collection methods (e.g., manual field traffic counts) normally associated with mobility studies were used. Instead, automated traffic data collection methods through the use of in-pavement loop detectors, road tubes, and city buses equipped with speed probes were utilized. Incident statistics were gathered from the ODOT incident database.

The baseline data collection period occurred between January 7 and February 1, 2002. During this time, data were gathered from ODOT's permanent loop detector system along I-5. Road tubes were placed at two locations along Barbur Boulevard. One year later, post-deployment data were collected during the same time frame; however, no incidents warranting use of the incident management system occurred during the post-deployment time period. Therefore, the data that were collected in January 2003 contained no useful post-deployment incident information.

Another round of post-deployment data was collected from January 15 through to February 1, 2004 (the loop detector system was not fully operational in the first 2 weeks of January 2004). These data were taken only from the permanent loop detectors on I-5 and from bus probes along Barbur Boulevard (i.e., no road tube were deployed along Barbur Boulevard). These data were primarily collected to determine if there had been a change in background traffic conditions between the baseline and post-deployment periods.

To supplement the background traffic data, additional traffic data associated with incidents were collected at the time of several major incidents that occurred during the morning peak period:

1. One baseline incident, which occurred before the system was deployed (i.e., “Incident 1” on December 3, 2002)

2. One incident in which the system was activated (i.e., “Incident 3” on August 26, 2003)

3. A second incident in which the system was activated (i.e., “Incident 4” on December 8, 2004

Data from these incidents were compared to data during similar morning peaks in which there was no incident:

1. A weekday morning in December 2002 (December 11, 2002)

2. A weekday morning in September 2003 (September 2, 2003)

3. A weekday morning in December 2004 (December 1, 2004)

Section 3.1.1 provides additional detail on the format, assumptions, and collection methods used in gathering data to study the impact of the incident management system on system efficiency and traveler mobility.

3.1.1 I-5 Mainline Traffic Volume and Speed

Data from the ODOT freeway loop detector stations were collected along I-5 within the boundaries of the Study Area (indicated by the thumb tacks noted in the Study Area in Figure 3-1). The following information pertains to freeway mainline data:

1. Data structure:

   - Data collected from detector stations on I-5 northbound during the morning peak period along a 6-mile segment from south of Pacific Highway (near Lesser Road) to I-405

   - Mainline traffic volume and speed data per freeway lane

   - On-ramp volume and speed data

   - All data aggregated to 15-minute periods

2. Assumptions:

   - ODOT mainline and on-ramp detectors were functional

   - ODOT had the majority of the mainline detectors in the study corridor were calibrated and operational when data were collected by the start of the data collection period and maintained their operation throughout the evaluation period

3. Evaluation periods:

- Historic background volume and speed data from January, September, and October in 2000 and 2001
- Baseline background volume and speed data collected from Monday, January 7, 2002 through Friday, February 1, 2002
- Post-deployment background data from 5:00 a.m. through 9:00 a.m. from January 15, 2004 through February 1, 2004
- “Before” Incident data from 6:30 – 8:30 a.m. on December 3, 2002 and non-incident control data from 6:30 – 8:30 a.m. on December 11, 2002
- “After” Incident data from 5 – 9 a.m. on August 26, 2003 and non-incident control data from 5 – 9:00 a.m. on September 2, 2003
- “After” Incident data from 5 – 10:30 a.m. on December 8, 2004 and non-incident control data from 5 – 10:30 a.m. on December 1, 2004

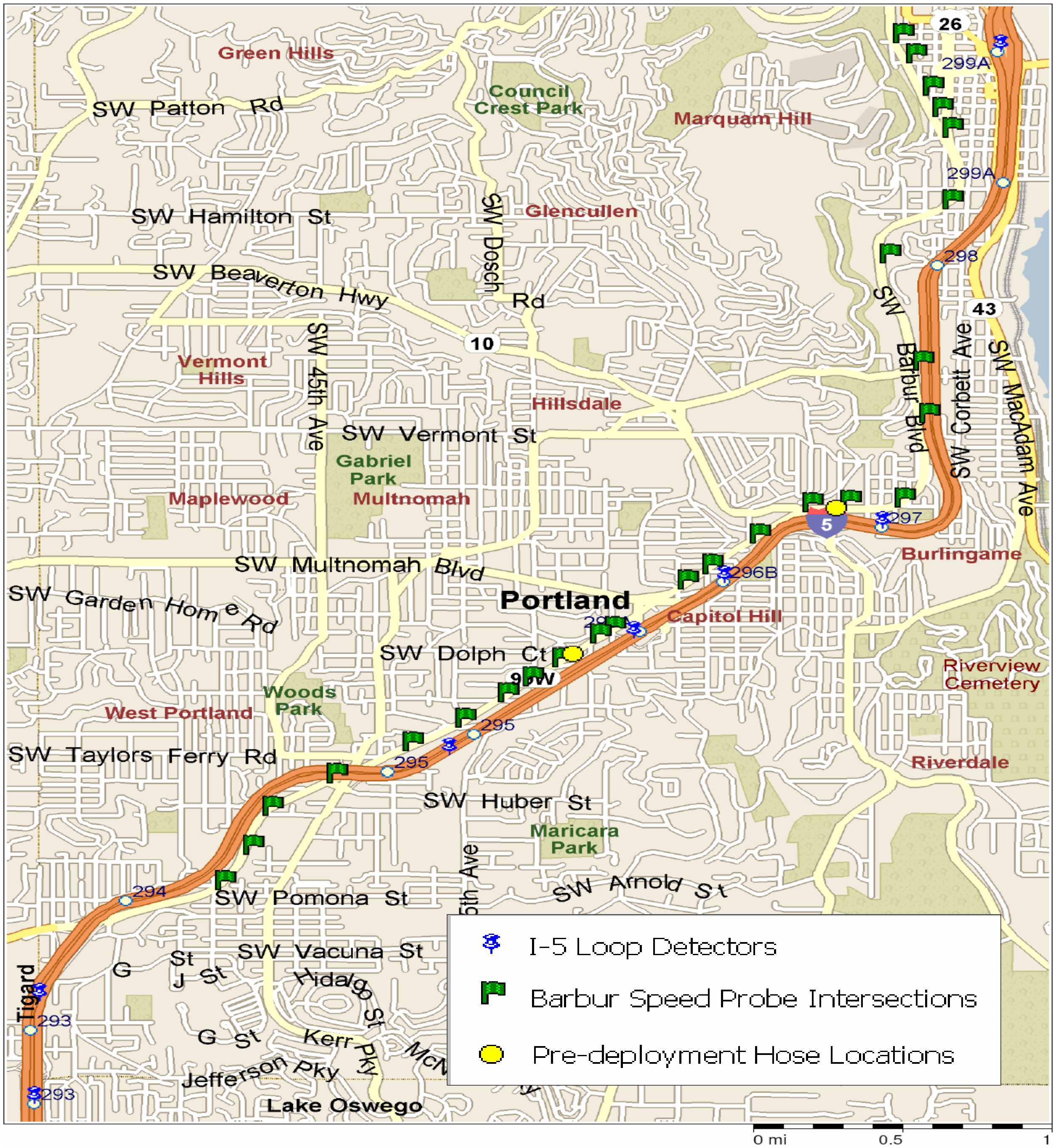


Figure 3-1. I-5 Northbound I-5/Barbur Boulevard Study Area.

3.1.2 I-5 Mainline Incident Logs

ODOT Incident logs were used to assess incident information along the study corridor within the boundaries of the Study Area. Details on the incident data requirements are provided below:

1. Data structure:

- Incident data containing date, time, location, lane blockages and duration

2. Evaluation periods:

- Historic volume and speed data from January, September, and October in 2000 and 2001
- Baseline volume and speed data collected from Monday, January 7, 2002 through Friday, February 1, 2002
- Post-deployment volume and speed data collected from January 15, 2004 through February 1, 2004

3.1.3 Barbur Boulevard Traffic Volumes and Speeds

During Phase II of this evaluation, the Evaluation Team and the City of Portland deployed temporary road tubes to measure baseline volume, speed, and speed reliability at two locations along Barbur Boulevard. The same procedures were repeated initially during Phase III of this evaluation to gather post-deployment data for comparison with the baseline data. However, these data were not used for the evaluation. The reason these data were not used is that the primary data needed for the evaluation are from incident conditions (to test the impacts of the incident management system).

While there were a few minor incidents that occurred during both the “Before” and “After” data collection periods, there were no incidents significant enough to justify use of the incident management system in the post-deployment period. Therefore, there were no incident-related data collected in the post-deployment phase. While these data are available on an on-going basis on I-5 (from permanent loop detector stations), no stationary means of gathering speed and volume data are available along Barbur Boulevard. Therefore, without volumes from Barbur Boulevard during incidents, there was no direct way of measuring system throughput/capacity.

To counter this, the Evaluation Team planned to use a combination of two other types of data: (1) transit bus probes as a source of speed data from Barbur Boulevard and (2) ramp volumes (from I-5 to Barbur Boulevard) as a “surrogate” measure of traffic volume on Barbur Boulevard). While the data needed to directly measure system throughput during incidents are not available, using the bus speed data and the ramp volumes together could provide some information as to the efficiency of the system. Unfortunately, there were no off-ramp data available with which to conduct the analysis. Therefore, there were no sufficient data available to conduct an efficiency analysis. The only data available were speeds on Barbur Boulevard from the bus probes. The use of these data is described in more detail below.

The city buses provided speed reads northbound along Barbur Boulevard at the intersections noted in Figure 3-1 (indicated by the flags). The following information pertains to the speed data:

1. Data structure:
   - Data were collected at the following intersections on Barbur Boulevard:
     - #11240
     - #11130
     - 53RD
     - LURADEL

- #10100
- CAPITOL HWY
- B1/12, 64, 94 IN
- #9500
- ALICE
- 30TH
- 26TH WAY
- #8604
- 22ND
- 19TH
- MOSS
- 13TH
- BERTHA
- TERWILLIGER
- 2ND
- BRIER
- NEBRASKA
- SLAVIN / CAPITOL
- HWY
- #4950
- HAMILTON
- LANE
- PENNOYER
- WHITAKER
- WOODS
- HOOKER

2. Assumptions:

   - The speed data are an accurate reflection of conditions along Barbur Boulevard.

3. Evaluation period:

- Historic background volume data from available intersection counts obtained for June 16, August 16, and October 16, 2000
- Baseline background data from January 7, 2002 through February 1, 2002
- Current background condition data from January 15, 2004 through January 31, 2004
- Speed data for the December 3, 2002 baseline incident, Incident 1, (6:30 – 8:30 a.m.) and the non-incident control day of December 11, 2002 (6:30 – 8:30 a.m.)
- Speed data for the August 26, 2003 post-deployment incident, Incident 3, (5 – 9 a.m.) and the non-incident control day of September 2, 2003 (5 – 9 a.m.)
- Speed data for the December 8, 2004 post-deployment incident, Incident 4, (5 – 10:30 a.m.) and the non-incident control day of December 1, 2004 (5 – 10:30 a.m.)

These bus speed data, coupled with the speed and volume data from the ODOT loop detectors along I-5 were used to conduct a mobility analysis during incident conditions.

3.2 FINDINGS

3.2.1 Comparison of Background Traffic Conditions

To give context to the post-deployment system data, a comparison between the historic, baseline, and current freeway traffic volumes and speeds on I-5 was performed as outlined in Table 3-1. This was done to determine whether traffic performance during the baseline study period was consistent with performance from the recent past.

Table 3-1. Summary of Northbound AM Freeway and Arterial Traffic Performance

Metric	Historic Jan/Sept/Oct 2000	Baseline Jan 2002	Current Jan 2004
I-5			
Average peak period flow (vph)	3,914	3,869	3,856
Average Peak 30-min volume	1,513	2,162	1,869
Average peak period speed (mph)	48	47	43
Average peak 30-min speed (mph)	45	43	45
Standard deviation of speed (mph)	9.4	9.2	7.1
Barbur Boulevard			
Average hourly volume	797	825	NA
Average speed (mph)	35.5	42.1	34.7
Standard deviation of speed (mph)	5.9	8.5	7.2

Interestingly, traffic volume on northbound I-5 during the morning peak period has remained very consistent over the past 4 years; however, volumes during the peak 30-minute period increased between January/September/October 2000 and January 2002 and then decreased between January 2002 and January 2004. Speeds on I-5 during the peak period have been slightly decreasing over the past 4 years, while speeds during the peak 30-minute period have remained fairly consistent. The speed variability appears to have decreased over the past few years.

On Barbur Boulevard, a similar peak period speed analysis was performed. It should be noted that the Barbur Boulevard data were mostly sporadic; they were taken from different time periods and locations, and might not be suitable for direct comparisons. The historic Barbur Boulevard speed data were taken from two locations on three non-consecutive days in 2000, while the baseline data were obtained from two other points in January 2002. The current data came from bus speed probes at 30 intersections along the Barbur Boulevard Corridor from January 15 to January 31, 2004. Table 3-1shows the comparison between historic, baseline, and current Barbur Boulevard speeds. While speeds on Barbur Boulevard seem to have increased between 2000 and 2002, they may have decreased again in 2004. Speed variability increased between 2000 and 2002, but showed a decrease between 2002 and 2004 (consistent with speed variabilities on I-5).

In the overall traffic profiles of I-5 and Barbur Boulevard, by comparing the most recent data to historic and baseline data, I-5 has similar speed variability to that of Barbur Boulevard. With this traffic profile in mind for both the interstate and parallel arterial, a comparison of three distinct days was undertaken. The findings of this analysis are discussed in more detail in Section 3.2.2.

3.2.2 Comparison of Traffic Performance in Specific Conditions

The analysis to this point has been focused on establishing an overview of AM Peak traffic conditions over a range of days (in this case January 15-31, 2004 as compared to January 2002 and January 2000). This section involves the estimation of performance during three incidents:

- Incident conditions on I-5 before system deployment (Incident 1: December 3, 2002 from 6:30 – 8:30 a.m.)
- Incident conditions on I-5 with system use (Incident 3:[6] August 26, 2003 from 5 – 9 a.m.)
- Incident conditions on I-5 with system use (Incident 4:December 8, 2004 from 5 – 10:30 a.m.)

Also reported in this section are performance data for control days for each of the three incidents listed above. These control days were used to compare the performance during the incidents, not only across the incident, but to “normal” traffic conditions. These non-incident control days include:

- December 11, 2002 (from 6:30 – 8:30 a.m.) – compares to December 3, 2002. Both dates were weekdays at a time when school was in session. Note, however, that the weather on these two dates does differ somewhat – December 3, 2002 was a fully clear day while December 11, 2002 had light rain.
- September 2, 2003 (from 5 – 9 a.m.) – readily compares to August 26, 2003, in that they were both Tuesdays during a time when school was not in session. According to historic

[6] Mobility data from Incident 2, which occurred on April 8, 2003, were not used in the mobility analysis, as the incident management system was only partially operational during this incident. The arterial signal flush plan was activated late in the incident, and the trailblazer signs were never activated.

weather records[7] the weather for both dates was similar – approximately 60 °F and partly cloudy.

- December 1, 2004 (from 5 – 10:30 a.m.) – readily compares to December 8, 2004, as both dates were Wednesdays in December at a time when school was in session. Additionally, both dates had similar weather – cloudy, light rain, and approximately 45 °F.

Table 3-2 presents the main data of interest in comparing traffic conditions on the aforementioned dates. Table 3-2 also provides beneficial information in comparing the volumes, speeds, and speed variabilities on I-5 for the incident day and the control day. This comparison shows how the traffic performance during each of the incidents compares to a “normal” day.

Following is a summary of the comparison of the I-5 volumes between the incident days and the control days for three analysis periods (before incident occurrence, during the incident, and after incident clearance):

- **Before incident occurrence.** In all three cases, average volumes in the 30-minute analysis period just prior to the incidents were about equal to or higher than average volumes on the control days. (Note: Average volumes were also relatively constant across the three incident days and the three control days for the same analysis period [5 – 5:30 a.m.], ranging from around 168 – 201 vehicles per hour per lane [vphpl]).

- **During the incident.** In the 30-minute analysis period just following occurrence of the incidents, average volumes were significantly lower than during the same analysis period on the control days. For example, during the August 26, 2003 incident, the average volume was only 254 vphpl as compared to the same analysis period on September 2, 2003 (the non-incident control day) when the average volume was 670 vphpl. In fact, the throughput during the incidents ranged from 58 to only 8 percent of the throughput on the “normal” days. This significant reduction in average volumes indicates a reduction in capacity/throughput on I-5 due to the incidents.

- **After incident clearance.** In the first 30-minute analysis period following incident clearance, average volumes on each of the incident days had more or less recovered up to the level of the control day. (Note: All post-incident volumes were slightly lower than the comparable control days [82 – 96 percent of normal], indicating that the traffic flow may still have been recovering in the minutes following clearance of the incidents.)

  In the second 30-minute analysis period following clearance of the incidents, the December 2002 and December 2004 average incident volumes had fully recovered, while the August 2003 average incident volume was still slightly below its level on the control day (86 percent of “normal”).

[7] Historic weather records accessed from: http://weather.unisys.com/archive/sfc_map/.

Table 3-2. Summary of Northbound AM Baseline and Post Deployment Traffic Performance During Incident Conditions

Metric	12/11/02 No Incident	12/3/02[1] "Before" Incident (7 – 7:30 AM)	Time (AM)	9/2/03 No Incident	8/26/03[2] "After" Incident (5:30 – 8 AM)	Time (AM)	12/1/04 No Incident	12/8/04[3] "After" Incident (5:45 – 9:30 AM)	Time (AM)
I-5									
Avg vol. (vphpl) prior to incident	180	190	5 – 5:30	61	168	5 – 5:30	208	201	5 – 5:30
	639	678	6:30 – 7						
Avg vol. (vphpl) during incident	623	363	7 – 7:30	670	254	7 – 7:30	374	195	5:45 – 6:15
							754	60	7 – 7:30
Avg vol. (vphpl) after incident	482	454	7:30 – 8	615	506	8 – 8:30	554	534	9:30 – 10
Avg vol. (vphpl) after incident	344	510	8 – 8:30	591	508	8:30 – 9	503	494	10 – 10:30
Avg speed (mph) prior to incident	47	47	5 – 5:30	49	47	5 – 5:30	55	55	5 – 5:30
	43	44	6:30 – 7						
Avg speed (mph) during incident	31	12	7 – 7:30	47	18	7 – 7:30	58	25	5:45 – 6:15
							46	18	7 – 7:30
Avg speed (mph) after incident	17	15	7:30 – 8	44	27	8 – 8:30	55	42	9:30 – 10
Avg speed (mph) after incident	11	16	8 – 8:30	48	50	8:30 – 9	57	39	10 – 10:30
Std dev. of speed prior to incident	24.2	24.2	5 – 5:30	19.6	17.4	5 – 5:30	9.7	11.1	5 – 5:30
	16.9	17.0	6:30 – 7						
Std. dev. of speed during incident	17.4	18.6	7 – 7:30	10.4	19.9	7 – 7:30	6.7	26.2	5:45 – 6:15
							9.1	26.0	7 – 7:30
Std dev. of speed after incident	5.2	7.1	7:30 – 8	11.2	10.7	8 – 8:30	6.1	13.5	9:30 – 10
Std dev. of speed after incident	2.2	3.9	8 – 8:30	11.9	12.3	8:30 – 9	6.0	19.6	10 – 10:30
Barbur Blvd									
Avg speed (mph) prior to incident	38	38	5 – 5:30	NA	37	5 – 5:30	37	38	5 – 5:30
	38	33	6:30 – 7						
Avg speed (mph) during incident	30	35	7 – 7:30	38	35	7 – 7:30	34	35	5:45 – 6:15
							37	30	7 – 7:30
Avg speed (mph) after incident	31	33	7:30 – 8	38	34	8 – 8:30	38	36	9:30 – 10
Avg speed (mph) after incident	35	32	8 – 8:30	37	37	8:30 – 9	37	36	10– 10:30
Std dev. of speed prior to incident	4.9	6.0	5 – 5:30	NA	7.0	5 – 5:30	3.5	5.2	5 – 5:30
	5.0	6.9	6:30 – 7						
Std. dev. of speed during incident	5.9	5.9	7 – 7:30	4.3	6.1	7 – 7:30	4.5	6.0	5:45 – 6:15
							6.9	10	7 – 7:30
Std dev. of speed after incident	5.6	9.3	7:30 – 8	5.0	10.3	8 – 8:30	6.9	7.2	9:30 – 10
Std dev. of speed after incident	7.4	8.6	8 – 8:30	5.5	5.3	8:30 – 9	4.8	8.7	10– 10:30

[1] Due to incident location at Taylors Ferry, data for analysis taken only from detectors at Pacific Hwy and Capitol Hwy.
[2] Due to incident location at Terwilliger Blvd., data for analysis taken only from detectors at Capitol Hwy, Spring Garden Street, Multnomah Blvd., Terwilliger Blvd., & Bertha
[3] Due to incident location at Multnomah Blvd., data for analysis taken only from detectors at Pacific Hwy, Capitol Hwy, Spring Garden St., Multnomah Blvd.

Next, the following is a summary of a similar comparison of the I-5 speeds and speed variability between the incident days and control days for the same three analysis periods:

- **Before incident occurrence.** In all three cases, average speeds and speed variability in the 30-minute analysis period just prior to the incidents were approximately equal to the average speeds and speed variability on the control days. (Note: Average speeds were also relatively constant across the three incident days and the three controls days for the same analysis period [5 – 5:30 a.m.], ranging from 47 – 55 mph.)

- **During the incident.** In the 30-minute analysis period just following incident occurrence, average speeds were significantly lower than during the same analysis periods on the control days, while speed variability during the incidents was significantly higher as compared to the non-incident control days. For example, during the August 26, 2003 incident, the average speed was only 18 mph as compared to the same analysis period on the September 2, 2003 control day when average speed was 47 mph. Likewise, speed variability was 19.9 mph as compared to the control day when speed variability was only 10.4 mph). Interestingly, in all three cases, speeds were reduced by about 60 percent during the incidents.

- **After incident clearance.** In the first 30-minute analysis period following incident clearance, average speeds on each of the incident days had not fully recovered up to the level of the control days (only 61 – 88 percent of normal); however, the average speeds following clearance of the incidents had increased from during the incidents, indicating that the traffic flow was in the process of recovering from the incidents.

  In the second 30-minute analysis period following clearance of the incidents, the December 2002 and August 2003 average speeds and speed variability had fully recovered, while the December 2004 (the longest of the three incidents) average speed was still operating at only 68 percent of “normal”, and speed variability were still over twice as high as “normal”.

This comparison of volumes, speeds, and speed variability on I-5 shows that traffic conditions were significantly impacted by the occurrence of the incidents. Throughput was reduced as much as 92 percent, and average speeds across all incidents dropped by about 60 percent. The data also show that the conditions on I-5 during incidents were likewise deteriorated in both the “Before” and “After” incidents. This can be expected, as most of the improvements of the incident management system (e.g., arterial signal flush plan, trail blazer signs) were located on Barbur Boulevard and not on I-5. The only thing likely to improve conditions along I-5 during incidents would be less volume on I-5 due to traffic diverting to alternate routes. However, without volumes on Barbur Boulevard and/or from the off ramps from I-5 to Barbur Boulevard, there was no way to determine for sure if and how much traffic did actually divert to Barbur. The volumes shown during the incidents in Table 3-2 represent the capacity of the freeway during the incidents and cannot be used to estimate how much traffic was actually on I-5.

With this in mind, a comparison of the traffic conditions from incident and non-incident days on Barbur Boulevard is warranted. Though it could not be determined as to how much traffic diverted from I-5 to Barbur Boulevard, it could be assumed that some amount of traffic did divert, especially considering the magnitude of both of the post-deployment incidents (both blocked two lanes and lasted more than 2 hours). It is likely that many motorists were seeking alternate routes in an attempt to avoid these incidents. The following is a summary of a comparison of the average speeds and speed variabilities on Barbur Boulevard for the three analysis periods:

- **Before incident occurrence.** In all three cases, average speeds and speed variability in the 30-minute analysis period just prior to the incidents were approximately equal to the average speeds and speed variability on the control days. (Note: average speeds were also relatively constant across the three incident days and the three controls days for the same analysis period [5 – 5:30 a.m.], ranging from 37 – 38 mph.)

- **During the incident.** Despite the potential increase in volume on Barbur Boulevard, the average speeds in the 30-minute analysis period following incident occurrence were only slightly lower than during the same analysis periods on the control days. For example, during the August 26, 2003 incident, the average speed was 35 mph, as compared to the same analysis period on the September 2, 2003 control day when average speed was 38 mph. Therefore, speeds were operating at 92 percent of “normal” levels during this fatal incident, which blocked two lanes of traffic on I-5 and lasted 2.5 hours.

  Likewise, during the December 8, 2004 incident, the average speed was 30 mph, as compared to the same analysis period on the December 1, 2004 control day when average speed was 37 mph. Therefore, speeds were operating at 81 percent of “normal” levels during this incident, which involved an overturned tractor-trailer truck, blocked two lanes, required closure of I-5, and lasted nearly 4 hours. While speed variability during the incidents increased as compared to the control days, speeds on Barbur Boulevard were not nearly as variable as speeds on I-5 during the incidents (ranging from 19 – 26 mph on I-5 while only 6 – 10 mph on Barbur), indicating a smoother flow of traffic on Barbur Boulevard than on I-5 during the incidents.

- **<u>After incident clearance</u>.** If the first 30-minute analysis period following incident clearance, average speeds during the “Before” incident (December 2002) had recovered, but average speeds during the two “After” incidents (August 2003 and December 2004) had not fully recovered. Interestingly, while the speeds on Barbur following clearance of the August 26, 2003 incident had not recovered at all from during the incident (operating at 89 percent of “normal”), speeds on Barbur during the December 8, 2004 incident had nearly recovered (operating at 95 percent of “normal”). This result could indicate a learning curve with use of the system. In the second 30-minute analysis period following clearance of the incidents, average speeds on Barbur Boulevard during both “After” incidents had fully recovered (while the speeds on I-5 following the December 8, 2004 incident were still significantly below where they were during the same period on the control day).

Figure 3-2 graphically represents the average speeds on Barbur Boulevard for the control days and the three incident days for four analysis periods (“Before” Incident 12/3/2002, “After” Incident 8/26/2003, and “After” Incident 12/8/2004):

- 5:00 – 5:30 a.m. (prior to incident occurrence)

- 7:00 – 7:30 a.m. (during incident)

- First 30-minute period following incident clearance (time varies by incident – see Table 3-2 for specific times)

- Second 30-minute period following incident clearance (time varies by incident – see Table 3-2 for specific times)

Figure 3-2 shows that prior to the incidents, the average speeds for the control days and the three incident days were nearly identical. During the incidents, average speeds on all incident days dropped below the speed of the control day. In the first 30-minute analysis period following incident clearance, average speeds were higher for the worst incident (December 2004) than for the other two incidents. In fact, average speeds were the lowest on Barbur Boulevard following clearance of the "Before" incident (December 2002), which was also the most minor of the three incidents, blocking only one lane of traffic on I-5 for 30 minutes.

In the second 30-minute analysis period following incident clearance, average speeds for the two "After" incidents had fully recovered, while speeds following the "Before" incident were still lower than "normal".

Figure 3-3 graphically represents the average speeds on I-5 for the control days and the three incident days for the same four analysis periods ("Before" Incident 12/3/2002, "After" Incident 8/26/2003, and "After" Incident 12/8/2004). Figure 3-3 shows that prior to the incidents, the average speeds for the control days and the three incident days were similar.

During the incidents, average speeds on all incident days dropped well below the average speeds on the control days. Interestingly, the average speeds during the "Before" incident were lower than average speeds during the "After" incidents, despite the fact that the "Before" incident could be considered minor compared to the two "After" incidents.

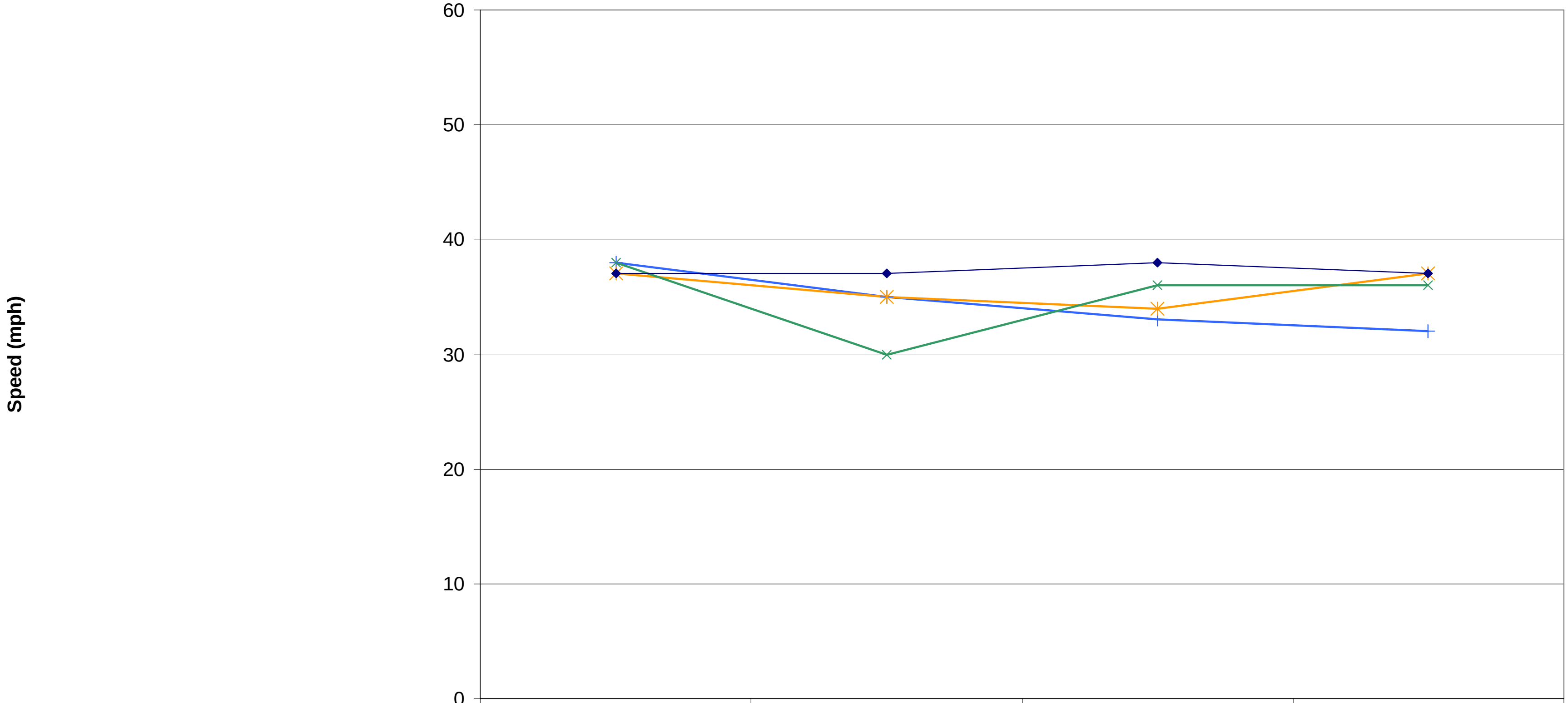
In the first 30-minute analysis period following incident clearance, average speeds were higher for the worst incident (December 2004) than for the other two incidents. In the second 30-minute analysis period following incident clearance, average speeds for the two "After" incidents had still not fully recovered; however, they were much higher than average speeds following the "Before" incident, which were still very low as compared to the average speeds on the control days.

These low speeds following the clearance of the "Before" incident (as compared to following the two "After" incidents) could be indicative of better use of corridor capacity with the incident management system due to diverting traffic to alternate routes and leaving less traffic backed up on I-5 (i.e., less traffic means higher speeds). The other possible explanation for the lower speeds following clearance of the "Before" incident is the time at which the three incidents were cleared.

The "Before" incident was cleared around 7:30 a.m., a time falling well within the normal peak period of commuting when there was certainly a lot of traffic on I-5. The first "After" incident (August 2003) was cleared around 8 a.m., a time falling a little later in the peak period of commuting when fewer drivers were potentially on the roadway.

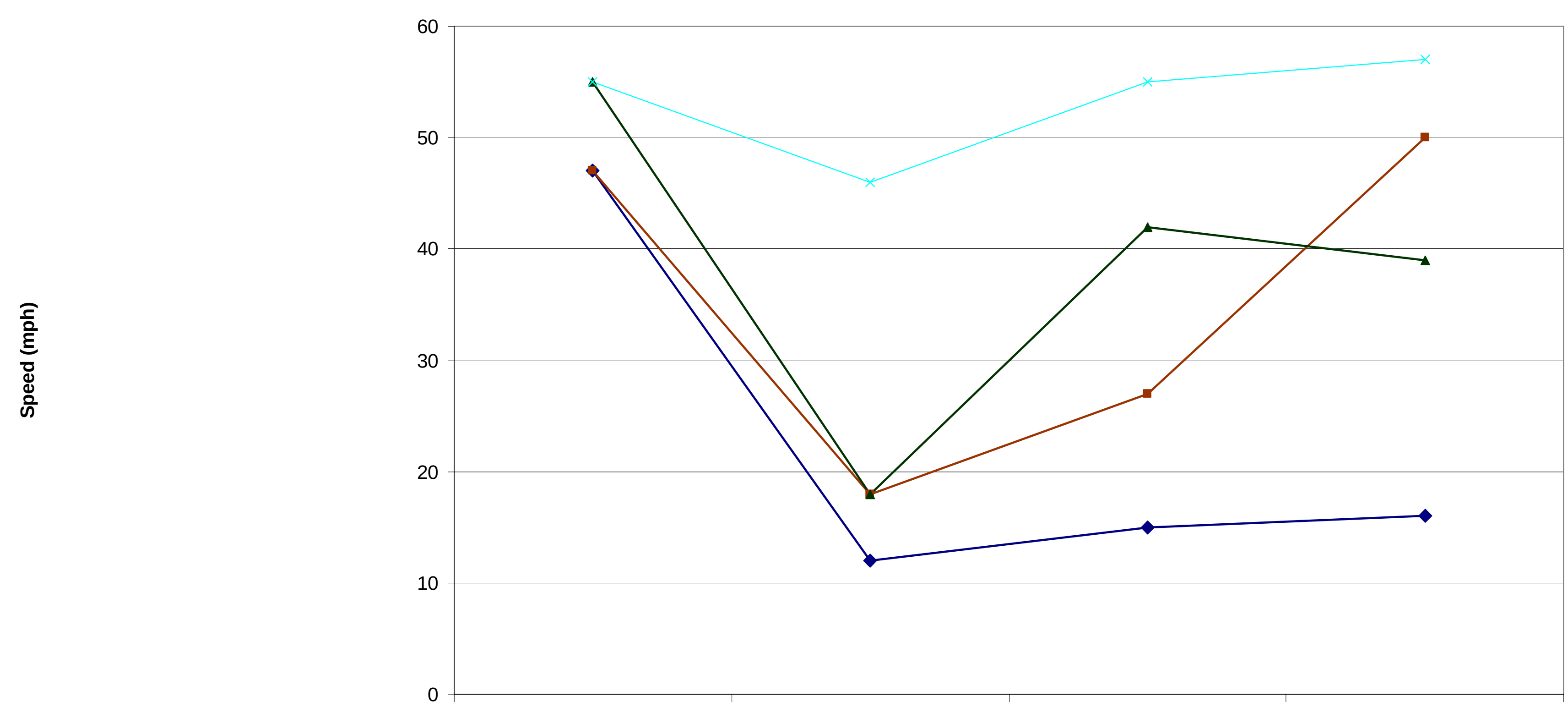
The second "After" incident (December 2004) was not cleared until around 9:30 a.m., a time falling outside of the normal peak period of commuting when even fewer commuters are expected to still be on the roadway.

When less traffic is on the roadway, speeds are expected to be higher. The clearance times of the incidents, therefore, could account for why higher speeds occurred following the clearance of the August 2003 "After" incident than following clearance of the December 2002 "Before" incident, and why even higher speeds occurred following clearance of the December 2004 "After" incident.



	(5 – 5:30 AM) - Prioir to Inicdent	(7 – 7:30 AM) - During Incident	1st 1/2hour following incident clearance	2nd 1/2 hour following incident clearance
12/3/2002 Barbur Speeds	38	35	33	32
8/26/2003 Barbur Speeds	37	35	34	37
12/8/2004 Barbur Speeds	38	30	36	36
12/1/2004 No Incident Control Barbur Speeds	37	37	38	37

Figure 3-2. Average Speeds on Barbur Boulevard for Control Days and Three Incidents.



	(5 – 5:30 AM) - Prioir to Inicdent	(7 – 7:30 AM) - During Incident	1st 1/2hour following incident clearance	2nd 1/2 hour following incident clearance
12/3/2002 I-5 Speeds	47	12	15	16
8/26/2003 I-5 Speeds	47	18	27	50
12/8/2004 I-5 Speeds	55	18	42	39
12/1/2004 No Incident Control I-5 Speeds	55	46	55	57

Figure 3-3. Average Speeds on I-5 for Control Days and Three Incidents.

3.3 SUMMARY

The data in Table 3-2, Figure 3-2, and Figure 3-3 show that even during major incidents, when capacity on I-5 was severely reduced (as evidenced by low volumes on I-5 during the incidents), speeds were significantly lower than normal. Speed variability was significantly higher than normal, yet traffic performance on Barbur Boulevard was only moderately impacted during incidents, with speeds operating at 81 percent of “normal” or better. These findings could be a direct result of the incident management system.

Moreover, average speeds on Barbur Boulevard during the two major “After” incidents fully recovered by the second 30-minute time period following clearance of the incidents, while average speeds on Barbur Boulevard had not fully recovered during the relatively minor “Before” incident. This finding indicates that the Barbur Boulevard incident management plan was effective at moving traffic along Barbur Boulevard.

4. SUMMARY AND CONCLUSIONS

4.1 INTRODUCTION

This document has presented the evaluation strategies and objectives, the data collection methodologies, and the results of the evaluation of the I-5/Barbur Boulevard Parallel Corridor Traffic Management Demonstration Project in Portland, Oregon.

4.2 SUMMARY

The results of the analyses are summarized here according to each of the four evaluation objectives:

- Assess customer satisfaction in the corridor during incidents.
- Assess corridor efficiency during incidents.
- Assess traveler mobility in the corridor during incidents.
- Assess traveler safety in the corridor during incidents.

4.2.1 Assess Customer Satisfaction in the Corridor During Incidents

Customer satisfaction was assessed through the use of a panel survey. Three "incident" surveys were administered throughout the course of the evaluation: (1) for an incident that occurred before system deployment; (2) for an incident that occurred around the time of system deployment; and (3) for an incident that occurred after system deployment. The responses to the three surveys were compared to determine if the system had any impacts on customer satisfaction during incident conditions.

While the characteristics of Incident 1 and Incident 2 were very similar, the characteristics of Incident 3 were very different. Incidents 1 and 2 were multi-vehicle crashes (one injury, one non-injury) that occurred around 7 a.m. and lasted for about 30 minutes. Incident 3, on the other hand, involved a pedestrian fatality, occurred before the morning peak period, and lasted through most of the morning peak. Therefore, while the responses to the incident questionnaires may reflect a change in customer perceptions and satisfaction as a result of the system, the responses may also reflect the differences in the types of incidents that occurred.

4.2.1.1 Driver Behavior During Incidents

While the large majority of respondents reported learning about Incidents 1 and 2 after leaving home, the majority of respondents reported learning of Incident 3 before leaving home. This may be a result of the magnitude of Incident 3 as compared to Incidents 1 and 2. In addition, the early occurrence of Incident 3 (5:30 a.m.) may have given the media more time to broadcast information related to the incident.

More respondents reported taking alternate routes when they learned of Incident 3 as compared to the other two incidents. At the same time, fewer respondents reported doing the "same as usual" during Incident 3 as compared to the other two incidents (results were significantly different for those learning of the incidents after leaving home, but not for those learning of the incidents before leaving home).

When asked specifically about their use of Barbur Boulevard to avoid the incidents, more respondents reported using Barbur Boulevard as an alternate route during Incident 3 than did during Incident 1; and likewise, fewer respondents reported staying on I-5 during Incident 3 than did during Incident 1.

All of these results could indicate that the VMSs were effective at getting commuters to take alternate routes (including Barbur Boulevard); however, the result could also be due to more commuters being aware of Barbur Boulevard as an alternate, as well as a result of the timing and nature of Incident 3.

4.2.1.2 Driver Perception of and Satisfaction with Traffic Operations During Incidents

As a whole, respondents perceived their commute times to be shorter during Incident 3 than during Incident 1, despite the dramatic difference in the magnitude and scope of Incident 3 as compared to Incident 1. Further, respondents who took Barbur Boulevard as an alternate route tended to perceive less additional time needed to commute than those respondents who stayed on I-5 during Incident 3 as compared to during Incident 1. These results suggest that the system was efficient in getting motorists around the incident and to their destination more quickly.

Respondents' ratings of traffic conditions along Barbur Boulevard during incidents varied only slightly across the three incident surveys. It did appear that the ratings for traffic signal operations tended to increase across the three surveys; however pair-wise t-tests of the average ratings showed no significant differences between average ratings for Incident 1 as compared to Incident 2, for Incident 1 as compared to Incident 3, or for Incident 2 as compared to Incident 3.

For those respondents who stayed on I-5 during the incidents, the same result was found; there were only slight variations in the distribution of ratings across the three surveys, and a pair-wise comparison of the average ratings showed no significant difference in average ratings between any of the surveys.

4.2.1.3 Driver Use of Traffic Information to Make Commute Decisions During Incidents

Respondents' reported use of information varied only slightly across the three incident surveys. While more respondents tended to report receiving some sort of information across the three surveys, the distributions of responses were not significantly different.

The large majority of respondents who learned of the incidents before leaving home had heard about the incident through television or radio reports. While most of those respondents who learned of the incidents after leaving home heard about the incidents on radio reports, many never received any information about the incidents (although their commute was affected). Interestingly, many fewer respondents had no information about Incident 3 (28 percent had no information) than did for Incident 1 (60 percent had no information – a significant result).

4.2.2 Assess Corridor Efficiency During Incidents

Corridor efficiency, or throughput, during incidents was to be measured using volumes from the freeway and Barbur Boulevard. Freeway volumes were available from ODOT. Originally, the Evaluation Team had hoped to use traffic counts from road tubes placed along Barbur Boulevard during a 1-month period both before and after system deployment. No incidents warranting use of the incident management system occurred during the post-deployment period in which the hose road tubes were in the field. Therefore, no volume data from Barbur Boulevard were available. With only volumes from I-5, an evaluation of corridor efficiency could not be conducted.

4.2.3 Assess Traveler Mobility in the Corridor During Incidents

Traveler mobility was assessed through an analysis of traffic volumes, speed, and speed variability from ODOT loop detectors along I-5, coupled with an analysis of speed and speed variability from bus probe data from TriMet along Barbur Boulevard. Volume, speed, and speed variability during incident days were compared with similar data from “control” days to determine patterns in traffic performance during incident conditions as compared to “normal”.

The comparison of volumes, speeds, and speed variability on I-5 showed that traffic conditions, as expected, were significantly impacted by the occurrence of the incidents. Throughput was reduced as much as 92 percent, and average speeds across all incidents dropped by about 60 percent. The data also showed that the conditions on I-5 during incidents were likewise deteriorated in both the “Before” and “After” incidents. This is not a surprising result, as most of the improvements of the incident management system (e.g., arterial signal flush plan, trail blazer signs) were located on Barbur Boulevard and not on I-5.

The comparison of average speeds and speed variability on Barbur produced a different result than those on I-5. Despite the potential increase in volume on Barbur Boulevard, the average speeds during the incidents were only slightly lower than during the same analysis periods on the control days. In one case, speeds were operating at 92 percent of “normal” levels during a fatal incident, which blocked two lanes of traffic on I-5 and lasted 2.5 hours. While speed variability during the incidents did show an increase as compared to the control days, speeds on Barbur Boulevard were not nearly as variable as speeds on I-5 during the incidents, indicating a smoother flow of traffic on Barbur Boulevard than on I-5 during the incidents.

These results showed that during the incidents, even when capacity on I-5 was severely reduced and speeds were significantly lower than normal, traffic performance on Barbur Boulevard was only moderately impacted by the incidents, with speeds operating at 81 percent of “normal” or better. Moreover, average speeds on Barbur Boulevard during the two major “After” incidents fully recovered by the second 30-minute time period following clearance of the incidents, while average speeds on Barbur Boulevard had not fully recovered during the relatively minor “Before” incident, indicating that the Barbur Boulevard incident management plan was effective at moving traffic along Barbur Boulevard.

4.2.4 Assess Traveler Safety in the Corridor During Incidents

There were insufficient data to support an analysis of traveler safety in the corridor. First, there were too few incidents that occurred in the Study Area during the evaluation period. Second, there were no secondary incidents that occurred during the incidents used for the evaluation. To support an analysis of secondary incidents, there would need to be many incidents required for analysis for both before and after system deployment.

4.3 CONCLUSIONS

Based on the evaluation results, the following conclusions are made:

- More respondents used Barbur Boulevard as an alternate route after implementation of the incident management system:
  - More respondents tended to use Barbur Boulevard (or other alternate routes) during Incident 2 as compared to Incident 1, and during Incident 3 as compared to Incident 2.

Likewise, fewer respondents reported staying on I-5 during Incident 2 as compared to Incident 1, and during Incident 3 and compared to Incident 2.

  - More respondents, who learned of the incidents *after* leaving home, tended to take alternate routes to avoid Incident 3 than did to avoid Incident 1 (60 percent took alternate routes during Incident 3 as compared to 40 percent during Incident 1). Further, fewer respondents, who learned of the incidents *after* leaving home, tended to do the "same as usual" (in terms of their commute) during Incident 3 than during Incident 1 (only 36 percent did the "same as usual" during Incident 3 as compared to 58 percent during Incident 1).

- It appears that the incident management system was effective at getting some commuters around the incident and to their destination more quickly than without:
  - More respondents reported additional commute times of more than 15 minutes during Incident 1 than during incident 3; likewise, fewer respondents reported the shortest additional commute times (up to 10 minutes) during Incident 1 than during Incident 3. As a whole more respondents perceived their commute times to be shorter after the incident management system was implemented, despite the magnitude of Incident 3 as compared to Incident 1.
  - During Incident 3, more respondents who stayed on I-5 reported the longest additional commute times (more than 15 minutes) as a result of the incident as compared to those who took Barbur Boulevard as an alternate route (63 percent for those on I-5 versus only 25 percent for those on Barbur); likewise, more respondents who took Barbur Boulevard as an alternate route reported the shortest additional commute times (up to 10 minutes) as a result of the incident as compared to those who stayed on I-5 (58 percent for those who took Barbur versus 21 percent for those who stayed on I-5). Many more respondents who took Barbur Boulevard to avoid the Incident 3 (after implementation of the incident management system) reported shorter commute times than those who stayed on I-5, while many more respondents who stayed on I-5 during Incident 3 reported the longest commute times.
- Satisfaction ratings for traffic conditions on I-5 and Barbur Boulevard were not significantly different across the three incident surveys. However, response trends tended to suggest that respondents' satisfaction ratings for Barbur Boulevard had increased across the three surveys. This was especially true for the satisfaction ratings of *traffic signal operations*, which indicated that commuters may perceive the positive impacts of the incident management signal timing "flush" plan. More surveys during more incidents would be needed to further test for the significance of this result.
- Respondents' ratings of the timeliness, accuracy, and usefulness of the traveler information they received regarding the incidents were not significantly different across the three incident surveys.
- The results of the mobility analysis suggest that the incident management system was successful at moving assumed large volumes of traffic along Barbur Boulevard during the After incidents:
  - While traffic conditions on I-5 were severely degraded during the After incidents (significantly reduced capacity and speeds, with significantly higher speed variabilities), traffic conditions on Barbur Boulevard were only moderately degraded during these major incidents, with speeds operating at 81 percent or "normal" or better.
  - In addition, speed variabilities on I-5 and Barbur Boulevard during the incidents indicated that traffic flow on Barbur Boulevard was much less variable than that on I-5.

- The customer satisfaction data support the mobility data in that drivers on I-5 during the incidents were far less satisfied with traffic conditions during the incidents than drivers traveling on Barbur Boulevard. This result further supports the idea that the incident management system was efficient at moving drivers down Barbur Boulevard during the incidents when freeway traffic was moving at significantly slower rates.

Based on the results of this evaluation and the conclusions drawn, the hypotheses stated up front have either been supported by the results of the evaluation, have not been supported by the results of the evaluation, or are inconclusive at this time:

- **Hypothesis: Improved integration with multi-jurisdictional signal systems will increase corridor efficiency without expanding existing roadways.** *The hypothesis is inconclusive due to insufficient volume data on Barbur Boulevard.*
- **Hypothesis: The project will reduce delay and travel times in the corridor during incident conditions, thereby improving traveler mobility.** *The hypothesis is supported through the customer satisfaction surveys; more respondents who took Barbur Boulevard reported a shorter additional commute time during the incidents than those who stayed on I-5, and more respondents who stayed on I-5 reported the longest additional commute times than those who took Barbur Boulevard. In addition, the hypothesis is supported through the mobility analysis – while traffic conditions were significantly degraded along I-5 during all incidents, traffic conditions on Barbur Boulevard were only moderately degraded. In addition, the traffic conditions on Barbur Boulevard recovered at a rate faster during the major "After" incidents than during the relatively minor "Before" incident.*
- **Hypothesis: Through improved incident management, the project will reduce accident risk during incident conditions.** *This hypothesis is inconclusive. There were not enough data available for the analysis.*
- **Hypothesis: Increased travel time reliability and decreased delays during incident conditions will improve customer satisfaction.** *The hypothesis is inconclusive with the current data; while the response trends appear to show an increase in satisfaction with traffic volume, speed, and traffic signal operations on Barbur Boulevard across the three incidents, the changes were not significantly different. More surveys of more incidents would be needed to determine the impact of the system on customer satisfaction ratings.*

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APPENDIX A: I-5/BARBUR BOULEVARD “BEFORE” INCIDENT SURVEY

PORTLAND, OREGON I-5 TRANSPORTATION SURVEY

INCIDENT QUESTIONNAIRE

On Tuesday, 12/2/2002, there was an incident on Northbound I-5 at Taylors Ferry. This incident involved a 3-vehicle non-injury accident and blocked 1 lane. This incident took place from approximately 7:05 AM to 7:42 AM.

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1. Did this incident have an impact on your normal commute?

❑ Yes, I was in my car, carpool, vanpool, or on my motorcycle
❑ Yes, but I was riding the bus at the time
❑ No, I found out about this incident but it didn't impact me
❑ No, I wasn't even aware of this incident
❑ No, I didn't make my normal commute on that day

2. When did you FIRST find out about this incident or the traffic congestion it created?

❑ BEFORE I left home
❑ In the car, AFTER I left home
❑ Later in the day, AFTER the morning commute

3. <u>How</u> did you FIRST find out about this incident or the traffic congestion it created?

[Question for those who found out about the incident before leaving home.]

❑ Television report at home (NOT including Channel 14)
❑ TV Channel 14
❑ Radio report at home
❑ Traffic information phone line at home
❑ Internet Website at home
❑ Other (please specify):

3. <u>How</u> did you FIRST find out about this incident or the traffic congestion it created?

[Question for those who found out about the incident after leaving home.]

❑ Radio report in my car
❑ Traffic information phone line in my car
❑ Overhead electronic message signs along the freeway
❑ Wireless Internet device in my car
❑ I had no information about this incident before I encountered the congestion it created
❑ Other (please specify):

4. Which ONE of the following actions did you take when you found out about this incident or the traffic congestion it created?

[Question for those who found out about the incident before leaving home.]

❑ I decided to stay home
❑ I left home earlier or later than normal to avoid the delays
❑ I used an alternate route that included a freeway
❑ I used an alternate that did not include a freeway
❑ I did the same as usual - I left at my normal time and used my normal route
❑ Other (please specify):

4. Which ONE of the following actions did you take when you found out about this incident or the traffic congestion it created?

[Question for those who found out about the incident after leaving home.]

❑ I went back home
❑ I used an alternate route that included a freeway
❑ I used an alternate that did not include a freeway
❑ I did the same as usual - I left at my normal time and used my normal route
❑ Other (please specify):

5. How much longer did it take you to get to your destination during this incident (as compared to your "normal" commute)?

❑ Less than 5 minutes longer than usual
❑ 5-10 minutes longer than usual
❑ 11-15 minutes longer than usual
❑ More than 15 minutes longer than usual

6. Did you avoid this incident by using Barbur Boulevard?

❑ Yes, I usually use I-5, but I took Barbur Boulevard to avoid this incident
❑ Yes, but I usually take Barbur Boulevard instead of I-5
❑ No, I stayed on I-5
❑ No, I used another alternate

7. When you used Barbur Boulevard to avoid this incident, do you think it saved you time (as opposed to staying on the freeway)?

❑ Yes
❑ No

8. While traveling on BARBUR BOULEVARD within the Study Area, how satisfied were you with each of the following during the incident?

	Extremely Satisfied	Satisfied	Neither Satisfied Nor Dissatisfied	Dissatisfied	Extremely Dissatisfied
Volume of traffic	❑	❑	❑	❑	❑
Travel speed	❑	❑	❑	❑	❑
Traffic signal operations	❑	❑	❑	❑	❑

9. You may have had several sources of information about this incident. Which ONE of the following was your MAIN (not necessarily your FIRST) source of information?

❑ Television report at home (NOT including Channel 14)
❑ TV Channel 14
❑ Radio report at home
❑ Traffic information phone line at home
❑ Internet Website at home
❑ Radio report in my car
❑ Traffic information phone line in my car
❑ Overhead electronic message signs along the freeway
❑ Wireless Internet device in my car
❑ I had no information about this incident
❑ Other (please specify):

10. While traveling on BARBUR BOULEVARD within the Study Area, how satisfied were you with each of the following during the incident?

	Extremely Satisfied	Satisfied	Neither Satisfied Nor Dissatisfied	Dissatisfied	Extremely Dissatisfied
Volume of traffic	❑	❑	❑	❑	❑
Travel speed	❑	❑	❑	❑	❑
Traffic signal operations	❑	❑	❑	❑	❑

11. You may have had several sources of information about this incident. Which ONE of the following was your MAIN (not necessarily your FIRST) source of information?

❑ Television report at home (NOT including Channel 14)
❑ TV Channel 14
❑ Radio report at home
❑ Traffic information phone line at home
❑ Internet Website at home
❑ Radio report in my car
❑ Traffic information phone line in my car
❑ Overhead electronic message signs along the freeway
❑ Wireless Internet device in my car
❑ I had no information about this incident
❑ Other (please specify):

12. While traveling on I-5 within the Study Area, how satisfied were you with the traffic conditions during this incident?

Extremely Satisfied	Satisfied	Neither Satisfied Nor Dissatisfied	Dissatisfied	Extremely Dissatisfied
❑	❑	❑	❑	❑

13. You may have had several sources of information about this incident. Which ONE of the following was your MAIN (not necessarily your FIRST) source of information?

❑ Television report at home (NOT including Channel 14)
❑ TV Channel 14
❑ Radio report at home
❑ Traffic information phone line at home
❑ Internet Website at home
❑ Radio report in my car
❑ Traffic information phone line in my car
❑ Overhead electronic message signs along the freeway
❑ Wireless Internet device in my car
❑ I had no information about this incident
❑ Other (please specify):

14. You may have had several sources of information about this incident. Which ONE of the following was your MAIN (not necessarily your FIRST) source of information?

- ❑ Television report at home (NOT including Channel 14)
- ❑ TV Channel 14
- ❑ Radio report at home
- ❑ Traffic information phone line at home
- ❑ Internet Website at home
- ❑ Radio report in my car
- ❑ Traffic information phone line in my car
- ❑ Overhead electronic message signs along the freeway
- ❑ Wireless Internet device in my car
- ❑ I had no information about this incident
- ❑ Other (please specify):

15. Please indicate whether your MAIN source of information (Internet Website at home) for <u>this</u> incident was timely, accurate or useful enough to help you make decisions about your commute:

	Yes, Very	Yes, Somewhat	I'm Not Sure	No, Not Very	No, Not At All
Was the information TIMELY enough?	❑	❑	❑	❑	❑
Was the information ACCURATE enough?	❑	❑	❑	❑	❑
Was the information USEFUL enough?	❑	❑	❑	❑	❑

16. Did you see any messages regarding this incident on <u>OVERHEAD ELECTRONIC SIGNS</u> at any time during your commute?

- ❑ Yes
- ❑ No
- ❑ I don't recall

17. Please indicate below whether messages related to <u>this</u> incident on the OVERHEAD ELECTRONIC SIGNS were timely, accurate or useful enough to help you make decisions about your commute:

	Yes, Very	Yes, Somewhat	I'm Not Sure	No, Not Very	No, Not At All
Was the information TIMELY enough?	❑	❑	❑	❑	❑
Was the information ACCURATE enough?	❑	❑	❑	❑	❑
Was the information USEFUL enough?	❑	❑	❑	❑	❑

APPENDIX B: I-5/BARBUR BOULEVARD“AFTER” INCIDENT SURVEY

PORTLAND, OREGON I-5 TRANSPORTATION SURVEY

INCIDENT QUESTIONNAIRE

On Tuesday, 4/8/2003, there was an incident on Northbound I-5 at Terwilliger. This incident involved a 4-vehicle accident with injury and blocked 2 lanes. This incident took place from approximately 7:02 AM to 7:33 AM.

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1. In the MORNING, do you still typically commute NORTHBOUND on I-5 or Barbur Boulevard within the bounds of the Study Area?

- ❑ Yes
- ❑ No (end survey)

2. Were you traveling in a car, carpool, vanpool, or on a motorcycle in the Study Area any time during the morning that this incident occurred?

- ❑ Yes
- ❑ No (end survey)

3. Before receiving notification of this incident from us, were you aware of this incident or the out-of-the-ordinary delays it caused?

- ❑ Yes
- ❑ No (end survey)

4. When did you FIRST find out about this incident or the out-of-the-ordinary delays it caused?

- ❑ BEFORE I left home
- ❑ In the car, AFTER I left home
- ❑ Later in the day, AFTER the morning commute

5. Was your commute time or route affected by this incident or the out-of-the-ordinary delays it caused?

- ❑ Yes
- ❑ No [end survey]

6. How did you FIRST find out about this incident or the out-of-the-ordinary delays it caused? [Question for those who found out about the incident before leaving home.]

- ❑ Television report at home (NOT including Channel 14)
- ❑ TV Channel 14
- ❑ Radio report at home
- ❑ Traffic information phone line at home
- ❑ Internet Website at home
- ❑ Other (please specify):

6. How did you FIRST find out about this incident or the out-of-the-ordinary delays it caused? [Question for those who found out about the incident after leaving home.]

- ❑ Radio report in my car
- ❑ Traffic information phone line in my car
- ❑ Overhead electronic message signs along the freeway
- ❑ Wireless Internet device in my car
- ❑ I had no information about this incident before I encountered the congestion it caused
- ❑ Other (please specify):

7. Which ONE of the following actions did you take when you found out about this incident or the out-of-the-ordinary delays it caused?
[Question for those who found out about the incident before leaving home.]

- ❑ I left home earlier or later than normal to avoid the delays
- ❑ I used an alternate route that included a freeway
- ❑ I used an alternate that did not include a freeway
- ❑ I did the same as usual - I left at my normal time and used my normal route
- ❑ Other (please specify):

7. Which ONE of the following actions did you take when you found out about this incident or the out-of-the-ordinary delays it caused?
[Question for those who found out about the incident after leaving home.]

- ❑ I went back home
- ❑ I used an alternate route that included a freeway
- ❑ I used an alternate that did not include a freeway
- ❑ I did the same as usual - I left at my normal time and used my normal route
- ❑ Other (please specify):

8. Did you avoid this incident by using Barbur Boulevard?

- ❑ Yes, I usually take Barbur Boulevard instead of I-5
- ❑ Yes, I took Barbur Boulevard in an attempt to avoid this incident
- ❑ No, I took a different alternate route in an attempt to avoid this incident [answer Q9 and then skip to Q12]
- ❑ No, I stayed on I-5 [answer Q9 and then skip to Q11]

9. How much longer did it take you to get to your destination as a result of the incident/delays (as compared to your "normal" commute)?

❑ Less than 5 minutes longer than
❑ 5-10 minutes longer than usual
❑ 11-15 minutes longer than usual
❑ More than 15 minutes longer than usual

10. While traveling on BARBUR BOULEVARD within the Study Area, how satisfied were you with each of the following during the incident?

	Extremely Satisfied	Satisfied	Neither Satisfied Nor Dissatisfied	Dissatisfied	Extremely Dissatisfied
Volume of traffic	❑	❑	❑	❑	❑
Travel speed	❑	❑	❑	❑	❑
Traffic signal operations	❑	❑	❑	❑	❑

10a. Did you see the electronic "detour" signs (directing you to I-5) along Barbur Blvd.?

❑ Yes
❑ No [GO TO Q12]

10b. Did you follow the directions to I-5 posted on the electronic "detour" signs?

❑ Yes
❑ No, I didn't understand them [GO TO Q12]
❑ No, I decided not to use them although I could've gotten back on I-5 to get to my destination [GO TO Q12]
❑ No, at that point I was almost at my destination [GO TO Q12]

10c. Do you think that following the directions back to I-5 saved you time?

❑ Yes
❑ No [GO TO Q12]
❑ I'm not sure [GO TO Q12]

10d. Would you follow the directions displayed on the electronic "detour" signs again?

❑ Yes [GO TO Q12]
❑ No [GO TO Q12]

11. While traveling on I-5 within the Study Area, how satisfied were you with the traffic conditions during this incident?

Extremely Satisfied	Satisfied	Neither Satisfied Nor Dissatisfied	Dissatisfied	Extremely Dissatisfied
❑	❑	❑	❑	❑

12. You may have had several sources of information about this incident. Which ONE of the following was your MAIN (not necessarily your FIRST) source of information?

❑ Television report at home (NOT including Channel 14)
❑ TV Channel 14
❑ Radio report at home
❑ Traffic information phone line at home
❑ Internet Website at home
❑ Radio report in my car
❑ Traffic information phone line in my car
❑ Overhead electronic message signs along the freeway
❑ Wireless Internet device in my car
❑ I had no information about this incident
❑ Other (please specify):

13. Please indicate whether your MAIN source of information (Internet Website at home) for this incident was timely, accurate or useful enough to help you make decisions about your commute:

	Yes, Very	Yes, Somewhat	I'm Not Sure	No, Not Very	No, Not At All
Was the information TIMELY enough?	❑	❑	❑	❑	❑
Was the information ACCURATE enough?	❑	❑	❑	❑	❑
Was the information USEFUL enough?	❑	❑	❑	❑	❑

14. Did you see any messages regarding this incident on OVERHEAD ELECTRONIC SIGNS at any time during your commute?

❑ Yes
❑ No
❑ I don't recall

15. Please indicate below whether messages related to this incident on the OVERHEAD ELECTRONIC SIGNS were timely, accurate or useful enough to help you make decisions about your commute:

	Yes, Very	**Yes, Somewhat**	**I'm Not Sure**	**No, Not Very**	**No, Not At All**
Was the information TIMELY enough?	❑	❑	❑	❑	❑
Was the information ACCURATE enough?	❑	❑	❑	❑	❑
Was the information USEFUL enough?	❑	❑	❑	❑	❑