An Analysis of the Puget Sound In-Vehicle Traffic Map Demonstration

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AN ANALYSIS OF THE PUGET SOUND IN-VEHICLE TRAFFIC MAP DEMONSTRATION

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This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT:

The purposes of this project were to gain a better understanding of the benefits of providing in-vehicle congestion information and to determine whether any detectable congestion level changes resulted from providing this information. The project tested an in-vehicle traffic map device (TrafficGauge) using 2,215 participants from the Puget Sound region. Three rounds of surveys (Entry, Daily and Exit) took place between November 2007 and May 2008 in which participants used the TrafficGauge for six months. The project also analyzed a roadway corridor to determine, in instances of unusual freeway congestion, how traveler's behavior affects congestion on alternative roadways. The analysis looked for correlations between the performance of the study corridor's three freeways and four arterials using conditional probability tables.

Most of the survey participants were young to middle-age males, well educated with middle or high incomes. The entry survey demographic data indicated that the participants were not representative of the general population but they were probably representative of those most likely to seek and pay for traveler information, particularly information delivered by an in-vehicle congestion map device.

On half the occasions when participants reported changing routines in the daily surveys, they reported not receiving any benefits. For the entire study, 25 percent of participants reported not benefiting at all from the device. Participants who changed routines saved time a mean number of 1.6 times. The mean amount of time saved on those instances was a little over 30 minutes. Thirty-two percent of participants indicated that they did not save any time by using the device. Over 59 percent of the participants indicated that the information provided by the device reduced their level of stress.

The study participants could be divided into three groups. One (about 20 percent) thought highly of the device, were confident that it had saved them considerable time and stress, and would purchase the device. Another (between 21 percent and 26 percent) saw little value in either the device or the information that it conveyed and would not purchase the device. The third, and largest, group saw value in the device and occasionally benefited from the information it provided. They did not, however, think that these benefits warranted purchasing the device.

The corridor analysis indicated that even without arterial performance information, some travelers seek alternative routes when the freeway becomes congested. The corridor analysis confirmed that many travelers diverted either on the basis of what they see on the roadway or what they get from en-route traffic information sources. Even the modest levels of diversion observed in this study increased arterial congestion, especially near freeway ramps. This visible arterial congestion near the freeway discouraged diversion. Consequently, providing arterial performance information on the entire arterial via in-vehicle devices is likely to increase initial diversion, thereby degrading arterial performance. Roadway agencies will, therefore, need to make traffic management of the ramps and arterial segments that connect the alternate routes a priority.

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EXECUTIVE SUMMARY

The purpose of this project was to gain a better understanding of the perceived and actual benefits to individuals of providing in-vehicle congestion information. The project also attempted to determine whether any changes in congestion levels could be detected as a result of providing this information to a large number of drivers who could use that information to change their travel behavior. The project tested an in-vehicle traffic map device made by TrafficGauge that was selected through a competitive bid process.

Researchers at the Washington State Transportation Center, with assistance from the Washington State Department of Transportation (WSDOT), recruited 2,215 participants from around the Puget Sound region. Three rounds of studies took place between November 2007 and May 2008 in which participants were given TrafficGauge devices to use for six months. An entry survey designed to learn about participants' demographics and their initial attitudes toward traveler information was administered before participants began the project. Then, after one month of owning the device, participants were asked to document their daily use of the device for 32 days. Once a week during this period, they were also asked to answer additional questions to describe the actions they took and the benefits they thought they obtained as a result of having access to the device. At the end of the six-month trial, participants were asked to fill out a final survey giving their overall impressions of the device and of the benefits they obtained from having mobile access to traveler information.

The project also analyzed the performance of a freeway and arterial roadway corridor in Bellevue, Washington, to determine, in instances of unusual freeway congestion, how the behavior of travelers affects congestion on alternative roadways. The analysis looked for correlations between the performance of the three freeways and the four arterials in the study corridor by using conditional probability tables.

Most of the participants in the test of the device were young to middle-age males (< 40 years old), well educated (college courses or degrees), with middle or high incomes (>$100,000 per year). They were familiar with technology, as indicated by a high frequency of Internet use, and they knew how to find traveler information. They commuted primarily by car, but approximately one-quarter of them had taken some alternative mode in the past three months. They frequently experienced delays in their commute, and a majority of them were dissatisfied with their commute. Most had flexibility to change their route or departure time. These demographic results indicated that the study's participants were not representative of the general population, but they were probably representative of the group most likely to seek and pay for traveler information, particularly that delivered by a device like the TrafficGauge.

On average, participants decided to change their intended travel plans once for every 4.2 times that they used the TrafficGauge information. The standard deviation of this result was 4.9. The most commonly reported changes in behavior were changes in travel route (66 percent) and time of departure (18 percent.)

It was clear from these and other survey responses that most people in the study group wanted to continue commuting by car, and they wanted a device that would give them a way over, around, or through congestion. Unfortunately, the TrafficGauge did not have the information on many of the alternative routes, such as arterial roadways, that would have given these commuters the edge over congestion and their fellow travelers that they desired. In general, most commuters in the Seattle area have few if any alternative routes to choose from when their primary route is congested. Those alternative routes that do exist often include arterials, which are also subject to heavy congestion. Thus, without arterial congestion information, re-routing decisions made for peak period commute trips are not assured of improving a commuter's travel time.

Consequently, when asked about the benefits of TrafficGauge, the most frequently cited benefit (54 percent) was that respondents had more peace of mind about the trips they were making. Thirty-seven percent thought that they had experienced a more reliable trip, and 35 percent thought that they had driven a shorter trip.

The lack of information on alternative travel choices for many trips was reflected in the daily survey results. On half the occasions when participants reported changing their travel routines, they reported not receiving any benefits. For the entire study, 25 percent of participants reported not benefiting at all from the device. The most likely benefit that travelers could expect was a reduced travel time. However, 32 percent of participants indicated that they did not save any time by using the device. The daily surveys did indicate that participants who changed routes saved time a mean number of 1.6 times during the course of the study. The mean amount of time saved on those instances was a little over 30 minutes. This would indicate that while in-vehicle congestion information often did not routinely save travel time, on those occasions when it did save time, the savings (either real or perceived) were substantial.

Not surprisingly, there was a direct relationship between the number of times the TrafficGauge device was checked by study participants and the number of days people indicated that they had changed behavior, their perception of both trip reliability and time savings, and their desire to purchase the device. That is, when respondents obtained positive benefits from their initial uses of the device, they tended to use it more. When their initial results were not positive, they tended to use the device far less. There was also a clear link between the number of days on which people indicated that they had changed behavior in the daily surveys and whether they thought using TrafficGauge resulted in a more reliable trip in the exit survey.

The information provided by TrafficGauge does seem to be good at relieving travel-related stress. When asked specifically about reduced stress in the exit survey, over 59 percent of the participants indicated that the information provided by the device had reduced their level of stress.

Prior to obtaining a study device, over 80 percent of study participants indicated that they would pay for "accurate, up-to-the minute traffic information for major, regional routes." Unfortunately, much of the traveler information that they indicated they wanted is not available from existing systems, including TrafficGauge, and some of it is not feasible to provide with the existing field device network and existing technology. For example, most participants in the entry surveys indicated that they wanted forecasts of traffic conditions for the next 60 minutes, which is beyond the capabilities of most information providers. However, the benefits that they said they expected to get from receiving traveler information, such as peace of mind, were generally reasonable and what would be expected by traffic engineers or travel information providers.

By the end of their six month use of the TrafficGauge, the study participants could be divided into three groups on the basis of their exit survey responses. One group (about 20 percent) thought very highly of the device, were confident that it had saved them considerable time and stress, and would purchase the device. Another group (between 21 percent and 26 percent) thought very poorly of the device and its content and would not purchase the device. This group saw little value in either the device or the information it conveyed. The third, and by far largest, group saw value in the device and had occasionally benefited from the information it provided. That benefit manifested itself as reduced stress as a result of a more predictable trip, more predictable estimated time of arrival, or reduced travel time. This group, however, did not think that obtaining these benefits warranted the purchase of such a device.

The corridor analysis indicated that even without good, real-time arterial performance information, some travelers seek alternative routes when the freeway becomes congested. A large percentage of the TrafficGauge survey participants were interested in arterial congestion information to help them make that diversion decision. The TrafficGauge device's lack of arterial traveler information was a serious shortcoming of the device. This suggests that many travelers divert either on the basis of what they see on the roadway or on the basis of the information they get from current en-route traffic information sources. The corridor analysis of traffic volumes on SR 520 and its parallel arterials further supports this conclusion.

Even the modest levels of diversion observed in this study created measurable increases in arterial congestion, especially near the freeway ramps. Because motorists have little information on the performance of the arterials to which they can divert, visible arterial congestion near the freeway is likely to discourage diversion. Consequently, providing reliable arterial performance information on the entire arterial to motorists via in-vehicle devices would be likely to significantly increase the number of drivers who divert, at least when the arterial is still functioning as an effective diversion route. Similarly, once the alternative arterial route congests, accurate real-time arterial performance information will limit the number of vehicles diverting to that road from the freeway.

The performance of the arterials to which the additional traffic diverts will likely degrade as a result of the increase in traffic volume. To accommodate those movements, roadway agencies should not only report on the current performance of the arterials, they should make proper traffic management of the ramps and arterial segments that connect the alternative routes a priority.

INTRODUCTION

Transportation agencies, the broadcast media, and their contracted traveler information services have provided traveler information for over 40 years. For the most part, this has been pre-trip travel information that people obtained from a television, telephone, or home, work, or school computer before the start of travel. For many years, the car radio was the only in-vehicle source of traveler information. Improved traveler information services, particularly in-vehicle services, were expected to be one of the early benefits of the effort to apply technology to transportation problems that came to be known as Intelligent Transportation Systems (ITS). In-vehicle traveler information is thought to be particularly important because traffic conditions can change rapidly, rendering pre-trip information quickly obsolete. However, traditional radio reports often do not contain information of relevance to the individual traveler. Often, a radio traffic report provides only high-level information in a 60-second "spot" repeated every 10 or 15 minutes at most. Thus, there is a low probability that the radio message will occur when the traveler is at a decision point where he or she could take advantage of it by changing routes.

Many companies have tried to market traveler information services and devices to consumers intended to overcome the limitations of conventional services, and most of them have gone out of business. The "conventional wisdom" is that traveler information is something that "everyone wants but few are willing to pay for," particularly when free[1], and sometimes high quality, traveler information is available.

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[1] The most ubiquitous form of traveler information, the commute period radio report, is "paid for" with advertising. The reports aren't "free" but require no direct monetary outlay by the consumer.

This inability to put a value on traveler information causes problems for transportation agencies that provide this information to their constituents, usually without charging a fee. In the past, the traveler information supplied by public agencies was provided as a by-product of, or a side benefit from, the systems used to manage freeway and arterial traffic. As more of this operations information was collected and disseminated, the public demanded even more information. As a result, infrastructure was installed solely to provide information on rural roads and city streets to the public. (This infrastructure was typically closed circuit TV cameras that could not provide real-time congestion information for the roadway system.) However, many jurisdictions require a favorable benefit-to-cost (B/C) ratio (B/C > 1.0) for a project to be funded, and problems arose when agencies were called on to measure the benefits of these systems so that a B/C ratio could be calculated.

Previous surveys have shown that people use traveler information to change routes, change time of travel, or change mode.[2] These people have said that traveler information helps them save time or reduce their level of stress. Unfortunately, research has been unable to effectively measure consistent changes in traffic congestion or delay due to the delivery of traveler information in areas where abundant travel information has been provided.

This project was an attempt to examine the benefits that individuals receive from traveler information obtained from an in-vehicle device called TrafficGauge, and to determine whether there are beneficial effects, like reduced congestion, on roadway operations when this information is provided. This report provides an examination of

[2] Real-Time Motorist Information for Reducing Urban Freeway Congestion: Commuter Behavior, Data Conversion and Display, and Transportation Policy, M. Haselkorn, et al., for Washington State Department of Transportation, WA-RD 240.1, 1992.

data, obtained through a series of surveys, describing the participants in the study, their use of the travel information given to them via TrafficGauge, and their perception of benefits obtained from the use of that information. It compares overall impressions of the device with their actual experiences on a daily basis. It also provides the results of a study that used actual traffic volumes on a roadway corridor to determine the effects of traffic diversions on roadway operations.

BACKGROUND AND METHODOLOGY

In the federal FY05 Consolidated Appropriations Act, an earmark was provided for a project called the "Puget Sound In-Vehicle Traffic Map Demonstration." This earmark provided funding to evaluate the benefits that could be gained by individual travelers and the changes in congestion levels that occurred as a result of providing individuals with access to in-vehicle, map-based congestion information.

The objectives of the project were as follows:

- to understand the perceived (and actual) benefits to individuals of providing in-vehicle congestion information
- to measure the congestion relief benefits to the roadway system that may accrue from a traveler's use of the congestion information.

The earmark funding was provided to the Washington State Department of Transportation (WSDOT). The WSDOT Office of Research and Library Sciences (ORLS) requested that the Washington State Transportation Center (TRAC) conduct the research. WSDOT advertised for bids to provide the in-vehicle traffic map device, and a contract was awarded to TrafficGauge to supply the 2,400 devices used in this study (see Figure 1).

Study participants were initially recruited through the University of Washington (UW) Parking Services. In November 2007, UW faculty, staff, and students, as well as Harborview Medical Center employees, holding valid parking permits were recruited to participate. The intent was to recruit a geographically concentrated group of device users so that changes in travel behavior resulting from access to congestion information would create traffic volume changes, and therefore congestion changes, large enough to be

Figure 1. Handheld Wireless TrafficGauge[3]

measured on the roadway system. The recruitment process consisted of a series of e-mail communications. Study participants were provided with a free in-vehicle device and free service costs for that device for six months in return for participation in a series of short surveys documenting how they used and benefited from that device.

Unfortunately, the recruitment process failed to attract a sufficient number of study participants. Of those contacted, only 418 UW-related individuals, roughly 12 percent, agreed to participate. It is unclear why the recruitment process was not more successful.

As a result, the decision was made to expand the group of potential participants to those using the WSDOT congestion Web page (called the Puget Sound Traffic Conditions Web page[4]). In February 2008, a banner was displayed on the Web page directing interested individuals to the study recruitment Web page until enough

[3] See: http://www.trafficgauge.com/device_sea_glance.html
[4] See: http://www.wsdot.wa.gov/traffic/seattle/

participants had been recruited. This effort was successful in recruiting the majority of study participants.

A final recruiting effort took place in April 2008 when TrafficGauge recruited 540 existing customers to participate in the study.

Three rounds of surveys took place between November 2007 and May 2008. An entry survey designed to learn about participants' demographics and their attitudes toward traveler information was administered before participants began the project. Then, after one month of owning the device, participants were asked to document their daily use of the device for a total of 32 days. Once a week during this period, they were also asked to describe the actions they took and the benefits they thought they obtained as a result of having access to the device. At the end of the six-month trial, participants were asked to fill out a final survey giving their overall impressions of the device and of the benefits they obtained from having mobile access to traveler information. (The surveys are included in Appendix A.)

At the same time that this effort was taking place, an analysis of a freeway and arterial roadway corridor in Bellevue, Washington, was under way to determine how the behavior of travelers whose freeway route was unusually congested affected the level of congestion on alternative roadways. The analysis looked for correlations between the performance of the three freeways and the four arterials in the study corridor using conditional probability tables.

I. IN-VEHICLE TRAFFIC MAP STUDY

THE STUDY GROUP

This section of the report discusses the general socio-economic characteristics of the study participants. All data reported in this section were obtained from study participants before they received and used the TrafficGauge device. In general, the study participants were well educated, technologically savvy, and interested in gaining access to information. Thus, they were not a truly representative sample of the general population, but they were an excellent example of "early adopters" of new technology and reasonably representative of those people most likely to use traveler information.

GENERAL CHARACTERISTICS

A TrafficGauge was given to the 2,215 people who agreed to complete the entry survey. Of those participants, most were young to middle-age males, well educated, and with middle or high incomes. Most participants were in white-collar, professional positions. Less than 4 percent were university faculty members, and less than 1 percent was retired. This socio-economic distribution is likely a function of the use of the WSDOT Web site to recruit the majority of participants (younger males being more frequent Web users than others). That is, individuals that self selected to participate in the study were likely to be those most interested in obtaining access to traveler information, and consequently, those most likely to use it to change their behavior in response to that information.

General Characteristics

Male	63%
College courses/degrees	85%
Age < 40	61%
Income > $100,000/yr.	38%

Of the participants, 63 percent were males (see Table 1), and 85 percent had taken some college courses, earned a college degree, or earned an advanced degree. Twenty-six percent were under 31 years old, 30 percent were between 31 and 40 years old, and 98 percent were under 65 years old. Forty-two percent had a household income of between $50,000 and $100,000 per year, and 38 percent had an income of over $100,000 per year.

Participants came from all over the metropolitan region (see Figure 2). No more than two percent lived in any single zip code. The four home zip codes with the largest representation in the study sample were as follows:

- 98052 — Redmond
- 98133 — Shoreline, Seattle (Bitter Lake, Richmond Highlands)
- 98103 — Seattle (Greenwood, Wallingford)
- 98115 — Seattle (Wedgewood, Maple Leaf)

Table 1. Gender

Gender	Frequency	Percent	Cumulative Percent
Male	1,391	62.8	62.8
Female	812	36.7	99.5
Non-participant	3	0.1	99.6
No answer	9	0.4	100.0
Total	2,215	100.0	

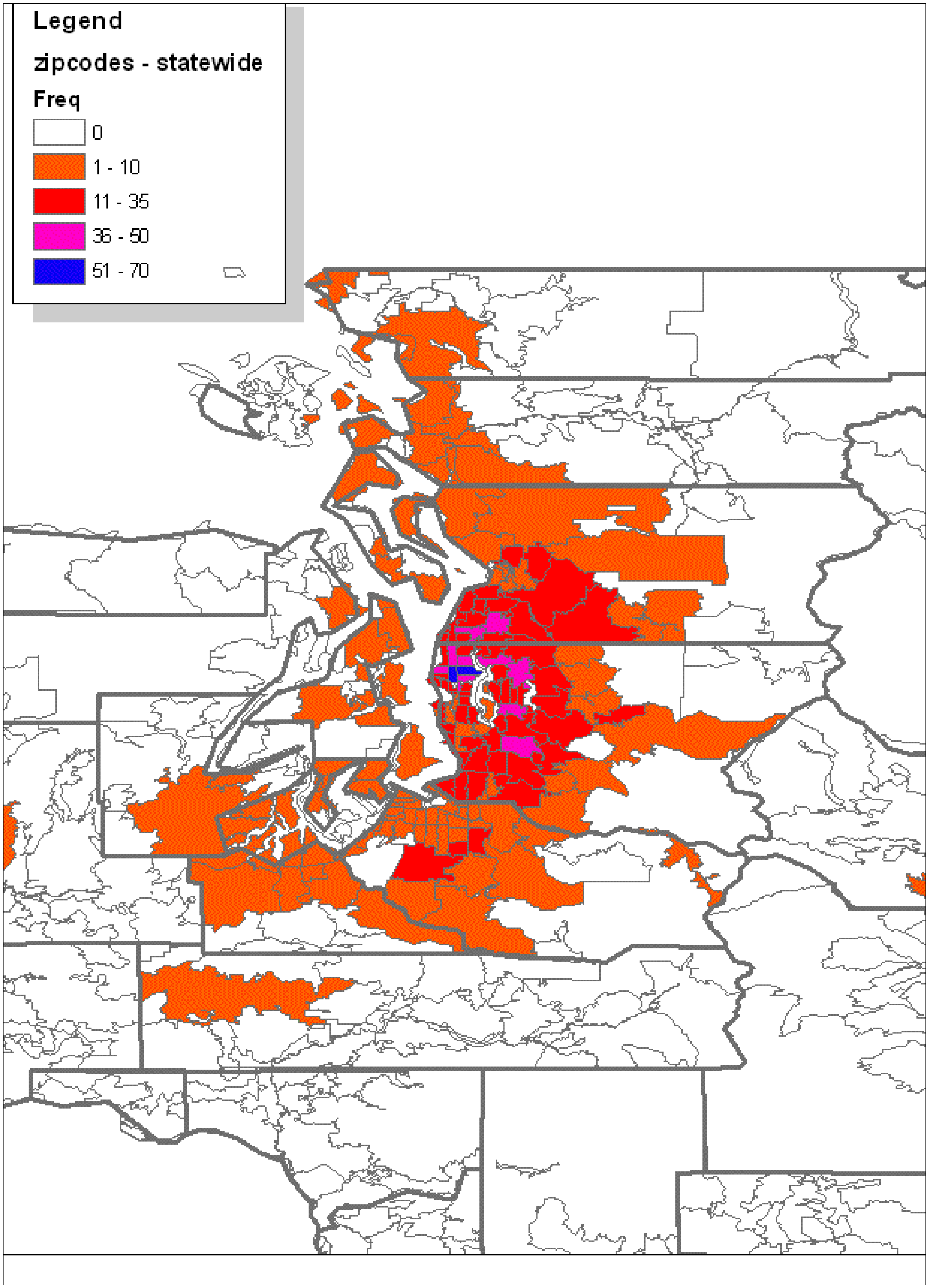


Figure 2. Study Area Participants (Origin by Zip Code)

FAMILIARITY WITH TECHNOLOGY

As expected, in a test of this type and with this recruitment method, the participants were familiar with and comfortable using communications and computer technology. Eighty-seven percent reported frequently accessing the Internet from work or school, and 90 percent frequently accessed it from home. Over 16 percent accessed it frequently from public locations, but 52 percent did so only occasionally. Twenty-seven percent never accessed the Internet from public locations.

Familiarity with Technology

Frequently accessed the Internet

From work or school	87%
From home	90%

Almost all of the participants reported relying on high-speed Internet connections. Sixty-three percent used a cable modem, and 29 percent used DSL to access the Internet. The most frequently used electronic device was a cell phone. It was used frequently by 86 percent of the participants and only occasionally by an additional 12 percent. PDAs were used by 28 percent of participants frequently and by 15 percent occasionally. Laptops with wireless connections were used by 61 percent of participants frequently and by 24 percent occasionally. However, only 17 percent of participants subscribed to a fee-based, on-line information service.

COMMUTING BEHAVIOR

As expected, most participants drove a car to work, and 82 percent preferred driving their own vehicle. Only 35 percent worked at different locations during the week, meaning most study participants consistently drove the same corridor during their work commute. Thirty-one percent had frequently or occasionally taken a bus to work or school in the past three months. Twenty-three percent had frequently or occasionally taken a carpool or vanpool, and 21 percent had frequently or occasionally walked at least 10 minutes to work or school in the past three months. Sixty percent had frequently or occasionally used the carpool lanes to travel to home or school in the past three months.

Eighty-two percent of participants used a private automobile to travel to work or school four or more times a week. Six percent were in a carpool or vanpool four or more times per week. Of the people who reported using public transit two or more times per week, 6 percent walked to public transit and 4 percent drove or rode a bicycle to public transit.

Sixty-nine percent of the participants said they were either frequently or occasionally required to have a car at work. Eighty-seven percent frequently or occasionally needed a car at work to run errands or pick up kids before or after work or school. Eighty-three percent of the participants said that their schedule at work or school was frequently or occasionally flexible.

Commuting Patterns

Taken during the past 3 months to work or school	
Bus	31%
Carpool/vanpool	23%
Walked 10 minutes	21%
Traveled to work/school by car four or more times/week	82%
Experienced unexpected commute delay twice a week	75%
Were not satisfied with their commute	54%

Seventy-five percent indicated that they experienced an unexpected delay at least twice a week on their regular commute route. Forty-eight percent said they had considered changing their work place within the last three years to reduce their commute time, and 36 percent had not. The comparable percentage of those who had considered moving their residence was 44 percent, and 42 percent had not. Nineteen percent were satisfied with their commute, and 54 percent were not. Twelve percent were traveling their regular commute route more quickly than they did a year ago, and 66 percent were not. Sixty-two percent said they could take alternative routes, and 17 percent could not.

Commute Flexibility

Had at least occasionally taken an alternative mode	43%
Would change route	94%
Would change departure time	76%

the group of participants appeared to be fairly flexible in their commuting habits. According to the entry surveys, about 30 percent had taken a bus in the past month, and 22 percent had taken a carpool or vanpool. A total of 43 percent had at least occasionally taken an alternative mode of transportation. Table 2 is a crosstabs run that compares those who had taken a bus to work or school during the past three months with those who had used a carpool or vanpool. The objective was to see whether these alternative mode users were

Table 2. Bus vs Carpool/Vanpool Users

Taken a Bus to Work or School – last three months	Carpool/Vanpool to Work or School – last three months				
	Never	Occasionally	Frequently	No answer	Total
Never	1047 (54%)	174	85	6	1312
Occasionally	325	85 (4%)	47	2	459
Frequently	87	20	10 (<1%)	0	117
No answer	2	1	1	42 (2%)	46
Total	1461	280	143	50	1934

different groups of people or mostly one group using the different modes. Fewer than 5 percent of them showed up as users of both modes either occasionally or frequently. Therefore, it appears that these bus users and carpool/vanpool users were mostly different groups of people.

Ninety-six percent thought that receiving traffic congestion information while en route would influence their choice of route. Forty percent reported that they could take alternative modes of transportation, 94 percent said they were willing to change routes, and 76 percent were willing to change departure times.

It is interesting to compare these results with those from a 1992 survey of Puget Sound area commuters.[5] That survey was able to categorize commuters into four groups: pre-trip changers, route and time changers, route changers, and non-changers. Pre-trip changers were willing to change departure time, route, and travel mode before leaving their residence but were unwilling to change route during their trip. The definitions of the other categories are evident from their labels. The average percentage of commuters in each category in 1992 was as follows:

- Pre-trip changers = 14 percent
- Route and Time changers = 44 percent
- Route changers = 18 percent
- Non-changers = 24 percent

Only 14 percent of participants in this 1992 study indicated that they would be willing to change their route, departure time, or mode before starting a trip, whereas 40 percent of participants in the current study reported that they could take alternative modes

[5] Real-Time Motorist Information for Reducing Urban Freeway Congestion: Commuter Behavior, Data Conversion and Display, and Transportation Policy, M. Haselkorn, et al., for Washington State Department of Transportation, WA-RD 240.1, 1992.

of transportation. In addition, 94 percent said they were willing to change routes, and 76 percent were willing to change departure times. Whether the greater willingness of the commuters in the current study to make travel changes, particularly mode changes, reflects a general trend among current commuters or a sample bias cannot be determined. It is probable, however, that those who self-selected into the study were more likely to be flexible commuters and to believe they could benefit from the information provided by TrafficGauge.

The survey suggests that personal predilections may have a strong influence on how people choose to travel. Of those who preferred driving their own vehicle, only a small percentage was willing to change modes. Table 3 is crosstabs comparison of participants who preferred driving their own vehicle with those who changed mode. The

Table 3. Mode Changers

Prefer driving own vehicle—extent of agreement	Changes Made—Changed Transportation Mode				
	Changed frequently	Changed occasionally	Never changed	No answer	Total
Agree strongly	9 (<1%)	24 (3%)	720 (77%)	183 (20%)	936
Agree	9 (1%)	55 (9%)	445 (72%)	111 (18%)	620
Neutral	3 (1%)	26 (12%)	150 (69%)	38 (18%)	217
Disagree	4 (5%)	12 (14%)	53 (63%)	15 (18%)	84
Disagree strongly	1 (3%)	4 (10%)	30 (77%)	4 (10%)	39
No answer	1 (3%)	4 (11%)	21 (55%)	12 (32%)	38
Total	27 (1%)	125 (6%)	1419 (73%)	363 (19%)	1934

table indicates that only 97 participants (shaded area of table) who preferred driving their own vehicle changed mode either frequently or occasionally. This was 6 percent of those who preferred driving and 5 percent of all study participants. Seventy-six percent of those who preferred to drive never changed mode.

In contrast, 15 percent of participants who did not necessarily prefer to drive their own vehicle changed transportation modes over the course of the study.

USE OF TRAVELER INFORMATION

Not surprisingly, given the way that many of the study participants learned about the study, 98 percent of all study participants said they used the Internet first when searching for information. Eighty-eight percent knew where to find Puget Sound area traffic information on the Internet. The comparable data were analyzed for just the UW-related individuals recruited in the first wave to determine whether there was any difference in their Internet usage or familiarity in comparison to the next wave, which was recruited by using a banner on the WSDOT Puget Sound Traffic Conditions Web site. The percentages were similar: 98 percent used the Internet first when searching for information, and 80 percent knew where to find Puget Sound area traffic information on the Internet.

Use of Traveler Information

Used the Internet first for information	98%
Knew where to find Puget Sound traffic information	88%

Prior to the study, 41% would pay $9.99/month for traffic information

Sixty percent of the people who signed up for the study indicated that they liked to plan ahead. Eighty-four percent agreed with the statement that people were able to contact them at any time. Forty-four percent preferred to find their own way rather than ask for directions, and 29 percent preferred to ask for directions. Only 4 percent of participants preferred to ask someone for information rather than relying on a computer to obtain it. Seventy-five percent preferred to look on a computer. Eighty-three percent worried about being late. Seventy-three percent were willing to take risks with new products or services. Taken together, these results suggest that the study's participants may not be representative of the population as a whole, but they are probably representative of the group most willing to search for, use–and pay for–traveler information delivered through modern electronic communications technologies.

Eighty-five percent said they thought that they could reduce their commute time if reliable, real-time information were available. Prior to the start of the study, 41 percent of all people who signed up for the project indicated that they would pay $9.99 per month for accurate, up-to-the-minute traffic information for major, regional routes. Seventy-eight percent knew how to get public transportation route and schedule information. Forty-four percent indicated that they wouldn't be bothered by delays if they could accurately forecast when they would arrive at their destination. Thirty-five percent disagreed with this view.

Before the start of the study, the following traveler information was rated "important" or "very important" by over 90 percent of the participants:

- traffic information covering all roads, not just freeways
- traffic reports tailored to individual travel routes
- easily accessible traffic information (obtained by pressing one button)
- forecasts of traffic conditions for the next 60 minutes
- estimated travel times, based on current traffic conditions, between major destinations.

It is important to note that TrafficGauge does not offer any of these services, except easily accessible traffic information. It provides no information on arterial roadways, which will be discussed later in the report as a drawback of the device.

Participants were less interested in comprehensive traveler information that included information on public transportation such as bus routes and schedules. Only 67 percent found this important or very important. Similarly, almost 65 percent of drivers who preferred to drive alone found this type of traveler information important. However, while this number is small relative to some of the other types of information requested, it is a large number in relation to the fact that 88 percent of the study participants normally drove to work (82 percent alone, 6 percent in carpools). While this seems to contradict the information presented previously that only 6 percent of those who preferred to drive changed mode, it suggests that many people who normally drive will at least <u>consider</u> transit as an option when congestion is abnormally bad.

Before the start of the study, participants indicated that the following benefits of receiving roadway congestion information were important or very important at least 90 percent of the time:

- reduced travel time
- more predictable travel times
- less stressful travel conditions
- alternative routes
- estimated travel times between major destinations based on current traffic conditions.

Fewer participants (86 percent) thought that safe travel conditions were very important or important benefits of receiving roadway congestion information.

More participants were aware of and used the Puget Sound Traffic Conditions Web site than the 511 telephone hotline. Only 5 percent of participants had never used the Web site versus 43 percent who had never used 511. Only 2 percent had never heard of the Web site versus 27 percent who were unaware of 511. Ten percent used the Web site "infrequently," 19 percent used it a few times a month, and 62 percent used it a few times a week. The comparable figures for 511 were 17 percent infrequently, 7 percent a few times a month, and 3 percent a few times a week (see tables 4 and 5). Comparing the data for the UW-related participants recruited in the first wave (and not recruited via the

Table 4. 511 Usage

	Frequency	Percent
Never	837	43
Infrequently	333	17
Few times monthly	128	7
Few times weekly	59	3
Never heard of service	522	27
Did not complete this survey	34	2
No answer	21	1
Total	1934	100

Table 5. WSDOT Puget Sound Traffic Conditions Web Site Usage

	Frequency	Percent
Never	87	5
Infrequently	200	10
Few times monthly	361	19
Few times weekly	1200	62
Never heard of service	44	2
Did not complete this survey	34	2
No answer	8	<1
Total	1934	100

WSDOT Web site), the disparities in usage and awareness were similar. Only 9 percent of participants had never used the Web site versus 52 percent who had never used 511. Only 4 percent had never heard of the Web site versus 30 percent who were unaware of 511. Twenty percent used the Web site "infrequently," 26 percent used it a few times a month, and 41 percent used it a few times a week. The comparable figures for 511 were 13 percent infrequently, 4 percent a few times a month, and 1 percent a few times a week.

Note that these results were not based on the 2,215 people who completed the entry survey. The responses of the 1,934 people who responded to the daily or exit surveys, as explained in the next section, were used for this analysis and for later comparison purposes.

While it is not surprising that a large percentage of study participants were aware of and actively used the WSDOT Web site (given the way that the majority became involved in the project), the percentage of people that did not use the 511 phone service is somewhat surprising. The fact that only 27 percent of this study's participants used 511 suggests that 511 is not effectively meeting the needs of a group very interested in traveler information, or that people are finding other sources of information to be more effective. This finding suggests that WSDOT may need to do more to promote and possibly improve the 511 service to better respond to customer needs, as the study group was an "information hungry" subset of the general population.

THE DAILY SURVEYS

Study participants were asked to fill out a very short survey each day for a month. That daily survey simply asked whether they had used their TrafficGauge the previous day. If they had used their TrafficGauge, additional questions were asked, once per week, about the actions that participants took as a result of the travel information they obtained, and whether any benefits were gained from using that information. The intent of this study design was to obtain data over an extended period about the frequency with which they used their in-vehicle device and the benefit they gained from that use, while limiting the effects of "survey burn out" among study participants.

This section describes the results of the analysis of these daily surveys.

USAGE

Of the 2,215 people who completed an entry survey, 1,934 people completed at least one of the remaining surveys: either one of the daily surveys or the exit survey.

Despite the study team's attempts to limit the time and effort needed to report on the use of the in-vehicle device, participant responses to the daily surveys were sporadic at best. Only 12 participants reported checking their TrafficGauges (a "Yes" on the daily survey) on every day of the 32-day survey. Eighty-five participants (4 percent) did not report that they checked their device on even one day.

Usage

32 day survey	
Mean number of times the device was checked	14.5
Standard deviation	8.0

The mean number of times the device was reported being checked during the 32-day survey was 14.5, with a standard deviation of 8.0. The largest number of participants (106) checked the TrafficGauge for half of the survey days (16).

There was no significant difference (p=95 percent for all tests) between male and female use of the TrafficGauge. The device appeared to appeal to older users. Participants under 40 appeared to use the device significantly less than would be expected if usage were distributed in a proportional manner. Those aged 41 to 64 appeared to use the device significantly more than expected. Those 65 and older appeared to use the device as frequently as expected.

To determine whether familiarity with similar electronic devices, such as PDAs, had any effect on the usage rate of the TrafficGauge, an analysis of variance was conducted to compare the participants' use of various electronic devices, as specified in the entry surveys, with their responses to the daily surveys. Regardless of whether participants had used PDAs frequently, occasionally, or never, there was no significant difference in their use of the TrafficGauge.

The same was true for participants who never, occasionally, or frequently accessed the Internet from work, school, or home. However, there was a significant difference in the frequency of use among those who never, occasionally, or frequently accessed the Internet from public locations. Those who never accessed the Internet from public locations used the TrafficGauge less frequently than would be expected if usage were distributed proportionally. Those who occasionally or frequently accessed the Internet from public locations used the TrafficGauge more often than expected (p=95 percent for all tests).

A final test looked at whether people who indicated in the entrance surveys that they worked in different locations during the week were more likely to use the TrafficGauge. However, there was no significant difference (p=95 percent) in the amount of TrafficGauge use between people who worked in different locations and those who did not.

TRAVEL CHANGES

During the course of the 32-day study, the 1,934 participants could have used the information provided by the TrafficGauge to change travel routines on 61,888 days. Responses were received from participants on 27,970 occasions (45 percent of possible responses) that the TrafficGauge information did or did not cause a change in normal travel routine that day. Participants chose to make changes 8,183 times (29 percent of the days on which they reported checking the device). On average, participants decided to change their expected travel routine once for every 4.2 times that they used the TrafficGauge information. The standard deviation of this result was 4.9.

BENEFITS

Change in Travel Routine

Participants who indicated that they made a change in their travel routine were periodically asked to answer additional questions about those changes. They were asked to answer these once each week on the first day that their travel behavior changed. Participants, therefore, were supposed to answer questions about benefits a maximum of five times during the course of the study. However, actual response rates varied from zero to nine times. (Note: A total of 54 people—less than 3 percent—responded more than five times.) Participants were asked whether they benefitted from using the TrafficGauge information. The mean positive ("yes") response rate was 2.0 times, with a standard deviation of 1.7 times. The largest group, 475 (25 percent), did not report gaining a travel benefit even once during the month-long survey. Of those 8,183 who changed their travel routine, as discussed previously, 3,781 (46 percent) indicated that "yes," they had benefitted from the TrafficGauge information, and 250 (3 percent) indicated "no," they had not. The remainder didn't reply.

Time Savings

When asked whether they thought that they had saved time by using the TrafficGauge, the largest number of participants, 617 (32 percent), did not indicate that they had saved time even once. As discussed previously, participants were asked to answer this question once each week on the first day that their travel behavior changed; thus, they were supposed to answer this question a maximum of five times during the course of the study. However, actual response rates varied from zero to eight times (Note: A total of 26 people—a little more than 1 percent—responded more than five times.) When asked whether they thought that they had saved time because of the changes made to their travel, the mean positive ("yes") response rate was 1.6 times, and the standard deviation was 1.5 times. Of those 8,183 who changed their travel routine, as discussed previously, 3,055 (37 percent) indicated that "yes," they had saved time as a result of their travel routine changes, and 975 (12 percent) indicated either "no" or that they "did not know." The remainder didn't reply.

When asked to estimate how much time they had saved or lost by changing their travel routine (this was supposed to be answered the first time that they varied their routine in a week), the minimum (maximum time lost) was –40 minutes (that is, they lost 40 minutes) and the maximum was 610 minutes saved. The mean time saved was 30.4 minutes, with a standard deviation of 43.8 minutes. Thirteen respondents (<1 percent) indicated that they had lost time as a result of reacting to the information the test device provided, 554 (29 percent) indicated that they had neither lost nor saved time, and the remainder, 70 percent, indicated that they had saved time.

Prior to the start of the study, the project team expected that those who needed a car at work, needed to run errands after work or school, or had a flexible schedule would obtain the most benefit from the TrafficGauge. While it was not possible, because of the way the survey was structured, to conduct a complete analysis of these factors, it was possible to take a look at the characteristics of those who claimed that they did not benefit once from the device.

The percentages of those who said that they did not benefit from the TrafficGauge information were very similar, regardless of whether the person's schedule was flexible or whether they needed a car at work or to run errands before or after work. Twenty-nine percent of the participants reported that their job never required them to have a car while at work. Of these, 26 percent didn't benefit once from the TrafficGauge information during the survey. Of the 68 percent who occasionally or frequently needed a car at work, 24 percent didn't benefit once. Twelve percent of the participants reported that they never needed a car before or after work to run errands. Of these, 28 percent didn't benefit once from the TrafficGauge information during the survey. Of the 86 percent who occasionally or frequently needed their car to run errands before or after work, 24 percent didn't benefit once. Fifteen percent reported that their schedule at work or school was flexible. Of those, 24 percent didn't benefit once from the TrafficGauge information. Of the 82 percent who occasionally or frequently had a flexible schedule, 25 percent didn't benefit once.

When those who changed their travel routine were asked whether their level of stress changed as a result of the changes they made in their travel routine because of the TrafficGauge information, the following results were obtained from the 8,183 possible replies:

- 176 (2 percent) indicated that the level of stress increased
- 1,470 (18 percent) indicated that the level of stress did not change
- 2,375 (29 percent) indicated that the level of stress decreased
- The remainder did not reply.

Interestingly, of the participants who indicated in the entry survey that less stressful travel was an important or very important benefit that they expected to obtain from receiving travel information, in the exit survey at the end of the six-month trial, only 54 percent rated "peace of mind" as one of the positive benefits from use of the TrafficGauge. Of those who rated this as important in the entry survey, 33 percent did not agree that this was one of the positive benefits of the device. These percentages were similar to the responses to the daily experiences reported above (2,375 out of 4,021 or 59 percent indicating stress levels decreased).

THE EXIT SURVEYS

At the end of the study period, each participant was asked to fill out an exit survey. The exit survey collected data on the perceived positives and negatives of the participants' experiences with in-vehicle congestion information. Unlike the daily surveys, which collected information on the day-to-day variations in their experiences, the exit survey was designed to gather their general impressions. This section provides a brief overview of those impressions and goes further to compare those overall impressions with the actual daily experiences reported. The surveys were analyzed to determine whether the responses in the entry and daily surveys predicted what people would say in the exit survey. The purpose was to determine whether a few large savings reported during the daily surveys carried more "perceptual weight" at the end of the survey, or whether specific individuals had trip-making characteristics that were particularly suited to obtaining benefits from in-vehicle congestion information.

In summary, the TrafficGauge was considered beneficial by a majority of study participants. Seventy-two percent found the TrafficGauge to be very or somewhat useful for commute trips, and 65 percent found it to be very or somewhat useful for non-commute trips. The percentages of those who thought the device was not useful were 16 percent for commute trips and 22 percent for non-commute trips.

However, in a finding that is very consistent with previous traveler information efforts, only 19 percent of the study participants said that they would purchase a device like this. Twenty-six percent would not purchase a device like this, and 43 percent would purchase only a version expanded to include arterial traffic information. Eighty-two percent of study participants said that having information about arterial roadways would make the device more useful.

PERCEIVED BENEFITS AND DISADVANTAGES IN THE EXIT SURVEY

When asked about the benefits of TrafficGauge, the most frequently cited benefit (54 percent) was that respondents had more peace of mind about the trip. Thirty-seven percent thought that they had a more reliable trip, and 35 percent thought that they had a shorter trip. Eight percent didn't report anything positive or had negative comments. Twenty-three percent cited other positive things. Of those other things, the following were the major items specified (see Appendix B for a complete list):

- improved awareness = 32 percent
- help in choosing alternative routes = 14 percent
- the features of the device = 9 percent
- remove this sentence: usefulness for planning = 7 percent
- allowing on-time arrival, furnishing ETA = 5 percent
- help in choosing alternative time to travel = 2 percent
- border crossing or event information = 2 percent
- increased safety = 1 percent

When asked about the negative features of the TrafficGauge, the participants mentioned geographic coverage most often (45 percent). Other negative aspects and their frequency in the study group were as follows:

- battery life = 10 percent
- small image = 20 percent
- information accuracy = 35 percent

- other = 32 percent - These other responses fell in the following categories (see Appendix C for a complete list):
    - coverage problems, lack of arterials, other routes, carpool lanes = 32 percent
    - data problems, granularity, update rate = 31 percent
    - display and other device problems = 30 percent
- no negative aspects = 5 percent.

The following sections discuss the perceived and actual experiences people had using TrafficGauge, as evaluated from data from the entry, daily, and exit surveys.

UTILITY

If TrafficGauge was considered useful by such a clear majority of respondents, why did so few people say that they would be willing to purchase a device? Most respondents gave TrafficGauge a rating of "somewhat useful" for commute trips, even if they never reported saving time on a daily survey. This suggests that "somewhat useful" was regarded as an ambivalent response or reflects the view that the device had potential be useful. Less than 5 percent of any group regarded TrafficGauge as "not useful" for commute trips.

The real difference in the numbers was between "very useful" and "somewhat useful." In general, the more days that a respondent reported saving time, the more likely they were to find TrafficGauge to be very useful for commute trips (see Figure 3).

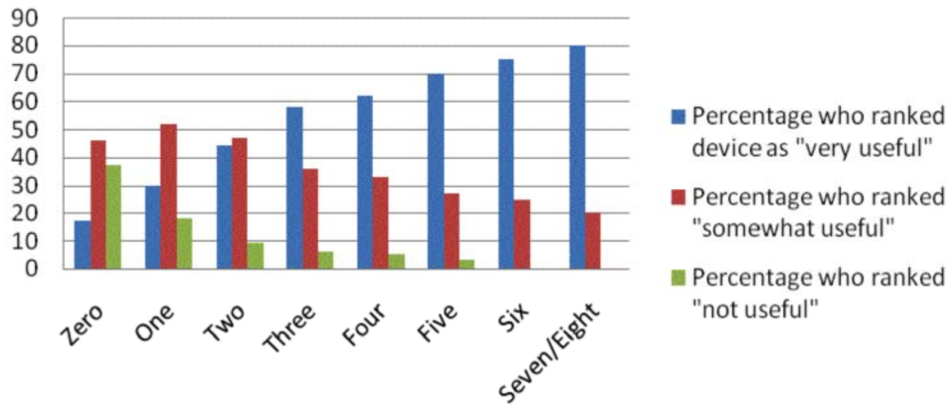


Figure 3. Commute Trips[6]: Time Savings vs Utility

The results for non-commute trips (see Figure 4) did not show a strong correlation between the number of days people reported saving time and the perceived usefulness of TrafficGauge, suggesting that the device was regarded as more useful for commute trips. This agrees with the data examined previously, which showed that a larger percentage (22 percent) of participants thought that the device was not useful for non-commute trips than those who thought that the device was not useful for commute trips (16 percent.)

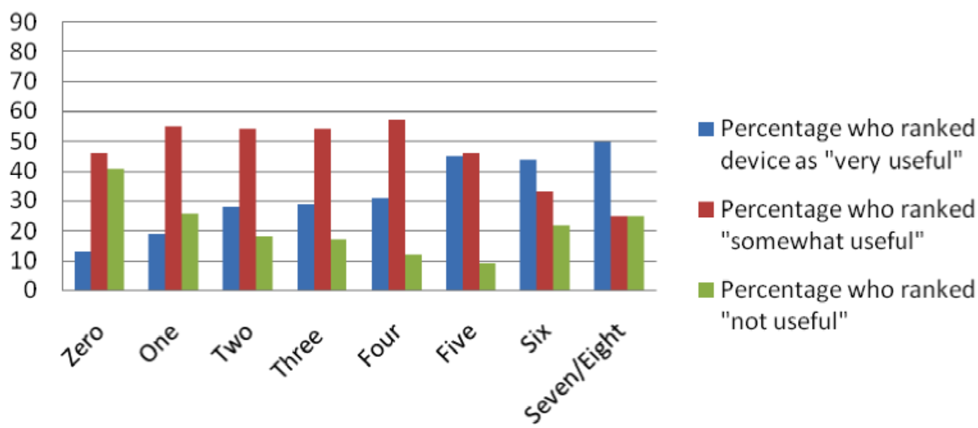


Figure 4. Non-Commute Trips[6]: Time Saved vs Utility

[6] The categories "Six" and "Seven/Eight" represent a total of 5 responses.

Results were similar when the number of times people changed their travel behavior were compared with those who ranked TrafficGauge as “very useful.” For commute trips, a greater percentage of people who reported changing their route on more than two days over the course of the daily surveys found TrafficGauge to be “very useful” (see Figure 5).

For non-commute trips (see Figure 6), again there was not a clear perceived benefit. The percentage of participants who ranked TrafficGauge as “somewhat useful” was over 50 percent for those who changed travel behavior on one, two, three, and four days. The percentage was over 40 percent for those who didn't change behavior on any days and those who changed on five days. This could imply that TrafficGauge was relied on more for commute trip information and that its use for non-commute trips was less critical, but this conclusion is somewhat speculative.

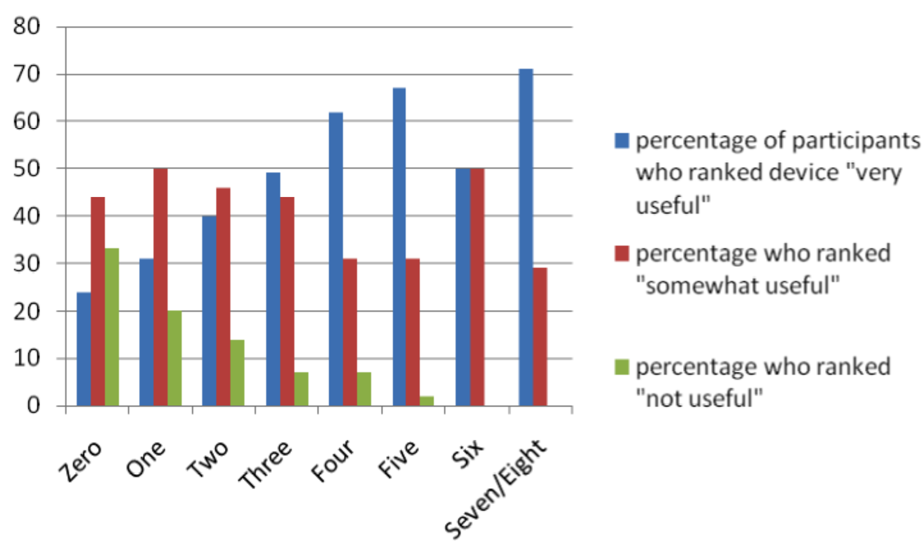


Figure 5. Commute Trips[7]: Changed Routine vs Utility

[7] The number of responses in the "Seven/Eight" category was 7

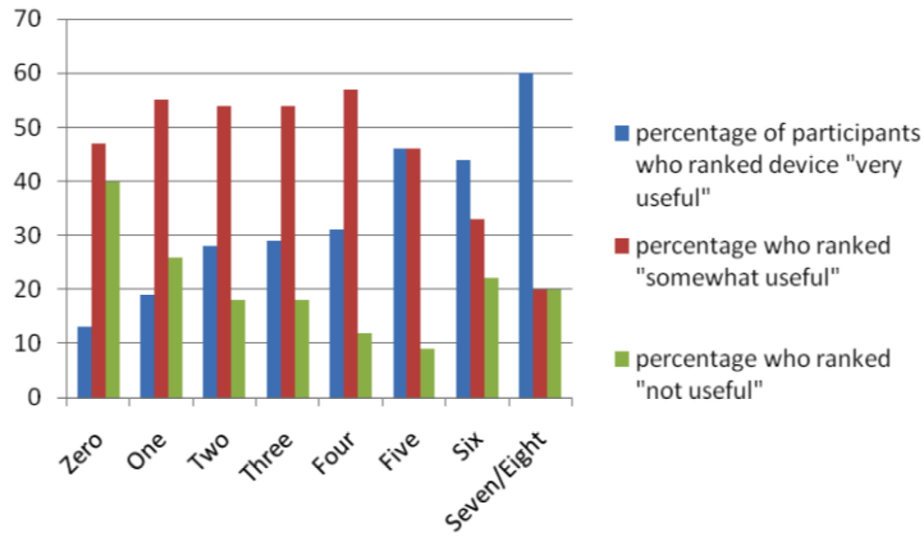


Figure 6. Non-Commute Trips[8]: Changed Routine vs Utility

RELIABILITY

There was a clear link between the number of days people indicated that they changed behavior in the daily surveys and whether they thought using TrafficGauge resulted in a more reliable trip in the exit survey.

A higher percentage of participants who indicated that they did not change behavior at all, or on just one or two days, said that they did not think TrafficGauge provided a more reliable trip. They may have been disappointed with the device given their initial expectations for the level of detailed information they would receive. However, the more days that people changed routes, the more they credited TrafficGauge for improving trip reliability. Those who indicated that they changed behavior on three, four, or five days were approximately evenly split on the reliability question. Two-thirds of those who changed on more than five days responded that using the TrafficGauge resulted in a more reliable trip (see Table 6).

[8] The number of responses in the "Seven/Eight" category was 5

Table 6. Changed Behavior vs Reliability

Number of days with changed travel behavior	More Reliable Trip	
	Yes	No
0	151 (36%)	269 (64%)
1	156 (40%)	239 (60%)
2	131 (41%)	189 (59%)
3	127 (51%)	120 (49%)
4	96 (54%)	81 (46%)
5	32 (49%)	33 (51%)
6, 7, 8	19 (66%)	10 (34%)

TRIP DURATION

The same trends were evident when the perceived length of their trip was evaluated. A greater percentage of participants who indicated that they did not change behavior at all, or on just one or two days, said that they did not think TrafficGauge resulted in a shorter trip. However, the more days that people changed behavior, the more that they credited TrafficGauge with making their trip shorter. Those who indicated that they changed on three days were close to evenly split on whether their trip was shorter as a result of those changes. A higher percentage of those who changed on more than three days said that TrafficGauge resulted in a shorter trip (see Table 7).

Table 7. Changed Behavior vs Trip Time

Number of days with changed travel behavior	Shorter Trip	
	Yes	No
0	104 (25%)	316 (75%)
1	128 (32%)	267 (68%)
2	148 (46%)	172 (54%)
3	129 (52%)	118 (48%)
4	95 (54%)	82 (46%)
5	42 (65%)	23 (35%)
6, 7, 8	19 (66%)	10 (34%)

Another interesting finding is that a greater percentage of people said that TrafficGauge did not result in a shorter trip if they initially expressed a strong preference for estimated travel times based on real-time traffic information. This could be due to high expectations that they had initially about the availability and accuracy of travel time predictions (see Table 8).

Table 8. Preference for Travel Times (Entry Survey) vs Trip Time (Exit Survey)

Preference for Travel Times between Destinations Based on Traffic Conditions	Shorter Trip	
	Yes	No
Very important	385 (38%)	621 (62%)
Important	230 (41%)	328 (59%)
Not Important	30 (54%)	26 (46%)

WILLINGNESS TO PAY

When all study participants were asked at the end of the trial, “How much would you be willing to pay for your TrafficGauge?” 50 percent indicated either \$50 or \$30, and 21 percent indicated that they would pay \$0 or would not purchase the device.

A large number of comments were provided regarding the price of the device. Thirteen of these indicated that they would pay between \$15 and \$25, and three indicated that they would pay \$40. Most of the other comments provided a qualified cost figure, i.e., they would pay a specified amount if a certain feature were provided. (These comments are provided in Appendix D.)

Because real-time information systems must pay for the communications necessary to transfer the travel information, most real-time devices require an ongoing (but usually modest) monthly service payment in addition to the initial purchase price. The exit survey asked what monthly subscriber fee they would consider to be reasonable for using a TrafficGauge. The responses to that question are summarized below:

- \$5 – 59 percent
- \$7 – 14 percent
- \$9 – 10 percent
- Higher – less than 1 percent

Note that these responses were irrespective of whether an individual would choose to purchase the device at all.

Initial preference for the device in the entry survey seemed to play a large role in participant responses in the exit survey. In other words, if someone thought she would pay for the device before she began the trial, then she would be more likely to like the device at the end and indicate that she saved more time. Table 9 compares participants who said they would pay for the TrafficGauge in the entry survey with their willingness to pay for the device at the end of the study. Twenty-eight percent of participants who said they would be willing to pay in the beginning said the same at the end of the survey. By contrast, only 10 percent of those who were not willing to pay in the beginning said they would pay for the device at the end of the study.

Willingness to pay indicators in the entry survey were compared with several other variables in the exit survey. The data showed that a much greater percentage of people who indicated at the beginning that they were willing to pay for the device found the device to be "very useful." The combined percentages of those who found the device to be very useful or somewhat useful were very similar, regardless of the initial willingness to pay response. The percentages of those who indicated that the device was not useful were similar in those who indicated a willingness to pay and those who did not (see Table 10). This reinforces the earlier conclusion that "somewhat useful" is an ambivalent response indicating recognition of potential usefulness.

Table 9. Willingness to Pay:
Entry Survey vs Exit Survey

Willingness to Pay (entry survey)	Willingness to Pay (exit survey)	
	Yes, would pay	No, would not pay
Agree strongly, Agree	215 (28%)	568 (72%)
Neutral	116 (15%)	646 (85%)
Disagree strongly, disagree	35 (10%)	311 (90%)

Table 10. Willingness to Pay (entry survey) vs Utility (exit survey)

Willingness to Pay (entry survey)	Perceived Usefulness		
	Very useful	Somewhat useful	Not useful
Agree strongly, Agree	353 (52%)	252 (37%)	78 (11%)
Neutral	220 (35%)	315 (51%)	87 (14%)
Disagree strongly, disagree	66 (24%)	166 (61%)	39 (14%)

Next, willingness to pay in the entry survey was compared with how much time participants reported saving each week using TrafficGauge in the exit survey (see Figure 7). People who saved little or no time with the TrafficGauge were split over whether they would pay for the device at the end. (People may have used TrafficGauge to confirm their decision to use their normal commute route, thus gaining the impression at the end of the study that using the device led to a more reliable trip.) More of those who reported saving more than 5 minutes per week said that they would be willing to pay for the device at the beginning of the study. The reason for this could be that people who expressed a willingness to pay for the device initially were predisposed to thinking the device was beneficial. These results might also mean that these individuals knew of reasonably good, time saving alternatives to their primary freeway trips when their primary routes were unusually congested—and they simply needed more timely information about when their normal routes were congested.

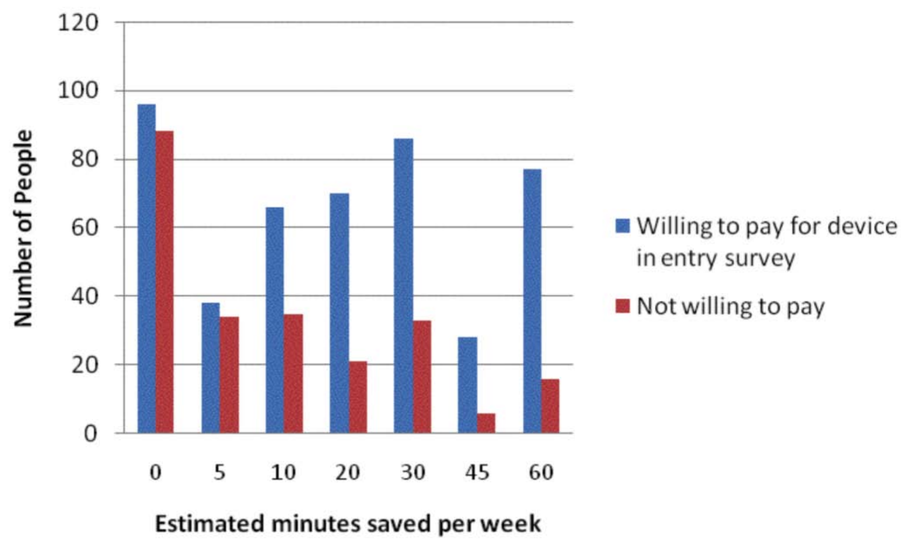


Figure 7. Willingness to Pay (entry survey) vs. Time Saved (exit survey)

For those who reported saving large amounts of time, the results were mixed. Of those who saved two hours per week, 23 would not purchase the device and 10 would. However, for those reporting having saved 150 minutes per week, the results were split, with five willing to purchase the device and five not willing to purchase the device. These results suggest that there is not a specific threshold for how much time people actually need to save before they consider TrafficGauge to be a worthwhile investment.

ADDITIONAL TAXPAYER SUPPORT

When participants were asked whether they favored the State of Washington using tax dollars to collect more traffic congestion data to support devices such as TrafficGauge, the responses were positive (56 percent said yes, and 32 percent said no). When individuals are able to spend "other people's money," they are more willing to buy items of "marginal benefit;" whereas with their own money, they need to have a higher perceived benefit. If this question were rephrased to ask, "Should the state spend more money on traveler information or on tax relief?" we suspect that a far smaller percentage would express support for traveler information.

It is interesting to examine whether participants who agreed that additional taxpayer dollars should be devoted to support devices such as TrafficGauge were those who found the device more useful. Table 11 is a comparison of attitudes toward the use of taxpayer dollars to fund traffic data collection versus perception of usefulness of the TrafficGauge. Those who found the TrafficGauge to be very useful were more likely to believe that taxpayer dollars should be used to gather traffic data.

Table 11. Commute Trips: Taxpayer Funding vs Utility

More Taxpayer Dollars Should be Used to Gather Data for TrafficGauge (exit survey)	Perceived Usefulness		
	Very useful	Somewhat useful	Not useful
Yes	509 (48%)	427 (40%)	134 (12%)
No	136 (22%)	307 (51%)	164 (27%)

TIME SAVINGS AND PURCHASE DECISIONS

The median frequency of reporting checking the device was 14.5 days out of a total of 32. However, those who reported saving time on six days reported checking TrafficGauge an average of 22 times per month. Those who saved time on seven or eight days reported checking TrafficGauge an average of 25 times per month. In contrast, those who saved time on just one or two days reported checking TrafficGauge an average of only 13 times per month**.** This reinforces the point mentioned earlier that those who saved time more frequently were those who checked the device more frequently.

A good explanation for the relative reluctance to pay for an in-vehicle device similar to the TrafficGauge may be found in the participants' responses to the exit survey's question about the users' estimated number of minutes saved per week. The estimates of time saved varied considerably. The number given most often was zero (21 percent). The next most common estimate was 30 minutes. Seventy-six percent of the estimates were 30 minutes or less. The mean value was 29 minutes, and the standard deviation was large at 49 minutes. Thirteen percent of exit survey respondents did not answer this question. Table 12 compares the responses to the exit survey question regarding purchase of the device with the daily survey estimate of the number of minutes saved each week. The purchase decision percentages are similar, indicating that the decision about whether to purchase the device was not based on estimated travel time savings.

Table 12. Purchase Decisions

Willingness to Pay	Estimated Time Savings	
	> 30 minutes	</= 30 minutes
Would not purchase	48 (12%)	207 (16%)
Would purchase	158 (38%)	445 (35%)
Would purchase an expanded version with arterial information	204 (50%)	612 (48%)
No answer	2 (<1%)	3 (<1%)
Total	412 (100%)	1267 (100%

The data were also analyzed to determine whether those who said that they would purchase the TrafficGauge in the exit surveys were those who checked the device more frequently during the course of the daily surveys (see Table 13).

The differences between these groups were all significant (p=95 percent) except for the differences between the "no answer" group and all of the others. It appears that those who used the device and checked it frequently were more likely to want to purchase it.

A similar comparison made by an exit survey question indicating whether respondents had benefited from using the device is shown in Table 14.

The differences among all of these groups were significant (p=95 percent). Again, this demonstrates that those who benefited from the device more often were more likely to buy it.

Table 13. Times Checked vs Purchasing Decision
Times TrafficGauge Checked

Would you purchase a device if you didn't already own one?	Mean	Number of Responses	Std. Deviation
Yes	17.6	375	7.06
No	13.3	505	7.66
Only an expanded version w/arterial info	15.5	835	7.48
Did not complete this survey	7.5	214	7.47
No answer	20.6	5	4.39
Total	14.5	1934	7.96

Table 14. Times Benefited vs Purchasing Decision

Would you purchase a device if you didn't already own one?	Times Benefited from TrafficGauge		
	Mean	Number of Responses	Std. Deviation
Yes	2.8	375	1.68
No	1.5	505	1.49
Only an expanded version w/arterial info	2.1	835	1.61
Did not complete this survey	1.1	214	1.53
No answer	2.6	5	1.14
Total	2	1934	1.67

PEACE OF MIND

Peace of mind was cited as one of the clearest benefits of the TrafficGauge. Survey participants felt better knowing that they had access to traffic information provided by the TrafficGauge, even if they were not convinced that it resulted in a shorter or more reliable trip. That seemed to hold true regardless of whether participants used the device to change their behavior, according to the daily surveys (see Table 15).

Table 15. Changed Travel vs Peace of Mind

Number of Days with Changed Travel Routes	Yes, better peace of mind	No, did not contribute to peace of mind
0	254 (60%)	166 (40%)
1	260 (66%)	135 (34%)
2	201 (63%)	119 (37%)
3	146 (59%)	101 (41%)
4	108 (61%)	69 (39%)
5	38 (59%)	27 (41%)
6, 7, 8	20 (69%)	9 (31%)

Many participants said in the comments section that TrafficGauge helped reduce their stress by letting them know what they could expect on their commute, even if they could not change their route. Representative comments when participants were asked about positive benefits included the following:

- “I think the most important thing on a commuter's mind is knowing roughly how long they can expect to spend sitting in traffic.”
- “It may not have changed my trips as much as I would have thought—but it's great to know about what is ahead.”
- “Simple preparedness for sitting in traffic reduced feelings of ‘road rage’.”
- “As is—I did not find it very useful except to note how late I would be due to traffic.”

<u>LOCATION OF PARTICIPANTS</u>

There were several particular zip codes (see Figure 2) with a higher percentage of respondents who ranked TrafficGauge as “very useful” for commute trips in the exit survey. At least 50 percent of respondents from the following zip codes ranked TrafficGauge as “very useful”:

- 98026 (Edmonds)
- 98030 (Kent)
- 98031 (Kent)
- 98045 (North Bend)
- 98055 (Renton)
- 98092 (Auburn)
- 98126 (West Seattle)
- 98168 (South Seattle/Duwamish)
- 98201 (Everett)
- 98208 (Everett)
- 98233 (Burlington)
- 98273 (Mount Vernon)
- 98332 (Gig Harbor)
- 98354 (Milton)
- 98372 (Puyallup)
- 98387 (Spanaway)
- 98391 (Bonney Lake)
- 98445 (Parkland/South Tacoma)
- 98467 (University Place)

Many of these zip codes are in areas that border I-5 or other major freeways, and they are relatively far from Seattle. Despite the lack of information on alternative routes for many study participants, the TrafficGauge may have offered enough information to be useful to participants near major freeways. As noted earlier in the report, the most participants in the study came from Redmond, Shoreline, and north Seattle. It is interesting that none of these areas produced a majority of participants who found TrafficGauge to be "very useful."

The following comment from one user seems to summarize the attitudes of others:

- "I believe, as is, this is a good tool for drivers who live far outside the major work centers (i.e.; Bellevue & Seattle). I do not think this is a good tool as is for drivers like myself who live just outside the centers (i.e., Northgate). I commute via Greenwood Ave and 15th to downtown."

The following zip codes only had one respondent, but they also ranked TrafficGauge as very useful:

- 98225 (Bellingham)
- 98226 (Bellingham),
- 98232 (Bow)
- 98249 (Freeland/Whidbey Island)
- 98349 (Lakebay)
- 98394 (Vaughn)
- 98502 (Olympia)
- 98550 (Hoquiam)

Most are also located at least 50 miles from Seattle along I-5.

For non-commuters, there were hardly any zip codes in which at least 50 percent of respondents ranked TrafficGauge as "very useful." Those in which this was the case had relatively small groups of respondents: 98188 (SeaTac), 98201 (Everett), 98251 (Gold Bar), and 98360 (Orting). The remaining zip codes each contained only one respondent who ranked the device as useful: 98015 (Bellevue), 98232 (Bow), 98233 (Burlington), and 98373 (Puyallup).

ARTERIAL INFORMATION

Arterial information was important to almost all respondents. Using the TrafficGauge for six months did not change most opinions; just as in the entry surveys, almost all respondents noted in the exit survey that they thought arterial information would be useful. Therefore, the importance of arterial information did not serve as a strong predictor of whether people thought TrafficGauge was a useful device. Regardless of whether someone indicated at the beginning that they would be willing to purchase the device, a large majority (around 90 percent) in each category thought that arterial information would have been helpful.

A lack of arterial information was seen as the biggest weakness of TrafficGauge and was cited as a major reason why people stopped short of saying they would purchase the device even if they saw other benefits. Some respondents also felt that WSDOT's traffic page, or other online sources, contained more comprehensive and reliable information free of charge. Representative comments included the following:

- "I think the idea is great but major arterials are only a fraction of my total commute times. Slowdowns on I-90 and I-405 ripple onto the feeders and surface streets which causes me way more delays than commuting on the highways."
- "With a wider range of coverage (like all of Western Washington) and higher detail, i.e. arterials, the TrafficGauge would grow from merely being a decent tool to a great one."

- "Internet provides more detailed information that I would usually check before taking a trip. At a certain point I'd probably get internet on my cell phone for traffic info."
- "I found the free information I could get on a cell phone more useful."

EFFECTS OF EARLIER ACCESS TO TRAVELER INFORMATION SERVICES

An interesting observation concerned the differences in the perception of usefulness of the TrafficGauge by users of other travel information services. A review of the data indicated that the TrafficGauge was perceived as more useful by previous users of the WSDOT traffic Web site and by those who had never used or never heard of 511. Perhaps those accustomed to getting traveler information by telephone were not comfortable with getting the information via a map display, but those experienced with map displays, such as that provided by the WSDOT Web site, were comfortable with that method of delivery. Table 16 indicates the relationship between awareness and use of the WSDOT 511 telephone hotline and the perception of usefulness of the TrafficGauge. The numbers are the percentage of total survey respondents (1,934). (Because the percentages for commuters and non-commuters were similar, they are shown together in the table.)

Table 16. Commuters/Non-Commuters: 511 Usage vs TrafficGauge Usefulness

511 Usage	TrafficGauge Usefulness	
	Very or Somewhat Useful	Not Useful
Never used or unknown	50%/45%	12%/16%
Previously used	20%/18%	3%/5%

Table 17. Commuters/Non-Commuters:
Web Site Usage vs TrafficGauge Usefulness

Web Site Usage	TrafficGauge Usefulness	
	Very or Somewhat Useful	Not Useful
Never used or unknown	4%/4%	2%/1%
Previously used	67%/59%	13%/21%

The comparable data for users of the Puget Sound Traffic Conditions Web site are shown in Table 17. (The data for commuters and non-commuters are shown together.)

The data were analyzed to determine whether those who used 511 or the Puget Sound Traffic Conditions Web site were more likely to purchase the TrafficGauge. The data for 511 users are shown in Table 18, and the data for the Web site are shown in Table 19. It does not appear that familiarity with the two major sources of traffic information had any influence on the participants' willingness to purchase TrafficGauge.

Table 18. 511 Usage vs Purchase Decision

511	Willing to Purchase		
	Yes	No	Only an Expanded Version
Never used/never heard of	71%	72%	73%
Used	29%	28%	27%

Table 19. Web Site Usage vs Purchase Decision

Web Site	Willing to Purchase		
	Yes	No	Only an Expanded Version
Never used/never heard of	4%	6%	8%
Used	96%	94%	92%

The number of respondents who said they had both subscribed to a fee-based online service and would pay for the TrafficGauge was small—59 people (see Table 20**).** There did not seem to be a strong relationship between those who had previously subscribed to a fee-based online service and those who indicated that they would be willing to purchase a TrafficGauge in the exit survey. The percentage of those who subscribed to a fee-based online service who were willing to purchase a TrafficGauge was only slightly higher than those who did not subscribe to such a service and said they would purchase the device. This indicates that the decision concerning whether to purchase a TrafficGauge was probably based on the value of the service and not simply an interest in trying the newest technology.

Table 20. Service Subscribers vs Purchase Decision

Subscribe to fee-based online service	Willingness to Purchase	
	Yes	No
Yes	59 (20%)	244 (80%)
No	306 (19%)	1285 (81%)

To confirm that this decision was based on perceived value, the data were compared to investigate whether the combined effect of subscribing to a fee-based online service and willingness to purchase was correlated with time savings due to usage of the TrafficGauge. Table 21 shows the number of days that participants reported saving time for each of the four categories shown in Table 20.

The following differences were statistically significant at the 95th percentile:

Yes/Yes (2.25) vs No/No (1.40)

Yes/Yes (2.25) vs Yes/No (1.34)

No/Yes (2.35) vs No/No (1.40)

No/Yes (2.35) vs Yes/No (1.34).

It appears that the participants fell into two time-savings groups. Those who reported saving time on two or more days were more willing to purchase the device, regardless of whether they subscribed to an online service. Those who reported saving time on fewer than two days were not willing to purchase the device, regardless of whether they subscribed to an online service.

**Table 21. Fee-based Subscription/
Purchase Decision vs Number of Days in which Time Was Saved**

Category (Subscription/Purchase)	# of Days Time Saved Mean	# of Days Time Saved Std. Deviation
Yes/Yes	2.25	1.59
No/Yes	2.35	1.59
Yes/No	1.34	1.40
No/No	1.40	1.43

EXIT SURVEY SUMMARY

In summary, the exit survey seemed to divide study participants into three groups. One group (about 20 percent) thought very highly of the device, were confident that it had saved them considerable time and stress, and would purchase the device. They tended to check the device more frequently and to have positive experiences with changing travel behavior on the basis of information received. Another group (between 21 percent and 26 percent) thought very poorly of the device and its content and would not purchase the device. This group saw little value in either the device or the information it conveyed. The third, and by far largest, group saw value in the device and had occasionally benefited from the information it provided. That benefit was manifested as reduced stress resulting from a more predictable trip, more predictable estimated time of arrival, or reduced travel time. This group, however, did not think that obtaining these benefits warranted the purchase of such a device.

CONCLUSIONS : IN-VEHICLE TRAFFIC MAP STUDY

As expected in a group primarily self-selected by a recruitment banner on a travel information Web site, the study group was comfortable using technology to get information. Participants were generally experienced in the ways of obtaining travel information. The large percentage of people who had never used the 511 traveler information telephone hotline was therefore surprising, particularly given how avidly the participants sought traveler information.

A large percentage of study participants, over 80 percent, indicated in the entry survey that they would pay for "accurate, up-to-the minute traffic information for major, regional routes." Unfortunately, much of the traveler information that they indicated they wanted is not available from existing systems, including TrafficGauge, and some of it is not feasible to provide with the existing field device network and existing technology. For example, most participants in the entry surveys indicated that they wanted forecasts of traffic conditions for the next 60 minutes, which is beyond the capabilities of most information providers. The benefits that they said they expected to get from receiving traveler information, however, were generally reasonable and what would be expected by traffic engineers or travel information providers.

Most people in the study group commuted in their cars. They wanted to continue to do so, and they wanted a device that would give them a way over, around, or through congestion. Unfortunately, the TrafficGauge did not have the information on alternative routes, such as arterial roadways, that would give these commuters the edge over their fellow travelers. In general, most commuters in the Seattle area have few if any alternative routes to choose from when their primary route is congested. Those alternative routes that do exist include arterials, which are also subject to heavy congestion. Therefore, without arterial congestion information, re-routing decisions made for peak period commute trips are not assured of improving a commuter's travel time.

This dilemma was reflected in the daily survey results. On half the occasions when participants reported changing routines, they reported not receiving any benefits. For the entire study, 25 percent of participants reported not benefiting at all from the device. The most likely benefit that travelers could expect was a reduced travel time. However, 32 percent of participants indicated that they did not save any time by using the device. The daily surveys did indicate that participants who changed routines saved time a mean number of 1.6 times. The mean amount of time saved on those instances was a little over 30 minutes.

Not surprisingly, there was a direct relationship between the number of times the TrafficGauge device was checked and the number of days people indicated that they changed behavior, their perception of both trip reliability and time savings, and their desire to purchase the device.

The information provided by TrafficGauge does seem to be good at relieving travel-related stress. When asked specifically about reduced stress in the exit survey, over 59 percent of the participants indicated that the information provided by the device reduced their level of stress.

It appears that the study participants could be divided into three groups based on their exit survey responses. One group (about 20 percent) thought very highly of the device, were confident that it had saved them considerable time and stress, and would purchase the device. Another group (between 21 percent and 26 percent) thought very poorly of the device and its content and would not purchase the device. This group saw little value in either the device or the information it conveyed. The third, and by far largest, group saw value in the device and had occasionally benefited from the information it provided. That benefit manifested as reduced stress resulting from a more predictable trip, more predictable estimated time of arrival, or reduced travel time. This group, however, did not think that obtaining these benefits warranted the purchase of such a device.

II. CHANGES IN ROADWAY PERFORMANCE AS A RESULT OF TRAVELER BEHAVIOR DUE IN PART TO TRAVELER INFORMATION

This portion of the project was undertaken to examine how the behavior of travelers whose freeway route is unusually congested affects the performance of alternative roadways. That is, the project examined whether additional capacity exists on arterial alternative routes and whether current levels of freeway diversion adversely affect the performance of those alternative routes. The intent of the study was to examine diversion that occurs as a result of current levels of traveler information. The effects of diversion on alternative routes is an issue because one major concern about the widespread use of real-time in-vehicle traveler information systems is that diversion from the mainline in response to in-vehicle information will overwhelm the capacity of alternative routes, significantly slowing those routes and creating even more widespread congestion.

STUDY LOCATION

The project team selected the freeways and arterials in the city of Bellevue, Washington, near the Microsoft campus in Redmond, as the site for this analysis. A map of the area and the key roadways are shown in Figure 8. This geographic area was selected for several reasons:

- Data were available for all sections of the freeway system in the area, including SR 520, I-405, and I-90.
- The city of Bellevue has instrumented all of the arterials in the region that it controls, and the University of Washington has access to these data, allowing the estimation of arterial use and performance.

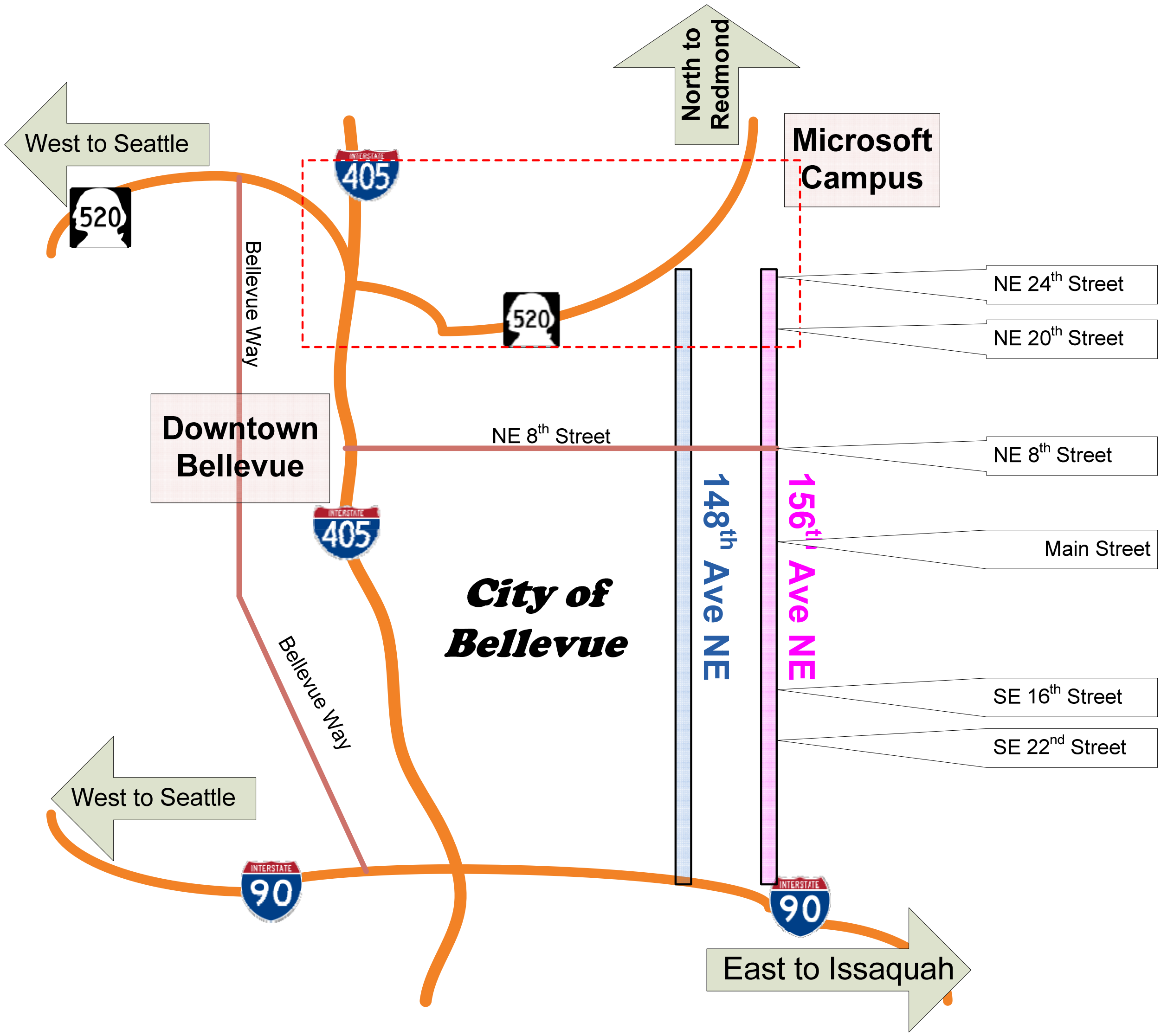


Figure 8. Map of Study Area (revised from Google Maps)

- Microsoft employees are known to be major users of the WSDOT's Internet-based traffic information system.
- As part of a company research project on user interface characteristics, Microsoft has given 3,000 employees cell phones with access to real-time traffic information, providing a significant number of employees with in-vehicle map-based traveler information.

- Bellevue has historic concerns about "cut through" traffic using 148th Ave NE and 156th Ave NE to travel between the Microsoft campus area near NE 24th St and I-90, which occurs as travelers try to avoid routine congestion on westbound SR 520 and southbound I-405.
- Bellevue has similar cut-though concerns about travel from downtown Bellevue through neighborhoods south of downtown to I-90 when I-405 southbound becomes congested.

As a result, the study was based on an area that contains roadways that serve as alternative routes to the freeways, a significant set of travelers who have access to data that inform them of freeway congestion—even after they have left their offices, and a set of arterials for which at least a modest amount of performance information is available.

As can be seen in Figure 8, the Microsoft campus sits just north of the study area, on its eastern side. A large number of Microsoft employees commute on SR 520. In the afternoon, these individuals head west on SR 520, either continuing west to Seattle, turning north on I-405 to reach the northern suburbs of the region, or turning south on I-405 to continue to the southern suburbs, turn west on I-90 (the traditionally less crowded bridge across Lake Washington to Seattle), or turn east on I-90 to the suburb of Issaquah.

I-405 southbound through downtown Bellevue is often very congested. In addition, when crashes occur on SR 520 west of the I-405 interchange, the back-ups can create significant delay on SR 520 east of the I-405 interchange. When congestion occurs in these locations, the use of the Bellevue arterials that run parallel to these facilities is thought to increase as travelers seek to avoid the stalled freeways. This study examined the relative performance (volume and travel time) of these arterials during times of both modest and severe PM peak freeway conditions.

DATA SOURCES

The primary data sources for these analyses were the loop detector systems that WSDOT operates as part of its freeway surveillance and control system and the city of Bellevue operates as part of its traffic signal control system.

Historical freeway loop detector data were retrieved from the Traffic Data Acquisition and Distribution (TDAD) website, developed at the University of Washington. The database contains measurements from all of WSDOT's single- and dual-loop detectors, taken at 20-second intervals from October 1998 to June 2007. The loop detectors in each loop station are capable of measuring the traffic parameters on every freeway lane.

A Google Map-based Arterial Traveler Information (GATI) system, developed by the Smart Transportation and Application Research Laboratory (STAR Lab) at the University of Washington, has been retrieving and archiving Bellevue's data every minute since January 1, 2007.[9] Volume data are obtained from advance loop detectors that are normally located 100 to 130 ft (30.5 to 45.7 m) upstream of stop bars. There are 12 data collection nodes on 148th Ave NE, starting from NE 20th Street at the north to SE Eastgate Way at the south, and on 156th Ave NE there are six nodes, starting from NE 20th Street at the north to Eastgate Way at the south.

[9] For a description of the GATI system, see
Wu, Y.-J., Wang, Y., and Qian, D. "A Google-Map-Based Arterial Traffic Information System." *IEEE Intelligent Transportation Systems Conference*, 968-973.

With the assistance of the GATI system, data were collected from these nodes for the period of April through June 2007. Only weekday (Monday to Friday) data were used to analyze traffic patterns. All loop datasets within the study period were aggregated to 5-minute intervals.

For the primary measure of "unusual" congestion on SR 520, the research team selected lane occupancy percentage at the loop detector located just downstream of the ramps leading to 148th Ave NE (Loop ES-535D). This location is not normally congested during the peak period. WSDOT uses 35 percent lane occupancy as a measure of "congestion" for its traveler information. For this study, different values of lane occupancy were tested against diversion rates to compare how drivers' views of freeway congestion influenced their behavior. (Drivers seeing heavy congestion at the location of Loop ES-535 would know that SR 520 was extremely backed up. Lane occupancy above 35 percent is essentially stop and go traffic. Thus, occupancy levels near 30 percent will indicate very heavy, but still moving, congestion occurring at a point on the roadway that is usually not congested.)

ANALYSIS METHODLOGY

The basic methodology for this study was as follows:

- Determine the baseline conditions for both the freeways and arterials in the study area. Baseline conditions included expected traffic volumes and roadway performance (speed, lane occupancy, travel time conditions) on both freeways and arterials during "routine" peak periods.
- Identify how these conditions change over the course of the peak period.

- Identify whether the performance of specific arterials is correlated to the performance of specific freeways.
- Identify days and times during which abnormally bad freeway conditions occur.
- Determine whether arterial performance changes negatively relative to "normal" conditions when freeway conditions are worse than normal.
- Determine whether unused capacity still exists on arterials during periods when freeway performance is considerably worse than normal.

The performance of the freeways and arterials was determined in terms of travel time, vehicle volume, and lane occupancy. In addition to the freeways shown in Figure 8, this study initially examined four arterials for the impacts of route diversion: 148th Ave NE, NE 8th St, Bellevue Way, and 116th Ave NE.

The study team performed correlation analyses between the performance of the three freeways and these four arterials by using conditional probability tables. These tables showed that the formation of congested conditions on freeways and arterials was imperfectly correlated. That is, when the freeway became congested, the arterials did not always become congested, and vice versa. This means that there are many times when arterials can serve as a limited capacity reserve that can relieve at least a limited amount of freeway congestion in the area. Table 22 shows the probability that congestion exists on a freeway, given arterial congestion, and vice versa. Darker cells illustrate those combinations of arterial and freeway segments where there is a high probability that the freeway segment will become congested given the fact that the arterial segment is

Table 22. Conditional Probability Table
Arterial Congestion Given Freeway Congestion (AC | FC)
and Freeway Congestion Given Arterial Congestion (FC | AC)

		SR-520 (WB)	I-405 (SB)	I-90 (WB)	SR-520 (EB)	I-405 (NB)	I-90 (EB)
148th AVE (S	P(AC | FC)	19.59%	24.49%	24.49%	4.08%	8.16%	6.12%
	P(FC | AC)	24.49%	24.49%	6.12%	1.02%	2.04%	1.53%
8th Street (W	P(AC | FC)	52.65%	57.14%	46.94%	73.47%	63.27%	51.02%
	P(FC | AC)	9.08%	7.88%	1.62%	2.53%	2.18%	1.76%
Bellevue Way	P(AC | FC)	26.94%	36.73%	14.29%	2.04%	12.24%	4.08%
	P(FC | AC)	26.94%	29.39%	2.86%	0.41%	2.45%	0.82%
116 th AVE (S	P(AC | FC)	4.90%	5.10%	6.12%	4.08%	0.00%	4.08%
	P(FC | AC)	24.49%	20.41%	6.12%	4.08%	0.00%	4.08%
148th AVE (N	P(AC | FC)	16.73%	17.35%	8.16%	6.12%	12.24%	2.04%
	P(FC | AC)	10.46%	8.67%	1.02%	0.77%	1.53%	0.26%
8th Street (E	P(AC | FC)	54.69%	46.94%	53.06%	42.86%	53.06%	26.53%
	P(FC | AC)	10.13%	6.95%	1.97%	1.59%	1.97%	0.98%
Bellevue Way	P(AC | FC)	3.27%	3.57%	0.00%	2.04%	4.08%	2.04%
	P(FC | AC)	8.16%	7.14%	0.00%	1.02%	2.04%	1.02%
116 th AVE (N	P(AC | FC)	32.24%	28.57%	26.53%	36.73%	57.14%	16.33%
	P(FC | AC)	7.68%	5.44%	1.26%	1.75%	2.72%	0.78%

congested (FC | AC), or that the arterial segment will become congested given that the freeway segment is congested (AC | FC).

After these findings were identified, the project team then focused on two specific arterials, 148th Ave NE and 156th Ave NE, and one freeway, SR 520. These two arterials serve as the key diversion routes for drivers traveling on SR 520 westbound in order to eventually reach I-90. The northern sections of these arterials also serve as diversion routes for motorists traveling on SR 520 to access downtown Bellevue.

The analysis examined how traffic volumes and roadway performance on these arterials changed when unusual congestion on SR 520 occurred. The concept behind the analysis was that, given limited travel time information on all possible routes, most drivers have determined over time which roadway is the optimal choice for their PM peak period trip. The outcome of these choices is a base level of traffic congestion on the freeways and arterials. However, on days when major traffic disruptions occur on SR 520, the unusual congestion on SR 520 likely causes a subset of travelers to divert to the arterials. By measuring the changes in arterial volumes and travel times on these days, it would be possible to determine whether the "spare" capacity identified in the base correlation analysis is overwhelmed by the diverting traffic volumes. If it is, then the individuals diverting to those arterials are unlikely to receive significant travel time benefits. Such a reduction in performance would also indicate that without additional traffic management activities, significant route diversion due to widespread, real-time freeway traveler information–but not arterial traveler information—is indeed likely to cause significant increases in congestion on arterial diversion routes, at least in the study corridors.

The decision whether to divert depends on a drivers' visual impressions of freeway traffic congestion before the off-ramp, any in-vehicle traveler information they have (e.g., radio traffic reports or cell phones with traffic reports), and any information they may have obtained before leaving for their destination (i.e., from the WSDOT roadway conditions Web site).

In order to replicate how travelers make spur-of-the-moment rerouting decisions, the research examined freeway congestion at a point just downstream of the off ramp that can be used to access arterial diversion routes. The methodology first examined what happened when "congestion," based on predefined lane occupancy thresholds, occurred. Then, it examined whether diversion actually occurred. Finally, it evaluated whether arterial performance changed as a result of the diversions. The "congestion" measures included the diversion rate, ramp occupancy, downstream mainline occupancy and the volume and occupancy, on the local arterials (148th Ave NE and 156th Ave NE).

Diversion Rate Calculation

Real-time diversion is one of the measures commonly used to determine how drivers react to specific events, such as congestion and incidents. The diversion rate calculation describes the outcome of drivers' real-time decision making as a result of their encountering unexpected congestion up ahead without complete information about the freeway slow-down or alternative routes. Herein, "incomplete information" means that the information drivers receive comes only from their view of the scene of "congestion" downstream and not from VMS or in-car information devices.

As shown in Figure 9, ES-539D, ES-537R and ES-535D are the loop detectors near the ramp to 148th Ave. The volume retrieved from the detector ES-539D was used as the total input volume. The diversion rate was defined as the portion of the mainline volume that was diverted to the ramp and was formulated as:

$$DR_i = RV_{ES535R,i} \; / \; MV_{ES539D,i} \qquad (1)$$

where:

DR_i is the diversion rate at time i

$RV_{ES535R,i}$ is the ramp volume detected by the loop station ES-535R

$MV_{ES539D,i}$ is the mainline volume detected by the loop station ES-539D.

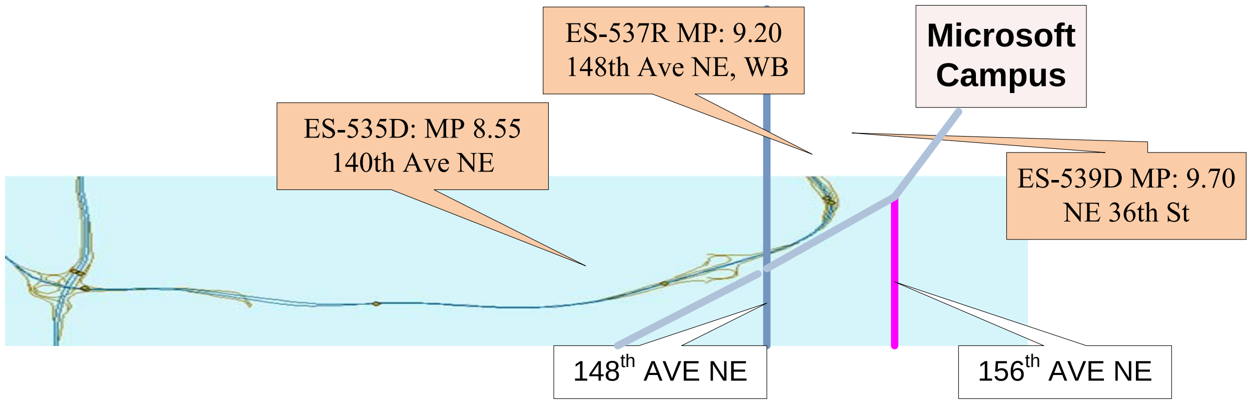


Figure 9. Loop Detector Locations for Data Collection

Determining Congestion Scenarios

To investigate the impact of freeway congestion on traffic diversion and the collateral impact on arterials, various scenarios were identified by selecting different levels of congestion on the freeway. The level of congestion was determined by 5-minute average mainline occupancy at Loop Station ES-535D, located 0.65 miles downstream from the ramp loop detector (ES-535R), as shown in Figure 9. The researchers tested three approaches to defining congestion that would be likely to cause motorists to react by diverting. All three approaches tested different measures of lane occupancy (thresholds) at which diversion might occur. These three approaches were defined as follows:

Absolute Occupancy Threshold (Th_{AbcOcc}): This approach determined the periods when the lane occupancy value was greater than a predefined threshold value. If the downstream loop detected occupancy greater than Th_{AbcOcc}, the section was regarded as congested enough to cause diversion. This threshold type can be used to compare travelers' behavior on the basis of absolute congestion levels on the freeway. WSDOT considers 35 percent lane occupancy to be highly congested.

Relative Occupancy Threshold ($\boldsymbol{Th_{RelOcc}}$): This approach determined the periods when the lane occupancy value at the downstream detector was greater than the median occupancy value, calculated for the same time-of-day interval during the study period. This threshold determines periods of non-recurring (unusual) congestion. This scenario can help investigate traveler behavior when congestion is higher than the traveler's expectation.

Dual Absolute Occupancy Threshold: A single threshold can separate a given day's data into the before and after analysis periods (before heavy/unusual congestion and after heavy/unusual congestion). However, a single measure cannot identify the abrupt changes in occupancy that often accompany non-recurring congestion (i.e., unexpected congestion caused by an accident). Consequently, a dual threshold method able to separate the time periods into different stages by using upper and lower thresholds was tested. A dual absolute occupancy threshold can be used to separate different congestion intervals and at the same time locate abrupt occupancy changes. For example, to investigate the downstream occupancy increases from 20 percent to 25 percent, the upper absolute threshold value, UTh_{AbsOcc}, can be set at 25 percent and the lower absolute threshold value, LTh_{AbsOcc}, can be set at 20 percent.

Before-and-After Scenario Analysis

The time effects of congestion (that is, how traffic conditions change with time) were considered by searching the continuous data records to find lane occupancy statistics that were above or below the threshold values being tested and by calculating the performance measures accordingly. As an example, consider the diversion rate. The diversion rate using three types of thresholds can be defined as follows:

$$\forall\ DR_{abs}(i,j) \xrightarrow{if} \begin{cases} Occ(i) < Th_{AbsOcc} & i = p_j, p_j+1, \ldots p_j+t \\ Occ(i) > Th_{AbsOcc} & i = p_j-t, p_j-t+1, \ldots, p_j-1 \end{cases} \tag{2}$$

$$\forall\ DR_{rel}(i,j) \xrightarrow{if} \begin{cases} Occ(i) - MedianOcc(i) < Th_{RelOcc} & i = p_j, p_j+1, \ldots p_j+t \\ Occ(i) - MedianOcc(i) > Th_{RelOcc} & i = p_j-t, p_j-t+1, \ldots, p_j-1 \end{cases} \tag{3}$$

$$\forall\ DR_{dual}(i,j) \xrightarrow{if} \begin{cases} Occ(i) > UTh_{AbsOcc} & i = p_j, p_j+1, \ldots p_j+t \\ Occ(i) < LTh_{AbsOcc} & i = p_j-t, p_j-t+1, \ldots, p_j-1 \end{cases} \tag{4}$$

where

$Occ(i)$ is the downstream occupancy at the time i and $i = 1, 2, \ldots, 288$

j is the case number and $j = 1, 2, \ldots, n$

n is the total number of cases found

$t = 12$ (that is, 12 5-minute intervals) because a study period of 1 hour before and after the congestion levels have reached the threshold value is desired (with a longer period, *t*, fewer cases, *n*, are likely to be found because the constraints are more strict)

$MedianOcc(i)$ is the median occupancy at time *i*

p_j is the "pivot point" when the downstream occupancy reaches the threshold value.

To make meaningful comparisons, the mean occupancy values for all the cases were calculated for each time interval *i*. That is, the final output was a one-dimensional time-series plot representing the average condition in each scenario. Using the same procedure, other measures—such as ramp occupancy, volume, and occupancy on freeways and arterials—were calculated. The analysis results are discussed in the Findings section.

FINDINGS

Traffic Diversion Analysis

This section discusses the findings of the analysis of how freeway congestion affects diversion rates onto local arterials. As noted above, three different definitions of "unusual congestion" were used. These different approaches all produced reasonably similar results. The results are summarized in a series of graphs. In each graph, one hour of diversion rate[10] is plotted before and after the defined congestion point. The "pivot point" (when x=0) is when the threshold value is initially reached. This allows the impact of the diversion to be visually analyzed and mathematically computed. Graphs are presented for each "threshold value" selected for testing. Along with the diversion rate, each graph plots either the ramp or downstream mainline lane occupancy rates. This allows the changing diversion rates to be compared with the ongoing freeway and ramp conditions. Finally, the correlation between the diversion rate and the plotted occupancy value is provided in terms of the R-squared value for the relationship.

Use of the Absolute Occupancy Threshold

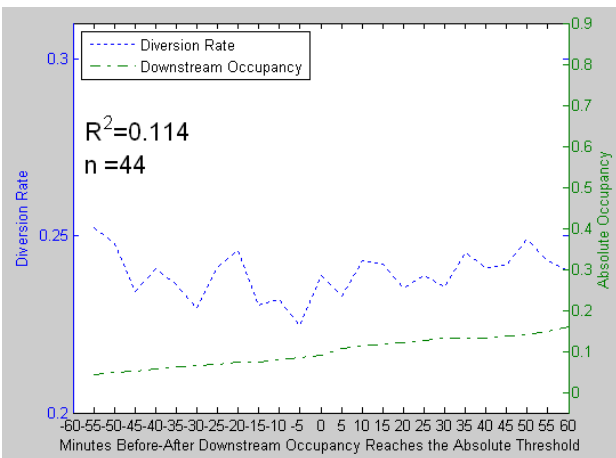
The plots in figures 10 through 14 are based on different absolute downstream occupancy threshold values to indicate unusual congestion. The following are the key features of the plots for the occupancies:

- Th_{AbcOcc} =10 percent: With this low threshold value, the diversion rate was moderately stable both before and after the pivot point, but no trend (or change) in the diversion rate was evident. The before and after diversion rates were not significantly different at a 5 percent significance level (t-test with p-value = 0.1224). However, the ramp occupancy levels were

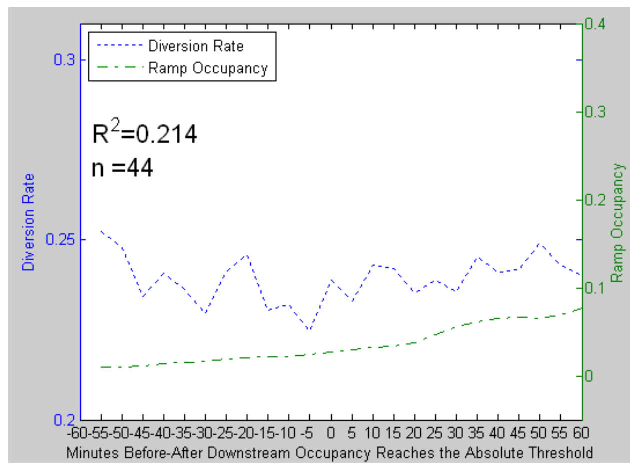
[10] See the definition of "Diversion Rate" in formula (1) in the Analysis Methodology section.

found to increase with the increase of mainline volume. It is not surprising that ramp usage would increase as mainline volume increased.

- Th_{AbcOcc} =20 percent: when the threshold value was raised to 20 percent, a clear separation in diversion rates between "uncongested" and "congested" conditions was observed, with a significant increase in diversion after the 20 percent threshold was reached.
- Th_{AbcOcc} =30 percent: The diversion rate, downstream occupancy and ramp occupancy were *similar* to those in the Th_{AbcOcc} =20 percent scenario.

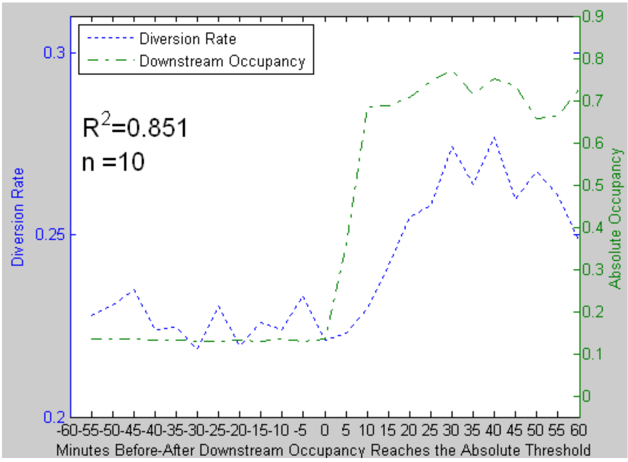


Downstream Occupancy

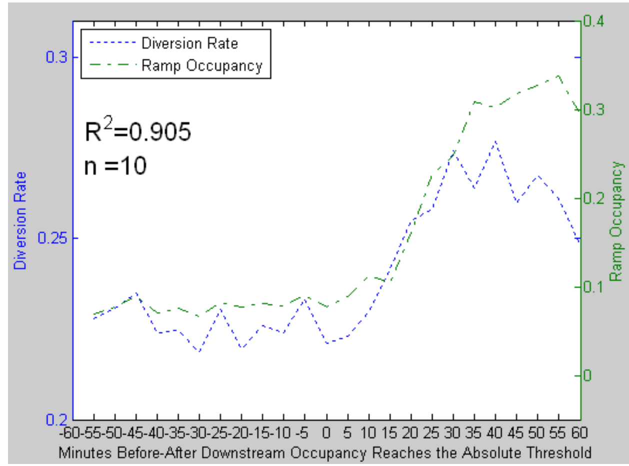


Ramp Occupancy

Figure 10. Diversion Rate at Absolute Occupancy Threshold = 10 Percent

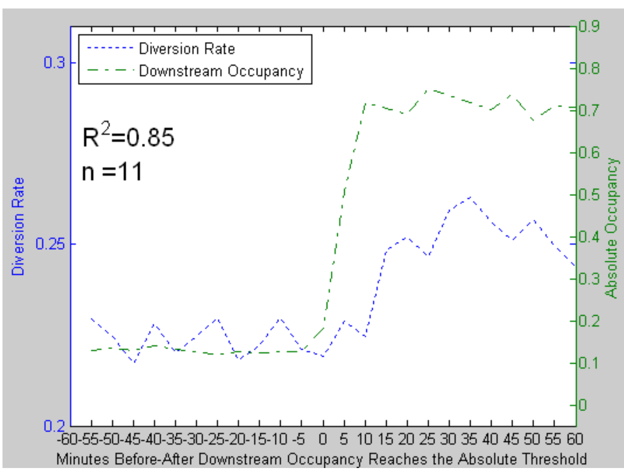


Downstream Occupancy

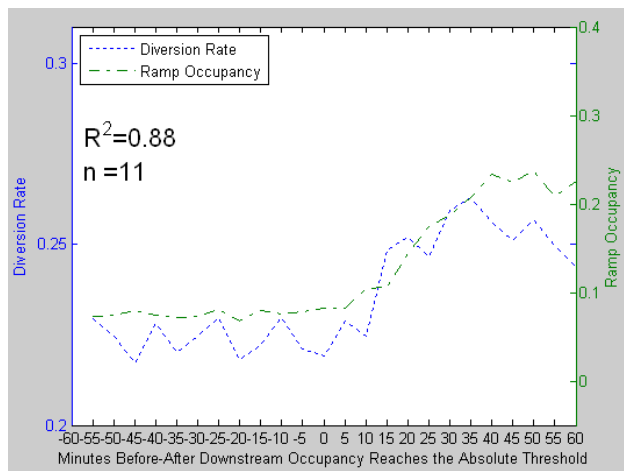


Ramp Occupancy

Figure 11. Diversion Rate at Absolute Occupancy Threshold = 20 Percent

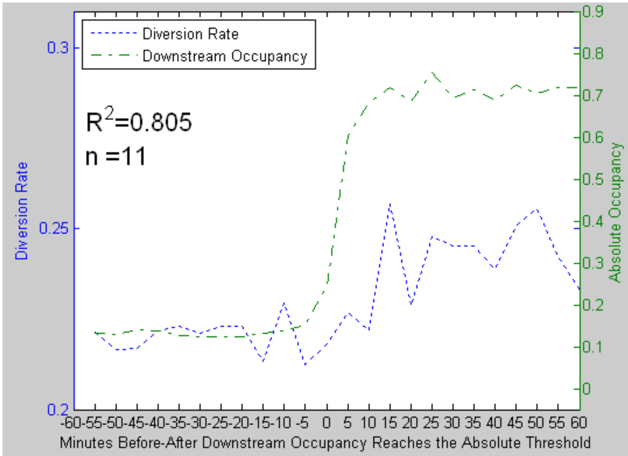


Downstream Occupancy

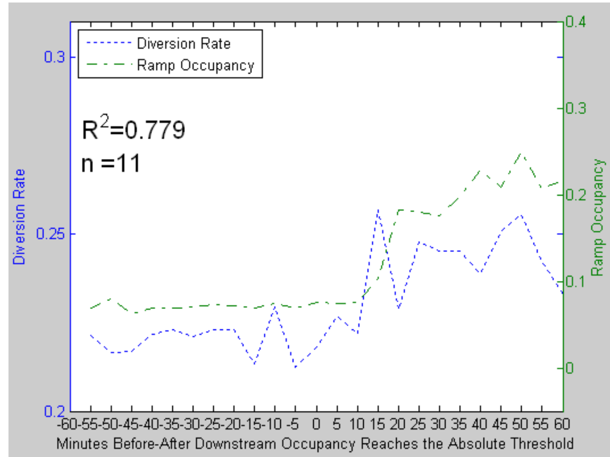


Ramp Occupancy

Figure 12. Diversion Rate at Absolute Occupancy Threshold = 30 Percent

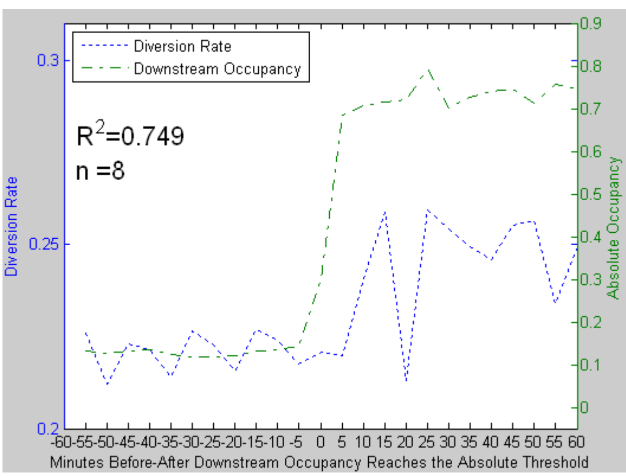


Downstream Occupancy

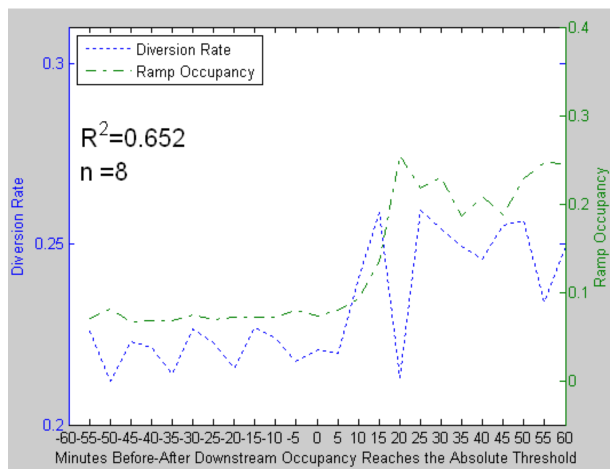


Ramp Occupancy

Figure 13. Diversion Rate at Absolute Occupancy Threshold = 40 Percent



Downstream Occupancy



Ramp Occupancy

Figure 14. Diversion Rate at Absolute Occupancy Threshold = 50 Percent

- Th_{AbcOcc} =40 percent: This threshold value exceeded the 35 percent value used by WSDOT as its definition of “very heavy congestion." In this scenario, after an initial dramatic jump, the diversion rate noticeably decreased 20 minutes after the threshold and remained unstable but higher than that before the start of congestion.

- Th_{AbcOcc} =50 percent: In this highly congested scenario, the diversion rate rose rapidly 15 minutes after the pivot point Ramp occupancy levels also increased steeply at that time. The ramp occupancy changes were more dramatic than those in the earlier scenarios. But in the next 5-minute period (at 20 minutes) the diversion rate dropped sharply by 4 percent (from 26 to 22 percent) and then rebounded 5 minutes later. This unusual result may have been a result of the backup formed on the ramp. Meanwhile, ramp volumes (not shown on the graph) stopped increasing and dropped 16 percent (from 74 to 62 vehicles in 5 minutes). The cause of this could have been that the size of the ramp queues discouraged travelers on the mainline from diverting.

Overall, as can be seen in the graphs, downstream occupancy was fairly stable during the before period and, for all but the lowest threshold level, rose significantly after the mainline occupancy value reached the threshold. As Th_{AbcOcc} was set higher (meaning that the mainline congestion was more substantial), the diversion rate became relatively unstable but still significantly higher than would be expected with lower levels of mainline congestion. The researchers believe that this lack of stability likely resulted from the fact that, as the ramp became more congested, travelers saw the growing ramp queues and became less willing to divert onto the arterial because the ramp queue gave them the perception that the arterial was likely to be as badly congested as the freeway. Without better arterial information, they had no information other than the size of the ramp queues by which to judge the performance of the arterials. In our analysis, as Th_{AbcOcc} became greater, the diversion rate became increasingly unstable. This could have been caused by changes in the visible ramp queue length, given the signal phasing at the intersection at the ramp terminal—and the perception that those changing ramp queues gave to motorists who were are considering diversion to the arterial. (That is, after a green light at the ramp terminal, the ramp queue would have shortened considerably, causing vehicles arriving at the ramp to observe a small queue and divert. However, once the signal changed to red, the ramp queue would have grown quickly, and that longer queue would have once again given the impression that the arterial was also congested, depressing the diversion rate. The result would have been a fluctuation in both diversion rates and ramp occupancy levels.)

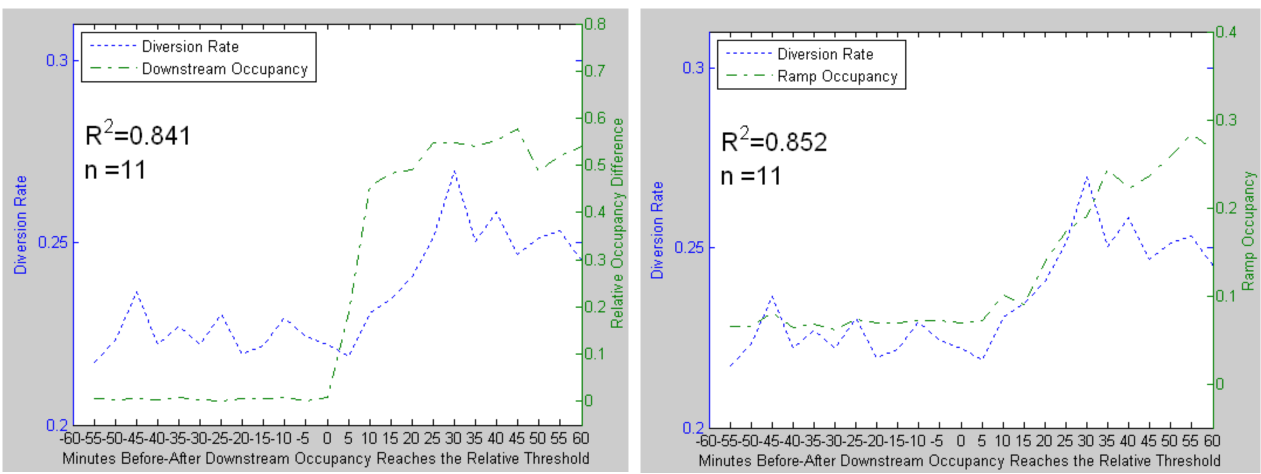
As indicated by the correlation coefficients in figures 10 through 14, diversion rate and ramp occupancy had a fairly high correlation with downstream occupancy, except when the downstream occupancy was low.

Use of the Relative Occupancy Threshold

The relative occupancy threshold scenarios show how travelers react to traffic congestion that is higher than expected. It is particularly good at showing how diversion rates change when mainline congestion levels change significantly from their "normal" condition. The results are shown in figures 15 through 18. The following are the key observations from the plots for the different tested downstream occupancy threshold values:

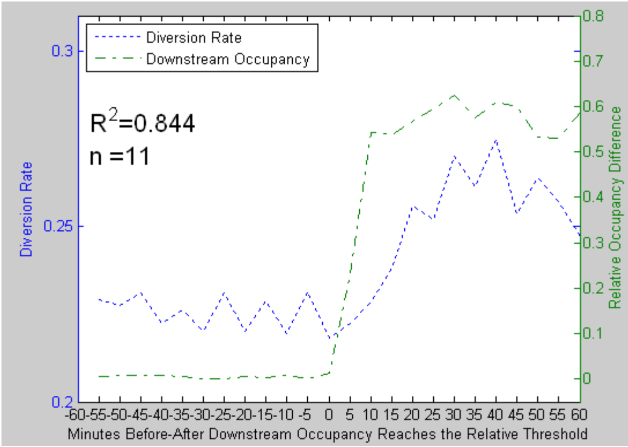
- Th_{RelOcc} =5 percent: This scenario showed that the diversion rates were correlated with changes in downstream occupancy rates. No diversion trend existed before the pivot point, but the diversion rate increased after the mainline occupancy value climbed above normal levels. However, this increase did not exceed the pre-threshold mean value until roughly 15 minutes after the threshold had been met.

- Th_{RelOcc} =10 percent: At this threshold, which represents higher levels of unusual traffic congestion, travelers started to divert slightly more quickly. The ramp occupancy and diversion rates both increased after the pivot point. While diversion rates stayed high after congestion occurred, these increased diversion rates became unstable after about 20 minutes, as was found at higher rates in the absolute occupancy cases described earlier.

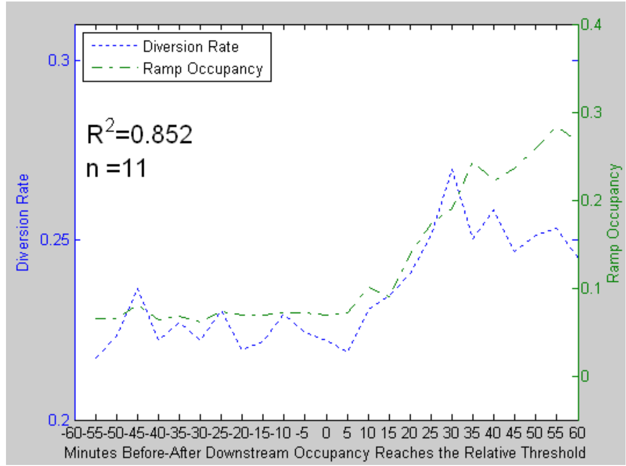


Downstream Occupancy Ramp Occupancy

Figure 15. Diversion Rate for Relative Occupancy Threshold = 5 Percent

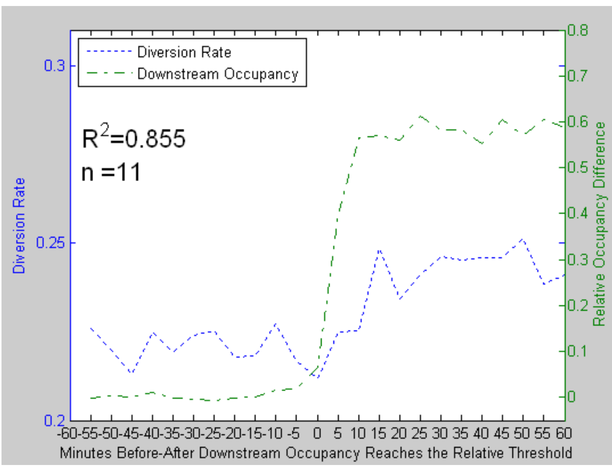


Downstream Occupancy

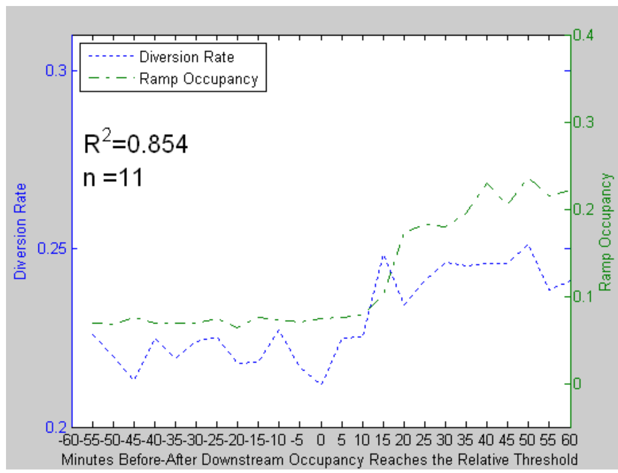


Ramp Occupancy

Figure 16: Diversion Rate for Relative Occupancy Threshold = 10 Percent

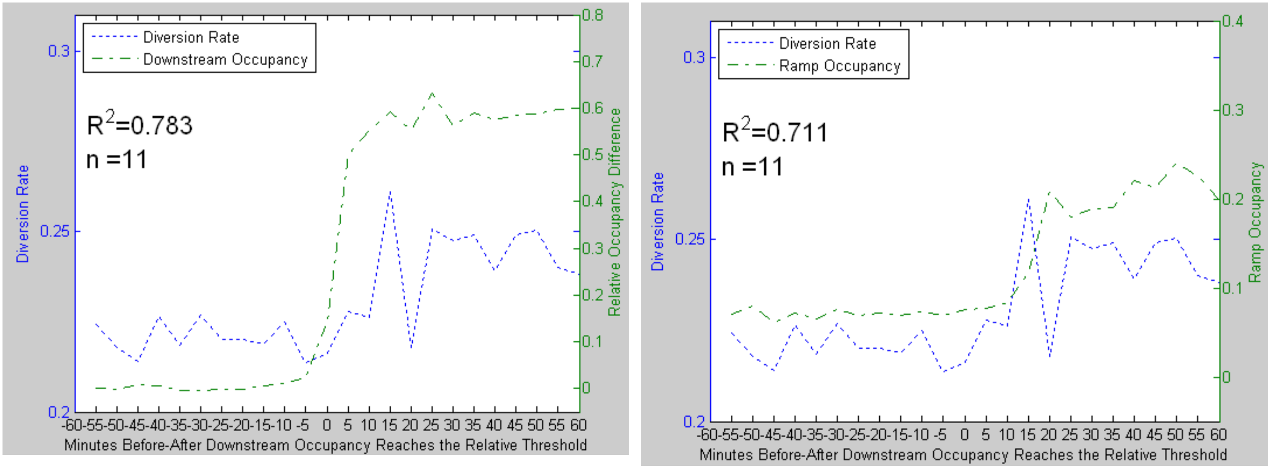


Downstream Occupancy



Ramp Occupancy

Figure 17. Diversion Rate for Relative Occupancy Threshold = 20 Percent



Downstream Occupancy Ramp Occupancy

Figure 18. Diversion Rate for Relative Occupancy Threshold = 30 Percent

- Th_{RelOcc} =20 percent: Surprisingly, while the diversion rate increased more quickly than at the lower threshold values, the maximum diversion rate and ramp occupancy levels during that increased diversion were lower in this scenario than the rates seen in the 5 and 10 percent scenarios.
- Th_{RelOcc} =30 percent: This test is an example of the effects of a severe increase over normal congestion. In this scenario, both the downstream and ramp occupancies increased dramatically in the 15th minute after the threshold had been reached. However, the diversion rate abruptly decreased 5 minutes later, followed in the next time period by a smaller decline in ramp occupancy levels. The diversion rates then jumped back up again and stayed moderately high through the rest of the monitoring period. This unusual pattern was also observed in the Th_{RelOcc} =50 percent scenario (not pictured). The cause of this may have been that the ramp was becoming congested (the ramp occupancy continued to increase even as

the diversion rate declined) because the ramp terminal and adjacent arterial reached capacity, and queues started forming, discouraging diversion.

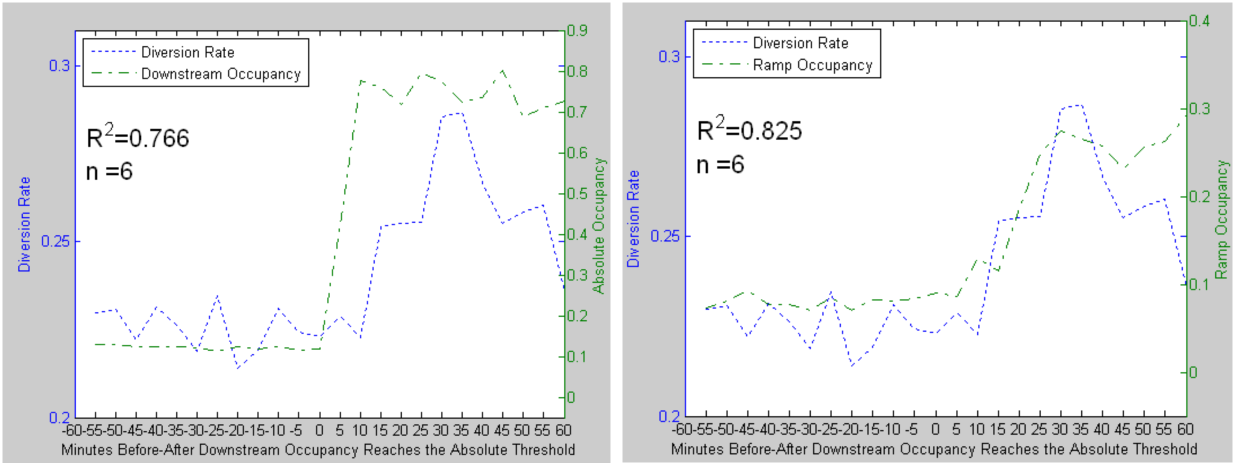
In general, for the relative occupancy threshold methodology, the diversion rate increased 10 to 15 minutes after unusual congestion formed, but this increased level of diversion decreased after 20 to 30 minutes while ramp occupancy levels continued to slowly increase after an initial jump in occupancy. (That is, while diversion was still increasing overall, the amount of extra diverting traffic decreased, while congestion on the ramps continued to slowly increase.) As with the absolute occupancy tests, the larger relative occupancy threshold scenarios showed fairly unstable—but still increased—levels of mainline diversion. For example, in the scenario in which 30 percent lane occupancy values were used as the congestion threshold to suggest a very bad congestion period, 10 to 20 minutes after the threshold had been reached, ramp occupancy percentages increased by 9 percent (from 0.12 to 0.21), but during the 15- to 20-minute interval, the diversion rate dropped by 5 percent (from 0.26 to 0.21).

Interestingly, when the relative occupancy was higher than 20 percent, travelers seemed less interested in diverting than at lower levels of unexpected congestion. This was seen in the overall diversion and ramp occupancy rates in the 20 percent and 30 percent scenarios, which were lower than those of the 5 and 10 percent relative occupancy threshold scenarios. In other words, the greater that the difference in occupancy is from “normal,” the smaller the number of people who chose to divert. This could be because local travelers may not expect their travel time to improve if they divert, given their experience. The arterial performance analysis presented later in this section indicates that considerable congestion occurs near the ramp interchanges when diversion is high. This would tend to discourage diversion—especially when ramp queues were already long—as the queues would suggest to drivers that considerable signal delay could be expected if they diverted.

As indicated by the correlation coefficients in figures 16 through 18, the downstream occupancy had a fairly high correlation with ramp occupancy and the diversion rate. As in the absolute-threshold scenario, when downstream traffic was highly congested, the unstable diversion would result in a relatively smaller correlation with ramp occupancy and downstream occupancy.

Use of the Dual Absolute Occupancy Threshold

Figure 19 shows an example of how an abrupt change in congestion affects diversion by identifying those periods with use of the dual threshold method. After the downstream occupancy rose rapidly from 20 percent to 30 percent within the first 5 minutes, the diversion rate and ramp occupancy increased concurrently for the following 10 minutes. The diversion rate then started declining, but the ramp occupancy still climbed. Again, we speculate that this was because the ramp started to get congested because of limited ability for the intersections and arterials near the ramps to accommodate the diverting vehicles; and travelers considering diversion then rethought that decision because the visual clues they received from the congested ramp suggested that the arterial might not reduce their travel time. These results were similar to the highly congested cases from the two previous methods.



Downstream Occupancy Ramp Occupancy

Figure 19. Diversion Rate for Dual Absolute Occupancy Threshold
UTh_{AbsOcc} = 30 percent and LTh_{AbsOcc} = 20 percent.

This analysis also found that mainline occupancy values did not always increase rapidly when the freeway downstream traffic was light, even when an incident had occurred. That is, the fact that an incident or crash occurred downstream of our detection point did not always equal a significant change in congestion, especially when traffic was light. Consequently, we found few cases in which the dual absolute occupancy threshold of 5 percent occurred when the starting occupancy levels were low—below 15 percent. The best cases for this study's dual occupancy test were found where the initial lane occupancy (LTh_{AbsOcc}) was set at 20 percent and the new (more congested) occupancy level (UTh_{AbsOcc}) was set at 30 percent. Even at these levels, only six cases were discovered. These results are presented in Figure 19.

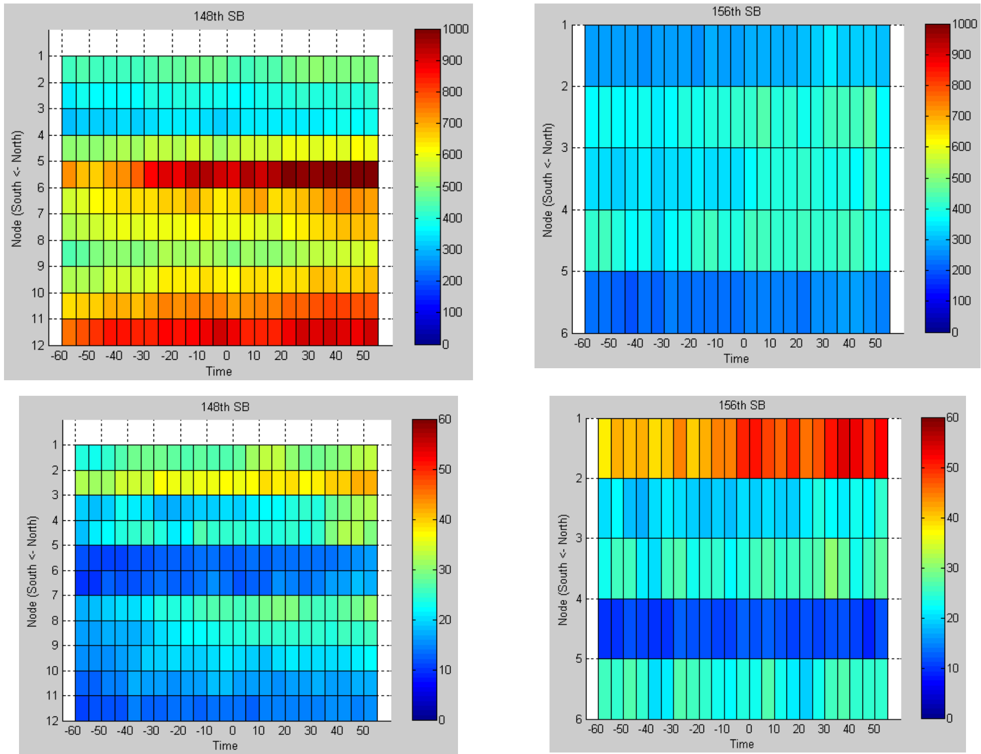
The Effects of Diversion on Arterial Performance

The results from the analysis of diversion rates when the mainline became congested showed that the number of cars exiting to the parallel ramps increased statistically significantly when the mainline became congested. The increases in ramp occupancy levels in those analyses also indicated that congestion grew on the ramps because of limitations in the capacity of the ramp terminal intersections. Part of these limitations were due to the signal timing of those ramps, and part may very well have been due to congestion on the arterial.

This section of the report describes how the performance of the arterials that lead south through Bellevue from the study area changed during the periods when diversion increased. These arterials are the primary diversion route for travelers headed to I-90.

Figures 20 through 24 illustrate several examples of the diversion impacts on the local streets (156th Ave NE and 148th Ave NE) given the freeway scenarios described above and the different threshold identification methods. Each figure illustrates southbound arterial traffic volumes and mid-block lane occupancies at consecutive intersections, moving from north to south as one moves down the page in the Y-axis. The X-axis, corresponding to the X-axis on figures 10 through 19, starts 60 minutes before the time point when the threshold value (pivot point) had been reached and continues until 60 minutes after the threshold had been reached. The colors of the cells represent the different levels of volume or occupancy present during that period. The legend for the color coding is on the right side of each figure.

The first roadway link (the upper most cell) of each study arterial is north of NE 24th St. On 148th Ave NE, this is the first intersection south of the ramp terminal that is the focus of the diversion analysis. 156th Ave NE does not connect directly to that freeway ramp, but it does capture diversion traffic from the Microsoft campus that avoids the freeway completely (as a result of advance notice from TrafficGauge or another



Volume

Occupancy

148th Ave NE

156th Ave NE

Figure 20: Arterial Performance at Absolute Occupancy Threshold = 20 Percent

traveler information service). In addition, traffic trying to avoid congestion on 148th Ave NE also diverts to 156th Ave NE, often turning left from 148th Ave NE onto NE 24th St, and then right on 156th Ave NE.

Because the study of both these arterials started at NE 24th St., they had the same approximate length, but 148th Ave NE had 12 points at which data were collected, whereas 156th Ave NE had only six data collection points. As can be seen in the following graphs, the northern-most intersections were a primary source of congestion on the corridors. The congestion at these intersections supports the previous conclusions that when significant diversion occurs, the intersections closest to the ramp terminals often become more congested, resulting in visual cues that influence whether drivers choose to divert or not divert from the freeway.

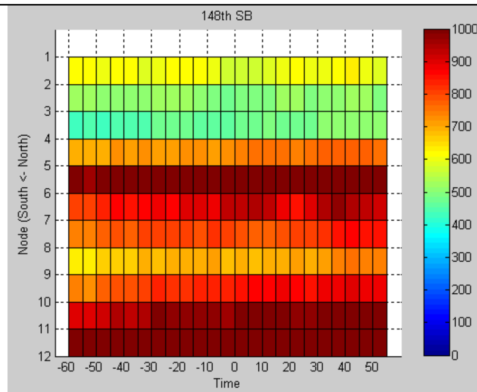
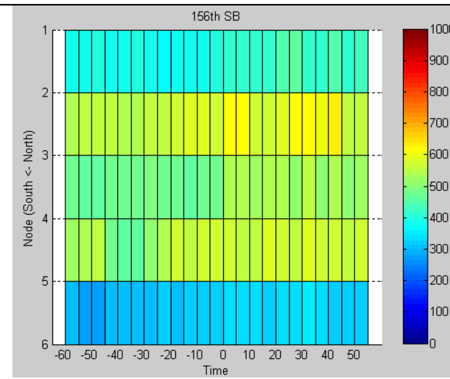
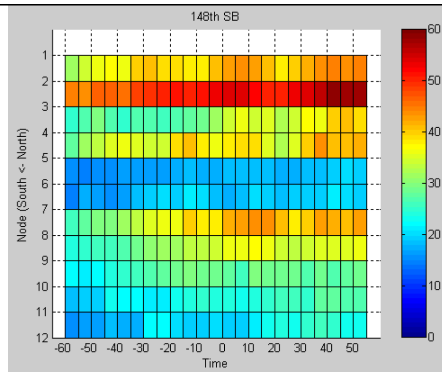
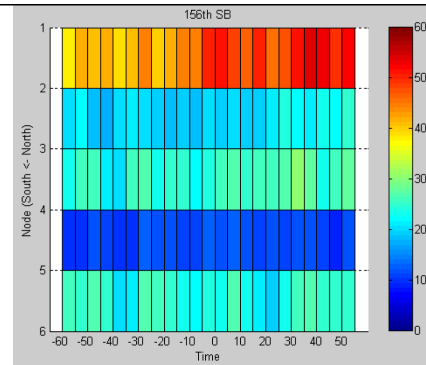
Volume		
Occupancy		
	148th Ave NE	**156th Ave NE**

Figure 21: Arterial Performance at Absolute Occupancy Threshold = 40 Percent

As travelers move south on 148th Ave NE, volumes tend to briefly decline after the first set of intersections. They then increase again approaching the NE 8th St intersection, decline again, and finally rise once again approaching the I-90 interchange. Lane occupancies generally decrease near NE 8th St, increase afterward, and then decrease again approaching I-90. This is in part due to the effects of signal timing plans that attempt to limit delays to the heaviest traffic volume movements.

On 156th Ave NE, volumes tend to rise in the middle sections of the corridor, in large part because of a large neighborhood shopping center (Crossroads), while occupancy levels fluctuate considerably because of daily changes in roadway congestion.

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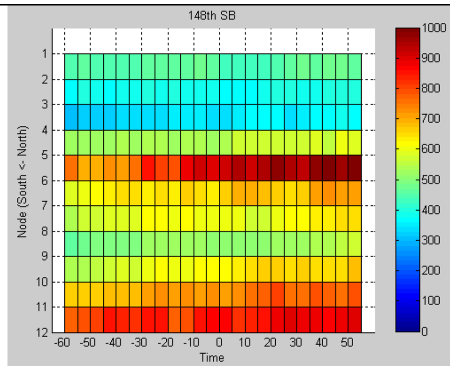
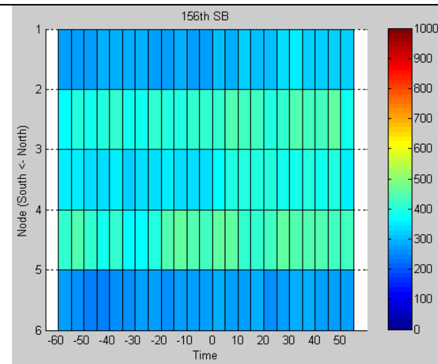
<tr><td>Volume</td><td>
</td><td>
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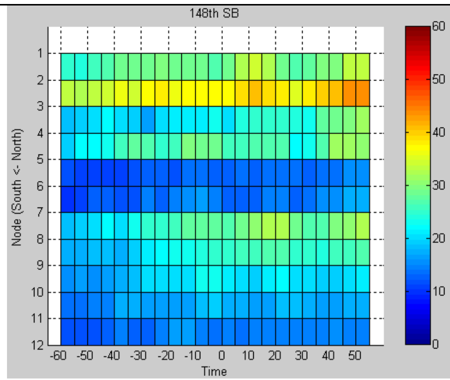
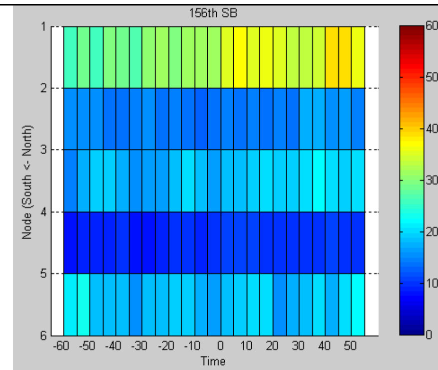
<tr><td>Occupancy</td><td>
</td><td>
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<tr><td></td><td>148th Ave NE</td><td>156th Ave NE</td></tr>
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Figure 22: Arterial Performance at Relative Occupancy Threshold = 5 Percent

Effects of Diversion Using the Absolute Occupancy Threshold Methodology

This section examines the effects of freeway diversion on arterial performance when absolute measures of lane occupancy are used to estimate whether conditions are sufficiently bad to encourage diversion.

Not surprisingly, when the freeway downstream occupancy value was low (Th_{AbcOcc} =10 percent), local arterials had lower volume and lower occupancy. However, as shown in Figure 20 (when Th_{AbcOcc} rose to 20 percent) and Figure 21 (when Th_{AbcOcc} equals 40 percent), the arterials showed definite increases in traffic volume and congestion when congestion formed on the freeways. In both of these figures, volume

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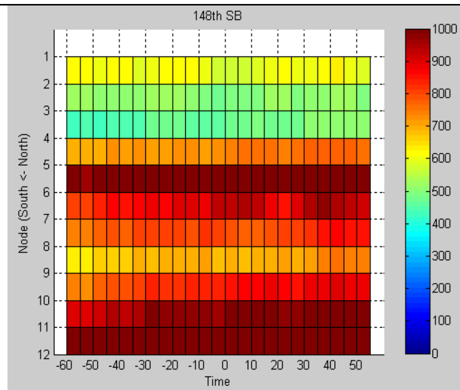
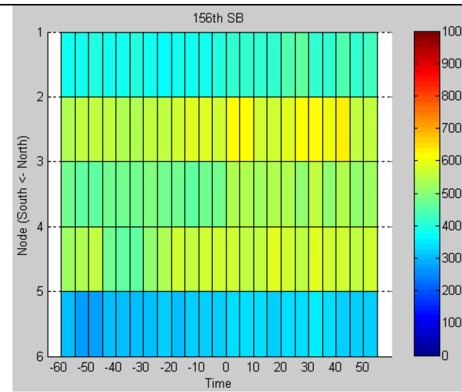
<tr><td>Volume</td><td>
</td><td>
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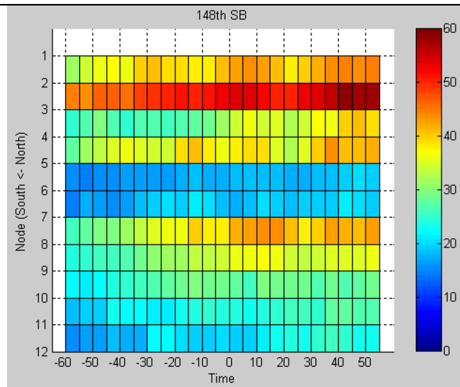
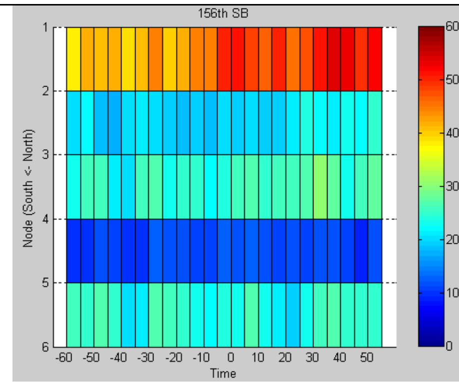
<tr><td>Occupancy</td><td>
</td><td>
</td></tr>
<tr><td></td><td>148th Ave NE</td><td>156th Ave NE</td></tr>
</table>

Figure 23: Arterial Performance at Absolute Occupancy Threshold = 30 Percent

and occupancy can be seen to grow (the colors in the figure shift from dark blue to brown) as time on the X-axis moves from the center of the graphic—when congestion on the freeway begins—to the right side of the graph).

Changes in volume and occupancy varied from location to location within each corridor. The most significant of the changes often took place in the first roadway segments. For example, on 148th Ave NE when freeway congestion was not significant (Th_{AbcOcc} equals 20 percent, as shown in Figure 20), the first four intersections showed the most significant increase in both traffic volume and congestion. Over the entire hour following the pivot point, the first link showed a modest 6 percent volume increase (from

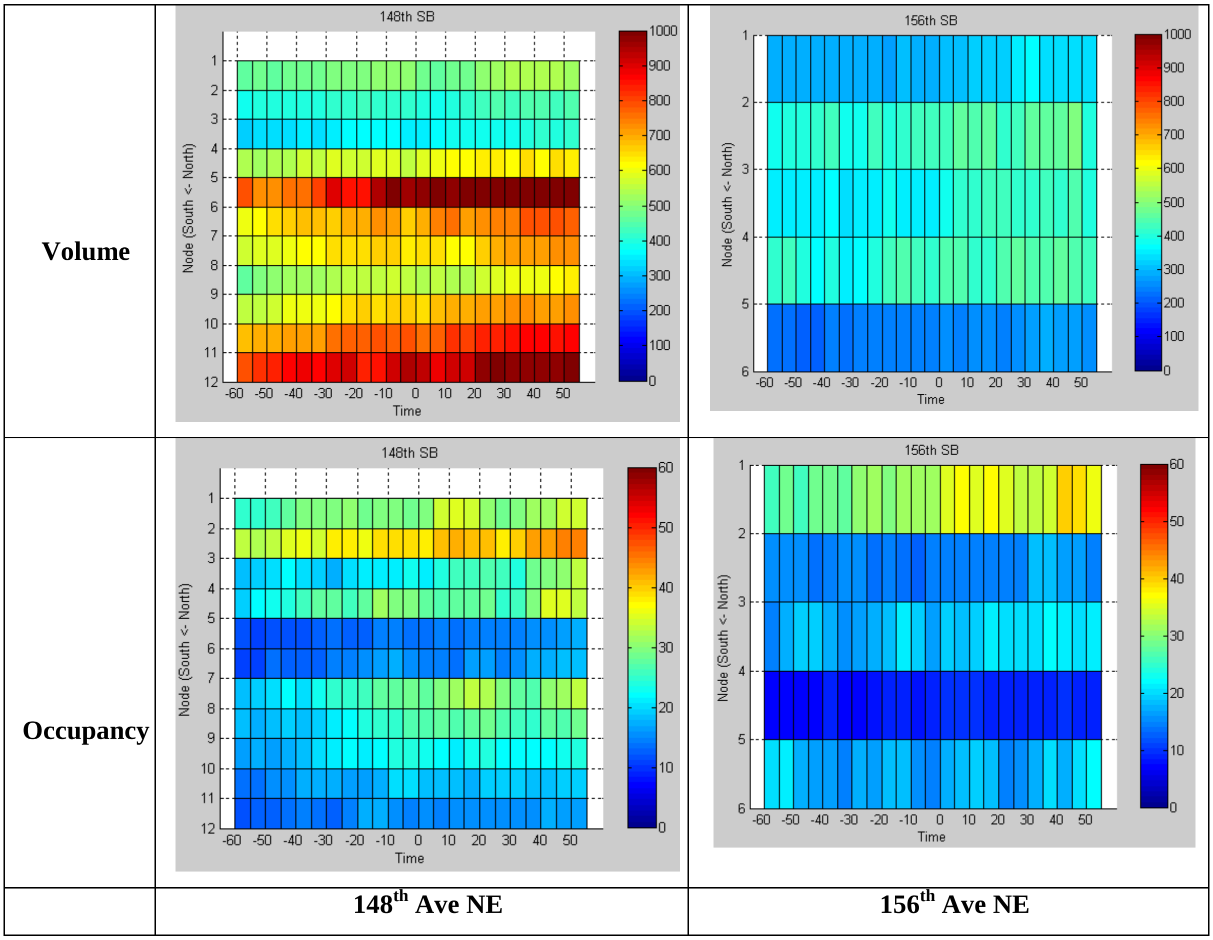


Figure 24. Arterial Performance for Dual Absolute Occupancy Threshold at UTh_{AbsOcc} = 30 percent and LTh_{AbsOcc} = 20 percent

460 veh/hr to 488 veh/hr). The third link showed the greatest percentage volume increase in the corridor, averaging 12 percent higher for that hour, with a maximum increase of 17 percent (41 vehicles) moving southbound. The greatest change occurred in the last 30 minutes of the study period. The southern-most sections were least impacted, averaging less than a 10 percent volume increase. Congestion levels changed similarly, with lane occupancy on the northern links increasing from 3 to 8 percent (for example, from 24.5 to 28.5 percent lane occupancy), while occupancy on the southern links changed less than 2 percent.

If just the first four links are examined, it can be seen that volume increased 10 to 15 minutes after the pivot point (this corresponds well with the timing of the increase in diversion from the freeway shown in Figure 11). Volumes then fluctuated around that new, higher value (between 20 and 60 additional vehicles per hour.). This fluctuation was likely a function of the amount of green time the traffic signals allocated to the southbound direction during each 5-minute reporting period.[11] Meanwhile, lane occupancies initially dropped just after the pivot point and then climbed fairly steadily afterward, again, allowing for some fluctuation between periods to reflect the effects of signalization.

The 156th Ave NE arterial was less affected than 148th Ave NE under the 20 percent Th_{AbcOcc} conditions, with no consistent change in volume or lane occupancy for most of the monitored locations following the pivot point. However, 30 minutes after the pivot point, additional volume (roughly 15 vehicles per hour) appeared at the first southbound intersection, with a resulting slight increase in lane occupancy. Volume and occupancy changes were slightly lower on the more southern links of the arterial.

Under the more highly congested freeway scenario (represented by Th_{AbcOcc} = 40 percent), similar diversion patterns occurred (see Figure 21); however, these changes took place within a context of higher arterial traffic volumes.[12] The result is that similar levels of diversion in terms of vehicle volume resulted in somewhat lower percentage

[11] If a signal cycle is 120 seconds, two and one half cycles occur in each 5-minute period. If half the time, the signal is green in the southbound direction, the result is that on one 5-minute reporting period, three green phases will be present – 180 total seconds of green time. During the next 5-minute reporting period, only two green phases will be present, and thus only 120 seconds of southbound green time. The result is an artificial fluctuation in volume being measured, simply because of the interaction of the signal timing plan and the fixed time recording/reporting of volume data.

[12] The use of the Absolute Occupancy threshold means that this approach may identify congestion that builds gradually, such as in a peak period. Thus, many drivers may already expect congestion and select the arterials. So background arterial volumes may be higher than "normal" when high absolute occupancy threshold values are used.

changes in volume and lane occupancy. In addition, on NE 148th, the northern links on the arterial appeared to reach a maximum level of flow and congestion 30 minutes after the pivot point. Once that maximum throughput and congestion had been reached, conditions stayed reasonably steady, with volumes and lane occupancies fluctuating around new, higher levels.

The most significant increase in congestion occurred at the third link from the north. The lane occupancy of this link increased just under 5 percent for the 1-hour period, with the greatest congestion occurring in the last 30 minutes of the monitored period. During that period, lane occupancy rose to just over 40 percent lane occupancy.

In the central sections of 148th Ave NE for this case, traffic volumes actually declined very slightly during this scenario, while lane occupancy grew 12 percent. Our interpretation of these data is that signal timing at the intersections near the freeway (NE 24,th NE 20,th and Bel-Red Road) limit the amount of traffic that can move southbound. At higher levels of volume (present on the arterial before the freeway congestion condition has been met at the pivot point), the changes in background traffic volume obscure the effects of the diverting traffic that can get through the northern intersections.

Congestion on 156th Ave NE was significant but not as bad as on 148th Ave NE. As with the 20 percent threshold value, traffic increases did not occur on this arterial until roughly 30 minutes after the pivot point. Unlike the 20 percent threshold, for this higher threshold, traffic volumes increased across all three of the first three monitored links on the arterial. However, as with 148th Ave NE, this increase in volume quickly flattened out along with a higher lane occupancy value—suggesting that the roadway had reached the highest level of southbound traffic volume that the signal timing allowed, given background traffic levels.

In both the of these study examples, the traffic volume increase on 156th Ave NE was higher in the middle segment of the arterial than at either the northern or southern ends. The volume increases then declined slightly in size before the intersection of 156th Ave with I-90 at the southern end of the corridor.

Without origin/destination information, it is not possible to determine how much of these trends were due to diversion and how much were due to other travel trends that occurred in the background of the study. What is clear is that, particularly on the northern end of the 148th Ave NE corridor, changes in both volume and lane occupancy started roughly 10 minutes after the pivot point (time = 0).

Effects of Diversion, Relative Occupancy Threshold Methodology

Figures 22 and 23 show the example results of a modest (Th_{RelOcc} = 5 percent) or significant (Th_{RelOcc} = 30 percent) change in relative lane occupancy on the freeway. The resulting arterial performance graphs are very similar to what can be seen in figures 20 and 21. When freeway traffic on SR 520 was slightly more congested than the "usual" condition (a sustained 5 percent increase in occupancy), traffic started to divert to 148th Ave NE starting about 10 minutes after the pivot point (see Figure 22). That modest volume surge leveled off after 20 minutes to around 30 vehicles per hour and stayed at that higher level for the rest of the monitored period. These modest increases in traffic volume appeared in the volumes that approached the next group of intersections to the south, beginning about 20 minutes after the pivot point. Traffic volume increases observed on 148th Ave NE were larger in the central portion of the corridor, indicating that additional vehicles reached the central portion of the corridor from other approaches besides southbound from the SR 520 interchange. That is, the background traffic levels were changing at the same time that traffic was diverting from SR 520.

Lane occupancy values on 148th Ave NE follow patterns similar to the traffic volumes. Lane occupancy (congestion) increased immediately after the pivot point, then declined, and then increased steadily beginning 15 to 20 minutes after the pivot point. Lane occupancy values then flattened out about 45 minutes after the pivot point. This suggests that intersections reached saturation levels after sustained increases in traffic volume occurred.

On the other hand, 156th Ave NE showed no increase in traffic or lane occupancy on any of its first three links until 30 minutes after the pivot point. At that time, volume and occupancy both increased markedly before quickly leveling off at new higher rates. However, these changes, while dramatic in percentage terms, were still reasonably small in absolute terms. The traffic volume increase was only about 20 vehicles per hour. Lane occupancy increased roughly 4 to 5 percentage points (from 33 to 38 percent) on the first link and from 14 to 18 percent on the second link to the south. This suggests that the first link on the corridor was acting as a bottleneck, limiting diverting cars from more quickly reaching the southern portion of the arterial.

In the more significant diversion causing situation, in which a very large change in operating condition occurred on the freeway (Th_{RelOcc} =30 percent—see Figure 23), the traffic patterns on 148th Ave NE showed some significant differences in comparison to the Th_{RelOcc} = 5 percent conditions shown in Figure 22, while the effects of diversion on 156th Ave NE looked remarkably similar for both cases.

On 148th Ave NE, traffic volumes at the first roadway segment increased more quickly than in the 5 percent condition. In the 30 percent case, volumes increased only 5 minutes after the congestion threshold had been reached. After the initial increase, the measured traffic volume increase fluctuated around 40 additional vehicles per hour. Similar patterns were observed on the second and third segments of the arterial, except that unlike the first segment, both of these segments initially experienced a small decrease in traffic volume, followed by an increase in volume similar in size to the first link. This increase occurred 15 minutes after the freeway congestion appeared, rather than 5 minutes after the pivot point. Traffic volumes on segments two and three then fluctuated around this increased traffic volume. This delay makes sense, given the time the diversion rate from the freeway took to increase (see Figure 18) and the time diverting vehicles took to reach these intersections.

Meanwhile, lane occupancies on all four of the northernmost arterial segments initially increased 10 percent from their pre-pivot point levels. This value then slowly grew to between 15 and 25 percent. These increases in lane occupancy leveled off about 30 minutes after the pivot point. This suggests that the arterial had reached saturation, given the deployed signal timing plan run by the traffic signal network.

South of the fourth segment on 148th Ave NE, the general congestion level again decreased in comparison to what was found in the first four segments, only to spike briefly on the sixth segment, before declining again before the I-90 interchange at the southern end of the corridor. As motorist traveled southward on 148th Ave, volumes again increased, but congestion decreased, and relatively little change in either volume or congestion levels can be traced to diversion from SR 520.

156th Ave NE is further removed from the freeway and has a lower base level of congestion. These differences are once again reflected in how this road was affected by traffic diversion from SR 520. Once again on this road, none of the monitored roadway segments showed an increase in traffic volume or congestion until 30 minutes after the freeway congestion occurred. Then traffic volume spiked, representing the arrival of diverting vehicles, with the largest increase in traffic occurring on the first segment of the corridor. After 10 minutes of high traffic volume increases, traffic volumes declined, although they stayed above previous levels.

Lane occupancy values also remained low for the first 30 minutes. They then spiked dramatically but quickly leveled off 5 to 15 percentage points higher than before the pivot point occurred.

As with the two scenarios based on absolute occupancy levels, under high congestion conditions, the northern intersections on 148th Ave NE appeared to act as a bottleneck for the corridor. This limited the number of vehicles moving southbound but kept the intersections in the middle of the corridor operating at unsaturated levels. On 156th Ave NE, the northern intersections appeared to act less as a bottleneck, allowing for both increases in volume and congestion in the middle of the corridor.

Effects of Diversion, the Dual Absolute Occupancy Threshold

Figure 24 illustrates how the study arterials reacted to traffic diverting from the freeway when major changes suddenly occurred in the level of congestion observed on that freeway. In this case, lane occupancy jumped from 20 percent to 30 percent (LTh_{AbsOcc} = 20 percent, UTh_{AbsOcc} = 30 percent). This captures cases where modest congestion quickly becomes heavy congestion, causing individuals to divert.

For this scenario, as in the other scenarios, the increase in traffic at the northernmost intersection on 148th Ave NE started 10 minutes after the pivot point had been reached on the freeway. Volumes on the second and third links on the corridor then increased shortly thereafter. What is significant about this scenario is that the changes in volume observed on 148th Ave NE were the largest measured in all of the examples discussed in this section. Sustained volume growth of over 40 vehicles per hour occurred in the first link for most of the hour following the pivot point. While some fluctuation in the traffic volume growth occurred during the hour following the pivot point, that fluctuation was smaller in magnitude than in the other scenarios examined. Substantial increases in traffic volume occurred throughout the corridor, suggesting that much of the increase was traffic diversion traveling the length of the corridor.

Interestingly, while volume increased, lane occupancy actually decreased on the first three links on the corridor for 15 to 20 minutes before rebounding and moving well above the starting value.

On 156th Ave NE, no change in corridor volume or lane occupancy was observed on the first link of the corridor for 50 minutes. At that point, the largest change in traffic volume measured on that link occurred. Interestingly, the third link in the corridor showed a significant increase in traffic volume 30 minutes after the pivot point—much as was seen in almost all of the earlier cases. In this case, this volume increase must have come from neighboring land uses, as it can not be attributed to southbound traffic on 148th Ave NE.

We interpret these data as indicating that a sudden change in traffic conditions on SR 520 caused diversion to quickly occur to the 148th Ave ramps. However, the majority of 156th Ave diversion was composed of travelers coming from the Microsoft campus area who had decided not to enter the freeway at all, whereas many of those on 148th had entered the freeway, observed the congestion, and then chosen to exit at 148th. The individuals using 156th Ave NE were probably using sources of information other than direct visual clues to inform their route choice. In this scenario, because the change in freeway performance was both dramatic and sudden, it took longer for these individuals to learn of the freeway conditions and change behavior. At that point, the congestion on SR 520 was severe, and therefore a larger than normal group made the diversion decision.

Summary of Arterial Performance Analysis During Diversion

This study effort confirmed that modest numbers of travelers do seek alternative routes when freeway performance suffers from higher than expected levels of congestion, even when no information is available to describe the performance of those arterials. As the freeway traffic becomes more congested, the diversion rate increases. However, the diversion rate is still modest relative to the freeway volume. (The maximum sustained diversion related increase in traffic volume on 148th Ave NE was 40 vehicles per hour, less than 2 percent of a freeway lane's capacity.)

Under high levels of congestion, the diversion rate becomes unstable. It is unclear how much of this instability is caused by congestion at the ramp terminals, how much is caused by variation in traffic flow caused by the vagaries of the implemented signal timing plan, and how much is a function of variations in when and where diversion occurs as a result of traveler information.

These results do show that when the diversion rates are high, the intersections at the end of the ramp, combined with the arterial sections connecting to those intersections, become more congested. This appears to act like a bottleneck, limiting the number of vehicles that can move quickly down the arterials being used as diversion routes.

These bottlenecks also appear to generate long queues on the freeway exit ramps, which provide visual clues that discourage travelers from taking the arterial exits that serve the primary diversion routes. It is not clear from our available data whether this theory is accurate. Another potential answer is that available traveler information resources (e.g., radio reports, Web sites) have given potential diverters advance notice of the freeway congestion, removing them from the freeway before they reach the monitored diversion point.

The good news about the limited amount of diversion that occurs outside of intersections near the ramp terminals is that, in our case study, the diversion traffic does not have a significant impact on the performance of the majority of the corridor. Diversion does have a measurable impact on the intersections near the freeway, but those impacts appear to fade as the diverting traffic moves away from the intersections near the freeway ramps.

This could be because the diverting vehicles are not attempting to reach I-90 as theorized and disperse to other local streets on the way south. It could also simply be that the initial set of intersections creates a bottleneck that prohibits enough cars from reaching the more remote arterial segments.

When the two study arterials are compared, 156th Ave NE has more spare capacity than 148th Ave NE when the freeway is suffering from moderate congestion (e.g., Th_{AbcOcc} =20 percent). However, neither of the arterials has sufficient "reserve capacity" to absorb even a third of a lane of freeway. Therefore, substantial freeway diversion would overwhelm these arterials, even if signal timing could be adjusted to maximize arterial throughput in the direction desired by freeway users. This can be seen by the different levels of arterial performance under light and heavy freeway congestion. In all cases when the freeway was substantially congested, at least two segments on 148th Ave NE appeared to be operating near capacity.

CONCLUSIONS FOR DIVERSION ANALYSIS

The analysis indicated that even without good, real-time arterial performance information, some travelers seek alternative routes when the freeway becomes more congested. The willingness to divert is a function of how well motorists know the alternative routes (or how obvious those routes are) and whether they believe that diverting will improve their trip.

Results from the survey of TrafficGauge users indicated that a significant percentage of users are interested in knowing about the current condition of the arterials to help them make that diversion decision. Our analysis of current diversion behavior indicates that a relatively limited percentage of motorists currently divert when congestion becomes significant on SR 520, despite the availability of effective diversion routes.

Responses to the TrafficGauge survey indicated that users considered the lack of arterial traveler information to be a serious shortcoming of the devices. This suggests that many travelers divert either on the basis of what they see on the roadway or on the basis of the information they get from current en-route traffic information sources. The analysis of traffic volumes on SR 520 and its parallel arterials further supported this conclusion.

Even the modest levels of diversion observed in this study create measurable increases in arterial congestion, especially near the freeway ramps. Because motorists have little information on the performance of the arterials to which they can divert, visible arterial congestion near the freeway likely discourages diversion rates.

Consequently, providing reliable arterial performance information on the entire arterial to motorists via in-vehicle devices would be likely to significantly increase the number of drivers who initially divert.

The performance of the arterials to which this additional diversion moves would degrade as a result of that increase in traffic volume. Therefore, roadway agencies should make sure that they are capable of adjusting signal timing plans on those arterials to accommodate an increase in vehicles being encouraged to use those roadways.

Operators controlling those arterials should develop control plans that will maintain flow along the majority of the arterial by limiting the number of vehicles that can enter the corridor from the freeway to just below the capacity of the arterial roadway (at its most congested point), much like what now happens to a limited extent on 148th Ave NE. This may require careful real-time adjustment of the timing at the signals nearest to the freeway. Timing these signals must balance the need to accommodate increased volume due to diversion with the need to keep that increased volume from degrading the performance of the rest of that arterial.

When such an integrated control strategy can be implemented, all parties stand to benefit. Travelers will gain less congested travel. Cities will lower their congestion levels, while also serving the population that travels in that area. In commercial areas, additional traffic may even be viewed favorably, as it increases the exposure of businesses in that area to the public. But without real-time control of the traffic signal system, encouraging diversion will be likely to create substantial delay beyond that already present.

APPENDIX A

SURVEY FORMS

...

Welcome To The
Puget Sound Congestion
Information Survey

Dear University of Washington and Harborview Medical Center Parking Permit Holder:

The Washington State Transportation Center at the University of Washington (TRAC-UW) has been asked to perform a study by the Washington State Department of Transportation. The basic research objective is to learn how the region actually benefits from motorists having access to current freeway traffic congestion information.

The study was funded by Congress in late 2005, and will begin data collection this summer. We are looking for volunteers from among UW faculty and staff to participate in this study, now called the ***Puget Sound Congestion Information Survey***.

Study participants will be given a small portable device called a ***TrafficGauge*** that shows which freeways in the Puget Sound metropolitan region are currently congested. The ***TrafficGauge*** device can be examined on the Internet by going to this URL: ***http://seattle.trafficgauge.com/product.html***.

In return for participating in this effort, participants will each receive a free ***TrafficGauge*** (normally retails for $79.95 plus tax and six months of service costs $47.94 plus tax). The device will function free of charge for six months; after six months of service, participants will be allowed to keep the ***TrafficGauge*** device and may continue service using rates published on their web site: ***http://www.trafficgauge.com***.

Participants are not required to extend the service. ***TrafficGauge*** will not know who receives a device and cannot contact anyone for billing or promotions, and they cannot send any information after the study ends. The device tells you when the free service ends and when it requires a new subscription, and it provides a phone number to call and pay using a credit card, if you choose to do this. (Plans range between $5 and $10 per month, depending on the length of the contract.)

Welcome To The
Puget Sound Congestion
Information Survey

To join the study, (1) ***review this information form*** that provides more details about the survey and your rights as a confidential respondent and (2) ***at the end of the information form*** you will find a link to the entry survey that will enroll you in the study. You will receive your TrafficGauge after you complete the survey.

Thank you for your participation.

Very truly yours,

Mark Hallenbeck
Study Principal Investigator
(206) 543-6261

Welcome To The
Puget Sound Congestion
Information Survey

Study participants are simply requested to continue traveling as they routinely do. During the project, you will be asked to fill out a series of surveys:

1. At the beginning of the study we will ask you to fill out a modest travel survey that describes your demographics and your normal travel routine. The entry survey will require roughly 15 minutes to complete.

2. Over a period of four weeks in the middle of the study we will ask you to respond to a short e-mail message each day asking if you used the TrafficGauge that day; and if so, whether you made any changes in your travel routine as a result of the information you obtained. The daily surveys should require no more than 1 minute to complete. If you change your normal travel routine because of information you received from the TrafficGauge, we will ask you a few additional questions about those changes once each week. This longer daily survey will require less than 3 minutes to complete.

3. At the end of the project we will ask you to fill out another travel survey similar to the one you completed at the beginning of the study, you should be able to complete this exit survey in less than 5 minutes.

4. All surveys will be completed on-line using your computer's browser and will be confidential.

TRAC-UW will be working in conjunction with the Volpe Transportation Systems Center and Battelle to design, conduct, and analyze the surveys. If you have any questions about this project or would like to know more before agreeing to participate, please contact the study coordinator, Ron Porter, or the project's principal investigator, Mark Hallenbeck, by phone. Ron can be reached at (206) 685-8447. Mark can be reached at (206) 543-6261. Or send an e-mail to maptest@u.washington.edu.

Please note that we cannot ensure the confidentiality of information sent via email.

Information Form
Puget Sound Congestion
Information Survey

Investigators:

Mark E. Hallenbeck Director TRAC/UW	(206) 543-6261	tracmark@u.washington.edu
Scott Rutherford Professor Civil & Environmental Engineering	(206) 685-2481	scottrut@u.washington.edu
Yinhai Wang Assistant Professor Civil & Environmental Engineering	(206) 616-2696	yinhai@u.washington.edu

Please note that we cannot ensure the confidentiality of information sent via email.

Investigators' Statement

We are asking you to be in a research study. The purpose of this information form is to give you the information you will need to help you decide whether or not to be in the study. Please read the form carefully. You may ask questions about the purpose of the research, what we would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called 'informed consent.' You can keep a copy of this statement

Purpose

We would like to know if providing drivers with traffic information both in and outside their cars will help both drivers and traffic. We would like to provide drivers with traffic information in their cars using a small, portable, electronic device. We would like to survey drivers who use the traffic device.

Procedures

If you choose to be in this study, we would like you to use an electronic device over a 4-month period. The device shows information about traffic congestion, and can be placed in the car where the information can be useful but is not distracting to you when you are driving. We will give you information about how to use the device safely.

Before using the device, we would like you to fill out an on-line survey that describes general information about you, such as your income and normal driving habits. The survey will take about 15 minutes to complete. You do not have to answer every question.

Over a **4-week period in the middle of the study**, we would like you to fill out short surveys on a daily and weekly basis. The daily survey will take about 1 minute each time. The weekly survey will take about 5 minutes each time. The surveys will ask you if you used the electronic device in planning or conducting your trip, and how the information from the device may have changed or reinforced your normal routine. You do not have to answer every question.

At the end of the 4-month period, we would like you to fill out a final on-line survey. The survey will ask more questions about your normal driving routine, and how the electronic device affected your routine, if at all. The survey will take no longer than 5 minutes. You do not have to answer every question.

Risks, Stress, Or Discomfort

Some people feel that providing information for research is an invasion of privacy. I have addressed concerns for your privacy in the section below (please review "Other Information").

The traffic device is not intended to be a distraction to driving or to otherwise lower driving safety. Be sure to read and to follow the Product Safety Warning guidance to ensure safe use of the device while driving.

Benefits

Except for the free TrafficGauge, you will not directly benefit from taking part in this research study. However, we hope that the results of this study will help improve traffic flow and the commuter experience in the greater Seattle area.

Other Information

Taking part in this study is voluntary. You can stop at any time. You can choose to take part in the study, to not take part in the study, or to withdraw from the study without loss of benefits to which you are otherwise entitled. For example, your choice will not affect your employment.

The first survey you fill out will be directly associated with your name and email address, if you provide it. After that, information about you is confidential. We are collecting survey information from you. The electronic device will not collect information about you. We will code the study information. We will keep a link between your name and the code until September 2010. Then we will destroy the link. If we share data with other researchers, or if the findings of this study are published or presented, we will not use your name.

Although we will make every effort to keep your information confidential, no system for protecting your confidentiality can be completely secure. It is possible that unauthorized persons might discover that you are in this study, or might obtain information about you. Government or university staffs sometimes review studies such as this one to make sure they are being done safely and legally. If a review of this study takes place, your records may be examined. The reviewers will protect your privacy. The study records will not be used to put you at legal risk or harm.

You may keep the traffic device after your participation in this study ends. We will pay the monthly fee to receive traffic information for the first 6 months that you have the device. After that time, you may choose to either keep or to discontinue the service. Participants are not required to extend the service. TrafficGauge will not know who receives a device and cannot contact anyone for billing or promotions, and they cannot send any information after the study ends. The device tells you when the free service ends and when it requires a new subscription, and it provides a phone number to call and pay using a credit card, if you choose to do this. Plans range between $5 and $10 a month, depending on the length of the contract. You may view published service rates at http://www.trafficgauge.com.

We may want to contact you about taking part in future research related to this study; for example, by taking part in a focus group. In that case, we will contact you and tell you more about the new study procedures. Please indicate in the exit survey (the final online survey that you will be asked to complete) whether we may contact you for this purpose. Choosing to allow us to re-contact you does not obligate you to take part in future studies in any way.

If you have questions later on about the research you can ask one of the investigators listed above. If you have questions about your rights as a research subject, you can call the Human Subjects Division at (206) 543-0098 or e-mail at hsd@u.washington.edu. You will receive a copy of this information form.

To sign up for the study and receive your free TrafficGauge, first complete the confidential entry survey:

Begin the Entry Survey here if you have a UW NetID.

Begin the Entry Survey here if you DO NOT HAVE a UW NetID.

Very truly yours,

Mark E. Hallenbeck
Director
TRAC/UW
tracmark@u.washington.edu

Product Safety Guidance
Puget Sound Congestion
Information Survey

When driving a car, DRIVING is your first responsibility. If you find it necessary to use TrafficGauge while driving, please give full attention to driving and to the road, use good common sense and remember the following tips:

1. Get to Know TrafficGauge

Carefully read the User Guide to understand TrafficGauge's features. Familiarize yourself with the TrafficGauge "at-a-glance" map display before you get behind the wheel, so you can easily acquire information for specific stretches of freeway in one quick glance.

2. Assess Driving Conditions

Use TrafficGauge sensibly. If possible, glance at TrafficGauge before you pull into traffic or when you are not moving.

3. Immediately stop using TrafficGauge if your situation, or driving conditions in general, become hazardous.

Entry Survey

Puget Sound Congestion Information

Information Confirmation Form

This study has been explained to me (you may review the research description at this URL: http://depts.washington.edu/maptest). I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later about the research, I can contact the study's principal investigator, Mark Hallenbeck, at (206) 543-6261 or by sending e-mail to maptest@u.washington.edu.

If I have questions about my rights as a research subject, I can call the UW Human Subjects Division at (206) 543-0098. I will not be charged for using the TrafficGauge during the study (not to exceed six months after the device is initialized). After the six months of free use, the device will stop working unless I contact the service providers directly to arrange for and pay for continued service. I agree to print a copy of the consent form (this page) or I request a copy when the TrafficGauge device is shipped to me.

Required.

- ◯ Yes, I agree to participate in this study and I have printed a copy of the information confirmation form (this page) for my records.
- ◯ Yes, I agree to participate in this study; please send a copy of the information confirmation form when you ship my TrafficGauge device to me.
- ◯ No. I do not agree to participate. (This survey ends if you decide not to participate.)

Next >>

Entry Survey

Puget Sound Congestion Information

Question 1.
What is your age?

- ◯ under 31
- ◯ 31 to 40
- ◯ 41 to 50
- ◯ 51 to 64
- ◯ 65+

Question 2.

What is your gender?

- ◯ Male
- ◯ Female

Question 3.
What is your current household income?

- ◯ Under $19,000
- ◯ $19,000 to $30,000
- ◯ $30,000 to $50,000
- ◯ $50,000 to $100,000
- ◯ Above $100,000

Question 4.
What is the highest level of education you have completed?

- ◯ High school or less
- ◯ High school graduate
- ◯ Some college/technical or vocational school/AA degree (2-year degree)
- ◯ College degree (4-year)
- ◯ Some post-graduate work or attended graduate school
- ◯ Advanced or professional degree (completed master's degree or higher)
- ◯ Other (please describe): ____________

Question 5.
Which best describes your occupation?

- Faculty
- Health care
- Professional or library staff
- Administrative support
- Accounting/fiscal/purchasing
- Student
- Service, retail
- Sales, marketing
- Installation, maintenance, repair
- Production
- Retired
- Other (please describe):

Question 6.

How often do you access the Internet?

N	ever	Occasionally	Frequently
Internet access from work/school	○	○	○
Internet access from home	○	○	○
WiFi Internet access from public locations	○	○	○

Question 7.

Which type of connection do you use to access the Internet from home?

- Cable modem
- DSL
- Shared phone line
- Modem (dial-up access)
- Internet not accessed from home
- Other (please describe):

Question 8.

How frequently do you typically use the following?

N	ever	Occasionally	Frequently
Cell phone	○	○	○
Pager or beeper	○	○	○

g p

PDA (personal digital assistant) with wireless communications	◯	◯	◯
Laptop computer with wireless communications (WiFi)	◯	◯	◯

Question 9.
Do you subscribe to any *fee-based* on-line information services (e.g., Wall Street Journal, ESPN, Business and Government Information Center (BGIC))?

◯ yes
◯ no

Question 10.

How often have you done the following while traveling to and from work or school during the *last 3 months*:

N	ever	Occasionally	Frequently
I have taken the bus as part of my trip to and from work or school.	◯	◯	◯
I have been part of an organized carpool or vanpool to travel to and from work or school.	◯	◯	◯
I have used the HOV lanes to travel to and from work or school.	◯	◯	◯
I have bicycled or walked for at least 10 minutes as part of my trip to and from work or school.	◯	◯	◯

Question 11.

Please indicate the extent to which you agree with the following statements about your travel to and from work or school:

Ag	ree strongly	Agree	Neutral	Disagree	Disagree strongly
I prefer driving my own vehicle.	◯	◯	◯	◯	◯
Receiving traffic congestion information while en route would influence my choice of	◯	◯	◯	◯	◯

route.

I can take alternative modes of transportation.	◯	◯	◯	◯	◯
I am willing to change routes.	◯	◯	◯	◯	◯
I am willing to change the time I leave home.	◯	◯	◯	◯	◯

Question 12.

Do you work at different locations during the week?

◯ Yes

◯ No

Question 13.

What is your 5-digit home address ZIPcode? (For instance, 98195.)

Enter an integer (without commas). Limit response to five characters.

Question 14.

How many round trips in a typical week do you make using the following transportation modes to and from work or school?

	4 or more round trips per week	2 to 3 round trips per week	0 to 1 round trip per week	I do not use this mode.
Private automobile	◯	◯	◯	◯
Carpool/vanpool	◯	◯	◯	◯
Walk to public transit	◯	◯	◯	◯
Drive or bicycle to public transit	◯	◯	◯	◯
Other modes of transportation	◯	◯	◯	◯

Question 15.

Please indicate the extent to which the following statements apply?

N	ever	Occasionally	Frequently
My job requires me to have a car while at work.	◯	◯	◯

I need my car before or after work or school to drop off or pick up children, or run errands.			
My schedule at work or school is flexible.			

Question 16.
Please indicate the extent to which you agree or disagree with the following statements:

A	gree strongly	Agree	Neutral	Disagree	Disagree strongly
I use the Internet first when searching for information.					
I don't like to have to plan ahead.					
People are able to contact me at any time.					
I prefer to find my own way than ask for directions.					
I worry about being late.					
I don't like to take risks with new products or services.					
When I need information, I prefer asking someone else rather than rely on a computer.					

Question 17.

Please indicate the extent to which you agree with the following statements:

Ag	ree strongly	Agree	Neutral	Disagree	Disagree strongly
An unexpected delay occurs at least twice a week on my regular route.					
Within the past 3 years, I have seriously considered changing where I work to reduce the amount of time I					

spend comuting.					
Within the past 3 years, I have seriously considered changing where I live to reduce the amount of time I spend commuting.	○	○	○	○	○
I am satisfied with my commute.	○	○	○	○	○
I am able to travel my regular route to or from work or school more quickly now than I could 12 months ago.	○	○	○	○	○
I usually travel to work or school during peak traffic periods.	○	○	○	○	○

	Agree strongly	Agree	Neutral	Disagree	Disagree strongly
If congestion exists on my regular route to or from work or school, I can travel via good alternate routes.	○	○	○	○	○
I could reduce the amount of time I spend commuting if reliable, real-time transit or traffic information were available.	○	○	○	○	○
I would pay $9.99 a month to receive accurate, up-to-the-minute traffic information for major regional roadways.	○	○	○	○	○
I know how to get route and schedule information for public transportation.	○	○	○	○	○
Travel delays don't bother me if I can accurately forecast when I will arrive at my destination.	○	○	○	○	○
I know where I can find Puget Sound area traffic information on the Web.	○	○	○	○	○

Question 18.

Please rate the following potential improvements to travel information services from *very important* to *not important*.

V	ery important	Important	Not important
Traffic information covering all roads, not just the freeways	○	○	○
Traffic reports that are tailored to the routes I travel	○	○	○
Easily accessible traffic information (e.g., by pressing one button)	○	○	○
Comprehensive traveler information (e.g., bus routes and schedules), in addition to real-time traffic information	○	○	○
Forecasts of traffic conditions for the next 60 minutes	○	○	○
Estimated travel times between major destinations based on current traffic conditions	○	○	○

Question 19.

What benefit do you hope to get from roadway congestion information? Please rate the following from *very important* to *not important*.

V	ery important	Important	Not important
Reduced travel time	○	○	○
More predictable (i.e., reliable) travel times	○	○	○
Safe travel conditions	○	○	○
Less stressful travel conditions	○	○	○
Alternate routes	○	○	○
Availability of public transit	○	○	○
Estimated travel times between major destinations based on current traffic conditions.	○	○	○

Question 20.

How often do you use these traffic information services?

	Ne ver	Infrequently	Few times monthly	Few times weekly	Never heard of the service
511 (national traveler information service)	◯	◯	◯	◯	◯
Puget Sound Traffic Conditions Web site (http://www.wsdot.wa.gov/traffic/seattle/)	◯	◯	◯	◯	◯

Question 21.

What is your name? (This information is required only at the beginning of the study for shipping the TrafficGauge device. Information you provide during the study will not be associated with your name.)

Required.

Question 22.

Complete shipping address:

Required.

Question 23.

Please enter your complete e-mail address. (This address will only be used to send reminders to complete daily and weekly surveys, The survey responses that you provide during the study will not be associated with your e-mail address.)

Required.

Question 24.

I have read the information confirmation form at the beginning of the survey and I want to receive a TrafficGauge.

Required.

◯ Yes

◯ No

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Entry Survey

Puget Sound Congestion Information

When driving a car, DRIVING is your first responsibility. If you find it necessary to use TrafficGauge while driving, please give full attention to driving and to the road, use good common sense and remember the following tips:

1. **Get to Know TrafficGauge**

   Carefully read the User Guide to understand TrafficGauge's features. Familiarize yourself with the TrafficGauge "at-a-glance" map display before you get behind the wheel, so you can easily acquire information for specific stretches of freeway in one quick glance.

2. **Assess Driving Conditions**

   Use TrafficGauge sensibly. If possible, glance at TrafficGauge before you pull into traffic or when you are not moving.

3. **Immediately stop using TrafficGauge if your situation, or driving conditions in general, become hazardous.**

<< Previous   Submit responses

Entry Survey

Puget Sound Congestion Information

Your responses have been submitted.

Thank you for participating. Your TrafficGauge will ship within a few days.

You may now exit the Internet browser or go to another Web page.

Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Question 1.

Did you check your TrafficGauge on Wednesday, March 5, 2008?

Required.

○ Yes

○ No

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Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Question 2.

Did the TrafficGauge information cause you to change your normal travel routine?

Required.

- ◯ Yes
- ◯ No

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Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Question 3.

Was this the first time this week that information on your TrafficGauge caused you to change your travel routine?

Required.

- Yes
- No
- Don't remember

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Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Question 4.

What did you do differently as a result of the information you received from your TrafficGauge? Select all that apply. (Remember: you only need to answer this question once each week, on the **first** day your travel behavior changes.)

- ☐ drove alone in my own vehicle
- ☐ used public transit
- ☐ used an organized carpool/vanpool
- ☐ formed a carpool/vanpool by contacting people I know
- ☐ used the HOV lanes
- ☐ changed travel routes
- ☐ changed travel times
- ☐ bicycled or walked
- ☐ telecommuted
- ☐ Other (please describe): ________

Question 5.

Do you think that you benefited from using the TrafficGauge information?

Required.

- ○ Yes
- ○ No

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Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Question 6.

Do you think you saved time because of the changes you made to your travel routine?

- Yes
- No
- Don't know

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Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Question 7.

Please estimate how much time you saved *or* lost by changing your travel routine (specify in minutes):

Enter a number (without commas). Limit response to three characters.

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Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Question 8.

Did your stress level change as a result of your changed travel routine?

- ○ Increased
- ○ Did not change
- ○ Decreased

<< Previous   Submit responses

Daily Log: Thursday, March 6, 2008

Puget Sound Congestion Information

Your responses have been submitted.

Thank you for completing today's survey. You may now go to another Web page or close the Internet browser.

APPENDIX B

SURVEY COMMENTS: BENEFITS

- A good gauge of traffic conditions
- a mix between peace of mind and reliability. Traffic Gauge at least let me know what to expect
- A very general idea of congestion was provided
- A warning against doing anything. Rather waist a day than face traffic.
- a way to check traffic while in the car
- ability to avoid congestion i normally would have been stuck in.
- ability to be flexible in trip planning
- Ability to better know ETA
- Ability to check traffic when I get in the car
- ability to choose alternate route
- ability to expect good or poor traffic conditions in advance
- Ability to make informed decision about which route to take
- ability to manage expecations with others regarding arrival times
- ability to plan ahead
- ability to plan ahead before you leave
- ability to plan errands and routes as hitting the road
- ability to re-plot course while in transit
- ability to see changing traffic conditions on longer trips (for example, seeing how the traffic in Tacoma would be when I drove from Seattle to Portland). For shorter trips you can usually get equally accurate information by checking wsdot's traffic page
- ability to see real time traffic updates on demand
- Ability to see slowdowns and take alternate routes
- ability to switch plans while in the car
- Ability to take routes with less traffic reducing congestion and potential accidents
- able to call clients to let them know I'd be late.
- able to do more
- ablilty to plan around traffic patterns
- advance info
- advance knowledge of route changing traffic conditions
- advance knowledge of traffic status
- advance notice of bad trip

- Advanced knowledge of being late
- again, soon after I began using the guage I added the DOT full color info to my phone. Checking one or the other at the outset and during the trip gave me the feeling that I had choices rather than just being trapped in an ever expanding commute.
- Alentative routes may not have always been quicker, but atleast i was moving.
- allowed me to plan a more efficient trip, with regard to freeway congestion
- already by-passing traffic
- Alt routes
- Alternate route info
- alternative routes
- alternative routes
- Although I haven't actually used it yet, the info about the boarder crossings could be valuable
- always connected to traffic feed
- always on- easy access
- always on
- Alternate routes may have had congestion too but at least I was moving.
- Always questionable due to no arterial road info.
- amount of congestion on the highway
- An alternate route! A REAL time saver!
- An alternative source of info when I wasn't connected to the Internet at home or work (i.e. useful for checking traffic while out shopping, visiting friends)
- An estimate of how long it would take to reach destination
- An informed choice
- an insight on what to expect
- an occasional heads-up about places to avoid
- another source of information about traffic
- anticipation of possible delay
- As is- I did not find it very useful except to note how late I would be due to traffic.
- At-a-glance information
- avoid james
- avoided occasional major traffic jams
- avoiding bottlenecks/jams
- Avoiding congested areas
- awareness
- Awareness of when to get off the freeway
- Be on time for appointment

- Being able to actually drive on I-405!   I hate this freeway.
- Better estimated trip time
- better able to predict when I would arrive
- Better ETA's
- better expectations
- Better idea of what traffic conditions lay ahead
- Better knowledge of route problems
- better planning
- better route
- better source of traffic info than radio reports
- Better use of time by postponing leaving work
- By knowing congestion before hand, it became expected. So it caused *alot* less stress
- changed timing of departure
- choice of routes around congestion
- chose which bridge to take to work
- commute planning
- confirmation of chosen route
- confirmation of route
- confirmation of route choice
- confirmation of the 'choke points' and that there really isn't much to be done to avoid them during commute times
- confirmation that conditions had not changed since checking traffic conditions online as I left the office
- Confirmation that the route I had chosen was the best one at the time.
- confirmed other traffic reports (radio & tv)
- consistent highway traffic load
- control over travel pattern knowing about slowdownsthat could allow me to alter my route in advance instead of being stuck in it
- convenience
- convenience of not having to load traffic map in Internet browser
- convenience: able to check road conditions without needing to go to a computer with a web browser. I mostly used the TrafficGauge to help with my commute, and I usually check the traffic web page before leaving home and before leaving work. With the Tra
- convenient
- Cool blinking lights

- cool toy for 'non' commute times. i found it more useful when i had a choice where i wanted to be. i.e. i had to go to work so i have to go that way....
- Correct expectations
- could see mess I inevitably had to deal with.
- Current traffic report on major roads.
- Decisionable information on best route during trip
- Definitely helped me decide when to make the trip- so I was able to avoid the worst traffic. At one point I was able to run a valuable- high priority errand because the TrafficGauge showed Hwy 99 to be clear while I-5 was (predictably) stopped.
- Delayed leaving work
- did not find it useful
- did not use
- earlier decision making on method of commuting
- Early Warning about major problems.
- Ease of confirmation of trip
- Easier than reading DOT maps on cell phone
- Easier to predict arrival time
- easy access to traffic conditions
- Easy to check at a glance.
- enabled me to make better commute choices
- Enterainment - see comments
- Entertainment
- estimated time of arrival
- Extends to include Tacoma traffic (when it worked).
- faster than 511 information
- faster trip not necessarily shorter
- flexibility
- Flexibility in determining time I travelled and best route options; sense of resignation (calm) when I knew I couldn't fight the traffic!
- flexibility of trip planning right on the spot
- foreknowledge of slow spots was helpful
- foresight about the trip
- frankly- not much better than the KOMO copter
- fun to look at
- fun to see the traffic
- gave me a better idea of which route should be taken
- gave me something to fiddle with on long drives

- gave me something to fiddle with on long drives
- Gave me the ability to decide on my route before 'it was too late'
- general information about upcoming route (when to expect slowdowns, etc.)
- Have small children to pick up from school bus, child in hospital, the guage really helped this work without concern for child safety
- Heads up on routes
- Help me decide between I-5 and I-405 when travelling from the southend to the northend.
- helped selecting which way to go.
- helped to decide method of commute
- Helped when there were games or really unexpected traffic
- helped with route choices
- highways to avoid
- How bad I was stuck
- How bad the congestion is
- how long is the traffic jam
- How much traffic to expect
- I can listen to CDs instead of waiting for traffic reports on a radio station
- I completely changed my normal daily travel routine.
- I could see the traffic jam and could call ahead to say i would be running late
- I couldn't always change my route (SR520) but it was good to know when I should plan accordingly for more time.
- I didnt use it that much
- I felt "in control", rather than surprised by a wall of brake lights because I knew where they were and avoided them. Very cool.
- I found it inaccurate and not positive at all
- i found it more annoying than helpful
- I knew what to expect
- I knew what to expect
- I knew what to expect but it didn't help other than that.
- I knew whether or not there was traffic so I could be prepared
- I know the traffic on my own commute fairly well, but the Gauge allowed me to determine when carpooling was needed, and helped weekend errands outside of my normal commute route go much more smoothly.
- i like to know about traffic even if I cant avoid it

- I think the most important thing on a commuter's mind is knowing roughly how long they can expect to spend sitting in traffic.
- I took the Freeway a few more times when traffic was light when I normally wouldn't have
- I was able to inform my son's daycare when I was running late due to traffic.
- I was able to plan
- I was able to select route options before hitting traffic
- idea of severity of traffic jams
- Idea of time it would take
- Ideally it would provide advance notice of congested areas.
- immediate information at a glance
- improved ETA
- Improved safety by knowing about backups before comming upon them
- In an emergency it dictated whether I took a child to Everett or Seattle.
- inaccuracies
- increased productivity
- increased work productivity
- info
- info about other routes too
- info to provoke alternate trip routes
- info wasn't useful
- Information
- information about I5 before getting on I5
- Information about what to expect
- Information about what to expect
- information abuot freeway condition
- information to help determine route
- Information to make decisions
- information where/when to expect traffic
- informed about how traffic was going to be
- Insight to semi-real time traffic condition
- instant traffic status vs radio
- interest
- interesting to see where traffic was slow- but didn't apply to my commute
- interesting
- it's only usefull to avoid big traffic on 520 and I90 (you can wait for the traffic to be less bad). The rest it not ebought detayled to use alternative routes.

- it did not do anything for me
- it didn't always work right, traffic would be backed up forever but it showed no traffic
- It gave me "some" idea of what my commute was going to be like.
- It gives me information only. Won't really make me change route because my route was pretty much don't have alternatives.
- It is heading in the right direction, but it really needs to be revamped towards a more user friendly format. I think different colors would help. Trying to focus on the little specs while driving was difficult.
- it let me know what I was getting into traffic-wise
- It made managing my time easier.
- It may not have changed my trips as much as I would have thought- but it's great to know about what is ahead.
- it once showed that I-5 and I-90 were clearly worth using over 405 No. from renton to bellevue
- It provided information about traffic I may encounter but based on the limited roadways I was still going to encounter the traffic with no choices regarding avoidance
- it provided me with additional information needed in making decisions. My one way commute is 50 miles from Tacoma to Bellevue I rely on information to help minimize the time it takes
- It showed me where I was most likely to have slow traffic instead of driving up it not knowing
- It showed me where major delays would occur so I could plan alternate routes around them if necessary
- It was frequently wrong about conditions
- It turned on...
- It was fun seeing who was stuck in traffic since the device was not applicable to my commute.
- It was good to be able to see the freeway conditions BEFORE getting on the freeway and being stuck there.
- it was great to be able to view the info enroute
- It was insurance more than anything...only time an alternative route is shorter/faster is when there is an accident.
- It was interesting
- it was interesting to compare the gauge to the reality
- It was nice to reference but the device in its current state did not provide any benefit for my specific commuting needs

- it was not reliable
- it was of academic interest to see what traffic conditions were like for other people
- just a simple heads up
- just did not use it much
- Just helpful to anticipate delays even if we cannot avoid them.
- Just information
- Just knew what to expect
- Just knowing that I would be stuck
- Just knowing what was ahead reduced my stress
- Just that you could check traffic before leaving the house or work.
- kept me from going into some big jams
- key area congestion
- knew how bad my commute would be ahead of time
- knew what to expect
- Knew what to expect when starting trip
- Knew when to vary routes
- know what to expect; i used to worry about making stops on my way home from the office because i could only check traffic on the WSDOT site when i left. No i have up to the minute traffic data!
- know which route to take home
- knowing for sure that the freeways were as jammed as expected
- Knowing how long the backup in front of me is.. IE: half a mile or five miles??
- knowing I'm taking the best route time wise
- knowing if traffic was bad I could plan for it accordingly if I couldnt change my route
- knowing in advance about congestion
- Knowing that there is something to check regarding traffic challenges
- knowing what I was in for
- knowing what sort of traffic is in front of me
- Knowing what the Puget Sound traffic situation is at any given time
- Knowing what the traffic was going to be like
- Knowing what to expect ahead.
- knowing what to expect on a commute. Reducing the unknown.
- knowing what to expect on the trip

- Knowing what to expect.
- knowing when the traffic might clear up
- knowing what was ahead
- Knowing where the backup ended was great
- knowing where traffic is
- knowing which route to take
- knowledge
- knowledge about border and sports events
- knowledge about the traffic snags
- knowledge and empowerment
- knowledge beforehand of how the commute was going to go
- knowledge of conditions ahead
- knowledge of traffic situation
- knowledge of trip
- knowledge of what to expect on trip
- Knowledge about what's going on
- knowledge and empowerment
- knowledge beforehand of how the commute was going to go
- knowledge of conditions ahead
- knowledge of traffic situation
- knowledge of what to expect on trip
- knowledge that i could be late to my destination due to high traffic volumes
- knowledge that I took the most effective route
- Less aggrevation
- less congested trip
- Less congested trip
- less hassel.
- less likely to drive quickly
- Less road time spent
- less stress
- Less stress
- Less stress because I knew what traffic was coming.
- less stress from running into gridlock
- less stress commuting
- Less stress knowing when you will arrive
- LESS STRESS!!
- less stress/avoiding jams
- less stressful
- Less time in stop/go traffic jams
- Let me know I didn't need to leave the freeway if I saw braking- that just temporary.

- let me know to leave a bit earlier if traffic was bad
- less time spent stopped in traffic
- Let me know to take my alternate route.
- Let me know what lay ahead. It was nice to see the blinking congestion spots. Kind of lets you know what you are in for.
- let us know what were in for
- Let me know if I need to reroute my plans
- level of highway traffic to expect while enroute
- love the mtn pass conditions and border crossing data
- May not be able to change route- but the info about traffic is helpful- fewer surprizes.
- lower stress
- lower stress level during commute
- managed my expectations of time
- Made the "Freeway or NO Freeway" decision very easy.
- May not be able to change route- but the info about traffic is helpful- fewer surprizes.
- More accurate information than on the WSDOT traffic map & available in the car where I couldn't check my PC
- more and timely information
- more confidence about travel times/expenses
- more efficient selection of departure time
- More knowledge of how bad the commute was going to be
- more practical route
- More relaxing knowing what's ahead.
- Mostly helps decide whether to telecommute.
- mostly no relevant info
- mostly TG showed me where NOT to go
- mountain passes
- N/A
- Need arterial routes
- nice to know about jams before you're stuck
- no help other than pointing out all the freeways are congested during rush hour - which we already knew
- None - I had great hopes, but it was unreliable during the times of my commute. I saw info about Tacoma at other times, but it never showed congestion when I was literally stopped on the freeway (construction, accident, etc)

- none - level of detail was too general to be useful in my case
- none
- None
- NONE
- none at all
- None. It is not accurate and had me locked up in traffic after I would change my course.
- Not always shorter but peace of mind is important to me
- not being tied to radio traffic reports on news stations and now I can listen to music
- Not dependent on radio for traffic reports.
- not having to wait for radio reports
- nothing
- not late if necessary to leave early
- Not much.
- not sure
- not sure about shorter trip
- nothing really, I found it unrealiable
- Nothing. There's always traffic. It only confirmed that fact.
- notice of where there are road problems
- Novelty.
- Occasionally it shortened my wait in traffic
- Offered a choice for trip
- One of the major things for me was to help me decide my route while transiting between appointments during the weed days.
- one time saved me from bad traffic mess
- Only 3 roads to travel North or South
- option of routes
- option to change route
- Overall knowledge about when to modify my route.
- overall picture
- Pass closure info
- Pass Conditions, everything else is inaccurate
- pass information during this winter season
- peace of mind
- picked between two common routes
- plan time of departure depending on traffic
- planning when to start the trip
- proof that I'm glad I don't commute to Federal Way

- Provided visual confirnation that regional traffic is consistently effed.
- quick check of congestion on major routes
- quick glance to avoid freeway or not
- quick reference guide to check route
- quick reference when in the car, I have different destinations every day.
- Quicker than phone traffic tool, easy check of express lane direction
- quicker trip
- Quicker trip
- Real time data to make adjustments. IE working later if otherwise would be stuck in traffic.
- real time traffic information allowing alternative route decisions as things change
- Real time traffic information to be able to choose the best route
- realtime data while en route
- reason to check the DOT traffic web site
- reduced stress
- reinforced that problems existed on area roadways
- roads to avoid
- route change
- route options
- Sadly I did not find the TrafficGauge helpful in my commute.
- safer trip
- Saved me money;   Enhanced Productivity at Work
- Saved time by using alternate routes
- see final comments
- sense of control
- set expectations of traffic to encounter
- set realistic expectations
- Set up new carpool
- setting expectations accurately
- shorter trip when 99 was not congested
- Show distance of problem
- showed me CHOICES
- showed potential problem spots overall
- simple preparedness for sitting in traffic reduced feelings of "roadrage"
- Situational Awareness

- sometimes longer but more pleasant trip taking the longer way around a backup
- sports events planning
- stopped my guessing
- stress reduction
- support for route selection
- take route home from work with least traffic
- the ability to share traffic problems with others who were coming to see me or meeting me elsewhere
- the need to use alternate routes.
- Time savings
- Timely traffic congestion on main traffic routes.
- timing is everything isn't it?
- timing of departure
- To see where there were traffic delays
- traffic gauge was a good attempt to make the morning commute easier. If the technology catches up with the functionality of other mobile devices or can be sold as an application to GPS units I think it would be more viable.
- Traffic info so I know what to expect
- travel time estimates
- Typical Morning Traffic Volumns
- U.S. border info was cool!
- Usually there wasn't a big difference in my choice of routes--at least not where it would made a time difference. But it was nice to KNOW that the traffic all over was hosed up. It was helpful to know that as soon as I was past a particular mess things would . . .
- Viable alternative routes
- visual was better than on cell phone
- warning of traffic congestion, so no surprizes
- was not useful without alternative roads (e.g., Alaskan Way) or without being able to zoom in to see the alternative roads
- was not useful
- way to see what is happening on the freeways
- Well, for us it needed to show more of the South Sound
- what freeways most trafficked
- What kind of sporting event was going on
- what was happening while I was looking at it
- when it worked properly

- where backups are currently located
- where the traffic was slower on the commute
- whether it would be a lighter or heavier commute that day.
- whether or not to delay the trip
- which route to take
- With only two chices to travel south from Seattle there was nothing psoitive about it that I could not ger from Komo news
- Working for Shuttle Express it helped to get to the pickups in a timely manner.

APPENDIX C

SURVEY COMMENTS: NEGATIVE ASPECTS

- I felt that the lights on the traffic gauge should not be lit from the sides but should be aluminous light a cell phone LED.
- 167 data was never correct
- 99 was often off line. This would be my alternate route after dropping off my son at The Center School.
- A color screen with more levels of traffic speed would be nice
- a couple of times accuracy was slow
- a couple times the traffic report was more accurate
- A larger coverage area would be nice.
- a little hard to read. Clearer images would be better. Old technology in display.
- a lot of outages
- Ability to provide alternative routes
- accidents and road work not reported
- actual fee is expensive considering cell phones with internet now have the same features
- Accuracy of where traffic was bad sometimes seemed different that what I experienced
- Again- I think that there needs to be several revisions to make the unit more user friendly- and useful overall.
- already have other devices that provide this information
- alternate routes
- alternative routes weren't necessarily quicker - just less congested.
- Amount of coverage (ie. surface steets, arterials) and detail of information (level of congestion, for example.)
- Amount of detail such as general traffic lanes v. HOV lanes
- Areas indicated were too broad to be of help. More detailed information such as is provided on the WSDOT website would be much more helpful.
- arterial
- arterial roadways info needed
- arterial street coverage
- arterials
- Arterials and small state routes were missing
- At first you assume that all roadways are monitored, but they are not. So it gives you a false sense of which roads to detour to.
- Aurora/Highway 99 data would be very useful to me. So would some of the other major streets, particularly the ones that are affected by exits/entrances.

Occasionally the data was a little late in displaying. That is I had to make a route decision at a point . . .

- awkward size no clip for visor
- back light was weak
- Background light was too weak.
- Backlight could be brighter
- backlight should be brighter
- batteries shipped with device were dead
- being able to determine where the problems really were; this would allow me to exit the road at the correct point and circumvent the congestion with more certainty
- Better coverage north of everett
- Better coverage on 512 & 167 south of Auburn is needed. Information was not accurate south of Auburn on 167 to Jct. at 512
- better definition of congestion similar to what is on the WSDOT Web site
- black and white display is hard to read at a glance
- black and white image
- black/white hard to see at night; color would be MUCH better
- Blinking to me meant slow, not stopped. It would have been great if the gridlock areas were in another color such as red.
- bulky not ergonomic
- bulky unit nowhere to store
- bulky form factor
- By the time the first dash showed up I was already in heavy traffic and the refresh time is too long
- bulky unit, nowhere to store
- can't look at it and the road at the same time
- cannot be specialized for my commute, to include more geographical detail, with arterials and travel times
- certain times this device has helped; however, it is not completely accurated compared to real world
- clarity of image in bright light
- clearly indicate traffic moving speed with bigger display screen
- colored bars might be easier to see against background
- colored blockages would be helpful
- Cold weather restriction
- could be more precise in segments shown, more segmenting would help

- Compared to Windows Mobile TrafficGauge version Color features are very helpful
- Could have used more arterial information such as SR99 and others
- could be more precise in segments shown, more segmenting would help
- could not tell where I-5 ended on the north boundary (does it go to 526? Farther?)
- Could have used more arterial information such as SR99 and others
- coverage limited to Interstates
- Couldn't get signal at my home in Snoqualmie
- Coverage on Hwy 99 seemed wrong most of the time
- Customizable to a city or a place
- Couldn't read in the dark
- data not up to date immediately
- data changes by the time you get to the point you were looking at
- dashes started to fade, but full battery indicated
- Data not very useful; hard to tell if traffic is sort of bad or really bad -- if device used color could code traffic based on speed (55+=green; 41-55=yellow; 31-40=flashing yellow;21-30=red; 11-20=flashing red; 0-10=black)
- data not up to date immediately
- delayed or false conditions indicated
- data refresh rate
- detail of coverage area
- details of info
- detail of information, colors would be nice
- device is a lot larger than a phone
- device is rather large compared to other electronic devices these days, ie iphone's screen is comparable but much slimmer
- device is too large
- device is too big. terrible lighting with the availability of backlighting so prevelant. one thing to see road traffic another to know if an accident is causing it. trafficgauge is good but for seattle not a viable market due to there is no viable alterna
- device not usable without support stand (not supplied!)
- Did not come with mounting for car
- did not expand far enough into Everett area
- did not cover all potential routes I would take as well as arterial roadways

- did not cover HOV lanes which I use and hence did not make it clear as to their traffic conditions
- did not cover Everett
- did not use; the roads and freeways (509) I use were not on the map
- didn't cover wide enough area
- Did not work in low temperatures (couldn't keep in car)
- didn't help too much with my route
- didn't cover much of Hwy 99- missing parts of freeways- no surface streets at all
- Didn't include carpool lane info
- didn't cover my alternative routes
- Didn't provide data bout alternate route
- Didn't show how to get around the traffic jams. No information on arterials.
- didnt show other roads
- difficult to read in the dark
- Difficult to see a night
- difficult to see/determine location detail
- difficult to see in the dark - the light button did very little
- difficulty visualizing after dark
- Difficult to tell where backups are - for instance on the 99 North portion, I come in at the West Seattle Bridge and it is difficult to tell where that lies in the display.
- difficult to use in low light; too large
- Display segments are too long (the traffic data is too generalized compared to the high level of detail on the WSDOT Web site), plus it had a slower data refresh than WSDOT site
- display size hard to read in seattle
- display was cheesy - info wasn't any more accurate than data available on the internet
- Displayed poorly in cold conditions
- distracts from driving
- Does not differentiate between HOV lanes and general lanes
- Does not include Lake City Way...
- Does not include state routes ie SR202
- doesn't cover back roads I use to commute
- Doesn't even match 'Traffic Cams'
- doesn't provide info for HOV lanes

- DOT doesn't have much data on highway 99
- ended at Everett
- ergonomics on the device are atrocious. Can't easily pick it up, activate the illumination button, and look at it with one hand
- estimated times would have been very helpful, also the TrafficGauge screen damages very easily. I also found that Hockey traffic would have been important to have had.
- even on 405 south from I-90, there seems to be an area without coverage
- Expand to North- Snohomish
- Figuring out where the "blocks" were
- Found I didn't need the device for my commute everyday. I only used it when I altered my normal route and it was during rush hour.
- frequency of traffic updates on TrafficGauge; it's frustrating to make last-minute decisions based on info even the slightest bit behind, especially during rush hour
- fumbling for it while driving
- glare
- Granularity of traffic information is too large
- granularity of traffic conditions. Sometimes traffic wasn't that bad even though a solid bar was displayed. Travel times would be most useful.
- granularity too coarse - in number of bars, and indicators (blinking, steady or off). Both could be improved to compete with other technologies, like the wsdot website and cell phones
- Graphical image is poor and often times hard to read.
- hat to be supplemented with radio
- graphics
- Half the locations were always out of data
- Hard to determine exactly where each segment starts and ends
- hard to gague exactly where traffic slows (approximate, but not as good as on the wsdot site)
- Hard to judge time effect of congestion
- hard to read at a glance; colors would be useful
- hard to read (black on grey background distracts too much from driving), the delay in information provided made it hard to figure out what was the best route, segments cover too much roadway to convey realistic planning info.

- hard to read at a glance, need color like DOT site maybe?
- Hard to read in the dark
- hard to read at a glance; colors would be useful
- hard to read; not particularly accurate
- Hard to read; would like color and would pay more for it
- Hard to read functionality
- Hard to read while driving; difficult to detect exactlhy where the freeway backup begins so you can get off ahead of time
- hard to read, not particularly accurate.
- have to be able to narrow focus on one area, rather than entire Puget Sound
- Hwy 522 East from 405 would often show backup when there isn't
- have to be able to narrow focus on one area, rather than entire Puget Sound
- Hwy 9
- I carried the gauge in my briefcase where the light button accidently was held down. The batteries died in two days. I had to figure out a less convenient place to store it.
- no info on arterial roadways
- no helpful information
- no alternate routes
- need zoom in and out feature
- I didn't find any negative issues.
- mileage not accurate for backups
- map ratio
- I didn't really feel it helped since I use arterial roads to get to work. More coverage of the larger ones (W 15th) would be great.
- level of detail
- late information
- I didn't get a dash holder for it so figuring out where to put it was an issue. I think it would be smarter to sell them with a holder.
- It basically said "you're good" or "you're screwed". In the latter, didn't help re-route.
- interchanges did not display traffic information accurately
- i found it to be inaccurate only one time; since there are usually several routes to a destination, I found information of routes several miles away to be most helpful, for example, if I am in Bothell going to Renton, the condition or 405, the 520 bridge,
- I kept wishing for brighter, colored display and a smaller device--since it apearred to be the same as the DOT info--the

only + compared to the info on my blackberry was the "instant on" rather than having to wait for the browser fav to pull up on my phon

- I live in burien and need info on hw509 and hw518
- I live near Everett and it didn't cover that area.
- I needed to see route alternatives, too. It was too hard to second guess where the traffic was heading during congestion.
- I thought the concept of the device was great, but I felt like sometimes it was not entirely clear
- I think the information would have been more useful if it showed when traffic was between 30mph and 45mph; that made a huge difference because sometimes I would take a route I wouldn't normally take because it was clear; however, the traffic was definitel
- I wish it should surface streets to and all of 522 through Lake City to I-5
- I thought the concept of the device was great, but I felt like sometimes it was not entirely clear
- I wish it would have a way to tell you if there is an accident, like a blinking car symbol
- I would like to see more accurate speed range icons
- Ideally it would be nice to be able to zoom into specific areas
- id required to enter survey info
- if the unit would stay logged in even when you were not on the freeway that would be great. Many times I could not see what traffic was doing (and which route to take) until it was too late
- Ideally it would be nice to be able to zoom into specific areas
- image burn-in
- Image detail; i.e., show exits for a reference
- image quality is poor compared with other devices, such as Web view or smart phones
- image quality compared with WSDOT website on i Phone device
- Image too dim, even with battery change
- In afternoon light, the flashing lines sometimes are difficult to see
- In regards to geo coverage, I live in marysville so snohomish would be nice as opposed to tacoma
- inconsistent/incorrect scale made it difficult to judge whether a problem area was really before or after a junction

- In some cases it doesn't seem like the information was updating fast enough; there were a few occasions where I got stuck in stop-and-go due to an accident or other problem when the device was showing clear traffic. Also, the device doesn't show issues v

- info differed from WSDOT site, and nothing, solid and blinking did not give a good guage of level of traffic. the dash size was too large and was misinterpreted a few times

- info not up to date or detailed enough

- info seemed delayed or unreliable

- info seemed to be delayed.

- info was sometimes wrong and needs more area coverage

- Information is too limited.

- information isn't fast enough. i've been in traffic jams that lasted for an hour or more and never shown on my traffic gauge

- information not granular enough

- information seemed dated at times; difficult to associate exact traffic location with image on screen

- Information shown on HWY 99 not very accurate

- Information update frequency

- Information was no more useful than just checking WSDOT traffic map before leaving

- Information wasn't as detailed as the wsdot traffic pages - at 405 & 520, more details matter b/c it indicates what kind of backup is going on.

- information wasn't detailed enough (map detail too general, traffic segments too large)

- infrequent updates

- Insufficent illumination.

- Insufficient data resolution - the road divisions on the device are too big to accurately display where traffic congestion is occuring. Also, the device often shows no traffic in areas with significant congestion.

- insufficient detail

- interface is not easy to "read" (black/white small scale no alternative road inability to zoom in and see alternative road or where the actual congestion is) interpreting raw data--would like color

- interchanges did not display traffic information accurately

- It's another clunky device that I don't need. iPhone map/traffic gauge functions much better.

- It's the side roads that really determine my travel time: Merce Street 509 518 etc., all the smaller roadways that are crucial to my commute. The TrafficGauge would only be effective if these were included . . . Otherwise it never really helped me.

- it's too heavy and bulky
- it's yet another gadget to keep track of
- It's very difficult to gauge which route will be better when ALL of the routes are "black" or have the flashing black.
- it's way to big and the screen is not very precise
- It didn't show surface streets do you couldn't adjust your route if the freeway was too backed up
- it's way to big and the screen is not very precise
- It does not cover the areas I travel, as I live in Monroe and use 522 heavily and other side roads (Duvall, Avondale, etc.)
- It basically said "you're good" or "you're screwed". In the latter, didn't help re-route.
- It does not cover the areas I travel, as I live in Monroe and use 522 heavily and other side roads (Duvall, Avondale, etc.)
- It just wasn't useful compared against existing options
- it kept sliding around and falling on the floor of the car. Would've liked it mounted somewhere easy to see.
- it lags behind reality, the radio provides better, more timely information
- it needs to show more of the side streets
- It often says there is congestion when there isn't, so I found it unreliable.
- It only updating every 4 minutes. Every 2 minutes would be more useful.
- it provides insufficient information
- it SHOWS 99, but it didn't really give any LIVE INFORMATION on 99 (got stuck in traffic a few times due to this)
- It was no different than WSDOT on a PDA/Smartphone. Actually, the PDA was more accurate in updates. Often I'd rely on it just to run into heavy traffic not shown on the TG.
- it would be nice to have real time ACCIDENT updates/info on the traffic guage.
- It would be nice to see arterials in Seattle and expand coverage to include Olympia
- It would have been nice if it were specific on HOV vs. regular lanes and on/off ramps
- It would have helped to have WS bridge
- its its own device, this would be so much better on a phone or pda

- its just one more gadget....
- just a little wider area of coverage would have been great
- just seattle area didn't help
- lack of accident information
- lack of alternate route info
- lack of alternative routes
- lack of arterial roads coverage
- lack of alternative surface street options
- lack of arterial coverage
- lack of arterial information
- lack of arterial information was incredible negative, as arterials are the alternatives to the major freeways.
- lack of arterial roadway information
- lack of arterials - West Seattle freeway/bridge
- lack of arterials
- lack of color
- Lack of coverage in the northeasterly corridor (e.g., Hwy 9, SR522, SR 527)
- lack of coverage on arterials
- Lack of coverage. Dead spots.
- lack of detail
-
- lack of detail regarding anything other than main highways
- Lack of detail on general transit lanes and HOV lanes
- Lack of features.
- Lack of fidelity on the screen due to ancient LCD technology
- lack of granularity- inclusion of areas I don't care about
- lack of local (intracity) information
- lack of in town roads (northup way, bellevue way, etc)
- lack of other streets
- lack of major arterial roads
- lack of side streets
- lack of provided dash holder/ built own
- lack of surface street info
- lack of travel time, blocks too large
- lacking in smaller arterials
- lacked useful info what about Hwy 169 need to be able to zoom in (think Google Maps)
- landmarks on highway hard to determine.
- latency
- LCD indicators started to fail after about three weeks.

- LED interface is dull, color would be nice
- Less detail than than the DOT website (e.g., no red/yellow/green, road segments are longer)
- Level of detail on the maps
- lighting poor
- light should stay on longer or have a switch. Hopefully it could be made less affected to cold temperatures.
- like to know travel times
- like to know travel times
- limited area
- Limited info-roads alternatives
- limitation of routes displayed and information provided.
- limited info- more detail would help
- limited roadways
- Limited info-roads alternatives
- limited to freeways
- limited to freeways. No coverage of heavily used byways.
- limited roadways displayed
- limted roads, mostly controled time of departure not route, no real alternate routes, need gps device with alternate options not static map
- Local streets not shown
- long delay in updates
- losing signal
- losing service in parking garages
- lousy backlight
- low contrast of roadway imagry makes it difficult to read at a glance.
- Low display lighting. Sometimes misread the direct of flow when splitting focus between unit and driving, arrows might help.
- low quality of LED display
- low resolution so data is pretty much what I already knew
- Major arterials - e.g. Airport Way
- map detail not great
- Map is not accurate to the roads, congestion info provided is limited or not accurate. The iPhone provides better traffic information.
- Miles of road within each traffic display - too long
- missing sections on covered roadways
- missing geographical markers, e.g., exit numbers

- Moderate to heavy traffic indications on traffic gauge did not match actual conditions
- missing sections on covered roadways
- monochrome - color would be better
- more detail on specific location
- more geographical coverage, pass information
- More variation in traffic patterns then three displays would be much more useful
- My commute is mainly during prime rush hour. The impact was minimal most of the time. It would bave been helpful to see if side streets would have been faster.
- Need arterial roadways
- my device died
- need broader geographical coverage
- need arterial info
- need farther north than Everett and Hwy 529/Hwy 9/Hwy 2 info
- Need hwy 99
- Need mile marks on traffic gauge.
- Need Montlake and Pacific!
- need more area coverage and arterial roads
- Need shorter time interval between data updates.
- need those arterials!
- need to show where the freeway exits are, so you can tell where the jam ups are; traffic jams sometimes happen after I check TrafficGauge and decide to commit to a route, my best guess on traffic at times of day was usually better because I could anticipa
- Need wider coverage area, greater detail, zoom in/out
- Needed arterials
- Needed more info on Lake City Way congestion
- Needed to be able to weigh traffic on alternate routes. Re. the small image- it took awhile to really understand that one line equaled 7 miles!
- needs better lighting
- Needs color screen
- needs Everett information
- Needs Hwy 16 and the Hwy 167 data seems inaccurate often.
- needs more data points on 99
- Needs more detail; hard [to read] in a tiny space
- needs more detail

- Needs more distinct way of identifying where the slow down starts. The generalized map lacks landmarks.

- Needs to be finer mesh. Also, I noted at times it seemed very innacurate

- Needs to be more detailed and faster.

- Needs to be smaller; maybe pocket size so you can carry it with you. Don't like leaving it in view in the car and don't want to buy one for each car. Sometimes showed "heavy" traffic on I-90 and there was little if any traffic congestion.

- Needs to be more detailed and faster.

- needs to expand as WSDOT info expands, i.e. recent expansion of the traffic flow map at WSDOT's website.

- needs to show Tacoma to Olympia area

- needs West Seattle Bridge

- never told me anything I didn't already know

- Night light too weak

- No "real time" estimates or details of congestion.

- no alarm to tell about changes when they happened.

- No alternate route info such as side streets to avoid main highways

- no alternate route provided

- no arterials

- no arterial routes

- no arterial roads

- No arterials, knowing what exits traffic jams where located. Had to guess based on location of segments.

- no arterial roadways. We all know when the traffic jams are and where so this was just a visual of what we know. No way to figure out around it with this device.

- no carpool lane info; sometimes doing 60+ when TrafficGauge shows heavy traffic and other times was under 20 mph when the gauge shows light traffic; not enough info to plan reasonable alternates

- no backroad data

- No bridge status

- No carpool lane indication

- no context in display, poor display quality, monochrome is very hard to interpret data

- no coverage of Avondale Way past Hwy520

- No eastside side street (116th or Bellevue Way, or 108th NE in Kirkland, etc.
- no explanation for traffic issues, eg accident, construction, etc
- No info on whether alternate routes without coverage were less congested
- no helpful information
- No information about Hwy 9
- no HOV lane view; color display would be easier to read
- No information about volume of flow or accidents.
- no info on West Seattle Bridge- lack of info some times on other routes
- no information on arterial roads
- no information about Hwy 9
- no information on Hwy 99 - would be very helpful to plan alternate routes when major thoroughfares are jammed
- No lane data map is fixed only three speed ranges
- No longer worked because subscription expired
- no multiple lanes coverage
- No negative issues
- spotty Hwy 99 coverage
- No North/South indicator - confusing sometimes
- should be in color
- Not enough information
- not enough detail with 3 traffic level indicators
- no on/offramp coverage. I use 520w to 405n every day and would have loved to know if the interchange was backed up
- not enough detail where congestion really ends/begins
- no side street information
- Not enough detail
- no side street information (e.g., Hwy 99 and 15th North)
- No side streets, no eastside info
- No signal available at my home. No method available for recommending alternative routes or estimated travel times.
- no signal in parking garage
- No signal on I-405 South going into Renton
- No surface streets
- no surface streets included
- no travel times
- No travel times given to make a comparative decision
- no W.Seattle Bridge!

- No West Seattle bridge info.
- non-functioning backlight; feels cheap.
- None. Loved it.
- none
- None. The device performed flawlessly during the whole course of the study.
- None
- None! It is GREAT!
- North & South direction indication - which lane goes North and which lane goes sounth. It was confusing at times.
- not able to secure to dashboard - window only
- not as granular as I needed; didn't always seem accurate
- not as rich and colorful as traffic applications for phones and PDA's
- not color display
- not enough arterial roads
- not enough detail
- not enough detail for other arterials
- not enough detail on image.
- not enough detail, could also use more landmarks like HWY524)
- not enough details -- need arterials info
- Not enough detail. It was also very difficult to see in the dark and as I was traveling mostly in the dark of morning and evening (winter hours) it was pretty usless to me if I was in the car.
- not enough details
- Not enough granularity (heavy traffic vs. completely stopped)
- not enough info to plot alt course
- not enough of 522 displayed for my use
- Not enough information
- not enough specific information or detail
- Not enough like WSDOT traffic conditions online
- not enough specific information or detail
- not granular enough -- wish I could get more exact idea of where traffic started/stopped
- not enough street coverage to accurately check my commute
- not new information (timeframes)
- not much - but really could've used info on arterials because that would've given me the info I needed for alternative routes.

- not sure what segment of freeway each bar represented
- not to scale (i.e. low granularity)
- Not up to date. I can get the same info from my home computer.
- Not useful for a route with no alternates
- not useful if there is only one route
- not very accurate, takes 5mins to boot-up
- nothing
- Nothing
- off-angle viewing is terrible on the LCD. Screen isn't impact-resistant enough, and one of the express lane-indicator arrows for I90 is permanently stuck in a half-on state. Device is also big and bulky (if the iPhone can be that small and do so much more
- Often out of range. Clear and "no info" available looked the same.
- Once you figure it out what you are looking at on the screen it works well
- On occasion I would encounter heavy traffic but the gauge had indicated the coast was clear. Also, I had the gauge for about a week when after checking and saw no traffic problems, entered a completely jammed up freeway. After finally getting to work I
- Only cover major highways
- only displays information not alternate routes
- only freeway coverage
- only gives the freeways.
- only main hwys listed
- Only one functionality..I rather get a iphone
- Only showed freeways, not other roads
- only showed road segments in 2 mile strips
- Only showed freeways, not other roads
- only shows freeways
- Only that information was not displayed 24/7
- only useful in Seattle area. would be nice for it to provide other cities on same device
- Other arterial routes (from the south)
- other streets besides just highways (like NE 8th in Bellevue) would be really beneficial to have
- outage areas where I wanted to travel- especially on hwy 99
- oversized device with very little information on details of actual

traffic conditions. Bulky, ugly, less useful than just calling 511

- please add alternate roads
- Please see my response to question 6.
- Poor axial viewing, relates to where I can reliably place device in my vehicle [2006 Touareg]
- Poor backlighting
- poor screen icon resolution and very poor illumination
- poor visual contrast, no ferry coverage
- possibly more detail
- precision of information
- Precision of map display... hard to decipher exactly where traffic jam was, which would allow me to avoid it more accurately.
- precision of information display
- Professional soccer games not indicated
- Precision of map display... hard to decipher exactly where traffic jam was, which would allow me to avoid it more accurately.
- Radio reports were more accurate and useful to avoid slowdowns
- Rarely did it accurately portray traffic in Everett. It also missed heavy traffic on 99 (viaduct).
- Really need arterial streets' info
- refresh rate slow
- Refresh rate
- resolution of data. webflow maps have more degrees of traffic represented
- Resolution of device is poor
- resolution of traffic data was low and needs arterial info, for instance, its not very usefull for a snouqlamie to issaquah or bellevue commute
- resolution too low to make exit choices, doesn't provide any useful detail
- roads other than freeways are not addressed
- scale for guage; refresh rate
- Scale is too large to make out details
- screen
- Scale made it hard to tell exactly where you actually are
- see comments below
- see final comments
- See 12 below
- segments are too large to pinpoint where traffic problems begin iand end
- see comments below
- separate carpool lane info

- Serious lag in real-time info from WSDOT, lack of detail for freeways - plenty of delays encountered when Traffic Guage indicated roads were clear. When the bars were solid there was huge variety in the amount of congestion encountered. The only time it

- Several times I was stopped on SR167 south and trafficgauge said 'all clear'. South of SR18 on SR167, it would be nice to have coverage/data.

- several times the information was not correct- there would be times that the device said the roads were clear and it was indeed backed up.

- Severe Lag in updates (15 Minutes +): Sometimes it indicated totally clear in spots where I was in stopped traffic for 15 minutes.

- Should be a color display

- Should be color. Some days it was yellow more than one little red area and extended my commute

- Should not use blinking for heavy traffic or at all. This required you to look at the gauge for too long a period to acertain if it is clear or heavy when driving than is safe

- Should offer a wired 12v solution.

- Should show more than just freeways

- Show Pacific Hwy 99, and 509

- signal

- signal strength

- since there was no information on arterials to make a judgement from traveling from Auburn to Everett at peak times best to stay on main line then to guess if an aterial is better.

- Size is a bit awkward- a little too small to find right away but too big to be put in convenient locations. Not bad, just not ideal.

- size and weight

- size of the device bulky

-

- Size of TrafficGauge

- size of unit and archaic design

- slow refresh rates

- slow update speeds

- slow updates to traffic status

- slow to update

- slow updating of some areas

- slow update speeds

- SMALL IMAGE!

- slow updating of some areas

- Sometimes we ran into traffic that wasn't noted yet on TrafficGauge though I'm sure there is always some delay

- Sometimes not updated fast enough to avoid trouble; could use more detail

- solid or blinking bars didn't necessarily mean there was heavy traffic or it underestimated the heavyness of traffic

- Sometimes there seemed to be a delay in the info being displayed.

- sometimes seemed to be behind real time

- specificity of image, the bars on the screen cover a wide area and don't provide the specific information for the gradation of delays and exactly where they are located

- SR 512 info not current. Three fatal accidents and the TrafficGauge showed SR 512 wide open when it was closed both ways.

- speed "zone" should start at 45mph

- static map is not good; want to zoom

- status of small freeways, 509, 518; and arterials eg Airport Way, S.180 Tukwila/S.43rd Renton

- stopped working and wasn't a battery problem. No good information on malfunctions or who to call

- stress of knowing what kind of traffic i was heading for

- Subscription to expire prematurely

- Surface street information

- surface streets- Lake City Way; Bothell Way

- the 4 minute update timeframe is a bit long for accuracy and route planning

- the amount of the delay was hard to determine, also the exact location of the delay

- The arterial roadways would have been helpful, specifically the west seattle bridge.

- the backlight didn't always respond and should also stay on a bit longer

- The bars are pretty big, meaning they cover a large area. I think I5 downtown is one or two bars. That's a huge area that might have traffic at the exits but not necessarily in between. A close up of downtown would be helpful.

- The data needs to be updated more quickly to help me avoid slowdowns

- the device was hard to hold the screen contrast was not good in daylight. better at nite w/backlite

- The gauge didn't always work. It was blank sometimes.

- the gauge sometimes didn't work

- The image is hard to see-especially at night. The back-lit-color image on the iPhone is much more useful.

- the images was almost an all or nothing thing. The color schematic on WADOT works better.

- The information I can access using a mobile phone with a web browser through the WSDOT website it a bit more accurate.

- The information on 99 was usually not accurate. 99 is my alternate route so there were numerous times when I'd cut over to 99 only to find it congested too.

- The Kirkland batteries failed after 4 days. Just as I was beginning to rely on the guage, the batteries went dead, showed a clear screen, and I hopped on the freeway into a major mess...very dissapointing.

- The newer larger device is harder to see than the original

- The relation of the black bars to actual freeway areas seemed to vary at times, especially Fife- Tacoma area.

- The scale is not quite accurate; sometimes the area that was congested would appear smaller on the gauge than it actually was.

- The scale of the "icons" is rather large, sometimes it would show an area as very busy but when I got there only a small part of the area was busy. Areas of non- coverage are not easy to identify.

- The scale of the map for puget sound region is not accurate

- the shape is awkward, it needs to be like a iPod or Blackberry and the screen need better backlighting

- The strokes were too broad. Needs more detail about freeway conditions.

- the three gradations of data were insufficient. Eg: more categories are needed between clear and solid and solid and blinking.

- The times I did travel north to Seattle, it was very difficult to distinguish northbound from southbound in a glance. They should use different colors for north and south or something that is less distracting to use while driving.

- The way it evalauted "light" traffic was terrible. Anything 30 mi/hr? 32 mi/hr on a 60 mi/hr road is not light!

- There are more traffic problems in Everett than Seattle.

- there were very few opportunites to change routes in this region. The guage gave me info about what to anticipate, but little benefit beyond that

- There was a delay in the delays
- There was often no reception in the morning when I needed to make decisions on the route
- There was really no good place to keep the device in my car. This should be considered in the design of the device... Maybe something not so square that could fit in a cup holder or on the dash. The only option seemed to be to purchase a device that could
- They should show the West Seattle Bridge; biggest part of my commute
- There weren't options for I-405, that was my only way to work
- This gets to accuracy - each segment covered too large of a distance to sometimes accurately show traffic.
- Those little flashing lights look small- but when you get there- the traffic is big.
- Three times during the study I was not able to get reception from my work in Redmond. Some of the display bars are fading making it difficult to read quickly. I have been caught in traffic at a dead stop and there is no corrisponding image on the traffic
- time delay of information; one time I was caught in a bad traffic jam on the 520 bridge, and the gauge didn't show it. (I'm not sure how long the delay is before the gauge indicates a jam; it might be very short and I was just very unlucky.) Also, the g
- time delay or data display finesse
- time it takes to hook up to satellite; i am usually already on the highway by then.
- time lag on I5 - sometimes it showed clear when the traffic was already backed up
- timeliness--there seemed to be a significant delay in when traffic began and when it was finally displayed
- timeliness of data displayed
- Timeliness of info
- timeliness of updates
- too big
- Too big to mount (obstruction) or fit nicely in a cupholder
- too broad of area on my device.
- too distracting from driving
-
- tough to figure out the 99 traffic
- tough to glance at and know how to adjust your route. Color makes a huge difference.
- TrafficGauge should display WSF sailing delays.

- traffic cam/coverage on the washington transportation page gave me better information and it's free.
- Traffic data was sometimes late in appearing
- traffic had to be really backed up for it to show on the display
- Traffic seems to change so fast around here that the four minute lag for updates can be too long an interval.
- traffic volumes didn't match information displayed
- twice I was in slow traffic, display showed a clear road
- unable to mount on dash
- unable to mount in my car for ease of checking during a trip
- unable to read the dimly lit screen without reading glasses . . . Needed to be brighter for use in darkness
- undocumented icons
- unable to mount on dash
- unit size too large to fit in pocket
- unable to read the dimly lite screen without reading glasses...needed to be brighter for use in darkness
- Unit was too primitive, better display would be nice
- unknown symbols
- Unsafe to use while driving.
- unsure if info timely--sometimes conditions did not match report
- Update Rate (see comments below)
- Update Time
- update time did not seam quick
- Updates too slow - a lot can change within a 10 minute cycle.
- very limited in its usefulness.
- Very poor backlighting, reading in darkness is unsafe.
- Very poor signal last 2 weeks made device all but unusable
- viewing in dark, light was not real effective
- want a nicer less static user interface
- want more granular info--like Seatraffic
- was about 5-10 mins off
- was not always accurate
- was not germane to the routes I use
- was out of juice- then off signal some of the time I needed to use it.
- was shit outage during the study
- Washington DOT website offered finer level of detail of traffic

- what alternative routes were like
- when highways are bad I'm still on my own to find alternative routes
- whether or not it received a signal
- wish it displayed info about time to get from A to B
- wonder if an arrow under a border crossing means good or means bad
- Would be better if were color coded like google traffic
- would be great to couple this with GPS
- would be nice if it were more localized
- would be nice to see color on the screen as well as the ability to choose different Puget Sound areas to focus in on to evaluate road conditions
- would be nice to have a reference (e.g. turn to a radio station) to learn about about abnormal congestion (e.g. congestion outside normal commute times)
- would be nice to shut off to save battery
- Would have liked color rather than black & gray
- would like color
- Would like info about major arterials such as Duvall Ave or WA 900 in Renton
- would like more specifics on mph
- would like to see estimated traffic times for a couple of my main routes, similar to what is provided on dot traffic page
- Would love to see Issaquah-Hobart road on the gauge (and WSDOT.wa.gov). I'd find myself avoiding 405 due to the Gauge's data, but delays on I-H often meant 405 was the better route anyway.
- WSDOT mobile traffic page seems to be more accurate
- you can get the same info on a mobile phone for free from the WA State DOT site

APPENDIX D

SURVEY COMMENTS: PRICE

- $0-50 if additional subscription fees apply, more for a single one time payment

- $0 - I drive from Auburn to Olympia for most commute days. The device regularly showed no congestion at all when the traffic was stopped or slowed to less than 20 miles per hour in Tacoma anywhere be

- $0 if a subscription is required

- $15

- $15 without expansion

- $20

- $25

- $25 maximum

- $30, but how about offering for a real small amount if lifetime service is purchased from the very beginning?

- $40

- $40 but only if it was expanded version as suggested in #2c

- $50 IF unit provided wider regional info

- $50 or $70, but only if it had expanded information

- 10

- 10 dollors

- 20

- 50 is a reasonable figure if the data was more expansive. However there are so few alternative choices for which way to go that the device provides little value. If the data were expanded to surface

- 50 to 150 depending on features

- a one-time fee isn't a big deal, but the subscriber fee is hard to swallow considering this data is free online

- About $40

- absolutely necessary to have data on main arterial roads - otherwise only info provided by freeway info is whether to leave now or later.

- After about three weeks, some of the LCD indicators failed to work on some roadways.

- As a feature to my cell phone/GPS or other device

- Between 30 - 50 would be a reasonable price to pay

- but I found it to not be working a fair amout of time. that would have to be fixed

- cellphones have similar technology

- depending on the features I would consider purchasing, but because it is a paid service the cost of the device detracts from the desirability, so I would not expect to pay much

- depends on how much improved
- Depends on how much information is available.
- Depends on info available on it
- Depends on level of functionality. Maximum $100
- Depends on service price, maybe $50 with reasonable service, more with lifetime service
- Depends on the cost of the monthly service - if monthly service rate is low I would pay more to purchase the devise
- depends on the features/monthly fee, etc.
- Depends on the monthly fee
- Depends on the overal annual cost.
- Depends upon monthly subscriber fee
- Depends upon the coverage and usefulness for my situation
- depends, I would pay more if I didn't have to buy a subscription
- Device should be free - or nearly - costs should be solely the monthly fees.
- device should be free if they are going to charge a subscriber fee
- Device should be free with subscription
- Device should be free, pay for service
- Don't think I would pay for it after using
- first, I thought this was neat gadget.. but there were lot of wrong information. picutre of current traffic would be a big help!
- for the device or the service? Device 30.00 dollars
- Found device hard to read and not realtime. STOPED in traffic and gauge showed clear.
- free with 2yr subscription (like cell phones)
- free with package deal
- Free with subscription to service
- highly depends on functionality, but probably no more than $50 and heavily dependent on monthly fee
- I'd be willing to buy it but I don't think I would buy into the monthly fee.
- I'd be willing to pay well over 100 dollars but the device should incorporate major arterials and a GPS-based position indicator - not actual GPS mapping, just a relative position indicator using the
- I'd buy the unit- but the monthly subscriber fee is too much.

- I'd love an ad-supported trafficgauge!
- I'd only purchase one with more arterial information and a way to customize the view.
- I'd only purchase the device if it was more accurate and had more info. This device cost me more time than it was worth.
- I'd pay at least $50, but it would have to include Eastside arterials.
- I'd pay more if it was apart of a GPS system
- I'd rather pay a one-off fee than a monthly subscription
- I'm more likely to check before I go, or call someone who can check the web for me.
- I already have a better version on my iPhone. However- if I didn't- probably in the $30 range.
- I can view more detailed information on the WSDOT traffic website using my Blackberry
- I didn't find this device informative enough to rely on it alone. I still checked the WDOT site to check the cameras.
- i dont mind spending money at all if the traffic gauge is very useful
- I find the display difficult to read, certainly can't do it at a glance therefore use is limited for me, and I wouldn't purchase
- I got an gps for my birthday
- I have a Blackberry to see traffic congestion.
- I have added DOT traffic maps to my blackberry device. For me, that is the best solution--to enable an existing device and beef up the info with arterial reporting.
- I think it should be free- it would enc myself and others to take alt routes if we had the live infromation.
- I think that more needs to be done to the device- before I would purches it. I did't find it very user friendly. I think color coding major congestions in red would be helpful- as well as having a s
- I would be willing to pay much more for a color version
- I would buy one if there wasn't a monthly fee
- I would consider purchasing a device if it had more detail on traffic conditions (< 4 mile increments)
- I would consider upgrading to a web phone with DOT info first.
- I would have paid $50 before I owned own. Now that I do, I am not impressed
- I would if I had not moved to Mercer Island just after I got this.

- I would not purchase this device-maybe another
- I would only be willing to pay if it were more inclusive...I think GPS systems with traffic enabled will take the place of this to be honest.
- I would pay for the monthly fee, but would expect to have a free device
- I would pay more for an integrated solution that included GPS navigation. The LCD screen on the TrafficGauge is hard to read and the night light is weak. I am unlikely to buy a device similar to the
- I would pay more if there were colors and better lighting. Probably $125.
- I would purchase a traffic gauge if it had more features...depending on the features I would be willing to pay between $30 and $50.
- I would purchase on for say $30.00 if I didn't have to pay a monthly access fee - and if more streets were available and if the coverage was 24 hours which it didn't seem to be.
- If arterials found to be helpful (e.g., Hwy 99 North)
- if it did Everrett & Tacoma
- if it had more comprehensive info
- if it were more accurate I would, sometimes there's traffic and the gauge doesn't show it.
- If there is a free download for cell phones why pay?
- If there was a more detailed map
- If there was additional info
- It's probably worth more, I just don't have it to spend.
- It all depends on the device. Can I upgrade the model and received some credit? What does the version consist of? Would it include other devices such as a scroll feature? Can the device be plugged
- It has been fun to look at but the radio traffic information was enough about 90% of the time. Possibly having more southsound info like Hwy 16 to the freeway and the new collector distributor would b
- It is info freely available to smartphones, so I would not purchase a seperate device
- It really depends on how well designed and user friendly it is. I found the current model too difficult to view.
- It would depend on any expanded features
- It would depend on the info it provided and the cost of the service.

- It would depend on the monthly fee.

- It would depend on the total feature set

- Make it stand on the side of major hightway instead of having it individually.

- Maybe I would spend $30. If I were buying a GPS system I think this would be a grat addition. But I doubt I would spend as much as they cost.

- mobile devices have this and they can worok in other cities if you move, you need to make sure you charge them for this data since they don't have/own the data

- Most of my drive is outside the TrafficGauge area and not a lot of alternative roads are available.

- my iphone can give me a color version of the same info plus all it's other features

- needs to be color screen

- Needs to be packaged [marketed] w/ cell or internet services. I'm already paying like 500+/mo for communication services (including cable TV))

- Needs to have Northend Seattle

- None for the device as-delivered; $30 for one w/ arterial roadways; $200 for one that suggested an alternate route with estimated travel time based on traffic conditions.

- Not sure

- Not sure, would depend on options

- now that I have the device, I'd probably the $7 for service

- Price would be relevant to capabilities of device.

- Probably $30-$50, if it included information about arterials and other major roads like highway 9. For both the device price and the service price, I think the key would be making it more informative

- see #1 & #2 - price not the issue

- Seems like traffic data integrated into one of the inexpensive GPS units would be the way to go to me...

- Should just be on cell phones

- Since the area covered doesn't include my area- I wouldn't purchase one at this time.

- Smartphones with internet access provide the same information - I think many people will use those instead.

- The amount depends heavily on the subscriber fee and whether arterial roadways were included in the device.

- The device lags real-time info from WSDOT by at least 15-20 min plus lacks sufficient detail about congestion on freeways.

Both issues make it difficult to justify purchase.

- The device would need to change to justify a monthly payment however I would pay a 1-time $50 fee for the device as-is

- The information on SR 167 is very inaccurate. Otherwise I'd consider it.

- the refresh rate on the device (4 min) is much too slow given the rapidity with which problems can occur and the limited number of alternate routes. By the time you see a problem, chances are your on

- the traffic gauge display wasn't easy to read while on the road and lacked the detail of the WSDOT website. I looked at my cell phone more often through MobileWeb to check traffic.

- The WSDOT has more granular data (carpool lane info, four levels of congestion, travel time estimates), is full color, is updated faster, and I can use it from my PDA phone for free. Why would I pay o

- there are some needed improvements to this device before I would purchase it. #1 it should display estimated drive times on routes. I make decisions based on time savings - not whether a route is over

- There was no answer for maybe. It would depend on many different things.

- These should be built into cars dashboards

- Thirty dollars or less

- This data can be accessed by cellphone, which includes colors... needs to be priced competitively like $40

- this would be a feature-driven decision. How useful would the TG be on a daily basis?

- To be willing to purchase- it would need better visibility and color coding - I find it very difficult to read while driving

- too basic cellphones can give better details

- Too hard to read. Can't read in the dark....

- typically around 50 depending on the monthly fee, free if fee is higher

- Under $20 is acceptable.

- up to $ 125 if it had arterial roadway info

- wasn't current information

- Willing to pay a higher purchase price to avoid a subscriber fee.

- with my current commute, probably not, but i would definitely consider it

- without a monthly fee

- would buy if covered Everett area

- would depend on the level of detail provided by the unit - I would not pay for the current TrafficGauge

- WSDOT's site has the same info- I don't travel long enough for conditions to change significantly.

- You'd want to make this free vs. as minimal as possible especially bec. of the subscriber fee which need to have a yearly incentive e.g. if the fee was $5/mo make it $50 yearly or $120/3 yrs. w/ disco