

ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)



Impacts of Traveler Information on the Overall Network

FINAL REPORT

Prepared by



September 2012

Technical Report Documentation Page

1. Report No. ENT-2012-2	2. Government Accession No.	3. Recipients Catalog No.	
4. Title and Subtitle Impacts of Traveler Information on the Overall Network		5. Report Date September 2012	
		6. Performing Organization Code	
7. Author(s) Dean Deeter		8. Performing Organization Report No.	
9. Performing Organization Name and Address Athey Creek Consultants 2610 Lexington Terrace West Linn, OR 97068		10. Project/Task/Work Unit No.	
		11. Contract (C) or Grant (G) No. (C) 2010-0316	
12. Sponsoring Organization Name and Address ENTERPRISE Pooled Fund Study TPF-5(231) Michigan DOT (Administering State) PO Box 30050 Lansing, MI 48909		13. Type of Report and Period Covered Final Report	
		14. Sponsoring Agency Code	
15. Supplementary Notes Final Report available at: http://enterprise.prog.org/Projects/2010_Present/travelinfoimpacts.html			
16. Abstract ENTERPRISE member agencies use a variety of tools and approaches to inform travelers about conditions on the roadways, including Dynamic Message Signs (DMS) and traffic flow maps on internet dissemination websites. The impacts of these tools are not clearly understood. While the public response to these dissemination tools has been very positive, there remains minimal solid evidence about the travel pattern changes caused by these messages or the impacts on other routes. Based upon the ENTERPRISE Travel Time Best Practices project, in nearly every state deployed, the travel time reports have received very positive feedback, and perhaps the value lies in informing travelers of conditions ahead, regardless of whether they divert. ENTERPRISE recognized the need for additional research on the impacts of traveler information and approved the <i>“Impacts of Traveler Information on the Overall Network Project”</i> to focus on understanding the impacts that travel time message displays (web and roadside) have on the network. To determine the impacts of travel times, on-line surveys were created and linked to the traveler information portion of the Minnesota and Washington State Department of Transportation (DOT) websites to gather feedback from travelers regarding their use of travel time information displayed on the web and on roadside DMS. In addition to surveying travelers’ opinions, historical travel time displays on DMS together with related traffic volume data (from locations downstream of the DMS) from the Minnesota and Washington State networks were analyzed.			
17. Key Words traveler Information, Washington, Minnesota, DMS, traffic flow maps		18. Distribution Statement No restrictions.	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 40	22. Price

Acknowledgements

This document was prepared for the [ENTERPRISE Transportation Pooled Fund TPF-5\(231\)](#) program. With agencies from North America and Europe, the main purpose of ENTERPRISE is to use the pooled resources of its members, private sector partners and the United States federal government to develop, evaluate and deploy Intelligent Transportation Systems (ITS).

Project Champion

Bill Legg, Washington State Department of Transportation, was the ENTERPRISE Project Champion for this effort.

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Photos included in this report were provided courtesy of the Minnesota Department of Transportation.

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1.0 Introduction and Executive Summary

ENTERPRISE member agencies use a variety of tools and approaches to inform travelers about conditions on the roadways, including Dynamic Message Signs (DMS) and traffic flow maps on internet dissemination websites. The impacts of these tools are not clearly understood. While the public response to these dissemination tools has been very positive, there remains minimal solid evidence about the travel pattern changes caused by these messages or the impacts on other routes.

ENTERPRISE recognized the need for additional research on the impacts of traveler information and approved the *“Impacts of Traveler Information on the Overall Network Project”* to focus on understanding the impacts that travel time message displays (web and roadside) have on the network.

To determine the impacts of travel times, on-line surveys were created and linked to the traveler information portion of the Minnesota and Washington State Department of Transportation (DOT) websites to gather feedback from travelers regarding their use of travel time information displayed on the web and on roadside DMS.

In addition to surveying travelers’ opinions, historical travel time displays on DMS together with related traffic volume data (from locations downstream of the DMS) from the Minnesota and Washington State networks were analyzed.

Summary of Findings

The findings of this project are summarized as follows:

- Traveler surveys in both Washington and Minnesota suggest that drivers do react to longer than typical travel time displays on roadside DMS by diverting to alternate routes.
- When asked to quantify how much the travel time display needs to exceed the typical time to cause a diversion, the survey responses suggest that posting a travel time value that is approximately double the typical travel time causes an increase in diversions to alternate routes:
 - Minnesota drivers responding to the survey indicated a threshold range of 5-10 minutes longer than typical travel times (note: Typical travel times displayed on Minnesota DMS at many locations are 5-8 minutes during normal traffic conditions).
 - Washington drivers responding to the survey indicated a threshold range of 15-20 minutes longer than typical travel time as the determining factor to divert to an alternate route (note: Seattle travel time displays describe routes with typical travel times of 15-20 minutes during normal traffic conditions).

- The analysis of data (volume and historical DMS travel time displays) in both cities confirms these thresholds:
 - In Minnesota, at four DMS locations analyzed for this project, a pattern was observed where travel times more than 5 minutes longer than typical resulted in an increase in diversions. In addition, travel times more than 10 minutes longer than typical resulted in a further increase in diversions.
 - In Washington, at four DMS locations analyzed for this project, there were a smaller number of situations where travel time displays were longer than typical. Nonetheless, a pattern was observed that suggested that travel times exceeding the typical travel times by 10 minutes create some diversions, and more diversions occur at when travel times are 20 minutes or more than typical.
 - In Washington, travelers appeared more willing to divert to (or remain on) arterials than they were willing to divert to freeways.

- Stopped or very slow traffic speeds at locations where an exit ramp to a viable alternate route were observed to result in increased diversions. However, DMS displays of travel times in addition to drivers observing stopped traffic has an impact as well:
 - With the addition of a DMS displaying travel times, drivers tend to divert more often when warranted (speeds are slower than 5 mph and travel times longer), and drivers tend to divert less often when not warranted (speeds faster than 5 mph and travel times closer to typical). In summary, travelers make better decisions whether to divert with the added DMS display of travel times.

How the Findings Relate to the Larger Industry Picture

The findings of this project should be viewed as a first step towards understanding drivers' reactions to a variety of travel information messages across multiple delivery mediums. The traffic management opportunities now exist to predict traveler route changes when increased travel times are displayed on DMS, allowing alternate signal timings or additional 'wayfinding' message displays on these alternate routes to manage the increased traffic. In addition, looking towards the era of connected vehicles and personalized information delivery, this research offers a glimpse of the impacts and the predictability of impacts when travel time diversion thresholds are met.

Additional research is suggested to understand the impacts of other messages, including alerts to crashes, lane closures, or event descriptions. The ENTERPRISE Program has a related project to this to research the impacts of 'Interpretable' travel information, defined as information displays such as CCTV camera images and weather data that may be interpreted differently by different drivers.

2.0 Project Objective

The overall objective for this project was to better understand how travel time information dissemination impacts drivers' behaviors, more specifically to understand if there are common thresholds where the value of a travel time message creates more diversions, and if this threshold can be understood.

3.0 Traveler Survey Results

Surveys were created using an online tool (Survey Monkey) as one mechanism to help understand the impacts of travel time messages on the network. The surveys were linked from the traveler information portion of the Minnesota and Washington DOT travel information websites. Figure 1 provides a screen shot of the Minnesota survey. The survey was developed with the option for respondents to quickly answer each question by providing multiple choice selections. However the survey also provided the opportunity for respondents to enter comments with free text.

It is critical to acknowledge that because the link to the survey was from the travel information portion of State DOT websites these surveys are not considered 'non-biased' as the sample was not a representative sample of all drivers on the highways. It is recognized that the travelers who are visiting a DOT travel information website represent those travelers who seek (and most likely use) travel information. Nonetheless, the surveys were intended to understand how those travelers that use travel information react to it. Therefore, the ENTERPRISE members agreed that the on-line survey and link from a travel information website was acceptable.

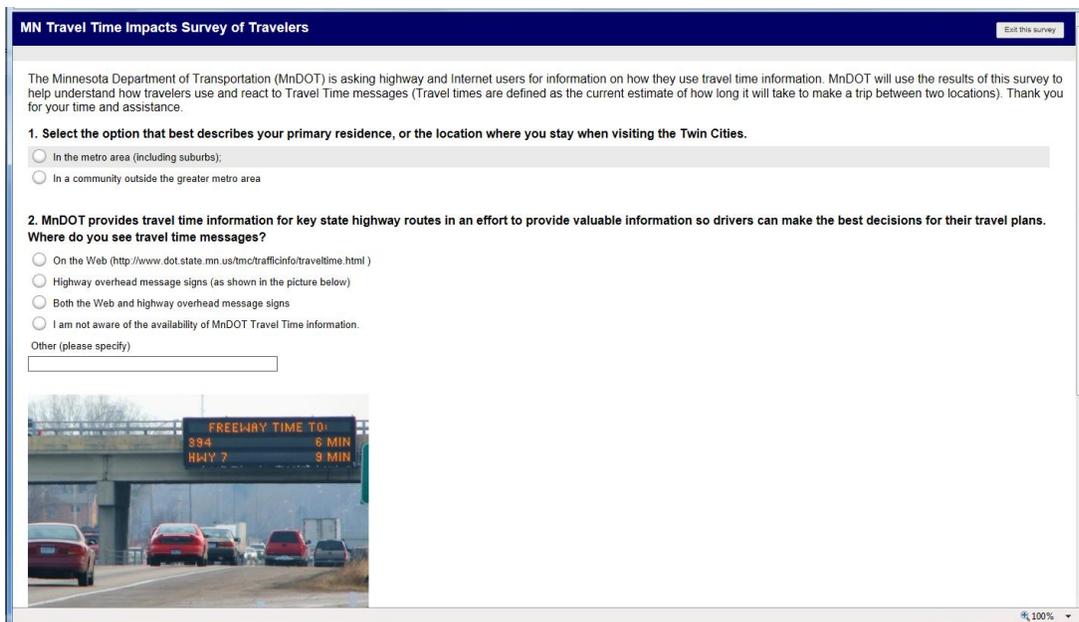


Figure 1: Screen Capture: Minnesota DOT Online Survey

The purpose of the survey was to gather feedback from travelers regarding their use of travel time information displayed on the web and on roadside signs. The same questions were asked on both the Minnesota and Washington surveys; however the language varied slightly to accommodate local nomenclatures and local web links.

The Minnesota survey was available for approximately 5 months from April to September 2012 and 1,030 participants contributed to the survey. The Washington survey was available for approximately 4 months and 693 participants contributed to the survey as shown in Table 1.

Table 1: Number of Survey Participants and Duration

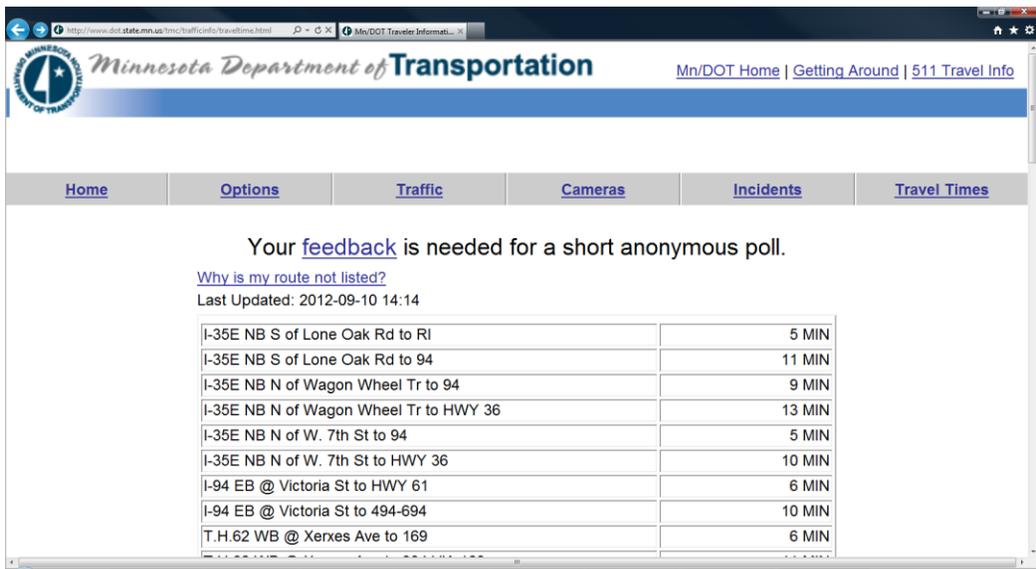
State	Minnesota	Washington
Number of Survey Contributors	1,030	693
Survey Duration	5 months (4.11.12 – 9.5.12)	4 months (5.30.12 – 9.10.12)

The following sections summarize the results and conclusions of the surveys. Appendix A and B include all the questions asked in the survey as well as the responses received for both the Minnesota and Washington surveys.

3.1 Minnesota Travelers' Survey

This section provides an overall summary of the results and conclusions of the online survey in Minnesota that was conducted to understand travelers' reactions to the travel time information disseminated by Minnesota Department of Transportation (MnDOT).

In Minnesota, travel times are provided via a tabular format on MnDOT's webpage as shown in Figure 2 or on signs located along freeways, as shown in Figure 3. The survey for this project was linked from the [MnDOT travel time webpage](http://www.dot.state.mn.us/tmc/trafficinfo/traveltime.html) that is operated by MnDOT.



The screenshot shows the Minnesota Department of Transportation website with a navigation menu and a table of travel times. The table lists routes and their corresponding travel times in minutes.

Route	Travel Time
I-35E NB S of Lone Oak Rd to RI	5 MIN
I-35E NB S of Lone Oak Rd to 94	11 MIN
I-35E NB N of Wagon Wheel Tr to 94	9 MIN
I-35E NB N of Wagon Wheel Tr to HWY 36	13 MIN
I-35E NB N of W. 7th St to 94	5 MIN
I-35E NB N of W. 7th St to HWY 36	10 MIN
I-94 EB @ Victoria St to HWY 61	6 MIN
I-94 EB @ Victoria St to 494-694	10 MIN
T.H.62 WB @ Xerxes Ave to 169	6 MIN

Figure 2: Minnesota DOT Travel Time Website (<http://www.dot.state.mn.us/tmc/trafficinfo/traveltime.html>)



Figure 3: Minnesota DOT Overhead Message Board

3.1.1 Minnesota Travelers' Survey – Summary of Results

Over the five month duration that the survey was online, 1,030 survey responses were collected. The majority (85%) of those that participated in the survey resided in the Twin Cities Metro Area which includes Minneapolis, St. Paul and surrounding suburbs. Only 160 of the respondents that answered questions in the survey were from outside the greater Metro Area.

The responses to the surveys are summarized below.

Travelers' Use of the MnDOT Website Travel Times

Forty-percent (40%) of the respondents indicated that they check the travel times on the website to decide whether to change their route. Additionally, 45% of respondents indicated that they check the website for a combination of three purposes (i.e. to understand the conditions for an upcoming trip, to decide whether to change routes, and to decide whether to change departure times). These results are illustrated in Figure 4.

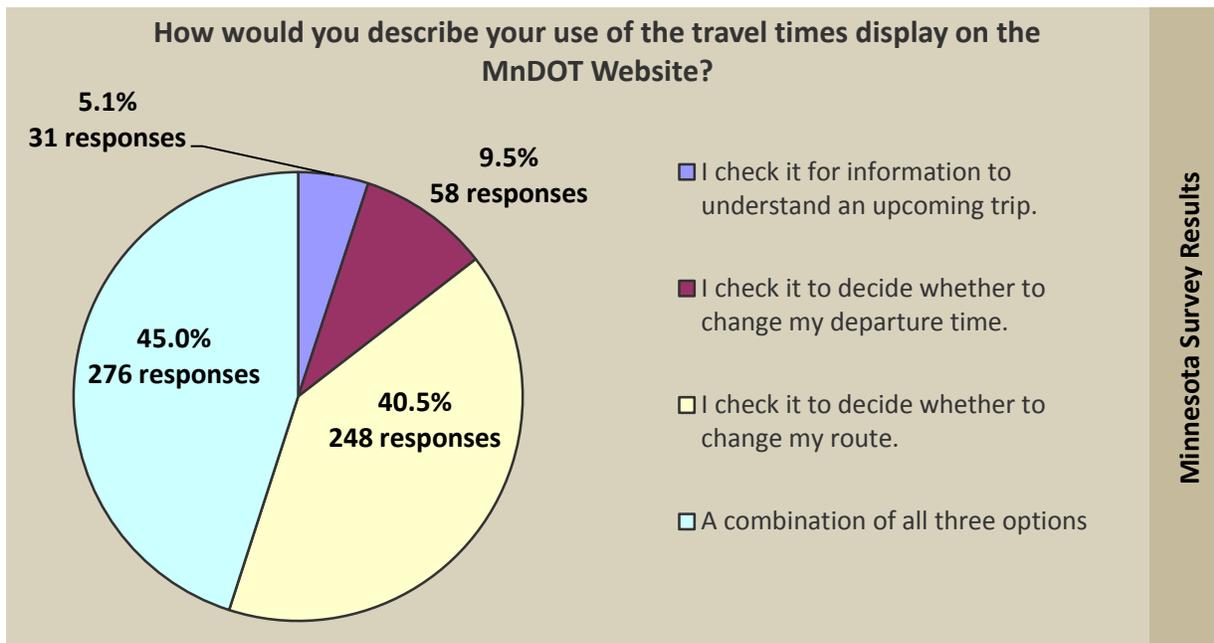


Figure 4: How would you describe your use of the travel times display on the MnDOT Website?

Understanding How DMS Displayed Travel Times Impacted Respondents' Most Recent Trip

Respondents were asked to select an option that most closely matches their reaction the last time they viewed a travel time message on an overhead message sign:

- 42% of respondents indicated that the travel time was longer than normal AND they changed their travel plans.
- 39% indicated that the travel time was typical and they did not change their plans.
- 18% indicated that the travel time was longer than normal but they did not change their travel plans.

Figure 5 illustrates these results.

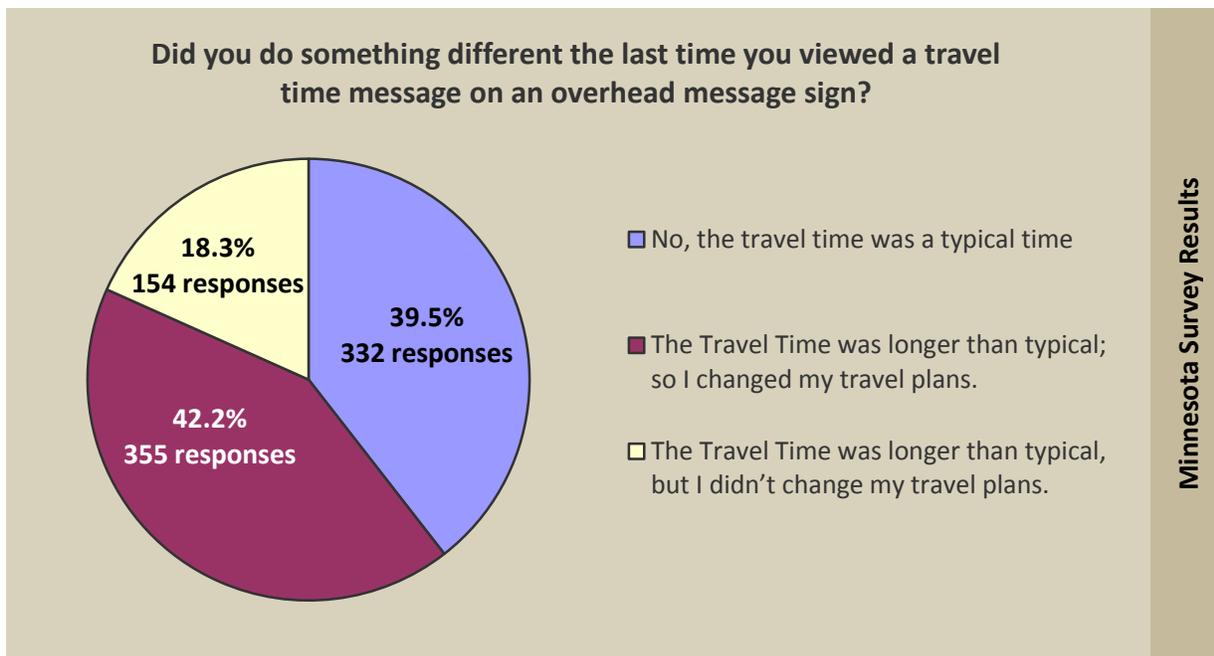


Figure 5: Did you do something different the last time you viewed a travel time message on an overhead message sign?

Understanding How Frequently Respondents Change Travel Plans Based on Travel Times

Respondents were asked to indicate whether they never, occasionally, or frequently change their travel plans based on travel time displays. Twenty-eight percent (28%) indicated that they often change to either local roads or other highways. Sixty-three percent (63%) indicated that they occasionally change to local roads or other highways (therefore 91% of those surveyed indicated that they at least occasionally change to local roads or highways based on travel times). Finally, only 9% indicated that they have not altered their trips. These results are illustrated in Figure 6.

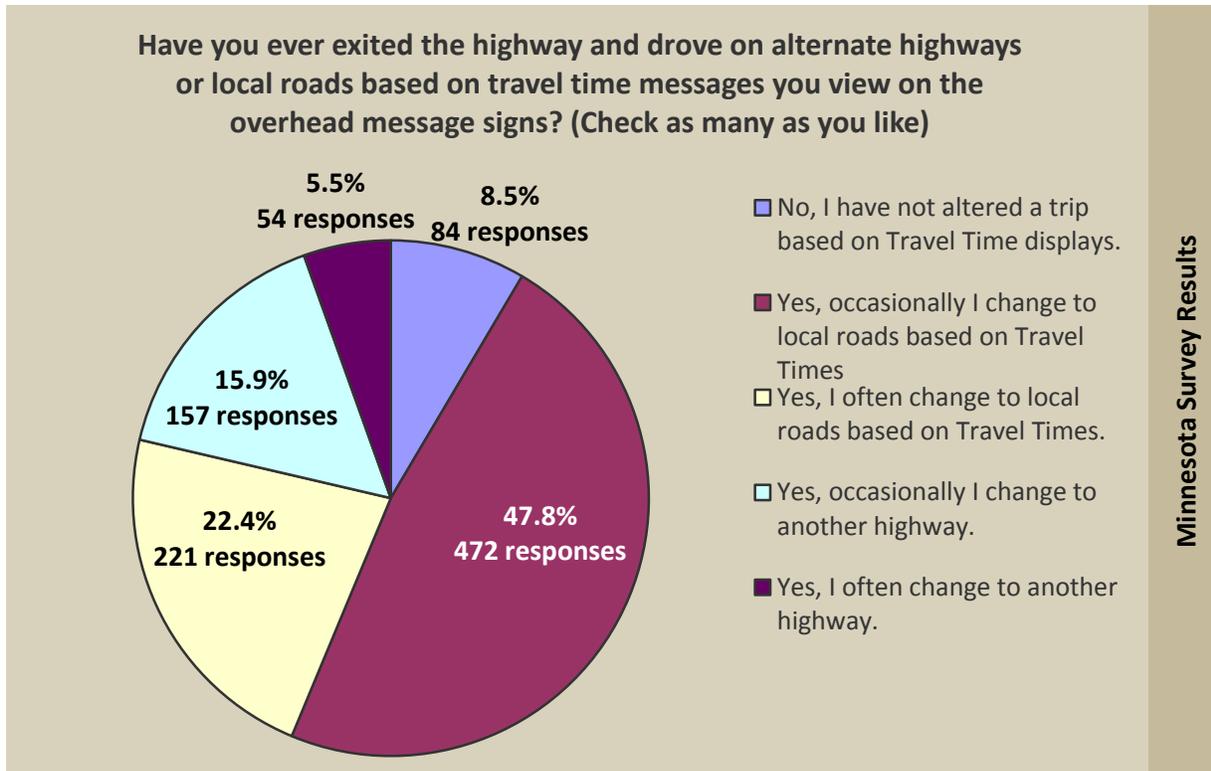


Figure 6: Have you ever exited the highway and drove on alternate highways or local roads based on the travel time message you view on the overhead message signs?

Respondents Description of How They Decide to Divert

An open ended, free text question asked respondents to describe what travel time values motivate them to divert to another road or highway. The free text responses ranged from explanations of their logic to their use of the signs. However, many respondents were able to articulate some quantitative threshold(s) that motivates them to divert. The analysis grouped together similar responses in an attempt to quantify the information shared. Table 2 summarizes when travelers decide to take an alternate route based on the travel times displayed.

Table 2: Minutes Over the Typical Travel Time that Survey Respondents Divert

Minutes Over the Typical Travel Time	Percent of Survey Respondents that described each threshold
5 min	36%
10 min	22%
15 min	4%
20 min	2%
30 min	2%
1.5 times	4%
Double	11%
Sign says 20 minutes or more	18%

An important consideration when examining the data in Table 2 is the fact that the majority of distances described by Minnesota’s freeway travel time signs are five (5) to seven (7) miles. Therefore, travel times under normal conditions are often 5-7 minutes (depending upon the route). Therefore, those respondents that indicated “Double the typical time” is another way of roughly saying 5 minutes to 10 minutes more than the typical time. Please note that the percentages included in Table 2 are the percentages of only those respondents that offered a quantified value for the threshold that causes diversion, not the overall percentage of respondents

Preferred Methods to Receive Traveler Information

Just over half (52%) of the respondents indicated that would prefer a combination of camera images, travel time displays and a map with colored roads indicating speeds and delays. However 30% prefer the map display as their preferred method for viewing travel information.

Respondents indicated that they would prefer receiving traveler information (e.g. travel times, incident notifications, roadwork alerts) by DMS first followed closely behind by the MnDOT website. The 511 phone system was ranked the lowest as a preferred way to receive travel information. See Figure 7.

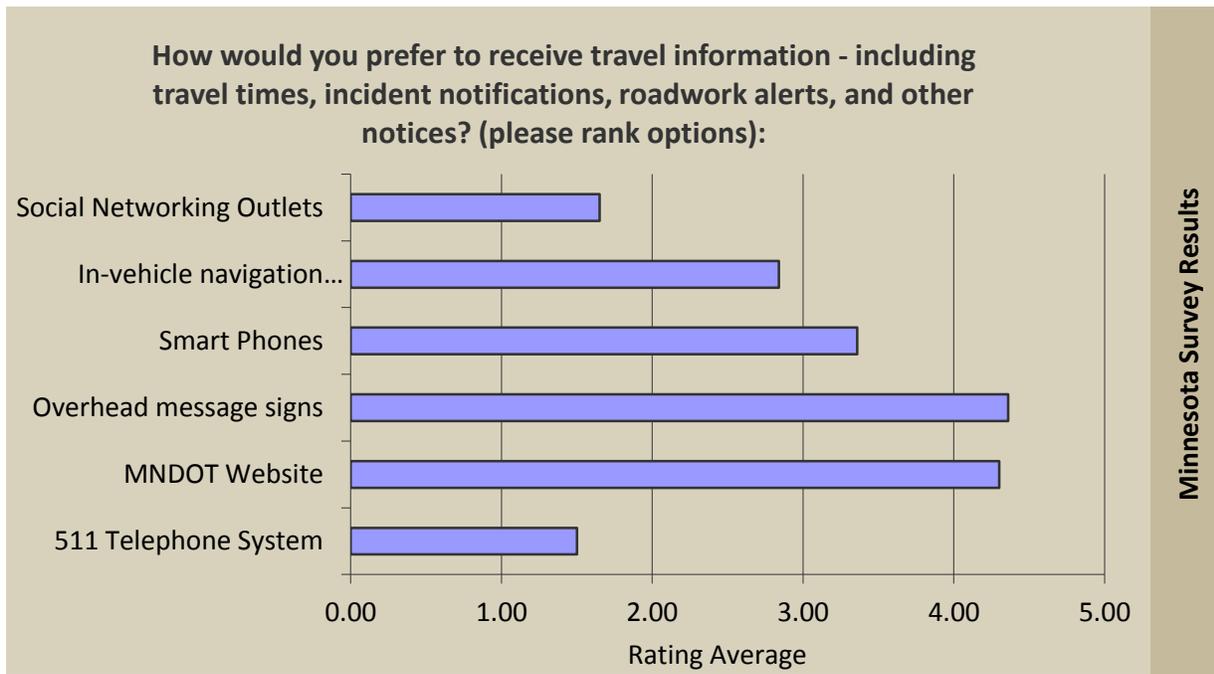


Figure 7: How would you prefer to receive travel information notices?

3.1.2 Minnesota Travelers' Survey – Conclusions

After review of the results from the Minnesota survey the following high level conclusions of the survey results were noted:

- Travel time displays on dynamic message signs do cause Minnesota travelers to divert to alternate routes (as illustrated by the fact that 91% of respondents have acknowledged that they have exited the highway and drove on an alternate route due to a travel time message);
- The more that the travel time displayed exceeds the typical travel time, the more diversions that will occur; and
- The feedback from respondents suggests that diversions begin to occur when the posted travel times exceed the typical travel times by 5 minutes, which also correlates to approximately a doubling of the typical travel times.

3.2 Washington Travelers' Survey

This section provides an overall summary of the results and conclusions of the online survey in Washington that was conducted to understand travelers' reactions to the travel time information disseminated by the Washington State Department of Transportation (WSDOT).

In Washington, travel times are disseminated on the WSDOT travel information website and on roadside signs along freeways and key arterials.

3.2.1 Washington Travelers' Survey – Summary of Results

Over the five month duration that the Washington State driver survey was online, 693 survey responses were collected. The spread of urban/suburban vs. rural responders was nearly equal, with 58% of respondents residing in the Seattle Tacoma metro area and 42% in rural areas. Please note that WSDOT does disseminate travel times along I-90 in the rural area of Snoqualmie Pass, which may have contributed to the large percentage of non-urban respondents.

The responses to the surveys are summarized below.

Travelers' Use of the WSDOT Website Travel Times

Approximately nineteen percent (19%) of the respondents indicated that they check the travel times on the website to decide whether to change their route. Additionally, 63% of respondents indicated that they check the website for a combination of three purposes (i.e. to understand the conditions for an upcoming trip, to decide whether to change routes and to decide whether to change departure times). These results are illustrated in Figure 8.

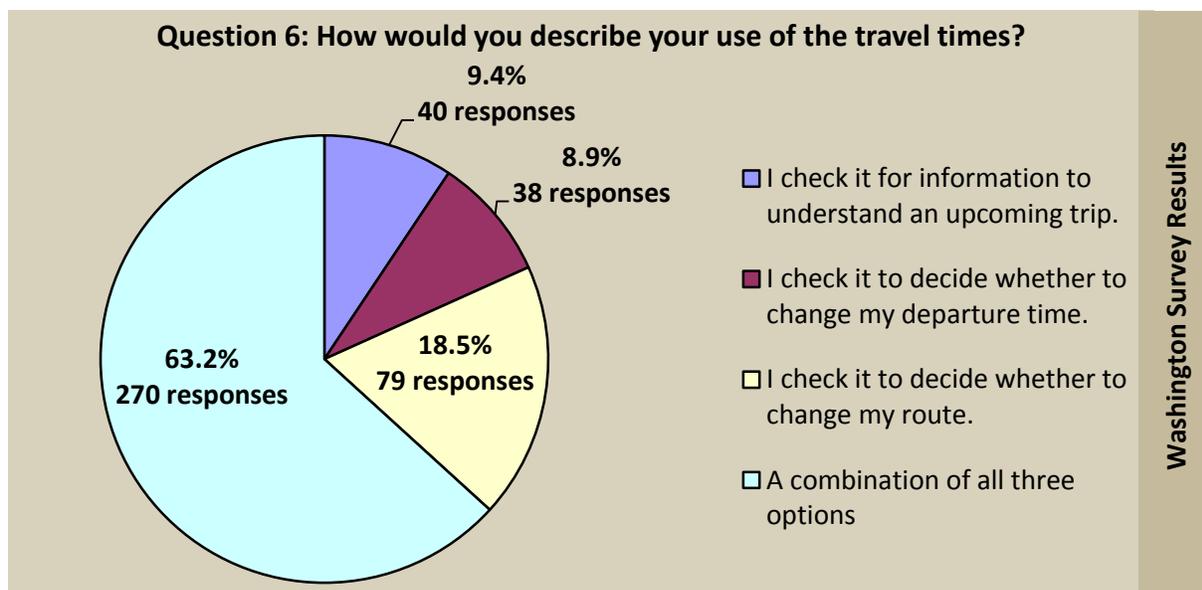


Figure 8: How would you describe your use of travel times?

Understanding How DMS Displayed Travel Times Impacted Respondents' Most Recent Trip

Respondents were asked to select an option that most closely matches their reaction the last time they viewed a travel time message on an overhead message sign:

- 58% of respondents indicated that the travel time was typical and they did not change their plans.
- 22% indicated that the travel time was longer than normal AND they changed their travel plans.
- 20% indicated that the travel time was longer than normal but they did not change their travel plans.

Figure 9 illustrates these results.

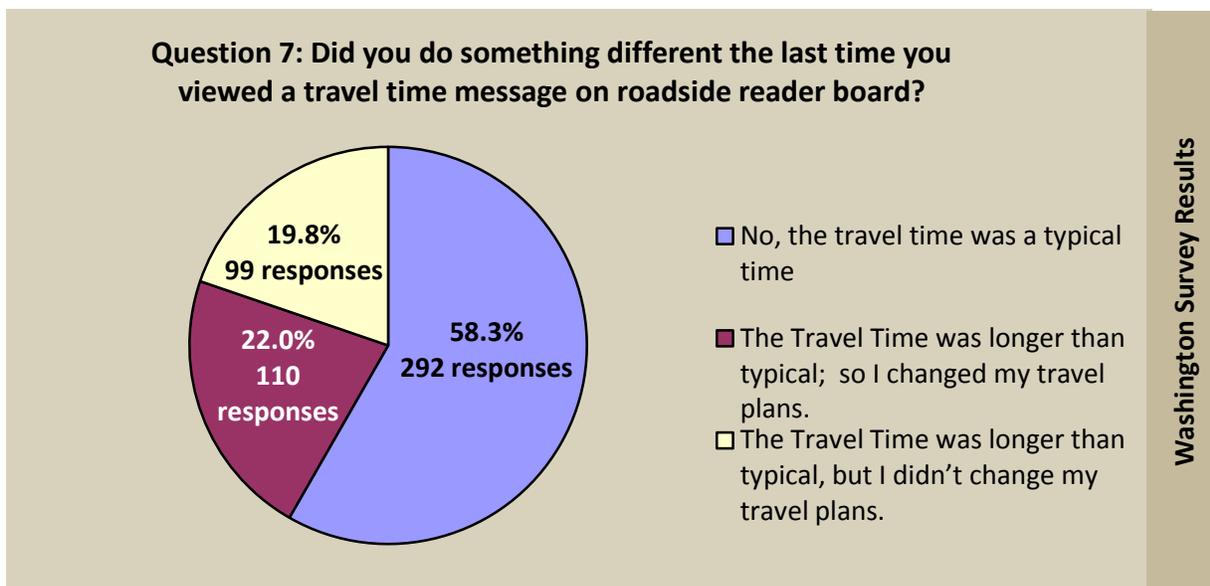


Figure 9: Did you do something different the last time you viewed a travel time message on a roadside reader board?

Understanding How Frequently Respondents Change Travel Plans Based on Travel Times

Respondents were asked to indicate whether they never, occasionally, or frequently change their travel plans based on travel time displays. Twelve percent (12%) indicated that they often change to either local roads or other highways. Sixty-six percent (66%) indicated that they occasionally change to local roads or other highways. Finally, only 22% indicated that they have not altered their trips. These results are illustrated in Figure 10.

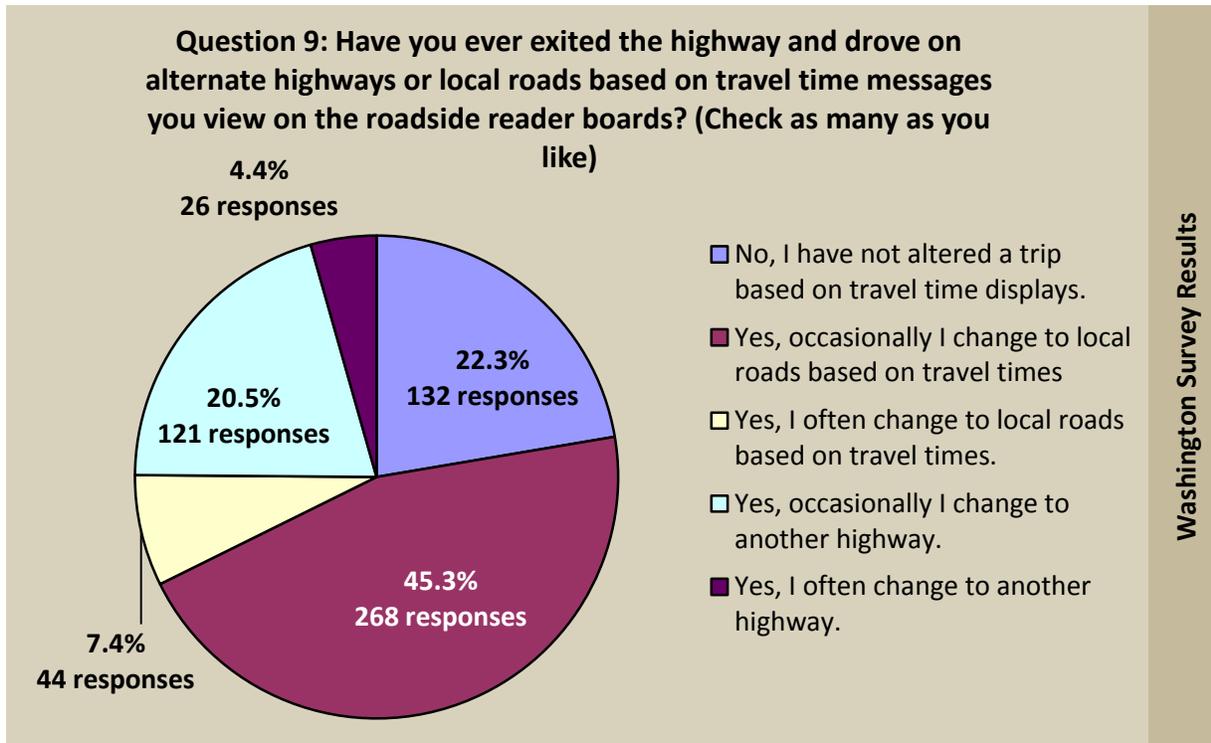


Figure 10: Have you ever exited the highway and drove on alternate highways or local roads based on the travel time messages you view on the roadside reader boards?

Respondents Description of How They Decide to Divert

An open ended, free text question asked respondents to describe what travel time values motivate them to divert to another road or highway. The free text responses ranged from explanations of their logic to their use of the signs. However, many respondents were able to articulate some quantitative thresholds that motivate them to divert. The analysis grouped together similar responses in an attempt to quantify the information shared. The following table summarizes when travelers decide to take an alternate route based on the travel times displayed. Please note that the percentages included in Table 3 are the percentages of only those respondents that offered a quantified value for the threshold that causes diversion, not the overall percentage of respondents.

Table 3: Minutes Over the Typical Travel Time that Washington State Survey Respondents Would Divert

Minutes Over the Typical Travel Time	Percent of Survey Respondents that described each threshold
5 min	16%
10 min	37%
15 min	26%
20 min	11%
30 min	11%

An important consideration when examining the data in Table 3 is the fact that the majority of distances described by Washington State’s freeway travel time signs are greater than 10 miles (often twice as long as the distances of the Minnesota routes).

Preferred Methods to Receive Traveler Information

Respondents indicated that their preferred method for receiving traveler information (e.g. travel times, incident notifications, roadwork alerts) is by WSDOT’s website, followed closely behind by the roadside reader boards (i.e. dynamic displays on highway signs). Social networking outlets were ranked the lowest as a preferred way to receive travel information. See Figure 11.

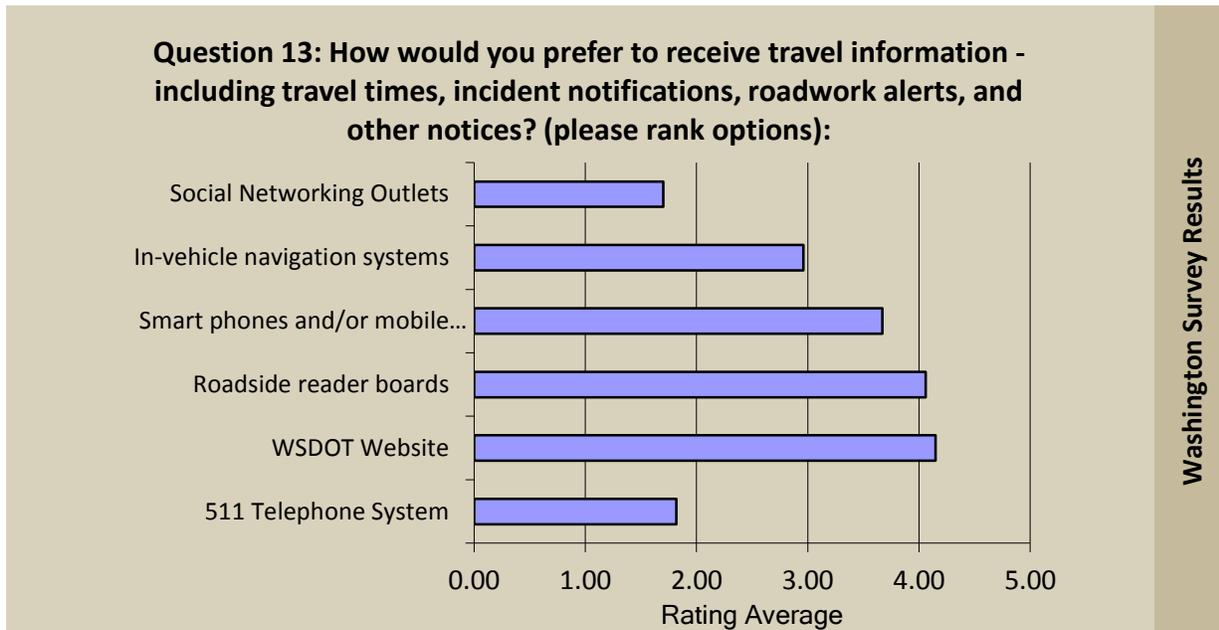


Figure 11: How would you prefer to receive the travel information?

3.2.2 Washington Travelers' Survey – Conclusions

After review of the results from the Washington State travelers' survey, the following high level conclusions were noted:

- Travel time displays on roadside signs do cause Washington travelers to divert to alternate routes, although preliminary feedback suggests that diversions in Washington are not as common as in Minnesota (71% of respondents have acknowledged that they have exited the highway and drove on an alternate route due to a travel time message);
- The more that the travel time displayed exceeds the typical travel time, the more diversions that will occur;
- The feedback from respondents suggests that diversions begin to occur when the posted travel times exceed the typical travel times by 5 minutes, however the majority of travelers who offered opinions described thresholds of 10-15 minutes above the typical travel time as the deciding factor to divert. The distances described by roadside travel time displays in the Seattle area are generally longer than in Minnesota. Therefore, the 10-15 minute value above the typical values is close to a doubling of the typical travel times.

4.0 Analysis of Traffic Volumes to Understand Diversion Rates with Travel Times on DMS

This section describes the data analyses conducted to explore a relationship between travel times displayed to travelers on DMS and the impacts on diversions at downstream locations. The research essentially focused on:

- Identifying situations with higher than typical travel times displayed to travelers;
- Identifying situations with traffic diversion rates outside the typical range; and
- Determining if there was a pattern between the high travel times and non-typical diversion rates, and if one could be linked to the other.

The approach to identify each of these is described below.

Identifying Situations with Higher than Typical Travel Times Displayed to Travelers

Each time WSDOT or MnDOT posted travel time messages to the DMS, a data log recorded the message that was displayed. The researchers examined the travel time messages posted, searching for patterns and/or threshold values. The calculated travel times were typically calculated every 30 seconds or every minute. Therefore, there are periods when travelers viewed different travel times every minute. The approach for this project was to look for periods of time when the free flow travel time was exceeded for a period of at least 15 minutes. The intent was that this would indicate a situation where traffic diversions could be understood.

Identifying Situations with Traffic Diversion Rates outside the Typical Range

The approach towards calculating the traffic diversion rates and identifying if the diversion rates are outside the typical range is summarized as follows:

For each location studied, there were two segments downstream of the DMS that were identified and agreed with MnDOT and WSDOT respectively to represent either traffic that has continued along the mainline or traffic that has diverted. For example, the most common example of two segments would be the sum of all mainline lanes (as one segment) and the exit ramp (as the other segment).

For each segment, the research team downloaded hundreds of days of volume counts in five (5) minute increments for the periods to be analyzed (for this project data was downloaded for Tuesday – Thursday, unless otherwise noted). The percentage of “thru” traffic was calculated for each 5 minute time slice on each day using the following calculation: $\% \text{ mainline} = \frac{\text{mainline volume}}{\text{mainline volume} + \text{exit volume}}$.

After calculating the %mainline for each time period, the research team calculated the average %mainline for each 5 minute time period and the standard deviation for each time period by considering hundreds of days of volume data.

These calculations allowed the research team to examine the diversion rate (%mainline) for each 5 minute time period of each day to determine when the %mainline differed from the average for that time period by more than the standard deviation for that time period. These are the time periods that were initially identified to be “Outside the Typical Range”. The final step was to ignore those situations where the diversion rate (%mainline) differed from the average for less than 15 minutes.

Finally, it is important to note that the analysis of the data was not a rigid statistical analysis. The research team followed a process to the extent possible to interpret the data in a non-biased manner. During the project, the ENTERPRISE member agencies were presented and agreed with demonstrations of the data analysis and the process followed to identify higher than normal travel times and diversion rates outside the typical range.

4.1 Analysis of Traffic Volumes – Minnesota Data Analysis

MnDOT posts travel times in real-time to DMS throughout the Twin Cities Metro area. Data from loop detectors are pulled into MnDOT’s Intelligent Roadway Information System (IRIS) software to calculate the travel times. Once calculated, the travel times are posted to the DMS, and MnDOT maintains an archive of the messages posted to the DMS. This allowed the research team to examine past travel times displayed. The volume data from loop detectors allowed the research team to examine diversion patterns and identify periods of time when the %mainline differed from the average by more than a standard deviation.

To provide the ENTERPRISE members with a data analysis of determining the time thresholds when travelers divert based on viewing a DMS travel time display, the following four DMS locations in Minnesota were selected:

- DMS Location 1: Hwy 36 Eastbound at Dale Street
- DMS Location 2: I-35 Southbound at 4th Street
- DMS Location 3: Hwy 212 Eastbound W of Prairie Center Drive
- DMS Location 4: Hwy 77 Northbound at I-35E

Figure 12 shows each of the four project locations in Minnesota. The following sections provide detailed descriptions of each location as well as the analysis and conclusions at each location.

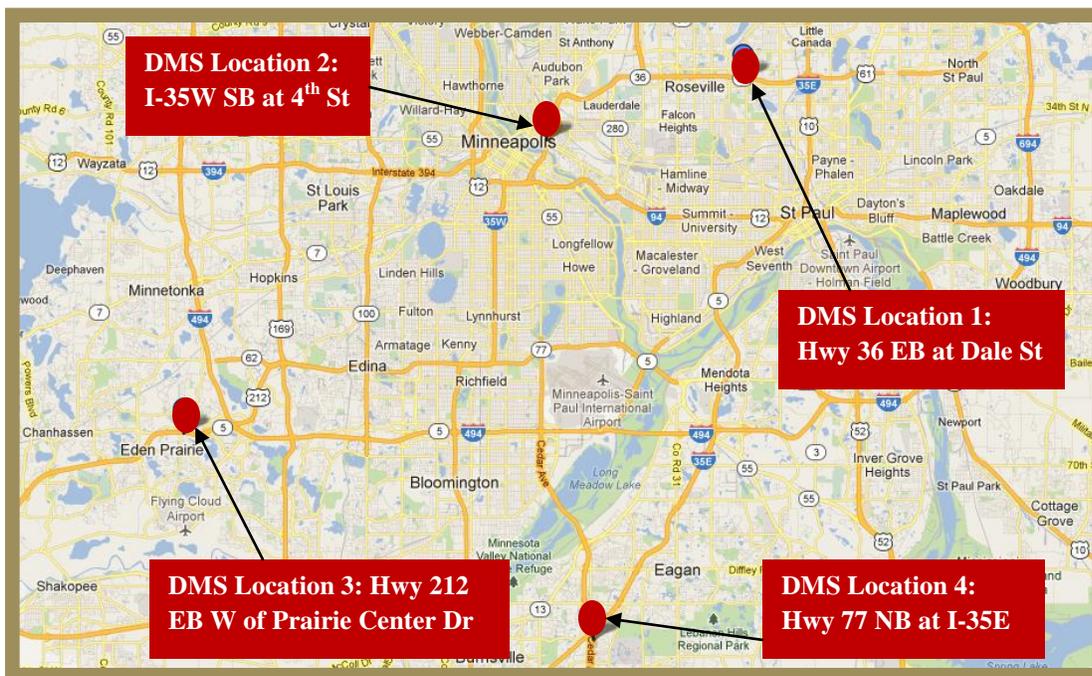


Figure 12: Minnesota DMS Project Locations

4.1.1 Location 1: Hwy 36 Eastbound at Dale Street Travel Time Analysis and Results

A DMS is located on Eastbound Hwy 36 prior to Dale Street on the eastside of the Twin Cities Metro Area as shown in Figure 13. At this location, travelers have the option to remain on Hwy 36 or exit North or South on Dale Street.

In 2011 a freeway exchange alignment was constructed on Hwy 36 at Rice Street, which is the next exit east from Dale Street. Construction and lane closures during the day often caused stopped traffic. Nonetheless, the travel delays were typically less than 5 minutes. For this project, data was analyzed for three situations:

- Before construction, with Hwy 36 in normal off-peak conditions;
- During construction while Hwy 36 often experienced stopped traffic with delays of less than 5 minutes but before a DMS was displaying travel times; and
- During construction with a DMS displaying travel times to I-35E.

Figure 13 shows the location of the construction zone on Hwy 36 at Rice Street and the location of the DMS (prior to Dale Street) on Eastbound Hwy 36. Also shown in purple is the Hwy 36 route that travelers would stay on through the construction zone. The green and red routes show 2 options that travelers may take after exiting at Dale Street to avoid the construction zone at Rice Street and Hwy 36.

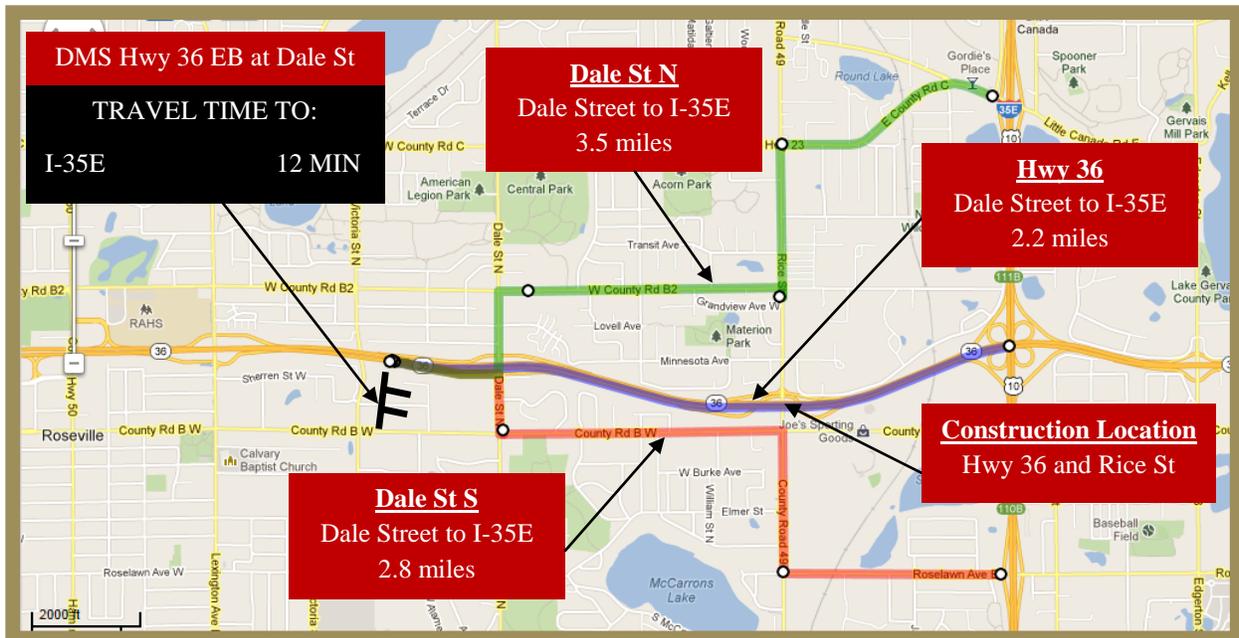


Figure 13: Location 1: Hwy 36 Eastbound at Dale Street

Analysis

Hwy 36 at Dale Street volume data from the three periods (before construction, during construction with no DMS, and during construction with DMS) was analyzed. As illustrated in Table 4, before construction, 89% of the traffic remained on Hwy 36 at the Dale St. exit. During construction when no travel times were posted, the percentage of traffic that stayed on Hwy 36 decreased to 79%. After deployment of the DMS and with displays of travel times (which typically reported times of 5 minutes or less to I-35E), the percentage of traffic remaining on Hwy 36 increased to 84%.

Table 3: Percentage of Traffic Staying on Hwy 36 vs. Exiting to Dale Street

Description	Percentage of Traffic Staying on Hwy 36	Percentage of Traffic Existing at Dale Street
Before Construction	89%	11%
During Construction NO Travel Times Posted	79%	21%
During Construction Travel Times Posted	84%	16%

Conclusions

This analysis suggests that stopped or slow traffic will cause a diversion. It also suggests that displaying travel times on a DMS in congested areas has an impact on traffic, and can cause less diversions than situations when drivers only observed stopped traffic or slow speeds. When travelers were aware of the actual travel time through the construction zone (and because the typical travel time was 5 minutes or less), they were more likely to travel through the construction zone, then divert to a local road.

4.1.2 Location 2: I-35W Southbound at 4th Street Travel Time Analysis and Results

A DMS is located on I-35W Southbound at 4th Street close to downtown Minneapolis, Minnesota as show in Figure 14. The DMS during the PM Peak displays the travel times to Hwy 62 and I-494 for vehicles traveling south on I-35W. One option for travelers after they view the travel times posted on the DMS at this location is to exit onto Hwy 55 (Hiawatha Ave) from I-35W to reach Hwy 62. Hwy 55 (Hiawatha Ave) runs parallel to I-35W.

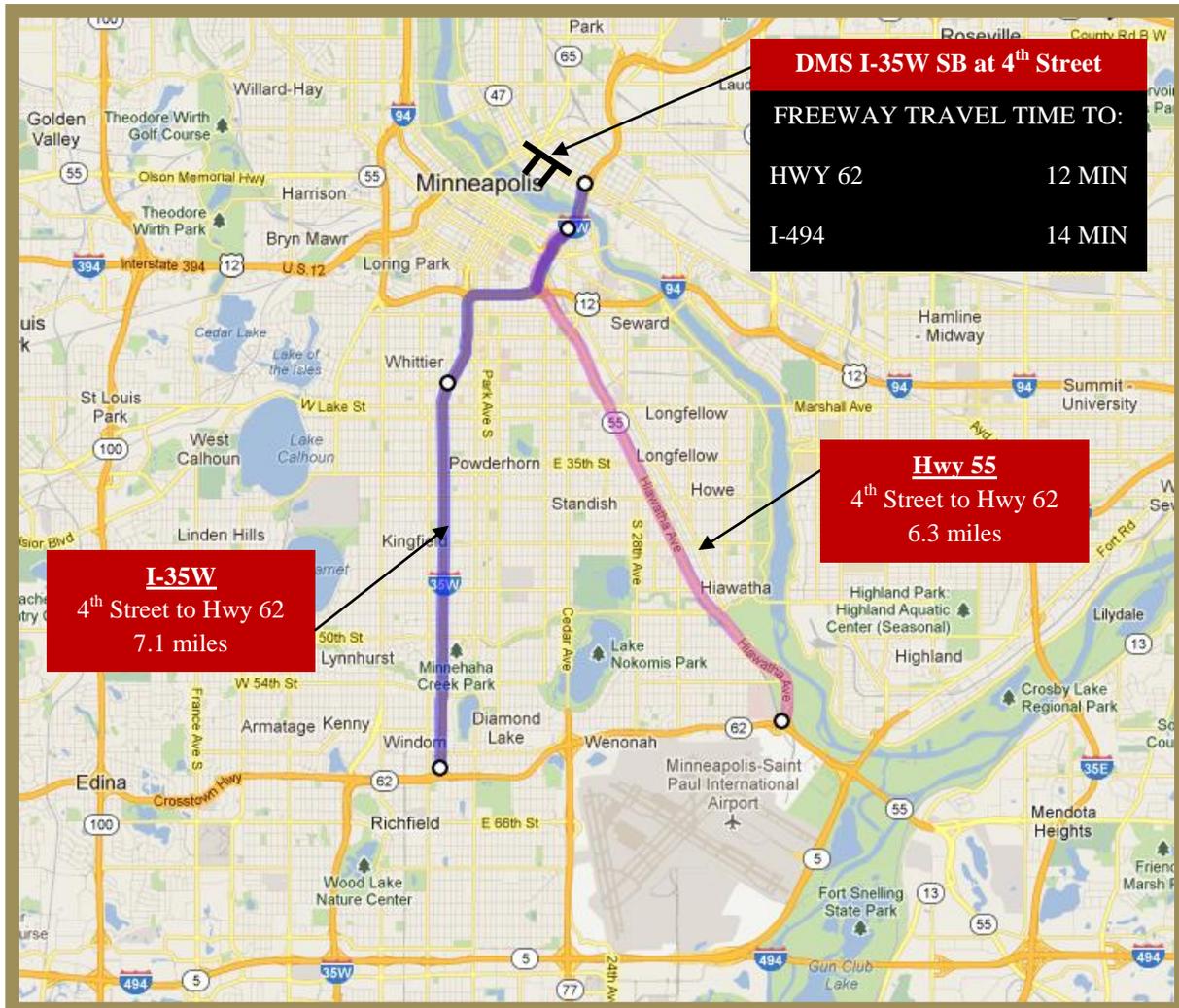


Figure 14: Location 2: I-35W Southbound at 4th Street

Analysis

The volumes at I-35W Southbound at the Hwy 55 Exit (Hiawatha Exit) were analyzed to identify periods when the diversion rate was outside the typical rate. For this analysis, 104 days of volume and DMS traffic log data was analyzed. There were 29 days when a situation occurred and the travel times posted to the DMS exceeded the typical travel time for that period by more

than 5 minutes. During each of these 29 situations, increases in the percentage of vehicles diverting to Hwy 55 (exceeding the standard deviation for the time periods) were observed. The results are shown in Table 5.

Table 5: I-35W SB at Hwy 55 Data Analyzed

Description	Number of Days
Days Analyzed	104
Day with Higher Travel Times posted (5 – 10 min) (> 10 min)	29
Days when High Travel Times match diversions	29
Days when High Travel Time Displays were accompanied by slow traffic near the exit	29

As you will note in Table 5, each time there was an instance of high travel times and high diversion rates (the diversion rate was outside the standard deviation range from the mean), there was also slow speeds (approximately stop and go traffic). This fact led the research team to initially question whether the DMS display of travel times had any impact on the diversion rate at this location, or if the stop and go traffic was the primary cause of the diversions. However, further analysis of the speeds that vehicles were traveling during these periods (gathered and calculated by MnDOT detectors), combined with analysis of diversion patterns from dates before the travel times were displayed on the DMS at this location, did reveal a pattern. Table 6 shows that the percentage of traffic that diverted from the mean volume for different speeds when no travel times were posted was approximately an equal amount at all speed categories. However, when travelers encountered stop and go traffic and had the advantage of a travel time message, the results show that more diversions occur when speeds are slower than 5 mph. Similarly, the correlation suggests that as the speeds increased, the diversion rate decreased. *One possible conclusion from this is that without the benefit of a travel time message, the drivers encountering very slow speeds had a tendency to divert more often when it was not appropriate and divert less often when it was appropriate than those drivers with the benefit of travel time displays.*

Table 6: I-35 SB at Hwy 55 Percentage Traffic Diverted from the Mean

MPH	Traffic Diversion from Mean	
	NO Travel Times on DMS	Display Travel Times > 10 min higher than normal
<5	14%	24%
5-7.5	14%	18%
7.5-10	11%	12%
10-15	16%	12%

Conclusions

This analysis suggests some possible conclusions:

- Stopped or slow traffic speeds cause diversions, as do DMS displays of travel time messages;
- When travel times are displayed in addition to the travelers observing slow or stopped traffic, there is an increase in diversion when travel times are high and speeds are low over travelers only observing the stop and go conditions. There is a decrease in diversions when speeds are higher and travel times are not as long.
- Analysis of the change in diversion rates based on travel times revealed:
 - 20% or more change in diversion patterns with travel times more than 20 minutes above typical.
 - 17%-20% change in diversion patterns with travel times more than 10 minutes above typical.
 - 10%-12% change in diversion with travel times more than 5 minutes above typical.

4.1.3 Location 3: Hwy 212 Eastbound West of Prairie Center Drive Travel Time Analysis and Results

A DMS is located on Hwy 212 eastbound just west of Prairie Center Drive as shown in Figure 15. During the peak periods, travel times are posted on this DMS describing times to Hwy 100 via Hwy 62 and to I-35W via I-494. During free flow periods it takes approximately 7 minutes to travel from Prairie Center Drive to Hwy 100 via Hwy 62 and 9 minutes to travel to I-35W on I-494 from Prairie Center Drive on Hwy 212.

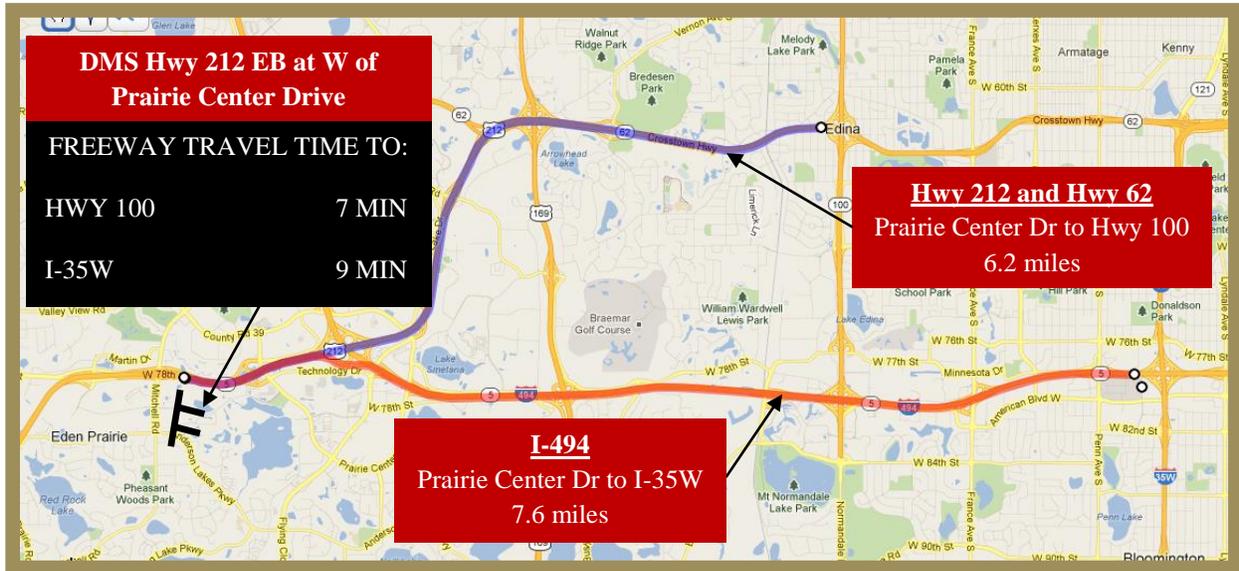


Figure 15: Location 3: Hwy 212 Eastbound W of Prairie Center Drive

Analysis

The volumes at Hwy 212 Eastbound West of Prairie Center Drive were analyzed to determine the percentage of traffic that continues on Hwy 212 rather than exiting on to I-494.

For this analysis, the research team calculated the amount that the diversion rate was increased (or decreased) during periods when the travel time displayed was 5-10 minutes higher than typical and when the travel time was greater than 10 minutes higher than typical. 79 days of volume and DMS traffic log data was analyzed. There were 82 time periods (5 minute periods) when higher than typical travel times were displayed, as shown in Table 7. It is important to note that at this location travel speeds are not typically below posted speeds when travelers make their route decision (backups occur downstream of the exit point).

Table 7: Hwy 212 and Prairie Center Drive – Diversion Rate Increases over the Mean

Difference in Travel Time above Typical Travel Time for this Route	# of Time Periods Analyzed¹	Diversion Rate Increase over the Mean (averaged over the number of time periods)
5-10 minutes	64	7%
10 minutes or more	18	10%

¹ Based on analysis of 79 days of data

Conclusions

This analysis suggests a pattern of increased diversions after the travel time display is increased by 5 minutes over typical. Similarly, it indicates that a higher diversion rate occurs when the travel time displayed is greater than 10 minutes higher than typical.

4.1.4 Location 4: Hwy 77 Northbound at I-35E Travel Time Analysis and Results

A DMS is located on the southern end of the Twin Cities Metro area on Hwy 77 Northbound at I-35E as shown in Figure 16 below. The travel time to I-494 if you remain on Hwy 77 is provided to travelers as this location. Two diversion routes are shown in Figure 17. One route is taking I-35E to I-494 and the other route shown is taking I-35W. Each of these routes end up at some point along I-494, however taking the diversion routes increases the number of miles traveled.

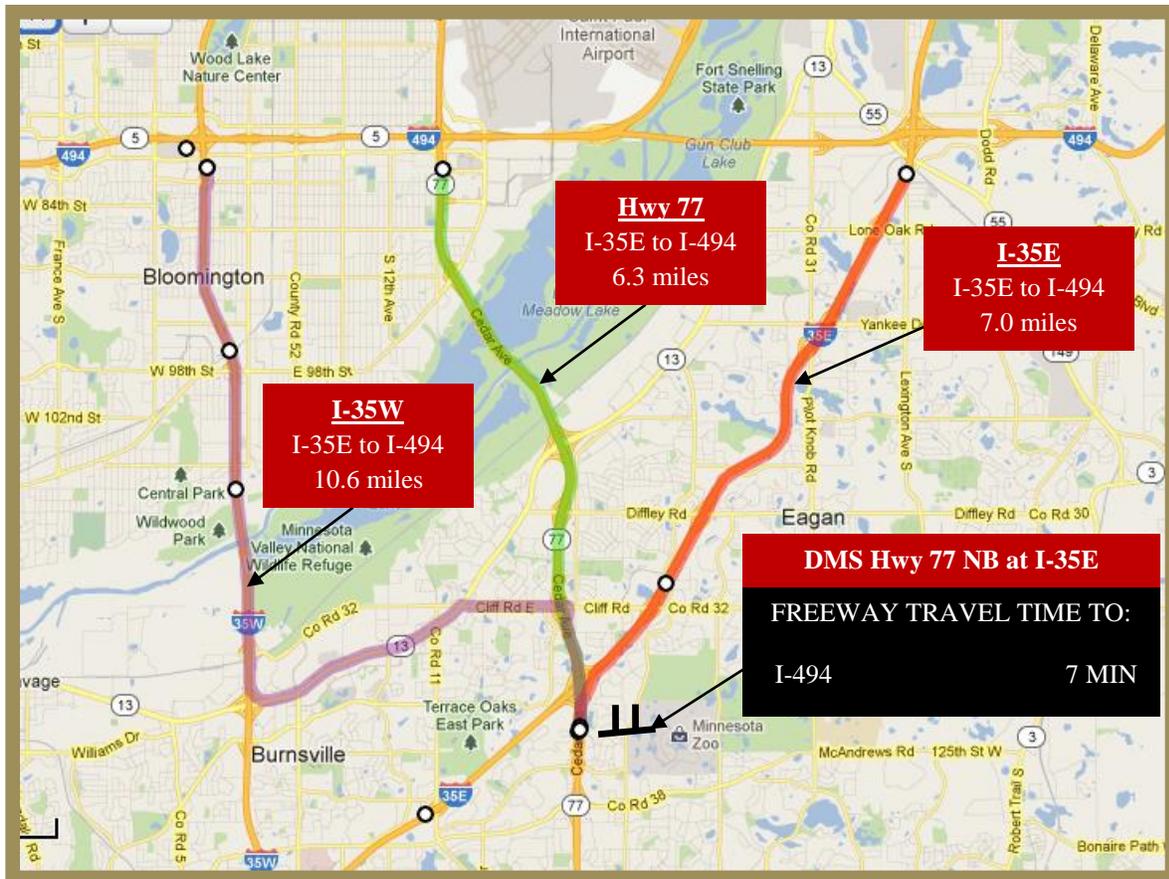


Figure 16: Location 4: Hwy 77 Northbound at I-35E

Analysis

The volumes at Hwy 77 Northbound at I-35E were analyzed to determine the percentage of traffic that diverted before and after travel times were posted on the DMS on Hwy 77.

This location was selected because of the unique aspect of the alternate route. The alternate route adds considerable miles to the range of destinations that travelers are headed towards, roughly estimated to be as much as 10 additional miles.

Tables 8 and 9 show the frequency, speeds and diversion percentage of traffic at Hwy 77 and I-35 E. An analysis similar to that conducted on the I-35W southbound data (Location 2) was conducted to examine the diversion rates before and after the DMS deployment when different speeds were experienced near the diversion location. The analysis showed that when the speeds were less than 5 mph at the diversion location, the diversion rate was the same before the DMS displayed travel times as it was with the travel times displayed. This corresponded to an increased travel time by more than 20 minutes over the typical traffic speeds.

However, when speeds were higher, there was a decrease in the diversions when travel times were displayed. Suggesting that drivers with better information were able to compare the added mileage against the additional travel time and as a result they decided diversions were warranted less often. Overall, the rates that the diversions increased were less (12% vs. 10%) when travelers had the travel times on DMS.

Table 8: Frequency, Speeds and Diversion before Travel Times were posted on Hwy 77 at I-35E

Frequency	Speeds	Diversion
22%	<5 mph	-16%
35%	5-7.5 mph	-14%
28%	7.5 - 10 mph	-9%
15%	>10 MPH	-7%
Overall		12%

Table 9: Frequency, Speeds, Diversion and Travel Time with Travel Times posted on Hwy 77 and I-35E

Frequency	Speeds	Diversion	Travel Time
4%	<5 mph	-16%	>20 from free flow
34%	5-7.5 mph	-10%	15-20 from free flow
52%	7.5 - 10 mph	-7%	10-15 from free flow
10%	>10 MPH	-6%	5-10 from free flow
Overall		-10%	

Conclusions

This analysis suggests that when traffic is nearly stopped (<5 mph) travelers divert at the same rate with or without travel times posted on the DMS at this location. When traffic is faster than 5 mph, the travel times on the DMS tend to have a slight impact and cause drivers to diver less.

If the travel time posted was 5 to 10 minutes longer than typical there was a 7 to 12% change in the diversion percentage. If the travel time was greater than 10 minutes longer than the typical, the data revealed a 12-20% change in the diversion. If traffic was slowed or stopped there were more diversions.

4.1.5 Overall Minnesota Conclusions

Based on the data analysis of travel times and diversions conducted at the four DMS locations in the Twin Cities Metro Area a pattern was observed where travel times more than 5 minutes longer than typical resulted in an increase in diversions. In addition, travel times more than 10 minutes longer than typical resulted in a further increase in diversions. This appears to confirm and validate the responses to the traveler survey.

4.2 Analysis of Traffic Volumes – Washington State Data Analysis

WSDOT calculates and posts travel times in real-time to DMS throughout the Seattle Area and maintains an archive of the messages posted. This allowed the research team to examine past travel times displayed. Volume data was also provided by WSDOT which allowed the research team to examine diversion patterns and identify periods of time when the %mainline differed from the average by more than a standard deviation.

To provide the ENTERPRISE members with a data analysis of determining the time thresholds when travelers divert based on viewing a DMS travel time display, the following four DMS locations in Washington were selected:

- DMS Location 1: Westbound SR 522 before I-405 Exchange
- DMS Location 2: Southbound I-405 before SR 520
- DMS Location 3: Westbound 520 in Bellevue
- DMS Location 4: Northbound I-5 before I-405 Exit

The following sections provide detailed descriptions of each location as well as the analysis and results at each location.

4.2.1 Location 1: Westbound SR 522 before I-405 Exchange Travel Time Analysis and Conclusions

Travel times are displayed to drivers on SR 522 westbound before the I-405 exchange as shown in Figure 17. The travel times describe the time to Seattle by remaining on SR 522 or by entering the I-405 freeway. The free flow travel time is 24 minutes via SR 522 and 20 minutes via I-405 to Seattle.

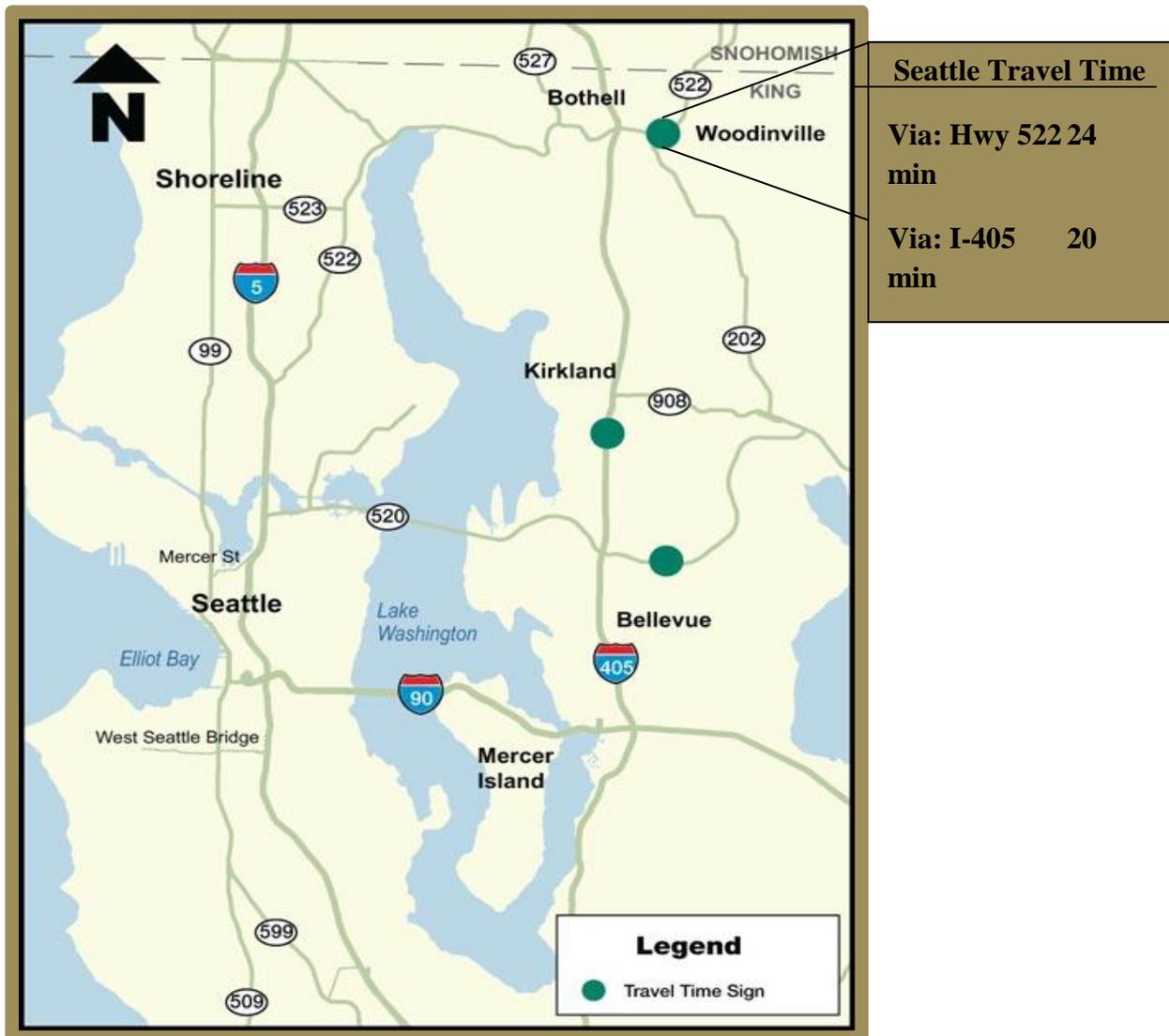


Figure 17: Location 1: Westbound Hwy 522 before I-405 Exchange

The travel route and travel time display analyzed on Westbound SR 522 is a situation where commuters are traveling to Seattle on an arterial (non-freeway) route. SR 522 typically operates with a more consistent travel time (less deviation) but in general is a longer commute time to Seattle than the freeway alternatives.

Analysis

The volumes on SR 522 and the ramp to I-405 southbound were examined, together with travel time information displayed to drivers on SR 522. At this location, an increase in the percentage of vehicles diverting to I-405 was only observed during 4 situations during the time period with available data. In each of these situations, the travel time on SR 522 was at least 14 minutes longer than the travel time on I-405 (a 10 minute increase over the free flow travel times). This is illustrated in Table 10.

Table 10: Days when SR 522 Had a Considerably Longer Travel Time than I-405 and the Percent of Volumes that Diverted to I-405

Date	Travel Time	Volume
11/1/11	SR 522 20-25 min higher than I-405	% of traffic entering I-405 increased by 12%
11/2/11	SR 522 15 min higher than I-405	% of traffic entering I-405 increased by 11%
11/10/11	SR 522 20 min higher than I-405	% of traffic entering I-405 increased by 11%
11/16/11	SR 522 14 min higher than I-405	% of traffic entering I-405 increased by 6%

Table 11 shows an analysis of 2 days when travel times on I-405 were higher than typical (typically SR 522 travel time is 4 minutes longer than I-405). As illustrated in Table 11, this small increase in the I-405 travel time resulted in a significant change in the diversion rate to SR 522.

Table 41: Days when SR 522 Had a Slightly Higher Travel Times than I-405 and the Percent of Volumes that Diverted to I-405

Date	Travel Time	Volume
11/1/11	SR 522 1-2 min higher than I-405	% of traffic remaining on SR 522 increased by 19%
11/16/11	SR 522 1-2 min higher than I-405	% of traffic remaining on SR 522 increased by 7%

Conclusions

This analysis suggests the following:

- Drivers that normally remain on SR 522 to Seattle understand and accept the fact that this route is typically 3 to 4 minutes longer than taking I-405 to Seattle.
- When SR 522 is 14 minutes or more longer than I-405 (10 minutes more than the normal) some traffic begin to divert to I-405. As the travel time value increases, the diversion rate to I-405 continues to increase.
- However, when I-405 has a slightly longer travel time than S522, I -405 traffic tends to divert to SR 522.
- In summary, it appears that traffic is more easily convinced based on longer travel times to change from the freeway route (I-405) than to change from the arterial route (SR 522).

4.2.2 Location 2: Southbound I-405 before SR 520 Travel Time Analysis and Conclusions

Seattle bound travelers heading southbound on I-405 have the option of SR 520 or I-90 to cross Lake Washington and enter Seattle (note: at the time the data was analyzed, neither route was tolled, however SR 520 now operates high occupancy tolling (HOT)). Travel times for the two optional routes are displayed to drivers southbound on I-405 as shown in Figure 18. The free flow speed is roughly 16 minutes via SR 520 and 14 minutes via I-90.



Figure 18: Location 2: Southbound I-405 before SR 520

Analysis

Volume and travel time displays were analyzed for the summer and fall months of 2011. There were only a limited number of times where significant differences in travel times were observed, as illustrated in Table 12.

Table 52: Days when I-90 had Higher Travel Times and the Percent of Volumes that Diverted to SR 520

Date	Travel Time Displayed	Diversion Change Observed
11/2/11	I-90 6 min higher than SR 520	% of traffic on SR 520 increased by 2%
11/9/11	I-90 15 min higher than SR 520	% of traffic on SR 520 increased by 0%
11/30/11	I-90 20 min higher than SR 520	% of traffic on SR 520 increased by 6%
11/2/11	SR 520 10 min higher than I-90	% of traffic on SR 520 increased by 3%

Based on the limited data, a significant change in the diversion rates was not observed at this location, with the exception of when the =travel time was more than 20 minutes above the typical travel time.

Conclusions

This analysis indicates that:

- There is not much variation in travel times between the two routes (both appear equally balanced)
- With limited data sets, there are some observed diversions but primarily after the travel time displayed is more than 20 minutes above typical (more than double the typical travel time).

4.2.3 Location 3: Westbound 520 in Bellevue Travel Time Analysis and Conclusions

Travelers along westbound Hwy 520 in Bellevue view a sign that displays travel times to Seattle via SR 520 and I-90 as shown in Figure 19 below. The travel time during free flow conditions is 17 minutes via SR 520 and 12 minutes via I-90.



Figure 19: Location 3: Westbound SR 520

Analysis

Volume and travel time data were analyzed during the period June 2011 to September 2011 at this location. Table 13 shows four AM peak periods where travel times posted on I-90 were more than 5 minutes longer than SR 520 to Seattle.

Table 63: Days when I-90 had Higher Travel Times than SR 520 during the AM peak

Date	Travel Time	Diversion Change Observed
6/1/11	I-90 4 to 6 minutes longer than SR 520	% of traffic on SR 520 increased by 4%
6/16/11	I-90 4 to 6 minutes longer than SR 520	% of traffic on SR 520 increased by 6%
7/26/11	I-90 8 to 10 minutes longer than SR 520	% of traffic on SR 520 increased by 9%
8/18/11	I-90 20 to 30 minutes longer than SR 520	% of traffic on SR 520 increased by 13%

Table 14 shows that on July 18, 2011 SR 520 travel time was 15 minutes longer than I-90 to Seattle and there was no volume change between the two routes (I-90 and SR 520).

Table 4: Days when SR520 had Higher Travel Times than I-90 – during the AM Peak

Date	Travel Time	Diversion Change Observed
7/28/11	SR 520 15 min longer than I-90	None
9/8/11	SR 520 15 -20 min longer than I-90	None
9/20/11	SR 520 20 - 30 min longer than I-90	None
9/28/11	SR 520 30 – 40 min longer than I-90	Unusual volumes observed, no pattern of diversions

Conclusions

This analysis indicates that:

- The data suggests that when small increases in travel times are reported for I-90, drivers tend to divert to SR 520. As the travel time difference increases, an increasing number of drivers divert to SR 520.
- The data also suggests that traffic tends not to divert to I-90 based on longer travel times on SR 520. This may be a reflection of the Interstate nature of I-90 (and different traffic volumes and increased commercial vehicle traffic). This might also be a reflection of the fact that for traffic heading southbound on I-405, the SR 520 access point is before the I-90, perhaps suggesting that travelers are more likely to exit I-405 before their typical exit rather than continue on beyond their typical exit.

4.2.4 Location 4: NB I-5 Before I-405 Exit Travel Time Analysis and Conclusions

Northbound traffic on I-5 near the Seattle – Tacoma Airport view a travel time display for the trip to Bellevue via I-405 (the most direct freeway route to Bellevue) and via I-5 and SR 520; this is illustrated in Figure 20 below. The typical free flow travel time along the I-5/SR 520 route is 25 minutes, and the I-405 typical time is 19 minutes.



Figure 20: Location 4: Northbound I-5 before I-405 exit

Analysis

Twenty three days of volume and travel time displays were analyzed at this location. Analysis of seven AM peak periods in which travel times along the I-5/S520 route were **greater than 15** minutes longer than I-405 indicated that:

- 4 days there was no change in volume outside of the standard deviation
- 1 day (a Saturday) there was a 2-3% change in volume (1% standard deviation)
- 1 day (Saturday) there was a 10% change in volume
- 1 day there was a 4-6% change in volume

Seven AM peak periods where travel times posted for I-5/S520 were **less than** I-405 indicated that:

- 4 days there was no change in volume which was outside of the standard deviation
- 1 day there was a 5% change in volume (1 time period only)
- 1 day there was a 3% change in volume which was with 1% of the standard deviation
- 1 day there was a 2% change in volume which was with 1% of the standard deviation

Conclusions

This analysis indicates that:

- The standard variation of traffic split is very low, not much variation
- Travel times posted seem to have little impact on traffic diversions (some diversions were outside of the standard deviation, but still low).
- All traffic speeds at the location where travelers would divert to the alternate route were greater than 52 miles per hour, suggesting that since traffic is flowing freely at the time the travel time displays are observed, drivers are less likely to divert.

4.2.5 Overall Washington Conclusions

Based on the data analysis of travel times and diversions conducted at the four DMS locations in the Seattle area there were a smaller number of situations where travel time displays were longer than typical. Nonetheless, a pattern was observed that suggested that travel times exceeding the typical travel times by 10 minutes create some diversions, and more diversions occur when travel times are 20 minutes or more than typical.

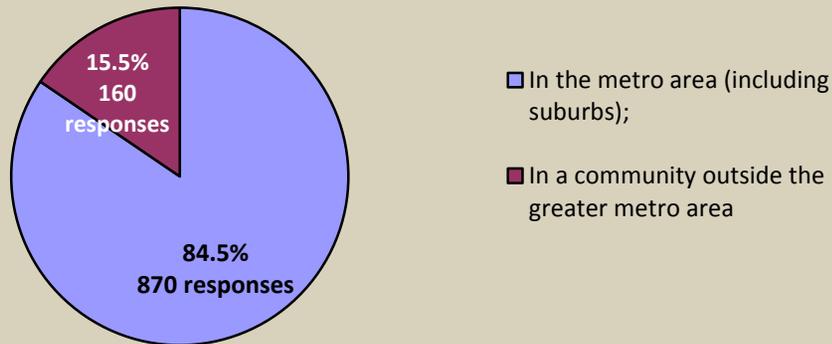
5.0 Conclusions – Combining Web Survey Results and Volume Analyses

The findings of this project are summarized as follows:

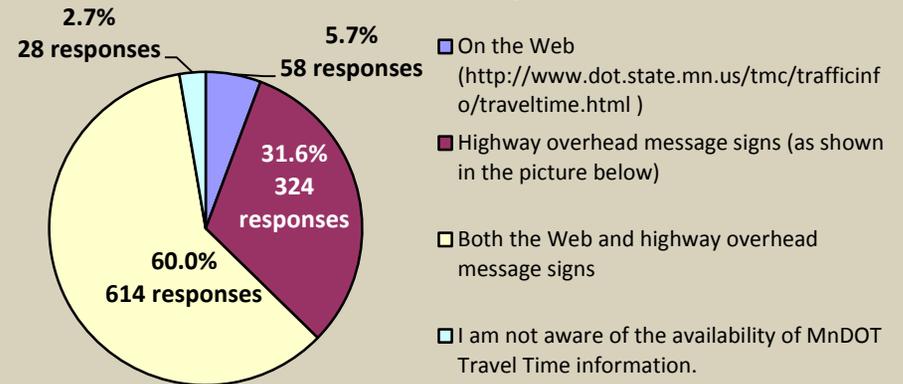
- Traveler surveys in both Washington and Minnesota suggest that drivers do react to longer than typical travel time displays on roadside DMS by diverting to alternate routes.
- When asked to quantify how much the travel time display needs to exceed the typical time to cause a diversion, the survey responses suggest that posting a travel time value that is approximately double the typical travel time causes an increase in diversions to alternate routes:
 - Minnesota drivers responding to the survey indicated a threshold range of 5-10 minutes longer than typical travel times (note: Typical travel times displayed on Minnesota DMS at many locations are 5-8 minutes during normal traffic conditions).
 - Washington drivers responding to the survey indicated a threshold range of 15-20 minutes longer than typical travel time as the determining factor to divert to an alternate route (note: Seattle travel time displays describe routes with typical travel times of 15-20 minutes during normal traffic conditions).
- The analysis of data (volume and historical DMS travel time displays) in both cities confirms these thresholds:
 - In Minnesota at four DMS locations analyzed for this project, a pattern was observed where travel times more than 5 minutes longer than typical resulted in an increase in diversions. In addition, travel times more than 10 minutes longer than typical resulted in a further increase in diversions.
 - In Washington at four DMS locations analyzed for this project, there were a smaller number of situations where travel time displays were longer than typical. Nonetheless, a pattern was observed that suggested that travel times exceeding the typical travel times by 10 minutes create some diversions, and more diversions occur at when travel times are 20 minutes or more than typical.
 - In Washington, the setting of the routes played a significant role as well. Travelers appeared more willing to divert to (or remain on) arterials than they are willing to divert to freeways.
- At locations where traffic is stopped or very slow near an exit ramp offering access to a viable alternate route, the research observed more diversion to the alternate route than when traffic speeds are free flow. However, DMS displays of travel times in addition to drivers observing stopped traffic had an additional impact on the diversion rates:
 - With the addition of a DMS displaying travel times, drivers tend to divert more often when warranted (speeds are slower than 5 mph and travel times longer), and drivers tend to divert less often when not warranted (speeds faster than 5 mph and travel times closer to typical). In summary, travelers make better decisions whether to divert with the added DMS display of travel times.

Appendix A – Minnesota Survey Questions and Results

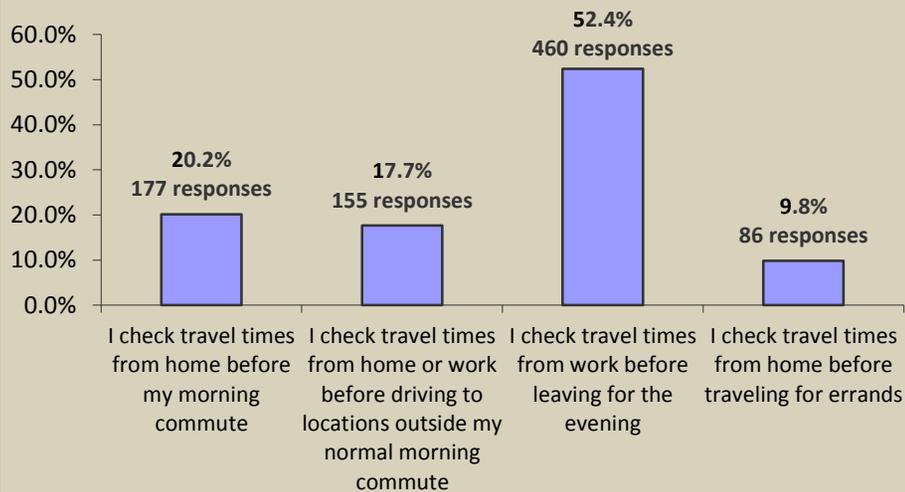
Question 1: Select the option that best describes your primary residence, or the location where you stay when visiting the Twin Cities.



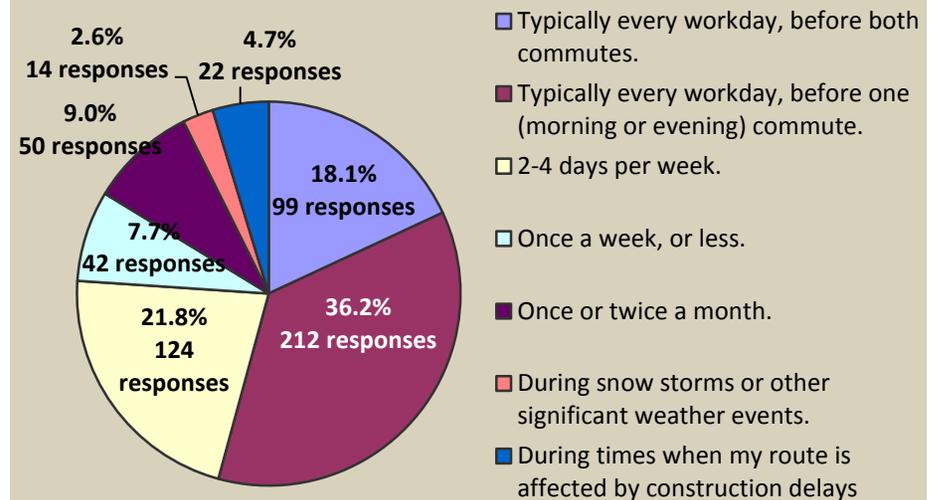
Question 2: MnDOT provides travel time information for key state highway routes in an effort to provide valuable information so drivers can make the best decisions for their travel plans. Where do you see travel time messages?



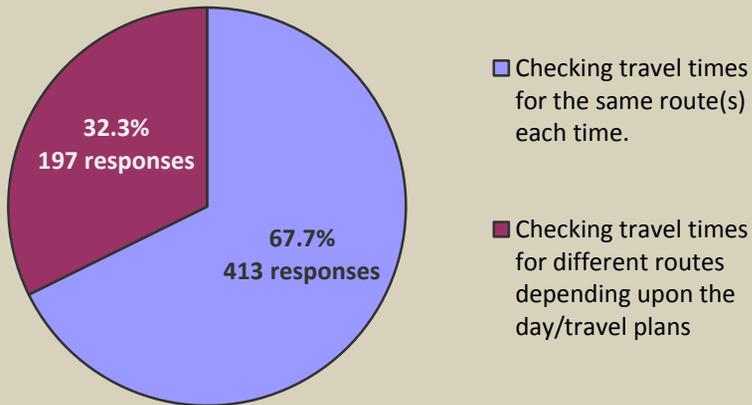
Question 3: Please describe the times when you typically view travel times on MnDOT's Website (choose as many as you like):



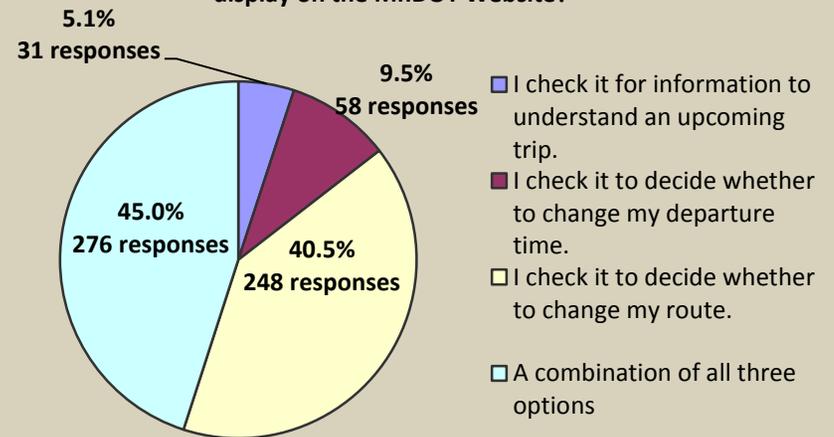
Question 4: How often do you check for travel times on MnDOT's website:



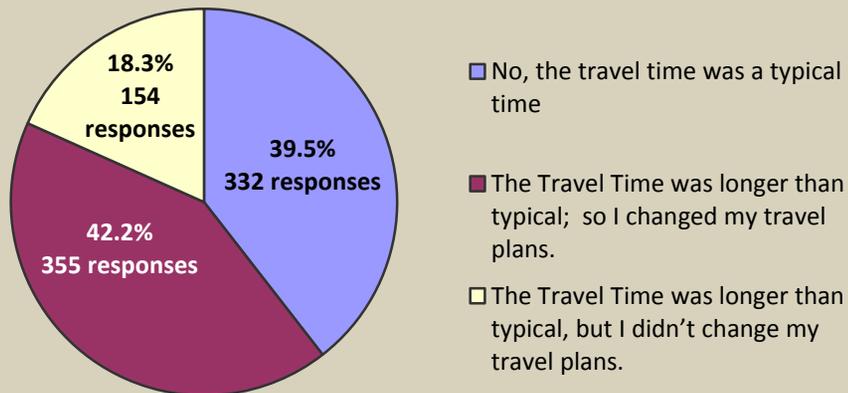
Question 5: When viewing Travel Times on the website, are you typically:



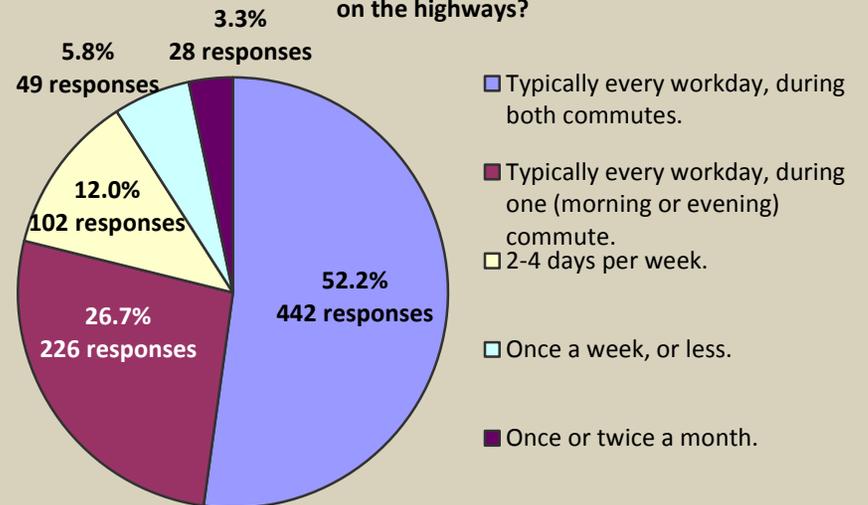
Question 6: How would you describe your use of the travel times display on the MnDOT Website?



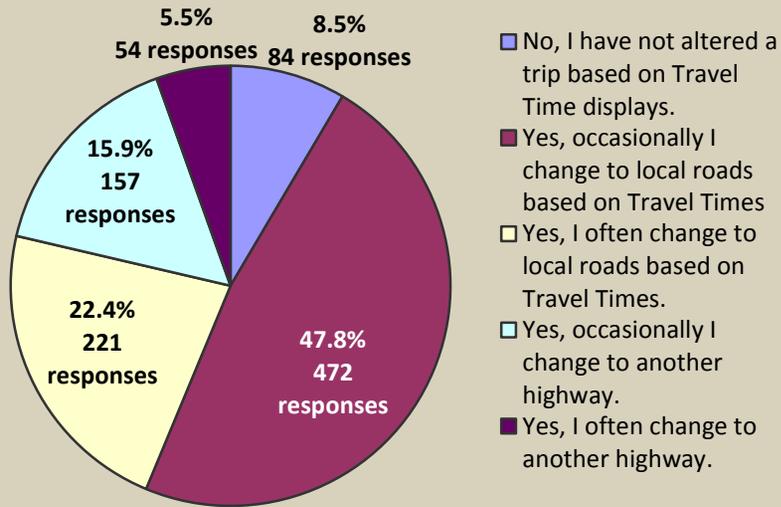
Question 7: Did you do something different the last time you viewed a travel time message on an overhead message sign?



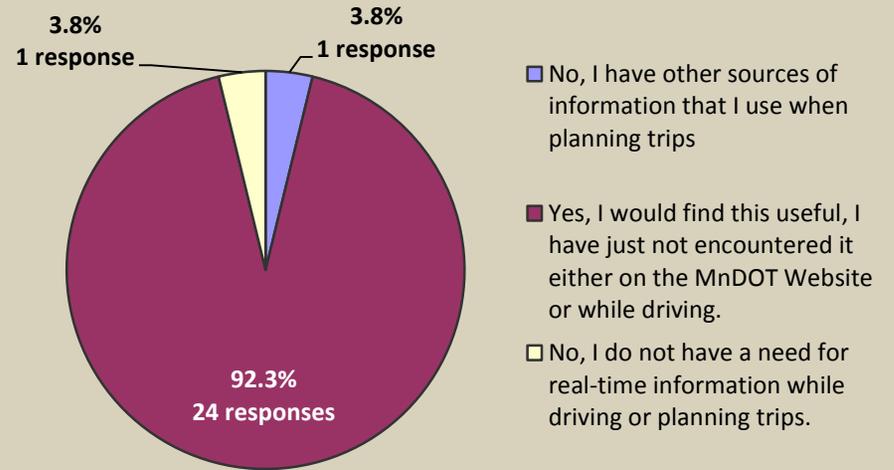
Question 8: How often do you notice signs displaying travel times on the highways?



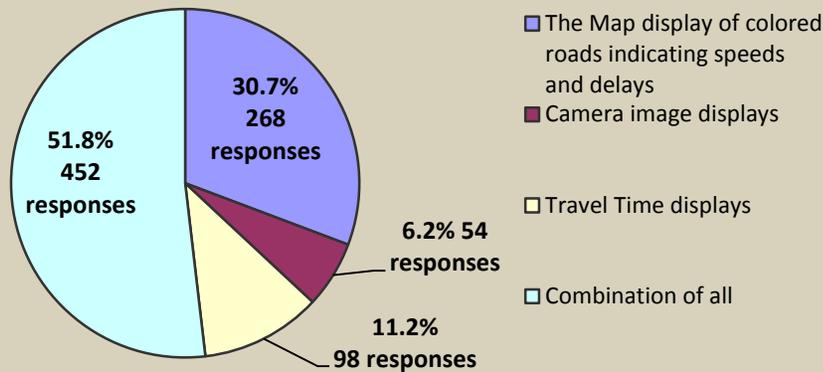
Question 9: Have you ever exited the highway and drove on alternate highways or local roads based on travel time messages you view on the overhead message signs? (Check as many as you like)



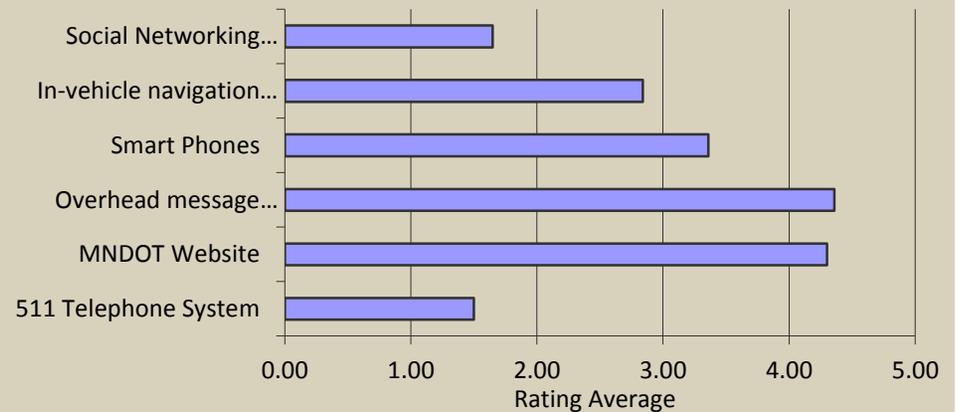
Question 10: MnDOT currently provides real-time reports of travel times between two locations on local highways. Do you feel this kind of information would be useful to you?



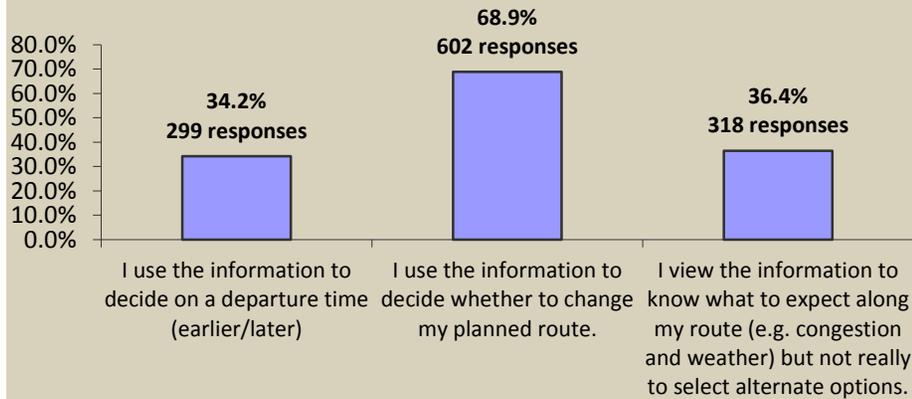
Question 11: MnDOT's travel information website (<http://511mn.org>) includes several features to provide travel information. Which is your preferred method for viewing information?:



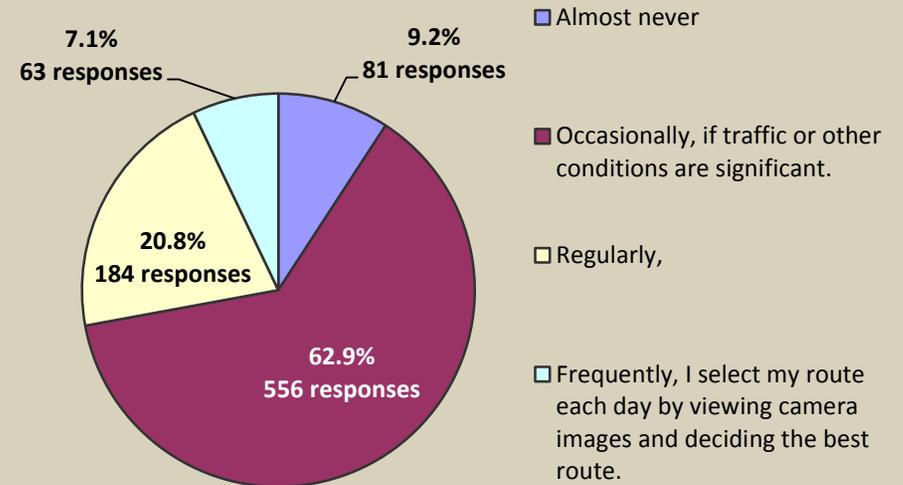
Question 12: How would you prefer to receive travel information - including travel times, incident notifications, roadwork alerts, and other notices? (please rank options):



Question 13: Please select the option that best describes how you use the other information displays on the MnDOT website that are not displaying travel times (e.g. camera image displays, map display of conditions and incidents/events, color coded roadway)

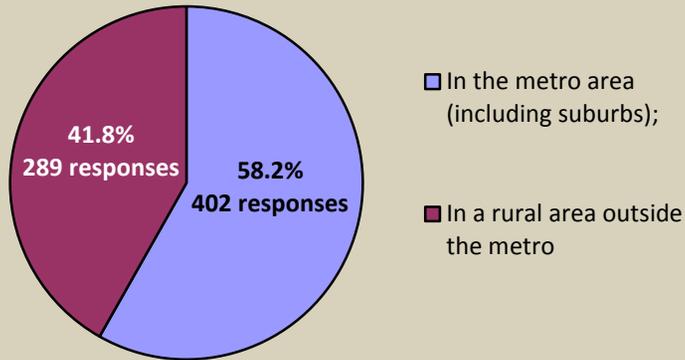


Question 14: How often would you estimate that you change your trip based on what you see on the camera images and/or map displays? (e.g. different departure time or different route)

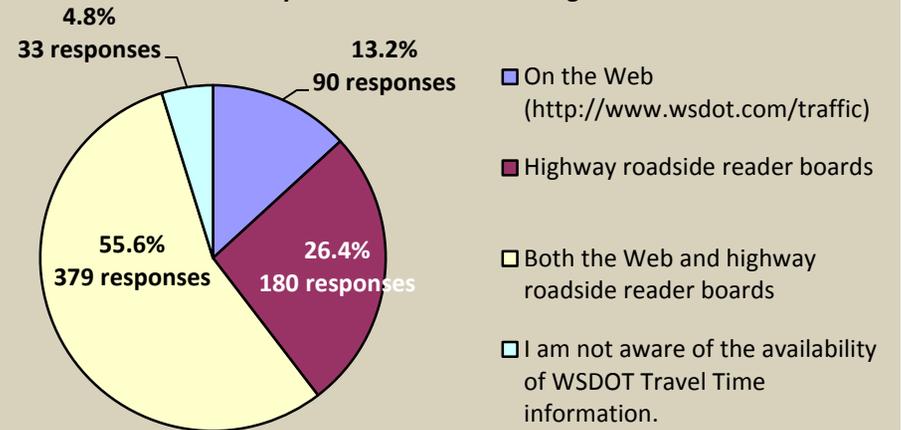


Appendix B – Washington Survey Questions and Results

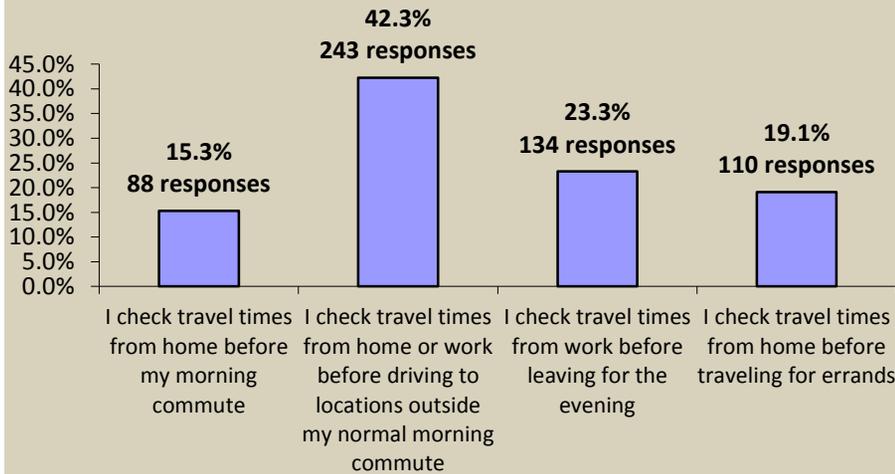
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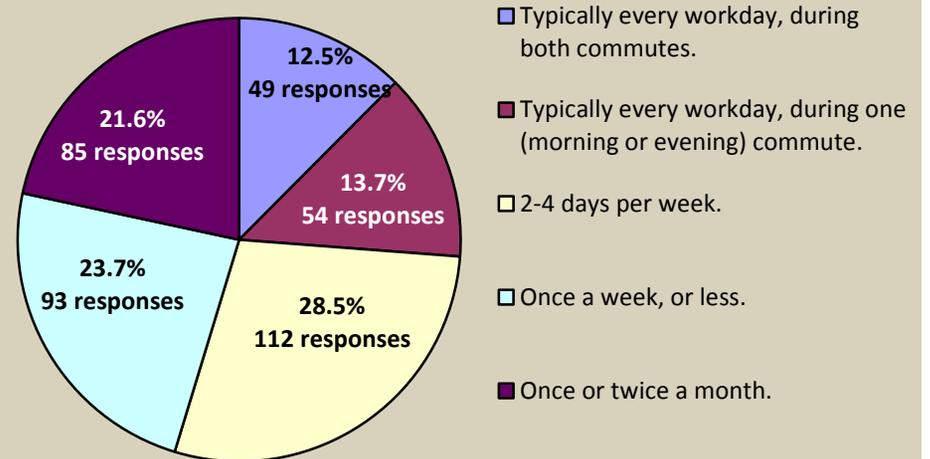
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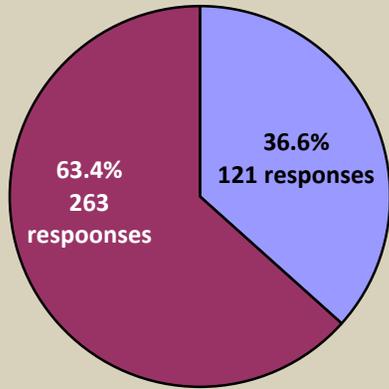
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Question 4: How often do you check for travel times on WSDOT's website:

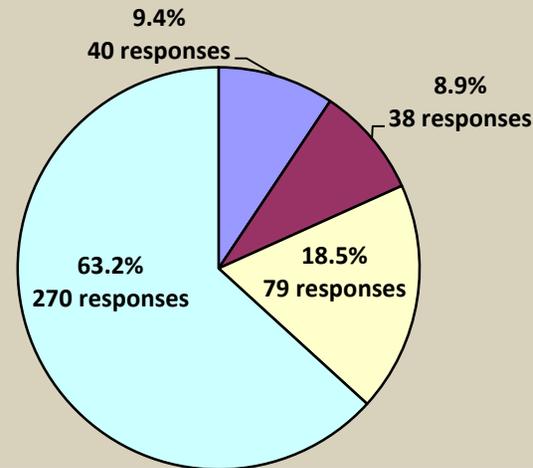


Question 5: When viewing travel times on the website, are you typically:



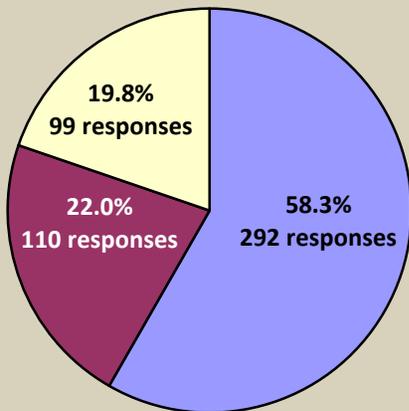
- Checking travel times for the same route(s) each time.
- Checking travel times for different routes depending upon the day/travel plans

Question 6: How would you describe your use of the travel times?



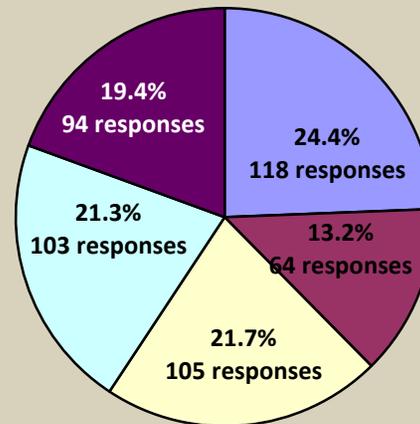
- I check it for information to understand an upcoming trip.
- I check it to decide whether to change my departure time.
- I check it to decide whether to change my route.
- A combination of all three options

Question 7: Did you do something different the last time you viewed a travel time message on roadside reader board?



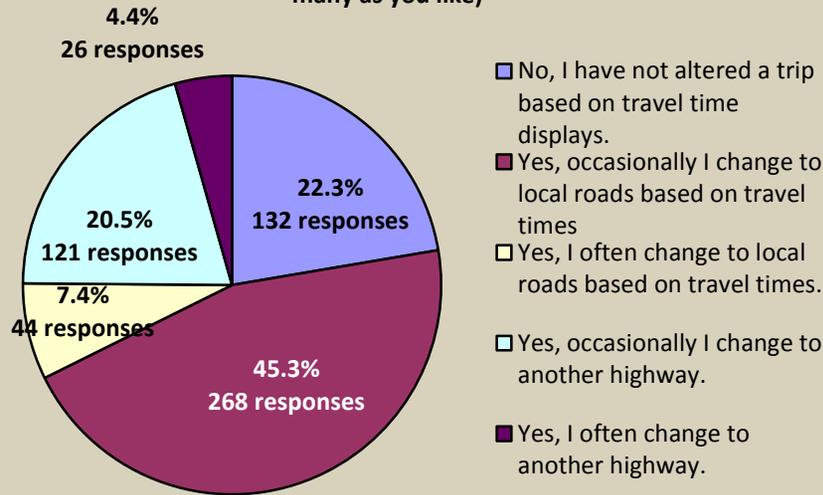
- No, the travel time was a typical time
- The Travel Time was longer than typical; so I changed my travel plans.
- The Travel Time was longer than typical, but I didn't change my travel plans.

Question 8: How often do you notice signs displaying travel times on the highways?

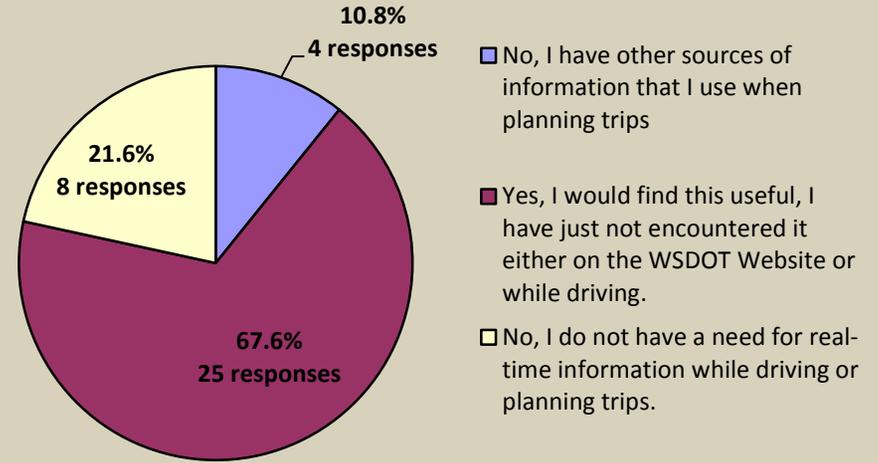


- Typically every workday, during both commutes.
- Typically every workday, during one (morning or evening) commute.
- 2-4 days per week.
- Once a week, or less.
- Once or twice a month.

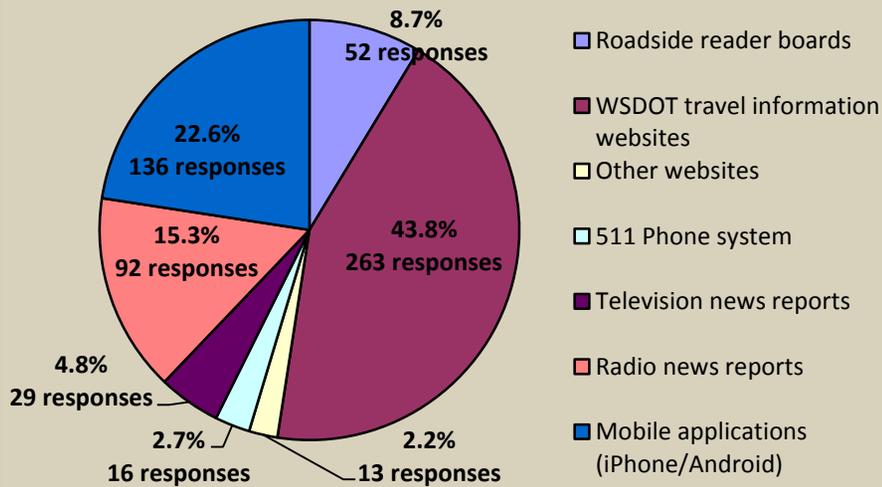
Question 9: Have you ever exited the highway and drove on alternate highways or local roads based on travel time messages you view on the roadside reader boards? (Check as many as you like)



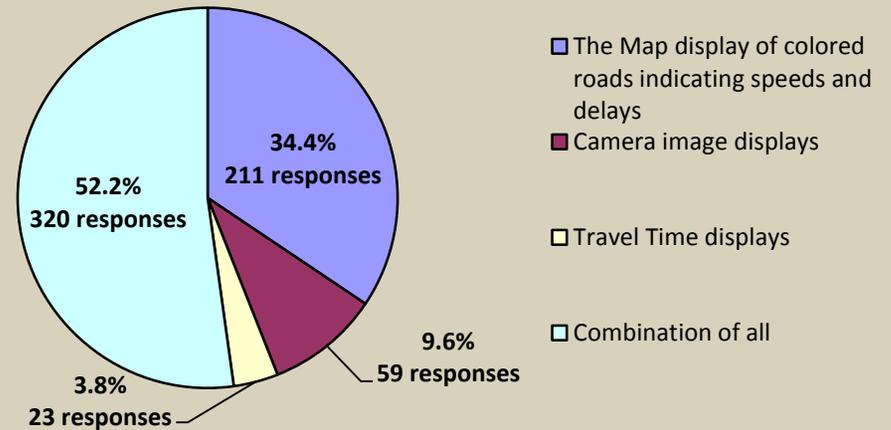
Question 10: WSDOT currently provides real-time reports of travel times between two locations on local highways. Do you feel you have a need for this type of information?



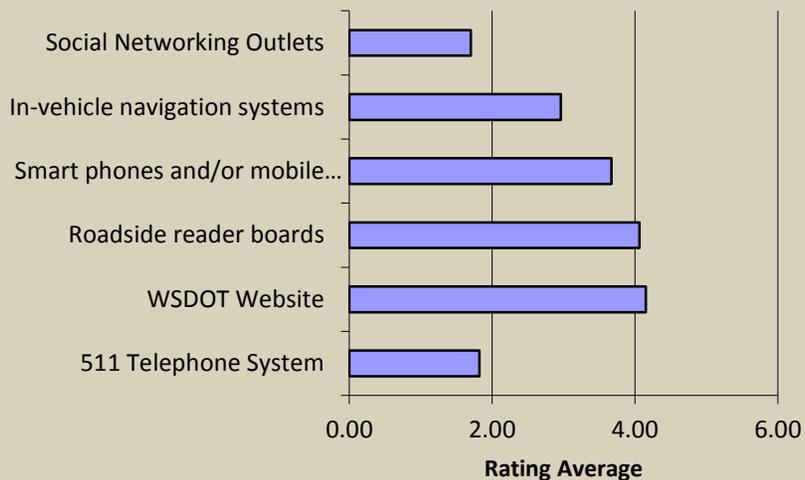
Question 11: What is your primary source for travel information today?



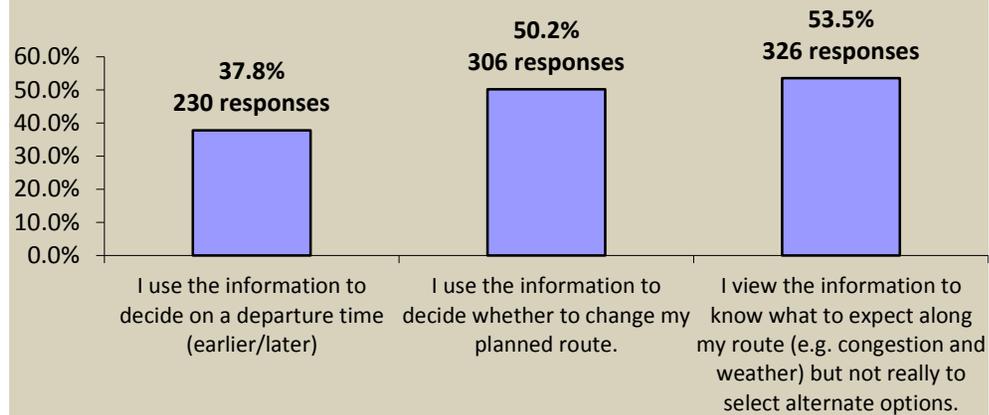
Question 12: WSDOT's travel information website www.wsdot.com/traffic includes several features to provide travel information. Of these features, which is your preferred method for viewing information?:



Question 13: How would you prefer to receive travel information - including travel times, incident notifications, roadwork alerts, and other notices? (please rank options):



Question 14: Please select the option that best describes how you use the other information displays on the WSDOT website that are not displaying travel times (e.g. camera image displays, map display of conditions and incidents/events, color coded roadway



Question 15: How often would you estimate that you change your trip based on what you see on the camera images and/or map displays? (e.g. different departure time or different route)

