

# **DEVELOPING IMPROVED TRAVEL TIME RELIABILITY MEASURES FOR REAL-TIME AND ARCHIVED ITS DATA APPLICATIONS**

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## **ABSTRACT**

Travel time estimation is of increasing importance as congestion worsens in major urban areas. Travel reliability on a given corridor may be more for travelers, shippers, and transport managers. This paper examines the use of measured travel time reliability indices for improving real-time transportation management and traveler information, using archived ITS data. Several reliability measures are tested including travel time, 95th percentile travel time, travel time index, buffer index planning time index, and congestion frequency. Results are aimed at improving the ways in which travel time reliability is communicated to users and managers through a comprehensive survey.

**KEYWORDS** Travel Time, Reliability, Archive

## **INTRODUCTION**

Travel time reliability is defined as the consistency of a given trip's travel time. More formally, it is said to be "the consistency or dependability in travel times, as measured from day to day and/or across different times of the day." [1] It is an important measure of the health of the transportation system in a region and can have far-reaching implications. Both individual travelers as well as industries depend on the transportation system, and reliability can make a significant difference in customer satisfaction and usage of the transportation network. An individual that can depend on her commute being 20 min every day doesn't have to add in extra time in case there's congestion or a crash holding up traffic; the same is true for businesses that depend on delivering or receiving products on time. The savings in time needed to plan for a trip results in greater overall efficiency of the transportation system.

This paper explores ways in which travel time reliability is measured using real time and archived data, and over a segment, a corridor and an entire urban area. It is important to communicate the ways that transportation investments can benefit an entire region. Increased amounts of information on travel time reliability can better inform travelers of the most appropriate usage of the system for their purposes. Using data along the I-5 freeway in Portland, Oregon, changes in travel time reliability will also be examined between 2004 and 2006 using different reliability measures.

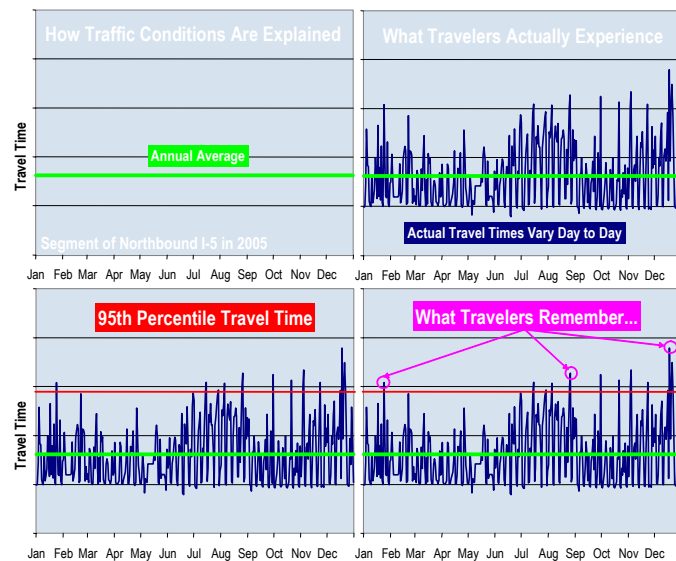
## **BACKGROUND**

Travel time reliability is a measure of the service provided by a transportation network [2]. A network that provides a high level of service has a high level of travel time reliability. Six standard measures of travel time reliability are used, based on travel time estimates directly

calculated from continuous probe vehicle data, estimated from continuous point-based detector data, collected in periodic special studies, or estimated using simulation [1,3]:

- **95th Percentile Travel Time:** how much delay will be on the heaviest travel days
- **Travel Time Index:** average time it takes to travel during peak hours compared to free flow conditions, computed as mean travel time divided by free flow travel time.
- **Buffer Index:** extra time so one is on time most of the time, computed as difference between 95th percentile travel time and mean travel time, divided by mean travel time.
- **Planning Time Index:** total time needed to plan for an on-time arrival 95% of the time, computed as 95th percentile travel time divided by free-flow travel time.
- **Frequency that congestion exceeds some expected threshold:** percent of days or time that mean speed falls below a certain speed.

Figure 1, modeled after [1] illustrates the concept using real data from a Portland, Oregon freeway. As shown, traffic conditions are usually explained as a point value, but users actually experience day to day variations. Even when the 95th percentile concept is understood, travelers actually remember the very worst experiences. A number of recent studies have pointed to the usefulness of travel time reliability and the need for more data on traveler preferences and responsiveness to different measures. [4,5,6,7]



**Figure 1 – Basic reliability introduction**



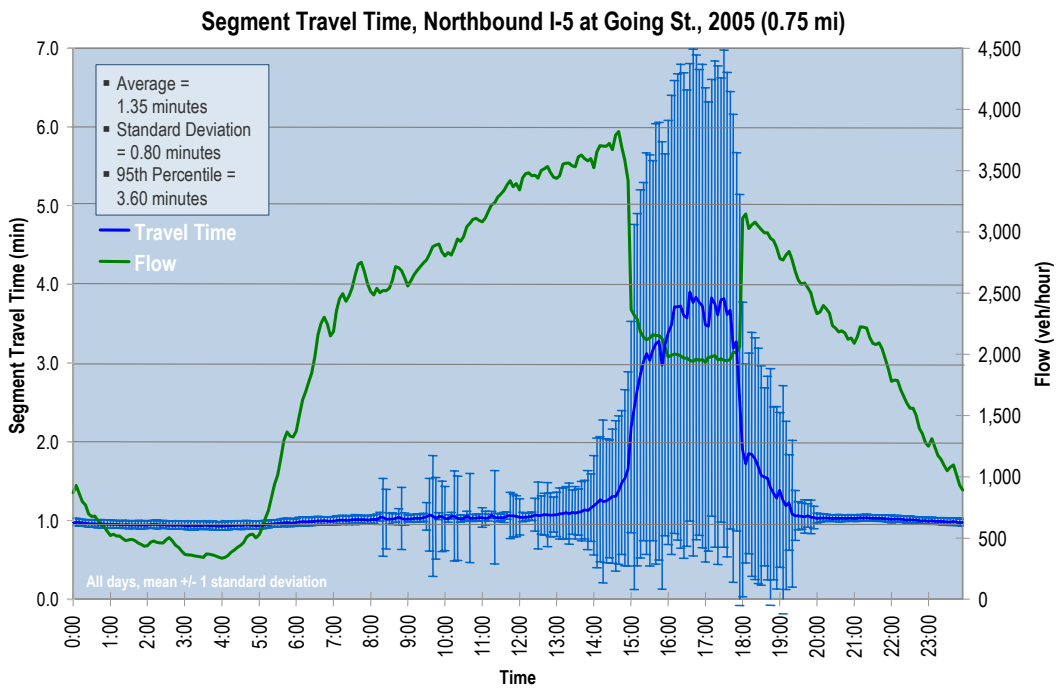
**Figure 2 – Portland region**

## ANALYSIS

The Portland Oregon Regional Transportation Archive Listing (PORTAL) serves as the Archived Data User Service (ADUS) for the Portland region (see <http://portal.its.pdx.edu>). Figure 2 shows a basic map of the Portland freeway system. With 20-second resolution count, speed and occupancy data from more than 500 freeway sensors since 2004, PORTAL is the foundation for the analysis that follows.

### Segment level analysis

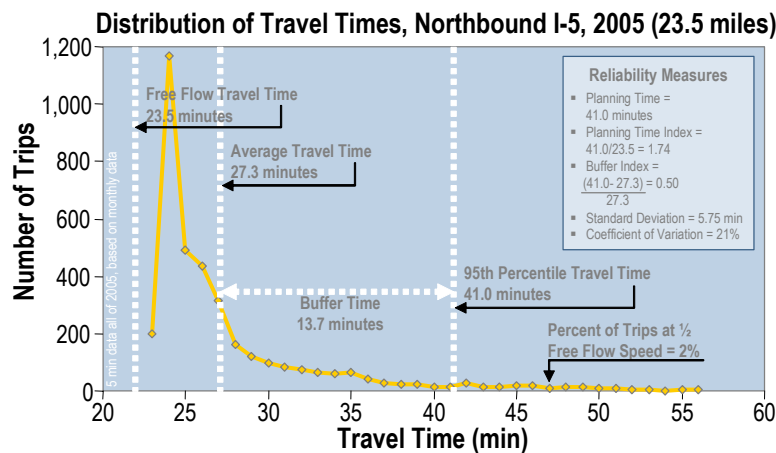
Figure 3 shows travel time data from all of 2005 for the Going St. detector station (see Figure 2), which covers a 0.75 mile segment. The figure illustrates several important features; first the travel time across the segment varies considerably throughout the day (solid line), and second its variability over the year increases during the afternoon peak period (the vertical error bars show plus and minus one standard deviation). As expected, the measured traffic flow also drops during the most congested period. This figure, made up of more than 1.5 million data points, would be difficult to construct without an archive like PORTAL.



**Figure 3 – Going St. segment travel time for 2005 (all days)**

### Corridor level analysis

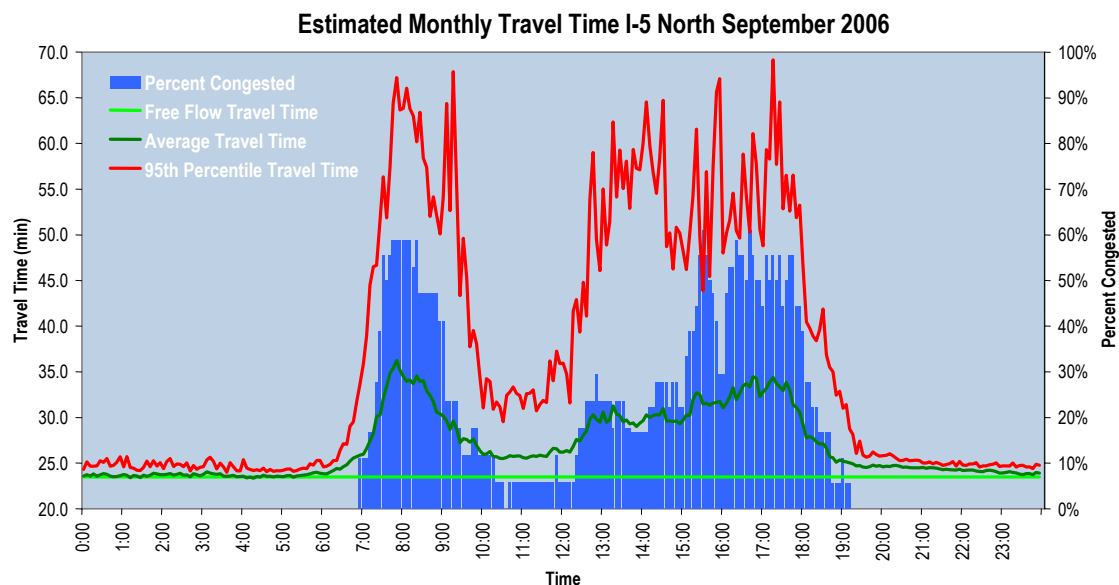
The northbound Interstate 5 corridor is a major freeway through Portland, Oregon, and has been chosen for this analysis. Figure 2 highlights the 23.5 mile corridor. Using PORTAL’s monthly report system, the collection of all measured corridor travel times were extracted at 5 min intervals for all of 2005. Figure 4 shows the sorted distribution of estimated travel times for northbound I-5.



**Figure 4 – Northbound I-5 travel time distribution for 2005**

As shown in the figure, the free flow travel time was 23.5 min, the average travel time was 27.3 min, the standard deviation was 5.75 min, the coefficient of variation was 21%, and the 95th percentile travel time was 41.0 min. The figure also shows the Buffer Time of 13.7 min. Reliability measures shown also include the Planning Time Index (1.74) and the Buffer Index (0.50). For a traveler who wants to traverse the corridor and be on time 95% of the time (i.e., late once per month), a total travel time of 41.0 min should be reserved for this trip.

PORTAL produces automated monthly performance reports that include mean travel time, the 95th percentile travel time and the percent of monthly readings (at a 5 min level) that were congested (threshold is defined at 1.3 times the free flow travel time). Figure 5 shows a monthly performance report for northbound I-5 from September 2006. As shown in the figure, the free flow trip time is about 23 min, and an average 8:00 trip would take about 35 min. However the 95th percentile travel time at 8:00 is about 67 min, revealing a required Buffer Time of 32 min at that time of the morning. Clearly as the 95th percentile curve drops closer to the mean travel time curve, the Buffer Time requirement is reduced.



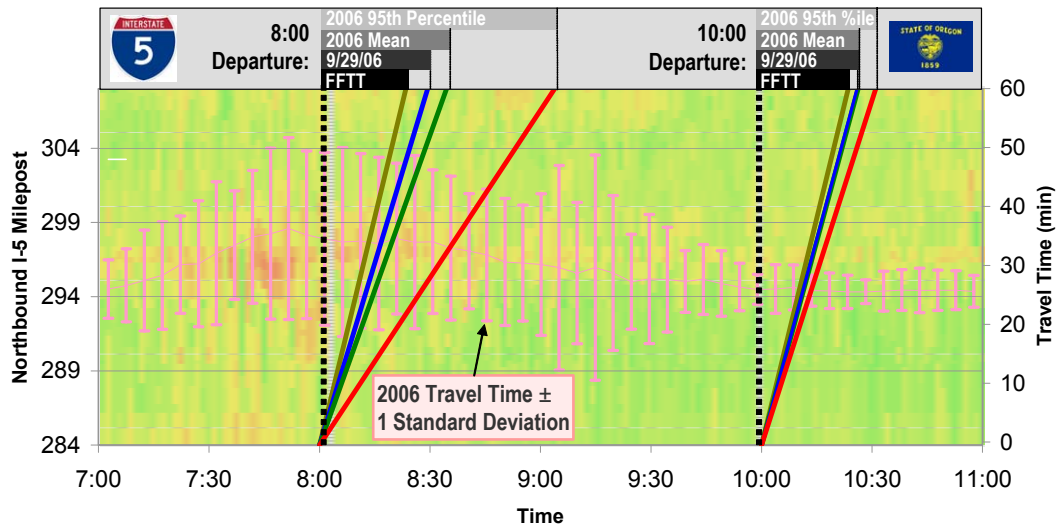
**Figure 5 – PORTAL monthly report for Interstate 5 in September 2006**

This paper compares travel time reliability measures for NB I-5 during September 2004, 2005 and 2006. Figure 3 shows monthly average travel times (at 5 min intervals) for the three years mentioned. As shown travel times during the AM peak have increased over the years, while in 2006 a notable increase occurred in the early afternoon.

Using data from 2006, Figure 6 displays a further comparison of the travel conditions on northbound I-5. The figure shows a time-space plane for the morning peak period (7:00-11:00 on the *x*-axis), and the entire northbound corridor (*y*-axis). The 2006 mean travel time is also shown at 5 min intervals with vertical error bars showing plus/minus one standard deviation for the entire year. It's clear that the travel time variability heightens by 8:00 and then decreases by 10:00.

The effects of an 8:00 northbound departure are shown in Figure 6 with hypothetical vehicle trajectories superimposed on the diagram. For the first departure, the trajectory with free flow travel time 23.5 min) is on the left. A trajectory traveling at the actual measured travel time

(on Friday September 29, 2006) of 29.3 min is shown next, followed by the trajectories for the 2006 average (34.5 min) and 95th percentile (63.8 min) respectively. The horizontal magnitude of the Buffer Time is clear in the figure, as is the point that travel time experienced on a particular day may be more or less (in this case) than average. A traveler departing on northbound I-5 at 10:00 on September 29 would require 26.2 min, compared with the 2006 average (25.9 min) and 95th percentile (31 min). Not only is the later departure saving several minutes on the sample day in question, but also on average in 2006 there was a substantial savings and improvement in reliability.

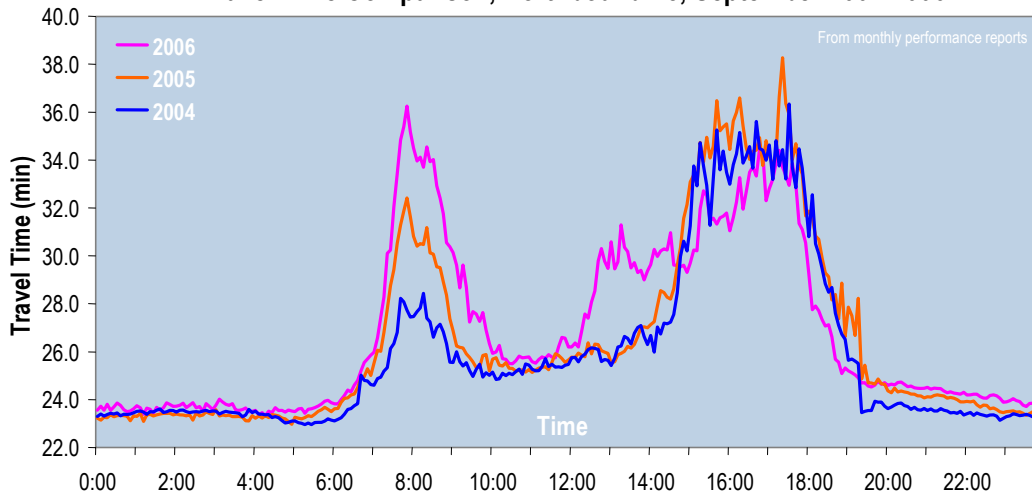


**Figure 6 – Northbound departure time comparison (2006)**

### Reliability measures over time

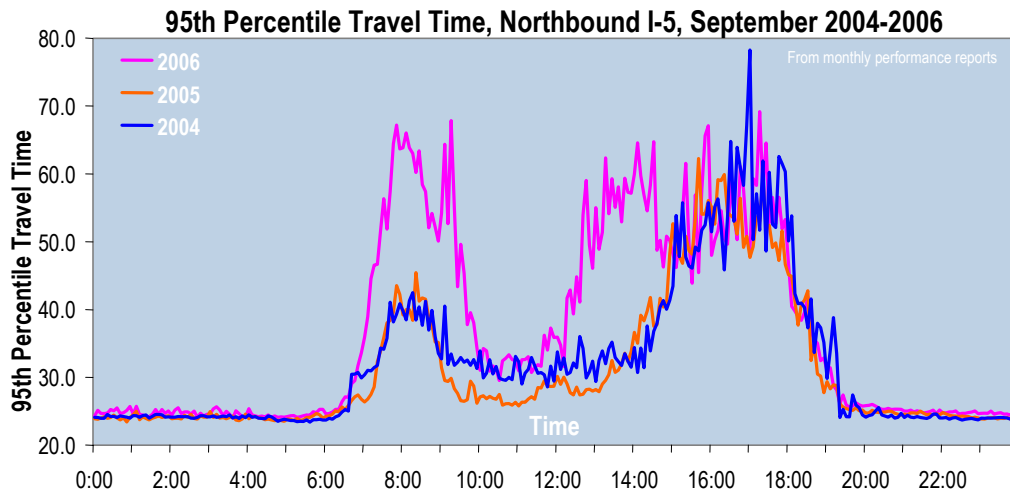
PORTAL also allows comparisons over time. Data in this study were monthly travel time data at 5-min intervals from September of 2004, 2005, and 2006 for I-5 Northbound at the I-205 Junction to the Interstate Bridge. These data were used to calculate travel time reliability using three different measures for each year. Results of this comparison are presented below. Since the travel time index is calculated as the ratio of the mean travel time to the estimated free flow travel time, a plot of travel time will look exactly like one of the travel time index. This can provide a metric for comparing actual conditions to those one might experience during an off-peak period (or overnight).

**Travel Time Comparison, Northbound I-5, September 2004-2006**



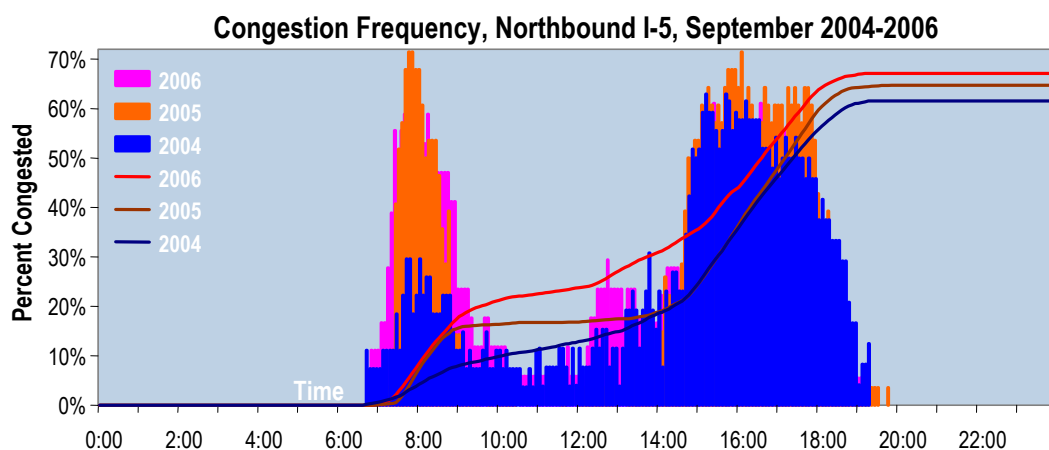
**Figure 7 – Travel time comparison**

Figure 7 shows the average travel times on this corridor in September 2004, 2005, and 2006. Average travel times rose substantially during the morning peak, and in 2006 there was a rise during the early afternoon. Apparently the peak period spread in 2006 resulting in lower average travel times between 16:00-18:00. This means that during the afternoon peak the travel time (and travel time index) has decreased slightly between 2004 and 2006. In 2006 an improved ramp metering software system was installed which could partially explain this.



**Figure 8 – 95th percentile travel time comparison**

Figure 8 shows the 95th percentile travel time at 5 min intervals for northbound I-5 (a 23.5 mile long corridor) for September 2004, 2005, and 2006. The main notable feature is that apparently the 95th percentile increased notably during 2006. The 2004 measurements were slightly higher than those from 2005 during the mid-day period, and spiked highest in the afternoon peak. As mentioned, the buffer index (the difference between the 95th percentile travel time and the mean travel time, divided by the mean travel time) is the extra time that travelers or shippers must add to their trip to ensure on time arrival 95% of the time (or to be late on average once a month). The graphs in Figure 8 would look exactly like the buffer index for northbound I-5.



**Figure 8 – Congestion frequency comparison**

Another popular method for measuring travel time reliability is to report the frequency that travel times are congested. Figure 8 shows a bar chart indicating the percent of the time

(during September 2004, 2005, and 2006) that a particular 5-min time interval was congested ( $>1.3 \times$  free flow travel time). From the figure it is possible to see the increase in 2006 in the early afternoon, and the increase in 2005 in the afternoon/evening peak. As another way to visualize how congestion accumulates over a day, the figure also shows these bar charts cumulatively. The slope of the solid lines indicates the time periods during which changes in this measure occurred. As shown by the position of the line for 2006, it is clear that the congestion (using this measure) increased throughout the day over that experienced in 2005 and 2004.

### Regional congestion and reliability measures

PORTAL includes monthly reports highlighting basic congestion and reliability measures for the entire Portland freeway system. Figure 9 shows the format, based on an FHWA template, used for May 2006. The percent congested travel, travel time index and buffer index are the three chosen performance measures, and the report shows how each measure changed from the previous month, as well as the 12-month high/low value. This snapshot of the region's traffic conditions has proven useful to regional transportation planning and operations personnel as well as decision-makers.

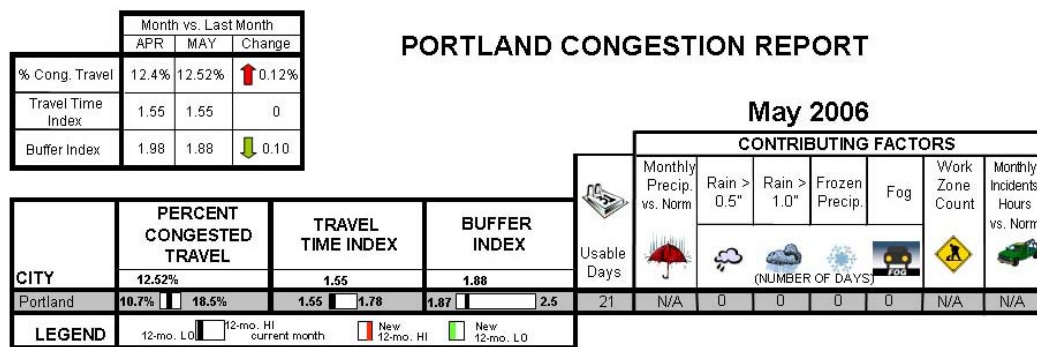


Figure 9 – Portland congestion report

### CONCLUSIONS AND NEXT STEPS

Measures of travel time reliability can provide important indicators as to the health of a transportation system. Not only can they give more accurate information regarding the change in system conditions from year to year, but they can also be used as supplements to existing sources of traveler information. This paper has explored ways in which travel time reliability is measured, briefly referencing recent literature analyzing measures and applications of travel time reliability. The analysis used existing freeway data along I-5 in Portland, Oregon to illustrate ways of reporting reliability and also analyzed changes in travel time reliability between 2004 and 2006 using different travel time reliability measures. Some trends were noticed, including increasing travel times and worsening reliability in the morning peak, travel time increases during the early afternoon and decreases in the later afternoon/evening.

One major challenge of travel time reliability is in communicating its benefits to the public. Services such as the Oregon Department of Transportation's [www.tripcheck.com](http://www.tripcheck.com) or the Tri-County Metropolitan Transit District of Oregon's Transit Tracker (<http://trimet.org/arrivals/index.htm>), although useful for real-time traveler information, do not currently offer measures of travel time reliability along particular corridors or for door-to-

door trips. Particularly with the availability of historical data, it is important to communicate the ways in which ITS investments can improve travel time reliability, and that these improvements can benefit an entire region—from transit riders, to auto commuters, to businesses that depend on the ability to deliver products just-in-time. Increased amounts of information on travel time reliability can better inform travelers of the most appropriate usage of the system for their purposes.

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