Washington State Department of Transportation

June 2011

WSDOT's Congestion Measurement Approach: Evaluating System Performance

Population and the economy has impacted demand on many of Washington's roadways, resulting in congestion. The growth in travel demand, particularly during peak periods, consumes the limited capacity of the highway system, leading to increased congestion. Recurring congestion occurs during peak travel periods for a simple reason—the number of vehicles trying to use the highway system exceeds the available capacity. Non-recurring congestion—congestion resulting from weather, construction, collisions, vehicle breakdowns, etc.—further reduces the operating efficiency of the highway system.

Measuring congestion at WSDOT

WSDOT collects real-time data for 52 commute routes in the Puget Sound region, two commute routes in Spokane, and on other highways statewide. In the central Puget Sound region alone, data are collected from over 5,000 loop detectors embedded in the pavement of the 709 centerline miles. Using this quality controlled data, WSDOT analyzes system performance by using a variety of performance measures. In tracking and communicating performance results, WSDOT adheres to congestion measurement principles including the use of accurate, real-time data rather than modeled data, and using language and terminology that is meaningful to the public ("Plain English").

New HOV lanes on Interstate 5 will help ease congestion in Pierce County.

WSDOT's congestion measurement principles

- Use real-time measurements (rather than computer models) whenever and wherever possible.
- Use maximum throughput as the basis for congestion measures.
- Measure congestion due to incidents (non-recurrent) as distinct from congestion due to inadequate capacity (recurrent).
- Show how reducing non-recurrent congestion from incidents will improve the travel time reliability.
- Demonstrate both long-term trends and short-to-intermediate-term results.
- Communicate about possible congestion fixes using an "apples-to-apples" comparison with the current situation (for example, if the trip takes 20 minutes today, how many minutes less will it be if WSDOT improves the interchange?)
- Use "Plain-English" to describe measurements and results.

WSDOT's congestion measurement speed thresholds

Measure	Threshold	Description
Posted speed	i.e. 60 mph	Spacing varies based on speed and volume, but fewer vehicles are able to use the system at this speed.
Maximum throughput speeds	70%-85% of posted speed (roughly 42-51 mph)	Vehicles are moving slower than the posted speed and the number of vehicles moving through the highway segment is higher. These conditions enable the segment to reach its maximum productivity in terms of vehicle volume and throughput.
Duration of the congested period	Duration triggered when vehicle speeds drop below 75% of posted speeds (45 mph)	The average weekday peak time period (in minutes) when average vehicle speeds drop below 45 mph. Highway is at less than maximum productivity because drivers are positioned at less than optimal spacing.
Percent of state highway system congested	Less than 70% of posted speeds	Percent of total state highway lane miles that drop below 70% of the posted speed limit.
Severe Congestion	Less than 60% of posted speeds (at or below 35 mph)	Speeds and spacing fall to below optimal, and the highway is well below maximum productivity.

Key congestion performance measures

Average peak travel time	The average travel time on a route during the peak five-minute interval for all weekdays of the calendar year.
95% reliable travel time	Travel time with 95% certainty (i.e. on-time 19 out of 20 work days).
Maximum Throughput Travel Time Index (MT^3I)	The ratio of peak commute period travel time compared to maximum throughput speed travel time.
Percent of days when speeds fall at or below 35 mph	Percentage of days annually that observed speeds for one or more five-minute interval is at or below 35 mph (severe congestion) on key highway segments.
Vehicle throughput	Measures how many vehicles move through a highway segment/spot location in an hour.
Lost throughput productivity	Percentage of a highway's vehicle throughput lost due to congestion.
Delay	The average total daily hours of delay per mile based on the maximum throughput speed of 50 mph measured annually as cumulative (total) delay.
Percent system congested	Percent of total state highway lane miles that drop below 70% of the posted speed limit.
Duration of the congested period	The time period in minutes when speeds fall below 45 mph.
HOV lane reliability	An HOV lane is deemed "reliable" so long as it maintains an average speed of 45 mph for 90% of the peak hour.
Person throughput	Measures how many people, on average, move through a highway segment during peak periods.
Before and After analysis	Before and after performance analysis of selected highway congestion relief projects and strategies.
Average clearance time of incidents (Statewide)	Operational measure defined as the time from notification of the incident until the last responder has left the scene for all incidents responded to by WSDOT Incident Response personnel statewide.

Travel time performance for selected central Puget Sound commutes

Length of route in miles; all travel times in minutes; peak of commuter rush and duration of congestion expressed in hours and minutes

Route	Direction of travel	Length of route	Peak of AM rush	Travel time on the route at: Posted speed	Travel time on the route at: Maximum throughput	Average travel time at peak of AM rush: 2007	2009	%Δ	95% reliable travel time: 2007	2009	Δ	Maximum throughput travel time (MT³ Index): 2007	2009	VMT during peak period: %Δ in VMT	Duration of congestion (how long is average speed below 45mph): 2007	2009	Δ
I-5–Everett to Seattle	SB	24	7:30	24	28	47	41	-13%	76	66	-10	1.66	1.44	1%	2:40	1:40	-1:00
I-5–Federal Way to Seattle	NB	22	7:35	22	26	47	35	-26%	65	52	-13	1.80	1.34	3%	4:05	1:50	-2:15
I-5/I-405–Everett to Bellevue	SB	23	7:25	23	28	49	42	-14%	78	68	-10	1.74	1.49	2%	2:55	2:00	-0:55
I-405–Lynnwood to Bellevue	SB	16	7:35	16	19	39	33	-15%	62	54	-8	2.04	1.72	2%	3:20	2:25	-0:55
1-405–Tukwila to Bellevue	NB	13	7:40	13	16	42	26	-38%	58	37	-21	2.60	1.61	16%	4:40	3:20	-1.20

Data source: WSDOT Traffic Operations and the Washington State Transportation Center (TRAC) at the University of Washington.

Measures that matter to drivers: speed, travel times, and reliability

Travel times and reliable travel times are important measures to commuters and businesses in Washington. Measuring the time to get from point A to point B is one of the most easily understood congestion measures and is one that matters to drivers whenever they make a trip. Reliability matters to drivers because it is important to be on time all the time. WSDOT's Congestion Report examines 52 tracked commute routes in the Puget Sound region, reporting in detail on 38 high-demand routes, as well as two Spokane commute routes and travel times for high occupancy vehicle (HOV) lanes. The metrics used in the travel time analysis include the average peak travel time, 95% reliable travel time, the duration of congestion, and the percent of weekdays when average travel speeds are at or below 35 mph. The performance of an individual route is compared to data from previous years.

Real-time travel times for key commutes around Puget Sound, Spokane, and Vancouver are available to the public and updated every five minutes on the WSDOT web site at http://www.wsdot.wa.gov/traffic/seattle/traveltimes/.

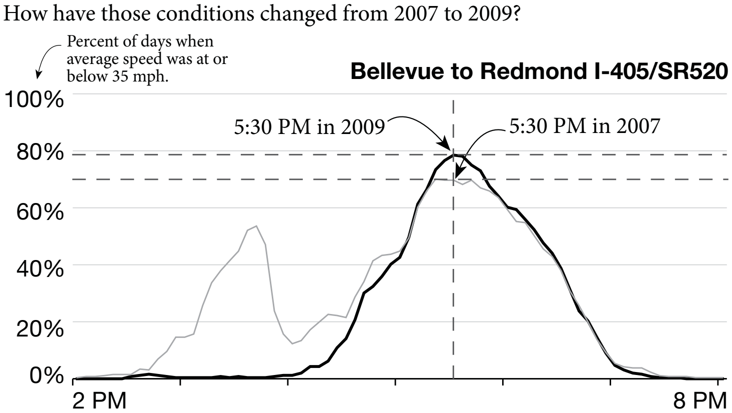
Measuring traffic volumes and vehicle miles traveled

WSDOT examines two volume metrics for each commute route: volumes during peak hours and the total daily volumes. WSDOT continues to examine factors such as the use of public transportation, population change, job growth, and fuel prices as they relate to volume and travel time changes.

Vehicle miles traveled (VMT) is a metric WSDOT uses to quantify travel along a route. It is simply the vehicle count multiplied by a length of roadway. Because traffic volumes vary along a route, each location's traffic volume is multiplied by the representative length of the route, and these values are added up to obtain a route's VMT. WSDOT uses this measure to better understand the number of trips taken for certain commute routes, as well as total miles traveled on state highways to predict future demands and establish needs.

How to read a stamp graph

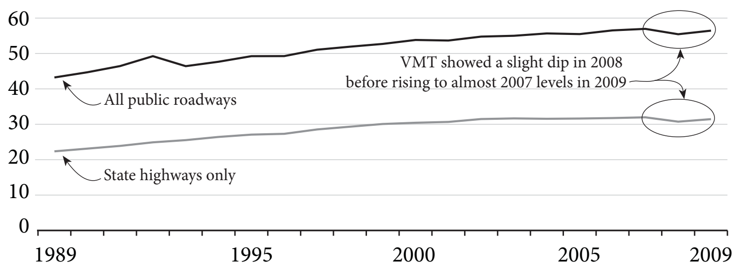
How frequently (and when) were the average trip speed at or below 35 mph? How have those conditions changed from 2007 to 2009?



At 5:30 pm in 2007, you had about a 70% chance that traffic would be moving at or below 35 mph. In 2009, the situation became worse (black line above the gray line); your chance that traffic would be moving at or below 35 mph was about 79% in 2009.

Annual vehicle miles traveled statewide

1989-2009; In billions



Data source: Statewide Travel and Collision Data Office (STCDO).

Traffic volume is a vehicle count at a given roadway location. It is measured by a detector in each lane at the location. WSDOT has loop detectors spaced at approximately half-mile intervals throughout the central Puget Sound freeway network, and at various locations on the highway system statewide.

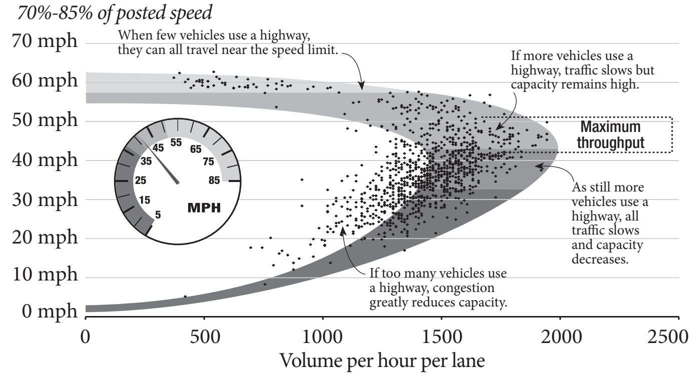
In 2008, the Legislature established per capita VMT as the primary measure connecting congestion and greenhouse gas emissions.

WSDOT uses maximum throughput as the basis for congestion performance measurement

From the perspective of operating the highway system as efficiently as possible, speeds at which the most vehicles can move through a highway segment (maximum throughput) is more meaningful than posted speed as the basis for measurement. It is logical for WSDOT to aim towards

Understanding maximum throughput: An adaptation of the speed/volume curve

I-405 northbound at 24th NE, 6am-10am weekdays volume in May 2010; Speed limit 60 mph; Maximum throughput speed ranges between: 70%-85% of posted speed



Data source: WSDOT Northwest Region Traffic Office.

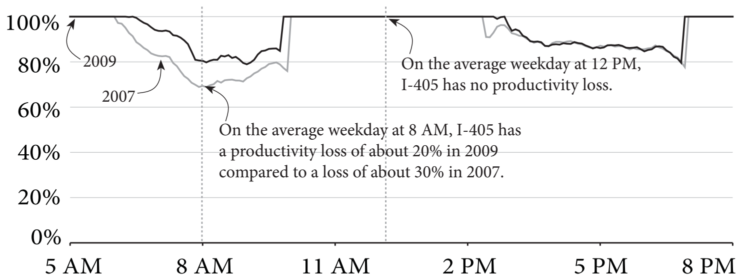
providing and maintaining a system that yields the most productivity (or efficiency) versus providing a free flowing system where not as many vehicles are passing through a segment during peak travel periods.

Maximum throughput is achieved when vehicles travel at speeds between roughly 70% and 85% of posted speeds (approximately 42-51 mph). At maximum throughput speeds, highways are operating at peak efficiency because more vehicles are passing through the segment than there would be at posted speeds. This happens because drivers at maximum throughput speeds can safely travel with a shorter following distance between vehicles than they can at posted speeds.

Maximum throughput speeds vary from one highway segment to the next depending on prevailing roadway design and traffic conditions, such as lane width, slope, shoulder width, pavement conditions, traffic compositions, conflicting traffic movements, heavy truck traffic, presence or lack of median barriers, etc. The maximum throughput speed is not static and can change over time as conditions change. Ideally, maximum throughput speeds for each highway segment should be determined through comprehensive traffic studies and validated based on field surveys. For surface arterials, maximum throughput speeds are difficult to predict because they are heavily influenced by conflicting traffic movements at intersections.

Lost vehicle throughput productivity: example

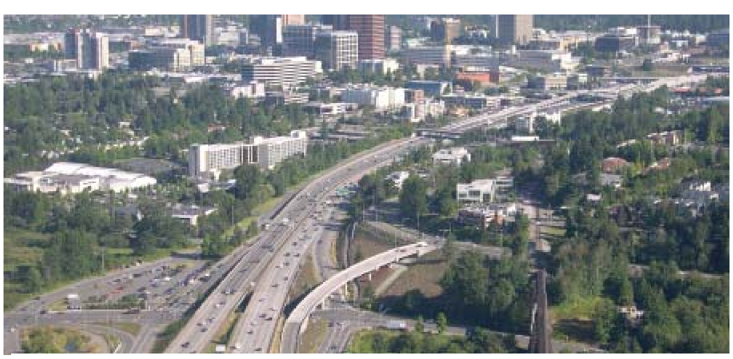
Based on the highest average five minute flow rates observed on I-405 at NE 160th Street MP 22.5 for both directions of traffic in 2007 and 2009



Data source: WSDOT Urban Planning Office.

Evaluating vehicle throughput productivity

Highways are engineered to move specific volumes of vehicles based on the number of lanes and other design aspects. Highways are not necessarily operating at their maximum efficiency when all vehicles are moving at 60 mph (the typical urban highway posted speed limit in Washington). As congestion increases, speeds decrease, and fewer vehicles pass through the corridor being measured. Throughput productivity may decline from a maximum of about 2,000 vehicles per hour per lane traveling at speeds between 42-51 mph (100% efficiency) to as low as 700 vehicles per hour per lane (35% efficiency) when traveling at speeds less than 30 mph.



Congestion starting to build on the freeways in Bellevue.

Measuring the percent of the highway system that is congested

The percent system congestion measure allows WSDOT to evaluate what percentage of the system that the agency manages is indeed congested. This measure is calculated by dividing the number of lane miles where speeds drop below 70% of posted speeds by total lane miles. This measure also differentiates what proportion of the congested lane miles are in urban areas versus rural areas of the state.

Percent of the state highway system that is congested

For all lane miles	2007	2009
All state highways	5.6%	5.2%
Urban state highways	5.1%	4.7%
Rural state highways	0.5%	0.5%

Data source: WSDOT Urban Planning Office.

Measuring total delay and per capita delay

Delay is typically calculated as the difference between actual travel times and travel times at posted speeds. WSDOT uses maximum throughput speeds, rather than posted speeds, to measure delay relative to the highway's most efficient operating condition. WSDOT measures travel delay statewide and on five major commute corridors in the central Puget Sound. In addition to measuring the total hours of delay, WSDOT also evaluates annual per capita delay and the cost of delay to drivers and businesses.

Cost of delay to Washington drivers and businesses drops by $159 million

Statewide delay compared to optimal flow speeds cost drivers and businesses $767 million in 2007. In 2009, that amount had dropped by $159 million to $608 million in delay. When measured against posted speeds, delay cost drivers and businesses $1,045 million in 2009, $185 million less than in 2007 ($1,230 million).

Calculating the cost of delay

The cost of delay is calculated by applying monetary values to the estimated hours of delay incurred by passenger and truck travel plus additional vehicle operating costs. The value of time for passenger trips was assumed to be half of the average wage rate.

Congestion, or delay, imposes costs for the lost time of travelers, higher vehicle operating costs from such things as wasted fuel, and other effects of stop and go driving. Truckers, shippers, and their customers also bear large costs from traffic delay. Direct and indirect impacts resulting from delay include:

- Increased travel time for personal travel;
- Increased travel time for business travel;
- Increased vehicle operating expense.

Travel delay on state highways declines in 2009

All state highways: average weekday delay comparison (daily and annual) and estimated cost of delay on state highways (annual)
Comparing 2007 and 2009

	Annual cost of delay on state highways (in millions of 2009 dollars)		
Actual travel compared to:	**2007**	**2009**	**% Δ**
Maximum throughput speeds (70%-85% of posted speed)	$767	$608	-21%
Posted speed	$1,230	$1,045	-16%

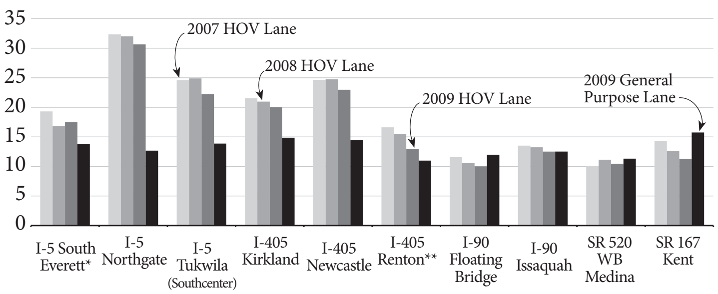
Data source: WSDOT Urban Planning Office.

WSDOT examines HOV lane performance

WSDOT uses several measures to evaluate HOV lane performance. WSDOT and the Puget Sound Regional Council adopted a reliability standard for HOV lanes which states that for 90% of the peak period, HOV lanes should maintain an average speed of 45 mph. This is the basis for WSDOT's HOV reliability measure. WSDOT also measures person throughput to gauge the effectiveness of HOV lanes in carrying more people compared to general purpose lanes. WSDOT also reports on HOV lane travel times as compared to general purpose lane travel times.

Comparison of HOV lane and general purpose lane person throughput

Total of AM and PM peak period volumes, number of people in thousands



Data source: Washington State Transportation Center (TRAC).

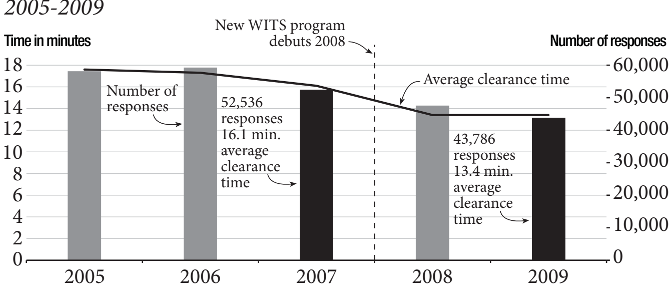
Notes: Volumes are for peak period directions only. *In 2007 the monitoring location changed because of construction. **The monitoring location changed from I-405 Tukwila to I-405 Rention. (Cedar Ave.)

Evaluating operational strategies: Incident Response

WSDOT conducts on-going performance evaluation of its Incident Response program which is published quarterly in the *Gray Notebook* and annually in the Congestion Report. Reducing the average clearance time for all incidents statewide and over-90-minute incidents on key congested corridors are specific performance targets related to Incident Response. WSDOT also measures the number and clearance times of incidents involving fatalities, blockages, disabled vehicles, injury collisions and non-injury collisions, among other measures.

Number of responses and overall clearance time

2005-2009



Data source: Washington Incident Tracking System, WSDOT Traffic Office.

Note: In Q1 2008, WSDOT's Incident Response Program moved to a new database system and began calculating average clearance time in a different way. This accounts for the apparent decrease in the average clearance time value.

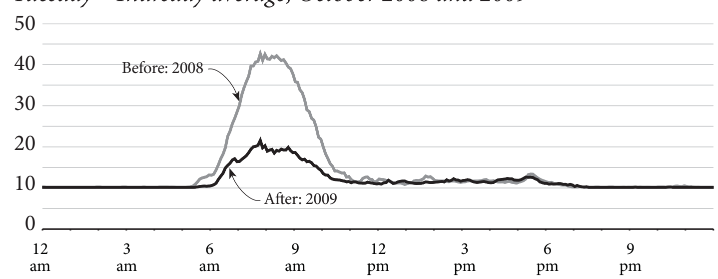
Before and After analyses of congestion relief strategies and projects

The I-405 South Bellevue widening project helps relieve congestion for drivers coming to and leaving from Bellevue – one of the worst I-405 bottlenecks. The project added a general purpose lane northbound from 112th Avenue SE to SE 8th Street, and southbound from NE 4th Street to I-90; it also added a southbound HOV lane from SE 8th Street to I-90. Widening the roadway required many construction phases, including removing the Wilburton Tunnel, widening the bridges over Coal Creek Parkway and SE 8th Street, and building a new bridge for southbound traffic over I-90. Construction began in July 2007, and all lanes were open by September 2009. The new northbound general purpose lane from 112th Avenue SE to I-90 opened in January 2009; the section from I -90 to SE 8th Street opened in August 2009.

The additional capacity has helped to reduce travel time and congestion conditions along this section of the I-405 corridor. One of the high-demand commute routes along this corridor, the I-405 between Tukwila and Bellevue, has seen a 16-minute improvement in travel time following the completion of this project, while having a 16% increase in VMT in 2009 compared to 2007.

Before and After travel times from capacity additions on I-405 northbound from SR 167 to NE 12th Street

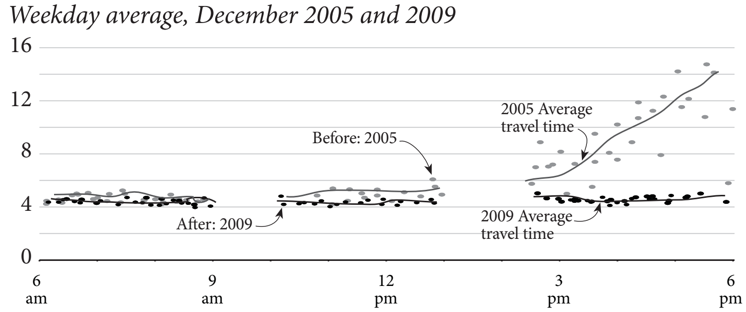
Travel time in minutes, corridor is 10.2 miles
Tuesday - Thursday average, October 2008 and 2009



Data source: WSDOT Northwest Region Traffic Office.

Before and After travel times from capacity additions on SR 518 eastbound from SR 509 to SR 181

Travel time in minutes, corridor is 4.1 miles
Weekday average, December 2005 and 2009



Data source: WSDOT Northwest Region Traffic Office.

Data note: Travel times recorded by test vehicle shown for 6am-9am, 11am-1pm, and 2pm-6pm peak periods only.

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