Transit Trip Analysis Methodology 10

Transit trip analysis is part of WSDOT's overall analysis of commutes to provide a multimodal view of regional travel patterns. WSDOT works with transit agencies in major urban areas statewide to align bus, light rail and commuter rail routes with the peak period commute trips (see the 2014 *Corridor Capacity Report* pp. 9-40 and Appendix pp. 13-14, 27-28 and 31-32).

Transit trip analysis measures

WSDOT computes the following average daily transit measures for each commute corridor statewide:

Transit trips

- Transit ridership
- Transit passenger miles traveled
- Vehicle miles avoided by transit use
- Emissions avoided due to transit
- Transit utilization
- Transit travel times

Capacity savings due to transit

Transit fleet in service during peak

Park and ride lot utilization

Transit trips

Transit ridership is the average maximum load of people using transit services each day during the morning and evening peak periods. WSDOT uses a peak period of 6-9 a.m. for the morning commutes and 3-6 p.m. for evenings based on recommendations from transit agency partners.

Transit ridership is calculated based on data provided by transit service providers in the region. Ridership for individual bus routes that closely follow WSDOT's defined commute routes is assigned to that commute route. The total "ridership" value for each commute corridor is the summation of the average maximum load for all transit trips that are assigned to the specific commute corridor.

$$\text{Transit ridership} = \sum_{\text{Peak period transit trips } 1-n}^{\text{Commute trip}} \text{Average maximum load}$$

Transit passenger miles traveled is the person miles traveled specifically by transit users (excluding the driver). Transit passenger miles traveled is calculated by multiplying the average maximum load of passengers for each transit trip by the trip distance (see the equation at the top of the next column).

$$\text{Transit passenger miles traveled} = \sum_{\text{Time period}}^{\text{Commute trip}} \left(\text{Average maximum load}_{\text{Transit trip}} \times \text{Distance traveled}_{\text{Transit trip}} \right)$$

WSDOT reports transit passenger miles traveled for major commute corridors in urban areas. Statewide transit passenger miles traveled are pulled from the National Transit Database. The calculation below gives the transit passenger miles traveled on the I-5 Everett to Seattle commute route. For more on miles traveled calculations see the vehicle miles traveled section on p. 11-12.

$$\text{Transit passenger miles traveled}_{2012} = \sum_{\text{Morning peak period}}^{\text{I-5 Everett to Seattle}} \left(832_{\text{ST 510 @ 4:11 am}} + 1{,}214 \ldots + 1{,}181_{\text{CT 412 @ 10:00 am}} \right)$$

$$= 137{,}646 \text{ transit passenger miles traveled}$$

Vehicle miles avoided by transit use is the approximate number of miles that were not traveled in a single occupant vehicle due to people taking transit instead. King County Metro provided WSDOT with the factor that approximately 62% of transit miles traveled would have been taken as equivalent single occupant vehicle (SOV) trips if transit services were not available. This takes into consideration the average rate of ridesharing in the central Puget Sound region served by Metro's transit services. Multiplying the passenger miles traveled by 0.62 results in the estimated SOV miles avoided due to transit services.

$$\text{Vehicle miles avoided through transit} = \text{Transit passenger miles traveled} \times \text{0.62 SOV miles per transit passenger mile}$$

For example, if we applying King County Metro's conversion factor to the transit passenger miles traveled for the 2012 Everett to Seattle commute we get the SOV miles avoided.

$$\text{Vehicle miles avoided through transit}_{\text{2012; Morning peak I-5 Everett to Seattle}} = \text{137,646 transit passenger miles traveled} \times \text{0.62 SOV miles avoided per transit passenger mile}$$

$$= 81{,}795 \text{ SOV miles avoided through transit use}$$

Emissions avoided due to transit is the net pounds of carbon dioxide equivalents (CO_2e) emissions avoided due to transit ridership. This value is the difference between what is not emitted when people take transit instead of driving, and the emissions from transit vehicle operations. See the greenhouse gas emissions chapter on pp. 15-18.

$$\text{Emissions avoided}_{\text{Due to transit use}} = \text{Transit ridership} \times \text{Trip length} \times \text{0.62 SOV miles per transit passenger mile} \times \text{1 lb } CO_2e \text{ per mile traveled}$$

$$- \sum_{\text{All transit trips}} \left(\text{Transit trip length} \times \text{Transit vehicle GHG factor} \right)$$

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WSDOT reports emissions avoided at the commute level. The example below gives pounds of CO_2e avoided due to transit ridership during the 6-9 a.m. morning commute peak period in 2012 on the Everett to Seattle commute corridor on service provided by Community Transit:

$$\text{Emissions avoided}_{\text{Due to transit use}} = 4{,}842 \text{ riders} \times 23.66 \text{ miles} \times 0.62 \text{ SOV miles per transit passenger mile} \times 1 \text{ lb } CO_2e \text{ per mile traveled}$$

$$- \sum_{\text{All transit trips}} (16.18 \times 5.448 + 15.77 \times 5.448 + 21.93 \times 5.448 + 23.66 \times 5.448 + 21.88 \times 5.448 + \ldots)$$

$$= 48{,}413 \text{ pounds of } CO_2e \text{ emissions avoided each weekday during the morning peak period}$$

Transit utilization is the percent of seats occupied on all transit trips during the peak commute periods. This figure is calculated by dividing transit ridership as described earlier by the total number of seats available on transit trips during the peak commute periods. A trip may have a utilization greater than 100% if there is standing room only during the trip.

$$\text{Transit utlization}_{\text{Commute ; Peak period}} = \frac{\sum \text{Transit ridership}}{\sum \text{Available seats}}$$

WSDOT reports transit utilization at the commute route level for major urban corridors. For example, the calculation below gives the transit utilization for the I-5 Everett to Seattle morning commute in 2012:

$$\text{Transit utlization}_{\text{I-5 Everett to Seattle; Morning peak}} = \frac{\sum (50 + 37 + \ldots + 27 + 47 + 68 = 4{,}842)}{\sum (60 + 77 + \ldots + 77 + 60 + 77 = 7{,}718)} = 62.7\%$$

WSDOT also reports the number of transit trips that are above 90% of their capacity to show the load experienced during the peak utilization of transit.

Transit travel times

Transit travel times reported in the *Corridor Capacity Report* are the planned travel time for a selected transit trip. WSDOT selects the transit trip that most closely aligns with commute origins and destinations, and occur closest to the 5-minute peak interval (see the Travel Time Trends chapter on pp. 21-22).

WSDOT compares the travel times on the commute corridors for transit, HOV lane user and those in the single-occupant vehicle lanes. See p. 30 for a sample illustration.

Capacity savings due to transit

Capacity savings due to transit is a measure of how many general purpose highway lanes worth of capacity transit provides during the morning and evening peak periods. Another way to think of it would be the number of lanes transit riders would take up during the peak periods if they drove in private automobiles. This figure is calculated by dividing the transit ridership by the number of hours in the peak periods (6 hours) and then dividing that figure by the average maximum throughput values on the corridor times average vehicle occupancy.

$$\text{Capacity savings due to transit} = \frac{\left(\frac{\sum \text{Transit Ridership}}{\text{Hours in Peak Periods}}\right)}{\text{Average Maximum Throughput} \times \text{Average Vehilce Occupancy}}$$

WSDOT reports capacity savings due to transit use in terms of the number of extra lanes of capacity for both individual commutes and at the corridor

Transit trip performance by commute corridor

2013 Commute Information			Commute	Origin/Destination		Milepost	Length	Transit travel time at commute peak		
			6-9 a.m.	Everett		189.41	23.61	Peak time	Cars	Transit
			I-5 southbound	Seattle		165.75		7:20 a.m.	50 min.	1 hr 3 min.
Summary Statistics		**Transit provider**	**Number of trips**	**Boardings**	**Average max load**	**Total seats**	**Percent utilization**	**# >90% capacity**	**Passenger miles traveled**	**Pounds of CO_2e not emitted due to transit**
		All	**119**	**4,993**	**4,842**	**7,718**	**62.7%**	**7**	**103,178**	**48,413**
Route	**Departure time**	**Arrival time**	**Planned travel time**	**Average boardings**	**Average max load**	**Seats**	**Vehicle load**	**Trip length**	**Passenger miles traveled**	**Emission factor**	**Emissions per trip**
CT 402	5:53	6:27	0:34	50	50	60	84%	16.18	812	5.448	88
CT 405	7:45	8:37	0:52	34	37	77	48%	15.77	579	5.448	86
CT 410	8:00	8:58	0:58	29	27	77	35%	21.93	592	5.448	119
CT 412	5:30	6:33	1:03	47	47	60	78%	23.66	1,388	5.448	129
CT 413	5:40	6:24	0:44	61	68	77	88%	21.88	1,483	5.448	119

Data source: WSDOT's Office of Strategic Assessment and Performance Analysis, and central Puget Sound area transit agencies.
Notes: CT = Community Transit, IT = Intercity Transit, KCM = King County Metro, ST = Sound Transit, STA = Spokane Transit Authority. Emission factors in terms of pounds of CO_2e emitted per transit vehicle mile traveled. For passenger vehicle emissions avoided, assume 62% of transit passenger miles traveled would occur by SOV if transit were not available, and passenger vehicle emissions average one pound of CO_2e per mile traveled.

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level. For example, the calculation below gives the capacity savings due to transit for the I-5 Corridor in the central Puget Sound region in 2014.

$$\text{Capacity savings due to transit}_{\text{I-5 Corridor Central Puget Sound Region}} = \frac{\left(\frac{\sum 11{,}975 + 5{,}264 + \ldots 2{,}919}{6}\right)}{1{,}635 \times 1.17} = 4.89 \text{ extra lanes of capacity due to transit use}$$

Transit fleet in service during peak

The transit fleet in service during the peak period is the total number of transit vehicles providing rides during the morning and evening peak commute periods. This metric helps give an understanding of the scope of transit service occurring in major urban areas around the state. The measure can also be reported as the percent of a transit agency's fleet in service during the peak.

Transit data

All of the data for the transit trip analysis comes directly from the transit agencies WSDOT works with including Community Transit, C-Tran, Intercity Transit, King County Metro, Sound Transit and Spokane Transit Authority. These partner agencies provide the following data directly to WSDOT:

- Average maximum load by trip. Collection methods vary based on each agency's available resources. For example, some transit agencies have automatic counters at the entrance and exits on their buses. Other agencies take regular sample counts of ridership on their buses.
- Transit trip length by trip.
- Transit capacity by trip.
- Planned transit travel times by trip.
- Number of vehicles in service during peak
- Emissions factors by trip. Transit agencies generally track the greenhouse gas emissions for their fleet by vehicle type. This information is provided to WSDOT by transit trip and used to calculate transit greenhouse gas emissions. Emissions factors for private automobiles were estimated as one pound of carbon dioxide per mile.

The following Washington state transit agencies provided transit ridership data after detailed, collaborative discussions with WSDOT:

- C-Tran (Vancouver region), Development and Public Affairs
- Community Transit (central Puget Sound region), Strategic Planning office
- Intercity Transit (south Puget Sound region), Planning Division
- King County Metro (central Puget Sound region), Strategic Planning and Analysis office
- Pierce Transit (central and south Puget Sound region), Service Planning department
- Sound Transit (central Puget Sound region), Service Planning office
- Spokane Transit Authority, Planning Division

http://www.watransit.com/Pages/OurMembers.aspx

Park and ride lot utilization

Park and ride (P&R) lots provide locations for commuters to meet up with a carpool or vanpool, or catch a bus to work if transit does not come close to their home. WSDOT monitors the usage of park and ride lots owned or managed by public agencies, as well as private lots. The utilization rate is calculated by dividing the

$$\text{Park and ride lot utlization}_{\text{Lot n}} = \frac{\text{Typical weekday occupancy}}{\text{Available parking stalls}}$$

average maximum weekday occupancy by the number of parking stalls. The final figure is the percent of total capacity used on a typical weekday. A utilization rate of 100% means that there are no available spaces at some point in time on an average weekday.

$$\text{Park and ride lot utlization}_{\text{Tacoma Dome}} = \frac{2{,}169 \text{ occupied stalls}}{2{,}283 \text{ available stalls}} = 95\% \text{ utilization}$$

WSDOT generally reports park and ride utilization by lot individual lot as in the example below. However, when multiple lots are close together such as in the Federal Way area, lot capacity and utilization is aggregated for reporting.

Park and ride data

WSDOT's Public Transportation Office maintains and publishes information on park and ride lot capacity and utilization rates. The data and more information is available at www.wsdot.wa.gov/Choices/parkride.htm

Incorporating transit use into commute trip performance analysis

WSDOT recognizes that transit agencies in urban areas serve a wide variety of travel needs, and that much of the service may not align with the pre-defined intra-urban highway commute corridors assessed in other portions of the *Corridor Capacity Report*. For example, many bus trips in Seattle begin and end within the city limits and do not use the I-5 corridor, while serving thousands of Seattle

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commuters, students, and other residents. Some of these riders would drive a personal vehicle on the freeway if bus service were not provided in close proximity to their residence and place of work. Therefore, WSDOT believes that the transit ridership reported for each of the commute corridors under-represents the actual transit use in the region. At the current time, no other ridership statistics are readily available that might help capture this ridership.

Two adjustments have been made in an attempt to capture ridership that does not exactly align with the origins and destinations of WSDOT's commute corridors:

1) Bus trips that travel on the primary highway corridor associated with WSDOT's commute corridors (such as I-5 in Seattle), while not traveling the full distance from or to Everett (or other regional origins/destinations), may be counted in the corridor's transit ridership numbers. The reasoning is that these trips, while going only part of the way on the corridor, take personal vehicle trips off the corridor, thereby improving conditions for other travelers. One example is Metro bus route #41 that travels between Northgate and downtown Seattle along I-5. Ridership will be counted in the I-5 Everett-Seattle commutes, while the passenger miles traveled and greenhouse gas emissions avoided will be prorated based on the relative length of this trip.

2) For bus trips that travel along two or more of WSDOT's commute corridors (such as Issaquah to Bellevue and continuing on to Seattle), the transit agencies perform more detailed stop-level analysis to determine the relative ridership for each segment of this trip, along with ridership that gets on at the first stop, and gets off at the last stop.

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Amtrak Cascades Corridor Capacity Analysis Methodology

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Amtrak Cascades system performance

Amtrak Cascades system performance measures include the annual passenger miles traveled, on-time performance, capacity utilization and ridership on the segments of the Amtrak Cascades system operating in Washington state. Amtrak Cascades operates service routes between Vancouver, British Columbia, and Eugene, Oregon, and provides five daily round trips for various segments of the corridor. As part of the state's long-term strategy to provide a sustainable multimodal transportation system and increase person throughput, Amtrak Cascades serves as an intercity travel option to reduce reliance on single-occupancy vehicles to leisure and business travelers alike.

Amtrak Cascades performance measures

WSDOT uses the following metrics to analyze and communicate intercity passenger rail system performance in the *Corridor Capacity Report* for each segment of the Amtrak Cascades service that passes through Washington:

Ridership

- Amtrak Cascades ridership
- Amtrak Cascades passenger miles traveled
- Amtrak Cascades capacity utilization

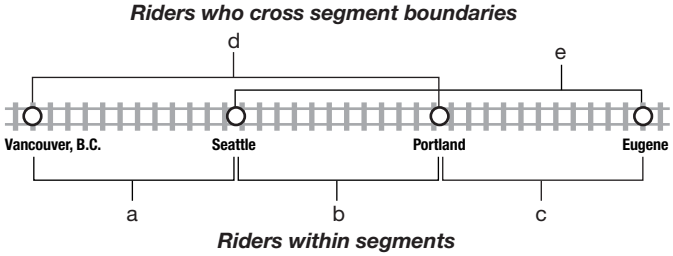
On-time performance

Ridership metrics:

Amtrak Cascades ridership is the number of ticketed riders traveling on the Amtrak Cascades service within a defined timeframe (quarterly, annually, etc.), reported for all segments that pass through Washington or for specific rail sub-segments (see the map on p. 6 for an explanation of segmentation terminology).

Riders fall into one of five categories

Total ridership calculated by adding riders within segments and riders across segments



Data source: WSDOT Rail Division.

WSDOT's Rail Division calculates ridership based on data from the WSDOT Ridership and Revenue Database for Amtrak Cascades. Ridership for each city pair is subtotaled and symbolically placed into one of the five categories (a, b, c, d or e) in the graphic at bottom left. The categories can then be summed for all city pairs within a geographic area.

$$\text{Amtrak Cascades ridership}_{\text{Washington}} = a + b + d + e$$

To calculate ridership just for Amtrak Cascades segments operating in Washington, categories that fall in Washington at any point are added. Riders who cross segments are riders who use a through-train (when a rider boards the train in one segment, then gets off the train in another segment (e.g., boards in Bellingham and gets off in Olympia). See the rounded example below for a sample calculation (figures exclude riders using RailPlus program and those who were either unidentified by Amtrak or deferred their trip to another date).

$$\text{Amtrak Cascades ridership}_{\text{Washington, 2014}} = 167{,}000 + 422{,}000 + 65{,}000 + 46{,}000$$
$$= 700{,}000 \text{ Amtrak Cascades riders}$$

Amtrak Cascades passenger miles traveled are the person miles traveled (PMT) specifically by Amtrak Cascades riders (excluding train staff). WSDOT uses its Ridership and Revenue Database to calculate PMT based on tickets purchased and the number of miles between origin and destination along the rail line.

$$\text{Intercity passenger miles traveled} = \sum_{\text{Trains}}^{\text{City pair}} \left(\underset{\text{City pair}}{\text{Number of passengers}} \times \underset{\text{City pair}}{\text{Distance traveled by rail}} \right)$$

To calculate PMT between two cities, WSDOT multiplies the number of riders traveling between the specific city pair by the number of miles between the trip's origin and destination. PMT can then be summed for any combination of city pairs or time period.

For an example, see the calculation below of passenger miles traveled for riders getting on the train in Olympia and getting off the train in Seattle:

$$\text{Intercity passenger miles traveled}_{2014} = \sum_{\text{Northbound trains}}^{\text{Olympia to Seattle}} \left(\underset{\text{Olympia to Seattle}}{\text{7,636 riders}} \times \underset{\text{Olympia to Seattle}}{\text{75.0 rail miles}} \right)$$
$$= 572{,}700 \text{ Amtrak Cascades passenger miles traveled}$$

Amtrak Cascades Corridor Capacity Analysis

Amtrak Cascades capacity utilization is calculated as the percent of seats occupied between stations averaged over a defined timeframe (quarterly, annually, etc.). WSDOT reports Amtrak Cascades capacity utilization at the sub-segment level. Utilization rates for the peak sub-segment can limit available capacity for the entire corridor. Any time demand on capacity for a sub-segment exceeds 100%, capital projects, such as increasing the number of seats per train trip or adding more frequent trips, would be necessary to increase capacity.

$$\text{Amtrak Cascades capacity utilization} = \frac{\sum \text{Number of passengers}}{\sum \text{Available seats}}$$

The number of passengers used in the above calculation includes only those passengers that got on the train prior to the first station and stayed on the train throughout the segment being measured, getting off the train after the segment.

On-time performance metric:

Amtrak Cascades on-time performance is the percentage of trains that arrive on time at their final station within a defined timeframe (quarterly, annually, etc.). It may be reported system-wide, or for specific city pairs. A train is considered on time if it is within 10 minutes of scheduled arrival times for trains operating the Vancouver, B.C. to Seattle and Seattle to Portland segments; or 15 minutes of scheduled arrival times for trains operating the Vancouver, B.C. to Portland and Seattle to Eugene segments.

$$\text{Amtrak Cascades on-time performance} = \frac{\sum \text{Number of trains on time}}{\sum \text{Number of trains operating}}$$

Rail operations data sources

- WSDOT Revenue and Ridership Database
- WSDOT On-Time Performance Records
- Rail Mileage Chart

Background information on Amtrak Cascades

- An Amtrak Cascades city pair is travel between any two of the specific stations along the corridor.
- An Amtrak Cascades sub-segment is travel between two adjacent stations along the corridor. An example sub-segment is the Bellingham to Mount Vernon sub-segment (see map at right).
- Performance data for Amtrak Cascades service is often calculated based on three major segment divisions:
  - Vancouver, B.C. to Seattle,
  - Seattle to Portland, Oregon, and
  - Portland, Oregon, to Eugene, Oregon.

  "Travel within Washington" refers to trains on the first two segments above–between Portland, Oregon, and Vancouver, B.C., regardless of funding entity. Stations included in the Washington analysis are in dark green on the map to the above right.
- For additional performance measures, see http://www.wsdot.wa.gov/Rail/PerformanceReports.htm.