MEASURE DESCRIPTIONS

Travel Delay

Description

The **total delay** (in person- or vehicle-hours) for a transit or roadway segment is the sum of time lost due to congestion. Delay can be expressed as a value relative to free-flow travel, maximum throughput speed or relative to the posted speed limit. Total delay in a corridor or an urban area is calculated as the sum of individual segment delays. With some adaptation for varying definitions of acceptable conditions on each mode, delay can also be used in a multi-modal analysis.

Use

This quantity is used as an estimate of the impact of improvements on transportation systems. The values can be used to illustrate the effect of major improvements to one portion of a corridor that affects several other elements of the corridor. The quantity is particularly useful in economic or benefit/cost analyses that use information about the magnitude of the mobility improvement for cost-effectiveness decisions. The measure can be averaged for freeways and arterial streets using the amount of travel on each portion of the network. An average corridor, region or state value can be developed using the number of persons using each facility type (or mode) to calculate the weighted average of the conditions on adjacent facilities. The corridor values can be computed for hourly conditions and weighted by the number of travelers or person-miles traveled to estimate peak period, daily, or annual index values.

Calculation

Total delay is calculated with data that can be drawn from regional traffic management centers, long-range planning models or roadway inventory files. Equation TD-1 shows the computation of delay in person-hours. The procedures will vary, but the end result will be similar to Equation TD-1.

$$\underset{(person\text{–}hours)}{Total\ Delay} = \left[\underset{(minutes)}{Actual\ Travel\ Time} - \underset{(minutes)}{FFS\ or\ PSL\ Travel\ Time} \right] \times \underset{(vehicles)}{Vehicle\ Volume} \times \underset{(persons/vehicle)}{Vehicle\ Occupancy} \times \frac{1\ hour}{60\ minutes}$$

Equation TD-1

In addition, using a delay measure of hours per mile of road, hours per 1,000 miles traveled, or hours per 1,000 travelers might be more meaningful to agencies at the corridor level, but the public may not understand these measures since it is difficult to relate to key decisions or travel experience. Any individual traveler rarely uses only the entire corridor for their trip.

Geographic:	State, Region, Corridor
Include Transit?	Yes
General Use:	Planning, Operations
Scale:	Corridor or Region total
Usage Time:	Monthly, Annual, Trend
Possible Targets:	State, Region, Corridor Near-Term & Long-Term
Data Items:	Travel Time (measured or estimated) Volume (for weighting)
Data Source:	Travel time/speed monitoring Planning models Roadway inventory data sets

MEASURE DESCRIPTIONS

Travel Delay or Travel Time Per Commuter

Description

The **delay per commuter** (in person- or vehicle-hours) or **per peak period traveler** or **per capita** for a transit or roadway segment is the sum of time lost due to congestion divided by the number of individuals suffering the congestion. Delay expressed in this way provides a connection to citizens with a quantity that is easier to relate to than a regional total.

Use

Delay per individual can be used at the regional level in many of the ways that an Index measure can be used. It can be used to illustrate the effect of improvements on transportation systems. The quantity is particularly useful in setting regional targets or communicating trends or current status of congestion. An average value can be developed for the corridor level, but it is more difficult to identify the persons that should be included in the measure. A region or state value can be developed more easily using the number of persons living or traveling in the area.

Calculation

Total delay divided by the number of residents or travelers can be calculated with data that can be drawn from regional traffic management centers, long-range planning models or roadway inventory files. Equation DP-1 shows the computation of delay per person. The procedures will vary, but the end result will be similar to Equation DP-1.

$$\underset{\text{(person-hours)}}{\text{Total Delay per traveler or per capita}} = \frac{\left[\underset{\text{(minutes)}}{\text{Actual Travel Time}} - \underset{\text{(minutes)}}{\text{FFS or PSL Travel Time}}\right] \times \underset{\text{(vehicles)}}{\text{Vehicle Volume}} \times \underset{\text{(persons/vehicles)}}{\text{Vehicle Occupancy}} \times \frac{1\ \text{hour}}{60\ \text{minutes}}}{\text{Number of peak-period travelers or population}}$$

Equation DP-1

Geographic:	State, Region
Include Transit?	Yes
General Use:	Planning
Scale:	Corridor or Region total
Usage Time:	Annual, Trend
Possible Targets:	State, Region, Corridor; Near-Term & Long-Term
Data Items:	Travel Time (measured or estimated) Volume (for weighting)
Data Source:	Travel time/speed monitoring Planning models Roadway inventory data sets

MEASURE DESCRIPTIONS

Congestion Cost

Description

A measure of the cost of the congestion problem is useful in many circumstances, but especially in communication with elected officials, the business community and the public. There are a number of elements that could be included, but extra travel time and extra fuel consumed due to slow speed conditions are two relatively easy factors to estimate. These values are directly related to travel speed and can be derived from other calculations. The calculation process described below uses factors that can be obtained from typical roadway inventory databases or from other performance measure calculations.

Use

Congestion cost is best used for larger areas of analysis. The corridor or regional effects of congestion can be averaged across the number of users or residents in these analyses. Totaling costs for freeways and major arterial streets will usually capture the effect of most problems and provide a good comparison point with solution analyses. Corridor and regional values can be computed annually for peak period conditions and congestion solutions can be compared on the basis of cost per delay hour reduced.

Calculation

Delay and fuel cost can be calculated by estimating travel speeds, using a simple linear equation to estimate fuel economy for that speed and applying values to the difference between travel time and fuel consumption in congested versus uncongested conditions. The process is evolving, and the new EPA emissions model (MOVES) may have an improved fuel economy algorithm that can be used with relatively simple datasets.

The value of lost time has two components: passenger vehicles and commercial vehicles. Equations C-1 and C-2 illustrate the calculations. In 2007, the national average values of time used in TTI's Urban Mobility Report were: passenger - $15.47 per hour; commercial - $102.12 per hour

$$\text{Annual Passenger Vehicle Delay Cost} = \text{Daily Passenger Vehicle Hours of Delay} \times \text{Value of Person Time } (\$ / \text{hour}) \times \text{Vehicle Occupancy (persons/vehicle)} \times \text{250 Working Days} \qquad \text{(Eq. C-1)}$$

$$\text{Annual Commercial Cost} = \text{Delay Vehicle Hours of Delay} \times \text{Percent of Commercial Vehicles} \times \text{Value of Commercial Vehicle Time} \times \text{250 Working Days} \qquad \text{(Eq. C-2)}$$

Fuel cost due to congestion for passenger vehicles in Equation C-3. This is done by associating the peak period congested speeds, the average fuel economy, and the fuel costs with the vehicle-hours of delay. Fuel cost is included in the commercial vehicle operating costs.

$$\text{Annual Fuel Cost} = \text{Daily Vehicle – Hours of Delay} \times \text{Percent of Passenger Vehicles} \times \text{Average Peak Period Congested System Speed} \div \text{Average Fuel Economy} \times \text{Fuel Cost Per Gallon} \times \text{250 Working Days} \qquad \text{(Eq. C-3)}$$

The total annual congestion cost is the sum of the cost due to travel delay and wasted fuel. A simpler calculation could also be used with a weighted average cost value created from the three components (passenger delay, passenger fuel and commercial cost).

Geographic:	State, Region, Corridor	Possible Targets:	State, Region, Corridor; Near-Term & Long-Term
Include Transit?	Yes		
General Use:	Planning, Operations	Date Items:	Travel Time (measured or estimated)
Usage Time:	Annual, Trend		Volume (for weighting)
		Data Source:	Travel time/speed monitoring Planning models Roadway inventory data sets

MEASURE DESCRIPTIONS

Travel Time Index

Description

The Travel Time Index (TTI) illustrates the comparison of peak period travel time to free-flow travel time. The Travel Time Index includes both recurring and incident conditions and is, therefore, an estimate of the conditions faced by urban travelers. For example, a TTI of 1.40 indicates that a trip that takes 20 minutes in the off-peak period will take 28 minutes in the peak period or 40 percent longer. TTI reflects travelers' perceptions of travel time on the roadway, transit facility, or other transportation network element. This comparison can be based on the travel time increases relative to free-flow conditions (or the posted speed limit) and compared to the target conditions. Thus, the same index formula can be applied to various modes or system elements with different free-flow or posted speeds.

Use

The measure can be averaged for freeways and arterial streets using the amount of travel on each portion of the network. An average corridor, region or state value can be developed using the number of persons using each facility type (or mode) to calculate the weighted average of the conditions on adjacent facilities. The corridor values can be computed for hourly conditions and weighted by the number of travelers or person-miles traveled to estimate peak period, daily, or annual index values.

Calculation

The index is calculated with data that can be drawn from regional traffic management centers, long-range planning models or roadway inventory files. The procedures will vary, but the end result will be similar to Equation TT-1.

$$\text{Travel Time Index} = \frac{\text{Peak Travel Time}}{\text{Free Flow Travel Time}}$$

Equation TT-1

Another version of the calculator formula is presented in Equation TT-2. Free-flow travel time may be estimated from the speed limit. Delay can be estimated with a variety of procedures and data sets, and can be used in a number of other performance measures. Delay should include both recurring and non-recurring elements so that problems resulting from all conditions are measured or estimated and can be compared to conditions after the improvements.

$$\text{Travel Time Index} = \frac{\text{Delay Time} + \text{Free Flow Travel Time}}{\text{Free Flow Travel Time}}$$

Equation TT-2

Equation TT-3 presents one formulation to develop a TTI value for multiple roadway types. This type of formula could also be used for multiple modes or regions; it concentrates on weighting travel on different parts of the system in relation to the amount of travel.

$$\text{Travel Time Index} = \frac{\left[\frac{\text{Freeway Travel Time}}{\text{Freeway Free Flow Travel Time}} \times \text{Peak Period Freeway VMT}\right] + \left[\frac{\text{Arterial Travel Time}}{\text{Arterial Free Flow Travel Time}} \times \text{Peak Period Arterial VMT}\right]}{\text{Peak Period Freeway VMT} + \text{Peak Period Arterial VMT}}$$

Equation TT-3

Geographic:	State, Region, Corridor
Include Transit?	Yes
General Use:	Planning, Operations
Scale:	Individual, Region average
Usage Time:	Monthly, Annual, Trend
Possible Targets:	State, Region, Corridor; Near-Term & Long-Term;
Data Items:	Travel Time (measured or estimated) Volume (for weighting)
Data Source:	Travel time/speed monitoring Planning models Roadway inventory data sets

MEASURE DESCRIPTIONS

Maximum Throughput Travel Time Index

Description

The Maximum Throughput Travel Time Index (MT3I) illustrates the comparison of peak period travel time to the travel time associated with the maximum volume. In practice this is defined as 45 mph or 50 mph on freeways. The MT3I includes both recurring and incident conditions and is, therefore, an estimate of the conditions faced by urban travelers. For example, a MT3I of 1.40 indicates that a trip that takes 20 minutes in the off-peak period will take 28 minutes in the peak period or 40 percent longer. MT3I reflects travelers' perceptions of travel time on the roadway, transit facility, or other transportation network element in relation to a target condition keyed to the point of maximum system productivity. Thus, the same index formula can be applied to various modes or system elements with different capacities.

Use

The measure can be averaged for freeways and arterial streets using the amount of travel on each portion of the network. An average corridor, region or state value can be developed using the number of persons using each facility type (or mode) to calculate the weighted average of the conditions on adjacent facilities. The corridor values can be computed for hourly conditions and weighted by the number of travelers or person-miles traveled to estimate peak period, daily, or annual index values.

Calculation

The index is calculated with data that can be drawn from regional traffic management centers, long-range planning models or roadway inventory files. The procedures will vary, but the end result will be similar to Equation MT-1.

$$Max\ Throughput\ Travel\ Time\ Index = \frac{Peak\ Travel\ Time}{Max\ Throughput\ Travel\ Time}$$

Equation MT-1

Another version of the calculator formula is presented in Equation MT-2. The maximum throughput travel time may be estimated from Highway Capacity Manual calculations or from detailed travel speed and volume data. Delay can be estimated with a variety of procedures and data sets, and can be used in a number of other performance measures. Delay should include both recurring and non-recurring elements so that problems resulting from all conditions are measured or estimated and can be compared to conditions after the improvements.

$$Max\ Throughput\ Travel\ Time\ Index = \frac{Delay\ Time + Max\ Thruput\ Travel\ Time}{Max\ Thruput\ Travel\ Time}$$

Equation MT-2

MEASURE DESCRIPTIONS

Equation MT-3 presents one formulation to develop an MT3I value for multiple roadway types. This type of formula could also be used for multiple modes or regions; it concentrates on weighting travel on different parts of the system in relation to the amount of travel.

$$\text{Max Throughput Travel Time Index} = \frac{\left[\frac{\text{Freeway Travel Time}}{\text{Freeway Max Thruput Travel Time}} \times \text{Peak Period Freeway VMT}\right] + \left[\frac{\text{Arterial Travel Time}}{\text{Arterial Max Thruput Travel Time}} \times \text{Peak Period Arterial VMT}\right]}{\text{Peak Period Freeway VMT} + \text{Peak Period Arterial VMT}}$$

Equation MT-3

Geographic:	State, Region, Corridor
Include Transit?	Yes
General Use:	Planning, Operations
Scale:	Individual, Region average
Usage Time:	Monthly, Annual, Trend
Possible Targets:	State, Region, Corridor; Near-Term & Long-Term
Data Items:	Travel Time (measured or estimated) Volume (for weighting)
Data Source:	Travel time/speed monitoring Planning models Roadway inventory data sets

MEASURE DESCRIPTIONS

Buffer Index

Description

The Buffer Index (BI) is a measure of trip reliability that expresses the amount of extra "buffer" time needed to be on time for 95 percent of the trips (e.g., late for work on one day per month). The measure is the difference between the 95th percentile travel time and the average travel time over an extended time period (e.g., one year). A Buffer Index value of 50% indicates that a traveler should allow 50% more travel time than the average if they wish to arrive on-time for 19 out of 20 trips. Indexing the travel time measure provides a time- and distance-neutral measure, but the actual minute values could be used by an individual traveler for a particular trip or displayed by an agency website for specific origin-destination pairs. On-going research suggests that an 80th percentile Buffer Index (worst trip of the week) may also be useful in measuring the effect of agency congestion relief efforts.

Use

A reliability measure can focus on the effect of relatively low-cost operational improvements and demand management actions. If these actions can "turn horrible days into only bad days" the measure will be more sensitive than traditional "average" condition measures. The buffer time concept also appears to relate particularly well to the way travelers make decisions. Conceptually, travel decisions proceed through questions such as: "How far is it?" "When do I need to arrive?" "How bad is the traffic?" "How much time do I need to allow?" "When should I leave?" In the "time allowance" stage, there is an assessment of how much extra time has to be allowed for uncertainty in the travel conditions. This includes weather, incidents, construction zones, holiday or special event traffic, or other disruptions or traffic irregularities. With continuously collected travel time data, the index is calculated for each road or transit route segment. A weighted average can be calculated for a corridor, region or state using vehicle-miles or person-miles of travel as the weighting factor.

Calculation

Travel rates for approximately 5-mile sections of roadway provide a good base data element for the performance measure. The Buffer Index can be calculated for each road segment or particular system element using Equation B-1. Note that a weighted average for more than one roadway section could be computed using VMT or PMT on each roadway section. The measure would be explained as "a traveler should allow an extra BI percent travel time due to variations in the amount of congestion delay on that trip."

$$Buffer\ Index\,(\%) = \left[\frac{\underset{(minutes)}{95th\ Percentile\ Travel\ Time} - \underset{(minutes)}{Average\ Travel\ Time}}{\underset{(minutes)}{Average\ Travel\ Time}} \right] \times 100\% \qquad \text{(Eq. B-1)}$$

Also note: Calculating the Buffer Index with the 80th percentile travel time may also be useful.

Geographic:	State, Region, Corridor
Include Transit?	Yes
General Use:	Planning, Operations
Usage Time:	Monthly, Annual, Trend
Possible Targets:	State, Region, Corridor; Near-Term & Long-Term
Data Items:	Travel Time (desirable: measured for all trips) Volume (for weighting)
Data Source:	Travel time/speed monitoring

MEASURE DESCRIPTIONS

Total Travel Time

Description

Total travel time is used to illustrate the effect of both land use and transportation improvements. The "door-to-door" travel time is an easily communicated term, although in practice many analysis tools are not well calibrated to produce this value. The power of the measure is that as land use patterns change toward denser and mixed-use development that promote travel modes such as walking, bicycling and transit use, the performance measure will show the effect of those decisions. Performance measures that only focus on roads or on vehicle and public transportation will miss some of the beneficial effects of transitions to non-motorized travel.

Use

The measure can be focused on freeways and arterial streets or used for all roads or all travel, depending on the source of data. Total travel time can be calculated for a corridor, but will probably be more useful at the sub-region or region level. Total travel time is best calculated as a part of the long-range planning model operation and, therefore, is not easily calculated in an annual update; estimates of the change from year to year can be made. It is quite useful as a strategic planning measure, assisting planning and operating agencies in identifying the full effect of their actions.

Calculation

Total travel time is calculated with long-range planning model data; it is one of the output measures from all modeling packages. It involves summing the travel time on all links of the roadway network, and desirably some estimate of the travel time by pedestrians, bicyclists and scooter riders. The calculation may be roughly estimated with roadway inventory or archived real-time travel time and volume data. Once developed for a base year, it can be updated using data from regional traffic management centers or roadway traffic counts and inventory files.

Geographic:	State, Region
Include Transit?	Yes (and other non-motorized modes)
General Use:	Planning
Usage Time:	20 year plan; periodic updates
Possible Targets:	State, Region; Long-Term
Data Items:	Travel Time for all trips and modes (usually estimated)
Data Source:	Planning models (usually)

MEASURE DESCRIPTIONS

Economic Benefits

Description

Several types of benefits can be estimated using local demographic information, project costs and projections of the effect of the transportation improvements. For example, direct effects on motorists will be less time and fuel consumed if systems provide more mobility. Effects on businesses may be even more important in discussions about improvement programs or funding proposals. Companies can serve more customers with the same equipment and personnel in regions with less congestion and the quality of life may be better for workers in areas with easier commutes. This may be more important in the future as more jobs can be done from "anywhere." Local governments will receive more tax revenue from the transportation improvement expenditures and construction of expanded systems provides jobs and payroll to the affected communities.

- **Direct benefits to travelers**

Fuel Savings – Improving the speed of travel and eliminating stop-and-go traffic results in fuel savings due to a more efficient fuel burn, which means cost savings for both personal and commercial travel.
Time Savings – Improving the speed of travel in the peak period means less time stuck in traffic for both individual and business travelers.

- **Indirect personal benefits**

Reduced Costs of Goods and Services – Time and fuel savings lead to greater business efficiencies and productivity because more finished goods can be delivered at lower cost within the same time period. The anticipated result would be lower costs to consumers, the reverse of the effect seen in the increase of costs of goods and services and fuel prices during 2007 and 2008.

- **Economic value of mobility investments to businesses**

Increased Business Profitability and Job Creation – Lower business costs lead to increased profit. Increased business profitability generates economic growth and creates jobs. The creation of jobs translates into population growth and more economic activity.
Increased Local Government Tax Revenues – More economic activity and population growth means greater tax revenues for local governments from property and sales taxes.
Economic Benefits of Construction Activity – The act of constructing improvements has positive economic benefits. Those benefits come from the income that is paid to workers who are employed as well as the purchase of materials and supplies used to build the project. Additional economic benefits result from the multiplier effect that occurs when those workers spend their salaries on food, clothing, entertainment, housing or other activities. That spending, called an indirect benefit, also has a positive economic effect, as does the personal spending of those employed by companies providing the materials for the project.

Use

The economic benefits of transportation spending have become more prominent as a performance measure during the economic stimulus discussion, but it has been a part of the discussion since (at least) the Interstate program. Business groups have been particularly prominent in using these measures as justification for investments, although transportation agencies have not shown much use in either regular communication or in special circumstances such as ballot measures. The case for developing and tracking economic effect measures would appear to be prudent given the need for continued investment, the improved analytical tools and the need for transportation spending to compete in a broader marketplace of ideas for public attention. The debate over transportation spending can be read as partly a failure to make the connection between the investment and the resulting benefits. The link between paying college tuition and the benefits of a college education, for example, are widely known. It appears that such an intrinsic connection does not exist on transportation spending.

MEASURE DESCRIPTIONS

Calculation

There are many ways to estimate economic benefits depending on the type of project, the funding package, the data that can be compiled and the local economic and demographic characteristics. There are also several models that can accomplish such estimates; these models have a range of complexity and data requirements that are detailed, but a short summary is included below.

A relatively simple (although not quick) approach to estimating economic benefits is to use an input/output model that replicates the state or regional economy. The additional annual expenditure of some amount generates jobs in order for the work to be accomplished (an estimated X jobs). Those employees are paid estimated wages of $Y annually. The increase in economic activity occurs over the project construction life and includes the primary, secondary, and tertiary effects of spending $Y on highway construction for the number of construction years. This economy-wide impact includes direct impacts such as spending on labor, equipment, and materials on the construction activity. It would also include secondary impacts such as the spending by those who earn salaries from work performed directly or indirectly as a result of the construction activity. Finally, it includes the effects of income/spending by those who received income from the expenditures of those who were directly or indirectly associated with construction activity.

There are other impacts as well. For example, the one reason for the expenditures is to improve mobility. One of the major ways that improving mobility manifests itself in an economy sense is in improving business efficiencies. As an illustration, if it takes a delivery truck only 30 minutes to make a delivery instead of 45 minutes, there are savings in fuel and operating expenses because trucks run more efficiently at normal speeds as opposed to a stop and go environment. In addition there are savings in driver time, allowing more deliveries to be made in an 8-hour day. These, and similar factors, have the effect of reducing production costs. Lower production costs make goods less expensive and affect consumption in a positive way for business. Further, because states and regions compete not only in the national but international economy, the cost savings from improved mobility make the goods from those states and regions more competitive in these larger markets.

The return on investment to the general economy highway expenditures was estimated to be approximately 16 percent annually in the mid-1990s (Source). That is to say that for every $100 spent on highways, there are $16 per year in increased economic efficiencies. Further, that increased efficiency continues to occur every year as long as the roadway improvement is maintained.

For the purposes of conservative estimates of effects in the second decade of the 2000s, the return on investment can be calculated at 8 percent rather than 16 percent. This reduction was adopted because the general trend since the advent of the Interstate Highway System is that return on investment has declined. This stands to reason in that the second and subsequent links between two or more markets has a smaller economic impact than the establishment of the first link between those markets. (It should also be noted that some believe this trend in declining return on investment may be reversing to some degree, primarily because of the increased time-sensitive demands of just-in-time inventory practices.)

When the 8 percent rate of return is applied annually to the roadway expenditures over Z years the increase in business efficiency that is created has an estimated value of 8 percent times the annual expenditure over the same period. The improvement in business efficiency has an economic impact for the same reasons as the economic benefits of construction. This economic impact is calculated on the basis of assuming a general rate of return (i.e., profit) of 6 percent to business on the operating savings of the value of business efficiency. This results in an increase in business profits over the construction time-period. That economic effect will, in turn, help support additional jobs.

MEASURE DESCRIPTIONS

Time and Fuel Savings

Another traditionally estimated benefit of improving mobility is the reduction of delay and fuel consumption. The improvements in system operations that reduce delay and fuel consumption have a value for passenger travel and, if data are available, freight travel as well. The freight value component is particularly important for identifying the effect of investments near ports, border crossings and intermodal terminals and ensuring the appropriate consideration as compared to commuter delay reduction projects.

Geographic:	State, Region, Corridor
Include Transit?	Yes
General Use:	Planning; Before-After; Project or program analysis
Usage Time:	Annual or project
Possible Targets:	Not applicable
Data Items:	Travel Time (measured or estimated), Volume, Economic profile, Demographics
Data Source:	Travel time/speed monitoring; Planning models; Roadway inventory data sets; Economic and demographic data sets

MEASURE DESCRIPTIONS

Border Crossing Time

Description

Border crossing time is a freight performance measure used to illustrate the effect of the combined operations of several agencies and companies at international border checkpoints. Security, trade, environmental, food safety and several other concerns are addressed and affect the performance of the transportation system. Transportation improvements are not the only solution, nor are lack of infrastructure or operations treatments the only problem. With many potential delay causing events and actions, the typical demand/capacity analysis is not useful. The border crossing time measure meets the analytical challenges by using a benchmark of low volume travel time. This can be further modified with information about security threat level, if desired. The basic concept is to use travel times from continuously collected data to identify the fastest crossing time, use that as the "free-flow" condition and then calculate other measures such as travel delay, travel time index, buffer index.

Use

The key to developing the measures is to identify a fixed point upstream of the border crossing queue that can be used as the "entry" point for measurement purposes. Using a fixed location allows comparable travel times to be prepared for all conditions and all times of day. More than one location may be needed depending on access routes to the crossing. A similar fixed exit point is also required, desirably before trucks are sent to the detailed inspection area, or with a monitoring device/process that identifies the vehicles that are sent for longer inspections. The average crossing values can be computed for hourly conditions and weighted by the number of trucks or the value of the commodities to estimate peak period, daily, or annual performance measure values.

Calculation

The measure calculation – whether delay, travel time index or buffer index – is identical to those described for non-border environments with the exception of the different "free-flow" value.

Geographic:	Crossing, Corridor
Include Transit?	No
General Use:	Planning, Operations
Usage Time:	Monthly, Annual, Trend
Possible Targets:	Crossing, Corridor; Near-Term & Long-Term
Data Items:	Travel Time (measured or estimated) Volume (for weighting)
Data Source:	Travel time/speed monitoring

MEASURE DESCRIPTIONS

Incorporating Public Transportation Service into Mobility Performance Measures

Using mobility performance measures for a number of purposes will require those measures to accommodate many different types of systems, operations, urban areas and travel modes. Public transportation service, in particular, has a number of mobility attributes that are identical to roadways. Both modes seek to rapidly and reliably move many people to destinations. Both modes are affected by congestion and the mobility solutions that might be deployed have a variety of effects. This travel is focused in a few hours each day and the effects of operations, design or infrastructure changes are felt by people, businesses, society and the economy. Inevitably there are cases when the mobility performance measures for the modes must relate to each other and be combined if it is relevant to the analysis.

Concept

Key to combining roadway and public transportation system mobility performance measures is to develop comparable standards that address the differences in modes. One key factor is the comparison of free-flow travel on roadways with same condition on public transportation. It appears that transit riders use the service based on the scheduled travel times or the headways.

- Scheduled travel times - potential riders examine departure and arrival times and compare them to their desired arrival times.
- Headways - if the time between service vehicles is relatively short, patrons may not consult the scheduled departure time; they will use the expected travel time to plan their trip.

The public transportation corollary to free-flow travel on roadways, therefore, would seem to be "scheduled travel time". As with free-flow road conditions, transit riders compare their travel experiences to the travel time they expected based on the schedule. Using the scheduled travel time as "free-flow" has three benefits:

- **It does not penalize transit operations** – Public transportation service (especially local bus service) may require more time to complete the same trip due to the unloading and loading of riders. The types of transit service also have different operating characteristics. It is not realistic to grade the service relative to roadway free-flow travel time, if one could decide on what roads to base that time (i.e. the nearest street/freeway? the highest speed on the corridor? the road with a similar construction cost per mile?, etc). Different free-flow speeds are used for streets and freeways.
- **It does not penalize the region for increasing transit ridership** – If free-flow roadway travel were used as the comparison standard a region's congestion measure might get worse if ridership increased. If transit service was increased to encourage more ridership on local routes (which might have travel times that are 50 percent longer than auto travel), the longer travel times would show that congestion had worsened. If the scheduled time were used and transit service operated with good on-time performance, however, the region's overall congestion level may decline.
- **A scheduled travel time standard focuses public transportation service providers on the important issue of reliability** – If a good on-time performance is achieved and public transportation ridership increases, mobility performance measures will improve. Late service will be deemed "congested" and the performance measures will worsen.

Calculation

For the purposes of combining modal performance measures, public transportation service will be evaluated with scheduled travel time or speed as the "free-flow" condition.

It may seem odd to disregard transit travel speed in this sense, but the service differences are important. Attempting to estimate the slower speeds on transit routes and incorporating them into the analysis would, as indicated above, double penalize the service. The "penalty" or "reward" for public

MEASURE DESCRIPTIONS

transportation in this mobility estimate comes from gain or loss in ridership. If the transit travel times become unreasonably long, ridership will decline, and the amount of “uncongested” passenger-miles contributed by public transportation will also decline. Faster transit route times, better access to transit, improved service from interconnected networks, or high-speed bus or rail links should result in higher ridership values, which would increase the amount of “uncongested” travel in the mobility measure calculations.

MEASURE DESCRIPTIONS

Summary Definitions

Description of Each Label in the Summary Box

- Geographic – What type of area is appropriate to evaluate with the measure?
- Include Transit? – Is public transportation service directly included? Or can the effects of transit be indirectly included?
- General Use – The typical phase or activity where the measure might be most useful
- Usage Time – The appropriate time between updates.
- Possible Targets – The geographic area and time period for which targets might be developed for the measure.
- Data Items – Basic elements required to produce the measure.
- Data Source – Potential sources of data for the primary data items.