CHAPTER 5—RECOMMENDED MOBILITY MEASURES AND DATA ELEMENTS

Chapter Summary

Travel time and speed are key elements in assessing the performance of the transportation system and for evaluating land use pattern changes. A wide range of mobility solutions are typically pursued for a variety of reasons. This chapter describes the measures and quantities that illustrate the effect of the spectrum of solutions on travelers using travel time-based measures. It also identifies the data elements needed to estimate or calculate the measures.

A system of mobility measures should be developed only after an examination of the uses and audiences to be served, the full consideration of program goals and objectives, and the nature of likely solutions. This chapter illustrates a system of travel time-based measures to estimate mobility levels. These procedures are useful for roadway systems, person and freight movement modes, and transportation improvement policies and programs. Although a number of analyses may not benefit from a broad focus, the user should consider the way that measures might be used before selecting the appropriate set of mobility measures.

The following sections describe techniques for measuring mobility on various portions of a transportation network (*1*). Many of the definitions used in this chapter were included in *Quantifying Congestion* (*1*) and the first version of *The Keys to Estimating Mobility in Urban Areas* (*2*).

5.1 Individual Measures

Travel time, speed, and rate quantities are somewhat more difficult to collect and may require more effort than the traffic volume counts that currently provide the basis for most roadway analysis procedures. Travel speed-related measures can, however, be estimated as part of many analysis processes currently used. The ultimate implementation of a set of time-related mobility measures in most urban areas will probably rely on some estimating procedures along with archived data. These measures may include current *Highway Capacity Manual*-based analysis techniques, vehicle density measures estimated from detectors in the pavement or from aerial surveys or relationships that estimate travel rate, or speed from generally available volume and roadway characteristics. The use of estimating procedures will be particularly important in setting policy and the prioritization of transportation improvement projects, pavement designing, responding to developer requests for improvement, and performing many other analyses.

This section describes the measurements that form the basis for the mobility analyses illustrated in subsequent sections of this paper. The focus of this section is those measures most applicable to the individual traveler. The mobility aspects and geographic areas that can be analyzed with the measure are summarized after the measures are presented. Summarizing the mobility aspects and geographic areas illustrates the flexibility of mobility measures based on time and person or freight movement. The application of the mobility measures will often satisfy two of the three "axis aspects" (level, location, and time) shown in Exhibit 4-2.

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 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. 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. Equation 5-1 shows the computation of delay in person-hours. 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.

$$\begin{matrix}\textit{Total Delay}\\(\textit{person–hours})\end{matrix}=\left[\begin{matrix}\textit{Actual}\\\textit{Travel Time}\\(\textit{minutes})\end{matrix}-\begin{matrix}\textit{FFS or PSL}\\\textit{Travel Time}\\(\textit{minutes})\end{matrix}\right]\times\begin{matrix}\textit{Vehicle Volume}\\(\textit{vehicles})\end{matrix}\times\begin{matrix}\textit{Vehicle Occupancy}\\(\textit{persons/vehicle})\end{matrix}\times\frac{\textit{1 hour}}{\textit{60 minutes}}\qquad\text{(Eq. 5-1)}$$

The **delay per person or delay per peak period traveler** (in daily minutes or annual hours) can be used to reduce the travel delay value to a figure that is more useful in communicating to non-technical audiences. It can normalize the impact of mobility projects that handle much higher person demand than other alternatives. Delay for the primary route or road, in these alternatives, may be higher due to this higher volume, but this also indicates the need to examine the other facilities or operations within the corridor included in the "before" case. To the extent possible, the initial analysis should include as much of the demand that might move to the improved facility, route, or road.

The **Travel Time Index (TTI)** is a dimensionless quantity that compares travel conditions in the peak period to travel conditions during free-flow or posted speed limit conditions. For example, a TTI of 1.20 indicates that a trip that takes 20 minutes in the off-peak period will take 24 minutes in the peak period or 20 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 system elements with different free-flow or posted speeds. Travel rate (in minutes per mile) is a direct indicator of the amount of travel time, which makes it relevant to travelers.

The measure can be averaged for freeways and arterial streets using the amount of travel on each portion of the network. An average corridor value can be developed using the number of persons using each facility type (or modes) 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 or daily index values.

The Travel Time Index in Equation 5-2 compares measured travel rates to free-flow or posted speed limit conditions for any combination of freeway and arterial streets. Index values can be related to the general public as an indicator of the length of extra time spent in the transportation system during a trip. Equation 5-2 illustrates a relatively simple version of the calculation using VMT, but PMT could also be used, as could a value of time calculation that incorporates person and freight travel.

$$\text{Travel Time Index} = \frac{\left[\dfrac{\text{Freeway Travel Rate}}{\text{Freeway Free-flow or Posted Speed Limit Rate}} \times \text{Freeway Peak Period VMT}\right] + \left[\dfrac{\text{Principal Arterial Street Travel Rate}}{\text{Principal Arterial Street Free-flow or Posted Speed Limit Rate}} \times \text{Principal Arterial Street Peak Period VMT}\right]}{\text{Freeway Peak Period VMT} + \text{Principal Arterial Street Peak Period VMT}} \quad \text{(Eq. 5-1)}$$

The **Travel Rate Index (TRI)** is similar to the TTI in that it is also a dimensionless quantity that compares travel conditions in the peak period to travel conditions during free-flow or posted speed limit conditions. However, the TTI includes incident conditions while the TRI does not. Continuous data streams allow for the direct measurement of a TTI that includes incidents. For some applications, incident conditions would not be included. For example, when travel time runs are performed for a corridor study, those runs that are affected by incident conditions are normally removed. This provides an estimate of the non-incident travel time along the corridor. In these conditions, the computed measure would not be a TTI, but rather a TRI. The TRI measure is computed in the same way as the TTI but does not include incident conditions. A typical application of the TRI would be calculating congestion levels from the travel demand planning model because incident conditions are not considered.

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). Indexing the measure provides a time- and distance-neutral measure, but the actual minute values could be used by an individual traveler for a particular trip length or specific origin-destination pair. With continuous data, the index is calculated for each road or transit route segment, and a weighted average is calculated using vehicle-miles or, more desirably, person-miles of travel as the weighting factor. 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 5-3. 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.”

$$\text{Buffer Index}(\%) = \left[\frac{\underset{(minutes)}{\text{95th Percentile Travel Time}} - \underset{(minutes)}{\text{Average Travel Time}}}{\underset{(minutes)}{\text{Average Travel Time}}} \right] \times 100\% \qquad \text{(Eq. 5-2)}$$

The buffer time concept 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.

The **Planning Time Index** represents the total travel time that should be planned when an adequate buffer time is included. The Planning Time Index differs from the Buffer Index in that it includes typical delay as well as unexpected delay. Thus, the Planning Time Index compares near-worst case travel time to a travel time in light or free-flow traffic. For example, a planning time index of 1.60 means that, for a 15-minute trip in light traffic, the total time that should be planned for the trip is 24 minutes (15 minutes × 1.60 = 24 minutes). The Planning Time Index is useful because it can be directly compared to the travel time index on similar numeric scales. The Planning Time Index is computed as the 95th percentile travel time divided by the free-flow travel time as shown in Equation 5-4.

$$\underset{(no\ units)}{\text{Planning Time Index}} = \frac{\underset{(minutes)}{95^{th}\ \text{Percentile Travel Time}}}{\underset{(minutes)}{\text{Travel Time Based on Free-Flow or Posted Speed}}} \qquad \text{(Eq. 5-3)}$$

The **90th or 95th percentile travel time** is perhaps the simplest measure of travel time reliability for specific travel routes or trips, which indicates how bad delay will be on the heaviest travel days. The 90th or 95th percentile travel times are reported in minutes and seconds and should be easily understood by commuters familiar with their trips. For this reason, this measure is ideally suited for traveler information. This measure has the disadvantage of not being easily compared across trips, as most trips will have different lengths. It is also difficult to combine route or trip travel times into a subarea or citywide average.

Several statistical measures of variability have been suggested to quantify travel time reliability, such as standard deviation and coefficient of variation. These are discouraged as performance measures, as they are not readily understood by non-technical audiences nor easily related to everyday commuting experiences.

5.2 Area Mobility Measures

The mobility measures described in the previous section mainly relate to the individual traveler. The measures described in this section are area measures where the area may be a corridor or region.

Congested travel is a measure that captures the extent of congestion. It estimates the extent of the system that is affected by the congestion. Equation 5-5 illustrates the computation of congested travel in vehicle-miles as the product of the congested segment length and the vehicle volume summed across all congested segments.

$$\begin{matrix}\text{Congested Travel}\\ (\text{vehicle - miles})\end{matrix} = \sum\left(\begin{matrix}\text{Congested}\\ \text{Segment Length}\\ (\text{miles})\end{matrix} \times \begin{matrix}\text{Vehicle Volume}\\ (\text{vehicles})\end{matrix}\right) \quad \text{(Eq. 5-5)}$$

The **percent of congested travel** is an extension of the congested travel measure. It also measures the extent of congestion. When speed and occupancy data are available for each roadway segment, this measure can be computed. It is computed as the ratio of the congested segment person-hours of travel to the total person-hours of travel. Equation 5-6 shows the computation.

$$\begin{matrix}\text{Percent}\\ \text{of}\\ \text{Congested}\\ \text{Travel}\end{matrix} = \left[\frac{\displaystyle\sum_{i=1}^{m}\left(\left(\begin{matrix}\text{Actual}\\ \text{Travel}\\ \text{Time}_i\\ (\text{minutes})\end{matrix} - \begin{matrix}\text{FFS or PSL}\\ \text{Travel}\\ \text{Time}_i\\ (\text{minutes})\end{matrix}\right) \times \left(\begin{matrix}\text{Vehicle}\\ \text{Volume}_i\\ (\text{vehicles})\end{matrix} \times \begin{matrix}\text{Vehicle}\\ \text{Occupancy}_i\\ (\text{persons/vehicle})\end{matrix}\right)\right)_{\text{Each congested segment}}}{\displaystyle\sum_{i=1}^{n}\left(\begin{matrix}\text{Actual Travel Rate}_i\\ (\text{minutes per mile})\end{matrix} \times \begin{matrix}\text{Length}_i\\ (\text{miles})\end{matrix} \times \begin{matrix}\text{Vehicle}\\ \text{Volume}_i\\ (\text{vehicles})\end{matrix} \times \begin{matrix}\text{Vehicle}\\ \text{Occupancy}_i\\ (\text{persons/vehicle})\end{matrix}\right)_{\text{All segments}}}\right] \times 100 \quad \text{(Eq. 5-6)}$$

Congested roadway is another measure of the extent of congestion. It is the sum of the mileage of roadways that operate under free-flow or posted speed limit conditions. This is shown in Equation 5-7.

$$\begin{matrix}\text{Congested Roadway}\\ (\text{miles})\end{matrix} = \begin{matrix}\sum\text{Congested Segment}\\ \text{Lengths }(\text{miles})\end{matrix} \quad \text{(Eq. 5-7)}$$

Accessibility is a measure that often accompanies mobility measures. It quantifies the extent that different opportunities can be realized. These might be accessibility to jobs, a transit station, or other land use or trip attractor of interest. Accessibility is satisfied if the travel time to perform the desired activity is less than or equal to the target travel time as indicted in Equation 5-8.

$$\underset{(opportunities)}{Accessibility} = \begin{matrix} \sum Objective\ Fulfillment\ Opportunities \\ (e.g.,\ jobs), Where \\ Travel\ Time \leq Target\ Travel\ Time \end{matrix} \quad \text{(Eq. 5-8)}$$

Exhibit 5-1 summarizes key characteristics of the primary mobility measures described in this section.

Exhibit 5-1. Key Characteristics of Mobility Measures.

Performance Measure	Congestion Component Addressed[1]	Geographic Area Addressed
Delay per traveler	Intensity	Region, Sub-area, Section, Corridor
Travel Time Index	Intensity	Region, Sub-area, Section, Corridor
Buffer Index	Intensity	Region, Sub-area, Section, Corridor
Planning Time Index	Intensity	Region, Sub-area, Section, Corridor
Total delay	Intensity	Region, Sub-area, Section, Corridor
Congested travel	Extent, Intensity	Region, Sub-area
Percent of congested travel	Duration, Extent, Intensity	Region, Sub-area
Congested roadway	Extent, Intensity	Region, Sub-area
Accessibility	Extent, Intensity	Region, Sub-area

[1]See Exhibit 4-1.

5.3 Basic Data Items

This section describes the basic data elements used to define mobility measures. The units are noted for typical urban analyses.

The **travel time** (in minutes) is the time required to traverse a segment or complete a trip. Times may be measured directly using field studies or archived data from traffic management centers, or can be estimated using empirical relationships with traffic volume and roadway characteristics, computerized transportation network models, or the projected effects of improvements.

The **segment or trip length** (in miles) is the distance associated with the travel time. Length can be measured directly with a vehicle odometer or scaled from accurate maps but is typically an established item in a transit or roadway inventory database.

The **average speed** (in miles per hour) for a segment can be used to calculate travel rate or travel times if field data are not readily available.

The **average travel rate** (in minutes per mile) is the rate at which a segment is traversed or a trip is completed (Equation 5-9). Travel rates may be determined directly using travel time field studies, or can be estimated using transit schedules or empirical relationships (e.g., Bureau of Public Roads formula) between traffic volume and roadway characteristics (e.g., capacity).

$$\underset{(minutes\ per\ mile)}{Travel\ Rate} = \frac{\underset{(minutes)}{Travel\ Time}}{\underset{(miles)}{Segment\ Length}} = \frac{60}{\underset{(mph)}{Average\ Speed}} \qquad \text{(Eq. 5-9)}$$

The **person volume** is the number of people traversing the segment being studied. The person volume can be collected for each travel mode or estimated using average vehicle occupancy rates for types of vehicles.

The **freight volume** is the amount of goods moved on a transport segment or system. It can be measured in units of ton-miles, or it can be estimated from truck percentages. Freight volume may be particularly important in analyses dealing with travel time reliability due to the sensitive nature of "just-in-time" manufacturing processes and goods delivery services.

The **person-miles of travel** is the magnitude of travel on a section of the transportation system or on several elements of the system. It is a particularly useful measure in corridor and areawide analyses where total travel demand is used in calculations. Equation 5-10 indicates it is the product of distance and person volume. Person volume can be estimated as the product of vehicle volume and average vehicle occupancy.

$$\underset{of\ Travel\ (PMT)}{Person\text{-}miles} = \underset{(persons)}{Person\ Volume} \times \underset{(miles)}{Distance} \qquad \text{(Eq. 5-10)}$$

The **target travel time** (in minutes) is the time that indicates a system or mode is operating according to locally determined performance goals. It focuses on the "door-to-door" trip time from origin to destination. The target travel time can be differentiated by the purpose of the travel, the expectation for each mode within the transportation system, the type of activity, and the time of day. It should be influenced by community input, particularly on the issue of the balance between transportation quality, economic activity, land use patterns, and environmental issues.

The **target travel rate** (in minutes per mile) is the maximum rate (slowest speed) at which a segment is traversed or a trip is completed without experiencing an unsatisfactory level of mobility. The target travel rate is based on factors similar to the target travel time. This is similar to the process used by many states and cities where a target level of service (LOS) is used to determine the need for additional transportation improvements.

In practice, there will also be a need for a corridor average travel rate value. This would be used as the target for facility expansions, operating improvements, program enhancements, or policy implementations. The facility/mode target travel rates can be used for evaluation, but improvement strategies and amounts should be based on corridor-level decisions.

5.4 Definition and Discussion of Speed Terms

Several speed terms are used in this paper and in the mobility analysis examples. This section provides definitions of primary speed measures and guidance on their use in mobility analyses.

Free-flow speed is the average speed that can be accommodated under relatively low traffic volumes (i.e., no vehicle interactions) on a uniform roadway segment under prevailing roadway and traffic conditions. It can be calculated or estimated in a number of ways, with a common approach being to use the 85th percentile speed in the off-peak period. The off-peak periods can be defined by time period (e.g., overnight—10 p.m. to 6 a.m., or midday—9 a.m. to 4 p.m.) or vehicle volume. Vehicle headways of 5 seconds or more could be used to define free-flow speed operating conditions (i.e., traffic volumes of approximately 700 vehicles per hour per lane [vphpl]). Ideally, a continuous data source (e.g., ITS, Weigh in Motion [WIM], Automatic Traffic Recorder [ATR], etc.) could be used to identify the free-flow speed using at least one year of valid data.

The **posted speed limit** is the posted speed of the roadway. For specific facilities, or sections thereof, this value is obtained by field data collection. Posted speed is a typical roadway inventory data element; therefore, posted speeds can be obtained from such roadway inventories, particularly for a system-level analysis that includes numerous facilities.

Target speed is the speed associated with the target Travel Time Index. The target speed can be computed given the target Travel Time Index and the free-flow travel rate or the posted speed limit travel rate.

5.4.1 Threshold Speed Values

Many analyses begin with the question, "What should we compare to?" The issue usually can be framed as a choice between using a desirable condition or using an achievable condition given the funding, approval, and other constraints.

It should be noted that posted speed limits are included in most roadway inventory files and should be readily available for analytical procedures. Computerized analysis procedures should be modified so that a "negative delay" value is not included in the calculations (as done in the examples in this report). If estimated free-flow speeds are used in the calculation of delay, the speed data collected from field studies may include values with very fast speeds (above the free-flow speed). Free-flow speeds that are higher than the posted speed limit may present an "illegal appearance" problem when used in public discussions. In addition, it may be difficult to justify delay being calculated for travel at the posted speed limit.

5.4.2 When Would I Use Free-flow Speed in Mobility Measure Computation?

Delay and congestion index measure computations can be computed relative to free-flow speed. Using free-flow speed for these computations is most appropriate when continuous data sources are available that allow for the computation of the 85th percentile speed in the off-peak period. The use of a free-flow speed provides an automated and consistent method for computing delay and index values across different metropolitan areas. The free-flow speed could also be used when the analyst does not have ready access to posted speeds along the corridors included in a mobility analysis—particularly large areawide analyses.

5.4.2 When Would I Use a Posted Speed Limit in Mobility Measure Computation?

The posted speed limit can also be used to compute delay and index measures. The posted speed limit can be used when continuous data are not available for the mobility analysis. Posted speed limits are an easy to communicate threshold, are more stable than free-flow speeds, and do not require "value" judgments of assessments of goals or targets.

5.4.3 How Does the Target Travel Time Index Relate to the Computed Measures?

The target Travel Time Index values would be developed with input from citizens, businesses, decision makers, and transportation professionals. The target values represent the crucial link between, 1) the vision that the community has for its transportation system, land uses, and its "quality of life" issues and 2) the improvement strategies, programs, and projects that government agencies and private sector interests will implement. The values are desirably the result of a process that is integrated with the development of the long-range plan, but they must be reasonable and realistic since overstatement or understatement could distort congestion assessment.

Urban areas should approach the use of a target Travel Time Index with a corridor and system strategy. The target value may be developed for every mode or facility as a way to identify individual performance levels, but the key application will be as a corridor or system target. Individual facility "deficiencies" can be addressed through improvements to that mode or route or by other travel mode improvements, strategies, or policies. For example, the freeway mainlanes may not satisfy the target value, but if an HOV lane is successful in moving a large number of people at high speeds, the average Travel Time Index, when weighted by person volume, may achieve the target value.

The target Travel Time Index value can be "adjusted" appropriately irrespective of whether a free-flow speed or a posted speed limit is used in the calculation of the TTI. For example, if free-flow speed is used, the target TTI value might be 1.40, whereas the target TTI value might be 1.30 if the posted speed limit is used.

5.4.5 Summary and Guidance

In summary, free-flow speed is better for matching how people drive given the roadway operating conditions (i.e., "I was 5 mph over the posted speed limit, and I was still being passed"). Posted speed limits are sometimes set for public policy reasons, rather than being tied to actual conditions. This fact makes comparisons between regions and comparisons over several years difficult. Posted speed limits could go down, reducing the apparent "delay," and yet if peak period speeds declined, which should show more congestion, there could be less delay.

These considerations should be evaluated when determining the appropriate reference (free-flow speed or posted speed limit) in delay and index computations for the community and stakeholders involved with the analysis.

5.5 Other Data Elements

There are several other factors that are needed to perform mobility analyses including the following:

Hourly volumes, expressed in vehicles or persons, may be very useful for the peak-period or 24-hour periods. Many roadway and transit analyses focus on the peak hour, but in most large cities this is not enough information to assess the mobility situation or to analyze alternatives. A range of improvements, including demand management, advanced traveler information systems, and high-occupancy vehicle lanes, have an effect on other hours in the peak period.

The **daily volume variation** is the variability in person or vehicle volume from day to day. These data are particularly important in analyses that examine mobility levels on particularly heavy volume days (e.g., Fridays or days before holidays) or days/time periods with different travel patterns (e.g., special events or weekends).

Incident information includes the number and duration of crashes and vehicle breakdowns that occur on roadway segments and transit routes. This information is used in analyses of the variation in mobility level. The reliability of transport systems is a particular concern in analyses of incident management programs, value pricing projects, and freight movement studies.

Weather information can explain a significant amount of the variation in travel conditions. Snow, ice, fog and rain can be noted in a database used for mobility analysis.

Road work information includes construction activities and their location. This includes the location, number of lanes affected, and time period.

Peak direction hourly travel demand and volume are two measures of person or vehicle travel used in system analyses. The two may be the same for uncongested corridors. Demand is higher than volume in congested corridors, however, and the "excess" volume travels on the main route in hours adjacent to the peak hour and on alternate routes. Improvements to primary routes or travel modes may result in higher traffic volumes in the peak hour that can be predicted if demand is estimated.

5.6 Time Periods for Analysis

5.6.1 Peak and Off-peak Period Analysis

The peak period is the time period most often used for urban mobility analysis. Off-peak periods may be of interest to study the extent of peak spreading at one area compared to another area. The TTI is computed relative to the free-flow speed or posted speed limit. If the analyst is investigating the TTI of an off-peak period that is beginning to experience congestion, the TTI could be used to illustrate the increased congestion if the actual travel rate during the off-peak is higher than the target value. The BI and delay measures could also be useful in the off-peak period in locations that may be experiencing some congestion in the off-peak.

5.6.2 Daily Analysis

Analysis using daily averages is often less useful with the TTI and BI. Using 24-hour speeds for computing the TTI is not meaningful because the measure is meant to compare peak and off-peak travel conditions. Likewise, the BI is intended to be a measure of reliability during a peak period. Daily values "wash out" the impact of peak-periods with the longer off-peak periods. Total delay is more meaningful as a daily congestion measure. Though the total delay in person- or vehicle-hours is less meaningful to an individual driver, it is a good measure for analyzing trends from year to year. Daily delay is used in the Federal Highway Administration-sponsored Mobility Monitoring Program (MMP) (*3*) in this manner.

5.6.3 Seasonal Analysis

Investigating the seasons of the year may also be of interest. Many areas have unique peaking characteristics due to seasonal events (e.g., academic calendars, sporting events, and tourism). These activities can alter the length and extent of the peak period. All of the measures discussed in this chapter can be used in a mobility analysis that compares peak or off-peak period measure changes by month of year.

5.6.4 Urban or Rural Analysis

The discussion above has assumed an urban mobility analysis. Rural locations can also be the subject of mobility analyses. For example, there might be an interest in freight movements in rural areas. Special events and tourism activities are also situations that may generate interest in a rural analysis.

As mentioned previously, continuous data sources provide speed (travel time), volume, and classification information in some urban areas. Point-to-point travel time information is also of interest for rural freight operations. As with travel conditions on an urban congestion map, such point-to-point travel time information would allow insight into rural freight operations. Transponders could be used to provide the continuous information. The University of Washington is investigating such applications in rural areas in the state of Washington. Of the primary measures discussed in this document, TTI and delay measures could be used for this rural application. The TTI could be used to compare current travel rates to a target travel rate for goods movement over the corridor of interest. If continuous data sources are available (e.g., toll tags or cellular telephone), the BI could also be computed for freight carriers. Prior to real-time systems, estimation measures could be used to estimate delay for goods movement.

Special events and tourism may also invite mobility analysis in a rural area. If real-time equipment is already installed, it could be used to obtain travel rate information to compare to a target travel rate. Delay could also be computed. For a special event, and possibly for a tourism activity/season, portable readers could also be installed to monitor mobility along rural corridors of interest.

5.7 The Right Measure for the Analysis Area

Exhibit 5-2 summarizes the mobility measures that should be used for several types of analyses and for different size areas or modal combinations (*1*,*4*). Individual traveler measures such as travel rate and the travel rate index are very useful for analysis up to the corridor level. At higher levels of analysis, magnitude statistics such as delay and accessibility are useful, but there is also a role for communication methods such as the travel rate index. Examples of the application of these measures to situations based on the level of analysis are included in following sections.

Exhibit 5-2. Recommended Mobility Measures for Analysis Levels.

	Mobility Measures									
Analysis Area	**Travel Time**	**Travel Rate**	**Delay per Traveler**	**Travel Time Index**	**Buffer Index**	**Total Delay**	**Congested Travel**	**Percent of Congested Travel**	**Congested Roadway**	**Accessibility**
Individual locations	S		P	P	P	P				
Short roadway sections	P	P	P	P	P	P				
Long roadway sections, transit routes or trips		S	P	P	P	P				
Corridors		S	S	P	P	P				S
Sub-areas		S		P	P	P	P	P	P	P
Regional networks		S		P	P	P	P	P	P	P
Multimodal analyses		S	S	P	P	P				P

Note: P = Primary mobility measure
S = Secondary mobility measure
Note: Measures with delay components can be calculated relative to free-flow or posted speed conditions.
Source: Adapted from NCHRP (*1*) and R. Ewing (*4*)

Most mobility studies should be conducted at geographic areas higher than individual locations and short sections of roadway. At relatively small areas the studies will typically be limited to near-term analysis of operational improvements where new modes or facilities are not realistic options and even the operational improvements will be limited. These analyses may proceed using *Highway Capacity Manual*-type procedures. Total delay, delay per person, and travel time difference are most useful for intersections or individual locations due to problems identifying the length needed for the rate-based measures.

Larger scale analyses, where more detailed analytical tools are used and a wider choice of improvement options is considered, are more frequently identified as mobility studies. The analysis and presentation of mobility data can be accomplished by the travel time index, travel rate index, total delay, and accessibility as primary measures. Secondary measures may also be used for cumulative analyses of several improvements and estimation of benefits.

Mobility for larger areas of analysis, such as long roadway sections and corridors can be quantified with some individual statistics if the roadways are of the same type. But if freeways, streets, and/or other travel modes are included, cumulative statistics and the travel rate index are very appropriate. Index statistics become useful at this higher level of analysis when multiple roadways and large numerical values make interpretation of relative conditions difficult.

5.8 The Right Measure for the Type of Analysis

The recommended uses in Exhibit 5-3 are another illustration of how the mobility measures vary by the scope of the analysis, but not by mode or facility included in the analysis (*1*,*4*). Travel time and speed measures, and the data and estimating techniques used to create them are very flexible analysis tools. When combined with person and freight movement quantities, they illustrate a range of mobility situations. Different values will be used for the target travel rate or target travel time depending on the facility type or travel mode, but the calculation and application of the measures are identical.

While it is difficult to cover every type of mobility analysis, Exhibit 5-3 illustrates recommended measures for many common types of studies and information requirements. As with Exhibit 5-2, the analyses where small areas are analyzed or quick answers are needed use simple measures. More complex analyses, those that typically cover larger areas or multiple modes and those targeting non-technical audiences, use index measures and summary statistics.

Exhibit 5-3. Recommended Mobility Measures for Various Types of Analyses.

	Mobility Measures									
Uses of Mobility Measures	**Travel Time**	**Travel Rate**	**Delay per Traveler**	**Travel Time Index**	**Buffer Index**	**Total Delay**	**Congested Travel**	**Percent of Congested Travel**	**Congested Roadway**	**Accessibility**
Basis for government investment or policies			P	P	P	P	P	P	P	P
Basis for national, state, or regional policies and programs			P	P	P	P	P	P	P	P
Information for private sector decisions	P	P	S	P	P	S	P	P	P	
Measures of land development impact	P	P	P	P	P	P	S	S	S	P
Input to zoning decisions	P	P		P	P					P
Inputs for transportation models	P	P			P					
Inputs for air quality and energy models	P	P	P		P					
Identification of problems	P	P	P	P	P	S	S	S	S	
Base case (for comparison with improvement alternatives)			S	P	P	P	S	S	S	P
Measures of effectiveness for alternatives evaluation		P	P	P	P	P	S	S	S	P
Prioritization of improvements			P	P	P	P				S
Assessment of transit routing, scheduling, and stop placement	P	P	P	P	P	S				
Assessment of traffic controls, geometrics, and regulations	P	P			P					
Basis for real-time route choice decisions	P	P	P	P	P					

Note: P = Primary mobility measure
S = Secondary mobility measure
Source: Adapted from NCHRP (*1*)

5.9 Index Measure Considerations

5.9.1 How Much Congestion is OK?

Analyses of system adequacy, the need for improvements, or time-series analyses conducted in a corridor or area can benefit from comparisons using "target" conditions.

Free-flow conditions will not be the goal of most large urban transportation improvement programs, but using them provides one consistent benchmark relevant for year-to-year and city-to-city comparisons. The "attainment of goals" standard might also be used at the national or state level, but more often during a discussion of planning and project prioritization techniques.

The use of a "target" travel rate can improve the guidance provided to system planners and engineers. If the target travel rates are a product of public discussion, they will illustrate the balance that the public wishes to have between road space, social effects, environmental impacts, economic issues, and quality of life concerns. Areas or system elements where the performance is worse than the target can be the focus of more detailed study. A corridor analysis, for instance, might indicate a problem with one mode, but the solution may be to improve another mode or program that is a more cost-effective approach to raising the corridor value to the target. The amount of corridor or areawide person-travel that occurs in conditions worse than the locally determined targets can be used to monitor progress toward transportation goals and identify problem areas.

5.9.2 Relationship to Door-to-Door Travel Time Measures

The measure of system performance that is closest to the concern of travelers is door-to-door travel time. Any performance measure should relate to door-to-door travel time as closely as possible. Calibrating the user view of system performance with measures that can be more readily collected from existing data sources is the key to the efficient and effective presentation of mobility information. Periodic updates of public opinion can be used to adjust corridor and areawide determinations of service quality. Ten pairs of origin-destination trip patterns, for example, could be used to show the change in travel time. The information for these key travel patterns can be updated daily, monthly, or annually with system monitoring equipment. Every five years the key patterns could be re-examined for relevance to the existing and future land use development patterns and transportation system.

Using target conditions as the comparison standard provides the basis for a map or table showing system deficiencies in a way that is readily understood and uniquely relevant to improvement analyses. A map showing the target travel rates on the system links would accompany such a presentation. This approach could also be easily used in a multimodal analysis, with a target Travel Time Index for the corridor. Future travel rates for the corridor can be changed by improving a facility or service, or by shifting travel to other modes/facilities. The "target" comparison standard would be broader than simply a congestion or mobility measure since it would directly incorporate the idea that the goal for a corridor is not always high-speed travel. It could be used in conjunction with an areawide planning effort to relate the link speeds, used in estimating the travel time index, to the outcome measures of door-to-door trip satisfaction.

5.9.3 Impact on Data Collection

One outcome of a move to the travel time index would be the ability to include directly collected travel time data from the various transportation system elements. Many areas do not collect this information, but the initial statistics can be developed from estimates of travel speed. As travel time studies are conducted or archived data systems developed, the actual data can be used to replace the estimates in the index, as well as to improve the estimation processes. The information derived from systems that automatically collect and analyze travel speed over sections of freeways provide a significant resource for the travel time index calculation.

5.10 References

1. *NCHRP Report 398*. Quantifying Congestion—Final Report and User's Guide. National Cooperative Highway Research Program Project 7-13, National Research Council, 1997.

2. *The Keys to Estimating Mobility in Urban Areas*. Texas Transportation Institute, College Station, Texas, 1999.

3. *Monitoring Urban Freeways in 2003: Current Conditions and Trends from Archived Operations Data*. U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-HOP-05-018, December 2004. Available at: http://mobility.tamu.edu/mmp/.

4. Ewing, R. "Transportation Service Standards—As If People Matter," In *Transportation Research Record 1400*, Transportation Research Board, National Research Council, Washington, D.C., 1993.