Measuring Transportation: Traffic, Mobility and Accessibility

THIS FEATURE COMPARES THREE APPROACHES TO MEASURING TRANSPORTATION SYSTEM PERFORMANCE. TRAFFIC-BASED MEASUREMENTS EVALUATE MOTOR VEHICLE MOVEMENT; MOBILITY-BASED MEASUREMENTS EVALUATE PERSON AND FREIGHT MOVEMENT; AND ACCESSIBILITY-BASED MEASUREMENTS EVALUATE THE ABILITY OF PEOPLE AND BUSINESSES TO REACH DESIRED GOODS, SERVICES AND ACTIVITIES.

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INTRODUCTION

Management experts often say that you cannot manage what you cannot measure. However, what is measured, how it is measured and how data are presented can affect how problems are evaluated and solutions are selected.

For example, a baseball player's performance can be evaluated based on batting averages, base hits, runs batted in and the ratio of wins to losses, plus various defense statistics that depend on the player's position. Performance statistics can be calculated per at-bat, per inning, per game, per season, or for a career. A player can be considered outstanding according to one set of statistics but inferior according to another.

This is just one example of how different measurement methods can give very different impressions about a person, group, or activity. Often, there is no single method or unit that conveys all the information needed for evaluation. Different measurement units represent different perspectives and assumptions. A coach needs to consider several different statistics when evaluating how a particular player fits into a team; it is important that decision-makers understand the different perspectives and assumptions implicit in the measurement units they use.

This feature discusses three common methods used to measure transportation, the perspectives they represent and how the selection of one method or another can affect planning decisions.

EVALUATION PERSPECTIVES

Transportation systems can be evaluated in various ways that reflect different perspectives concerning users; modes; land use; transport problems and solutions; how transport activity is measured; and the type of performance indicators used.[1] Three perspectives—traffic, mobility and accessibility—are compared in this feature.

Traffic

Traffic refers to vehicle movement. This perspective assumes that "travel" means vehicle travel and "trip" means vehicle trip. It assumes that increased vehicle mileage and speed benefits society.

Users: From this perspective, transportation users are primarily motorists (including drivers and passengers). Non-motorists are considered a relatively small and unimportant minority, defined as members of households who do not own an automobile.

Modes: This perspective focuses on automobile travel. It places little value on transit and cycling because they represent a small portion of vehicle mileage and are relatively slow. It considers walking primarily as a way for motorists to access parking facilities or as a form of recreation. Therefore, it devotes little transportation funding to non-motorized facilities.

Land use: This perspective evaluates land use primarily in terms of proximity to highways and parking supply. The best location for public facilities is along a major arterial or freeway intersection. Downtown locations are undesirable due to excessive roadway congestion and parking costs.

Transport problems and solutions: This perspective defines transportation problems in terms of costs, barriers and risks to motorists. It favors solutions that increase road and parking capacity, roadway traffic speeds, vehicle ownership and the affordability of driving. From this perspective, the best way to benefit nondrivers is to help them become motorists by making automobile and taxi travel convenient and inexpensive.

Measurement: Vehicle traffic is relatively easy to measure. Most jurisdictions have data on motor vehicle registrations, drivers' licenses and vehicle mileage. Performance indicators include traffic volumes, average traffic speeds, roadway level of service, congestion delay, parking supply, vehicle operating costs and crash rates.

Mobility

Mobility refers to the movement of people or goods. It assumes that "travel" means person- or ton-miles and "trip" means person or freight vehicle trip. It assumes that any increase in travel mileage or speed benefits society.

Users: From this perspective, transport users are mainly motorists because most person- and ton-miles are made by motor vehicles. However, it recognizes that some people rely on non-automobile modes and some areas have large numbers of transit, ridesharing and cycling trips.

Modes: This perspective considers automobiles most important but values transit, ridesharing and cycling where there is sufficient demand (such as in downtown areas and on college campuses) and, so, justifies devoting a portion of transport funding to transit, high-occupancy vehicle (HOV) and cycling facilities. It supports an integrated view of the transportation system, with attention to connections among modes. For example, it considers walking and transit complementary modes because most transit trips involve walking links.

Land use: From this perspective, convenient highway access and parking are most important, but transit and HOV access also is desirable in areas where density and demographics concentrate enough riders. The best location for public facilities has a combination of convenient roadway access, adequate parking, transit service and cycling routes.

Transport problems and solutions: This perspective defines transportation problems in terms of constraints on physical movement and, so, favors solutions that increase motor vehicle system capacity and speed, including road and parking facility improvements; transit and ridesharing improvements; and high-speed train, aviation and intermodal connections. It gives little consideration to walking and cycling except where they provide access to motorized modes because they represent a small portion of person-miles. From this perspective, the best way to benefit non-drivers is to improve motorized transport, including automobile, transit and taxi modes, with more modest consideration of walking and cycling.

AN ACCESSIBILITY PERSPECTIVE SUPPORTS AN INTEGRATED VIEW OF TRANSPORTATION AND LAND USE SYSTEMS, WITH ATTENTION TO CONNECTIONS AMONG MODES AND BETWEEN TRANSPORT AND LAND USE CONDITIONS.

Measurement: Mobility is measured using travel surveys to quantify person-miles, ton-miles and travel speeds, plus traffic data to quantify average automobile and transit vehicle speeds. In recent years, techniques have become available to evaluate multimodal transportation system performance, such as transit and cycling level of service ratings, although these are not yet widely used.[2]

Accessibility

Accessibility (or "access") refers to the ability to reach desired goods, services, activities and destinations—collectively, "opportunities".[3] Access is the ultimate goal of most transportation, except a small portion of travel in which movement is an end in itself with no destination (such as jogging, horseback riding and pleasure drives). This perspective assumes that improved access benefits society. Mobility is one way to achieve this goal.

Users: From this perspective, transportation users consist of people and businesses that want to reach a good, service, activity, or destination. It recognizes that most people use various access options and cannot be classified simply as motorists or transit riders.

Modes: This perspective considers all access options as potentially important, including motorized and non-motorized modes and mobility substitutes such as telecommuting and delivery services. It supports an integrated view of transportation and land use systems, with attention to connections among modes and between transport and land use conditions. It values modes according to their ability to meet users' needs and does not necessarily favor longer trips or faster modes if shorter trips and slower modes provide adequate access. It supports the broadest use of transport funding, including mobility management and land use management strategies, if they increase accessibility.

Land use: From this perspective, land use is as important as mobility in the quality of transportation. Different land use patterns favor different types of accessibility. The distribution of destinations, land use mix, network connectivity and walking conditions all affect transportation system performance. The best location for public facilities has a combination of convenient proximity, roadway access, transit service and walkability.

Transport problems and solutions: Accessibility-based planning expands the range of transport problems and potential solutions that can be considered. From this perspective, transport problems include any cost, barrier, or risk that prevents people from reaching desired opportunities. Solutions can include traffic improvements, mobility improvements, mobility substitutes (such as telecommuting and delivery services) and more accessible land use.

Measurement: Accessibility is evaluated based on the time, money, discomfort and risk (the generalized cost) required to reach opportunities. Access is relatively difficult to measure because it can be affected by so many factors. For example, access to employment is affected by the location of suitable jobs, the quality and cost of travel options that reach worksites and the feasibility of telework (which may allow employment for a firm that is physically difficult to reach). Activity-based travel models and integrated transportation/land use models are most suitable for quantifying accessibility.[4]

LAND USE ACCESSIBILITY

Land use patterns affect mobility and accessibility in various ways:[5]

- Density (the number of people or jobs per unit of land area) increases the proximity of common destinations and the number of people who use each mode, increasing demand for walking, cycling and transit.
- Land use mix (locating different types of activities close together, such as shops and schools within or adjacent to residential neighborhoods) reduces the amount of travel required to reach common activities.
- Non-motorized conditions (the existence and quality of walking and cycling facilities) can have a major effect on accessibility, particularly for non-drivers.
- Network connectivity (more roads or paths that connect one geographic area with another) allows more direct travel.

Access can be evaluated at different geographic scales. At a fine-grained scale, accessibility is affected by the quality of pedestrian conditions and the clustering of activities within a site, mall, or commercial center. At the neighborhood level, accessibility is affected by the quality of sidewalks and cycling facilities, street connectivity, geographic density and mix. At the regional level, accessibility is affected by street connectivity, transit service, geographic density and mix. Interregional accessibility refers to the quality of highways, air service, bus and train service and shipping services to other regions.

THE ROLE OF DIFFERENT MODES

How transportation is measured affects the perceived value of different modes. Different modes play different roles in providing mobility and accessibility.[6] For example, non-motorized modes serve shorter-distance trips and motorized modes serve longer-distance mobility. Some modes are more suitable for people with physical disabilities or low incomes. Some modes are particularly important for industrial activity.

ACCESSIBILITY-BASED PLANNING EXPANDS THE RANGE OF TRANSPORT PROBLEMS AND POTENTIAL SOLUTIONS THAT CAN BE CONSIDERED.

Standard transport statistics indicate that, in North America, more than 90 percent of households own an automobile and more than 90 percent of trips are made by automobile. Only about 5 percent of trips are made by non-motorized modes and less than 2 percent are made by transit.[7] This suggests that private vehicle travel is the most important form of transport by far and that improving other modes can do little to address transport problems.

However, the high priority given to automobiles and the low priority given to other modes is partly an artifact of how data are collected and presented. Most travel surveys count only the primary mode used between relatively large transportation analysis zones (TAZ) and some count only peak-period travel or commute trips.

As a result, they undercount shorter trips (those occurring within a TAZ), non-motorized links of motorized trips, off-peak trips, non-work trips, travel by children and recreational travel. For example, most surveys would not count a walking trip from a parking space to a worksite or a walk to a restaurant during a lunch break. If a traveler cycles 10 minutes to a bus stop, rides a bus for 5 minutes and walks another 5 minutes to a destination, this bike-transit-walk trip usually is coded simply as a transit trip, even though the non-motorized links take more time than the motorized link.

Although only about 5 percent of trips are made exclusively by non-motorized modes, four to six times as many involve at least some walking or cycling on public right-of-way.[8] Similarly, although only about 2 percent of total trips are made by public transit, about 5 percent of U.S. adults report that they rely primarily on public transit for transport and 12 percent used public transit at least once during the previous two months.[9]

TRADE-OFFS AMONG DIFFERENT FORMS OF ACCESSIBILITY

There are inherent trade-offs among different forms of accessibility. This occurs because roadway design and land use patterns that are optimal for one mode generally are less suited for other modes. As a result:

- Highways designed for maximum vehicle mobility have poor accessibility (few off-ramps, driveways, or cross-streets) while roads designed for maximum accessibility (many driveways and intersections) cannot safely accommodate higher-speed traffic.
- Land use patterns that maximize automobile access (low-density development with activities located along arterials and highway intersections) tend to have poor transit and non-motorized access while transit-oriented development (clustered development with limited parking and good pedestrian access) may increase traffic and parking congestion.
- Wide roads and higher traffic speeds tend to create barriers to walking; vehicle and pedestrian street design objectives often conflict.

As a result of these trade-offs, traffic-based performance indicators tend to favor automobile access over other modes. For example, roadway "improvements" that increase vehicle traffic volumes and speeds tend to create barriers to walking and, therefore, to transit travel because most transit trips involve walking links. Such projects are considered beneficial from a traffic perspective, which focuses on vehicle travel conditions, but not from an accessibility perspective, which also considers impacts on other modes. It is important that planners understand these tradeoffs and take them into account when making transportation and land use decisions.

REFERENCE UNITS

Reference units are measurement units normalized to help compare impacts. Common reference units include per capita, per mile, per trip, per vehicle and per dollar. For example, a city's transport budget might be measured per capita to compare it with other expenditure categories, years and communities. The reference units used can affect how problems are defined and which solutions are considered, as described below.

- Vehicle-mile units reflect a traffic perspective that gives high value to automobile travel.
- Passenger-mile units reflect a mobility perspective that values automobile and transit travel but gives less value to non-motorized modes because they tend to be used for short trips.
- Per-trip units reflect an access perspective that gives equal value to automobile, transit, cycling, walking and telecommuting.
- Travel time units reflect an access perspective that gives higher priority to walking, cycling and transit travel because they tend to represent a relatively large portion of travel time.
- Generalized cost units (time and money costs) reflect an access perspective.

For example, an HOV lane may carry a relatively small portion of total vehicle-miles and, therefore, it appears inefficient if measured in this way. However, it carries a relatively large portion of passenger-miles and reduces total travel time and vehicle costs. Therefore, it may be considered cost effective when measured using mobility and accessibility perspectives. Similarly, road pricing and smart growth strategies can reduce total vehicle-miles and, therefore, they may appear undesirable from a traffic perspective. However, they provide benefits in terms of reduced total generalized costs.

Table 1. Example of daily person trips.

Purpose	Mode	Distance (miles)	Time (minutes)
To work	Drive	15	30
From parking to office	Walk	0.2	4
To restaurant for lunch	Walk	0.5	10
From restaurant after lunch	Walk	0.5	10
From office to parking	Walk	0.2	4
To home	Drive	15	30
To commercial center	Bike	1	6
To errands (travel between shops)	Walk	0.5	10
From shopping center to home	Bike	1	6
Walk dog	Walk	0.5	10
Drive	2 trips (20 percent)	30.0 (87 percent)	60 (50 percent)
Walk	6 trips (60 percent)	2.4 (7 percent)	48 (40 percent)
Bike	2 trips (20 percent)	2.0 (6 percent)	12 (10 percent)
Total	10 trips (100 percent)	34.4 (100 percent)	120 (100 percent)

* Note: Assumes that Drive = 30 miles per hour (mph); Walk = 3 mph; and Bike = 10 mph. Values in parentheses indicate percentage of total travel.

EXAMPLES

Three examples of how measurement methods can affect evaluation are discussed below.

Comparing Modes

Consider the daily travel for someone who commutes by car but walks and bikes for errands, as summarized in Table 1. A traffic perspective, which counts only motor vehicle travel, classifies the person as an auto-commuter and measures car mileage. A mobility perspective counts walking and cycling trips, but because driving represents 87 percent of person-miles, it considers non-motorized modes of little importance. However, an access perspective indicates that driving represents just 50 percent of travel time and 20 percent of trips, suggesting a more important role for alternative modes.

Different perspectives give different conclusions for how best to improve transport. A pedestrian shortcut that reduces walking distance from the office to nearby restaurants by 0.2 miles provides only a 1-percent reduction in travel distance and appears to have little value if evaluated in terms of mobility. However, this reduction saves 12 percent of total travel time—the same time savings provided by a major roadway improvement that increases average traffic speeds from 30 to 38 miles per hour for a 15-mile commute.

Similarly, a particular road might carry 5,000 cars with 6,000 passengers, 100 transit buses carrying 2,000 passengers, 500 pedestrians and 200 bicyclists and have 100 adjacent homes and businesses. Traffic-based analysis, measured in vehicle trips, considers motorists the dominant road user group and justifies road designs that maximize vehicle volume and speed.

Mobility-based analysis, measured in person-miles, gives greater value to buses and rideshare vehicles and may justify HOV priority features. Access-based analysis, measured in person-minutes-of-exposure, gives greater value to pedestrians, cyclists and residents because they spend more time on the roadway. This justifies greater emphasis on non-motorized improvements, traffic calming and landscaping.

Evaluating Problems and Solutions

Suppose a community experiences growing peak-period traffic congestion. A traffic perspective, which evaluates transport system performance based on roadway level of service or average traffic speeds, justifies adding traffic lanes. This primarily benefits motorists. Improvements to other modes, such as transit, cycling and walking, are considered worthwhile only if they significantly reduce vehicle traffic congestion.

A mobility perspective, which measures multimodal level of service and travel speeds, considers delays, risks and costs to all travelers and expands the range of solutions to include improvements to alternative modes and connections among modes. This tends to result in a wider distribution of benefits.

An accessibility perspective further expands the range of problems and solutions. It takes into account land use factors, the quality of travel modes and mobility substitutes. From this perspective, traffic congestion is just one indicator of transport system quality. Some areas with high levels of traffic congestion have good accessibility and areas with little congestion have poor accessibility. Accessibility can be improved not only by increasing vehicle flow and personal mobility but also by increasing land use clustering and mix, improving walkability and improving mobility substitutes such as telecommunications and delivery services.

School Location Decisions

From a traffic perspective, the best location for a public school (or other major public facility) is adjacent to a major roadway at the urban fringe where land is available for abundant parking. This assumes that most staff and students will arrive by car or school bus.

From a mobility perspective, the best location is on a major urban street with adequate parking, frequent public transit service and, perhaps, a bike lane. This assumes that most staff and students will arrive by automobile but some will bicycle or use transit.

From an accessibility perspective, the best location for a school may be within a residential neighborhood, even if driving is inconvenient, because most students and some staff will walk or bicycle.

THE HIGH PRIORITY GIVEN TO AUTOMOBILES AND THE LOW PRIORITY GIVEN TO OTHER MODES IS PARTLY AN ARTIFACT OF HOW DATA ARE COLLECTED AND PRESENTED.

CONCLUSIONS

Transportation system performance can be measured in many ways, each reflecting a particular perspective concerning the who, what, where, how, when and why of transport. Different methods favor different types of transport users and modes, different land use patterns and different solutions to transport problems.

Vehicle traffic is easiest to measure, but this approach only considers a narrow range of transportation problems and solutions. Mobility is more difficult to measure because it requires tracking people's travel behavior. It still considers physical movement an end in itself rather than a means to an end, but it expands the range of problems and solutions considered to include alternative modes such as transit, ridesharing, cycling and walking.

Accessibility is most difficult to measure because it requires taking into account land use, mobility and mobility substitutes, but it most accurately reflects the ultimate goal of transportation and allows the widest range of transport problems and solutions.

There is no single way to measure transportation performance that is both convenient and comprehensive. Transportation professionals should become familiar with the various measurement methods and units available, learn about their assumptions and perspectives and help decision-makers understand how they are best used to accurately evaluate problems and solutions. ■

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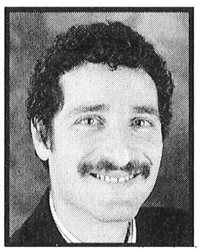

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