Measuring transportation: Traffic, mobility and accessibility

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Measuring Transportation

Traffic, Mobility and Accessibility

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The ultimate goal of most transportation is "access," people's ability to reach desired goods, services and activities. Transportation decisions often involve tradeoffs between different forms of access. How transport is measured can have a major impact on these tradeoffs.

Abstract

This article compares three approaches to measuring transportation system performance and discusses their effects on planning decisions. *Traffic-based* measurements (such as vehicle trips, traffic speed and roadway level of service) evaluate motor vehicle movement. *Mobility-based* measurements (such as person-miles, door-to-door traffic times and ton-miles) evaluate person and freight movement. *Accessibility-based* measurements (such as person-trips and generalized travel costs) evaluate the ability of people and businesses to reach desired goods, services and activities. Accessibility is the ultimate goal of most transportation and so is the best approach to use.

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Introduction

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

For example, a baseball player's performance can be evaluated based on batting averages, base hits, runs batted in, and 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 article discusses three common methods used to measure transportation, the perspectives they represent, and how the selection of one or another method can affect planning decisions.

Accuracy Versus Precision
Statisticians make a distinction between *accuracy* and *precision*. "Accurate" means truthful or correct. "Precise" means measured using small units. Data can be very precise, but inaccurate.

For example, doctors often measure their patients' weight to help evaluate their health. But weight by itself is an inadequate indicator of health. It would be inaccurate to say that everybody who weighs less than 175 pounds is healthy and everybody who weighs more than 175 pounds is unhealthy. People with different heights and builds have different optimal weights, so medical professionals must use weight-height tables or body-mass indices to interpret the health implications of a particular person's weight.

A standard medical scale can measure a person's weight within about 0.5 pound of accuracy. A more expensive scale can provide greater precision, but there is little point in purchasing a super-precise scale simply to track body weight. Knowing that you weigh exactly 168.305 pounds rather than about 170 pounds does little to improve your health assessment. Weight is relatively easy to measure and understand, but focusing too much attention on weight may distract doctors and patients from considering other health factors that are equally important but more difficult to measure, such as whether you eat a balanced diet or get sufficient exercise.

Similarly, vehicle traffic volumes and speeds are relatively easy to measure and so are often used to evaluate transport system quality. But other more difficult factors may be equally important, such as walking conditions, the distribution of common destinations, and the ease with which non-drivers can perform activities such as commuting and shopping. An *accurate* assess of transport system quality requires that these factors be considered even if their measurement is less *precise* than those measuring traffic.

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, called *traffic*, *mobility* and *accessibility*, are compared below.

Traffic

Definition

Traffic refers to vehicle movement. This perspective assumes that "travel" means vehicle travel and "trip" means vehicle-trip. It assumes that the primary way to improve transportation system quality is to increased vehicle mileage and speed.

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 that do not own an automobile.

Modes

This perspective focuses on automobile travel. It places little value on transit and cycling, since they represent a small portion of vehicle-mileage and are relatively slow. It considers walking primarily as a way for motorist to access parking facilities or as a form of recreation, and so devotes little transportation funds to nonmotorized facilities.

Figure 1 **Traffic**

"Traffic" refers to vehicle movement. A traffic perspective measures vehicle traffic speeds and volumes, using Level of Service ratings and average traffic speeds as indicators. This tends to favor high-speed, high-volume roadways, resulting in more automobile-dependent transportation systems and land use patterns.

Land Use

This perspective evaluates land use primarily in terms of proximity to highways and parking supply. The best location for a public facility 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 non-drivers 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 (LOS), congestion delay, parking supply, vehicle operating costs and crash rates.

Mobility

Definition
Mobility refers to the movement of people or goods. It assumes that "travel" means person- or ton-miles, "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, since most person- and ton-miles are by motor vehicle, but recognizes that some people rely on non-automobile modes, and some areas have large numbers of transit, rideshare and cycling trips.

Figure 2 **Mobility**

"Mobility" refers to the movement of people and goods. This recognizes both automobile and transit modes, but still assumes that movement is an end in itself, rather than a means to an end. It tends to give little consideration to nonmotorized modes or land use factors affecting accessibility.

Modes
This perspective considers automobiles most important, but values transit, ridesharing and cycling where there is sufficient demand, such as downtowns and college campuses, and so justifies devoting a portion of transport funding to transit, HOV and cycling facilities. It supports an integrated view of the transportation system, with attention to connections between modes. For example, it considers walking and transit complementary modes since most transit trips involve walking links.

Land Use
From this perspective, convenient highway access and parking is most important, but transit and HOV access are also 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

A mobility 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, high-speed train, aviation and intermodal connections. It gives little consideration to walking and cycling except where they provide access to motorized modes, since 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.

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 multi-modal transportation system performance, such as transit and cycling Level of Service (LOS) ratings.[2]

Accessibility

Definition

Accessibility (or just *access*) refers to the ability to reach desired goods, services, activities and destinations (collectively called *opportunities*).[3, 4] Access is the ultimate goal of most transportation, except a small portion of travel in which movement is an end in itself (jogging, horseback riding, pleasure drives), with no destination. This perspective assumes that there may be many ways of improving transportation, including improved mobility, improved land use accessibility (which reduce the distance between destinations), or improved mobility substitutes such as telecommunications or delivery services.

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 so cannot be classified as simply a motorist or transit rider.

Figure 3 **Accessibility**

Accessibility reflects both mobility (people's ability to travel) and land use patterns (the location of activities). This perspective gives greater consideration to nonmotorized modes and accessible land use patterns. Accessibility tends to be optimized with multi-modal transportation and more compact, mixed-use, walkable communities, which reduces the amount of travel required to reach destinations.

Modes
This perspective considers all access options as potentially important, including motorized and nonmotorized modes, and mobility substitutes such as telecommunications 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, and 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.[5]

Land Use Accessibility

Land use patterns affect mobility and accessibility in various ways:[6]

1. *Density* (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.
2. *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.
3. *Nonmotorized conditions*. The existence and quality of walking and cycling facilities can have a major effect on accessibility, particularly for non-drivers.
4. *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 the 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.

Figure 4 **Land Use Affects Transportation**

Land use patterns have major impacts on transportation system performance. Automobile-oriented land use has dispersed destinations, wide roadways and a generous portion of land devoted to parking. A more multi-modal land use pattern has destinations clustered into walkable centers.

Travel time maps use *isochrones* (lines of constant time) to indicate the time needed to travel from a particular origin to other areas.[7] For example, areas within one hour may be colored a dark red, within two hours a lighter red, within three hours a dark orange, and within four hours a light orange. Maps can indicate and compare travel times by different modes. For example, one set of maps could show travel times for automobile travel and another for public transit travel. Travel time maps are an indication of accessibility.

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.[8] For example, nonmotorized 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.

Standard transport statistics indicate that in North America more than 90% of households own an automobile, and more than 90% of trips are made by automobile, while only about 5% of trips are made by nonmotorized modes and less than 2% by transit.[9] This suggests that private vehicle travel is by far the most important form of transport, and that improving other modes can do little to address transport problems.

But the high priority given automobiles and the low priority given other modes is partly an artifact of how data are collected and presented. Most travel surveys only count the primary mode used between relatively large Transportation Analysis Zones (TAZs), and some only count peak-period travel or commute trips. As a result, they undercount shorter trips (those occurring within a TAZ), nonmotorized links of motorized trips, off-peak trips, non-work trips, travel by children, and recreational travel.[10] 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 five minutes, and walks another 5 minutes to their destination, this *bike-transit-walk* trip is usually coded simply as a transit trip, even though the nonmotorized links take more time than the motorized link.

Although only about 5% of trips are made exclusively by nonmotorized modes, four to six times as many involve at least some walking or cycling on public right-of-way.[11] Similarly, although only about 2% of total trips are made by public transit, about 5% of US adults report that they rely primarily on public transit for transport, and 12% used public transit at least once during the previous two months.[6, 12] According to a U.K. survey, walking represents 2.8% of total mileage, 17.7% of travel time, and 24.7% of trips, as indicated in Table 1 and Figure 5. If measured simply in terms of distance, walking seems insignificant, but not if evaluated in terms of trips, travel time, or exposure to street environments. Walking conditions therefore have a major impact on how people perceive the transportation system and the local environment, since we experience activities by the amount of time they take, not just distance traveled.

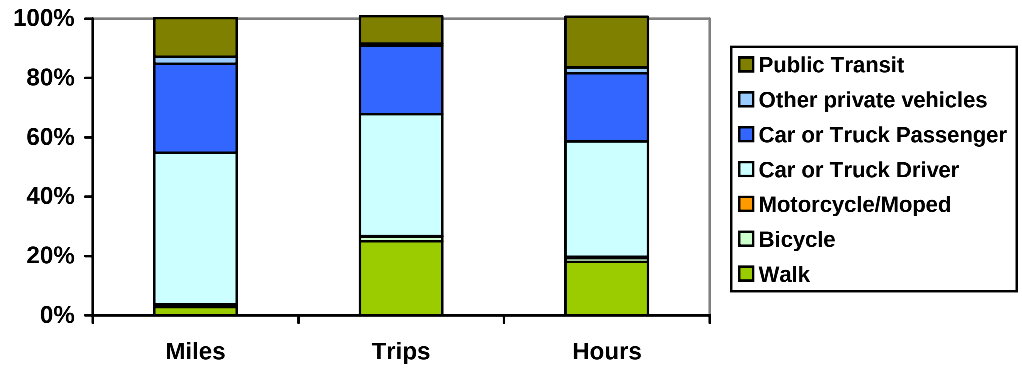
Table 1 **Average Annual Travel By Mode, UK**[13]

	Travel		Travel Time		Trips	
	Miles	*Percent*	*Hours*	*Percent*	*Trips*	*Percent*
Walk	192	2.8%	64	18%	245	25%
Bicycle	34	0.5%	5	1.3%	14	1.5%
Motorcycle/Moped	36	0.5%	1	0.4%	3	0.3%
Car or Truck Driver	3,466	51%	140	39%	401	41%
Car or Truck Passenger	2,047	30%	82	23%	226	23%
Other private vehicles	162	2.4%	7	1.9%	8	0.8%
Public Transit	897	13%	62	17%	92	9.3%
Totals	*6,833*	*100%*	*361*	*100%*	*990*	*100%*

Walking represents just 2.8% of personal mileage, but a much larger portion of travel time and trips.

Figure 5 compares how the choice of measurement units can affect the perceived importance of different modes. When measured by miles, walking is of less significance than when measured by trips or time. People tend to perceive travel based on time, not distance. A short walking trip often replaces a longer automobile trip, for example, walking to a local store rather than driving across town to a supermarket. Motorists tend to travel far more annual miles than people who do not have a car. As a result, it is often most appropriate to compare travel based on time and trips than miles.

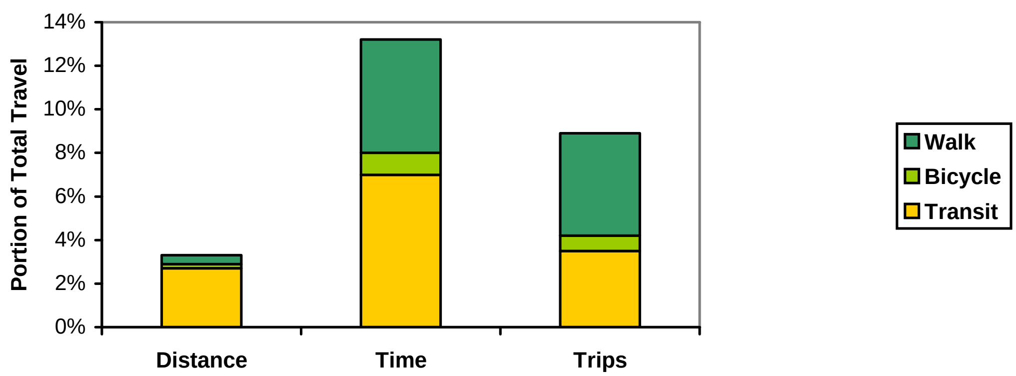
Figure 5 **Portion of Travel By Various Units**



This figure shows how the portion of travel by different modes from Table 1 varies significantly depending on the units used for measurement.

The U.S. National Household Travel Survey shows similar patterns, as indicated in Figure 6. The relative importance of walking, cycling and public transit travel is much higher when measured based on travel time or trips rather than distance. Transportation planners often evaluate travel based on mileage, which tends to favor motorized modes at the expense of walking and other slower modes.

Figure 6 **Portion of Travel By Various Units**[14]



The portion of travel by different modes varies depending on how it is measured.

Trade-offs Between Different Types of Accessibility

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

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

Figure 7 **Transportation Decisions Involve Trade Offs**

Transportation decisions often involve tradeoffs between different forms of access, such as how much road space to devote to different modes and how much parking to require at destinations. A transport and land use system optimized for vehicle traffic often provides poor access by other modes.

Because of these trade-offs, traffic-based performance indicators tend to favor of automobile access over other modes. For example, roadway "improvements" that increase vehicle traffic volumes and speeds tends to create barriers to walking, and therefore to transit travel since 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 considerers impacts on other modes. It is important that planners understand these tradeoffs and take them into account when making transportation and land use decisions.

Assumptions About Travel Demand
Conventional transport planning and modeling is based on the concept of *travel demand*, which assumes that consumers have freely chosen one possibility over all other, and so observed travel patterns represent the best possible set of actions that individuals could have taken given their preferences and the spatial structure of the city.[15] However, current travel demand also reflects existing constraints, such as inadequate alternatives to driving. Given other options, such as improved walking, cycling and public transit conditions, or different price structures, travel demand could be quite different.

Reference Units

Reference units are measurement units normalized to help compare impacts per mile, per trip, per vehicle, per dollar or per capita. Which reference units are used can affect how problems are defined and which solutions are considered. Measured one way, a particular program or project may seem costly and inefficient. Measured another way and the same proposal may seem affordable and worthwhile.

For example, a project may seem expensive if measured in total lifetime expenses, but cheap if measured as "cents per day" per person. It is generally best to report costs and benefits in real (inflation adjusted) per-capita-annual-dollars, which is relatively easy to understand and compare with other expenditures. Exactly which costs are included, and the group included in the denominator (residents, taxpayers, households, users, etc.) should be clearly defined. It is also helpful to compare costs with similar programs or with peers. For example, a new transportation program can be compared with current transportation expenditures, or with what other jurisdictions spend on similar services. If possible, projects should be evaluated based on incremental costs and benefits.

It is important to be comprehensive and realistic when comparing different modes. For example, when comparing the cost efficiency of road and transit improvements, it is important to estimate the full incremental costs of each option in a particular situation, such as on a particular corridor. It would be unfair to compare the full cost of providing urban transit services with just the cost of adding a roadway lane, since automobile trips also require parking spaces at destinations, and they require each traveler to pay vehicle ownership and operating costs.[16]

Different measurement units reflect different perspectives:

1. *Vehicle-mile* units reflect a *traffic* perspective that gives high value to automobile travel.
2. *Passenger-mile* units reflect a *mobility* perspective that values automobile and transit travel, but gives less value to nonmotorized modes because they tend to be used for short trips.
3. *Per-trip* units reflect an *access* perspective which gives equal value to automobile, transit, cycling, walking and telecommuting.
4. *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.
5. *Generalized costs* (time and money costs) units reflect an *access* perspective.

Transportation professionals often use distance-based reference units, such as emissions per vehicle-mile or crash fatalities per billion vehicle-kilometers, although this ignores the increases in these costs that result from increased per capita vehicle travel, and the benefits of mobility management strategies that reduce total vehicle mileage. For example, urban highway expansion tends to reduce emissions and crashes per vehicle-kilometer, but by stimulating increased total vehicle travel it often increase per capita emissions and crash costs. It is usually best to measure these impacts per capita. Other reference units may be appropriate for project evaluation. For example, the mobility and congestion reduction impacts of improvements to various modes (automobile, ridesharing and public transit) can be compared *per additional peak-period person trip*.

Summary

Table 3 summarizes differences between these three ways to measure transportation, including their planning perspectives and assumptions.

Table 3 **Comparing Transportation Measurements**

	Traffic	Mobility	Access
Definition of Transportation	Vehicle travel.	Person and goods movement.	Ability to obtain goods, services and activities.
Unit of measure	Vehicle-miles and vehicle-trips	Person-miles, person-trips and ton-miles.	Trips.
Modes considered	Automobile and truck.	Automobile, truck and public transit.	All modes, including mobility substitutes such as telecommuting.
Common performance indicators	Vehicle traffic volumes and speeds, roadway Level of Service, costs per vehicle-mile, parking convenience.	Person-trip volumes and speeds, road and transit Level of Service, cost per person-trip, travel convenience.	Multi-modal Level of Service, land use accessibility, generalized cost to reach activities.
Assumptions concerning what benefits consumers.	Maximum vehicle mileage and speed, convenient parking, low vehicle costs.	Maximum personal travel and goods movement.	Maximum transport options, convenience, land use accessibility, cost efficiency.
Consideration of land use.	Favors low-density, urban fringe development patterns.	Favors some land use clustering, to accommodate transit.	Favors land use clustering, mix and connectivity.
Favored transport improvement strategies	Increased road and parking capacity, speed and safety.	Increased transport system capacity, speeds and safety.	Improved mobility, mobility substitutes and land use accessibility.

This table compares the three major approaches to measuring transportation.

Evaluating transportation based on *traffic* and *mobility* tends to place little value on mobility substitutes and land use management strategies, because they reduce the need for physical travel. From this perspective, higher density, clustered development is usually considered harmful because it tends to increase congestion and reduce roadway level-of-service, even if this is offset by improved access that reduces per capita vehicle travel and congestion delay. Only by measuring transport in terms of *access* can all impacts and transportation improvement options be considered, as illustrated in Table 4.

Table 4 **Comparing Transportation Improvement Strategies**

Transportation Improvement Strategies	Traffic	Mobility	Access
Roadway improvements	✓	✓	✓
Transit improvements		✓	✓
Ridesharing		✓	✓
Pedestrian and cycling improvements		✓	✓
Delivery services			✓
Telework			✓
Location-Efficient Development			✓

*When measured in terms of **vehicle traffic**, the main way to improve transportation is to increase roadway capacity and speeds. When measured in terms of **mobility**, transit, ridesharing and nonmotorized transportation improvements are also recognized as potential solutions. When measured in terms of **access**, the widest possible range of solutions can be considered, including strategies that substitute for physical travel and increase land use accessibility.*

Examples

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

Comparing Modes

Consider the daily travel of somebody who commutes by car but walks and bikes for errands, as summarized in Table 5. A *traffic* perspective, which only counts motor vehicle travel, classifies her as an auto-commuter and measures her car mileage. A *mobility* perspective also counts walking and cycling trips, but since driving represents 87% of person-miles, considers nonmotorized modes of little importance. However, an *access* perspective indicates that driving represents just 50% of her travel time and only 20% of her trips, suggesting a more important role for alternative modes.

Table 5 **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
Errands (travel between shops)	Walk	0.5	10
Home from shopping center.	Bike	1	6
Walk dog.	Walk	0.5	10
Drive	*2 trips (20%)*	*30.0 (87%)*	*60 (50%)*
Walk	*6 trips (60%)*	*2.4 (7%)*	*48 (40%)*
Bike	*2 trips (20%)*	*2.0 (6%)*	*12 (10%)*
Totals	***10 trips (100%)***	***34.4 (100%)***	***120 (100%)***

(Assumes Drive = 30 mph, Walk = 3 mph, Bike = 10 mph. Values in parentheses indicate percentage of total travel.)

Different perspectives give different conclusions as to how best to improve transport. A pedestrian shortcut that reduces walking distance from an office to nearby restaurants by 0.2 miles provides only a 1% reduction in travel *distance*, and so appears to have little value if evaluated in terms of mobility. But this saves 12% of total travel *time*, the same time savings that might be provided by a major roadway improvement that increases average traffic speeds from 30 to 38 mph 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, 200 bicycles, and have 100 adjacent homes and businesses. Traffic-based analysis, measured in vehicle-trips, considers motorists the dominant road user group, justifying road designs that maximize vehicle volume and speed. Mobility-based analysis, measured in person-mile, gives greater value to buses and rideshare vehicles, and so may justify HOV priority features. Access-based analysis, measured in person-minutes-of-exposure, gives greater value to pedestrians, cyclists and residents, since they spend more time on the roadway. This justifies greater emphasis on nonmotorized improvements, traffic calming and landscaping.

Evaluating Problems and Solutions
Say 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 only considered worthwhile if they significantly reduce vehicle traffic congestion.

A *mobility* perspective, which measures multi-modal 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 between modes. This tends to result in a wider distribution of benefits.

An accessibility perspective expands the range of problems and solutions further. 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.

Figure 8 **How Transport Is Measured Affects School Location And Design**

A school designed for convenient automobile access is located on a busy street, at the urban fringe where there is abundant land for parking. A school optimized for multi-modal access is located in the center of a residential neighborhood, where most children can walk, although this may be inconvenient for access by automobile.

Biased Transport Planning Language[17]

Many transport planning terms unintentionally favor motor vehicle travel over other forms of access. For example, increased road and parking capacity is often called an "improvement," although wider roads and larger parking facilities, and the increased traffic volumes and speeds that result, tend to degrade pedestrian and cycling mobility. Calling such changes "improvements" indicates a bias in favor of one mode over others. Objective language uses neutral terms, such as "added capacity," "additional lanes," "modifications," or "changes."

The terms "traffic" and "trip" often refer only to motor vehicle travel. Short trips, non-motorized trips, travel by children, and non-commute trips are often undercounted or ignored in transport surveys, models, and analysis. Although automobile and transit trips often begin and end with a pedestrian or cycling link, they are often classified simply as "auto" or "transit" trips.

The term "efficient" is frequently used to mean increased vehicle traffic speeds. This assumes that faster vehicle traffic always increases overall efficiency. This is not necessarily true. High vehicle speeds can reduce total traffic capacity, increase resource consumption, increase costs, reduce transportation choice, create less accessible land use patterns, and increase automobile dependency, reducing overall system efficiency.

Transportation professionals often rate the overall quality of the roadway network based on Level of Service (LOS) ratings that evaluate conditions for automobile traffic, but apply no comparable rating for other travel modes. It is important to indicate which users are considered when level of service values are reported.

Biased	Neutral Terms
Traffic	Motor vehicle traffic, pedestrian, bike traffic, etc.
Trips	Motor vehicle trips, person trips, bike trips, etc.
Improve	Change, modify, expand, widen
Enhance	Change, increase traffic speeds
Deteriorate	Change, reduce traffic speeds
Upgrade	Change, expand, widen, replace
Efficient	Faster, increased vehicle capacity
Level of service	Level of service for…

Examples:
Biased: "*Level of service* at this intersection is rated 'D.'' The proposed *improvement* will cost $100,000. This *upgrade* will make our transportation system more *efficient* by *enhancing* capacity, preventing *deterioration* of *traffic* conditions."

Neutral: "*Level of service* at this intersection is rated 'D' *for motorists* and 'E' *for pedestrians*. A *right turn channel* would cost $100,000. This *road widening project* will *increase motor vehicle traffic speeds and capacity* but may *reduce safety and convenience to pedestrian travel*."

Conclusions

There are many ways to measure transportation system performance, each reflecting particular perspectives concerning who, what, where, how, when and why. 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, since it requires tracking people's travel behaviour. It still considers physical movement an end in itself, rather than a means to an end, but 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 most accurately reflects the ultimate goal of transportation, and allows widest range of transport problems and solutions to be considered. For example, an accessibility perspective may identify low-cost solutions to transportation problems, such as improving local walkability; encouraging land use mix so common destinations such as stores, schools and parks are located near residential areas; and improving communications services for isolated people and communities.

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.

Figure 9 **How Transport Is Measured Affects Planning Decisions**

Conventional ways of measuring transportation system performance, such as roadway Level of Service and traffic speed, tend to favor vehicle travel over other forms of access. Only by developing better methods of measuring mobility and accessibility will the full value of multi-modal transport systems and more accessible land use patterns, be recognized.

Endnotes

[1] Performance indicators are practical ways to measure progress toward a goal. See Michael Meyer and Richard Schuman, "Transportation Performance Measures and Data," *ITE Journal* (www.ite.org), November 2002, pp. 48-49 and VTPI, "Measuring Transportation," *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org), 2002.

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