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Towards More Comprehensive and Multi-Modal Transport Evaluation

30 December 2024

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Conventional planning evaluates transport system performance based primarily on motor vehicle travel conditions, which often results in roads like this central Manila arterial designed to maximize car traffic and parking convenience, with poor walking, cycling and public transport conditions.

Abstract

This report describes ways to make transportation planning evaluation more comprehensive and multi-modal. Conventional transport planning is *mobility-based*, it assumes that the planning objective is to maximize travel speed, and evaluates transport system performance based primarily on motor vehicle travel conditions. A new paradigm recognizes that the ultimate goal of most transport activity is *accessibility*, which refers to people's overall ability to reach desired services and activities. This new paradigm applies more comprehensive and multi-modal evaluation which expands the range of modes, objectives, impacts and options considered in the planning process. This is particularly important in large growing cities where increased motor vehicle traffic imposes particularly large costs, and in developing countries where a major portion of households cannot afford cars.

A summary of this report was published in
"Towards More Comprehensive and Multi-modal Transport Evaluation,"
JOURNEYS, September 2013, pp. 50-58, LTA Academy, Singapore; at www.vtpi.org/JOURNEYS_2013.pdf.

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Introduction

Transportation policy and planning decisions can have many economic, social and environmental impacts. It is important to consider all significant impacts when evaluating potential transport system changes. More comprehensive and multi-modal evaluation can lead to better decisions.

This is a timely issue. Transport planning is undergoing a *paradigm shift*, a change in the way problems are defined and solutions evaluated (GIZ 2011; IEG 2017; ITF 2022; Lockwood 2017; Litman 2013; Metz 2021). The old paradigm assumed that *transportation* refers simply to *mobility* (physical travel), and evaluated transport system performance based primarily on traffic conditions. The new paradigm recognizes that the goal of most transport is *accessibility* (people's ability to reach services and activities), and considers a wider range of impacts, objectives and options (LaPlante 2010; Marshall, Piatkowski and McCahill 2019). Table 1 compares the old and new paradigms.

Table 1 **Changing Transport Planning Paradigm** (Litman 2013)

	Old Paradigm	New Paradigm
Definition of *Transportation*	*Mobility* (physical travel), mainly *automobile travel*.	*Accessibility* (people's overall ability to reach services and activities).
Modes considered	Mainly automobile	Multi-modal: Walking, cycling, public transport, automobile, telework and delivery services.
Objectives	Congestion reduction; roadway cost savings; vehicle cost savings; and reduced crash and emission rates per vehicle-kilometer.	Congestion reduction; road and parking savings; consumer savings and affordability; accessibility for non-drivers; safety and security; energy conservation and emission reductions; public fitness and health; efficient land use (reduced sprawl).
Impacts considered	Travel speeds and delay, vehicle operating costs and fares, crash and emission rates.	Various economic, social and environmental impacts, including indirect impacts.
Favored transport improvement options	Roadway capacity expansion.	Improve transport options (walking, cycling, public transit, etc.). Transportation demand management. More accessible land development.
Performance indicators	Vehicle traffic speeds, roadway Level-of-Service (LOS), distance-based crash and emission rates.	Quality of accessibility for various groups. Multi-modal LOS. Various economic, social and environmental impacts.

The old planning paradigm favored automobile-oriented transportation improvements. The new planning paradigm expands the range of objectives, impacts and options considered.

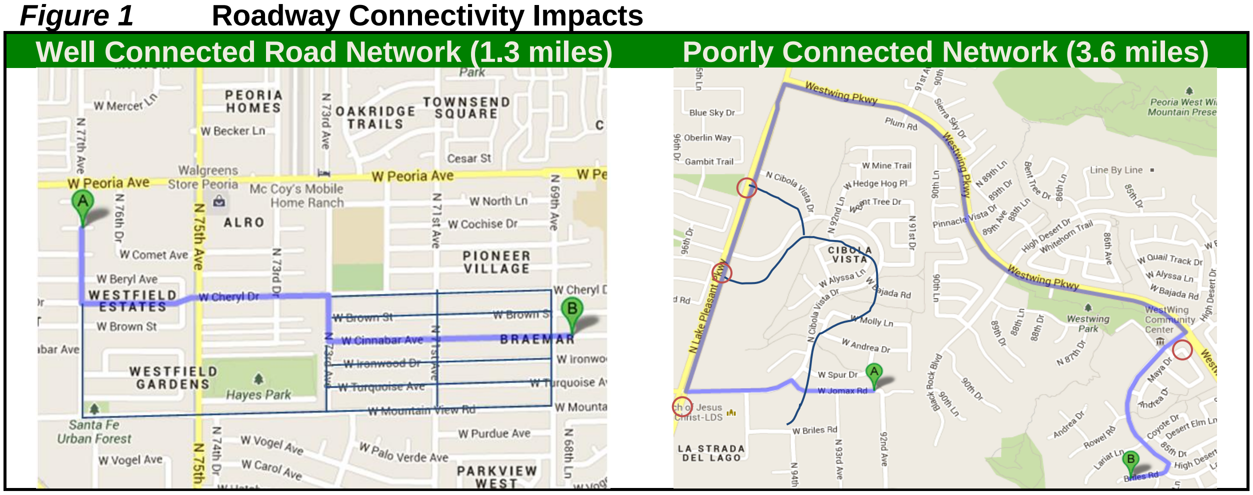
Many current transport economic evaluation practices are biased in ways that overvalue automobile improvements and undervalue other modes and transportation demand management strategies (EVIDENCE 2014; Holian and McLaughlin 2016; Hüging, Glensor and Lah 2014; ITF 2021; Road Investment Scrutiny Panel 2023). The following section discusses key concepts for more comprehensive and multi-modal evaluation.

Mobility- Versus Accessibility-Based Evaluation

Conventional planning tends to evaluate transport system performance based primarily on *mobility*, measured as vehicle travel speed. But mobility is seldom an end in itself (excepting the small portion of travel that lacks a destination), the goal of most transport activity is *accessibility*, which refers to people and industry's ability to reach desired services and activities: jobs, education, services, recreation, etc. Various factors affect accessibility (Levinson and King 2021; Litman 2014):

- *Automobile travel* (vehicle travel speed, affordability, safety and parking convenience).
- The *quality and affordability of other modes* (walking, cycling and public transport).
- *Transport network connectivity* Roadway connectivity (Figure 1) and the quality of connections between modes, such as the ease of walking and cycling to public transit, the quality of transit to airports, and the efficiency of intermodal freight terminals.
- *Land use accessibility* (also called *geographic proximity*) which refers to the distances between activities, which is affected by development density and mix.
- *Mobility substitutes* including telecommunications and delivery services that reduce the need for physical travel.

Figure 1 **Roadway Connectivity Impacts**



*Although points **A** and **B** are approximately the same distance apart in both maps, the functional travel distance is nearly three times farther with the poorly-connected, hierarchical road network. Because it forces most trips onto major roads a hierarchical network tends to increase total traffic congestion and accident risk, particularly where vehicles turn on and off major arterials (red circles).*

New research improves our understanding of how such factors affect accessibility. For example, Levine, et al (2012) found that development density tends to affect the number of jobs and services available within a given travel time much more than vehicle travel speed. Ewing and Cervero (2010) and Handy, Tal and Boarnet (2014) conclude that roadway connectivity significantly affects the travel distances required to reach destinations. Ewing and Hamidi (2014) find that each 10% increase in the compact development index reduces total journey-to-work drive time by 0.5%.

Comprehensive analysis is important because transport planning often involves trade-offs between these accessibility factors. For example:

- Road space must often be allocated between sidewalks, bike lanes, bus lanes, general traffic lanes and parking lanes, and therefore between accessibility by different modes.
- Wider roads with higher traffic speeds can increase automobile access but degrade pedestrian and bicycle access (called the *barrier effect*), and therefore transit access since most transit trips include walking and cycling links.
- One-way streets, longer block lengths, and reduced cross-streets tend to increase traffic speeds, but increase travel distances.
- Urban fringe highway locations tend to offer convenient automobile access but poor access by walking, cycling and public transit. Conversely, urban center locations tend to be more difficult to access by car but easier to access by walking, cycling and transit.

Table 2 describes the degree these factors are considered in conventional planning, and requirements for more comprehensive and multi-modal evaluation. Failing to consider these factors often results in decisions that improve one form of accessibility but reduce others, such as a roadway expansion that reduces walkability, and urban fringe locations that are convenient to access by automobile but difficult to reach by other modes.

Table 2 **Consideration of Accessibility Factors In Transport Planning**

Factor	Consideration in Conventional Evaluation	Required for Comprehensive Evaluation
Automobility – motor vehicle traffic speed, congestion delays, vehicle operating costs, crash rates per mile or kilometer.	Usually considered using indicators such as roadway level-of-service, average traffic speeds and congestion costs and crash rates.	Impacts should be considered per capita (per capita vehicle costs and crash casualties) to take into account the amount that people travel.
Quality of other modes – speed, convenience, comfort, safety and affordability of walking, cycling, public transport and other modes	Considers public transit speed but not comfort. Active mode (walking and cycling) access is often ignored.	Multi-modal performance indicators that account for convenience, comfort, safety, affordability and integration (Dowling, et al. 2008)
Transport network connectivity – density of connections between paths, roads and modes, and therefore the directness of travel between destinations	Traffic network models consider regional road and transit networks but often ignore local streets, sidewalks and paths, and intermodal connections	Fine-grained analysis of path and road network connectivity, and connections between modes, such as the ease of walking and biking to transit stations
Land use accessibility – development density and mix, and therefore travel distances	Often ignored. Some integrated models consider some land use factors.	Fine-grained analysis of how land use factors affect accessibility by various modes.
Mobility substitutes – telecom-munications and delivery services that reduce the need to travel	Only occasionally considered in conventional transport planning.	Consider these accessibility options in transport planning.

Conventional planning evaluates transport system performance based primarily on regional travel speed. Additional factors must be considered for comprehensive accessibility evaluation.

Analysis Scope

Conventional evaluation tends to focus on some impacts but overlook others, as indicated in Table 3. For example, it considers roadway but not parking facility costs, and vehicle operating but not ownership costs. It seldom explicitly considers mobility for non-drivers and other equity objectives, public fitness and health impacts, or strategic planning objectives, and so undervalues walking, bicycling and public transit improvements. More comprehensive evaluation considers a wider range of impacts (DeRobertis, et al. 2014; Holian and Ralph McLaughlin 2016).

Table 3 Scope of Impacts Considered

Usually Considered	Often Overlooked
	Downstream and indirect impacts
	User comfort and convenience (e.g., by transit passenger)
	Affordability, including vehicle ownership costs
	Parking congestion and costs
	Mobility for non-drivers and social equity impacts
Public infrastructure costs	Per capita crash risk
Traffic speed and congestion delays	Public fitness and health
Vehicle operating costs (fuel, tolls, tire wear)	*Barrier effect* (delay to pedestrians and bicyclists)
Crash rates	Indirect environmental impacts
Road construction environmental impacts	Strategic land use impacts (smart growth)

Conventional transportation planning tends to focus on a limited set of impacts.

For example, detailed analysis by Oldham and Mills (2020) found that some public programs that are primarily intended to reduce crime or pollution emissions also provide large traffic safety co-benefits, but these impacts were overlooked or undervalued in the program evaluations, which is likely to lead to their underinvestment.

Table 4 Comparing Strategies

Planning Objective	Roadway Expansion	Efficient and Alt. Fuel Vehicles	TDM and Smart Growth
Congestion reduction	✓		✓
Roadway savings			✓
Parking cost savings			✓
Consumer savings and affordability			✓
Traffic safety			✓
Improved mobility options for non-drivers			✓
Energy conservation		✓	✓
Pollution reduction		✓	✓
Physical fitness and health (exercise)			✓
Land use objectives (more compact development)			✓

(✓ = Achieve objectives.) Roadway expansion and more efficient or alternative fuel vehicles help achieve fewer planning objectives than Transportation demand management (TDM) and smart growth.

More comprehensive analysis can help identify *win-win* solutions that achieve multiple objectives. Table 4 illustrates this concept. For example, expanding roadways may reduce traffic congestion, and more efficient and alternative fueled vehicles may reduce energy consumption and pollution emissions, but these strategies provide few other benefits. Transportation demand management (TDM) and smart growth strategies tend to provide a greater range of benefits, and so can be considered win-win solutions.

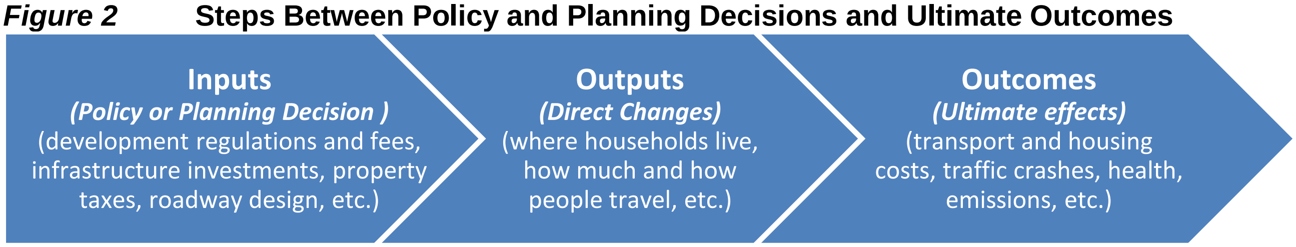
Policy and planning decisions can have three levels of impacts:

- *First-order: direct user impacts* (e.g., changes in travel speed, financial costs, comfort and safety, etc.)
- *Second order: external impacts* (e.g., changes in subsidy burdens, congestion delays, accident risks and pollution emissions to other people).
- *Third order: structural impacts* (e.g., changes in future development patters, vehicle ownership rates, public attitudes about different travel options, etc.)

Conventional analysis focuses primarily on first-order impacts and a limited set of second-order impacts, but often overlooks or undervalues second and third order impacts.

To evaluate impacts it is important to model the various steps between a policy or planning decision, its outputs and outcomes, as illustrated in the figure below.

Figure 2 **Steps Between Policy and Planning Decisions and Ultimate Outcomes**



There are often several steps between a policy or planning decision and ultimate economic, social and environmental outcomes. It is necessary to model these relationships for evaluation.

Considering Diverse Travel Demands

More comprehensive and multi-modal evaluation recognizes the diversity of travel demands and the unique and important roles that various modes in an efficient and equitable transport system. In a typical community, 20-40% of the population cannot or should not drive due to age (too young), disability, low income, or impairment (after consuming alcohol or drugs), and other modes are sometimes the most efficient option, such as neighborhood trips best made by walking and cycling, and travel on congested urban corridors most efficiently made by public transit. Table 5 summarizes various non-automobile travel demands and consequences if they are not served.

Table 5 **Non-Automobile Travel Demands**

Type of Demand	Portion of Typical Community	Consequences of Failing to Meet These Demands
Youths (10-22 years old)	10-20%	Lack independent mobility. Must be chauffeured.
Seniors (over 65 years)	10-15% and growing	Lack independent mobility. Must be chauffeured.
Young males	5-10%	Increased high-risk driving.
Lower-income households	20-40%	Lack mobility or bear unaffordable vehicle expenses.
Non-driving tourists	Varies	Lack mobility. Must rely on taxis.
Urban-peak commuters	10-40%	Increased traffic and parking congestion
Neighborhood trips	5-15%	Reduced physical fitness, increased local traffic problems.
Post-drinking or drug use	Varies	Reduced restaurant and bar business. High-risk driving.

Various types of travelers and trips are most efficiently made by walking, cycling and public transit. Failing to serve those demands reduces non-drivers' independence, increases drivers' chauffeuring burdens, imposes financial burdens, and increases traffic problems.

Several current issues highlight the importance of serving such demands:

- Traffic safety programs that discourage high-risk driving (by inexperienced and impaired drivers) can only be effective and fair if these travelers have good alternatives.
- Concern about the health risks of sedentary living justify efforts to encourage walking and cycling for recreation and utilitarian travel.
- Concerns about transport unaffordability, the high financial costs of automobile travel justify improvements to affordable transport modes.
- Solutions to specific transportation problems, including traffic and parking congestion and the costs of expanding roads and parking facilities, excessive energy consumption and pollution emissions, and high traffic accident rates, often involve shifting travel to more resource efficient modes.
- Community economic development and livability often depend on reducing local vehicle traffic and creating more compact, walkable neighborhoods.

Scope of Analysis Summary

Table 6 indicates the scope of accessibility factors and economic impacts considered in conventional transport evaluation, indicated by blue cells. Other factors and impacts are sometimes discussed but seldom quantified or monetized. For example, conventional planning seldom quantifies the vehicle ownership and parking cost savings that can be provided by improving alternative modes or more accessible land use development.

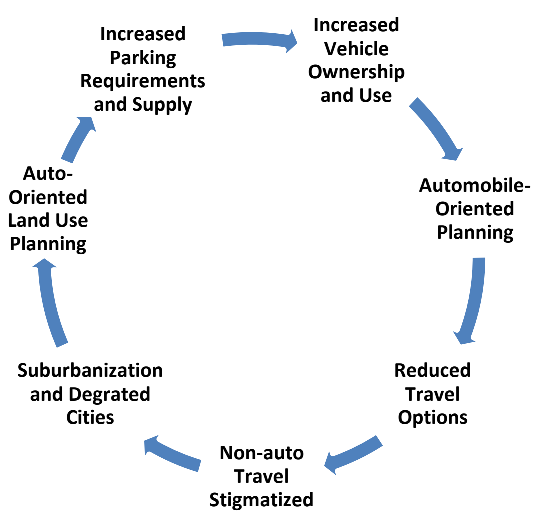
Table 6 **Accessibility Factors and Impacts Considered In Conventional Evaluation**

	← Accessibility Factors →				
← Impacts →	Automobile	Transit	Active Modes	Road Connectivity	Land Use Accessibility
Government costs	Yes	Yes	Yes	Yes	Yes
Travel speeds, delays	Yes	Yes	No	Sometimes	Sometimes
Safety and security	Yes	Yes	Sometimes	No	No
User costs & affordability	Oper. costs	Oper. costs	No	No	No
Mobility for non-drivers	No	Yes	Sometimes	No	No
User comfort	No	No	No	Not Applicable	Not Applicable
Parking costs	No	No	No	No	No
Energy consumption	Sometimes	Sometimes	Sometimes	No	No
Pollution emissions	Sometimes	Sometimes	Sometimes	No	No
Land use objectives	No	Sometimes	No	No	No
Public fitness and health	No	No	Sometimes	No	No

Blue indicates the scope of impacts normally considered in conventional transport planning. Many accessibility factors and economic impacts are often overlooked.

These omissions tend to bias planning decisions in favor of roadway expansion to the detriment of other solutions and modes. This contributes to a self-reinforcing cycle of increased motor vehicle travel, reduced transport options (degraded walking and cycling conditions and reduced public transit service), and more sprawled development, as illustrated in Figure 3. The result is sometimes called "predict and provide" planning.

Figure 3 **Cycle of Automobile Dependency**



Many common planning practices contributed to a cycle of automobile dependency and sprawl, which created communities where it is difficult to get around without a personal automobile.

Defining and Evaluating Transport System Efficiency

Efficiency refers to the ratio of outputs (benefits) to inputs (costs). How efficiency is defined and measured can significantly affect planning decisions. Factors that can affect efficiency analysis are described below.

- *The scope of inputs and outputs.* Table 7 summarizes various costs that can be considered in transportation project evaluating. For example, automobie travel often seems most efficient when evalauted based only on travel time and vehicle operating costs, but less considering other costs, including vehicle ownership, road and parking facilities, accident risks and pollution emssions.

Table 7 **Scope of Impacts (Costs and Benefits) Considered**

	Internal (User)	External (Other People)
Market	Vehicle costs Fares	Infrastructure (roads, parking facilities, etc)
Non-Market	Travel time Accident risk	Congestion delays imposed on others Accident risks imposed on others Pollution damages

The scope of impacts considered in analysis affects efficiency.

- *Vehicle traffic or mobility.* Transportation planning can measure vehicle traffic, or the mobility of people and goods. Mobility-based analysis recognizes the additional efficiency provided by policies that favor higher-capacity vehicles, such as High Occupancy Vehicle (HOV) lanes.

- *Mobility or accessibility.* Mobility is seldom an end in itself; the ultimate goal of most transporatation is access to desired services and activities (e.g., school, work, shops, recreation, friends, etc.). As a result, transportation efficiency should generally be evalauted based on accessibility, measured door-to-door (i.e., to a destination). Many factors can affect accessibility including mobility (phycial movement), transport system diversity (the range of transport options available), transport network connectivity, geographic proximity (the distance to desired destinations), and mobility substitutes such as telecommunication and delivery services.

- *Economic efficiency.* Economic efficiency recognizes the variations in travel demands and values. For example, some people may prefer walking and bicycling, even if they are slower than motorized modes, because they enjoy the experience and value the exercise, and emergency, commercial and utility vehicles tend to have relatively high travel time costs, so transport systems become more economically efficient if those trips are favored over lower-value travel.

Table 8 compares different types of transport efficiency analysis.

Table 8 **Types of Transport Efficiency Analysis**

Type	Description	Planning Implications
Cost effectiveness	Evaluates efficiency based on unit costs of achieving a specific goal, such as dollars to build each road-kilometer, or operating costs per bus-kilometer. *Lifecycle analysis* accounts for both shorter- and longer-run costs.	Reflects the efficiency of a particular project or program. Does not reflect overall system efficiency.
Automobile traffic	Evaluates efficiency based on the vehicle traffic speeds, using indicators such as roadway level-of-service (LOS) and the Travel Time Index (TTI).	Favors roadway automobile-oriented improvements such as roadway expansions. Overlooks other travel modes.
Multimodal mobility	Evaluates efficiency based on the costs of moving people and goods, using indicators such as multimodal LOS.	Favors multimodal planning, so travellers can choose the most efficient travel option for each trip.
Accessibility	Evaluates efficiency based on door-to-door travel costs, considering factors including mobility, transport network connectivity, geographic proximity, and mobility substitutes.	Recognizes the benefits transport system diversity, transport network connectivity, more compact and mixed development, and mobility substitutes.
Economic efficiency	Evaluates efficiency based on the value of travel, for example, the relatively high time costs for emergency and commercial vehicle travel.	Recognizes the benefits of regulations or pricing that favor higher value trips and more resource-efficient modes.
Planning efficiency	Evaluates efficiency based on the degree that a planning process responds to consumer demands and community goals.	Favors more responsive and comprehensive planning.

There are various ways to define and measure transport system efficiency which tend to favor different outcomes.

Conventional planning often evaluates transport system efficiency using relatively narrow analysis scope, such as motor vehicle traffic speeds on certain links, which overlooks other impacts and options. For example, conventional evaluation recognizes the inefficiency of traffic congestion delays, but generally ignores the inefficiency if some travellers are forced to drive for trips that they would prefer to perform by alternative modes. More comprehensive efficiency analysis recognizes other impacts and modes, measures transportation based on accessibility, and applies economic efficiency analysis which responds to consumer demands and community needs.

Comprehensive analysis is important because planning decisions often involve trade-offs between different types of transport efficiency. For example, roadway expansions increase vehicle traffic speeds but can reduce active transport (walking and bicycling) access. Conventional analysis can therefore justify school-area roadway expansions to reduce delay for parents chauffeuring students, even if that reduces the efficiency of children walking and bicycling to school. More comprehensive analysis recognizes the trade-offs involved in such decisions, and so can justify more multimodal planning.

Comprehensive and Multi-modal Planning Practices

This section describes specific practices for more comprehensive and multi-modal planning.

More Comprehensive Transportation Data

Current planning is often biased by the greater quantity and quality of data on motor vehicle travel demand and conditions, compared with what is available for other modes and impacts. Table 9 summarizes various types of data required for effective transport planning. Comprehensive and multi-modal evaluation requires more detailed data on many factors such as the travel demands of physically, economically and socially disadvantaged people; walking, cycling and public transit travel conditions; transportation expenditures by governments and households (ABW 2014; Litman 2011).

Table 9 **Examples of Transport-Related Data**

Facilities and Services	Activities	Impacts	Land Use
Road and railroad supply and quality Parking supply and price Public transit service quality Walking and cycling facility supply and quality Port and airport size and condition Transport system connectivity Accessibility indicators	Vehicle ownership (by type and user) Vehicle travel (by type, purpose and location) Freight transport Person travel (by mode, purpose and location) Mode share Active mode improvements Travel speeds and delay (congestion)	Transport facility and service expenditures Transport expenditures Traffic accidents and casualties by mode Energy consumption Pollution emissions and exposure Traffic and aircraft noise Transport quality for disadvantaged groups	Density and mix Various measures of accessibility Portion of land devoted to transport facilities Land valuation (as impacted by transport facilities and services) Costs and market values

This table lists various types of data needed for transport policy, planning and research.

Accessibility-based Transport Planning

As previously discussed, comprehensive and multi-modal planning requires accessibility-based analysis which accounts for all accessibility factors (automobile travel, alternative modes, transport network connectivity, land use accessibility and mobility substitutes), using indicators such as multi-modal levels-of-service, per capita travel time, and transportation affordability (Proffitt, et al. 2019). New tools are available to help with such evaluation (Levinson and King 2021; SSTI 2021):

- Multi-modal level-of-service indicators (Dowling, et al. 2008).
- Single-mode indicators such as WalkScore and BikeScore, which measure the number of services and activities available within convenient walking and cycling distance.
- Mapping systems that measure the numeber jobs available within a given commute time by various modes and job categories (Levin, et al. 2012; Levinson 2013; RPA 2014).
- Surveys which measure the amount of time that residents in a community spend on travel, and the factors that affect that (Ewing and Hamidi 2014).
- Integrated and comprehensive transportation and land use models.

Comprehensive Impact Analysis

Comprehensive and multi-modal evaluation considers all significant planning objectives and impacts, as summarized in Table 10. New modeling techniques and targeted research can help quantify and monetize the additional impacts, such as the quality of accessibility for disadvantaged people, and physical fitness (Litman 2009; NZTA 2010).

Table 10 **Comprehensive Impact Analysis** (Litman 2014; SSTI 2021)

Impact	Consideration in Conventional Planning	Improvements for More Comprehensive Evaluation
Comfort and convenience, such as walkability, crowding, user information, etc.	Although often recognized as important, not generally quantified or included in benefit-cost analysis.	Incorporate multi-modal performance indicators that reflect convenience and comfort factors.
Traffic congestion	Motor vehicle delays are usually quantified but active mode travel delays are generally ignored.	Use multi-modal indicators that reflect both motorized and non-motorized travel delays.
Roadway costs	Generally considered.	
Parking costs	Generally ignored.	Include parking costs when evaluating options that affect vehicle ownership or trip generation rates.
User costs	Operating cost savings are generally recognized but vehicle ownership savings are generally ignored.	Include vehicle ownership costs when evaluating policies and projects that affect vehicle ownership rates.
Traffic risks	Measures crash rates per vehicle-km., ignoring the additional crashes cause by induced vehicle travel.	Develop comprehensive evaluation of traffic risks measured per capita.
Transport options, including the quantity of accessibility, for physically and economically disadvantaged people	Sometimes recognized as a planning objective but seldom quantified or included in formal economic evaluation.	Develop indicators of the quality of mobility and accessibility for various user types, including physically and economically disadvantaged people.
Energy consumption	Measures per-km fuel consumption, which ignores additional consumption from induced travel.	Measure per capita.
Pollution emissions, including air, noise and water pollution	Measures emissions per vehicle-km., which ignores additional emissions cause by induced vehicle travel.	Measure per capita.
Public fitness and health (the amount that people exercise by walking and cycling)	Increasingly recognized but not usually quantified.	Measure walking and cycling activity, particularly by high risk (overweight and sedentary) groups.
Land use objectives such as more compact, development, openspace preservation and community redevelopment	Sometimes recognized as a planning objective but seldom quantified or included in formal economic evaluation.	Develop indicators, including changes in land use accessibility and loss of openspace.

This table summarizes the degree that current planning considers various impacts, and ways to better incorporate these impacts into the planning process.

More Nuanced Travel Time Analysis

Conventional evaluation tends to apply the same travel time unit costs (cents per minute or dollars per hour) to all travel, although this value can vary significantly depending on travel conditions, with higher values for urgent errands and travel in uncomfortable conditions, for example, when walking on roads that lack sidewalks or when traveling on a crowded bus or train. Comprehensive evaluation uses more variable travel time values that account for these factors, which helps quantify the value to consumers of congestion pricing and improved travel comfort.

Multi-Modal Benefit Analysis

Conventional transport evaluation tends to overlook or undervalue many of the benefits of non-automobile modes, and therefore many of the benefits of policies that improve transport options, apply more multi-modal roadway design, and encourage shifts from automobile to other modes (Holian and McLaughlin 2016). Table 11 lists various types of benefits and costs of improving alternative modes and increased their use. Not every walking, cycling, rideshare and public transit project has all of these impacts, but most have many of them.

Table 11 **Non-Automobile Mode Benefits and Costs** (Litman 2009)

Category	Improve Mobility Options	More Use of Non-Auto Modes	Reduced Automobile Travel	More Efficient Development
Indicators	Service Quality (speed, reliability, comfort, safety, etc.)	Transit Ridership (passenger-miles or mode share)	Mode Shifts or Automobile Travel Reductions	More Compact, Mixed, Accessible Development
Benefits	• More convenience and comfort for existing users. • Equity benefits (since existing users tend to be disadvantaged). • Option value (the value of having an option for possible future use). • Improved operating efficiency (if service speed increases). • Improved security (reduced crime risk).	• Mobility benefits to new users. • Increased user security, as more people walk, bike and use public transit. • Increased fare revenue. • Increased public fitness and health (from more walking or cycling trips).	• Reduced traffic and parking congestion. • Road and parking facility cost savings. • Consumer savings. • Reduced chauffeuring burdens. • Increased traffic safety. • Energy conservation. • Air and noise pollution reductions.	• Additional vehicle travel reductions ("leverage effects"). • Improved accessibility, particularly for non-drivers. • Reduced crime risk. • More efficient development (reduced infrastructure costs). • Farmland and habitat preservation.
Costs	• Increased capital and operating costs. • Land and road space. • Increased congestion and accident risk.	• Crowding of sidewalks, paths and transit vehicles.	• Reduced vehicle business activity.	• Various problems associated with more compact development.

Walking, cycling and public transport improvements can have various benefits and costs, many of which tend to be overlooked or undervalued in conventional transportation economic evaluation.

Multi-Modal Performance Evaluation

Performance evaluation refers to a monitoring and analysis to determine how well policies, programs and projects perform relative to their intended goals and objectives. *Performance indicators* (also called *measures of effectiveness*) are specific measurable outcomes used to evaluate progress toward goals and objectives. Conventional planning evaluates transport system performance primarily based on motor vehicle traffic speeds and roadway level-of-service (DeRobertis, et al. 2014). In recent years planning organizations have developed performance indicators for other modes, as indicated in Table 12. These can be used to identify problems, evaluate trade-offs (for example, if roadway expansion reduces walkability), set targets, and measure progress.

Table 12 **Performance Indicators for Various Modes** (Dowling and Asso. 2010; Holian and McLaughlin 2016)

Mode	Service Indicators	Outcome Indicators
Walking	Sidewalk, crosswalk and path supply and conditions Universal design Pedestrian level-of-service (LOS)	Walking mode share Per capita pedestrian travel Pedestrian casualty (crash and assault) rates Pedestrian satisfaction ratings
Cycling	Bikelane, path and bike parking supply and conditions Cycling LOS	Cycling mode share Per capita cycling travel Cycling casualty rates Cyclist satisfaction ratings
Automobile	Road and parking supply and conditions Traffic speeds and roadway LOS Motor vehicle crash casualty rates	Automobile mode share Motorist satisfaction ratings
Public transit	Transit service supply and conditions Transit stop and station quality Transit LOS Fare affordability	Transit mode share Per capita transit travel Transit passenger casualty rates Transit user satisfaction ratings
Taxi	Taxi supply and conditions Average response time Taxi fare affordability	Per capita taxi travel Taxi passenger casualty rates Taxi user satisfaction ratings
Multi-modal connectivity	Quality of transport terminals Information integration Fare integration	Transport terminal use Transport terminal user casualty rates Taxi user satisfaction ratings
Overall accessibility	Number of services and jobs accessible within a given time and money budget Affordability of accessible housing	Portion of household budgets devoted to transport Quality of accessibility for disadvantaged people

This table illustrates performance indicators for various transport modes and overall accessibility.

Consider Social Equity Objectives

Equity refers to the distribution of resources and opportunities. Transportation decisions can have significant equity impacts so it is important to consider them in the planning process. There are three major categories of transportation equity impacts:

- *Horizontal equity.* This assumes that people with similar needs and abilities should be treated equality. This tends to suggest that consumers should "get what they pay for and pay for what they get" unless a subsidy is specifically justified.
- *Vertical equity with respect to income.* This assumes that transport policies should be progressive with respect to income, meansing that they favor lower-income people.
- *Vertical equity with respect to transport ability or need.* This assumes that transport policies should favor people with constrained mobility (for example, due to a disability) or who require extra transport (for example, because they are traveling with children).

Various tools can be used to quantify equity impacts in a particular situation, such as how a policy or project impacts various groups (DfT 2013; Manaugh, Badami and El-Geneidy 2015; Stanley, et al. 2010). Table 13 summarizes indicators that can be used to evaluate a policy or project's equity impacts.

Table 13 **Types of Transportation Equity**

Horizontal	1. *Fair resource allocation*. This reflects whether individuals or groups receive a fair share of public resources such as funding, road space or planning priority. It implies that people should generally "get what they pay for and pay for what they get" unless subsidies are specifically justified.
	2. *External costs.* Costs that travel activities impose on other people, such as the delay, risk and pollution, are unfair. Fairness requires minimizing or compensating for such impacts.
Vertical	3. *Inclusivity - vertical equity with regard to need and ability*. This considers how transport systems serve people with impairments and other special needs. It justifies universal design and multimodal planning.
	4. *Affordability - vertical equity with regard to income*. This considers how decisions affect income classes. Policies that favor lower-income people are called *progressive* and those favoring wealthier people are called *regressive*. It supports affordable mode improvements and low-income traveller subsidies.
	5. *Social justice*. This considers how transportation systems serve disadvantaged and underserved groups, and address structural injustices such as racism and sexism.

Comprehensive analysis should apply various indicators of transportation equity.

Transportation Modeling Improvements

Transportation models predict how specific policy and planning decisions affect future travel activity. Most older models primarily reflected vehicle traffic conditions. They tend to exaggerate vehicle trip generation rates in compact, multi-modal locations (McDonald and Combs 2020; Millard-Ball 2015; Schneider, Handy and Shafizadeh 2014), which discourages infill and encourages sprawled development. Some newer models evaluate overall accessibility, taking into account the quality of access by various modes, transport network conditions, land use patterns and other factors (Bartholomew and

Ewing 2009; Dowling and Associates 2008) . For example, accessibility models can quantify the number of stores or jobs available within 20-minute travel time by walking, cycling, public transit and automobile (Holian and McLaughlin 2016; Levine, et al. 2012; Levin, et al. 2012; RPA 2014), considering actual walking and cycling conditions.

More Accurate Congestion Costing

Conventional transport planning tends to place considerable importance on congestion costs, and congestion reduction is often a primary planning objective, so how congestion costs are calculated and potential congestion reduction strategies are evaluated can significantly affect planning decisions. The methods commonly used to quantify congestion costs are biased in various ways that tend to exaggerate roadway expansion benefits and underestimate the benefits of other congestion reduction strategies (Dumbauth 2012; Litman 2021), summarized in Table 14.

Table 14 **Congestion Costing Biases, Impacts and Corrections** (Litman 2009)

Type of Bias	Planning Impacts	Corrections
Measures congestion *intensity* rather than total congestion costs	Favors roadway expansion over other transport improvements	Measure per capita congestion costs and overall accessibility
Assumes that compact development increases congestion	Encourage autom-dependent sprawl over more compact, multi-modal infill development	Recognize that smart growth policies can increase accessibility and reduce congestion costs
Only considers impacts on motorists	Favors driving over other modes	Use multi-modal transport system performance indicators
Estimates delay relative to free flow conditions (LOS A)	Results in excessively high estimates of congestion costs	Use realistic baselines (e.g., LOS C) when calculating congestion costs
Applies relatively high travel time cost values	Favors roadway expansion beyond what is really optimal	Test willingness-to-pay for faster travel with road tolls
Uses outdated fuel and emission models that exaggerate fuel savings and emission reductions	Exaggerates roadway expansion economic and environmental benefits	Use more accurate models
Ignores congestion equilibrium and the additional costs of induced travel	Exaggerates future congestion problems and roadway expansion benefits	Recognize congestion equilibrium, and account for generated traffic and induced travel costs
Funding and planning biases such as dedicated road funding	Makes road improvements easier to implement than other types of transport improvements	Apply least-cost planning, so transport funds can be used for the most cost-effective solution.
Exaggerated roadway expansion economic productivity gains	Favors roadway expansion over other transport improvements	Use critical analysis of congestion reduction economic benefits
Considers congestion costs and congestion reduction objectives in isolation	Favors roadway expansion over other congestion reduction strategies	Use a comprehensive evaluation framework that considers all objectives and impacts

This table summarizes common congestion costing biases, their impacts on planning decisions, and corrections for more comprehensive and objective congestion costs.

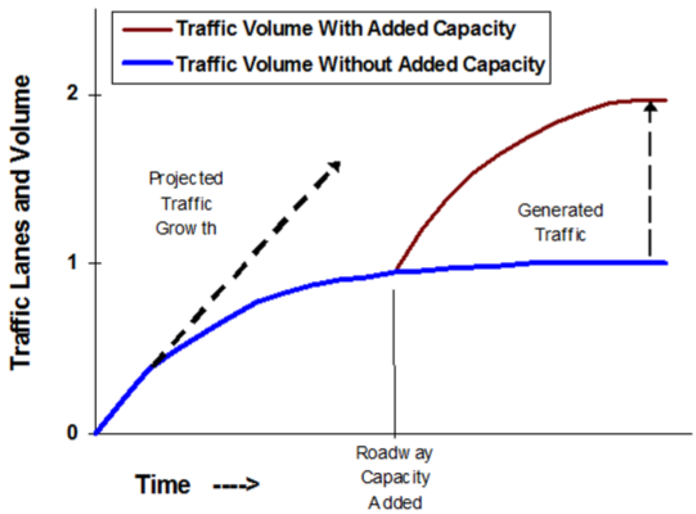
Account for Generated and Induced Travel Impacts

Generated Traffic is the additional vehicle travel that occurs when a roadway improvement increases traffic speeds or reduces vehicle operating costs (Holian and McLaughlin 2016; Gorham 2009; Litman 2001). Increasing urban roadway capacity tends to generate additional peak-period trips that would otherwise not occur, as illustrated in Figure 3. Over the long run, generated traffic often fills a significant portion (50-90%) of added urban roadway capacity. This has three implications for transport planning:

1. Generated traffic reduces roadway expansion congestion reduction benefits.
2. Induced travel increases external costs, including downstream congestion, parking costs, crashes, pollution, and other environmental impacts.
3. The additional travel that is generated provides relatively modest user benefits since it consists of marginal value trips (travel that consumers are most willing to forego).

Improved traffic models can account for these impacts (Metz 2021). Ignoring generated traffic and induced travel tends to overstate roadway expansion benefits and undervalues alternative modes and transportation demand management alternatives.

Figure 4 **How Road Capacity Expansion Generates Traffic**



Traffic grows when roads are uncongested, but the growth rate declines as congestion develops, reaching a self-limiting equilibrium (indicated by the curve becoming horizontal). If capacity increases, traffic grows until it reaches a new equilibrium. This additional peak-period vehicle travel is called "generated traffic." The portion that consists of absolute increases in vehicle travel (as opposed to shifts in time and route) is called "induced travel."

Consider Diverse Transportation Improvement Options

Conventional planning tends to consider a relatively limited set of transport system improvement options, which typically include roadway and parking facility expansions, and sometimes major public transit improvements. More comprehensive and multi-modal planning considers additional types of improvements, as indicated in Table 15. Many of these strategies have synergistic effects (they are more effective implemented together than individually) and so they should be planned and evaluated as integrated programs (EVIDENCE 2014; SUTP 2014).

Table 15 **Transport System Improvement Options Considered**

Conventional	Comprehensive and Multi-Modal
	Walking and cycling improvements and encouragement
	Incremental public transit improvements
	HOV lanes, bus lanes and bus rapid transit (BRT) programs
	Efficient parking management
	Transport pricing (fuel, road, parking, insurance, etc.) reforms
	Commute trip reduction programs
Roadway expansion	Mobility management marketing programs
Parking facility requirements and subsidies	Complete streets policies
Major transit projects	Smart growth land use policies

Comprehensive evaluation expands the types of transport system improvements considered.

Comprehensive Impact Analysis

Comprehensive impact analysis indicates how a transportation system change will affect travel activity, benefits and costs. An example is the *Project Evaluation Toolkit* (*PET*) a free, open-source transportation project evaluation toolkit that assesses how various project types affect benefits and costs to travelers, project financing feasibility, air quality, and total crashes (Kockelman, et al 2014).

Table 16 **Transport System Improvement Options Considered** (PET 2014)

Transportation Project Types	Impacts Considered
• Capacity Expansion and Grade Separation • Tolling (can vary by mode, user class, and time of day) • Shoulder Lane Use • Reversible Lanes • Ramp Metering • Transit Route & Headway Changes • Work Zone Phasing/Scheduling • Traffic Safety Projects • Advance Traveler Information Systems • Variable Speed Limits (Speed Harmonization) • Incident Management • Changes to Parking & Other Fixed Trip Costs	• Traveler Welfare (consisting of operating costs and changes in travel time) • Travel Time Reliability (based on the valuation of travel time variance) • Crash Counts (by severity) • Emissions (14 pollutant species) • Tolling Revenues • Fuel Use • Link-level Volumes & Speeds by Time of Day

Comprehensive evaluation expands the types of transport system improvements considered.

Implement Multi-Modal Planning

Multi-modal planning involves various planning and design practices that help create corridors, neighborhoods and regions with diverse transport options, including convenient, comfortable and affordable alternatives to automobile travel (VDRPT 2013). This includes Multimodal System Planning which integrates transport and land use planning data to identify transport system disconnects such as areas with poor walking and cycling conditions, and constraints on public transit access.

Finance Reforms

Conventional transportation finance often includes substantial funding that is dedicated to roads and parking facilities and cannot be used to improve other modes, or for transportation demand management programs, even if they are more cost effective and beneficial overall. This biases transportation planning to overinvest in automobile facilities and underinvest in alternatives. *Least-cost planning* refers to planning and funding practices that allow funds to be dedicated to the most cost effective and beneficial option overall, considering all impacts (VTPI 2012).

Explicitly Indicate Omissions and Biases

Conventional planning often reports analysis results with an unjustified degree of confidence, for example, producing benefit/cost ratios and net values with three or four significant figures. More comprehensive and multi-modal planning explicitly describes omissions and biases in analysis, and often reports results as ranges rather than point values using various types of statistical analyses which reflect uncertainty.

Engage Stakeholder

The planning process should involve stakeholders (people affected by a decision), including those who are physically, economically and socially disadvantaged. This requires informing stakeholders about planning issues and how they can become involved in the planning process.

Conclusions

Conventional transportation economic evaluation practices originally developed to determine whether roadway improvement costs would be offset by future motor vehicle travel time and operating cost savings. They tend to give little consideration to other accessibility factors, other modes, and other impacts, and generally overlook the costs of increased vehicle traffic and many benefits of improved other modes.

Conventional planning incorporates often subtle and technical biases related to how travel demand is measured and how potential solutions are evaluated. People usually believe statements such as "95% of all trips are by automobile," "Los Angeles traffic congestion costs $10,999 million annually," or "this highway expansion project will provide $3.74 billion in net benefits," yet, such statements are often incomplete. Active travel is more common than most travel surveys indicate, commonly-used evaluation methods tend to exaggerate congestion costs, and highway expansion net benefits are often overestimated by ignoring induced travel and its incremental external costs. Described differently, improving transport system diversity, transportation demand management strategies, and smart growth development policies tend to provide significantly greater benefits than conventional evaluation indicates.

This has important implications. These omissions and biases tend to favor mobility over accessibility and automobile travel over other modes. The results contradict many strategic planning objectives such as resource conservation, affordability, improved accessibility for disadvantaged residents, pollution emission reductions, and improved public fitness and health. It also tends to be unfair and regressive because it favors motorists who tend to be wealthier and abler than people who rely on other modes. Many planning professionals are working to improve evaluation practices by improving data collection and modelling, considering more impacts, modes and potential solutions to transportation problems, and by better engaging stakeholders. This report provides an overview of these various efforts.

More comprehensive evaluation is especially important in growing urban areas where accommodating increased automobile travel is particularly costly; in developing countries where a major portion of residents cannot afford a car; and in any situation where energy conservation, environmental protection or sprawl reduction are considered important objectives.

More comprehensive evaluation helps identify truly optimal transport improvement options, considering all impacts and options. It can help avoid conflicts between planning objectives, such as congestion reduction programs that unintentionally increase accidents or reduce mobility for non-drivers, and can identify *win-win* strategies that provide multiple benefits. This can help build cooperation between stakeholders with different goals and priorities. Table 16 summarizes various problems with existing transportation evaluation and potential reforms for correcting them.

Table 16 **Reforms for More Comprehensive and Multi-modal Evaluation**

Problems With Existing Evaluation Methods	Reforms For More Comprehensive Evaluation
Inadequate data on alternative mode activity and demands.	Collect more comprehensive travel activity and demand data, particularly for active travel (walking and cycling).
Mobility-based analysis which evaluates transport system performance based primarily on motor vehicle travel conditions.	Use accessibility-based analysis which considers various accessibility factors, and therefore potential trade-offs between them.
Often considers a limited set of economic impacts (travel speed, vehicle operating costs, accident and emission rates.	Consider all potentially significant impacts, including indirect impacts, and generally measure impacts per capita rather than per vehicle-mile.
Applies constant travel time unit costs, which fail to account for variations due to different types of trips, and traveler comfort.	Adjust travel time unit costs to reflect variations in demand, and traveler comfort.
Overlooks many impacts of non-automobile modes.	Apply more comprehensive analysis of the benefits and costs of improving alternative modes, increasing use of those modes, and more compact land use development.
Evaluates transport system performance using automobile-oriented indicators such as roadway level-of-service and the Travel Time Index.	Use multi-faceted and multi-modal level-of-service indicators which recognize various impacts and various modes.
Ignores equity impacts, including planning that favors motorists over other mode users, and fails to provide basic mobility for disadvantaged people.	Use comprehensive evaluation of equity impacts, including horizontal and vertical equity.
Current models are insensitive to many factors that affect travel activity.	Develop and use better models that more accurately predict how improving alternative modes, pricing reforms and land use changes affect travel activity, and the benefits and costs that result.
Analysis uses exaggerated congestion cost estimates.	Use best practices when calculating congestion costs and congestion reduction benefits.
Ignores generated and induced travel impacts, which tends to exaggerate roadway expansion benefits.	Take into account generated and induced travel impacts when evaluating roadway expansion projects.
Considers a limited set of transport system improvement options consisting primarily of roadway facility expansions and major public transit projects.	Consider a diverse range of transport system improvement options including improvements to alternative modes, demand management strategies and policies that encourage more accessible development.
Planning favors spending resources (money and road space) on roadways, parking facilities and large transit projects, even if alternatives are more cost effective overall.	Apply *least-cost* principles, so resources can be spent on the most cost effective solutions, considering all benefits and costs, including alternative modes and demand management strategies.
Inadequate understanding by decision-makers of evaluation omissions and biases.	Identify any potential omissions and biases, and report quantitative analysis results as ranges rather than point values to indicate uncertainty.
Stakeholders are not effectively involved in decision making that will affect them.	Inform and involve people who may be affected by a planning decision.

This table summarizes ways to make transport planning more comprehensive and multi-modal.

References

ABW (2014), *Bicycling and Walking in the U.S.: Benchmarking Reports*, Alliance for Biking & Walking (www.peoplepoweredmovement.org); at www.peoplepoweredmovement.org/benchmarking.

Steve Abley, Paul Durdin and Malcolm Douglass (2010), *Integrated Transport Assessment Guidelines*, Report 422, Land Transport New Zealand (www.nzta.govt.nz); at https://bit.ly/2MIwY6N.

ATAP (2017), *Australian Transport Assessment and Planning Guidelines*, ATAP Steering Committee Secretariat (https://atap.gov.au) Australia Department of Infrastructure and Regional Development.

Ivonne Audirac, et al. (2024), *Transportation Policies, Programs and History*, Univeristy of Texas Press (https://uta.pressbooks.pub); at https://uta.pressbooks.pub/oertransportationpoliciesandhistory.

Keith Bartholomew and Reid Ewing (2009), "Land Use-Transportation Scenarios and Future Vehicle Travel and Land Consumption: A Meta-Analysis," *Journal of the American Planning Association*, Vol. 75, No. 1, Winter (dx.doi.org/10.1080/01944360802508726).

Marlon G. Boarnet (2013), "The Declining Role of the Automobile and the Re-Emergence of Place in Urban Transportation: The Past will be Prologue," *Regional Science Policy & Practice,* Vol. 5/2, pp. 237–253 (DOI: 10.1111/rsp3.12007).

Daniel Bongardt, et al. (2011), *Sustainable Transport Evaluation: Developing Practical Tools for Evaluation in the Context of the CSD Process*, Commission on Sustainable Development, United Nations Department of Economic and Social Affairs (www.un.org); at https://bit.ly/3cMpOc8.

Eric Bruun (2017), "Assessment Methods from Around the World Potentially Useful for Public Transport Projects," *Journal of Public Transportation*, Vo. 20/2, pp. 103-130; at http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1618&context=jpt.

Michelle DeRobertis, et al. (2014), "Changing the Paradigm of Traffic Impact Studies: How Typical Traffic Studies Inhibit Sustainable Transportation," *ITE Journal* (www.ite.org), May, pp. 30-35; at https://bit.ly/31f7qFh.

CAPCOA (2021), *Handbook for Analyzing Greenhouse Gas Emission Reductions*, Calif. Air Pollution Control Officers Assoc. (www.caleemod.com); at www.caleemod.com/handbook/index.html.

DfT (2010-2017), *Transport Analysis Guidance*, Integrated Transport Economics and Appraisal, Department for Transport (www.gov.uk/guidance/transport-analysis-guidance-webtag). This website provides comprehensive guidance on how to identify problems, establish objectives, develop potential solutions, model highway and public transport, and conduct economic appraisal studies.

Chhavi Dhinghi (2011), *Measuring Public Transport Performance- Lessons for Developing Cities: Sustainable Transport Sourcebook*, Sustainable Urban Transport Project (www.sutp.org) Asia and GIZ; at www.sutp.org/index.php?option=com_content&task=view&id=2826.

Richard Dowling, et al. (2008), *Multimodal Level of Service Analysis for Urban Streets*, NCHRP 616, Transportation Research Board (www.trb.org); at http://trb.org/news/blurb_detail.asp?id=9470.

Eric Dumbaugh (2012), *Rethinking the Economics of Traffic Congestion*, Atlantic Cities (www.theatlanticcities.com), 1 June 2012; at https://bloom.bg/2YzRPzD.

EC (2014), *Guide to Cost-Benefit Analysis of Investment Projects Economic Appraisal tool for Cohesion Policy 2014-2020*, European Commission (http://ec.europa.eu); at https://bit.ly/3f3rekg.

EVIDENCE (2014), *How Urban Transport Projects are Appraised: Current Practice in the EU*, by the Wuppertal Institute for Climate, Environment and Energy for the EVIDENCE Project: Economic Benefits of Sustainable Transport (http://evidence-project.eu); at http://tinyurl.com/m36e4un.

Reid Ewing and Robert Cervero (2010), "Travel and the Built Environment: A Meta-Analysis," *Journal of the American Planning Association*, Vol. 76, No. 3, pp. 265-294; at https://bit.ly/3dJwBWd.

Reid Ewing and Shima Hamidi (2014), *Measuring Urban Sprawl and Validating Sprawl Measures*, Metropolitan Research Center, University of Utah, Smart Growth America (www.smartgrowthamerica.org); at https://bit.ly/3kLQPT7.

FDOT (2014), *Multimodal Transportation Best Practices and Model Element*, Report BDK85-977-49, National Center for Transit Research, Florida Department of Transportation (www.fdot.gov); at www.fdot.gov/research/Completed_Proj/Summary_PL/FDOT-BDK85-977-49-rpt.pdf.

Ann Forsyth, Kevin J. Krizek and Asha Weinstein Agrawal (2010), *Measuring Walking and Cycling Using the PABS (Pedestrian and Bicycling Survey) Approach: A Low-Cost Survey Method for Local Communities*, Mineta Transportation Institute, San Jose State University (www.transweb.sjsu.edu); at www.transweb.sjsu.edu/project/2907.html.

GIZ (2003-2020), *Sustainable Transportation: A Sourcebook for Policy-Makers in Developing Countries*, (www.sutp.org), by the Sustainable Urban Transport Project – Asia (www.sutp-asia.org) and Deutsche Gesellschaft fur Internationale Zusammenarbeit (www.giz.de).

GIZ (2011), *Changing Course in Urban Transport – An Illustrated Guide*, Sustainable Urban Transport Project (www.sutp.org) Asia and GIZ; at https://bit.ly/3aYHdiB.

Roger Gorham (2009), *Demystifying Induced Travel Demand*, Sustainable Transportation Technical Document, Sustainable Urban Transportation Project (www.sutp.org); at https://bit.ly/3kN0tov.

Susan Handy, Gil Tal and Marlon G. Boarnet (2014), *Draft Policy Brief on the Impacts of Network Connectivity Based on a Review of the Empirical Literature*, California Air Resources Board (http://arb.ca.gov/cc/sb375/policies/policies.htm).

Matthew Holian and Ralph McLaughlin (2016), *Benefit-Cost Analysis for Transportation Planning and Public Policy: Towards Multimodal Demand Modeling*, Mineta Transportation Institute (http://transweb.sjsu.edu) for the California Department of Transportation; at http://bit.ly/2bYJ0Zj.

Hanna Hüging, Kain Glensor and Oliver Lah (2014), *The TIDE Impact Assessment Method for Urban Transport Innovations: A Handbook For Local Practitioners*, TIDE (Transport Innovation Deployment for Europe) Project (www.tide-innovation.eu); at https://bit.ly/2UkC25F.

IEG (2017), *Mobile Metropolises: Urban Transport Matters, An IEG Evaluation of the World Bank Group's Support for Urban Transport*, Independent Evaluation Group, World Bank (www.worldbank.org); at https://bit.ly/2MM5tsY.

ITF (2021), *Travel Transitions: How Transport Planners and Policy Makers Can Respond to Shifting Mobility Trends*, International Transport Forum (www.itf-oecd.org); at https://bit.ly/3BGJewh.

ITF (2022), *Broadening Transport Appraisal: Summary and Conclusions*, ITF Roundtable Report 188, Organization for Economic Cooperation and Development (www.itf-oecd.org); at www.itf-oecd.org/sites/default/files/docs/broadening-transport-appraisal.pdf.

Kara M. Kockelman, et al. (2014), *The Economics of Transportation Systems: A Reference for Practitioners*, University of Texas at Austin (https://bit.ly/3llrBdR).

Kara M. Kockelman, et al. (2014) *PET. A Toolkit for Anticipating & Comprehensively Evaluating Transportation Project Impacts*, Center for Transportation Research, University of Texas at Austin (www.caee.utexas.edu); at www.caee.utexas.edu/prof/kockelman/PET_Website/homepage.htm.

J. Richard Kuzmyak (2012), *Land Use and Traffic Congestion*, Report 618, Arizona DOT (www.azdot.gov); at www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ618.pdf.

John LaPlante (2010), "The Challenge of Multi-Modalism; Theodore M. Matson Memorial Award," *ITE Journal* (www.ite.org), Vol. 80, No. 10, October, pp. 20-23.

Jonathan Levine, et al. (2012), "Does Accessibility Require Density or Speed?" *Journal of the American Planning Association*, Vol. 78, No. 2, pp. 157-172, http://dx.doi.org/10.1080/01944363.2012.677119; at http://bit.ly/1CkF1KW.

David Levinson (2021), *How to Value Transport Projects*, The Transportist (https://transportist.org); at https://transportist.org/2021/10/05/transportist-october-2021.

David Levinson and David King (2020), *Transport Access Manual: A Guide for Measuring Connection between People and Places*, Committee of the Transport Access Manual, University of Sydney (https://ses.library.usyd.edu.au); at https://hdl.handle.net/2123/23733.

Todd Litman (2001), "Generated Traffic; Implications for Transport Planning," *ITE Journal*, Vol. 71, No. 4, Institute of Transportation Engineers (www.ite.org), pp. 38-47; at www.vtpi.org/gentraf.pdf.

Todd Litman (2009), *Transportation Cost and Benefit Analysis*, Victoria Transport Policy Institute (www.vtpi.org/tca).

Todd Litman (2011), *Well Measured: Developing Indicators for Comprehensive and Sustainable Transport Planning*, VTPI (www.vtpi.org); at www.vtpi.org/wellmeas.pdf.

Todd Litman (2013), "The New Transportation Planning Paradigm," *ITE Journal* (www.ite.org), Vo. 83, No. 6, pp. 20-28; at www.vtpi.org/paradigm.pdf.

Todd Litman (2013b), "Towards More Comprehensive and Multi-modal Transport Evaluation," *JOURNEYS*, September 2013, pp. 50-58, LTA Academy, Singapore.

Todd Litman (2014), *Evaluating Accessibility for Transportation Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/access.pdf.

Todd Litman (2014), *Congestion Evaluation Best Practices*, presented at the International Transportation Economic Development Conference, 9-11 April 2014, Dallas, Texas; at www.vtpi.org/ITED_congestion.pdf.

Todd Litman (2014), *Economically Optimal Transport Prices and Markets: What Would Happen If Rational Policies Prevailed?*, paper 11, International Transportation Economic Development Conference; at www.vtpi.org/ITED_optimal.pdf.

Todd Litman (2016), *Guide to Calculating Mobility Management Benefits*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/tdmben.pdf.

Todd Litman (2017), *Evaluating Transportation Diversity*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/choice.

Todd Litman (2017), "Determining Optimal Urban Expansion, Population and Vehicle Density, and Housing Types for Rapidly Growing Cities," *Transportation Research Procedia*, for the 2015 World Conference on Transport Research; at www.vtpi.org/WCTR_OC.pdf.

Todd Litman (2022), "Evaluating Transportation Equity: Guidance for Incorporating Distributional Impacts in Transport Planning," *ITE Journal* (www.ite.org), Vo. 92/4, April; at https://vtpi.org/Litman_ITEJ_Equity_Apr2022.pdf.

Todd Litman (2021), *Smart Congestion Relief: Comprehensive Analysis of Traffic Congestion Costs and Congestion Reduction Benefits,* Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/cong_relief.pdf.

Ian Lockwood (2017), "Making the Case for Transportation Language Reform: Removing Bias," ITE Journal (www.ite.org), Vol. 87, No. 1, January, pp. 41-43; at https://bit.ly/2XjnC7T.

Glenn Lyons and Cody Davidson (2016), Guidance for Transport Planning and Policymaking in the Face of an Uncertain Future," *Transportation Research Part A*, Vo. 88, pp. 104-116 (https://doi.org/10.1016/j.tra.2016.03.012).

Noreen C. McDonald and Tabitha S. Combs (2020), "Reinventing TIA: Contemporary Approaches to Addressing the Traffic Impacts of Urban Development," *ITE Journal* (www.ite.org); at https://bit.ly/2Js3dsv.

Kevin Manaugh, Madhav G. Badami and Ahmed M. El-Geneidy (2015), "Integrating Social Equity into Urban Transportation: A Critical Evaluation of Equity Objectives and Measures in Transportation Plans in North America," *Transport Policy*, Vol. 37, pp. 167–176 (http://dx.doi.org/10.1016/j.tranpol.2014.09.013); at https://bit.ly/3lZq7p8.

Michael J. Markow (2012), *Engineering Economic Analysis Practices for Highway Investment*, NCHRP Synthesis 424, Transportation Research Board (www.trb.org); at https://bit.ly/37enWYy.

Wesley Marshall, Daniel Piatkowski and Chris McCahill (2019), "[Re]Evaluating How We Value Transportation," *Research in Transportation Business & Management* (http://dx.doi.org/10.1016/j.rtbm.2019.01.005); athttps://bit.ly/3e5mq00.

David Metz (2021), "Economic Benefits of Road Widening: Discrepancy Between Outturn and Forecast," *Transportation Research Part A*, Vo. 147, pp. 312-319 (https://doi.org/10.1016/j.tra.2021.03.023).

Adam Millard-Ball (2015), "Phantom Trips: Overestimating the Traffic Impacts of New Development," *Journal of Transportation and Land Use* (www.jtlu.org); at http://tinyurl.com/m6ay4ut; summarized in, *ACCESS 45*, pp. 3-8; at www.accessmagazine.org/articles/fall-2014/phantom-trips.

Multimodal Benefit-Cost Analysis Tool (http://tredis.com/mbca) is a free, web-based calculation system for comparing the costs and user benefits of individual transportation projects

NZTA (2010-2017), *Economic Evaluation Manual*, Volumes 1 and 2, New Zealand Transport Agency (www.nzta.govt.nz); at www.nzta.govt.nz/resources/economic-evaluation-manual.

K. Oldham and J. Mills (2020), *A Cross-Portfolio Consideration of Interventions Impacting Transport Safety Outcomes*, Research Report 668, NZ Transport Agency (www.nzta.govt.nz); at https://bit.ly/35kDppo.

Lee Pike (2011), *Generation of Walking, Cycling and Public Transport Trips: Pilot Study*, New Zealand Transport Agency (www.nzta.govt.nz); at https://bit.ly/2YuQoSn.

John Poorman (2005), "A Holistic Transportation Planning Framework For Management And Operations," *ITE Journal*, Vol. 75, No. 5 (www.ite.org), May, pp. 28-32; at https://bit.ly/3f2Yyb4.

David G. Proffitt, et al. (2019), "Accessibility Planning in American Metropolitan Areas: Are We There Yet?" *Urban Studies*, Vol. 56(1), pp. 167-192 (https://doi.org/10.1177/0042098017710122).

Ricardo-AEA (2008-2014), *Handbook on Estimation of External Cost in the Transport Sector,* CE Delft (www.ce.nl); at http://bit.ly/2qAyPRx.

Road Investment Scrutiny Panel (2023), *Key Questions for Road Investment and Spending*, University of the West of England; at https://uwe-repository.worktribe.com/output/10295773.

RPA (2014), "Access to Jobs," *Fragile Success*, Regional Plan Association (www.rpa.org); at http://fragile-success.rpa.org/maps/jobs.html.

Robert J. Schneider, Susan L. Handy and Kevan Shafizadeh (2014), "Trip Generation for Smart Growth Projects," ACCESS 45, pp. 10-15; at http://tinyurl.com/oye8aqj. Also see the *Smart Growth Trip-Generation Adjustment Tool*, (http://ultrans.its.ucdavis.edu/projects/smart-growth-trip-generation).

Smart Growth and SSTI (2015), *The Innovative DOT: A Handbook of Policy and Practice*, Smart Growth America and the State Smart Transportation Initiative (www.smartgrowthamerica.org); at www.smartgrowthamerica.org/documents/the-innovative-dot-third-edition.pdf.

SSTI (2018), *Modernizing Mitigation: A Demand-Centered Approach*, State Smart Transportation Initiative (www.ssti.us) and the Mayors Innovation Project; at https://bit.ly/3hqEzoi.

SSTI (2021), *Measuring Accessibility: A Guide for Transportation and Land Use Practitioners*, State Smart Transportation Initiative (https://ssti.us); at https://ssti.us/accessibility-analysis.

John Stanley, et al. (2010), *Social Exclusion and the Value of Mobility*, ITLS-WP-10-14, Institute of Transportation and Logistical Studies, University of Sydney (http://sydney.edu.au); at http://sydney.edu.au/business/__data/assets/pdf_file/0004/72913/itls-wp-10-14.pdf.

Peter R. Stopher and Stephen P. Greaves (2007), "Household Travel Surveys: Where Are We Going?" *Transportation Research A*, Vol. 41/5 (www.elsevier.com/locate/tra), June, pp. 367-381.

Eric Sundquist, Chris McCahill and Logan Dredske (2018), *Accessibility in Practice: A Guide for Transportation and Land Use Decision Making*, State Smart Transportation Initiative (www.ssti.us); at www.vtrans.org/resources/Accessibility_Guide_Final.pdf.

SUTP (2014), *Urban Mobility Plans – National Approaches and Local Practice*, Sustainable Urban Transportation Project (www.sutp.org); at www.sutp.org/files/TD13_UMP_final.pdf.

Swiss ARE (2005 and 2010), *External Cost of Transport in Switzerland*, Swiss Federal Office of Spatial Development (www.are.admin.ch); at https://bit.ly/3dHitvU.

TIDE (2013), *Impact Assessment Handbook: Practitioners' Handbook for Cost Benefit and Impact Analysis of Innovative Urban Transport Measures*, Transport Innovation Deployment for Europe (www.eltis.org); at www.eltis.org/resources/tools/tide-impact-assessment-handbook.

UITP (2012), *Better Urban Mobility in Developing Countries: Problems, Solutions and Good Practices*, International Association of Public Transport (www.uitp.org); at https://bit.ly/2AULhlX.

UKDfT (2013), *New Approach to Transport Appraisal* (NATA), Department for Transport (www.webtag.org.uk/overview-pages/the-appraisal-framework).

VDRPT (2013), *Multimodal System Design Guidelines*, Virginia Department of Rail and Public Transportation (www.drpt.virginia.gov); at https://bit.ly/2MJmVi0.

VTPI (2012), *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org/tdm).

Glen Weisbrod (2015), *Estimating Wider Economic Impacts in Transport Project Prioritisation Using Ex-Post Analysis*, International Transport Forum (www.internationaltransportforum.org) *OECD Roundtable on Quantifying the Socio-Economic Benefits of Transport*, International Transportation Forum (www.itf-oecd.org); at https://bit.ly/37i7LK6.

World Bank (2008), *A Framework for Urban Transport Projects: Operational Guidance for World Bank Staff*, Transport Sector Board, World Bank (www.worldbank.org); at https://bit.ly/2AWC24L.

WRA (2014), *State of the Art Practice for Cost-Effectiveness Analysis (CEA), Cost-Benefit Analysis (CBA) and Resource Allocation*, World Road Association (www.piarc.org); at http://tinyurl.com/kvgwpnv.