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Towards More Comprehensive and Multi-Modal Transport Evaluation

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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 automobile 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.

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Introduction

Transportation policy and planning decisions affect our lives in many ways. 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 fundamental change in the way problems are defined and solutions evaluated (ADB 2009; GIZ 2011). The old paradigm assumed that *transportation* simply means *mobility* (physical travel), and so evaluated transport system performance based mainly on travel speeds. The new paradigm recognizes that the ultimate goal of transport is *accessibility* (people's ability to reach desired services and activities), and considers a wider range of impacts, objectives and options (LaPlante 2010; Litman 2013). Table 1 compares the old and new paradigms.

Table 1 **Changing Transport Planning Paradigm** (ADB 2009; Litman 2013)

	Old Paradigm	New Paradigm
Definition of *Transportation*	*Mobility* (physical 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 cost savings; consumer savings and affordability; improved access for disadvantaged people; safety and security, energy consumption and emission reductions; public fitness and health; support for strategic land use objectives (reduced sprawl)
Impacts considered	Travel speeds and congestion delays, 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.

Conventional transportation planning tends to consider a limited set of impacts (benefits and costs), including travel speed, vehicle operating costs and roadway costs, as indicated in Table 2. Other impacts are overlooked or undervalued. This biases planning decisions in favor of faster modes, such as automobile travel, and undervalues slower but more resource-efficient and affordable modes such as walking, cycling and public transit travel. It also tends to undervalue transportation demand management and smart growth strategies.

Table 2 **Scope of Impacts Considered**

Usually Considered	Often Overlooked
Travel speed (congestion delays)	Downstream congestion
Vehicle operating costs (fuel, tolls, tire wear)	Traffic delay to non-motorized travel (the *barrier effect*)
Per-mile crash risk	Parking costs
Roadway costs	Vehicle ownership costs
Road construction environmental impacts	Mobility for non-drivers
	Social equity objectives
	Indirect environmental impacts
	Strategic land use impacts (compact development)
	Public fitness and health

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

The old paradigm was *reductionist*, meaning that problems were evaluated by individual agencies with narrowly defined responsibilities. For example, transport agencies were concerned with traffic congestion, social service agencies with helping disadvantaged people, environmental agencies with pollution reduction, and public health agencies with public fitness and health. This can result in agencies implementing strategies to achieve their objectives which exacerbate other problems, and tends to undervalue solutions that provide multiple benefits. The new paradigm applies more integrated analysis, and so can identify *win-win* solutions that achieve multiple objectives.

Table 3 illustrates this concept. Expanding roadways can reduce traffic congestion, and more efficient and alternative fueled vehicles 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.

Table 3 **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 provide few benefits. Transportation demand management (TDM) and smart growth strategies provide a wider range of benefits and so can be considered win-win solutions.

The new paradigm recognizes the benefits provided by a multi-modal transport system. It recognizes the unique and important roles that walking, cycling and public transport can play in an efficient and equitable transport system. It recognizes that in a typical community, 20-40% of the population cannot or should not drive an automobile due to age, impairment (physical or mental disability, or alcohol or drug inebriation), or poverty. The new paradigm recognizes that active modes (walking and cycling) are often the most efficient mode for local trips, public transit is often the most efficient mode for travel on congested urban corridors, and automobile travel is most efficient for other destinations, when carrying heavy loads or traveling in groups. Table 4 indicates the most efficient mode for various combinations of travelers and trips.

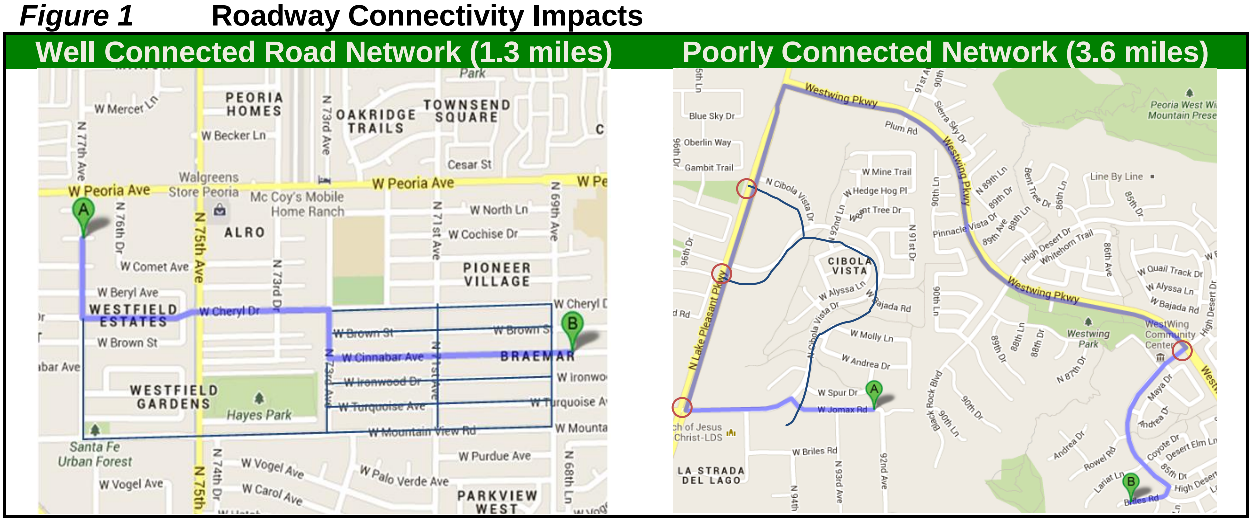
Table 4 **Efficient Mode By Traveler and Trip**

	Local	Commuting on Congested Corridor	Other Trips and Destinations
Adolescent	Active	Transit	Transit, taxi, chauffeured
Impaired, low-income	Active if possible	Transit	Transit, taxi, chauffeured
Unimpaired, low-income	Active	Transit	Transit, taxi, chauffeured
Impaired, higher-income	Active if possible	Transit, taxi	Drive, transit, taxi
Unimpaired, higher-income	Active if enjoyable	Drive, transit	Drive

The most efficient mode depends on the type of trip, travel and travel conditions.

The new transport planning paradigm recognizes other accessibility factors besides vehicle travel speeds, including roadway connectivity, and land use proximity. These overlooked factors can significantly affect overall accessibility. For example, research by Ewing and Cervero (2010) and Handy, Tal and Boarnet (2010) indicate that roadway connectivity (the density of connections within a road network) significantly affects the distances that people must travel to reach destinations, as illustrated in Figure 1.

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).*

Similarly, studies by Levine, et al (2012) and Levinson (2013) indicate that development density has a much greater effect than automobile travel speed on the number of jobs and services available within a given travel time.

Transport planning decisions often involve 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 5 summarizes various accessibility factors and how they can be considered in comprehensive and multi-modal evaluation.

Table 5 **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. Non-motorized 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, non-motorized networks, 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.

Table 6 summarizes the impacts and accessibility factors considered in conventional transport evaluation. It focuses on government costs, and vehicle travel speed, safety and operating costs. Other impacts and accessibility factors are sometimes discussed, but are generally not quantified or monetized, and so are not considered in formal economic evaluation. This favors highway investments over other transport improvements.

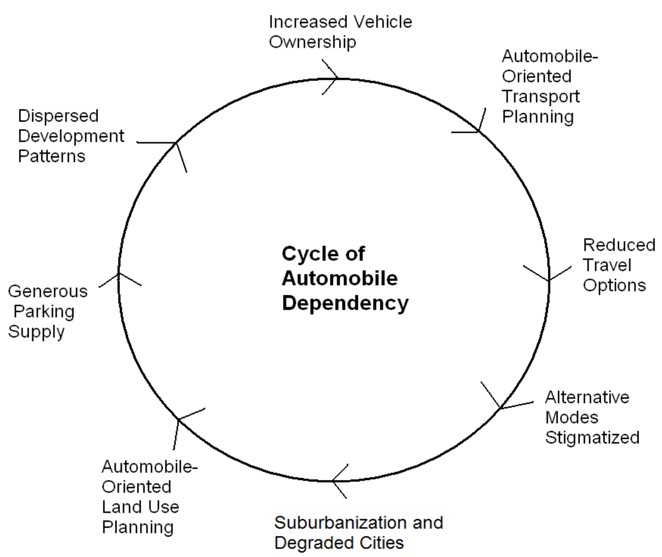
Table 6 **Impacts and Accessibility Factors Considered In Conventional Evaluation**

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

Conventional planning considers a limited scope of impacts and accessibility factors.

Conventional transport planning tends to result in *predict and provide* planning, in which projected motor vehicle traffic growth justifies transport system changes that favor automobile travel, which creates a self-fulfilling prophecy of increased motor vehicle travel, reduced transport options (degraded walking and cycling conditions and reduced public transit service), and sprawled development, as illustrated in Figure 2.

Figure 2 **Cycle of Automobile Dependency**



Many common planning practices contributed to a cycle of automobile dependency and sprawl. These tend to reduce the supply of affordable housing in compact, mixed, walkable and transit oriented communities.

Redefining Transport System Efficiency

Efficiency refers to the ratio of outputs (benefits) to inputs (costs). Engineers and economists often use efficiency analysis in transport system evaluation: the more efficient option is considered best. Analysis results depend on the scope of outputs and inputs considered:

- *Mobility-based planning* evaluates efficiency based on the traffic speeds, so the policy or project that increases vehicle speeds at the lowest cost is considered most efficient.
- *Multi-modal transport planning* measures the movement of people rather than vehicles, recognizes that not everybody can drive, and that different modes are most resource efficient for different types of trips. From this perspective transport systems are most efficient if they allow system users to select the most appropriate mode for each trip, such as walking and cycling for local errands, public transit and ridesharing for travel on major corridors, and automobile travel when it is truly most efficient overall.
- *Accessibility-based transport planning* recognizes the various factors that affect accessibility including mobility, the quality of transport options, transport network connectivity, land use accessibility, and mobility substitutes such as telecommunications and delivery services that eliminate trips. This recognizes that a lower-speed but more diverse and connected transport system may allow travelers to reach destinations faster than a system with higher speeds but longer trip distances. From this perspective, a transport system is most efficient if it optimizes these factors to maximize access.
- *Economic efficiency* refers to the degree that a system maximizes economic value. From this perspective a transport system is most efficient if it favors higher-value trips and more efficient modes over lower-value trips and less efficient modes. This can justify priority for commercial vehicles (which tend to have high value) and public transit vehicles (which tend to be space efficient), and pricing that allows higher value trips and more space-efficient modes can outbid lower-value trips and space-intensive modes for scarce road and parking space.
- *Planning efficiency* refers to the degree of planning process integration, so that short-term decisions support strategic, long-term goals. From this perspective transport systems are most efficient if planned and managed to support strategic objectives, for example, if transport, land use, environmental objectives, social and economic development planning are effectively integrated.

Efficiency analysis can also be applied to individual transport system components. For example, the number of people who can travel on a roadway varies depending on mode: single-occupant vehicle drive requires 2 to 6 times as much roadspace as rideshare passengers, 5 to 15 times as much space as pedestrians and cyclists, and 20 to 50 times as much space as public transit passengers, so a road can become more efficient – it carries more people per lane – if it is managed to favor space-efficient modes over single-occupant vehicles with dedicated lanes for bikes, rideshare vehicles and buses, or with efficient pricing. Similarly, a transit system becomes more efficient if its unit costs decline, its ridership increases, or its external costs are reduced, and a parking facility becomes more efficient if each parking space serves more users.

Comprehensive and Multi-modal Planning Practices

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

Comprehensive Transportation Data

Transportation data includes statistics on transport facilities, vehicles, activities and impacts (Table 7). Roadway and motor vehicle travel data is widely collected, but other types of data are often incomplete. Comprehensive and multi-modal evaluation requires more detailed data on walking, cycling and public transit travel conditions, on latent demands for alternative modes (the amount people would walk, bike and use public transport if they were more convenient or affordable), and on the travel activity by people who are physically, economically and socially disadvantaged people.

Table 7 **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 Non-motorized travel 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, the old transport planning paradigm is *mobility-based*, it assumed that the planning goal is to maximize vehicle travel speeds. The new paradigm is *accessibility-based*, it recognizes that the ultimate goal of most transport activity is to access services and activities, and considers a wider range of accessibility factors, including the quality of various travel modes, transport network connectivity, geographic proximity (the distances between activities and therefore travel distances and time), and mobility substitutes such as telecommunications and delivery services. Accessibility-based planning recognizes that planning decisions often involve trade-offs between different forms of access, such as the tendency of wider roads and increased traffic speeds to create barriers to pedestrian travel, and the reduced accessibility that results from sprawled development patterns.

Consider Social Equity Impacts

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 whose ability to travel is constrained (for example, because they have an impairment) or who require extra transport (for example, because they are traveling with children).

Various indicators can be used to quantify equity impacts in a particular situation, such as the degree that a transport policy or project unjustifiably subsidizes a particular activity or group, and whether it provides savings and benefits to physically, economically or socially disadvantaged people.

Comprehensive Impact Analysis

Conventional transport evaluation quantifies and monetizes a limited set of impacts, primarily travel time, vehicle operating costs, and sometimes accident and emission rates. Other impacts, including parking and vehicle ownership costs, the quality of accessibility for non-drivers, public fitness are considered at all, are overlooked or described qualitatively. They are not generally included in formal economic evaluation, such as benefit cost or net benefit analysis, and so tend to receive much less consideration in the planning process.

Some of these omissions simply reflect tradition. Conventional transport project evaluation originally developed to evaluate roadway investments, such as comparing different highway route options. They generally assume that total vehicle ownership and trip generation rates are the same for each option. As a result, they are unsuited to evaluate alternative modes or demand management strategies which affect vehicle ownership and trips, for example, evaluating a major transit improvement that will allow some households to reduce their vehicle ownership, or a road toll that will encourage commuters to shifts from automobile to alternative modes, and so reduces employer parking costs.

Table 8 summarizes how various impacts are considered in conventional transport planning and how they could be evaluated better. 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 8 **Comprehensive Planning Objectives** (Litman 2010)

Impact	Consideration in Conventional Planning	Improvements for More Comprehensive Evaluation
User comfort and convenience, such as transit crowding, walking conditions, 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 non-motorized travel delays are generally ignored	Incorporate multi-modal performance 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., which ignores 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 fuel use per vehicle-km., which ignores additional consumption cause by induced vehicle 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 achieve physical activity targets by walking and cycling)	Not usually quantified	Develop indicators of walking and cycling activity, particularly by high risk groups (e.g., people who are overweight and sedentary)
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 Accurate Congestion Costing

Conventional planning often considers traffic congestion the largest urban transport problem, and congestion reduction is often the largest benefit of transport improvement projects, so how congestion costs are calculated can have significantly affect planning decisions. In fact, the methods used to quantify and monetize congestion costs are biased in various, often subtle ways that tend to exaggerate roadway expansion benefits and underestimate the benefits of improvements to alternative modes (Dumbauth 2012; Litman 2012). Table 9 summarizes various types of biases, their impacts on transport planning decisions and ways to rectify them.

Table 9 **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 automobile-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 congestion reductions 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.

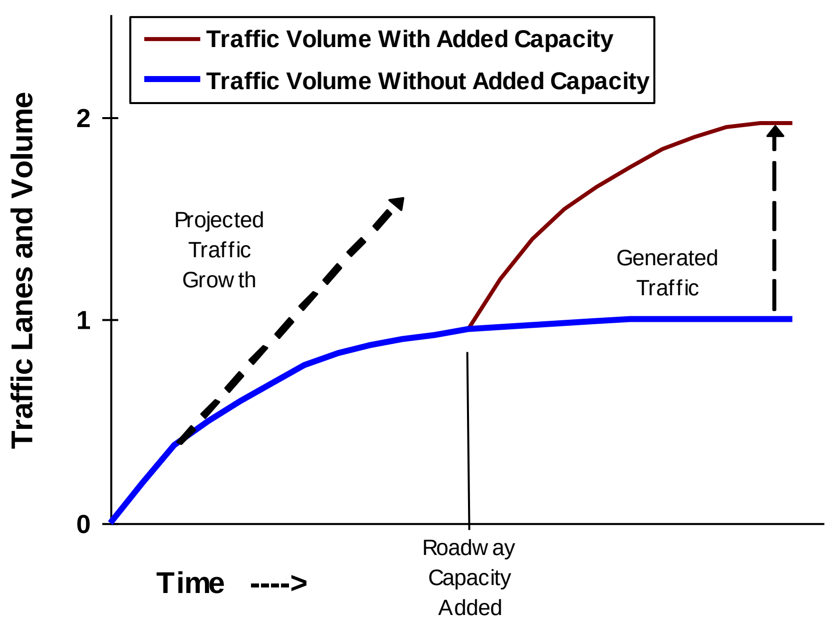
Account for Generated and Induced Travel Impacts

Generated Traffic is the additional vehicle travel that occurs when a roadway improvement increases traffic speeds or reduces vehicle operating costs (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. Generated traffic has three implications for transport planning:

1. Generated traffic reduces the predicted congestion reduction benefits of roadway expansion.
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).

Ignoring generated traffic and induced travel tends to overstate the benefits of roadway capacity expansion, and undervalues alternative modes and transportation demand management alternatives. Improved traffic models can account for generated and induced travel impacts. Comprehensive, multi-modal transport planning incorporates this information into project evaluation.

Figure 3 **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."

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. In recent years planning professional organizations have developed performance indicators for other modes, as indicated in Table 10. These can be used to identify problems, evaluate trade-offs between options (for example, if roadway expansion reduces walkability), set targets, and measure progress.

Table 10 **Performance Indicators for Various Modes**

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 Diverse Transport Improvement Options

Conventional transport planning tends to consider a relatively limited set of transport system improvement options, which typically consist of various roadway expansions and major new public transit services. More comprehensive and multi-modal planning considers additional options including non-motorized facility improvements, incremental transit service improvements, various transportation demand management strategies, and smart growth development policies. Table 11 compares the types of strategies considered by conventional and comprehensive transport planning. These strategies often have synergistic effects (they are more effective implemented together than individually) and so they should generally be planned and evaluated as integrated programs.

Table 11 **Transport System Improvement Options Considered**

Conventional	Comprehensive and Multi-Modal
Roadway expansion Parking facility requirements and subsidies Rail transit	Pedestrian and cycling improvements and encouragement programs Incremental public transit improvements HOV lanes, bus lanes and bus rapid transit (BRT) programs Efficient parking pricing and management Congestion tolls Increased fuel taxes Distance-based insurance and registration fees Commute trip reduction and mobility management marketing programs Complete streets policies Smart growth land use policies

Comprehensive evaluation expands the types of transport system improvements considered.

Transport Modeling Improvements

Transport models predict how specific policy and planning decisions will affect future travel activity. Most older transportation models primarily reflected vehicle traffic conditions. 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. For example, these models can quantify the number of stores or jobs available within 20-minute travel time by walking, cycling, public transit and automobile. Some of these models take into account actual walking, cycling and public transit travel conditions, including the quality of sidewalks, crosswalks, paths, hills and crowding.

Explicitly Indicate Omissions and Biases

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

Funding 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.

Complete Streets Planning

Comprehensive and multi-modal planning supports *complete streets* planning (also called *streetscaping* and *road diets*), which refers to roads designed to accommodate diverse modes, users and activities including walking, cycling, public transit, automobile, nearby businesses and residents (Burden and Litman 2011; McCann 2013). This typically involves reducing motor vehicle traffic speeds, improving sidewalks and crosswalks, and adding bike lanes, bus lanes, bus shelters and other street furniture, which helps create more multi-modal transport systems and more livable communities.

Stakeholder Involvement

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 planning tends to evaluate transport system performance based primarily on automobile travel conditions using indicators such as average traffic speeds and roadway level-of-service. It gives less consideration to other modes (walking, cycling and public transport), accessibility factors (roadway connectivity and geographic proximity), other planning objectives, or other impacts. It ignores many walking, cycling and public transit benefits, and many costs that result from increased motor vehicle travel. It is therefore unsuited for evaluating multiple modes and transportation demand management strategies.

Many of these biases are subtle and technical, based on how travel demand is measured and potential transport improvement options are evaluated. People usually believe statements by transportation agencies, such as "95% of all trips are by automobile," "in Los Angeles traffic congestion $10,999 million annually," or "this highway expansion project will provide $3.74 billion in net benefits," yet, such statements are often incomplete. Non-motorized travel is more common than reported by most travel surveys, congestion costs are actually smaller than commonly-used methodologies estimate, and highway expansion net benefits are often overestimated by ignoring generated traffic and induced travel impacts. Described differently, improving transport system diversity, transportation demand management strategies, and smart growth development policies often provide 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 sustainable development objectives such as resource conservation, affordability, economic opportunity, habitat preservation, pollution emission reductions, and improved public fitness and health. It also tends to be unfair and regressive because it favors motorists, who generally have higher average incomes, over non-motorists who include many physically, economically and socially disadvantaged people.

Many planning professionals are working to correct these biases. A new planning paradigm requires more comprehensive and multi-modal evaluation, which considers a wider range of planning objectives, impacts and options, as summarized in Table 12. More comprehensive evaluation helps identify truly optimal transport improvement options, considering all impacts. It can help avoid conflicts between planning objectives, and identify *win-win* strategies that provide multiple benefits, and so can help build cooperation between stakeholders with different goals and priorities.

Table 12 **Reforms for More Comprehensive and Multi-modal Evaluation**

Problems With Existing Evaluation Methods	Reforms For More Comprehensive Evaluation
Inadequate data on alternative mode (walking, cycling and public transport) activity and demands.	Collect more comprehensive data on travel activity and demands, particularly for non-motorized travel
Mobility-based analysis, which evaluates transport system performance based primarily on motor vehicle travel speeds, which ignores the ways that planning decisions that favor automobile travel can reduce accessibility in other ways	Use accessibility-based analysis which considers various modes, transport network connectivity and affordability, land use accessibility, and mobility substitutes, and therefore trade-offs between different accessibility factors
Conventional traffic modeling provides little guidance on how qualitative improvements and land use policy changes affect transport system performance	Improve modeling to better reflect how policy and planning changes will affect travel activity
Economic evaluation primarily measures per-mile travel time, operating costs, crash and emission rates	Consider all significant economic, social and environmental impacts
Analysis uses exaggerated congestion cost estimates	Use best practices when calculating congestion costs and congestion reduction benefits
Evaluates transport system performance using roadway level-of-service, which only reflects motor vehicle travel speeds and congestion delay	Use multi-faceted, multi-modal level-of-service indicators which recognize the speed, convenience and comfort of various modes
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
Ignores equity impacts, including the unfairness of planning that favors motorists over non-motorizes and fails to provide basic mobility for disadvantaged people	Use comprehensive evaluation of equity impacts, including horizontal and vertical equity
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
Inadequate understanding by decision-makers of evaluation omissions and biases	Describe to decision-makers any potential evaluation process 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 decisions
Planning is constrained in ways that favor roadways, parking facilities and large transit projects, even if alternatives are more cost effective overall	Allow transport resources (money and road space) to be spent on the most cost effective solutions, considering all benefits and costs, including alternative modes and demand management strategies.

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

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.

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