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Toward More Comprehensive and Multi-modal Transport Evaluation

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Todd Litman

Victoria Transport Policy Institute

Abstract

This report critically evaluates transport policy and project evaluation practices, and describes ways to make them more comprehensive and multi-modal. The conventional transport planning paradigm is *mobility-based*, it assumes that the planning objective is to maximize travel speed and distance, and evaluates transport system performance based primarily on automobile travel conditions. A new paradigm recognizes that mobility is seldom an end in itself and 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 expands the range of objectives, impacts and options considered in the planning process, and recognizes additional costs from increased motorized transportation and more benefits from walking, cycling and public transport. More comprehensive and multi-modal planning 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.

Introduction

Transportation policy and planning decisions can have diverse impacts (benefits and costs), including many that are indirect and external (imposed on non-users). Conventional transport evaluation tends to overlook and undervalue many impacts. Many of these omissions and biases are subtle, based on how problems are defined, and the technical methods used to measure impacts and evaluate solution. More comprehensive and multi-modal evaluation can help determine truly optimal solutions, considering all impacts.

This is a timely issue. A *paradigm shift* (a fundamental change in the way problems are defined and solutions evaluated) is occurring in the transport planning field (ADB 2009; Litman and Burwell 2006). The old paradigm assumed that *transportation* refers simply to *mobility* (physical travel), the new paradigm recognizes that the ultimate goal of most transport is *accessibility* (people's ability to reach desired services and activities), and that many factors can affect accessibility including the quality of mobility options, transport network connectivity, the geographic distribution of activities, and mobility substitutes such as telecommunications and delivery services. The new paradigm recognizes that planning decisions often involves tradeoffs between different types of access, for example, if roadway expansion improves motor vehicle access but reduces non-motorized access, or when choosing between an urban fringe location that is convenient to access by car, or a city center location convenient for access by other modes.

The new planning paradigm expands the range of objectives, impacts and options considered in transport planning. It recognizes that planning must optimize for multiple objectives and consider various economic, social and environmental impacts. It applies more comprehensive and multi-modal transport system performance indicators. It expands the range of potential solutions to include improvements to alternative modem transportation demand management (TDM) strategies and smart growth development policies. This helps identify *win-win* solutions that help achieve multiple objectives; for example, congestion reduction strategies that also helps reduce parking problems, increases affordability, or improves access for non-drivers over other congestion reduction strategies that have fewer co-benefits. Table 1 compares the old and new paradigms.

The new planning paradigm is particularly appropriate 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 important objectives.

Table 1 **Changing Transport Planning Paradigm** (ADB 2009; Litman and Burwell 2006)

	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, telecommunications 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; reduced crash, energy consumption and emission rates per capita; improved 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 transportation improvements. The new planning paradigm expands the range of objectives, impacts and options considered.

Critique of Conventional Transport Evaluation

The conventional transportation planning process begins with travel surveys that collect information on travel activity, which is used to estimate *travel demands* (how and how much people want to travel). Such surveys tend to undercount non-motorized travel because they often undercount shorter trips, off-peak trips, non-work trips, travel by children, recreational travel (ABW 2010; Stopher and Greaves 2007). They often ignore non-motorized links of motor vehicle trips, for example, a *bike-transit-walk* trip is usually coded simply as a *transit* trip, and a motorist who walks several blocks from their parked car to a destination is simply considered an automobile user. Non-motorized travel is typically three to six times more common than such surveys report, so if statistics indicate that only 5% of trips are non-motorized, the actual amount is probably 15-30% (Forsyth, Krizek and Agrawal 2010; Pike 2011).

Conventional transport planning evaluates transport system performance based primarily on motor vehicle traffic speeds and congestion delays, measured using roadway level-of-service (LOS), a rating from A (best) to F (worst), as indicated in Table 2.

Table 2 **Roadway Level-Of-Service (LOS) Ratings** (Wikipedia)

LOS	Description	Speed (mph)	Flow (veh./hour/lane)	Density (veh./mile)
A	Traffic flows at or above the posted speed limit and all motorists have complete mobility between lanes.	Over 60	Under 700	Under 12
B	Slightly congested, with some impingement of maneuverability. Two motorists might be forced to drive side by side, limiting lane changes.	57-60	700-1,100	12-20
C	Ability to pass or change lanes is not assured. Most experienced drivers are comfortable, and posted speed is maintained, but roads are close to capacity. This is often the target LOS for urban highways.	54-57	1,100-1,550	20-30
D	Typical of an urban highway during commuting hours. Speeds are somewhat reduced, motorists are hemmed in by other cars and trucks.	46-54	1,550-1,850	30-42
E	Flow becomes irregular and speed varies rapidly, but rarely reaches the posted limit. On highways this is consistent with a road over its designed capacity.	30-46	1,850-2,000	42-67
F	Flow is forced; every vehicle moves in lockstep with the vehicle in front of it, with frequent drops in speed to nearly zero mph. A road for which the travel time cannot be predicted.	Under 30	Unstable	67-Maximum

This table summarizes roadway Level of Service (LOS) rating. These only account for motor vehicle traffic speeds and congestion delay. Other modes and impacts are often ignored.

Future traffic conditions are predicted using a four-step model, which follows these steps:

1. *Trip generation.* Predict total trips that start and end in a particular area (called *Traffic Analysis Zones* or TAZs), based on factors such as each zone's land use patterns, number of residents and jobs, demographics and transport system features (number of roads, quality of transit service, etc.).
2. *Trip distribution.* Trips are distributed between pairs of zones, based on the distance between them.
3. *Mode share.* Trips are allocated among the available modes (usually auto and transit).
4. *Route assignment.* Trips are assigned to specific road and transit routes.

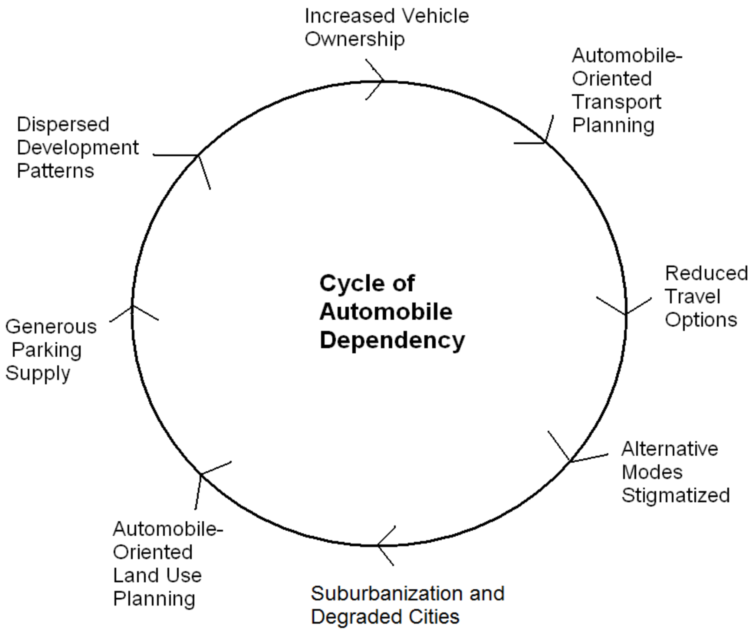
These modeling results are used to predict future traffic congestion problems and prioritize transport system improvements. Transport planning agencies often produce maps showing current and projected future peak-period vehicle traffic speeds and roadway level of service ratings, color coded to highlight those that that the have LOS ratings D or worse. These road segments are considered to *fail* and therefore require improvement, which often involves expansion. Economic evaluation models, such as MicroBenCost and HDM-4, are used to calculate the value of motorists' travel time and vehicle operating cost savings from roadway expansions. The results are reported as a benefit/cost ratio or net benefits, often with several significant digits implying a high degree of accuracy.

This process seems logical and rational, but it is actually incomplete and biased for the following reasons:

- It undercounts non-motorized travel activity, and so tends to undervalue these modes.
- It provides little information on demand for alternative modes, such as how walking and cycling improvements, and land use policy changes, would affect travel activity. It often gives little consideration to the travel demands of physically, economically and socially disadvantaged people who rely primarily on non-automobile modes.
- It reflects *mobility*- rather than *accessibility-based* planning and so fails to consider trade-offs between different types of accessibility, such as when wider roads and increased traffic speeds reduce pedestrian access, and therefore public transit access since most transit trips involve walking links, and if expanding urban road, and their noise, air pollution and risk stimulates more dispersed urban fringe development.
- It evaluates transport system performance based primarily on motorized travel conditions, with little consideration to other modes. It highlights automobile travel level-of-service but provides no comparable ratings for other modes.
- It tends to overlook or underestimate *generated traffic* (additional peak-period traffic) and *induced travel* (net increases in total vehicle travel in an area) impacts, which exaggerates roadway expansion benefits and underestimates the benefits of alternative congestion reduction strategies.
- It only quantifies (measures) and monetizes (measures in monetary units) a limited set of impacts, which typically include travel time, vehicle operating costs, crash and emission rates. It tends to overlook other important impacts including parking costs, vehicle ownership costs, noise costs, barrier effect costs (the delay that wider roads and increased vehcile travel impose on pedestrians), and sprawl-related costs.
- The methods used to monetize congestion often exaggerate this cost. Travelers' actual willingness-to-pay is generally much lower than these estimates claim.
- It fails to account for social equity objectives, such as the quality of accessibility options for physically and economically disadvantaged people, and affordability (costs savings to lower-income people). By favoring automobile travel over over more affordable modes conventional planning is regressive (it imposes excessive costs on lower-income people).
- The evaluation process is mechanistic and difficult to understand. People who use the analysis results often have little idea of their omissions, biases and uncertainties, nor the tendency of such planning to create self-fulfilling prophecies by encouraging automobile travel to the detriment of other modes.
- Affected people often have little opportunity to influence decisions. Information about the planning process and opportunities for stakeholder involvement are often limited, particularly for physically, economically and socially disadvantaged people.

The conventional transport planning process reflects *predict and provide* planning, in which projected motor vehicle traffic growth justifies policies and projects 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 1.

Figure 1 **Cycle of Automobile Dependency** (Litman, 2004)



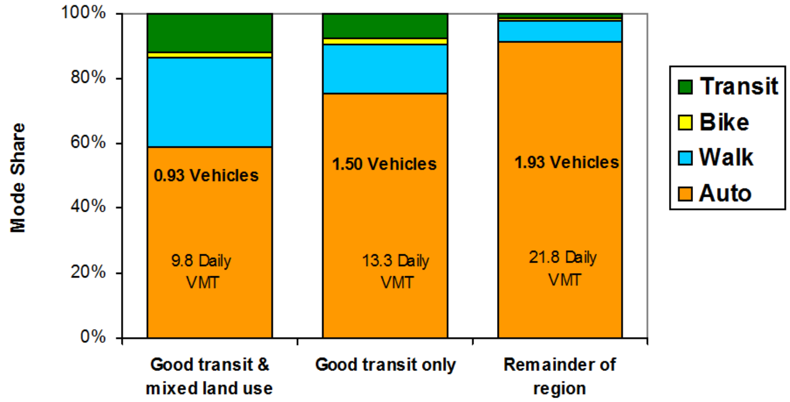
Many common planning practices contributed to a cycle of automobile dependency and sprawl. These tend to reduce the supply of affordable housing in compact, mixed, walkable and transit oriented communities.

Conventional planning does not totally ignore walking, cycling and public transport, but they tend to be undervalued in monetized economic evaluation. To their credit, planners and decision-makers often support non-automobile improvements more than justified by economic evaluation results; they know intuitively that these modes play important roles in an equitable and efficient transport system that are not reflected in conventional planning, but this occurs despite rather than supported by their evaluation process. More comprehensive and multi-modal planning usually results in very different decisions because it recognizes additional costs of automobile dependency and additional benefits from a more diverse and resource-efficient transport system.

For many years transport planning practices that favored automobile travel were justified on the assumption that they helped create modern, efficient transport systems. This assumption is often wrong. Although a modern and efficient transport system requires a certain amount of motor vehicle travel, and so justifies some investments in paved roads and parking facilities, this should be limited and carefully evaluated. A key insight of the new planning paradigm is that efficient transport requires diverse transport options and appropriate incentives so travelers will choose the most cost-effective mode for each trip, considering all impacts, which includes walking and cycling for local errands, public transit for traveling on busy urban corridors, and mobility substitutes (telecommunications and delivery services) when cost effective. The world's most modern, affluent and livable cities such as London, New York and Singapore have low automobile mode shares and high reliance on walking, cycling and public transport.

Even in affluent cities, residents of walkable neighborhoods with good public transit service own fewer motor vehicles, drive much less, and rely more on alternative modes than in automobile-dependent, sprawled communities, as illustrated in Figure 2.

Figure 2 **TOD Impacts On Vehicle Ownership and Use** (Portland 2009)



Residents of walkable, mixed-use neighborhoods with good transit tend to own fewer vehicles, drive less and use alternative modes more than in automobile-oriented communities. "Daily VMT" indicates average daily vehicle miles traveled per capita.

The conventional evaluation process was designed to evaluate intercity highway projects, where there are minimal external impacts or effective alternatives to automobile travel. More comprehensive and multi-modal evaluation is needed for:

- Urban transport planning, where wider roads and increased motor vehicle travel may impose significant external and indirect costs.
- Planning decisions that involve trade-offs between different tranpsort modes, such as when choosing between roadway or transit improvements.
- Transport planning decisions that may affect land use development patterns, such as where a highway or public transit improvement may stimulate urban fringe development, new industrial activity, or a new tourist resort.

A Planning Framework
The first step in a planning process is to produce a *workplan* which describes the *planning framework* that will be used. This should define the following:

- *Goals* – What the planning process ultimately wants to achieve.
- *Objectives* – Specific, potentially measurable ways to achieve goals.
- *Scope* – The range (area, time, population, etc.) that will be considered.
- *Stakeholders* – people who will be consulted during the process.
- *Evaluation methodology* – The process that will be used to value and compare options.
- *Evaluation criteria* – The impacts (costs and benefits) considered in an analysis.
- *Performance indicators* – Practical ways to measure progress toward objectives.
- *Tasks and responsibilities* – What will be accomplished and by whom.
- *Schedule* – When each task will be accomplished.
- *Budget* – The resources that will be provided to accomplish each task.

Comprehensive and Multi-modal Planning Practices

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

More Comprehensive Travel Activity and Demand Data

Comprehensive and multi-modal evaluation needs detailed information on travel activity and demands. This requires travel surveys which account for short trips, off-peak and non-commute travel, children's travel, and non-motorized links of trips that involve motorized modes. Special efforts are needed to collect comprehensive travel data from physically, economically and socially disadvantaged people, many of whom have no telephones or regular mailing addresses, and for freight, tourist and recreational travel. It is also important to improve data on latent demands for alternative modes (the amount people would walk, bike and use public transport if they were more convenient or affordable), barriers to the use of these modes, and how travelers would respond to various transport system changes. This can be collected through improved travel surveys, targeted research, and case studies of transport system changes.

Shift from Mobility- to Accessibility-based Transport Planning

As previously discussed, the old transport planning paradigm was *mobility-based*, it assumed that the planning goal is to maximize the speed and distance that people can travel within their time and money budgets. The new paradigm is *accessibility-based*, it recognzies that the ultimate goal of most transport activity is to access services and activities, and that various factors can affect overall accessibility (see box below), and that planning decisions often involve trade-offs between different types of access.

Factors Affecting Accessibility

- *Mobility options*, the speed, quality and affordability of physical travel. This can include various modes including walking, cycling, public transit, ridesharing, taxi, automobiles, etc.
- *Transport network connectivity*, which refers to the directness of links in path or road networks, and the quality of connections between modes.
- *Land use patterns*, that is, the geographic distribution of activities and destinations.
- *Mobility Substitutes*, such as telecommunications and delivery services.

Shifting from mobility- to accessibility-based planning substantially changes the evaluation process. For example, mobility-based planning tends to evaluate transport system performance based on vehicle traffic speeds and so considers traffic congestion a major problem; accessibility-based planning considers other impacts and modes, and so recognizes that traffic congestion is not a major problem if other accessibility options are convenient and affordable, for example, if commonly-used services are nearby and commuters can use high quality public transit. 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.

Transport Modeling Improvements

Transport models predict how specific policy and planning decisions will affect future travel activity. There may be several steps between a particular decision and its ultimate impacts, as illustrated in the box below.

Policy and Planning Decision
(infrastructure investment, zoning, development charges, utility fees, etc.)
↓
Land Use Patterns
(location, density, mix, connectivity, parking supply, etc.)
↓ ↓

Land Use Impacts
(Impervious surface coverage, greenspace, public service costs)
↓

Travel Behavior
(amount and type of walking, cycling, public transit and automobile travel)
↓

Economic, Social and Environmental Impacts
(consumer costs, public service costs, crashes, pollution emissions, physical fitness, etc.)

There may be several steps between a planning decision, its land use and travel behavior impacts, and its ultimate economic, social and environmental impacts.

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, corsswalks, paths, hills and crowding.

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 3 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 3 **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 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 4 summarizes various types of biases, their impacts on transport planning decisions and ways to correct them.

Table 4 **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.

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 5. 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 5 **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.

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. Over the long run, generated traffic often fills a significant portion (50-90%) of added urban roadway capacity. Geneated traffic has three implications for tranpsort 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.

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 tranpsortation 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, measning 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.

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 6 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 6 Transport System Improvement Options Considered

Conventional	Comprehensive and Multi-Modal
Roadway expansion	Pedestrian and cycling improvement and encouragement programs
Parking facility requirements and subsidies	Incremental public transit improvements
Rail transit	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.

Explicitly Indicate Omissions and Biases

Conventional the transport planning often reports analysis results with an unjustifed degreee 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.

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.

Conclusion

The process commonly used to evaluate transport problems and prioritize improvements is incomplete and biased. It evaluates transport system performance based primarily on automobile travel speeds. It does not account for many of the costs that result from increased motor vehicle travel nor many of the benefits of increasing transport system efficiency and improving transport options. 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 in 2010," or "this highway expansion project will provide $3.74 billion in net benefits," yet, such statements are incomplete and biased. Non-motorized trips are actually much 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 the effects of generated traffic and induced travel. Described differently, improving alternative modes, transportation demand management strategies, and smart growth land use policies usually 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 tend to 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 7. 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 7 **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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