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Introduction to Multi-Modal Transportation Planning

Principles and Practices

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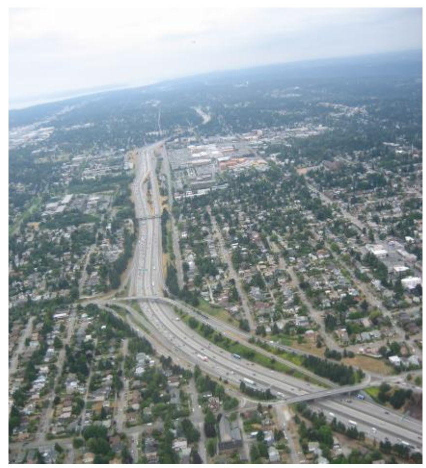

Abstract

This report summarizes basic principles for transportation planning. It describes conventional transport planning, which tends to focus on motor vehicle traffic conditions, and newer methods for more multi-modal planning and evaluation.

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Introduction

To be efficient and fair a transportation system must serve diverse demands. For example, would be inefficient if inadequate sidewalks and paths force parents to chauffeur children to local destinations to which they would rather walk or bicycle, or if inadequate mobility options force urban commuters to drive although they would prefer to rideshare or use transit. Physically, economically and socially disadvantaged people in particular need diverse mobility options: walking and cycling for local travel, public transit for longer trips, and automobiles (ridesharing, chauffeuring and taxi travel) when necessary. As a result, to be efficient and fair transportation must be multimodal.

Before about 1940, walking, bicycling and public transit were recognized as important travel modes, but for most of the last century transport planning was automobile-oriented. As a result, most communities now have well developed road systems that allow motorists to drive to most destinations with relative convenience and safety; at worst they may be delayed by peak period congestion, and pay tolls and parking fees at some destinations. However, such planning ignored non-automobile travel demands, such as those in the following box.

Non-Automobile Travel Demands

- Youths 10-20 (10-30% of population).
- Seniors who do not or should not drive (5-15%).
- Adults unable to drive due to disability (3-5%).
- Lower income households burdened by vehicle expenses (15-30%).
- Law-abiding drinkers, and other impaired people (a small but important demand to serve).
- Community visitors who lack a vehicle or driver's license.
- People who want to walk or bike for enjoyment and health.
- Drivers who want to avoid chauffeuring burdens.
- Residents who want reduced congestion, accidents and pollution emissions.

Of course, not everybody uses all travel options, but most communities include people who need each one. For example, not everybody uses public transit or needs universal design features such as curbcuts and ramps, but most communities include some people who require them to travel independently, and most people will need them sometime in their lives. As a result, even people who don't currently use a particular mode may value having it in their community, similar to lifeboats on a ship that are seldom used but important to have available; called *option value*.

Travel demands, and therefore the value of more multimodal planning, can be evaluated from different perspectives. The narrowest only counts people who currently depend on a particular mode. However, this often reflects a self-fulfilling prophecy: underinvestment in these modes makes them difficult to use. A broader perspective also considers occasional users, and latent demand (potential walking, cycling and public transit trips that could be made if their conditions were improved), external impacts (benefits to other people when travellers can walk, bicycle and use public transit rather than drive) and strategic community objectives (reduced traffic and parking congestion, affordability, improved mobility for non-drivers, etc.). These tend to justify more multimodal planning. As a result, many people around the world increasingly recognize the diversity of travel demands and the importance of more multimodal planning.

This report examines these issues. It discusses various travel demands, and how multimodal transportation planning can effectively respond to those demands.

Multimodal Planning Concepts

Multi-modal planning refers to planning that considers various modes (walking, cycling, automobile, public transit, etc.) and connections among modes.

There are several specific types of transport planning which reflect various scales and objectives:

- *Traffic impact studies* evaluate traffic impacts and mitigation strategies for a particular development or project.
- *Local transport planning* develops municipal and neighborhood transport plans.
- *Regional transportation planning* develops plans for a metropolitan region.
- *State, provincial and national transportation planning* develops plans for a large jurisdiction, to be implemented by a transportation agency.
- *Strategic transportation plans* develop long-range plans, typically 20-40 years into the future.
- *Transportation improvement plans (TIPs)* or *action plans* identify specific projects and programs to be implemented within a few years.
- *Corridor transportation plans* identify projects and programs to be implemented on a specific corridor, such as along a particular highway, bridge or route.
- *Mode- or area-specific transport plans* identify ways to improve a particular mode (walking, cycling, public transit, etc.) or area (a campus, downtown, industrial park, etc.).

Figure 1 **Transport Planning Process** (FHWA and FTA, 2007)

A transport planning process typically includes the following steps:

- Monitor existing conditions.
- Forecast future population and employment growth, and identify major growth corridors.
- Identify current and projected future transport problems and needs, and various projects and strategies to address those needs.
- Evaluate and prioritize potential improvement projects and strategies.
- Develop long-range plans and short-range programs identifying specific capital projects and operational strategies.
- Develop a financial plan for implementing the selected projects and strategies.

Conventional transportation evaluation tends to focus on certain impacts, as summarized in Table 1. Commonly-used transport economic evaluation models, such as *MicroBenCost*, were designed for highway project evaluation, assuming that total vehicle travel is unaffected and is unsuitable for evaluating projects that include alternative modes or demand management strategies.

Table 1 **Impacts Considered and Overlooked**

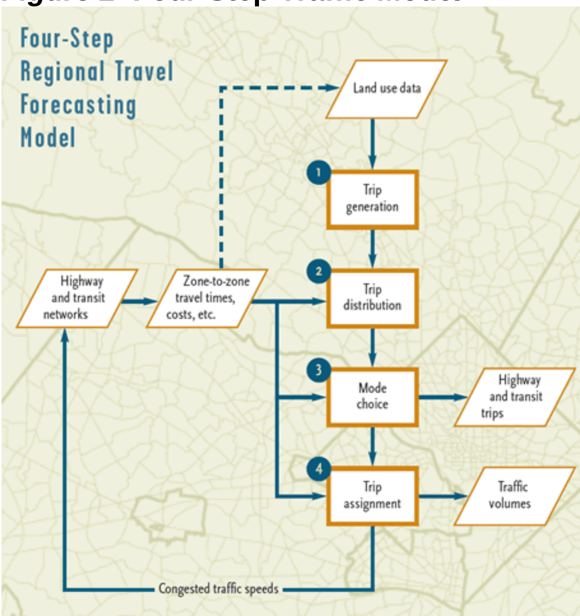
Usually Considered	Often Overlooked
	Generated traffic and induced travel impacts
	Downstream congestion
	Impacts on non-motorized travel (barrier effects)
	Parking costs
	Vehicle ownership and mileage-based depreciation costs.
	Project construction traffic delays
	Indirect environmental impacts
	Strategic land use impacts (sprawl versus smart growth)
Financial costs to governments	Transportation diversity and equity impacts
Vehicle operating costs (fuel, tolls, tire wear)	Per-capita crash risk
Travel time (reduced congestion)	Public fitness and health impacts
Per-mile crash risk	Travelers' preferences for alternative modes (e.g., for walking and cycling)
Project construction environmental impacts	

Conventional transportation planning tends to focus on a limited set of impacts. Other impacts tend to be overlooked because they are relatively difficult to quantify (e.g., equity, indirect environmental impacts), or simply out of tradition (e.g., parking costs, vehicle ownership costs, construction delays).

Conventional transportation planning strives to maximize traffic speeds, minimize congestion and reduce distance-based crash rates using a well-developed set of engineering, modeling and financing tools. Many jurisdictions codify these objectives in *concurrency requirements* and *traffic impact fees*, which require developers to finance roadway capacity expansion to offset any increase in local traffic. Alternatives to roadway expansion, such as *transportation demand management* and *multi-modal* transport planning, are newer and so have fewer analysis tools. As a result, conventional planning practices support *automobile dependency*, which refers to transport and land use patterns favoring automobile travel over alternative modes (in this case, *automobile* includes cars, vans, light trucks, SUVs and motorcycles).

In recent years transportation planning has expanded to include more emphasis on non-automobile modes and more consideration of factors such as environmental impacts and mobility for non-drivers. In recent decades many *highway agencies* have been renamed *transportation agencies*, and have added capacity related to environmental analysis, community involvement and nonmotorized planning. Some are applying more comprehensive and multi-modal evaluation (Litman 2012). Transport modeling techniques are improving to account for a wider range of options (such as alternative modes and pricing incentives) and impacts (such as pollution emissions and land use effects). In addition, an increasing portion of transport funds are flexible, meaning that they can be spent on a variety of types of programs and projects rather than just roadways.

***Figure 2* Four-Step Traffic Model**



www.mwcog.org/transportation/activities/models/4_step.asp

Most regions use *four-step models* to predict future transport conditions (see Figure 2). The region is divided into numerous *transportation analysis zones* (TAZs) each containing a few hundred to a few thousand residents. *Trip generation* (the number and types of trips originating from each TAZ) is predicted based on generic values adjusted based on local travel surveys that count zone-to-zone peak-period trips. These trips are assigned destinations, modes and routes based on their *generalized costs* (combined time and financial costs), with more trips assigned to relatively cheaper routes and modes, taking into account factors such as travel speeds, congestion delays and parking costs. Transport models are being improved in various ways to better predict future travel activity, including the effects of various transport and land use management strategies.

This predicts future peak-period traffic volumes on each route, and identifies where volumes will exceed capacity (based on the *volume/capacity ratio* or *V/C*) of specific roadway links and intersections. The intensity of congestion on major roadways is evaluated using *level-of-service* (LOS) ratings, a grade from *A* (best) to *F* (worst).

Table 2 summarizes highway LOS ratings. Similar ratings are defined for arterial streets and intersections. Roadway level-of-service is widely used to identify traffic problems and evaluate potential roadway improvements. Figure 3 illustrates a typical model output: a map showing LOS ratings of major regional roadways.

Figure 3 **Highway LOS Map** (PSRC 2008)

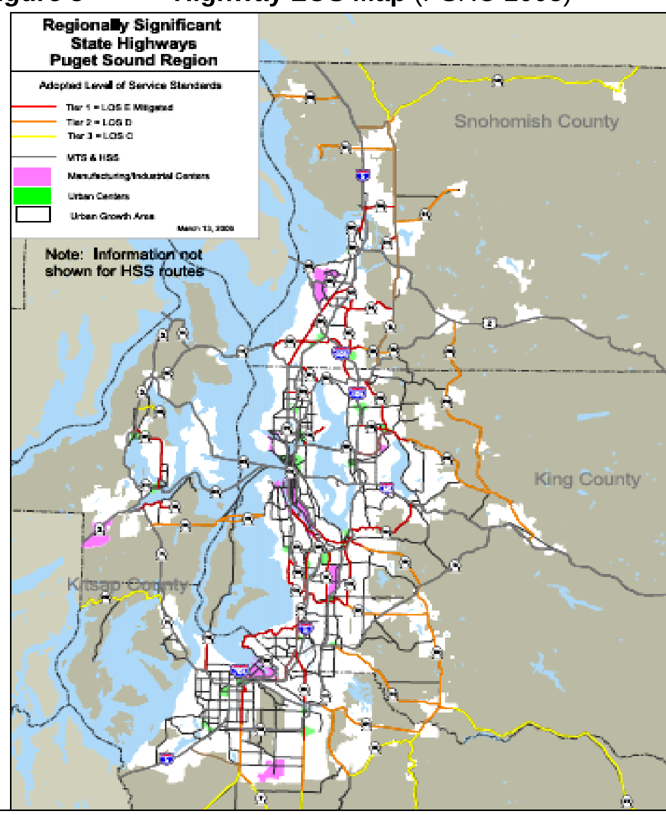


Table 2 **Highway Level-Of-Service (LOS) Ratings** (Wikipedia)

LOS	Description	Speed (mph)	Flow (veh./hour/lane)	Density (veh./mile)
A	Traffic flows at or above posted speed limit. 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 the target LOS for most 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, with frequent drops in speed to nearly zero mph. Travel time is unpredictable.	Under 30	Unstable	67-Maximum

This table summarizes highway Level of Service (LOS) rating, an indicator of congestion intensity.

Under optimal conditions a grade separated highway can carry up to 2,200 vehicles per hour (VPH) per lane, and an arterial with intersections about half that. Table 3 indicates commonly used traffic measurement units. These are generally measured during *peak hours*. Speed is generally based on the *85th percentile* (the speed below which 85% of vehicles travel). Traffic volumes are also sometimes measured as *Annual Average Daily Traffic* (AADT).

Table 3 **Basic Traffic Units**

Parameter	Typical Units	Reciprocal	Typical Units
Flow	Vehicles per hour (Veh/h)	Headway	Seconds per vehicle (s/veh)
Speed	Kilometers or miles per hour (Km/h)	Travel time	Seconds per km or mi (s/km)
Density	Vehicles per lane-km or mi (veh/lane-km)	Spacing	Feet or meters per vehicle (m/veh)

This table summarizes units commonly used to measure vehicle traffic.

<u>Terms and Concepts</u>

- Traffic congestion can be *recurrent* (occurs daily, weekly or annually, making it easier to manage) or *non-recurrent* (typically due to accidents, special events or road closures).
- *Design vehicle* refers to the largest vehicle a roadway is designed to accommodate. *Passenger Car Equivalents* (PCE) indicate a larger vehicle's traffic imapcts compared with a typical car.
- A *queue* is a line of waiting vehicles (for example, at an intersection). A *platoon* is group of vehicles moving together (such as after traffic signals turn green).
- *Capacity* refers to the number of people or vehicles that could be accommodated. *Load factor* refers to the portion of capacity that is actually used. For example, a load factor of 0.85 indicates that 85% of the maximum capacity is actually occupied.

A typical transport planning process defines the minimum level-of-service considered acceptable (typically LOS C or D). Roads that exceed this are considered to *fail* and so deserve expansion or other interventions. This approach is criticized on these grounds:

- It focuses primarily on motor vehicle travel conditions. It assumes that transportation generally consists of automobile travel, often giving little consideration to travel conditions experienced by other modes. As a result, it tends to result in automobile dependency, reducing modal diversity.
- It defines transportation problems primarily as traffic congestion, ignoring other types of problems such as inadequate mobility for non-drivers, the cost burden of vehicle ownership to consumers and parking costs to businesses, accident risk, and undesirable social and environmental impacts.
- It ignores the tendency of traffic congestion to maintain equilibrium (as congestion increases, traffic demand on a corridor stops growing), and the impacts of *generated traffic* (additional peak-period vehicle travel that results from expanded congested roadways) and *induced travel* (total increases in vehicle travel that result from expanded congested roadways). As a result, it exaggerates the degree of future traffic congestion problems, the congestion reduction benefits of expanding roads, and the increased external costs that can result from expanding congested roadways.
- It can create a self-fulfilling prophecy by directing resources primarily toward roadway expansion at the expense of other modes (widening roads and increasing traffic speeds and volumes tends to degrade walking and cycling conditions, and often leaves little money or road space for improving other modes).
- Short trips (within TAZs), travel by children, off-peak travel and recreational travel are often ignored or undercounted in travel surveys and other statistics, resulting in walking and cycling being undervalued in planning.

In recent years transportation planning has become more multi-modal and comprehensive, considering a wider range of options and impacts. Transport planners have started to apply Level-of-Service ratings to walking, cycling and public transit, and to consider demand management strategies as alternatives to roadway capacity expansion.

Green Transportation Hierarchy

1. Pedestrians
2. Bicycles
3. Public transportation
4. Service and freight vehicles
5. Taxis
6. Multiple occupant vehicles (carpools)
7. Single occupant vehicles

The Green Transportation Hierarchy favors more affordable and efficient (in terms of space, energy and other costs) modes.

Some urban areas have established a transportation hierarchy which states that more resource efficient modes will be given priority over single occupant automobile travel, particularly on congested urban corridors. This provides a basis for shifting emphasis in transport planning, road space allocation, funding and pricing to favor more efficient modes.

Multimodal Transportation Planning

Multmodal planning refers to transportation and land use planning that considers diverse transportation options, typically including walking, cycling, public transit and automobile, and accounts for land use factors that affect accessibility. A growing body of resources are being developed for multimodal planning (Williams, Claridge and Carroll 2016).

Multimodal transportation accounts for the differing capabilities of different modes, including their availability, speed, density, costs, limitations, and therefore their most appropriate uses (Table 4).

Table 4 Mode Profiles

Mode	Availability	Speed	Density	Loads	Costs	Potential Users			Limitations
	Times and locations served	typical speeds	space needed	carrying capacity	user costs	Non-Drivers	Poor	Handi-capped	
Walking	Wide (nearly universal)	2-5 mph	High	Small	Low	Yes	Yes	Varies	Requires physical ability. Limited distance and carrying capacity. May be difficult or unsafe to use.
Wheelchair	Limited (requires suitable facilities)	2-5 mph	Medium	Small	Med.	Yes	Yes	Yes	Requires suitable sidewalk or path. Limited distance and carrying capacity.
Bicycle	Wide (feasible on most roads and paths)	5-15 mph	Medium	Small to medium	Med.	Yes	Yes	Varies	Requires bicycle and ability. Limited distance and carrying capacity.
Taxi	Moderate (in most urban areas)	20-60 mph	Low	Medium	High	Yes	Limited	Yes	High costs and limited availability.
Fixed Route Transit	Limited (major urban areas)	20-40 mph	High	Small	Med.	Yes	Yes	Yes	Limited availability. Sometimes difficult to use.
Paratransit	Limited	10-30 mph	Medium	Small	High	Yes	Yes	Yes	High cost and limited service.
Auto driver	Wide (nearly universal)	20-60 mph	Low	Medium to large	High	No	Limited	Varies	Requires driving ability and automobile. Costly.
Ridesharing (auto passenger)	Limited (only suited for some trips)	20-60 mph	High	Medium	Low	Yes	Yes	Yes	Requires cooperative motorist. Chauffeuring (special trips) require driver's time.
Carsharing (vehicle rentals)	Limited (needs nearby services)	20-60 mph	Low	Medium to large	Med.	No	Limited	Varies	Requires convenient and affordable vehicle rentals services.
Motorcycle	Wide (nearly universal)	20-60 mph	Medium	Medium	High	No	Limited	No	Requires motorcycle and ability. Moderate costs.
Telecommute	Wide (nearly universal)	NA	NA	NA	Med.	Yes	Varies	Varies	Requires equipment and skill.

This table summarizes the performance of various transportation modes.

Why Not Drive?

Driving is often the fastest mode of travel, and although automobiles are expensive to own (considering fixed costs such as depreciation, insurance, registration fees, scheduled maintenance and residential parking expenses) they are relatively cheap to drive, typically costing just a few cents per mile in operating expenses. Automobile travel also tends to be more comfortable and prestigious than other modes. This explains why 70-90% of trips are made by automobile (depending on definitions and conditions).[1]

But for various reasons travelers often need or prefer travel by alternative modes:

- Many people *cannot* drive. In a typical community, 20-40% of the total population, and 10-20% of adolescents and adults, cannot drive due to disability, economic, age constraints, or vehicle failures. Inadequate transport options reduces non-drivers ability to access activities and forces motorists to chauffeur non-drivers (according to the 2009 *National Household Travel Survey*, 5% of total trips were specifically to transport a passenger).[2]
- Many people *should not* drive for some trips, due to inebriation, disability, or economic constrains. For example, efforts to reduce driving by higher-risk groups (people who are impaired by alcohol or drugs, young males, or people with dementia) can only be successful if there are good alternatives to driving. The high costs of automobile transport places a major financial burden on many lower-income people.
- Travelers sometimes *prefer* using alternative modes, for example, because walking and cycling are more enjoyable and provide healthy exercise, or public transit commuting imposes less stress and allows commuters to read, work or rest.
- Society could benefit from more efficient road, parking, fuel and insurance pricing, or more efficient management of road space, that favor higher value trips and more efficient modes in order to reduce traffic congestion, parking costs, accidents and pollution emissions.

It is therefore interesting to consider what mode share is overall optimal to users and society, and the portion of automobile travel that occurs because travelers lack suitable alternatives. For example, if walking and cycling conditions, and public transit service quality were better, how much more would people rely on these mode, and how much less automobile travel would occur?

In fact, walking, cycling and public transit travel do tend to be much higher, and automobile travel is much lower, in communities with better transport options. For example, Guo and Gandavarapu (2010) estimate that completing the sidewalk network in a typical U.S. town on average increases non-motorized travel 16% (from 0.6 to 0.7 miles per day) and reduces automobile travel 5% (from 22.0 to 20.9 vehicle-miles). Similarly, residents of transit-oriented communities tend to use alternative modes 2-10 times more frequently, and drive 10-30% fewer miles, than residents of automobile-oriented communities (Cervero and Arrington 2008; Litman 2009). Even larger travel reductions occur if improvements in alternative modes are implemented in conjunction with incentives such as more efficient road, parking and insurance pricing.

This indicates latent demand for alternative modes, that is, people would like to rely more on alternative modes but are constrained by poor walking and cycling conditions and inadequate public transit services. This is not to suggest that in an optimal transport system people would forego driving altogether, but it does indicate that given better transport options and more efficient incentives, people would rationally choose to drive less, rely more on alternative modes, and be better off overall as a result.

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[1] Travel surveys tend to undercount walking and cycling trips, so actual non-motorized mode share is often much higher than indicated by conventional surveys. Walking, cycling and public transit represent a greater mode share in urban areas, and among people who are young, have disabilities, or low incomes.

[2] http://nhts.ornl.gov/tables09/fatcat/2009/pmt_TRPTRANS_WHYTRP1S.html.

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Such analysis is even more complex because each mode includes various subcategories with unique characteristics. For example, "pedestrians" include people standing, walking alone and in groups, using canes and walkers, jogging and running, playing, walking pets, carrying loads, and pushing hand carts. Their actual needs, abilities, impacts and value to society can vary significantly, as indicated in Table 5.

Table 5 **Nonmotorized Facility Uses Compared**

Mode or Activity	Facility Requirements	Risk to Others	Basic Mobility
	Quality and quantity of pedestrian facilities	Danger these users impose on others	Whether the mode provides basic mobility benefits)
People standing	Minimal	None	NA
People sitting at benches or tables	Seats or benches	None	NA
Individual walkers	Minimal	Low	High
Walkers in groups	Medium	Low	High
Walkers with children	Medium	Low	High
Children playing	Medium to large	Medium	Medium
Walkers with pets	Medium to large	Low	Medium
Human powered wheelchairs	Medium	Low	Very High
Motor powered wheelchairs	Medium to large	Medium to high	Very High
Joggers and runners	Medium to large	Medium	Medium
Skates and push-scooters	Large	Medium	Low
Powered scooters and Segways	Large	Medium	Low to high
Human powered bicycle	Medium to large	Medium to high	Medium
Motorized bicycle	Large	High	Low
People with handcarts or wagons	Medium to large	Low to medium	Medium
Vendors with carts and wagons	Medium to large	Low	Sometime (if the goods sold are considered 'basic').

This table compares various nonmotorized facility users.

Similarly, *public transit* (also called *public transportation* or *mass transit*) includes various types of services and vehicles. Table 6 summarizes the performance of various types of public transit. Actual performance depends on specific circumstances; for example costs per trip can vary depending on which costs are included (for example, whether major new road or rail improvements are required, whether Park-and-Ride facilities are included in transit budgets, construction and operating costs, load factors and types of trips.

Table 6 **Transit Modes Compared**

Name	Description	Availability	Speed	Density	Costs
		Destinations served	Passenger travel speeds	Passenger volumes	Cost per trip
Heavy rail	Relatively large, higher-speed trains, operating entirely on separate rights-of-way, with infrequent stops, providing service between communities.	Limited to major corridors in large cities	High	Very high	Very high
Light Rail Transit (LRT)	Moderate size, medium-speed trains, operating mainly on separate rights-of-way, with variable distances between stations, providing service between urban neighborhoods and commercial centers.	Limited to major corridors	Medium	High	High
Streetcars (also called trams or trolleys)	Relatively small, lower-speed trains, operating primarily on urban streets, with frequent stops which provide service along major urban corridors.	Limited to major corridors	Medium	High	High
Fixed route bus transit	Buses on scheduled routes.	Widely available in urban areas	Low to medium	High	Low to medium
Bus Rapid Transit (BRT)	A bus system with features that provide a high quality of service.	Limited to major corridors	Medium to high	High	Low to medium
Express bus	Limited stop bus service designed for commuters and special events.	Limited to major corridors	High	High	Low to medium
Ferry services	Boats used to transport people and vehicles.	Limited to major corridors	Low to medium	Low to medium	Medium to high
Paratransit	Small buses or vans that provide door-to-door, demand-response service.	Widely available	Low	Low	High
Personal Rapid Transit (PRT)	Small, automated vehicles that provide transit service, generally on tracks.	Limited to major corridors	Low to medium	Low to medium	Medium to high
Vanpool	Vans used for ridesharing.	Widely available	Medium to high	High	Low
Shared taxi.	Private taxis that carry multiple customers.	Limited to busy corridors	Medium to high	Low to medium	Medium to high
Taxi	Conventional taxi service.	Widely available	Medium to high	Low	High

This table summarizes different types of public transit and their performance attributes.

Multi-modal transport planning requires tools for evaluating the quality of each mode, such as Level-of-Service standards which can be used to indicate problems and ways to improve each mode. Tables 7 and 8 indicate factors that can be considered when evaluating different modes.

Table 7 Nonmotorized Level-Of-Service Rating Factors

Feature	Definition	Indicators
Network continuity	Whether sidewalks and paths exist, and connect throughout an area.	• Portion of streets with nonmotorized facilities. • Length of path per capita. • Network connectivity and density (kilometers of sidewalks and paths per square kilometer).
Network quality	Whether sidewalks and paths are properly designed and maintained.	• Sidewalk and path functional width. • Portion of sidewalks and paths that meet current design standards. • Portion of sidewalks and paths in good repair.
Road crossing	Safety and speed of road crossings	• Road crossing widths. • Motor vehicle traffic volumes and speeds. • Average pedestrian crossing time. • Quantity and quality of crosswalks, signals and crossing guards.
Traffic protection	Separation of nonmotorized traffic from motorized traffic, particularly high traffic volumes and speeds.	• Distance between traffic lanes and sidewalks or paths. • Presence of physical separators, such as trees and bollards. • Speed control.
Congestion and user conflicts	Whether sidewalks and paths are crowded or experience other conflicts.	• Functional width of sidewalk and paths. • Peak-period density (people per square meter) • Clearance from hazards, such as street furniture and performers within the right-of-way. • Number of reported conflicts among users. • Facility management to minimize user conflicts.
Topography	Presence of steep inclines.	• Portion of sidewalks and paths with steep inclines.
Sense of Security	Perceived accident, crime or abuse threats.	• Reported security incidents. • Quality of visibility and lighting.
Wayfinding	Station area navigation aids.	• Availability and quality of signs, maps and visitor information services.
Weather protection	User protected from sun and rain.	• Presence of shade trees and awnings.
Cleanliness	Cleanliness of facilities and nearby areas.	• Litter, particularly potentially dangerous objects. • Graffiti on facilities and nearby areas. • Effectiveness of sidewalk and path cleaning programs.
Attractiveness	The attractiveness of the facility, nearby areas and destinations.	• Quality of facility design. • Quality of nearby buildings and landscaping. • Area Livability (environmental and social quality of an area). • Community cohesion (quantity and quality of positive interactions among people in an area). • Number of parks and recreational areas accessible by nonmotorized facilities.
Marketing	Effectiveness of efforts to encourage nonmotorized transportation.	• Quality of nonmotorized education and promotion programs. • Nonmotorized transport included in Commute Trip Reduction programs.

This table summarizes factors to consider when evaluating walking and cycling conditions.

Table 8 Transit Level-of-Service Rating Factors

Feature	Description	Indicators
Availability	Where and when transit service is available.	• Geographic coverage (Portion of destinations within 500 meters of transit) • Annual service-kilometers per capita. • Daily hours of service. • Hours of service.
Frequency	Frequency of service and average wait time.	• Operating frequency. • Headways (time between trips). • Average waiting times.
Travel Speed	Transit travel speed.	• Average vehicle speeds. • Transit travel speed relative to driving the same trip. • Door-to-door travel time.
Reliability	How well service actually follows published schedules.	• On-time operation. • Portion of transfer connections made. • Mechanical failure frequency.
Boarding speed	Vehicle loading and unloading speed.	• Dwell time. • Boarding and alighting speeds.
Safety and security	Perceived user safety and security.	• Perceived passenger security. • Accidents and injuries rates. • Reported security incidents. • Visibility and lighting. • Absence of vandalism.
Price and affordability	Fare prices, structure, payment options, ease of purchase.	• Fares relative to average incomes. • Fares relative to other travel mode costs. • Payment options (cash, credit cards, etc.). • Ticket availability (stations, stores, Internet, etc.).
Integration	Ease of transferring between transit and other modes.	• Quality of connections between transit routes. • Quality of connections between transit and other modes (train stations, airports, ferry terminals, etc.).
Comfort	Passenger comfort	• Seating availability and quality. • Space (lack of crowding). • Quiet (lack of excessive noise). • Air quality (lack of unpleasant smells) and temperature. • Cleanliness. • Washrooms and refreshments (for longer trips).
Accessibility	Ease of reaching stations and stops.	• Distance from transit stations and stops to destinations. • Walkability (quality of walking conditions) in areas serviced by transit.
Baggage capacity	Accommodation of baggage.	• Ability, ease and cost of carrying baggage, including special items such as pets.
Universal design	Accommodation of diverse users & needs.	• Accessible design for transit vehicles, stations and nearby areas. • Ability to carry baggage.
User information	Ease of obtaining user information.	• Availability and accuracy of route, schedule and fare information. • Real-time transit vehicle arrival information. • Availability of Information for people with special needs (disabilities, limited language and reading ability, etc.).
Courtesy and responsiveness	Courtesy with which passengers are treated.	• How passengers are treated by transit staff. • Ease of filing complaints. • Speed and responsiveness with which complaints are treated.
Attractiveness	The attractiveness of transit facilities.	• Attractiveness of vehicles and facilities. • Attractiveness of documents and websites.
Marketing	Effectiveness of efforts to encourage public transport.	• Popularity of promotion programs. • Effectiveness at raising the social status of transit travel. • Increases in public transit ridership in response to marketing efforts.

This table summarizes factors that can be considered when evaluating public transit services.

Automobile Dependency and Multi-Modalism

Automobile dependency refers to transportation and land use patterns that favor automobile travel and provide relatively inferior alternatives. Its opposite, *multi-modalism*, refers to a transport system that offers users diverse transport options that are effectively integrated, in order to provide a high degree of accessibility even for non-drivers. Table 9 compares automobile dependency and multi-modal transport systems.

Table 9 Auto Dependency and Multi-Modal Transportation Compared

Factor	Automobile Dependency	Multi-modal Transportation
Motor vehicle ownership	High per capita motor vehicle ownership.	Medium per capita motor vehicle ownership.
Vehicle travel	High per capita motor vehicle mileage.	Medium to low vehicle mileage.
Land use density	Low. Common destinations are dispersed.	Medium. Destinations are clustered
Land use mix	Single-use development patterns.	More mixed-use development.
Land for transport	Large amounts of land devoted to roads and parking.	Medium amounts devoted to roads and parking.
Road design	Emphasizes automobile traffic.	Supports multiple modes and users.
Street scale	Large scale streets and blocks.	Small to medium streets and blocks.
Traffic speeds	Maximum traffic speeds.	Lower traffic speeds.
Walking	Mainly in private malls.	Mainly on public streets.
Signage	Large scale, for high speed traffic.	Medium scale, for lower-speed traffic.
Parking	Generous supply, free.	Moderate supply, some pricing.
Site design	Parking paramount, in front of buildings.	Parking sometimes behind buildings.
Planning Practices	Non-drivers are a small minority with little political influence.	Planning places are high value on modal diversity.
Social expectations	Non-drivers are stigmatized and their needs given little consideration.	Non-drivers are not stigmatized and their needs are considered.

This table compares automobile dependency and multi-modal transport systems.

Automobile dependency is a matter of degree. Few places are totally automobile dependent (that is, driving is the *only* form of transport). Many relatively automobile dependent areas often have significant amounts of walking, cycling, and transit travel among certain groups or situations. Even 'car free' areas usually have some automobile travel by emergency, delivery and service vehicles.

Automobile dependency has many impacts. It increases total mobility (per capita travel), vehicle traffic, and associated costs. It makes non-drivers economically and socially disadvantaged, since they have higher financial and time costs or less ability to access activities. This tends to reduce opportunities, for example, for education, employment and recreation. In an automobile dependent community virtually every adult is expected to have a personal automobile (as opposed to a *household* automobile shared by multiple drivers), non-drivers require frequent chauffeuring, and it is difficult to withdraw driving privileges from unfit people since alternatives are inferior. Automobile dependency reduces the range of solutions that can be used to address problems such as traffic congestion, road and parking facility costs, crashes, and pollution.

Summary of Factors Affecting Accessibility

The table below lists factors that affect accessibility and the degree to which they are considered in current transport planning. Multi-modal transportation planning requires consideration of all of these factors.

Table 10 **Summary of Factors Affecting Accessibility** (Litman 2006)

Name	Description	Current Consideration
Transport Demand	The amount of mobility and access that people and businesses would choose under various conditions (times, prices, levels of service, etc).	Motorized travel demand is well studied, but nonmotorized demand is not. Travel demand is often considered exogenous rather than affected by planning decisions.
Mobility	The distance and speed of travel, including *personal mobility* (measured as person-miles) and *vehicle mobility* (measured as vehicle-miles).	Conventional transport planning primarily evaluates mobility, particularly vehicle mobility.
Transportation Options	The quantity and quality of access options, including walking, cycling, ridesharing, transit, taxi, delivery services, and telecommunications. Qualitative factors include availability, speed, frequency, convenience, comfort, safety, price and prestige.	Motor vehicle options and quality are usually considered, using indicators such as roadway level-of-service, but other modes lack such indicators and some important service quality factors are often overlooked.
User information	The quality (convenience and reliability) of information available to users on their mobility and accessibility options.	Frequently considered when dealing with a particular mode or location, but often not comprehensive.
Integration	The degree of integration among transport system links and modes, including terminals and parking facilities.	Automobile transport is generally well integrated, but connections between other modes are often poorly evaluated.
Affordability	The cost to users of transport and location options relative to incomes.	Automobile operating costs and transit fares are usually considered.
Mobility Substitutes	The quality of telecommunications and delivery services that substitute for physical travel.	Not usually considered in transport planning.
Land Use Factors	Degree that factors such as land use density and mix affect accessibility.	Considered in land use planning, but less in transport planning.
Transport Network Connectivity	The density of connections between roads and paths, and therefore the directness by which people can travel between destinations.	Conventional planning seldom considers the effects of roadway connectivity on accessibility.
Roadway Design and Management	How road design and management practices affect vehicle traffic, mobility and accessibility.	Some factors are generally considered, but others are not.
Prioritization	Various strategies that increase transport system efficiency.	Often overlooked or undervalued in conventional planning.
Inaccessibility	The value of inaccessibility and external costs of increased mobility.	Not generally considered in transport planning.

This table indicates factors that affect accessibility and whether they are currently considered in planning.

Transportation for Everyone Ratings

As previously discussed, a transportation system must be diverse in order to serve diverse travel demands. No single travel option is sufficient; walking, bicycling, public transit and automobiles all play important roles in an efficient and equitable transport system. Since land use factors affect accessibility, multimodal planning must also consider development density and mix.

Table 11 summarizes the *Transportation for Everyone* rating system, which evaluates multimodalism in an area, and helps identify potential gaps and improvement options.

Table 11 **Transportation for Everyone Rating** (Litman 2017)

Accessibility Factors	Rating (1-10)
1. All-weather (paved) roads, and reliable motor vehicle fuel supplies.	
2. Compact, mixed urban development, which creates *Transit-Oriented Development* (if located around major transit stations) or *Urban Villages* (if pedestrian oriented), where most common services (shops, restaurants, schools, parks, transit stops, etc.) can be reached within a 5-10 minute walk or bicycle ride of most homes and worksites.	
3. Good walking and cycling conditions, including adequate sidewalks, crosswalks, paths, bike lanes, bike parking, and vehicle traffic speed control.	
4. High quality public transit services, with good coverage, frequency, comfort, safety and affordability for both local and interregional (between city) services.	
5. Good connectivity, including dense walking and road networks, and intermodal connections such as walking and cycling access, and taxi services at transit stations.	
6. Convenient and affordable carsharing and bikesharing, taxi and ride-hailing services (e.g., Uber and Lyft).	
7. Universal design (transportation systems and services accommodate people with diverse needs and abilities, including those with disabilities and heavy loads).	
8. Good telework options, such as on-line shopping, banking and municipal services, and efficient delivery services ((mail, courier and local shops).	
9. Convenient user information concerning transportation options.	
10. Social marketing that promotes non-automobile modes and enhances their status.	

Each factor can be rated from 0 (worst) to 10 (best).

This rating system recognizes the integrated nature of multimodalism. For example, most public transit trips including walking links, so walkability affects public transit service quality, and since land use factors such as density and mix affect the destinations that pedestrians can reach, these also affect public transit accessibility. As a result, walkability improvements and Smart Growth land use policies are often an important way to improve public transit service quality and increase transit ridership, and pedestrian and public transit improvements can have synergistic effects; implemented together their impacts are larger than the sum of their individual impacts.

Examples and Case Studies

The report, *Integrating Australia's Transport Systems: A Strategy For An Efficient Transport Future* (Booz Allen 2012) describes cities with integrated transport planning:

London

London's overall public transport network is characterised by a well-established rail network complemented by an extensive bus network and a ferry network. These networks are integrated by multi-modal stations designed for ease of interchange for high volumes of passengers. At major stations, purpose built bus interchanges have been developed to be within walking distance of the railway and underground stations, often manned by bus station staff and furbished with real time information systems (e.g. Countdown – which shows the number of minutes until the next bus is due to arrive).

Hong Kong

Hong Kong public transport services include railways, trams, buses, minibuses, taxis and ferries. This results in very high public transit mode share (90%) and very low vehicle ownership rates (50 vehicles per 1000 population). Hong Kong transport services are provided by several operators.

Singapore

Singapore is considered an international leader in integrated multi-modal transport planning. It established the world's first area licensing and electronic road pricing systems, and uses a quota system to limit vehicle ownership. The government makes continued investments in transport infrastructure.

Table 12 **Examples of Integrated Transport Services** (Booz Allen 2012)

Type	London	Hong Kong	Singapore
Physical	Extensive network of modes (walking, cycling, taxi, bus, rail, ferry and airports) with well-designed stations and terminals	Well-designed intermodal stations integrated into neighborhoods.	Transit stations are designed to integrate multiple modes and local development
Fare	*Oyster card* introduced in 2003, can be used for most urban transport services.	*Octopus Card* introduced in 1997 useable on most transport services.	*EZ Card* usable on all public transport modes, parking, and small retail purchases.
Information	London has led the way in public transport signage.	Good signage	TransitLink Guide and extensive signage provide comprehensive information on all aspects of travelling.
Institutional	The City of London manages all aspects of transport planning and operations.	Single governing authority helps to implement integration	TransLink multi-modal agency established in 1989. Provides strategic planning and integrated services.

Leading cities are developing integrated, multi-modal transport systems.

Best Practices

The following are recommendations for multi-modal transportation planning:

- Multi-modal transportation planning should have integrated institutions, networks, stations, user information, and fare payment systems.
- Consider a variety of transportation improvement options, including improvements to various modes, and mobility management strategies such as pricing reforms and smart growth land use policies. Consider various combinations of these options, such as public transport improvements plus supportive mobility management strategies.
- Consider all significant impacts, including long-term, indirect and non-market impacts such as equity and land use changes. This should at least include:
  - Congestion
  - Roadway costs
  - Parking costs
  - Consumer costs
  - Traffic accidents
  - Quality of access for non-drivers
  - Energy consumption
  - Pollution emissions
  - Equity impacts
  - Physical fitness and health
  - Land use development impacts
  - Community livability
- Impacts that cannot be quantified and monetized (measured in monetary values) should be described.
- Multi-modal comparisons should be comprehensive and marginal, and should account for factors such as transit system economies of scale and scope.
- Special consideration should be given to transport system connectivity, particularly connections between modes, such as the quality of pedestrian and cycling access to transit stops and stations.
- Special consideration should be given to the quality of mobility options available to people who are physically or economically disadvantaged, taking into account universal design (the ability of transport systems to accommodate people with special needs such as wheelchair users and people with wheeled luggage) and affordability.
- Indicate impacts with regard to strategic objectives, such as long-range land use and economic development.
- Use comprehensive transportation models that consider multiple modes, generated traffic impacts (the additional vehicle traffic caused by expansion of congested roadways), and the effects of various mobility management strategies such as price changes, public transit service quality improvements and land use changes.
- People involved in transportation decision-making (public officials, planning professionals and community members) should live without using a personal automobile for at least two typical weeks each year that involve normal travel activities (commuting, shopping, social events, etc.) in order to experience the non-automobile transportation system.

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