

Introduction to Multi-Modal Transportation Planning

Principles and Practices

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Abstract

This paper 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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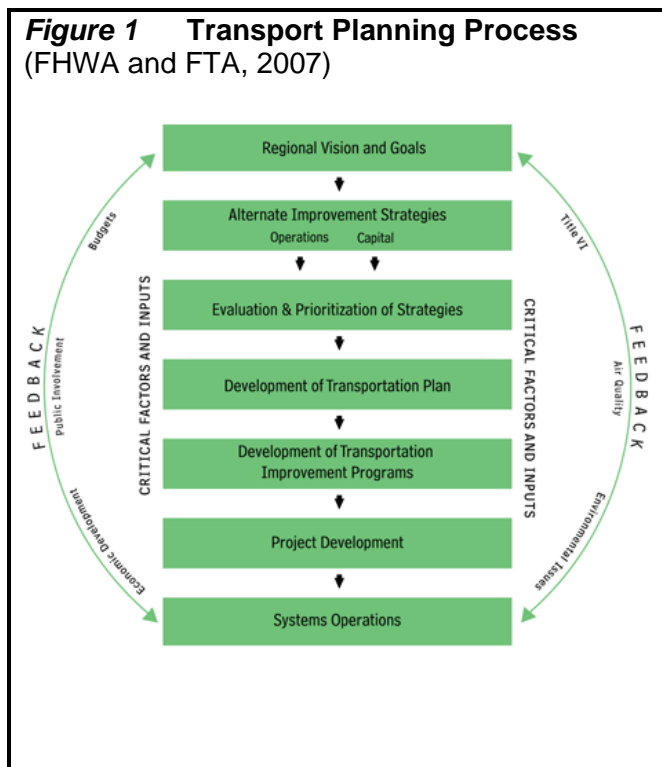
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Conventional Transportation Planning

Conventional (also called *traditional* or *business as usual*) transportation planning refers to current practices for making transport policy, program and investment decisions.

Multi-modal planning refers to decision making that considers various modes (walking, cycling, automobile, public transit, etc.) and connections among modes so each can fill its optimal role in the overall transport system. There are several specific types of transport planning for reflecting different 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.).



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 planning tends to focus on a specific set of options (primarily automobile travel) and impacts (summarized in Table 1). Commonly-used transportation 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

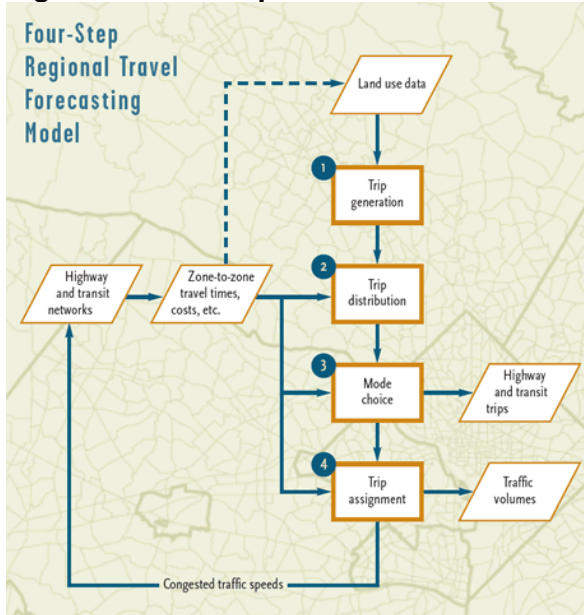
| Usually Considered | Often Overlooked |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Financial costs to governments Vehicle operating costs (fuel, tolls, tire wear) Travel time (reduced congestion) Per-mile crash risk Project construction environmental impacts | 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) Transportation diversity and equity impacts Per-capita crash risk Public fitness and health impacts Travelers' preferences for alternative modes (e.g., for walking and cycling) |

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 crash rates (generally measured per vehicle-mile) 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. One indication of this shift is that over the last two decades, many *highway agencies* have been renamed *transportation agencies*, and have added departments and experts related to environmental analysis, community involvement and nonmotorized planning. Transportation 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.mwcoq.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.

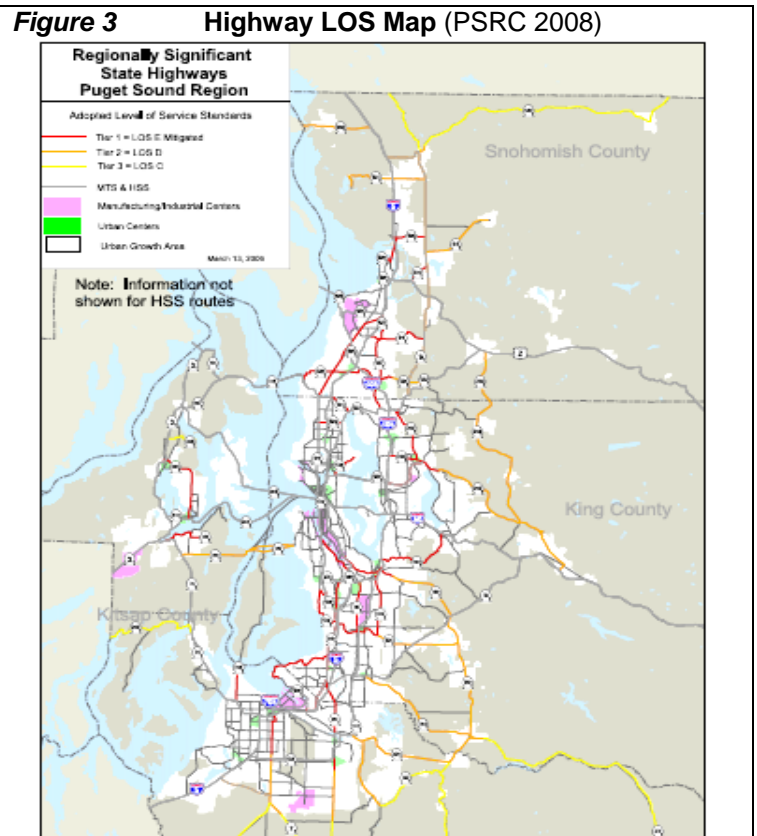


Table 2 Highway Level-Of-Service (LOS) Ratings (Wikipedia)

| 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* (no cross traffic) can carry up to 2,200 vehicles per hour (VPH) per lane. An arterial with intersections can carry about half that. Table 3 indicates units commonly used to measure traffic. 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)*, indicating traffic volumes averaged over a year.

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.

Terms and Concepts

- 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 and heaviest vehicle a roadway is designed to accommodate. *Passenger Car Equivalents (PCE)* indicate the traffic impacts of larger vehicles 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
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.

Table 4 Mode Profiles

| Mode | Availability Portion of locations and times served | Speed typical speeds | Density space requirements | Loads ability to carry baggage | Costs user costs | Potential Users | | | Limitations | Appropriate Uses |
|------------------------------|-------------------------------------------------------|-------------------------|-------------------------------|-----------------------------------|---------------------|-----------------|---------|--------------|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| | | | | | | 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. Sometimes difficult or unsafe. | Short trips by physically able people. |
| Wheelchair | Limited (requires suitable facilities) | 2-5 mph | Medium | Small | Med. | Yes | Yes | Yes | Requires suitable sidewalk or path. Limited distance and carrying capacity. | Short urban trips by people with specific physical disabilities. |
| Bicycle | Wide (feasible on most roads and some paths) | 5-15 mph | Medium | Small to medium | Med. | Yes | Yes | Varies | Requires bicycle and physical ability. Limited distance and carrying capacity. | Short to medium length trips by physically able people on suitable routes. |
| Taxi | Moderate (in most urban areas) | 20-60 mph | Low | Medium | High | Yes | Limited | Yes | High costs and limited availability. | Infrequent trips, short and medium distance trips. |
| Fixed Route Transit | Limited (major urban areas) | 20-40 mph | High | Small | Med. | Yes | Yes | Yes | Limited availability. Sometimes difficult to use. | Short to medium distance trips along busy corridors. |
| Paratransit | Limited | 10-30 mph | Medium | Small | High | Yes | Yes | Yes | High cost and limited service. | Travel for disabled people. |
| Auto driver | Wide (nearly universal) | 20-60 mph | Low | Medium to large | High | No | Limited | Varies | Requires driving ability and automobile. Large space requirements. High costs. | Travel by people who can drive and afford an automobile. |
| Ridesharing (auto passenger) | Limited (requires motorist, matching services) | 20-60 mph | High | Medium | Low | Yes | Yes | Yes | Requires cooperative motorist. Consumes driver's time if a special trip (chauffeur). | Trips that the driver would take anyway (ridesharing). Occasional special trips (chauffeur). |
| Carsharing (vehicle rentals) | Limited (requires nearby services) | 20-60 mph | Low | Medium to large | Med. | No | Limited | Varies | Requires convenient and affordable vehicle rentals services. | Occasional use by drivers who don't own an automobile. |
| Motorcycle | Wide (nearly universal) | 20-60 mph | Medium | Medium | High | No | Limited | No | Requires riding ability and motorcycle. High fixed costs. | Travel by people who can ride and afford a motorcycle. |
| Telecommute | Wide (nearly universal) | NA | NA | NA | Med. | Yes | Varies | Varies | Requires equipment and skill. | Alternative to some types of trips. |

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 constraints. 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.

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.

Multi-modal transportation planning is complicated because modes differ in various ways, including their availability, speed, density, costs, limitations, and most appropriate uses (Table 4). They are not equal substitutes; each is only appropriate for specific users and uses.

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. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • Portion of sidewalks and paths with steep inclines. |
| Sense of Security | Perceived threats of accidents, assault, theft or abuse. | <ul style="list-style-type: none"> • Reported security incidents. • Quality of visibility and lighting. |
| Wayfinding | Guidance for navigating within the station and to nearby destinations. | <ul style="list-style-type: none"> • Availability and quality of signs, maps and visitor information services. |
| Weather protection | User protected from sun and rain. | <ul style="list-style-type: none"> • Presence of shade trees and awnings. |
| Cleanliness | Cleanliness of facilities and nearby areas. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • Annual service-kilometers per capita. • Daily hours of service. • Portion of destinations located within 500 meters of transit service. • Hours of service. |
| Frequency | Frequency of service and average wait time. | <ul style="list-style-type: none"> • Trips per hour or day. • Headways (time between trips). • Average waiting times. |
| Travel Speed | Transit travel speed. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • On-time operation. • Portion of transfer connections made. • Mechanical failure frequency. |
| Boarding speed | Vehicle loading and unloading speed. | <ul style="list-style-type: none"> • Dwell time. • Boarding and alighting speeds. |
| Safety and security | Users perceived safety and security. | <ul style="list-style-type: none"> • Perceived transit passenger security. • Accidents and injuries. • Reported security incidents. • Visibility and lighting. • Absence of vandalism. |
| Price and affordability | Fare prices, structure, payment options, ease of purchase. | <ul style="list-style-type: none"> • 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. | <ul style="list-style-type: none"> • Quality of connections between transit routes. • Quality of connections between transit and other modes (train stations, airports, ferry terminals, etc.). |
| Comfort | Passenger comfort | <ul style="list-style-type: none"> • Seating availability and quality. • Space (lack of crowding). • Quiet (lack of excessive noise). • Fresh air (lack of unpleasant smells). • Temperature (neither too hot or cold). • Cleanliness. • Washrooms and refreshments (for longer trips). |
| Accessibility | Ease of reaching stations and stops. | <ul style="list-style-type: none"> • Distance from transit stations and stops to destinations. • Walkability (quality of walking conditions) in areas serviced by transit. |
| Baggage capacity | Accommodation of baggage. | <ul style="list-style-type: none"> • Ability, ease and cost of carrying baggage, including special items such as pets. |
| Universal design | Accommodation of diverse users including special needs. | <ul style="list-style-type: none"> • Accessible design for transit vehicles, stations and nearby areas. • Ability to carry baggage. • Accommodation of people who cannot read or understand the local language. |
| User information | Ease of obtaining user information. | <ul style="list-style-type: none"> • Availability and accuracy of route, schedule and fare information. • Real-time transit vehicle arrival information. • Information available to service people with special needs (audio or visual disabilities, inability to read or understand the local language, etc.). |
| Courtesy and responsiveness | Courtesy with which passengers are treated. | <ul style="list-style-type: none"> • How passengers are treated by transit staff. • Ease of filing a complaint. • Speed and responsiveness with which complaints are treated. |
| Attractiveness | The attractiveness of transit facilities. | <ul style="list-style-type: none"> • Attractiveness of vehicles and facilities. • Attractiveness of documents and websites. |
| Marketing | Effectiveness of efforts to encourage public transport. | <ul style="list-style-type: none"> • 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 <i>personal mobility</i> (measured as person-miles) and <i>vehicle mobility</i> (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.

Best Practices

The following are recommendations for multi-modal transportation planning:

- 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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