# PART 2
# TRANSIT IN NORTH AMERICA

## CONTENTS

## LIST OF EXHIBITS

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# CHAPTER 1. INTRODUCTION

## OVERVIEW

Part 2 of the *Transit Capacity and Quality of Service Manual* (TCQSM) presents a summary of transit's role and usage, and describes and provides statistics for the various transit modes used in North America. Chapters 2 through 5 introduce concepts covered in much greater detail in Parts 4 through 7 of the TCQSM.

Within the TCQSM, "North America" generally refers to the United States and Canada. Rail data also include Mexico.

- *Chapter 1* discusses the role of transit and provides summary national statistics of transit usage by mode.
- Chapter 2 covers bus transit and its service, vehicle, and facility types.
- Chapter 3 addresses rail transit, defines the different modes that are considered to be rail transit, and describes typical operating environments for those modes.
- Chapter 4 describes ferry services and vessel types.
- Chapter 5 summarizes the types of transit stops, stations, and terminals.
- Chapter 6 provides references for material presented in Part 2.

## ROLE OF TRANSIT

Transit plays two major roles in North America. The first is to accommodate *choice* riders—those riders who choose to use transit for their trip-making even though they have other means of travel, in particular, a motor vehicle. These riders may choose transit over other modes for a variety of reasons, including saving money (particularly parking costs), avoiding driving in congested traffic, being able to use travel time productively for other activities, and helping the environment. Choice riders particularly use transit during peak periods for work trips. As a result, transit increases the number of people that can be carried by urban transportation systems. In this role, transit is essential for mobility in the downtowns of some major cities—which could not survive without it—and in other concentrated employment centers.

Choice riders particularly use transit for work trips, especially in larger cities.

The other major transit role of transit is to provide basic mobility for those segments of the population too young, too old, or otherwise unable to drive due to physical, mental, or financial disadvantages. About 35% of the population in the United States and Canada do not possess a drivers license[(R6)] and must depend on others to transport them, in autos, on transit, or by other modes—walking, cycling, taxis, and so forth. This is the principal role for those transit services provided specifically for persons with disabilities and the dominant role in many smaller transit systems. Such transit users have been called *captive* riders.

Transit serves captive riders as well.

In the major cities in North America, transit serves higher numbers of both choice and captive riders. The variation in transit mode share among urban areas reflects differences in population, central business district employment and parking costs, extent of bus and rail transit services, and geographic characteristics.

Transit trips can be both time and cost competitive to the auto under certain operating conditions, where exclusive right-of-way operation, on-street transit lanes, or traffic signal priority can be provided. With the trend towards *Transportation System Management* solutions to urban transport problems, there has been an increased focus on moving persons and not simply vehicles on transportation systems. This has increased awareness on the part of local jurisdictions of the benefits transit preferential treatments can play in attracting transit ridership and reducing overall traffic congestion. With the higher transit ridership levels in larger cities, transit can provide more efficient use of energy and improve air quality.

Increased emphasis on moving persons in addition to vehicles on urban transportation systems.

Different transit service configurations.

Transit service can be provided in several operating configurations. *Fixed-route* service occurs where there is sufficient population or employment density to support higher transit volumes. *Demand-responsive* service occurs where transit trips are served on demand or by reservation, typically in lower-density areas and/or to accommodate riders unable to use the fixed-route service. Concepts combining characteristics of both service types, such as *deviated fixed-route* service, provide some regularity of service and improve transit accessibility for all riders.

Other forms of public transportation.

Other traditional forms of transportation provide an important component of overall public transportation. Taxis can serve as short feeders to transit and an emergency role for commuters who must return home outside the hours of commute service. They also serve as an effective alternative, particularly when trips are subsidized, for the elderly and persons with disabilities. School buses in the United States provided 94 billion passenger-miles (152 billion passenger-kilometers) of service in 1993,[R6] over four times the amount provided by all transit buses. The fleet of 550,000 school, church, and institutional buses in the U.S. is nine times larger than the 61,000 transit bus fleet. In Europe, most large Canadian cities, and a few U.S. cities, school trips are combined with transit, providing considerable savings for the school boards and additional revenues and economies of scale for the transit agency.

Importance of good pedestrian connections to transit.

Transit passengers must of necessity be pedestrians at one, or usually, both ends of their trips. Thus it is important that land uses surrounding transit stops incorporate good pedestrian linkages. In recent years, there has been an emergence of neo-traditional developments that provide for higher urban densities, thus promoting transit ridership as well as improving local pedestrian connections to transit. Safe pedestrian crossings of streets are also essential for pedestrian access to and from transit stops.

## DOMINANCE OF LARGE SYSTEMS

North American transit experience.

Transit systems carry a majority of all peak-hour travelers to the downtown areas in many older major North American cities, but in other metropolitan areas, they carry a smaller proportion of downtown trips. Transit systems carry more than two-thirds of all peak-hour travelers to or from the New York, Chicago, and Toronto downtown areas, and more than one-third of all peak-hour travelers entering or leaving most other downtowns of major North American cities. At the very high end, in the densely occupied core of lower Manhattan in New York City, 84% of morning commuters arrive by public transportation.[R23]

Buses carry 86 percent of all peak-hour person-trips through the Lincoln Tunnel into New York City,[R23] about one-half of all peak-hour travelers on the Long Island and Gowanus Expressways in New York City, and more than one-quarter of all passengers on radial freeways approaching or leaving other large-city CBDs. Buses carry an even higher proportion of peak-hour travelers on many city streets. More than 80 percent of all peak-hour travelers are carried by buses on Hillside Avenue and Madison Avenue in New York City, Market Street in Philadelphia, and Main Street in Dallas. Buses accommodate more than one-half of all peak-hour person-trips on downtown streets in many other cities.[R18] Sixty percent of morning peak hour trips into lower Manhattan on Fifth Avenue occurred by bus in 1992.[R13]

These observations do not necessarily represent maximum possible bus volumes or total traffic volumes. They do, however, clearly indicate that while buses account for a relatively small proportion of the vehicles in a traffic stream, they can carry a sizable part of the total person flow. Rail rapid transit offers higher capacities and its fixed-route nature makes it more visible and attractive in dense areas. Light rail is gaining broader use in North America: Boston, Calgary, Philadelphia, Portland, Sacramento, St. Louis, San Diego, San Francisco, and Toronto are examples of cities with successful light rail lines.

## STATISTICS

National Transit Database.

The Federal Transit Administration (FTA) maintains an extensive database of statistics, the National Transit Database (NTD), covering the larger agencies it funds. In 2000, the NTD included statistics on 433 bus operators, 416 demand-responsive agencies, and a range of less numerous modes.(R12) However, the database does not include many smaller bus systems that are exempted from its reporting requirements. As a result, the American Public Transportation Association (APTA) reports a much larger total number of bus systems—2,262.(R2)

Canadian Urban Transit Association data.

The Canadian Urban Transit Association (CUTA) collects statistics from its member systems. These data indicate there were 92 fixed-route transit systems in Canada in 2000,(R9) although many of the smaller systems are omitted. Most Canadian ridership figures are reported as *linked* trips, meaning that each transit trip is counted only once even if transfers are required. In contrast, FTA data counts *unlinked* trips, meaning that passengers are counted every time they step aboard a transit vehicle even if they are making a continuous trip. Canadian systems are not required to report passenger kilometers and so generally do not do so.

Unlinked vs. linked trips.

The NTD categorizes U.S. transit systems by urbanized area population and by the number of vehicles operated in maximum service. Population is used in Exhibit 2-1 for comparison purposes. This exhibit illustrates the number of transit systems, transit vehicles, and passenger trips in each of the three NTD population categories.

**Exhibit 2-1**
U.S. Transit Systems by Size Grouping (2000)(R12)

| Population | # of Agencies* | # of Vehicles in Max. Service | % of Total | Unlinked Passenger Trips | % of Total |
|---|---|---|---|---|---|
| Under 200,000 | 254 | 7,277 | 8.6% | 254,573,100 | 2.9% |
| 200,000 to 1 million | 122 | 14,530 | 17.1% | 747,051,200 | 8.6% |
| Over 1 million | 210 | 63,000 | 74.3% | 7,718,266,600 | 88.5% |
| U.S. Total | 588 | 84,807 | 100.0% | 8,719,890,900 | 100.0% |

* Sum of agencies reporting to FTA. Most smaller agencies are not required to report to the FTA; APTA reports the number of U.S. public transit systems in 2000 as 6,000.

Concentration of transit ridership.

As can be seen, a small number of systems carry nearly 90% of the total U.S. transit ridership. This group, in turn, is dominated by the New York region, which accounts for more than 35% of the total U.S. ridership. Taken from a different point of view, however, most U.S. transit agencies operate in areas with populations under 200,000. This fact is reinforced by Exhibit 2-2, which lists the number of U.S. providers of various public transportation modes. The greatest number of agencies by far are the demand-responsive and fixed-route bus modes, both of which are suited for areas with smaller populations that have no need for high-capacity transit modes, yet still require basic transportation services.

**Exhibit 2-2**
U.S. Public Transportation Providers by Mode (2000)(R2)

| Mode | # of Agencies |
|---|---|
| Aerial tramway | 1 |
| Automated guideway transit | 5 |
| Fixed-route bus | 2,262 |
| Cable car | 1 |
| Commuter rail | 19 |
| Demand-responsive bus | 5,252 |
| Ferryboat* | 33 |
| Heavy rail | 14 |
| Inclined plane | 5 |
| Light rail | 25 |
| Monorail | 2 |
| Trolleybus | 6 |
| Vanpool | 67 |
| Total** | 6,000 |

*Excludes international, rural, rural interstate, island, and urban park ferries.
**Total is not the sum of all modes since many agencies operate more than one mode.
NOTE: Table includes some services provided by private or quasi-public providers not included in later exhibits.

Unless otherwise noted, statistical exhibits only cover service directly operated or purchased by public agencies.

Exhibit 2-3 summarizes U.S. public transit ridership by transit mode along with the average trip length for each mode. Of note are the long average trip lengths for passengers using the commuter rail and demand-responsive modes, and the short trips that characterize electric trolleybus and "other rail" services. Services provided by private and non-profit operators under contract to a public agency are included in this and subsequent exhibits; however, other services provided by private or non-profit operators are not included unless specifically noted. Also, services provided by agencies exempt from reporting requirements (fewer than ten vehicles operated) are not included. In particular, the following types of services are not included in the ridership statistics:

- Commuter bus services provided by private operators not under contract to a public agency;
- Many demand-responsive services provided by non-profit organizations, as well as small (fewer than ten vehicle) public operators;
- Privately operated ferry transit services, which in New York City alone in 2000 accounted for more than 5 million annual passenger trips, not including contracted services;
- Vanpools sponsored by private companies or transportation management associations;
- Non-transit automated guideway operations, such as airport inter-terminal shuttles, which served more than 200 million annual passenger trips in 1995; and
- Other minor modes (e.g., private/non-profit or exempt vintage trolleys, inclined planes, and aerial ropeways) that serve a transit function.

**Exhibit 2-3**
Public Transit Ridership in the United States by Mode (2000)[R12]

Modal ridership and trip lengths.

| Mode | Annual Unlinked Pass. Trips (millions) | Millions of pass-mi | Millions of pass-km | Avg. Trip Length (mi) | Avg. Trip Length (km) |
|---|---|---|---|---|---|
| Bus | 5,677.7 | 21,241.0 | 34,176.8 | 3.7 | 6.0 |
| Heavy rail | 2,632.2 | 13,843.5 | 22,274.2 | 5.3 | 8.5 |
| Commuter rail | 412.9 | 9,402.0 | 15,127.8 | 22.8 | 36.6 |
| Light rail | 320.1 | 1,355.9 | 2,181.6 | 4.2 | 6.8 |
| Electric trolleybus | 122.4 | 191.9 | 308.8 | 1.6 | 2.5 |
| Demand responsive | 104.5 | 838.8 | 1,349.6 | 8.0 | 12.9 |
| Ferry | 53.3 | 330.0 | 531.0 | 6.2 | 10.0 |
| Público | 44.2 | 205.3 | 330.3 | 4.6 | 7.5 |
| Vanpool | 12.6 | 434.8 | 699.6 | 34.5 | 55.5 |
| Cable car | 9.2 | 10.5 | 16.9 | 1.1 | 1.8 |
| AGT | 6.4 | 6.3 | 10.1 | 1.0 | 1.6 |
| Monorail | 2.5 | 2.2 | 3.5 | 0.9 | 1.4 |
| Inclined plane | 1.8 | 0.6 | 1.0 | 0.3 | 0.5 |
| Aerial tramway | 0.9 | 0.5 | 0.8 | 0.6 | 1.0 |
| Total | 9,400.7 | 47,863.3 | 77,012.0 | 5.1 | 8.2 |

AGT: automated guideway transit

# CHAPTER 2. BUS TRANSIT

## OVERVIEW

The bus is the most commonly used form of public transport in North America. In 2000, it accounted for 62% of all U.S. passenger trips by transit and 61% of transit trips on the five largest Canadian transit systems. There were an estimated 2,262 bus systems in the U.S. in 2000.(R2) Exhibit 2-4 provides a list of the most-utilized bus systems in the U.S. and Canada, ranked by annual ridership. The figures shown consolidate all bus modes operated by each agency and thus include trolleybuses and contracted services. Note the very high ridership for San Francisco's Muni relative to its fleet size. This can be ascribed to the compactness of the service area and a high number of transfers resulting from the grid nature of the route structure.

**Exhibit 2-4**
Top 10 U.S. and Top 5 Canadian Bus Systems Based on Annual Ridership (R2,R12)

| Transit Agency | 2000 Annual Unlinked Pass. Trips (thousands) | 2000 Buses Operated in Max. Service |
|---|---|---|
| **UNITED STATES** | | |
| MTA-New York City Transit | 821,995 | 3,840 |
| Los Angeles County MTA | 359,002 | 2,017 |
| Chicago Transit Authority | 302,090 | 1,577 |
| Muni (San Francisco) | 174,856 | 634 |
| SEPTA (Philadelphia) | 172,014 | 1,191 |
| New Jersey Transit | 149,780 | 1,825 |
| WMATA (Washington, DC) | 129,524 | 1,179 |
| MBTA (Boston) | 104,154 | 924 |
| MTA of Harris County (Houston) | 86,736 | 1,017 |
| MARTA (Atlanta) | 83,119 | 580 |
| **CANADA** | | |
| Toronto Transit Commission | 380,660* | 1,301* |
| MUCTC (Montréal) | 362,801 | NA |
| TransLink (Vancouver) | 112,300* | 940* |
| OC Transpo (Ottawa) | 118,630* | 750* |
| Calgary Transit | 52,400* | 620* |

*2001 data provided by CUTA and individual agencies.
NOTE: The New York City DOT contracts service to seven private operators, who collectively carried more than 111 million passengers in 2000, using 1,084 buses in maximum service. This service is in addition to that provided by MTA-New York City Transit. NA = not available.

Top 10 U.S. and top 5 Canadian bus systems.

## SERVICE TYPES

### Fixed-Route

Local, limited-stop, and express bus service.

Fixed-route services are provided along a designated route and are operated at set times or headways. These services fall into three major operating categories. *Local services* provide service to all stops along a route and consequently provide relatively slow service and are best for short-distance trips. *Limited-stop services* are frequently overlaid over a local route or routes and provide a higher-speed service by stopping only at major destinations, such as key transfer points and major activity centers. *Express services* tend to be used for longer distance trips and provide local service near the end points of the route, with the intervening distance covered without passenger stops. Local passengers are often prohibited from riding the local portions of express services in core areas of the city where other local services are available.

### Demand-Responsive

Demand-responsive vs. paratransit service.

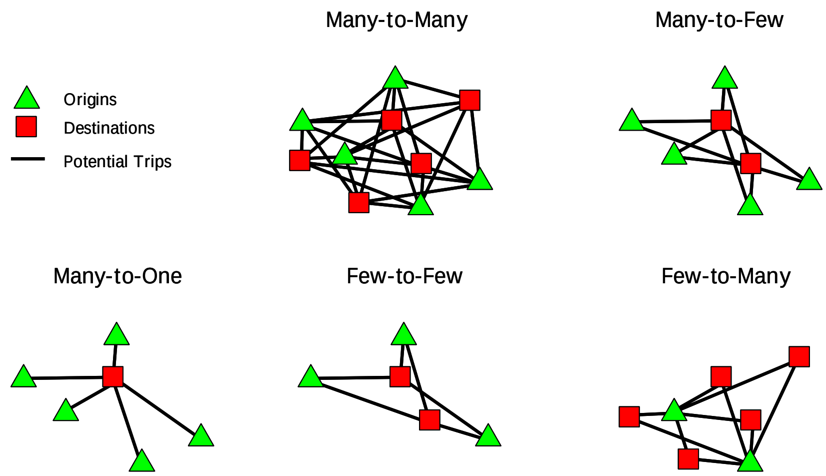
Demand-responsive transportation (DRT) is one of several types of *paratransit* service, where paratransit service is defined as those forms of public transportation that fall within the spectrum between the private automobile and conventional fixed-route transit.(R16) DRT, often called *dial-a-ride* service, fits within the middle range of paratransit service, as illustrated in Exhibit 2-5.

**Exhibit 2-5**
Paratransit Service Type Comparison[R16]

| | | HIRE AND DRIVE SERVICES | HAIL OR PHONE SERVICES | | | PREARRANGED RIDE-SHARING SERVICES | | |
|---|---|---|---|---|---|---|---|---|
| | Private Auto | Daily & Short-Term Rental Car | Taxi | Dial-a-Ride | Jitney | Carpool | Subscription Bus | Fixed-Route Transit |
| Direct (D) or indirect (I) route? | D | D | D | I | I | I | I | I |
| Door-to-door? | Yes | Maybe | Yes | Yes | No | Yes | Maybe | No |
| Travel time spent as driver (D) or passenger (P)? | D | D | P | P | P | P/D | P | P |
| Ride shared (S) or personal (P)? | P | P | P/S | S | S | S | S | S |
| System routes fixed (F), semi-fixed (S), or variable (V)? | V | V | V | V | S | S | S | F |
| Access determined by prior arrangement (A), fixed schedule (F), phone (P), street hailing (H), or at user's discretion (U)? | U | U | H/P | P | H | A | A | F |

DRT is variable route, activated in response to users' requests, provided as shared ride (typically door-to-door or curb-to-curb) and on a point-to-point basis. DRT point-to-point service can be operated as many origins to many destinations, many origins to few destinations, few origins to many destinations, few origins to few destinations, and many origins to one destination, as illustrated in Exhibit 2-6:

**Exhibit 2-6**
DRT Service Pattern Types




Specialized transportation.

When DRT service is provided to a targeted or special rider group, it is generally called *specialized transportation*. Most frequently, specialized transportation is point-to-point service pre-arranged by or for elderly riders and/or persons with disabilities. With passage of the Americans with Disabilities Act (ADA) in 1991, the focus of many specialized transportation programs became riders with disabilities unable to use fixed-route service, in response to the ADA's mandate that fixed-route transit systems provide "paratransit or other special service to individuals with disabilities that is comparable to the level of service provided to individuals without disabilities who use the fixed-route system."

Demand-responsive service is highly vehicle intensive. An average demand-responsive vehicle operating in the United States in 1995 provided 4,125 passenger trips per year. By comparison, buses and trolleybuses together carried an average of 106,620 passenger trips per vehicle in 1995 in the U.S.

### Deviated Fixed-Route

Deviated fixed-route service—also called *route deviation* or *flex route* service—is essentially fixed-route service with flexibility to go off route to provide occasional pick-ups and drop-offs. If there are no requests for deviation, the service operates as a traditional fixed-route, fixed-schedule service. Requests for deviations can be handled in several ways. For pick-ups off the route, riders typically call the transit office in advance with their request for deviation. For drop-offs located off the route, riders may call the transit office in advance or ask the driver upon boarding. The specific procedures for accommodating deviation requests are determined by transit providers based on policy, level and type of demand, or other factors.

Deviated fixed-route service can be used to expand the potential service area of a single route in a low-density area, particularly in rural areas, by allowing deviations up to a set distance from the regular route to serve additional riders. It is also used by some transit providers as a way to meet ADA requirements mandating complementary paratransit service: ADA regulations consider deviated fixed-route to be "demand-responsive" service and, as such, it is not subject to complementary paratransit requirements.

ADA requirements for transit are mainly contained in 49 CFR Part 37, Subpart F.

### Rural and Intercity

Rural and intercity service can take the form of any of these types—fixed-route, demand-responsive, or deviated fixed-route. Service to outlying areas is often infrequent and is designed to accommodate persons traveling for medical, shopping, and other personal business needs rather than commuting. It is not uncommon for rural bus service to operate fewer than 5 days per week, with schedules designed to allow for a same-day return trip on days service is provided.

Rural services are often contracted or privately run.

Transit services outside urban areas are often provided by private bus services. However, in some areas of the United States, public transit agencies provide service in rural areas and between regional population centers. Such is the case in New Jersey where the state transit operator (New Jersey Transit) provides service throughout the state. Heavy-duty highway-type coaches or minibuses are often used for such services, depending on demand.

### Other Modes

The NTD defines three other rubber-tired roadway modes that are not addressed in detail in this manual. *Vanpools* provide shared rides in vans or buses between homes or a central location to a regular destination. Vanpools can be publicly or privately operated or sponsored, but only public operations are included in the NTD ridership summaries. *Jitneys* and *públicos* are privately owned passenger cars or vans operating on fixed routes as demand warrants, without fixed schedules or stops. Públicos are government-regulated (and thus appear in FTA statistics), while jitneys are not. Many jurisdictions prohibit jitneys.[R12]

Vanpools, jitneys, and públicos are included in NTD statistics, but are not addressed in detail in this manual.

## OPERATING ENVIRONMENTS

Bus services can be operated on a variety of types of roadway, ranging from streets with mixed traffic to exclusive bus-only highways. Greater degrees of separation from other traffic provide transit vehicles and their riders with faster, more predictable journeys as the interference with other road users is reduced or eliminated. Providing special lanes or roads for buses also serves a marketing function as it indicates an institutional preference given to buses over the private automobile. Bus operation on dedicated rights-of-way, however, is not very common relative to mixed-traffic operation. About 515 miles (830 km) of roadway lanes with full-time occupancy restrictions favoring buses existed in 1995 in the United States.

Bus use of roadways.

Another 575 miles (930 km) of lanes offered preferential access for buses during at least part of the day. In contrast, about 150,000 miles (250,000 km) of roadway used by buses are shared with mixed traffic.(R2)

### Segregated Right-of-Way

Busways typically provide a two-way roadway in a segregated right-of-way designated for the exclusive use of buses. Maximum operating speeds are typically in the 45 to 50 mph (70 to 80 km/h) range. Stations are provided for passenger service.

Industry usage of the terms *busway* and *transitway* is not consistent. The terms are often used interchangeably.

Well-known examples of grade-separated busways in North America include Pittsburgh's three busways, the downtown Seattle bus tunnel, and Ottawa's five busways. The Ottawa system includes 16 miles (26 km) of bus-only roadways,[1] which carry 9,000-10,000 passengers in 190 buses per hour in the peak direction into downtown Ottawa. Frequent bus service is accommodated by providing passing lanes at stations, which resemble light rail stations in scale.(R20)

The busways in Ottawa, Pittsburgh, Miami, and Brisbane, Australia provide both express and all-stop services.

At-grade busways in North America include the 8-mile (13-km) South Dade Busway in Miami, Florida; the 1.6-mile (2.6-km) busway south of Seattle's bus tunnel; and a 1.2-mile (2.0-km) median busway in the Vancouver suburb of Richmond. All of these facilities have traffic signals along them that act to meter the flow of buses and thus have lower overall travel speed and capacity characteristics compared with grade-separated busways. A number of South American cities have developed busways in the medians of arterial streets.

*Guided busways* are a form of busway developed for constrained rights-of-way and can be either grade-separated or at-grade. Lateral guidance is provided using a set of guidance wheels on the bus that roll against curbs developed on the side of the guideway. As of 2003, no facilities of this type existed in North America. The most extensive international application is in Adelaide, Australia (shown in Exhibit 2-7); other guided busways exist in Essen, Germany, and Leeds, England.

**Exhibit 2-7**
Busway Examples

(a) Grade-Separated Busway (Ottawa)

(b) Guided Busway (Adelaide, Australia)

(c) At-Grade Busway (Miami)

(d) Median Busway (Vancouver)

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1 The entire Transitway system, including reserved freeway lanes and arterial street bus lanes, totals 37 miles (60 km) in length.

## High-Occupancy Vehicle (HOV) Lanes

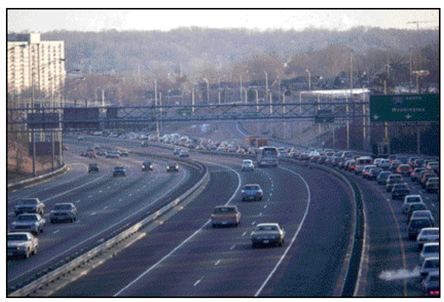
HOV lanes may be bus-only or may allow other vehicles.

Where capacity permits, buses can successfully operate in HOV lanes. HOV lanes, illustrated in Exhibit 2-8, are preferential lanes that are available only to vehicles carrying a number of passengers above a set threshold occupancy. In practice the occupancy requirement varies widely, depending on local policies, and ranges from a minimum requirement of two occupants per vehicle to the exclusive bus lanes previously mentioned. Some jurisdictions also permit motorcycles or taxis to use HOV lanes, as well as all emergency vehicles. While, in theory, occupancy requirements can be raised in order to maintain a desired level of service and increase person-moving capacity, reductions in occupancy requirements have been much more common in order to reduce the negative public perception caused by "empty lane syndrome."(R13)

HOV lanes can be provided in the same direction as general traffic (*concurrent flow*) or by using an underutilized lane in the opposite direction (*contraflow*). Both types are used in North America. A well-known contraflow facility is the Lincoln Tunnel bus lane from New Jersey to Manhattan in New York City, which carries over 32,000 passengers per hour in 735 buses. In many cases, HOV lanes are in effect during peak periods only and are available to all traffic at other times. Short reserved lane segments, known as *queue bypasses* or *queue jumpers*, are often used to allow buses, and sometimes other HOVs, to bypass congestion points such as metered freeway ramps. In 1990, there were over 950 HOV ramp bypasses in North America.(R13)

**Exhibit 2-8**
HOV Lane Examples

(a) Lincoln Tunnel Approach (New Jersey)



(b) Shirley Highway (Northern Virginia)

## Arterial Street Bus Lanes

Lanes reserved for buses, either on a full-time or part-time basis, are used in portions of many larger cities where relatively high numbers of buses are scheduled. These lanes reduce or eliminate traffic and on-street parking conflicts, thus providing faster and more reliable bus operations on surface streets. Where scheduled bus volumes are particularly high, more than one lane in each direction may be reserved for buses, as is the case on the Madison Avenue dual bus lanes in New York City, shown in Exhibit 2-9, and on 5th and 6th Avenues in Portland, Oregon. Entire streets reserved for buses, known as *bus malls,* are used in a number of cities but their use has waned in recent years. The more prominent remaining examples include the Nicollet Mall in Minneapolis, the Fulton Street Mall in Brooklyn, the 16th Street Mall in Denver, and the Granville Mall in Vancouver, British Columbia.

**Exhibit 2-9**
Arterial Street Bus Lane Examples

(a) Bus Mall (Denver)

(b) Dual Bus Lanes (New York)

(c) Exclusive Bus Lane (San Antonio)

(d) Part-Time Bus Lane (San Francisco)

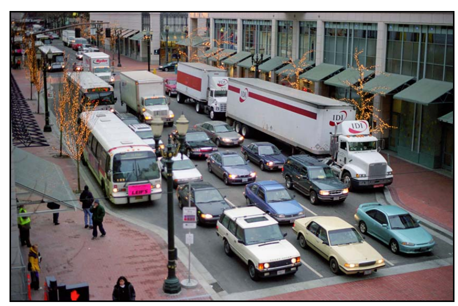
## Mixed Traffic

Mixed-traffic bus operation (Exhibit 2-10) accounts for over 99 percent of total bus route distance in North America. While operating buses in general traffic lanes is straightforward for planning and political purposes, it does result in buses being subject to delays caused by traffic. Mixed-traffic operation complicates capacity calculations for both bus and automobile flow since it exposes buses to automobile traffic congestion and slows automobiles as buses stop to serve passengers.

**Exhibit 2-10**
Mixed-Traffic Operation

The Portland photo shows operations during a temporary detour resulting from New Year's 2000 celebrations.

(a) Milwaukee



(b) Portland, Oregon

## VEHICLE TYPES

Bus services can be provided by a number of vehicle types ranging from minibuses to articulated and double-deck buses. The composition of the U.S. transit bus fleet is shown in Exhibit 2-11. Examples of buses used in fixed-route and demand-responsive service are shown in Exhibits 2-12 and 2-13, respectively. (Larger demand-responsive vehicles are also sometimes used in fixed-route service.)

**Exhibit 2-11**
Non-Rail Vehicles in Active Transit Service in the U.S. (2000)[R12]

| Vehicle Type | Directly Operated Bus Service |
|---|---|
| Class A Bus (>35 seats) | 43,945 |
| Class B Bus (25-35 seats) | 5,822 |
| Class C Bus (<25 seats) | 5,113 |
| Articulated Bus | 1,881 |
| Trolleybus | 894 |
| School Bus | 6 |
| Van | 7,394 |
| Automobile | 223 |
| Total | 65,278 |

NOTE: Class A, B, and C bus totals do not include the specialized bus types listed separately.

Standard 40-foot (12-meter) buses with more than 35 seats are by far the dominant form of bus operated by U.S. transit systems and constitute more than 65% of the national transit bus fleet. Articulated buses 60 feet (18 meters) in length have been embraced by a smaller number of transit agencies, but their use is growing as agencies seek to improve capacity and comfort with relatively low increases in operating costs. Double-deck buses are not currently used for public transit in the United States; however, public transit fleets in Brampton, Ontario, and Victoria, British Columbia, include double-deck buses.

The requirements of the ADA and parallel policies in Canada have resulted in most new transit vehicles being designed to accommodate passengers using wheeled mobility aids, those who have difficulty with stairs, and those carrying luggage or other bulky items. In 2001, 86% of the U.S. transit bus fleet was accessible to wheelchairs.[R2] While providing wheelchair lifts has been the most common means of meeting these obligations, a recent trend has been the move toward low-floor buses. These buses allow easier boarding for all passengers by eliminating the need for steps and wheelchair lifts; however, the ramps used on low-floor buses are designed for level boarding from a curb and may not be able to be deployed in areas without curbs and sidewalks.

While most transit buses are diesel powered, natural gas and electric-powered buses are also used by some agencies for environmental (reduced or eliminated bus exhaust), noise (quieter acceleration), ride comfort (no transmission in electric-only buses), improved hill-climbing ability (electric trolleybus), and/or operating cost reasons (e.g., reduced fuel costs). Electric trolleybuses (also known as *trackless trolleys*) operate in seven cities in Canada and the United States, but constitute less than 2% of the total U.S. transit bus fleet.

*Hybrid-electric* buses have both an electric motor and a motor powered by other fuels, including diesel, compressed natural gas (CNG), or some other fuel. These buses allow some of the energy generated during braking to be stored and reused for propulsion. Trials of hybrid-electrics have been ongoing since the late 1990s, and these buses are now being purchased by agencies for regular service. Denver, for example, introduced 116-passenger hybrid CNG-electric buses on its 16th Avenue Mall service in 2001.

**Exhibit 2-12**
Examples of Buses Used in Fixed-Route Service

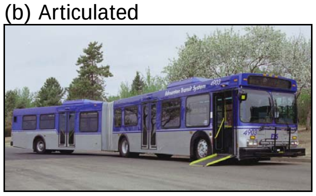
| Bus Type | Typical Applications | Capacity/QOS Factors |
|---|---|---|
| (a) Standard Bus<br> | • Forms more than 80% of U.S. bus fleet | • Bus length influences seating capacity, bus width influences standing capacity<br>• High floor |
| (b) Articulated<br> | • Routes where added capacity is desired without adding more buses<br>• Routes where reduced number of buses, but same capacity, is desired | • 50% more seats and standing capacity than standard bus<br>• High or low floor<br>• Reducing frequency may increase passenger service times and overall travel times |
| (c) Low-Floor<br> | • Provides easier access by eliminating steps<br>• Airport routes where passengers carry luggage | • Fewer seats than comparable standard bus<br>• Faster boarding times, particularly for wheelchairs<br>• Prefer streets developed with curbs for ramp deployment |
| (d) Electric Trolleybus<br> | • Routes replacing streetcars<br>• Downtown tunnels<br>• Routes on steep hills<br>• Cities with city-owned electric utilities | • Quieter acceleration<br>• No diesel exhaust<br>• Unless dual-powered, can only operate on facilities equipped with overhead wires<br>• Visual clutter from dual wires |
| (e) Over-the-Road Coach<br> | • Long-distance commuter routes<br>• Intercity routes<br>• Heavier-duty bus for high-speed running | • Larger, more comfortable seats<br>• Usually overhead storage racks<br>• Typically no standees allowed<br>• High floor |
| (f) Electric<br> | • Short-distance circulator service, particularly in downtown areas | • Quieter acceleration<br>• No diesel exhaust or overhead wires<br>• Limited range before recharging or swapping batteries |
| (g) Special-Purpose Bus<br> | • Short-distance circulator or point-to-point service carrying high volumes of passengers<br>• Bus/rail station distributor<br>• Airport air-side shuttles | • Most passengers stand, but trips tend to be short<br>• Multiple doors allow quick loading/unloading<br>• Low floor |
| (h) Replica Trolley<br> | • Tourist-oriented circulator service<br>• Special event service (e.g., city festival, county fair) | • Distinctive vehicle reassures passengers this is their bus<br>• Increases transit service visibility<br>• Seats may be less comfortable<br>• High floor |

Photo locations:
(a) Tallahassee
(b) Edmonton
(c) Victoria, British Columbia
(d) Philadelphia
(e) Cleveland
(f) Chattanooga
(g) Denver
(h) Albuquerque


(a) Chillicothe, Missouri

(b) Maple Ridge, British Columbia

**Exhibit 2-13**
Examples of Vehicles Used in Demand-Responsive Service

## OBSERVED BUS AND PASSENGER FLOWS

### Streets and Highways

Observed bus volumes on urban freeways, city streets, and bus-only streets clearly show the reductive effects of bus stops on bus vehicle capacity. The highest bus volumes experienced in a transit corridor in North America, 735 buses per hour through the Lincoln Tunnel and on the Port Authority Midtown Bus Terminal access ramps in the New York metropolitan area are achieved on exclusive rights-of-way where buses make no stops (and where a 210-berth bus terminal is provided to receive these and other buses).(R18) Where bus stops or layovers are involved, reported bus volumes are much lower. Exhibit 2-14 shows bus flow experience for a number of North American cities.

**Exhibit 2-14**
Observed Peak Direction Peak Hour Passenger Volumes on U.S. and Canadian Bus Transit Routes (1995-97)(R10,R21,R26)

| Location | Facility | Peak Hour Peak Direction Buses | Peak Hour Peak Direction Passengers | Average No. of Pass. per Bus |
|---|---|---|---|---|
| New Jersey | Lincoln Tunnel Approach | 735* | 32,600 | 44 |
| Ottawa | West Transitway | 225 | 11,100 | 49 |
| New York City | Madison Avenue | 180 | 10,000 | 55 |
| Portland | 6th Avenue | 175 | 8,500 | 50 |
| New York City | Long Island Expy. | 165* | 7,840 | 48 |
| New York City | Gowanus Expy. | 150* | 7,500 | 35 |
| Newark | Broad Street | 150 | 6,000 | 40 |
| Pittsburgh | East Busway | 105 | 5,400 | 51 |
| Northern Virginia | Shirley Highway | 160* | 5,000 | 35 |
| San Francisco | Bay Bridge | 135* | 5,000 | 37 |
| Denver | I-25 | 85* | 2,775 | 33 |
| Denver | Broadway/Lincoln | 89 | 2,325 | 26 |
| Boston | South/High Streets | 50 | 2,000 | 40 |
| Vancouver | Granville Mall | 70 | 1,800 | 26 |
| Vancouver | Highway 99 | 29 | 1,450 | 50 |

*no stops

Bus malls.

When intermediate stops are made, bus volumes rarely exceed 120 buses per hour. However, volumes of 180 to 200 buses per hour are feasible where buses may use two or more lanes to allow bus passing, especially where stops are short. An example is Hillside Avenue in New York City. Two parallel bus lanes in the same direction, such as along Madison Avenue in New York and the 5th and 6th Avenue Transit Mall in Portland, Oregon, also achieve this flow rate. Up to 45 buses one-way in a single lane in 15 minutes (a flow rate of 180 buses per hour) were observed on Chicago's former State Street Mall; however, this flow rate was achieved by advance marshaling of buses into three-bus platoons and by auxiliary rear-door fare collection during the evening peak hours to expedite passenger loading.(R27)

Several downtown streets carry bus volumes of 80 to 100 buses per hour where there are two or three loading areas per stop and where passenger boarding is not concentrated at a single stop. (This bus volume corresponds to about 5,000 to 7,500 passengers per hour, depending on passenger loads.)(R27)

Historic streetcar volumes.

These bus volumes provide initial capacity ranges that are suitable for general planning purposes. They compare with maximum streetcar volumes on city streets in the 1920s which approached 150 cars per track per hour, under conditions of extensive queuing and platoon loading at heavy stops.(R5) However, the streetcars had two operators and large rear platforms where boarding passengers could assemble. (R27)

### Terminals

Peak hour bus flows observed at 13 major bus terminals in the United States and Canada range from 2.5 buses per berth at the George Washington Bridge Terminal in New York to 19 buses per berth at the Eglinton Station, Toronto.(R27)

Buses occupy loading areas at bus terminals for much longer periods of time than they occupy loading areas at on-street bus stops.

The high berth productivity in Toronto reflects the special design of the terminal (with multiple positions in each berthing area); the wide doors on the buses using the terminal; the free transfer between bus and subway, which allows use of all doors; and separate boarding and alighting areas. The relatively low productivity at the New York terminals reflects the substantial number of intercity buses that use the terminals (which occupy berths for longer periods of time) and the single-entrance doors provided on many suburban buses.(R27)

This experience suggests an average of 8 to 10 buses per berth per hour for commuter operations. Intercity berths typically can accommodate 1 to 2 buses per hour.(R27)

## BUS PRIORITY TREATMENTS

Much attention has been paid to expediting transit flow by providing various forms of priority treatment. Such treatments are aimed at improving schedule adherence and reducing travel times and delays for transit users. They may attract new riders, increase transit capacity, and/or improve the transit quality of service.

A growing number of cities have established exclusive bus lanes and other bus priority measures to improve person-flow over city streets and highways. Bus priority measures are an essential part of transportation system management (TSM) programs that attempt to maximize transport system efficiency consistent with social, economic, and environmental objectives.

Effective distribution of buses in downtown areas remains an important challenge, and communities are giving this issue increased attention. Freeway-related treatments generally provide good access to the downtown perimeter, but do not substantially improve service within the downtown core. Terminals are not always located near major employment concentrations and may require secondary distribution. Because concurrent-flow curb bus lanes have not always been effective, there have been several efforts to install contraflow bus lanes in downtown areas. Traffic signal priority for buses is another measure effectively used to minimize bus delay and increase service quality. As a capital-intensive solution to downtown bus distribution, a 1.3-mile (2.1-km), five-station bus tunnel opened in downtown Seattle in 1991. Bus routes using the tunnel are operated with a special fleet of dual-mode buses which run on electric power in the tunnel and diesel power on the surface portions of their routes. Both ends of the tunnel connect to freeway ramps.

Many bus priority measures have produced important passenger benefits, especially those relating to freeways. Some have achieved time savings of 5 to 30 minutes—savings that compare favorably with those resulting from rail transit extensions or new systems. The contraflow bus lane leading to the Lincoln Tunnel in New Jersey, for example, provides a 20-minute time saving for bus passengers. However, even when passenger time savings are small, bus priority can still provide substantial schedule reliability improvements, which benefit both passengers and transit operators. A study of implementing traffic signal priority along a 6-mile (10-kilometer) corridor in Portland, Oregon, found average travel time savings of 2.5 minutes, but an improvement in reliability sufficient to remove 10 minutes of recovery time from the end of each trip.[R7]

Successful priority treatments are usually characterized by one or more of the following:[R19]

- An intensively developed downtown area with limited street capacity and high all-day parking costs,
- A long-term reliance on public transportation,
- Highway capacity limitations on approaches to downtown,
- Major water barriers that limit road access to the central business district (CBD) and channel bus flows,
- Fast non-stop bus runs for considerable distances,
- Bus priorities on approaches to major congestion points,
- Special downtown bus distribution (often off-street terminals), and
- Active traffic management, maintenance, operations, and enforcement programs.

## BUS RAPID TRANSIT

### Description

Bus Rapid Transit (BRT) is a relatively new term that describes a form of bus transit that has been in use since the 1970s. Certain elements of BRT, such as freeway running, have been used since the 1950s. BRT has drawn considerable interest in recent years, particularly as the amount of federal funding available for new rail starts has not matched the demand for such funding, and as the FTA has sponsored a consortium of transit agencies to develop BRT systems.

BRT is a complete rapid transit system that combines flexible service and new technologies to improve customer convenience and reduce delays. BRT includes the seven major service features listed below. Not all of these features need to exist in order for a service to be considered BRT, although all BRT systems typically include frequent service as part of the service package. In fact, implementing any of these BRT components will provide quality of service and/or capacity benefits:[R20]

- *Exclusive running ways.* Vehicles operate primarily in fast, easily identified busways and transit lanes. Vehicles can also operate in general traffic, achieving improved speed and reliability benefits through transit signal priority measures rather than exclusive facilities.
- *Enhanced stations.* Stations are attractive, easily accessible, and integrated with the surrounding community. A higher level of amenities is provided than at a regular bus stop. Bus-side station design includes provision for passing, so that express buses can bypass local buses stopped at the station.
- *Enhanced vehicles.* BRT uses high-capacity, rubber-tired vehicles that are easy to board and comfortable to ride. Many agencies are opting for larger windows, similar to rail vehicles, clean fuels, and on-board visual and audible stop announcements. A distinctive bus design, color, and/or graphics distinguish BRT buses from regular buses, providing reassurance to unfamiliar riders that this is their bus, and also raising awareness of the presence and frequency of service among current non-riders.

BRT can provide one-seat service from an origin to a major activity center, eliminating the transfer involved with feeder bus to rail service.

Proof-of-payment fare collection entails passengers purchasing fares in advance at the station and having receipts available for inspection by roving agency staff.

- *Frequent, all-day service.* BRT operates at high frequencies, reducing or eliminating the need for passengers to consult schedules. Long hours of service are also provided, to serve a variety of passenger trip types.
- *Flexible route structure.* BRT can be designed around a combination of local and express service to improve passenger service times. More extensive infrastructure, such as a busway, can be built as a trunk facility used by all routes for a portion of their trip, with routes splitting off the main facility to pick up and drop off passengers in local neighborhoods. A light rail facility providing the same function would require feeder bus service (and the associated transfer), as well as multiple tracks to provide the combined frequent express/local service.
- *Improved fare collection.* The time required to board passengers is minimized through the use of proof-of-payment fare collection (as is done on many light rail systems), or through technology such as smart cards that speeds the fare payment process. Multiple-door boarding may also be used to speed passenger boarding.
- *Applications of technology.* Intelligent Transportation System (ITS) technologies can be applied to provide bus arrival time information, next-stop announcements, automatic vehicle location, traffic signal priority, improved surveillance and security, and other functions.

## Applications

Exhibit 2-15 provides examples of existing BRT services in North America, according to the FTA. (Express or limited-stop services with no other existing or planned aspects of BRT are not included.) The exhibit lists the features provided by each service as of 2002. (A number of systems were planning further enhancements over time.) Other regions that were designing BRT services as of 2002 included Charlotte, North Carolina; Cleveland, Ohio; Eugene, Oregon; Hartford, Connecticut; Minneapolis, Minnesota; Northern Virginia; San Juan, Puerto Rico; and Santa Clara, California.

**Exhibit 2-15**
North American BRT Applications (2002)

| | | Service Features | | | | | |
|---|---|---|---|---|---|---|---|
| **Region** | **Service Type** | **Method** | **Stations** | **Vehicles** | **Local-Express** | **Fares** | **ITS** |
| Boston | line-haul | EL/B | ● | ● | | | ● |
| Honolulu | line-haul | EL | | ● | | | |
| Los Angeles | line-haul/rail feeder | SP | ● | ● | ● | | ● |
| Miami | rail feeder | B | ● | | ● | | |
| Montréal | rail feeder | EL | ● | | ● | | |
| Oakland | line-haul | LS | | ● | ● | | |
| Ottawa | line-haul | B | ● | | ● | | |
| Pittsburgh | line-haul | B | | | ● | POE | |
| Seattle | CBD distribution | B | ● | ● | | POE | |
| Vancouver | line-haul | B/EL/SP | ● | ● | ● | | ● |

NOTE: All systems include frequent service as a service feature.
Method: Primary means used in 2002 to improve speed, other than a limited number of stops: B =busway, EL = exclusive lanes, SP = signal priority, LS = limited stops only. Many systems were planning to implement additional means in the future.
Stations: dot indicates upgraded amenities and/or distinctive station treatments.
Vehicles: dot indicates different vehicle and/or livery than regular bus fleet.
Local-express: dot indicates mix of local and express service along BRT route.
Fares: POE = pay on exit for outbound trips.
ITS: dot indicates Intelligent Transportation System applications other than signal priority (e.g., real-time info).

# CHAPTER 3. RAIL TRANSIT

## OVERVIEW

Rail transit systems in North America carry more than 5 billion passengers each year. As of 1995, a total of 53 agencies operated 207 routes of the four major rail transit modes—heavy rail, light rail, commuter rail, and automated guideway transit—with a total length of 5,100 miles (8,200 kilometers), providing 18 billion passenger-miles (29 billion passenger-kilometers) of service annually. Less common rail modes include monorails, funicular railways (inclined planes), aerial ropeways, and cable cars. Collectively, as part of public transit operations, these modes provided approximately 14.4 million annual unlinked passenger trips in 2000.(R12)

Two systems dominate. The largest operator is MTA-New York City Transit, which carried 1,678 million passengers in 2000, 50% of the U.S. rail total and 30% of the continent's total. The second largest operator, Sistema de Transporte Colectivo in Mexico City, carried 1,434 million passengers in 2000, 26% of the continent's total. Adding all New York City area rail operators together, New York accounts for approximately 2 billion annual rail trips, 59% of the U.S. total and 36% of the continent's total. The New York and Mexico City rail systems combined account for two-thirds of all North American unlinked rail trips.

Rail transit plays a vital role in five metropolitan areas, carrying over 50% of all work trips and, in three regions, over 70% of all downtown-oriented work trips. Rail transit plays an important but lesser role in another six regions. Other rail transit systems carry a smaller proportion of regional trips but fill other functions, such as defining corridors and encouraging densification and positive land-use development.

Ridership data are summarized in Exhibit 2-16 and Exhibit 2-17, while Exhibit 2-18 summarizes other key North American statistics for each rail mode.

**Exhibit 2-16**
North American Rail Ridership by Mode (millions) (2000)(R2,R12,R15)

| Mode | Annual Unlinked Trips | % |
|---|---|---|
| Heavy Rail | 4,650.1 | 83.4% |
| Light Rail | 475.2 | 8.5% |
| Commuter Rail | 444.7 | 8.0% |
| Automated Guideway | 6.4 | 0.1% |
| Total | 5,576.4 | 100.0% |

NOTE: Data include U.S., Canadian, and Mexican public transit operators.

Heavy rail carries 83% of all rail transit passengers in North America.

**Exhibit 2-17**
National Transit Ridership Summary (millions) (2000)(R2,R12,R15)

| Country | All Transit | Rail Transit | % by Rail |
|---|---|---|---|
| USA | 9,401 | 3,368 | 36% |
| Canada | 2,323 | 669 | 29% |
| Mexico | NA | 1,540 | NA |

NA: not available

**Exhibit 2-18**
Comparison of Key North American Rail Mode Statistics (1995)(R25)

| Type | Routes | Avg. Line Length (mi) | Total Length (mi) | Average Station Spacing (mi) | Average Line Speed (mph) |
|---|---|---|---|---|---|
| AGT | 3 | 3.9 | 11.8 | 0.43 | 15.1 |
| CR | 77 | 45.8 | 3,524.5 | 3.55 | 32.7 |
| LRT | 51 | 8.6 | 440.2 | 0.52 | 13.7 |
| HR | 76 | 15.7 | 1,161.1 | 0.91 | 22.5 |

| Type | Routes | Avg. Line Length (km) | Total Length (km) | Average Station Spacing (km) | Average Line Speed (km/h) |
|---|---|---|---|---|---|
| AGT | 3 | 6.3 | 19.0 | 0.70 | 24.3 |
| CR | 77 | 73.7 | 5,672.1 | 5.71 | 52.7 |
| LRT | 51 | 13.9 | 708.5 | 0.83 | 22.1 |
| HR | 76 | 25.3 | 1,868.6 | 1.47 | 36.2 |

AGT: automated guideway transit, CR: commuter rail, LRT: light rail transit, HR: heavy rail

## OPERATING ENVIRONMENTS

While the rail mode employed on a rail transit line has some bearing on capacity, the type of right-of-way used by the line is of vital importance. The three major types of rights-of-way are described below.

### Exclusive Right-of-Way

The right-of-way is reserved for the exclusive use of transit vehicles. There is no interaction with other vehicle types. Intersections with other modes are grade-separated to avoid the potential for conflict. Exclusive rights-of-way provide maximum capacity and the fastest and most reliable service, although at higher capital costs than other right-of-way types. Automated guideway transit systems must operate on this type of right-of-way, as their automated operation precludes any mixing with other modes. This right-of-way type is most common for heavy rail systems and many commuter rail systems, and occurs on at least portions of many light rail systems.

### Segregated Right-of-Way

Segregated rights-of-way provide many of the same benefits of exclusive rights-of-way but permit other modes to cross the right-of-way at defined locations such as grade crossings. Segregated rights-of-way are most commonly employed with commuter rail and light rail transit systems. The use of this right-of-way type for heavy rail transit systems has largely been eliminated.

### Shared Right-of-Way

A shared right-of-way permits other traffic to mix with rail transit vehicles, as is the case with streetcar lines. While this right-of-way type is the least capital intensive, it does not provide the benefits in capacity, operating speed, and reliability that are provided by the other right-of-way types.

## RAIL MODES

### Heavy Rail

Introduction and characteristics.

Heavy rail transit (Exhibit 2-19) is by far the predominant urban rail travel mode in North America, in terms of system size and utilization. Exhibit 2-3 illustrated the lead heavy rail transit in the United States has over the other rail modes in both annual passenger trips and annual passenger miles. Heavy rail transit is characterized by fully grade-separated rights-of-way, high level platforms, and high-speed, electric multiple-unit cars.

The expeditious handling of passengers is enabled through the use of long trains of up to 11 cars running frequently. Loading and unloading of passengers at stations is rapid due to level access and multiple double-stream doors.

Power is generally collected from a third rail, but can also be received from overhead wires as in Cleveland, the Skokie Swift in Chicago, and a portion of the Blue Line in Boston. Third-rail power collection, frequent service, and high operating speeds generally necessitate the use of grade-separated pedestrian and vehicular crossings. A small number of grade crossings is an unusual feature of the Chicago system.

**Exhibit 2-19**
Heavy Rail Examples

(a) Chicago

(b) Toronto

(c) Cleveland

(d) San Francisco Bay Area

Status of heavy rail systems.

U.S. and Canadian heavy rail systems generally fall into two groups according to their time of initial construction. Pre-war systems are often characterized by high passenger densities and closely spaced stations, although the postwar systems in Toronto and Montréal also fall into this category. The newer U.S. systems tend to place a higher value on passenger comfort and operating speed, as expressed by less crowded trains and a more distant spacing of stations, especially in suburban areas. Newer systems also tend to provide extensive suburban park-and-ride facilities.

Some overlap exists between heavy rail, light rail, and AGT.

BART in the San Francisco Bay Area is a prime example of the latter category with its fast trains and provision of upholstered seats. BART station spacing outside downtown San Francisco and Oakland is great enough to allow the high overall speed required to compete with the automobile. Vancouver's SkyTrain and Toronto's Scarborough Rapid Transit lines are included in the heavy rail category rather than the light rail or automated guideway categories since they most closely resemble heavy rail transit systems in operating practices and right-of-way characteristics.[2]

The high costs of constructing fully grade-separated rights-of-way (subway or elevated) for heavy rail transit have limited expansion in recent decades. Exhibit 2-20 identifies the 18 existing heavy rail transit systems in North America.

Of the U.S. heavy rail systems, the three New York City systems carried two-thirds of all riders using this mode in 2000. Heavy rail transit's efficiency in moving large volumes of passengers in densely populated areas is evident in this, the largest metropolitan area in the United States. Heavy rail transit plays a key role in enabling such dense urban areas to exist. In 1995, 51.9% of business day travel into Lower Manhattan was by heavy rail transit. During the 7:00 to 10:00 a.m. time period, this share increased to 62.2%.(R24)

[2] Philadelphia's Norristown high-speed line is another illustration of the difficulty of characterizing some rail transit modes. The Norristown line is entirely grade-separated, uses third rail, and has high platforms (characteristics often associated with heavy rail), but uses one-car trains, makes many stops only on demand, and has on-board fare collection (characteristics often associated with light rail). SEPTA and the FTA classify it as heavy rail.

**Exhibit 2-20**
North American Heavy Rail Transit Systems (2000)(R2,R12,R15,R25)

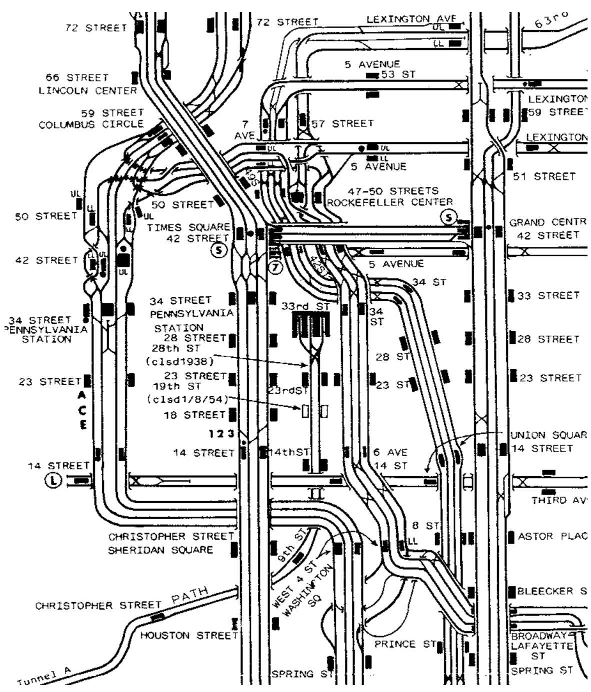
| Region | Directional Route Length (mi) | (km) | Avg. Weekday Boardings | Vehicles Operated in Max. Service |
|---|---|---|---|---|
| Atlanta | 92.1 | 148.2 | 274,000 | 178 |
| Baltimore | 29.4 | 47.3 | 47,800 | 66 |
| Boston | 76.3 | 122.8 | 448,400 | 320 |
| Chicago | 206.3 | 331.9 | 589,400 | 914 |
| Cleveland | 38.2 | 61.5 | 24,100 | 28 |
| Los Angeles | 31.9 | 51.3 | 83,200 | 58 |
| Mexico City | 250.7 | 403.4 | 4,405,400** | 2,450** |
| Miami | 53.2 | 85.6 | 47,200 | 80 |
| Montréal | 76.0 | 122.3 | 920,600 | 555* |
| New York (MTA-NYCT) | 492.9 | 793.1 | 5,512,700 | 4,891 |
| New York (MTA-Staten Isl.) | 28.6 | 46.0 | 15,400 | 40 |
| New York (PATH) | 28.6 | 46.0 | 270,600 | 288 |
| Philadelphia (SEPTA) | 76.1 | 122.4 | 296,200 | 298 |
| Philadelphia (PATCO) | 31.5 | 50.7 | 38,000 | 96 |
| San Francisco (BART) | 190.1 | 305.9 | 310,300 | 523 |
| San Juan | 21.4 | 34.4 | scheduled 2003 opening | |
| Toronto | 70.2 | 113.0 | 881,900** | 540** |
| Vancouver | 35.8 | 57.6 | 146,400** | 140** |
| Washington | 193.5 | 311.3 | 738,200 | 632 |

*1995 data
**2001 data provided by the Canadian Urban Transit Association or individual agencies

Complexity of the New York subway.

The New York City subway system is one of the largest and most complex in the world. This extensive subway system carries almost twice as many riders as does the local bus system. Most lines are triple or quadruple tracked to allow the operation of express services. A large number of junctions permit trains to be operated on a variety of combinations of line segments to provide an extensive network of service. Exhibit 2-21 shows a diagram of the subway tracks in midtown Manhattan.

**Exhibit 2-21**
MTA-NYCT Subway Tracks in Midtown Manhattan

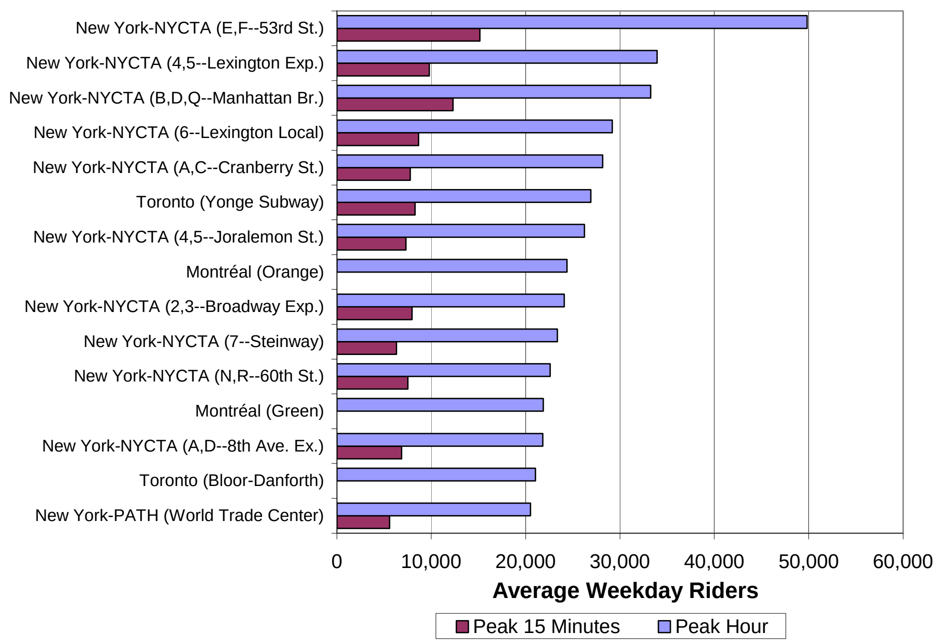



SOURCE: From *New York Railway Map*, courtesy John Yonge, © 1993 Quail Map Company, 31 Lincoln Road, Exeter, England.

Exhibit 2-22 illustrates the peak hour and peak 15-minute passenger flow rates for the 15 busiest heavy rail transit trunk lines in the U.S. and Canada. The graph uses trunks rather than routes in order to group those services sharing tracks together. All the trunks listed are double tracked and have at least one station used by all routes.

When four-track lines in New York are taken into consideration, the maximum load is a combination of the Lexington Avenue Express and Local at 63,200 passengers per peak hour direction, with almost comparable volumes on the combined Queens Boulevard lines at Queens Plaza. In comparison, the busiest two-track heavy rail line in the world is in Hong Kong, with 84,000 passengers per peak hour direction.

**Exhibit 2-22**
Peak Hour and Peak 15-minute Flows for the Busiest 15 U.S. and Canadian Heavy Rail Transit Trunk Lines (1995)(R25)




NOTE: Data could not be obtained for Philadelphia's SEPTA. However, it is unlikely that any of the SEPTA rapid transit lines would feature in this chart if data were available. Peak 15-minute flow data were not available for all lines for which peak hour data were available.

## Light Rail Transit

Light rail transit, often known simply as LRT, began as a development of the streetcar to allow higher speeds and increased capacity. Light rail transit is characterized by its versatility of operation, as it can operate separated from other traffic below grade, at-grade, or on an elevated structure, or can operate together with motor vehicles on the surface (Exhibit 2-23). Service can be operated with single cars or multiple-car trains. Electric traction power is obtained from an overhead wire, thus eliminating the restrictions imposed by having a live third-rail at ground level. This flexibility helps to keep construction costs low and explains the popularity this mode has experienced since 1978 when the first of 14 new North American light rail transit systems was opened in Edmonton. These newer LRT systems have adopted a much higher level of segregation from other traffic than earlier systems enjoyed.

Diesel light rail.

A recent trend is the introduction of diesel light rail cars by European manufacturers. Trials of such cars have generated considerable interest in some areas, given the ease with which diesel light rail service can be established on existing rail lines. Ottawa opened a 5-mile (8-km) line connecting two busway stations in 2002. New Jersey Transit is constructing a diesel light rail line between Trenton and Camden, scheduled to open in 2003. It should be noted that the TRB Committee on Light Rail Transit's definition of light rail encompasses only electric-powered lines, and therefore would not consider diesel light rail to be "light rail transit." However, The TCQSM's capacity procedures are primarily based on right-of-way type, with mode a secondary consideration.

the TCQSM's capacity procedures are based primarily on right-of-way type and secondarily by mode. The basic light rail capacity procedures can be applied to diesel light rail, but differences in vehicle operating characteristics (such as acceleration) would need to be taken into account.

Three major types of light rail operations exist:

- *Light rail,* with relatively frequent service along mostly exclusive or segregated rights-of-way, using articulated cars and up to four-car trains.
- *Streetcars,* operating along mostly shared or segregated rights-of-way, with one-car (or rarely, two-car) trains. Vehicle types and ages can vary greatly.
- *Vintage trolleys* provide mainly tourist- or shopper-oriented service, often at relatively low frequencies, using either historic vehicles or newer vehicles designed to look like historic vehicles.

**Exhibit 2-23**
Light Rail Examples

(a) Light Rail (San Diego)

(b) Light Rail (Portland, Oregon)


(c) Light Rail (Cleveland)

(d) Streetcar (Philadelphia)


(e) Streetcar (San Francisco)

(f) Vintage Trolley (Memphis)

As of 2002, there are 27 light rail and streetcar systems and 5 vintage trolley systems operated by public transit agencies in North America. An additional three light rail, one streetcar, and one vintage trolley systems will open by 2004. These systems are listed in Exhibit 2-24.

**Exhibit 2-24**
North American Light Rail Transit Systems (2000)[R2,R12,R15]

| Region | Type | Dir. Route Length (mi) | Dir. Route Length (km) | Avg. Weekday Boardings | Veh. Operated in Max. Service |
|---|---|---|---|---|---|
| Baltimore | LR | 57.6 | 92.7 | 27,400 | 40 |
| Boston | LR/SC | 51.0 | 82.1 | 255,600 | 154 |
| Buffalo | LR | 12.4 | 20.0 | 23,200 | 23 |
| Calgary | LR | 40.4 | 65.0 | 132,100 | 81 |
| Cleveland | LR | 30.8 | 49.6 | 14,100 | 25 |
| Dallas | LR | 40.8 | 65.6 | 37,700 | 48 |
| Denver | LR | 28.0 | 45.1 | 22,500 | 29 |
| Edmonton | LR | 13.9 | 22.4 | 38,000* | 31* |
| Galveston, TX | VT | 5.2 | 8.4 | 300** | 4** |
| Guadalajara | LR | 29.8 | 48.0 | 149,000 | NA |
| Houston | LR | 14.0 | 22.5 | scheduled 2004 opening | |
| Jersey City (Hudson-Bergen) | LR | 13.8 | 22.2 | 3,100 | 12 |
| Kenosha, WI | VT | 1.9 | 3.1 | 150 | 1 |
| Little Rock | VT | 4.2 | 6.8 | scheduled 2004 opening | |
| Los Angeles | LR | 82.4 | 132.6 | 91,300 | 51 |
| Memphis | VT | 5.8 | 9.3 | 3,500 | 9 |
| Mexico City | LR | 32.3 | 52.0 | 55,000 | NA |
| Minneapolis | LR | 23.2 | 37.3 | scheduled 2004 opening | |
| Monterrey | LR | 28.6 | 46.0 | 123,000 | NA |
| New Orleans | SC/VT | 16.0 | 25.7 | 14,900 | 23 |
| Newark (City Subway) | LR | 8.3 | 13.4 | 16,900 | 16 |
| Ottawa | DLR | 10.0 | 16.1 | 5,800* | 2* |
| Philadelphia | LR/SC | 69.3 | 111.5 | 83,100 | 108 |
| Pittsburgh | LR/SC | 34.8 | 56.0 | 24,600 | 47 |
| Portland (MAX) | LR | 64.9 | 104.4 | 73,600 | 56 |
| Portland (Streetcar) | SC | 4.8 | 7.7 | 4,200* | 4* |
| Sacramento | LR | 40.7 | 65.5 | 29,100 | 32 |
| St. Louis | LR | 34.0 | 54.7 | 41,500 | 26 |
| Salt Lake City | LR | 29.6 | 47.6 | 20,100 | 20 |
| San Diego | LR | 96.6 | 155.4 | 83,500 | 83 |
| San Francisco | LR/SC | 70.0 | 112.6 | 134,600 | 125 |
| San Jose | LR | 55.8 | 89.8 | 25,600 | 43 |
| Seattle | VT | 3.7 | 6.0 | 600 | 3 |
| Southern New Jersey | DLR | 68.0 | 109.4 | scheduled 2003 opening | |
| Tacoma | SC | 3.2 | 5.2 | opened 2003 | 2† |
| Tampa | VT | 4.6 | 7.4 | 1,200* | 4* |
| Toronto | SC | 136.4 | 219.5 | 196,000 | 155* |

*2002 data from agency **1998 data †2003 data from agency
LR = light rail, DLR = diesel light rail, SC = streetcar, VT = vintage trolley, NA = not available
NOTE: Only those vintage trolleys operated by public transit agencies are included. The privately operated Tandy Subway in Fort Worth, 1.0-mi (1.6-km) long, closed in 2002.

Light rail passenger volumes.

Exhibit 2-25 gives typical peak hour peak direction passenger volumes, service frequencies, and train lengths for principal U.S. and Canadian light rail transit lines. Exhibit 2-26 provides an indication of the maximum peak passenger volumes carried on a number of light rail systems for which data are available. The exhibit illustrates the peak passenger volumes carried over the busiest segment of the LRT system; in many cases, this represents passengers being carried on more than one route.

Historic streetcar volumes.

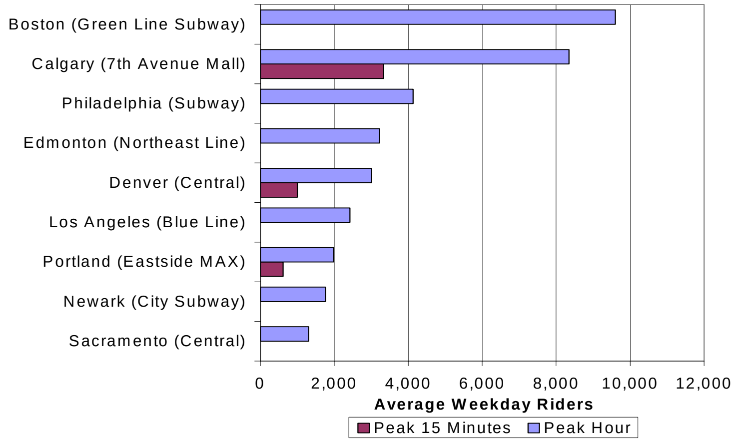
Some streetcar and light rail lines carried substantially higher passenger flows in the peak years of 1946-1960. Post-World War II streetcars operated at as close as 30-second headways both on-street (Pittsburgh) and in tunnels (Philadelphia). Peak hour passenger flows were approximately 9,000 persons per hour.[R27] San Francisco's Market Street surface routes carried 4,900 peak hour one-way passengers per hour before they were placed underground.[R27] Now, the observed number of peak hour passengers at the maximum load point usually reflects demand rather than capacity. Peak 15-minute volumes expressed as hourly flow rates are about 15% higher.

**Exhibit 2-25**
Observed U.S. and Canadian LRT Passenger Volumes: Peak Hour at the Peak Point for Selected Lines (1993-96 Data)[(R25)]

| City | Location | Trains/h | Cars/h | Head-way (s) | Peak Hour p/dir | Peak Hour Load (p/ft) | Peak Hour Load (p/m) |
|---|---|---|---|---|---|---|---|
| Boston | Green Line Subway* | 45 | 90 | 80 | 9,600 | 1.6 | 5.3 |
| Calgary | South Line | 11 | 33 | 320 | 4,950 | 2.1 | 6.8 |
| Denver | Central | 12 | 24 | 300 | 3,000 | 1.4 | 4.7 |
| Edmonton | Northeast LRT | 12 | 36 | 300 | 3,220 | 1.2 | 4.0 |
| Los Angeles | Blue Line | 9 | 18 | 400 | 2,420 | 1.6 | 5.4 |
| Newark | City Subway | 30 | 30 | 120 | 1,760 | 1.4 | 4.6 |
| Philadelphia | Subway-Surface* | 60 | 60 | 60 | 4,130 | 1.5 | 5.0 |
| Portland | Eastside MAX | 9 | 16 | 400 | 1,980 | 1.6 | 5.1 |
| Sacramento | Sacramento LRT | 4 | 12 | 900 | 1,310 | 1.5 | 4.9 |
| Toronto | Queen at Broadway* | 51 | 51 | 70 | 4,300 | 1.9 | 6.1 |

*Trunks with multiple-berth stations.
NOTE: In a single hour a route may have different lengths of trains and/or trains with cars of different lengths or seating configurations. Data represent the average car. In calculating the passengers per foot of car length, the car length is reduced by 9% to allow for space lost to driver cabs, stairwells, and other equipment. Data were not available for the heavily used Muni Metro subway in San Francisco.

**Exhibit 2-26**
Peak Hour and Peak 15-Minute Directional Flows for Selected U.S. and Canadian Light Rail Transit Trunks (1995)[(R25)]




NOTE: Data not available for the heavily used Muni Metro subway in San Francisco.

## Commuter Rail

Commuter rail (Exhibit 2-27) is generally a long distance transit mode using trackage that is a part of the general railroad system but which may be used exclusively for passenger movement. A few commuter rail operations, such as the Long Island Rail Road and the New Canaan branch of MTA Metro-North's New Haven line, were built solely for passenger movement. Track may be owned by the transit system or access may be by agreement with a freight railroad. Similarly, train operation may be by the transit agency, the track owner, or a third-party contractor. Service is heavily oriented towards the peak commuting hours, particularly on the smaller systems. All-day service is operated on many of the mainlines of the larger commuter rail systems and the term *regional rail* is more appropriate in these cases.

**Exhibit 2-27**
Commuter Rail Examples


(a) Toronto

(b) Chicago

Commuter rail scheduling is often tailored to the peak travel demand rather than operating consistent headways throughout the peak period. Where track arrangements and signaling permit, operations can be complex with the use of local trains, limited-stop express trains and zoned express trains. Zoned express trains are commonly used on busy lines with many stations where express trains serve a group of stations then run non-stop to the major destination station(s).

Commuter rail scheduling.

### *Commuter Rail Propulsion and Equipment*

Diesel and electric power are both used for traction on commuter rail lines. Electric traction is capital intensive but permits faster acceleration while reducing noise and air pollution. It is used mainly on busy routes, particularly where stops are spaced closely together or where long tunnels are encountered. Both power sources can be used for locomotive or multiple-unit operation. All cars in a multiple-unit train can be powered, or some can be unpowered "trailer" cars which must be operated in combination with powered cars. Electric multiple-unit cars are used extensively in the New York, Philadelphia, and Chicago regions, and the entire SEPTA regional rail system in Philadelphia is electrified. Dallas is currently the only city operating diesel multiple-unit cars in commuter rail service.

Multiple-unit cars are self-propelled, as opposed to needing a locomotive to provide power.

Locomotive-hauled commuter trains are standard for diesel operation and are becoming more common on electrified lines as a way to avoid the high costs of multiple-unit cars. New Jersey Transit and SEPTA have both purchased electric locomotives as an economical alternative to buying multiple-unit cars. Other systems value the flexibility of multiple-unit cars in varying train length. Montréal's STCUM commuter rail system has replaced a mixed fleet with a standard new electric multiple-unit design.

Commuter rail train length can be tailored to demand with cars added and removed as ridership dictates. This is particularly easy with multiple-unit equipment and can result in trains of anywhere from two to twelve cars in length. Where train length is constant all day, unneeded cars can be closed to passengers to reduce staffing needs and the risk of equipment damage.

Commuter rail is unique among the rail transit modes in that a high priority is placed on passenger comfort, as journeys are often long and the main source of competition is the automobile. All lines operate with a goal of a seat for every passenger except for the busy inner portions of routes where many lines funnel together and frequent service is provided. Such is the case for the 20-minute journey on the Long Island Rail Road between Jamaica and Penn Stations. Service between these points is very frequent (trains on this four-track corridor operate as close as 1 minute apart in the peak hours) as trains from multiple branches converge at Jamaica to continue to Manhattan.

Passenger comfort and car design.

Commuter rail cars are generally designed with the maximum number of seats possible, although this tradition is changing somewhat where persons in wheelchairs and bicycles are accommodated. A number of common approaches are taken to achieve maximum seating over the car length. The simplest is the use of 2+3 ("two-by-three") seating where five seats are placed in each row as opposed to the usual four. This can be done quite easily in wide railroad-type cars and brings the number of seats per car to around 120. It is not especially popular with passengers. This type of seating is used by many agencies, including the Long Island Rail Road and the MBTA in Boston, but it places a constraint on aisle width that may make the provision of wheelchair access difficult.

The other main approach to increasing car capacity is to add additional seating levels to the car, subject to any height restrictions, such as tunnels and underpasses, on the rail lines. The gallery-type car is one example and adds an upper seating level to the car with an open well to the lower level. The well serves to permit ticket collection and inspection from the lower level but does limit the upper level to single seats on each side. Gallery cars can typically seat 150 to 160 passengers and are used most extensively by Chicago's Metra commuter rail system. A more recent development is the bi-level car[3] which has upper and lower levels over the center of the car with an intermediate level at each end of the vehicle. Toronto's GO Transit popularized this design with relatively spacious seating for 160. It is now also being used by Metrolink in Los Angeles, the Coaster in San Diego, the Sounder in Seattle, Tri-Rail in Florida, and the West Coast Express in Vancouver. This style of car has become common on many European commuter rail (suburban) services.

Commuter rail platform height.

Passenger access to commuter rail trains can be from platform (high) or ground level (low). High-level boarding is commonly used on busy lines or at major stations to speed passenger movements. Standard railway type "traps" in the stepwells allow cars to use both types of platform but require the train crew to raise and lower the trap door above the steps. The electric multiple unit cars used by the Northern Indiana Commuter Transportation District on the South Shore line out of Chicago employ an extra set of doors at the center of the cars that are used exclusively at high platform stations while the car end doors are fitted with traps in the conventional manner for use at high and low platform stations. This arrangement is also used on the electric multiple-unit cars used on Montréal's Mount Royal tunnel line.

Commuter rail status.

As of 2002, commuter rail services operated in 18 North American metropolitan regions, with more than one agency providing service in three of these regions, as shown in Exhibit 2-28. There has been rapid growth in this mode as a result of the availability of government funding and the relatively low capital costs of the mode. This is offset by higher operating costs per passenger trip—particularly for lower-volume commuter rail services.

**Exhibit 2-28**
North American Commuter Rail Systems (2000)(R2,R12)

| Region | Directional Route Length (mi) | Directional Route Length (km) | Avg. Weekday Boardings | Veh. Operated in Max. Service |
|---|---|---|---|---|
| Baltimore (MARC) | 373.4 | 600.9 | 20,900 | 110 |
| Boston | 710.2 | 1,143.0 | 129,500 | 379 |
| Burlington | 25.0* | 40.2* | 200* | 2* |
| Chicago (Metra) | 940.4 | 1,513.4 | 268,400 | 996 |
| Chicago (N. Indiana) | 179.8 | 289.4 | 12,800 | 52 |
| Dallas-Ft. Worth | 51.6 | 83.0 | 4,200 | 12 |
| Los Angeles | 770.0 | 1,239.2 | 26,300 | 134 |
| Miami | 142.2 | 228.8 | 7,400 | 20 |
| Montréal | 116.8 | 188.0 | 51,900 | NA |
| New Haven | 101.2 | 162.9 | 1,100 | 16 |
| New Jersey | 1,091.4 | 1,756.4 | 212,000 | 735 |
| New York (Long Island RR) | 638.2 | 1,027.1 | 355,000 | 954 |
| New York (Metro-North) | 545.7 | 878.2 | 249,100 | 772 |
| Philadelphia (PennDOT) | 144.4 | 232.4 | 700 | 9 |
| Philadelphia (SEPTA) | 449.2 | 722.9 | 104,200 | 291 |
| San Diego | 82.2 | 132.3 | 4,300 | 20 |
| San Francisco (CalTrain) | 153.6 | 247.2 | 30,600 | 93 |
| San Jose (ACE) | 172.0 | 276.8 | 3,500 | 12 |
| Seattle | 78.6 | 126.5 | 1,100 | 14 |
| Syracuse | 7.0 | 11.3 | 100* | 1* |
| Toronto | 448.7 | 722.0 | 117,100 | 296** |
| Vancouver | 80.8 | 130.0 | 7,600 | 32** |
| Washington (VRE) | 177.5 | 285.7 | 8,100 | 54 |

*2002 data
**2001 data from CUTA or individual agencies
NA: not available
Additional source: operator survey
NOTE: Burlington's Champlain Flyer ceased operations in March 2003. Syracuse's OnTrack City Express operates 11:15 a.m. to 6:30 p.m. Wednesday through Sunday.

3 Less commonly known as tri-level cars, as there are technically three floor levels.

Extensions and expansions are planned on other systems to enlarge the service area and provide additional parking for patrons. With many commuter rail lines serving low-density suburban areas, the provision of adequate customer parking is a key to maximizing ridership. To meet this need, "cornfield" stations are built to allow parking capacity to be expanded at low cost in relatively undeveloped areas.

Commuter rail ridership is highly concentrated—the New York and Chicago metropolitan systems are the four busiest on the continent, as shown in Exhibit 2-28. Toronto's GO Transit, one of the first of the new generation of commuter rail systems, ranks fifth. Exhibit 2-29 illustrates the peak hour and peak 15-minute flows handled on the busier commuter rail lines in North America.

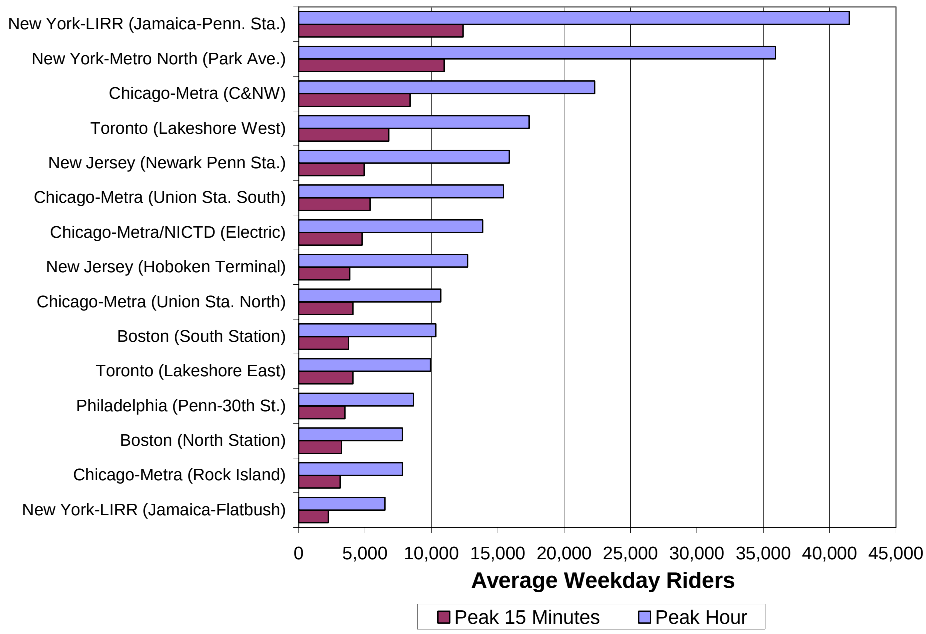



**Exhibit 2-29**
Peak Hour and Peak 15-minute Flows for the Busiest 15 U.S. and Canadian Commuter Rail Trunk Lines (1995)(R25)

## Automated Guideway Transit (AGT)

As their name indicates, AGT systems (Exhibit 2-30) are completely automated (vehicles without drivers), with personnel limited to a supervisory role. Their automated nature requires guideways to be fully separated from other traffic. Cars are generally small and service is frequent—the name "people mover" is often applied to these systems, which can take on the role of horizontal elevators. The technologies used vary widely and include rubber-tired electrically propelled vehicles, monorails, and cable-hauled vehicles.

AGT status.

Nearly 40 AGT systems are operated in the United States today, with none operating in Canada. The SkyTrain in Vancouver and the Scarborough RT in Toronto, while automated and sharing the same basic technology that is used on the Detroit People Mover, have more in common with heavy rail systems than AGT lines in their service characteristics, ridership patterns, and operating practices, and so are included in the heavy rail listings.

AGT systems operate in four types of environments:

- Airports;
- Institutions (universities, shopping malls, government buildings);
- Leisure and amusement parks (e.g., Disneyland); and
- Public transit systems.

Most of these systems are operated by airports or by private entities, especially as amusement park circulation systems.

**Exhibit 2-30**
Automated Guideway Transit Examples

(a) Airport Shuttle (Newark)

(b) Downtown People Mover (Miami)

(c) Institutional (Honolulu)

(d) Leisure (Memphis)

AGT transit services.

There are three public transit AGT systems operating in the United States, serving the downtown areas of Detroit, Jacksonville, and Miami. The Detroit People Mover line has remained unchanged from its opening in 1987, while the Miami MetroMover added two extensions in 1994. Jacksonville opened the first 0.7-mile (1.1-kilometer) section of its Skyway in 1989, with new extensions opening from 1997 to 1999 to serve both sides of the St. Johns River.

A relatively large institutional system is the one at the West Virginia University campus in Morgantown. This 3-mile (5-kilometer) line features off-line stations that enable close headways, down to 15 seconds, and permit cars to bypass intermediate stations. The cars are small, accommodating only 21 passengers, and are operated singly. On-demand service is possible during off-peak hours.

Exhibit 2-31 lists ridership and other statistics for the North American AGT systems used for public transit.

**Exhibit 2-31**
North American AGT Systems Used for Public Transit (2000)[R12]

| | Directional Route Length | | Avg. Weekday | Vehicles Operated in |
|---|---|---|---|---|
| **Region** | **(mi)** | **(km)** | **Boardings** | **Maximum Service** |
| Detroit | 2.9 | 4.7 | 4,200 | 7 |
| Jacksonville | 4.3 | 6.9 | 2,100 | 6 |
| Miami | 8.5 | 13.7 | 14,300 | 15 |

Daily ridership data for other North American AGT systems are shown in Exhibit 2-32. Caution should be exercised with many of these figures, as the non-transit systems are not required to provide the reporting accuracy mandated by the FTA. Ridership on many systems is also likely affected by seasonal patterns and less pronounced peaking (with the notable exception of airport systems) than occurs on transit systems. Regardless of these qualifications, the total daily ridership on the 36 non-transit systems amounts to over 500,000, compared to about 20,000 on the three transit AGT lines.

**Exhibit 2-32**
U.S. Non-Transit AGT Systems (2003)

| Location | Technology | 1995 Avg. Daily Ridership |
|---|---|---|
| **AIRPORTS** | | |
| Atlanta, GA | People Mover | 109,000 |
| Chicago-O'Hare, IL | People Mover | 12,000 |
| Cincinnati, OH | Cable | 30,000 |
| Dallas-Fort Worth, TX | People Mover | 50,000 |
| Denver, CO | People Mover | 50,000 |
| Detroit, MI | Cable | NA |
| Houston, TX | People Mover | 8,500 |
| Las Vegas, NV | People Mover | 15,000 |
| Miami, FL | People Mover | 15,000 |
| Minneapolis, MN (Lindbergh Term.) | Cable | NA |
| Minneapolis, MN (parking) | Cable | NA |
| Newark, NJ | Monorail | NA |
| New York, NY (JFK AirTrain) | Automated Light Rail | opens 2003 |
| Orlando, FL | People Mover | 49,000 |
| Pittsburgh, PA | People Mover | 50,000 |
| San Francisco, CA | People Mover | NA |
| Seattle-Tacoma WA | People Mover | 43,000 |
| Tampa, FL (concourses) | Monorail | 71,000 |
| Tampa, FL (parking) | Monorail | 8,000 |
| **INSTITUTIONAL** | | |
| Clarian Health, Indianapolis, IN | People Mover | NA |
| Duke Univ. Hospital, NC | Cable | 2,000 |
| Getty Center, Los Angeles, CA | Cable | NA |
| Huntsville Hospital, AL | Cable | NA |
| Los Colinas, Dallas, TX | People Mover | NA |
| Mystic Transp. Center, Boston, MA | Cable | NA |
| Pearlridge Mall, Honolulu, HI | Monorail | 4,000 |
| Senate Subway, DC | Linear Induction | 10,000 |
| University of West Va., Morgantown | People Mover | 16,000 |
| **LEISURE** | | |
| Bellagio-Monte Carlo, Las Vegas, NV | Belt | NA |
| Circus-Circus, Las Vegas, NV | Cable | 11,000 |
| Circus-Circus, Reno, NV | Cable | 6,000 |
| Circus-Water Park, Las Vegas, NV | Cable | 2,000 |
| Luxor-Mandalay Bay, Las Vegas, NV | Cable | 10,000 |
| Mudd Island, Memphis, TN | Cable Monorail | 2,000 |
| Mirage-Treasure Is., Las Vegas, NV | Cable | 8,000 |
| MGM-Sahara, Las Vegas, NV | Monorail | opens 2004 |
| Primm Vly.-Buffalo Bill, Primm, NV | Monorail | NA |
| Whiskey Pete's, Primm, NV | Cable | NA |
| Total | | 532,500 |

NA: not available (Los Colinas) or not applicable (others)—systems opened after 1995
NOTE: "People Mover" indicates third-rail power collection, and either steel-wheeled or rubber-tired vehicles.
SOURCES: Transit Pulse, P.O. Box 249, Fields Corner Station, Boston, MA 02122; owner data

## Monorail

Although often thought of as being relatively modern technology, monorails (Exhibit 2-33) have existed for over 100 years, with the first monorail, in Wuppertal, Germany, having opened in 1901.(R28) Vehicles typically straddle or are suspended from a single rail. Driverless monorails fall into the category of AGT, and include the systems identified as monorails in Exhibit 2-32, plus the Jacksonville Skyway. Monorails that use drivers are by definition not automated, and thus form their own category. For the purposes of determining capacity, monorails can use the grade-separated rail procedures provided in Part 5, with appropriate adjustments for the technology's particular performance characteristics.

The 0.9-mile (1.5-kilometer) Seattle Center monorail, originally constructed for the 1962 World's Fair, is the only existing U.S. example of a non-automated public transit monorail. It carried approximately 6,100 passengers a day in 1999.(R12) About 1 dozen privately operated monorails are in use at North American zoos and amusement parks. Outside the United States, several monorails are used for public transit service similar to an elevated heavy rail line. Examples include the Wuppertal, Germany monorail, seven systems in Japan, and a downtown circulator in Sydney, Australia.(R22)

**Exhibit 2-33**
Monorail Examples


(a) Straddle (Seattle) (b) Suspended (Wuppertal, Germany)

### Funiculars, Inclines, and Elevators

Funicular railways, also known as *inclined planes* or simply *inclines*, are among the oldest successful forms of mechanized urban transport in the United States, with the first example, Pittsburgh's Monongahela Incline, opening in 1870 (and still in operation today). Funiculars are well suited for hilly areas, where most other transportation modes would be unable to operate, or at best would require circuitous routings. The steepest funicular in North America operates on a 100% (45°) slope, and a few international funiculars have even steeper grades.

Early funiculars were used to transport railroad cars and canal boats in rural areas, as well as to provide access to logging areas, mines, and other industrial sites. Funiculars have played a role in many transit systems, moving not just people, but cars, trucks, and streetcars up and down steep hillsides. An example of a remaining vehicle-carrying incline that is part of a transit system is in Johnstown, Pennsylvania. Nearby, in Pittsburgh, the Port Authority owns the 2 remaining inclines from a total of more than 15 that once graced the hilly locale.

Inclined plane status.

The number of remaining inclined planes in North America is small, but they are used extensively in other parts of the world to carry people up and down hillsides in both urban and rural environments. Switzerland alone has over 50 funiculars, including urban funiculars in Zürich and Lausanne. Many other cities worldwide have funiculars, including Barcelona, Budapest, Haifa, Heidelberg, Hong Kong, Paris, Prague, and Valparaíso, Chile (which has 15). Many of these systems are less than 30 years old or have been completely rebuilt in recent years. In addition, funiculars are still being built for access to industrial plants, particularly dams and hydroelectric power plants, and occasionally, ski resorts. New funiculars, primarily in Europe, also provide subway or metro station access. New designs rarely handle vehicles and make use of hauling equipment and controls derived from elevators.

The person capacity of older inclined planes is modest, but modern designs can carry large numbers of people.

Capacity is a function of length, number of intermediate stations (if any), number of cars (one or two), and speed. Person capacity is usually modest—on the order of a few hundred passengers per hour. However, high-speed, large-capacity funiculars are in use, and a new facility, designed for metro station access in Istanbul, has a planned capacity of 7,500 passengers per direction per hour.

Most typical design involves two cars counterbalancing each other, connected by a fixed cable, using either a single railway-type track with a passing siding in the middle or double tracks. Single-track *inclined elevators* have just one car and often do not use railway track—see, for example, the Ketchikan example in Exhibit 2-34(e). When passing sidings are used, the cars are equipped with steel wheels with double flanges on one set of outer wheels per car, forcing the car to always take one side of the passing siding without the need for switch movement. Earlier designs used a second emergency cable, but this is now replaced by automatic brakes, derived from elevator technology, that grasp the running rails when any excess speed is detected. Passenger compartments can either be level, with one end supported by a truss, or sloped, with passenger seating areas arranged in tiers.

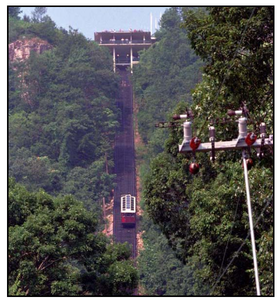
To minimize wear-and-tear on the cable, and make the design mechanically simpler, an ideal funicular alignment is a straight line, with no horizontal or vertical curves. To achieve this design, a combination of viaducts, cuttings, and/or tunnels may be required, as illustrated in Exhibit 2-34(c). However, many funiculars have curved alignments.

Public elevators, as shown in Exhibit 2-34(f), are occasionally used to provide pedestrian movement up and down steep hillsides where insufficient pedestrian volumes exist to justify other modes. These elevators allow pedestrians to bypass stairs or long, out-of-direction routes to the top or bottom of the hill.

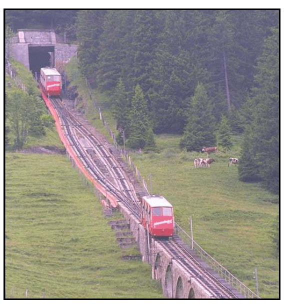
Exhibit 2-35 provides statistics for North American funiculars.

**Exhibit 2-34**
Funicular and Elevator Examples

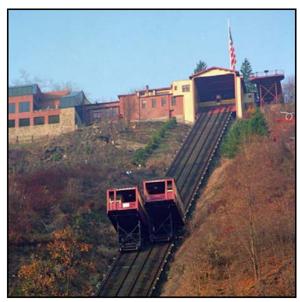
(a) Passenger Incline (Pittsburgh—Duquesne Incline)



(b) Passenger Incline (Chattanooga)

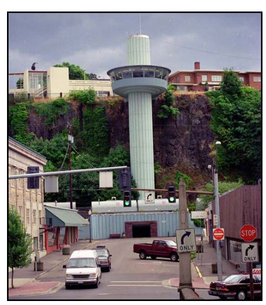


(c) Passenger Incline (Mürren, Switzerland)



(d) Vehicle Incline (Johnstown, Pennsylvania)

(e) Inclined Elevator (Ketchikan, Alaska)



(f) Public Elevator (Oregon City, Oregon)

**Exhibit 2-35**
U.S. and Canadian Funiculars and Public Elevators (2001)[R2,R3]

| Location | Average Weekday Boardings | Length (ft) | Length (m) | Maximum Grade (%) |
|---|---|---|---|---|
| **PUBLIC TRANSIT FUNICULARS** | | | | |
| Chattanooga, TN (Lookout Mountain) | 1,400 | 4,750 | 1,448 | 73 |
| Johnstown, PA (Inclined Plane) | 600 | 897 | 273 | 71 |
| Pittsburgh, PA (Duquesne Incline) | 1,200 | 400 | 122 | 50 |
| Pittsburgh, PA (Monongahela Incline) | 2,600 | 635 | 194 | 58 |
| **OTHER FUNICULARS** | | | | |
| Altoona, PA (Horseshoe Curve) | NA | 270 | 82 | 37 |
| Cañon City, CO (Royal Gorge) | NA | 1,550 | 473 | 100 |
| Diablo, WA (Seattle City Light) | NA | 560 | 171 | 56 |
| Dubuque, IA (Fenelon Place Elevator) | NA | 296 | 90 | 83 |
| Industry, CA (Industry Hills Resort) | NA | 492 | 150 | 33 |
| Los Angeles, CA (Angels Flight) | (closed) | 298 | 91 | 33 |
| Niagara Falls, ON | NA | 170 | 52 | 73 |
| Québec, QC | NA | 287 | 87 | 93 |
| **PUBLIC ELEVATORS** | | | | |
| Oregon City, OR | NA | Not applicable | | |

Additional sources: Owner data. Single-track inclined elevators not included in exhibit.
NA: not available.

## Aerial Ropeways

Aerial ropeways (Exhibit 2-36) encompass a number of modes that transport people or freight in a *carrier* suspended from an aerial rope (wire cable). The carrier consists of the following components:

- A device for supporting the carrier from the rope: either a *carriage* consisting of two or more wheels mounted on a frame that runs along the rope, or a *fixed* or *detachable grip* that clamps onto the rope;
- A unit for transporting persons or freight: an enclosed *cabin,* a partially or fully enclosed *gondola,* or an open or partially enclosed *chair*; and
- A *hanger* to connect the other two pieces.

The rope may serve to both suspend and haul the carrier (*monocable*); or two ropes may be used: a fixed track rope for suspension and a moving haul rope for propulsion (*bicable*); or multiple ropes may be used to provide greater wind stability. Carriers can operate singly back-and-forth, or as part of a two-carrier shuttle operation, or as part of a multiple-carrier continuously circulating system.

The common aerial ropeway modes are the following:

- *Aerial tramways,* which are suspended by a carriage from a stationary track rope, and propelled by a separate haul rope. Tramways have one or, more commonly, two relatively large (20 to 180 passenger) cabins that move back and forth between two stations. Passenger loading occurs while the carrier is stopped in the station.
- *Detachable-grip aerial lifts*, consisting of a large number of relatively small (6 to 15 passenger) gondolas[4] or 2 to 8 passenger chairs that travel around a continuously circulating ropeway. The carriers move at higher speeds along the line, but detach from the line at stations to slow to a creep speed (typically 0.8 ft/s or 0.25 m/s) for passenger loading.
- *Fixed-grip aerial lifts,* which are similar to detachable-grip lifts, with the important exception that the carriers remain attached to the rope through stations. Passenger loading and unloading either occurs at the ropeway line speed (typical for ski lifts), or by slowing or stopping the rope when a carrier

[4] The term "gondola" is frequently used to apply to the entire aerial lift, rather than just the passenger carrier, although this is incorrect usage, according to the ANSI B77.1 definition.

arrives in a station (typical for gondolas). Some fixed-grip gondolas are designed as *pulse* systems, where several carriers are attached to the rope in close sequence. This allows the rope to be slowed or stopped fewer times, as several carriers can be loaded or unloaded simultaneously in stations.

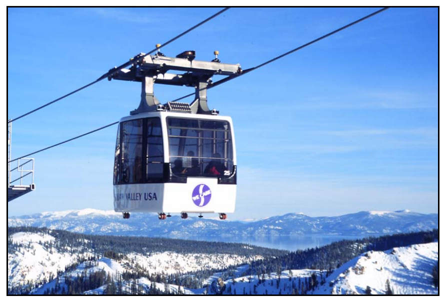
- *Funitels* are a relatively new variation of detachable-grip aerial lifts, with the cabin suspended by two hangers from two haul ropes, allowing for longer spans between towers and improved operations during windy conditions.

**Exhibit 2-36**
Aerial Ropeway Examples


(a) Aerial Tramway (New York)

(b) Detachable-Grip Gondola (Stowe, Vermont)

(c) Detachable-Grip Chair Lift (Jackson, Wyoming)



Nathan Kendall/Squaw Valley Ski Corp.

(d) Funitel (Squaw Valley, California)

Aerial ropeways are most often associated with ski areas, but are also used to carry passengers across obstacles such as rivers or narrow canyons, and as aerial rides over zoos and amusement parks. A few are used for public transportation. The Roosevelt Island aerial tramway in New York City, connecting the island to Manhattan, carries approximately 3,000 people each weekday. A gondola system in Telluride, Colorado, transports residents, skiers, and employees between the historic section of Telluride, nearby ski runs, and the Mountain Village resort area, reducing automobile trips between the two communities and the air pollution that forms in the communities' box canyons. In 2006, the Delaware River Port Authority plans to complete a detachable-grip gondola across the river between Philadelphia and Camden, primarily to serve tourists visiting attractions on both sides of the river. Finally, several North American ski areas use aerial ropeways for site access from remote parking areas, as an alternative to shuttle buses.

Aerial ropeway alignments are typically straight lines, but allow changes in grade (vertical curves) over the route. Intermediate stations are most often used when a change in horizontal alignment is required, resulting in two or more separate ropeway segments—detachable-grip carriers can be shuttled between each segment, but passengers must disembark from other types of carriers and walk within the station to the loading area for the next segment. Gondola systems and chair lifts can also have changes in horizontal alignment without intermediate stations, but this kind of arrangement is much more mechanically complex and is rarely used.

Exhibit 2-37 lists aerial tramway, detachable-grip gondola, and funitel systems in use in North America, along with their main function and technical data.

**Exhibit 2-37**
U.S. and Canadian Aerial Ropeways (2002)

| Location | Primary Function | Length (ft) | Length (m) | Climb (ft) | Climb (m) | Carrier Cap. (p) |
|---|---|---|---|---|---|---|
| **AERIAL TRAMWAYS** | | | | | | |
| Albuquerque, NM (Sandia Peak) | scenic | 14,657 | 4,469 | 4,000 | 1,220 | 50 |
| Alyeska, AK (Tramway) | ski | 3,867 | 1,179 | 2,024 | 617 | 60 |
| Big Sky, MT (Lone Peak) | ski | 2,828 | 862 | 1,450 | 442 | 15 |
| Boston Bar, BC (Hells Gate) | scenic | 1,118 | 341 | 500 | 152 | 25 |
| Cañon City, CO (Royal Gorge) | scenic | 2,200 | 670 | 0 | 0 | 35* |
| El Paso, TX (Wyler) | scenic | 2,500 | 760 | 940 | 287 | 8 |
| Estes Park, CO (Aerial Tramway) | scenic | | | 1,200 | 365 | |
| Franconia Notch, NH (Cannon Mtn.) | ski | 5,139 | 1,567 | 2,146 | 654 | 70 |
| Gatlinburg, TN (Ober Gatlinburg) | scenic | 11,000 | 3,350 | 1,335 | 405 | 120 |
| Heavenly Valley, CA (Aerial Tram) | ski | | | 1,710 | 521 | 25 |
| Jackson, WY (Aerial Tram) | ski | 12,595 | 3,840 | 4,139 | 1,262 | 45 |
| Jasper, AB (Tramway) | scenic | 6,550 | 2,000 | 3,191 | 973 | 30 |
| Jay Peak, VT (Aerial Tramway) | ski | 7,776 | 2,371 | 2,153 | 656 | 60 |
| Juneau, AK (Mt. Roberts) | scenic | 3,087 | 941 | 1,745 | 532 | 60 |
| New York, NY (Roosevelt Island) | urban | 3,100 | 945 | 0 | 0 | 125 |
| Niagara Falls, ON (Spanish Aero Car) | scenic | 1,768 | 539 | 0 | 0 | 40* |
| Palm Springs, CA (Tramway) | scenic | 10,775 | 3,285 | 5,874 | 1,791 | 80 |
| Québec, QC (Chute-Montmorency) | scenic | | | | | 40 |
| Snowbasin, UT (Olympic Tram) | ski | 1,165 | 355 | 510 | 155 | 15 |
| Snowbird, UT (Aerial Tram) | ski | | | 2,900 | 885 | 125 |
| Squaw Valley, CA (Cable Car) | ski | | | 2,000 | 610 | 115 |
| Stone Mountain, GA (Skylift) | scenic | | | 825 | 252 | |
| Vancouver, BC (Grouse Mtn. Red) | ski | | | 2,800 | 850 | 100 |
| Vancouver, BC (Grouse Mtn. Blue) | ski | | | 2,800 | 850 | 40 |
| **DETACHABLE-GRIP GONDOLAS** | | | | | | |
| Aspen, CO (Silver Queen) | ski | | | 3,267 | 996 | |
| Banff, AB (Sulphur Mountain) | scenic | 5,117 | 1,560 | 2,289 | 698 | 4 |
| Big Sky, MT (Gondola One) | ski | 8,530 | 2,601 | 1,525 | 465 | 4 |
| Blackcomb, BC (Excalibur) | ski | | | 1,486 | 453 | |
| Deer Valley, UT (Gondola) | ski | 5,170 | 1,576 | 1,322 | 403 | |
| Gore Mountain, NY (Northwoods) | ski | | | 1,700 | 520 | 8 |
| Heavenly Valley, CA (Gondola) | ski | 12,672 | 3,863 | 2,583 | 788 | 8 |
| Jackson, WY (Bridger) | ski | | | 2,781 | 848 | |
| Joseph, OR (Wallowa Lake) | scenic | 9,650 | 2,942 | 3,700 | 1,130 | 4 |
| Killington, VT (K1 Express) | ski | 6,600 | 2,010 | 1,690 | 515 | 8 |
| Killington, VT (Skyeship) | ski | 13,000 | 3,950 | 2,520 | 768 | 8 |
| Loon Mountain, NH (Gondola) | ski | 7,133 | 2,175 | 2,100 | 640 | 4 |
| Mammoth Mountain, CA (Panorama) | ski | | | 3,100 | 945 | |
| Northstar, CA (Big Springs) | ski | | | 470 | 143 | |
| Panorama, BC (Village) | ski access | | | 3,100 | 945 | |
| Park City, UT (Canyons) | ski access | 2,682 | 818 | 181 | 55 | 8 |
| Silver Mountain, ID (Gondola) | ski access | 16,368 | 4,990 | 3,100 | 945 | 8 |
| Ski Apache, NM (Gondola) | ski | | | 1,800 | 550 | 4 |
| Snowbasin, UT (Middle Bowl Exp.) | ski | 9,494 | 2,895 | 2,310 | 704 | |
| Snowbasin, UT (Strawberry Express) | ski | 9,576 | 2,920 | 2,472 | 754 | |
| Steamboat Springs, CO (Gondola) | ski | | | 2,200 | 670 | 8 |
| Stowe, VT (Gondola) | ski | | | 2,080 | 634 | 8 |
| Stratton, VT (Gondola) | ski | | | 2,000 | 610 | 12 |
| Sugar Bowl, CA (Village) | ski access | 3,202 | 976 | 87 | 27 | 4 |
| Sunshine Village, AB (Sunshine) | ski access | 16,400 | 5,000 | 1,640 | 500 | 8 |
| Telluride, CO (Gondola I/II) | ski access | 13,100 | 4,000 | *** | *** | 8 |
| Telluride, CO (Gondola III) | ski access | | | 0 | 0 | 8 |
| Vail, CO (Eagle Bahn) | ski | | | 2,220 | 677 | |
| Whistler, BC (Creekside) | ski | | | 2,112 | 644 | |
| Whistler, BC (Village) | ski | | | 3,893 | 1,187 | |
| Whiteface, VT (Cloudspitter) | ski | | | 2,456 | 749 | 8 |
| **FUNITELS** | | | | | | |
| Squaw Valley, CA (Gold Coast) | ski | 9,065 | 2,764 | 1,742 | 531 | 28 |

*one carrier only (single reversible tramway)
***from Telluride, climbs 1,785 ft (544 m) to an intermediate station, then drops 995 ft (303 m) to a third station
NOTE: Table does not include the numerous fixed-grip gondola systems.
access = used to transport passengers from remote parking to an activity center.
scenic = used to provide scenic views of mountains, canyons, etc.
ski = used primarily to access ski runs; some are also used for scenic rides during the summer.
urban = used in an urban setting to transport commuters and/or tourists.
SOURCE: Owner data.

## Cable Cars

Cable cars are now only found in San Francisco, but were once used briefly throughout the United States.

Cable cars (Exhibit 2-38) now operate only in San Francisco, where the first line opened in 1873.[5] Although associated with San Francisco's steep hills, more than two dozen other U.S. cities, including relatively flat cities such as Chicago and New York, briefly employed this transit mode as a faster, more economical alternative to the horse-drawn streetcar. Most cable lines were converted to electric streetcar lines between 1895 and 1906 due to lower operating costs and greater reliability, but lines in San Francisco, Seattle, and Tacoma that were too steep for streetcars continued well into the 20th century.(R14)

Three cable car routes remain in San Francisco as a National Historic Landmark and carried 9.2 million riders in 2000.(R12) The cars are pulled along by continuous underground cables (wire ropes) that move at a constant speed of 9 mph (15 km/h). A grip mechanism on the car is lowered into a slot between the tracks to grab onto the cable and propel the car. The grip is released from the cable as needed for passenger stops, curves, and locations where other cables cross over the line.(R14)

Cable car systems are not very efficient, as 55 to 75% of the energy used is lost to friction. However, cars can stop and start as needed, more-or-less independently of the other cars on the system, and a large number of cars can be carried by a small number of ropes. The Chicago City Railway operated around 300 cars during rush hours on its State Street line in 1892, which comprised four separate rope sections totaling 8.7 miles (13.9 km) in length.(R14)

Cable-hauled automated people movers often use technology adapted from cable cars and aerial ropeways.

Modern automated people movers (APMs) that use cable propulsion have retained many of the original cable car technological concepts, albeit in an improved form. Modern cable-hauled APMs often include gripping mechanisms and, in some cases, turntables at the end of the line. Some of these APMs can be accelerated to line speed out of each station, in a similar manner as detachable-grip aerial ropeways. Once at line speed, a grip on these APMs attaches to the haul rope, and the vehicle is moved at relatively high speed along the line. At the approach to the next station, the vehicle detaches from the rope, and mechanical systems brake the vehicle into the station. This technology addresses two of the major issues with the original cable cars: (1) having only two speeds, stop and line speed (up to 14 mph or 22 km/h), which caused jerky, uncomfortable acceleration for passengers and (2) rope wear each time cars gripped the cable, as the cable slid briefly through the slower moving grip before the grip took hold and caught up to the cable's speed. The airport shuttle at the Cincinnati-Northern Kentucky Airport is an example of a detachable-grip APM, while the Mystic Transit Center APM (Exhibit 2-38b) is an example of an APM with a permanently attached cable. Other examples were listed in Exhibit 2-32.

**Exhibit 2-38**
Cable Car Examples


(a) Cable Car (San Francisco)

(b) Cable-Hauled APM (Boston)

[5] An elevated cable car system opened in New York City in 1868, but failed within 2 years and was converted to steam locomotive operation in 1871.(R14)

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# CHAPTER 4. FERRY TRANSIT

## OVERVIEW

Ferry services (Exhibit 2-39) play a role in the transit systems of a number of North American cities, providing pedestrian, bicycle, and—in some cases—vehicle transport across waterways where transportation connections are desirable but conditions do not justify a bridge or tunnel or alternative bridges and tunnels are congested.

The busiest route in North America, New York's Staten Island Ferry, carries more passengers per day (70,000) than all but the busiest light rail and commuter rail routes, and more than many heavy rail routes. In addition, five private operators provide a variety of commuter services into Brooklyn and Manhattan, as well as special services to New York's major league baseball stadiums.

The Staten Island Ferry carries more passengers than many rail transit routes.

Other services carry more modest numbers of passengers, but still play vital roles in their area's transportation system. Vancouver's SeaBus ferry, for example, operates high-speed vessels between North Vancouver and downtown Vancouver and connects to Vancouver's rapid transit, commuter rail, and bus systems. In the San Francisco Bay Area, as of 2002, four publicly operated services[6] and one privately operated service operated a total of seven routes, as well as special services to San Francisco's baseball stadium. The Washington State Ferry system operates nine routes, carrying private automobiles, bicycles, and walk-on passengers, and—on the route between Vashon Island and Seattle—King County Metro buses.

The Alaska Marine Highway System provides the sole means of access, other than by air, to a number of communities in southeastern and southwestern Alaska, including the state capital, Juneau. BC Ferries performs roles similar to both the Alaska and the Washington ferry systems along the British Columbia coast.

Internationally, ferries play an important role in providing cross-harbor transportation, as in Sydney, Australia, and Hong Kong, and along rivers, as in Brisbane, Australia, and London.

Ferries offer flexible routing, subject only to dock availability, and services can be implemented relatively quickly. This adaptability has helped two metropolitan areas cope with emergencies in the recent past. For example, when the 1989 Loma Prieta earthquake closed the Bay Bridge between Oakland and San Francisco for 1 month, new ferry routes from three East Bay communities were open within 1 week, with a fourth route open within 2 weeks. The combination of the four new routes, plus one existing route, carried an average of 20,000 passengers per weekday while the bridge was closed. The service was popular enough that two of the once-temporary routes continue to exist as a combined route.[R4,R8] Following the World Trade Center attacks in New York in 2001, new trans-Hudson ferry routes were opened to replace the lost capacity resulting from damage to the PATH heavy rail station at the World Trade Center. In the first 6 months following the attacks, trans-Hudson ferry ridership nearly doubled to 67,000 passengers per day.[R1]

Ferries have quickly provided needed capacity during emergencies.

## SERVICE AND VESSEL TYPES

Many different types of ferry services exist, and the vessels used tend to be custom-built to meet the specific needs of the service to be operated. Considerations include passenger and vehicle demand, dock configurations, speed, and

[6] All of the public services, with the exception of the Golden Gate Ferry services, are contracted to private operators.

environmental issues (e.g., wake and exhaust). Part 6 of the TCQSM focuses on urban scheduled ferry transit services; however, other types of ferry services are described here for completeness.

### Urban Services

Urban ferry services provide trips into or within major cities, and experience similar peaks in passenger demand as other urban transportation modes. Typical travel times range from a few minutes to 45 to 60 minutes, and service is often provided once per hour or more frequently. There are four major types of urban services:

- *Point-to-point services,* typical of most urban ferry services, crossing harbors or major rivers;
- *Linear multiple-stop services,* either along a river (e.g., the East River service in New York) or a waterfront (e.g., Boston);
- *Circulators,* with fixed routes but often not fixed schedules, that serve destinations around the edge of, or a designated portion of, a harbor or riverfront via a loop route; and
- *Water taxis,* which have fixed landing sites, but pick up passengers on demand, similar to a regular taxi service.[7]

Because ferries can only take passengers to the water's edge, intermodal transfers are usually required at one, and often, both ends of the ferry trip. Options for providing this transfer include park-and-ride lots; feeder bus service; roll-on, roll-off bus service (for auto ferries); and terminals located close to rail service (as in New York and at San Francisco's Ferry Building).

### Coastal Services

Coastal services provide inter-city and inter-island trips on salt water and large freshwater lakes, such as the Great Lakes. Travel times are typically in the range of one to a few hours, but can be fairly short for service to nearby islands, to more than 1 day (e.g., some of the Alaska Marine Highway routes). Service frequencies range from several trips per day to one trip per week. Vehicles are often transported in a roll-on, roll-off mode (or rarely, as cargo, in a lift-on, lift-off mode—for example, service along the northern shore of the Gulf of St. Lawrence in Québec).

### Rural Services

Rural ferries cross rivers and narrow lakes in areas where traffic volumes do not justify constructing a bridge. Routes are short and are often operated on demand. Vessels tend to be small (a capacity of 6 to 12 automobiles is common). Walk-on passengers and bicycles are generally infrequent.

### Vessel Types

Examples of vessels used for various types of ferry services are presented in Exhibit 2-39. Vessels can also be categorized in terms of their physical and mechanical characteristics; examples of these are provided in Part 6.

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[7] Some harbor circulator and multiple-stop services also call themselves "water taxis," although they operate on fixed routes and sometimes with fixed schedules.

**Exhibit 2-39**
Ferry Service Examples


(a) Harbor Point-to-Point (New York)

(b) Harbor Point-to-Point (Vancouver)

(c) River Circulator (Brisbane, Australia)


(d) River Point-to-Point (Brisbane, Australia)

(e) Vehicle/Passenger Ferry (Seattle)

(f) Vehicle/Passenger Ferry (New Orleans)

(g) Rural Ferry (Wheatland, Oregon)

(h) Coastal Ferry (Juneau, Alaska)

## RIDERSHIP

Exhibit 2-40 provides ridership data for North American ferry systems operated by public transit agencies and identifies a selection of privately operated services in major metropolitan areas.

**Exhibit 2-40**
U.S. and Canadian Ferry Systems (2000)(R11,R12)

| Region | Directional Route Length (mi) | Directional Route Length (km) | Avg. Weekday Boardings | Vessels Op. in Max. Service |
|---|---|---|---|---|
| **PUBLIC TRANSIT** | | | | |
| Boston (MBTA) | 45.0 | 72.4 | 5,200 | 12 |
| Bremerton, WA (Kitsap Transit) | 5.7 | 9.2 | 1,000 | 2 |
| Corpus Christi | 0.8 | 1.3 | 300 | 1 |
| Halifax | NA | NA | 4,800* | 3* |
| Hartford | 1.0 | 1.6 | 600* | 2 |
| Long Beach | 0.5 | 0.8 | 70 | 2 |
| New Orleans | 3.0 | 4.8 | 8,500 | 5 |
| New York (Metro-North) | 11.0 | 17.8 | NA | 1 |
| New York (NYC DOT) | 10.4 | 16.7 | 60,900 | 4 |
| New York (Port Authority) | 3.4 | 5.5 | 8,900 | 4 |
| Norfolk | 1.0 | 1.6 | 1,000** | 3** |
| Philadelphia (RiverLink) | 1.2 | 1.9 | NA | NA |
| Portland, ME | 20.0 | 32.2 | 2,800 | 4 |
| Providence | 50.4 | 81.1 | 200‡ | NA |
| San Francisco (Alameda-Oakland) | 27.6 | 44.4 | 2,100 | 3 |
| San Francisco (Golden Gate) | 43.0 | 69.2 | 6,200 | 5 |
| San Francisco (Harbor Bay) | 17.3 | 27.8 | 750‡ | NA |
| San Francisco (Vallejo Transit) | 79.0 | 127.1 | 2,300 | 2 |
| San Juan | 10.0 | 16.1 | 2,900 | 4 |
| Seattle (Washington State) | 245.8 | 395.5 | 40,700 | 28 |
| Tacoma (Pierce County) | 11.1 | 17.9 | 500 | 1 |
| Vancouver (SeaBus) | 4.0 | 6.4 | 14,700† | 2† |
| **MAJOR PRIVATE SYSTEMS** | | | | |
| Boston (Airport Water Shuttle) | 2.3 | 3.7 | NA | NA |
| Boston (City Water Taxi) | NA | NA | NA | NA |
| Boston (Harbor Express) | 61.0 | 98.2 | 2,600‡ | NA |
| Chicago (RiverBus) | NA | NA | NA | NA |
| Ft. Lauderdale (Water Taxi) | NA | NA | NA | NA |
| New York (Circle Line) | 12.5 | 20.1 | 29,700‡ | NA |
| New York (Fox Navigation) | 190.5 | 306.5 | NA | NA |
| New York (NY Fast Ferry) | 50.2 | 80.7 | 1,300‡ | NA |
| New York (NY Waterway) | 55.0 | 88.5 | 35,000† | NA |
| New York (Seastreak) | 51.6 | 99.2 | 1,400‡ | NA |
| San Diego (SD-Coronado) | 3.5 | 5.6 | 3,400‡ | NA |
| San Francisco (Blue & Gold) | 10.6 | 17.0 | 3,000‡ | NA |
| Seattle (Elliott Bay) | NA | NA | NA | NA |

NA: not available
*1996 data **1999 data †2001 data
‡1999 estimate, based on dividing annual ridership by 150 (average of commuter-oriented services with both weekday and annual ridership values available), except for New York's Circle Line, which operates tourist services to the Statue of Liberty and Ellis Island and whose ridership was divided by 365.
NOTE: Some public system services are contracted to private operators who also operate independent services. Some private services accept public transit fare instruments.

# CHAPTER 5. STOPS, STATIONS, AND TERMINALS

## OVERVIEW

Passengers begin, end, and continue their transit trips at these facilities.

Transit stops, stations, and terminals come in many sizes, with differing levels of activity and passenger amenities, but all serve as points where transit passengers begin, end, or continue their transit trips. For this reason, the quality of the passenger environment at stops, stations, and terminals can be as important to passengers as the quality of the in-vehicle portion of the trip.

Stops, stations, and terminals can include a number of elements, including transit stops, waiting areas, walkways, doors, stairs, escalators, elevators, fare gates, ticket machines, information displays, shops, and park-and-ride lots. Station element design involves a combination of estimating passenger flows—particularly those flows occurring during micro-peaks when a heavily loaded bus or train arrives and discharges it passengers—and providing sufficient space for passengers, as determined by a design level of service.

Station design must accommodate persons with disabilities, but attention should be given to designs that are convenient to passengers with disabilities (e.g., elevators co-located with stairways), rather then merely ADA-compliant (e.g., an elevator provided in a remote location). Design should also consider the possibility of some station elements, such as ticket machines, being out of service, and the potential delays passengers may experience when those events happen. Finally, design must consider emergency evacuation requirements dictated by fire codes.

## TRANSIT STOP TYPES

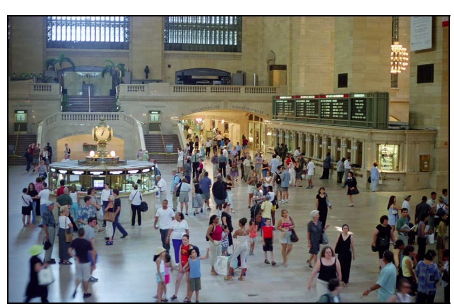
Part 7 of the TCQSM considers four categories of transit stops. These are bus stops, transit stations, transit centers, and transit terminals. Exhibit 2-41 provides examples of each of these.

**Exhibit 2-41**
Transit Stop Types

(a) Bus Stop (Albuquerque)

(b) Transit Station (Baltimore)

(c) Transit Center (Olympia, Washington)



(d) Transit Terminal (New York)

### Bus Stops

Bus stops are the most common of the four categories and frequently are served by only one or a small number of routes. However, downtown stops served by multiple routes may be very busy during peak times and require multiple loading positions for buses (*loading areas* or *berths*). The most basic stop, used by *hail-and-ride* services where passengers flag down buses along the route, has no infrastructure at all. However, most fixed-route services provide designated stops, marked by bus stop signs, to manage the number of stops buses must make and to ensure that passenger boardings and alightings take place in safe and appropriate locations. New or relocated stops must meet ADA requirements, which include provisions for a landing pad for the wheelchair lift or ramp, minimum horizontal clearances, and maximum slopes, among other factors. The sidewalk adjacent to the bus stop is frequently used as the passenger waiting area. Depending on passenger volumes at the stop, additional infrastructure could include a bench or shelter, and informational signage.

### Transit Stations

Transit stations include rail and busway stations. The routes serving these stations have higher capacities, and consequently the stations must be designed to serve greater numbers of people than the typical bus stop. The higher passenger volumes also permit more extensive passenger infrastructure than normally would be provided at a bus stop. This infrastructure usually includes a canopy covering a portion of the platform, limited seating, ticket machines (when fares are not collected on-board), information displays, trash receptacles, and newspaper vending. Busier stations may also have vending kiosks, electronic information displays, park-and-ride lots, and passenger drop-off areas (*kiss-and-rides*). Heavy rail and commuter rail stations may also have a station agent located on-site to monitor the station and provide information to customers. Vertical circulation elements (stairs, elevators, and possibly escalators) are needed at heavy rail and commuter rail stations, and possibly at light rail and busway stations. When passengers are allowed to cross the tracks or guideway at light rail and busway stations, consideration should be given to signing, striping, gates, fences, and similar devices that delineate and control access to the area used by transit vehicles.

Further information about pedestrian safety at light rail crossings can be found in *TCRP Report 69*.[R17]

### Transit Centers

The term *transit center* is normally applied to facilities where multiple bus routes converge, allowing transfers between lines. Rail service is sometimes also provided, but the bus-to-bus transfer activity is at least as important as the bus-to-rail activity. Individual stops, with a shelter or canopy, are typically provided for each direction of travel of each bus route serving the station. Facility design should accommodate the movement of passengers between bus stop locations, as well as access to and from adjacent land uses. Concession and information services may be provided in a central location. Larger transit centers may also have an associated park-and-ride lot.

### Intermodal Terminals

Intermodal terminals are designed for transfers between modes and typically experience the highest passenger volumes of the four categories of transit stops. Longer distances are generally involved in making transfers than at a transit center, and vertical movements may also be required. Terminals will have all of the passenger infrastructure listed for the other transit stop categories and may also be integrated with retail shopping, services, and entertainment.

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