URBAN PUBLIC TRANSPORT MODAL CHARACTERISTICS AND ROLES

Outline

1. Range of Modes and Services
2. Modal Descriptions
3. Modal Comparisons and Performance Characteristics
4. Simple Capacity Analysis

Roles for Each Mode

Low density flows --------> High density flows

Spread O-D flows --------> Concentrated O-D flows

Auto-> Car pools -> Van pools

Automated guideway

subscription bus

taxi -> shared ride taxi -> publicos -> fixed bus route -> light rail -> heavy rail

Spectrum of Services

Increasing vehicle capacity ----->
Increasing passenger flows ----->

Operating Arrangements \ Vehicle Type	Car	Van	Minibus	Bus	Light Rail	Heavy Rail
Drivers	Free		Low Cost		High Cost (conventional transit)	Low cost (automated)
Right of way		Shared			Dual Mode	Dedicated
Routing and Scheduling	Flexible		Hybrid		Fixed	

Transit Categories (based on Vuchic)

Rights of Way

Based on degree of segregation

- **Surface with mixed traffic: buses, light rail: with/without preferential treatment**
- **Longitudinal separation but at-grade crossing interference: light rail, bus rapid transit**
- **Full separation: at-grade, tunnel, elevated**

Modal Descriptions

Bus: vehicles operating individually with rubber tires, with manual lateral and longitudinal control

Key decisions:

Vehicle size:	**minibus (20 passengers) up to bi-articulated (165+ passengers)**
Vehicle design:	**high floor or low floor**
Right-of-way:	**all options are available**
Guidance:	**is guided operation appropriate at some locations?**
Propulsion:	**all options available**
Fare payment:	**on-vehicle or off-vehicle**

Modal Descriptions (cont'd)

Light Rail: vehicles operating individually or in short trains with electric motors and overhead power collector, steel wheel on steel rail with manual or automatic longitudinal control

Key decisions:

- **Vehicle design: high floor or low floor, articulated or rigid body**
- **Right-of-way: all options available**
- **Operating arrangements: automated or manually driven**

Modal Descriptions (cont'd)

Heavy Rail/Metro: vehicles operating in trains with electric motors on fully separated rights-of-way with manual signal or automatic longitudinal control; level boarding, off-vehicle fare payment

Key decisions:

- **Train length**
- **Right-of-way: at-grade, elevated, or tunnel**
- **Station spacing**
- **Operating arrangements: degree of automation**

Modal Descriptions (cont'd)

<u>Commuter Rail</u>: vehicles operating in trains with long station spacing, serving long trips into central city, large imbalance between peak hour and other period ridership.

Traditional Transit Services

- Bus on shared right-of-way
- Streetcar on shared right-of-way
- Heavy rail on exclusive right-of-way
- Commuter/Regional rail on semi-exclusive right-of-way

Newer Service Concepts

- Bus Rapid Transit
- Light Rail on exclusive right-of-way

Increasing Diversity

- Driver arrangements: part-timers, 10-hour days, pay by vehicle type
- Routing and scheduling: fixed, flexible, advance booking
- Vehicle types: minibuses, articulated buses and railcars, bi-level railcars, low-floor
- Control options: fixed block, moving block, manual, ATO, ATC
- Priority options: full grade separation, semi-exclusive right-of-way, signal pre-emption
- Dual mode operations: bus, light rail

Modal Comparison: Bus vs. Rail

Rail advantages:

- High capacity
- Lower operating costs
- Better service quality
- Stronger land use influence
- Fewer negative externalitites

Bus advantages:

- Low capital costs
- Wide network coverage
- Single vehicle trips
- Flexibility
- "Dual mode" nature

2004 US Transit Mode Performance Measures

	Bus	Heavy Rail	Light Rail	Commuter Rail	Paratransit
Unlinked Passenger Trips (x 10^9)	5.7	2.7	.3	.4	.1
Annual Pass-miles (x 10^9)	21.4	14.4	1.6	9.7	1.0
Op. Cost/ Rev Veh Hr ($)	93.91	154.31	206.08	403.27	47.52
Op. Cost/Rev Veh Mile ($)	7.45	7.58	13.32	12.80	3.29
Op. Cost/Unlinked Pass Trip ($)	2..80	1.72	2.54	8.31	22.17
Op. Cost/Pass. Mile ($)	.75	.33	.56	.35	2.62
Unl. Pass Trips/ Rev Veh Hr	33.60	89.56	81.26	48.53	2.14
Pass Miles/Rev Veh Hr	125	468	366	1139	18
Mean Trip Length (miles)	3.7	5.2	4.5	23.5	8.5
Mean Pass Load	9.9	23.0	23.7	36.1	1.3
Mean Operating Speed (mph)	12.6	20.4	15.5	31.5	14.4

Ridership Trends by Mode

Mode		2003 Ridership (Millions)	Change 1975-2003 (%)
Metro	- 5 old systems - 9 new systems	2,199 468	575 (+35%)
Light Rail	- 7 old systems - 20 new systems	166 172	42 (+34%)
Commuter Rail	- 4 old systems - 17 new systems	377 33	126 (+49%)
Bus		5,692	-2 (0%)
Total		9,107	1,414 (+18%)

Simple Capacity Analysis

Question: **Given a pie-shaped sector corridor serving a CBD served by a single transit line, what will be the peak passenger flow at the CBD?**

Simple Capacity Analysis

Given: P_c = population density at CBD

dP = rate of decrease of population density with distance from CBD

θ = angle served by corridor

r = distance out from CBD

L = corridor length

t = number of one-way trips per person per day

c = share of trips inbound to CB

m = transit market share for CBD-bound trips

p = share of CBD-bound transit trips in peak hour

Then:

Population in corridor = $\int_0^L r\theta\left(P_c - dPR\right)dr$

= $L^2\theta\left(\frac{P_c}{2} - \frac{dPL}{3}\right)$

Simple Capacity Analysis

Peak Passenger Flow = $$L^2\theta\left(\frac{P_c}{2}-\frac{dPL}{3}\right)tcmp$$

Maximum access distance to transit line = *L❑* /2

Examples:

P_c	dP	❑	L	t	c	m	p	Req. Capacity	Max Access
10,000	800	2Π /9	10	2.5	0.2	0.5	0.25	10,000	3.5
20,000	1,600	2Π /9	10	1.5	0.3	0.8	0.25	30,000	3.5

Actual Capacities

Rail: 10 car trains, 200 pass/car, 2-minute headway	**≡ 60,000 pass/hr**
Bus: 70 pass/bus, 30-second headways	**≡ 8,400 pass/hr**
BRT: 200 pass/bus, 20 second headways	**≡ 36,000 pass/hr**
Light rail: 150 pass/car, 2-car trains, 1-minute headway	**≡ 18,000 pass/hr**

MBTA Rail Line
Peak Hour Volumes

Red Line:	Braintree branch	6,100
	Ashmont branch	3,700
	Cambridge	8,200
Orange Line:	North	8,100
	Southwest	7,400
Blue Line:		6,000
Green Line:	B	2,000
	C	1,900
	D	2,200
	E	900
	Central Subway	6,500

Worldwide Urban Rail Systems

A. Full Metro Standards

Started system operation	N. America	Europe	Rest of World	Total Starts	Cumulative Starts
Pre 1901	2	5	--	7	7
1901-1920	2	4	1	7	14
1921-1940	--	4	2	6	20
1941-1960	1	5	1	7	27
1961-1980	3	17	12	32	59
1981-2000	3	4	12	19	78
Post-2000 or In Construction	1	7	5	13	93
TOTALS	12	47	32		

B. Light Rail Systems: total in operation

	N. America	Europe	Rest of World	Total
Total Systems	22	50	15	87