PUBLIC TRANSPORT MODAL CHARACTERISTICS AND COSTS

Outline

1. Modal Comparisons (cont'd)
2. Simple Capacity Analysis
3. World-Wide Status
4. Capital Costs
5. Operating Costs

Changes in Service Provided (1990-2000) by Mode

	Active Vehicles	Vehicle Miles Operated
Metro	+2%	+11%
Light Rail	+73%	+118%
Commuter Rail	+15%	+27%
Bus	+28%	+9%

Service Utilization Trends by Mode

	Boardings/Vehicle Mile		Avg. Passenger Load	
Mode	2000		2000	
Metro	4.4	-1%	23	---
Light Rail	6.1	-16%	26	+9%
Commuter Rail	1.5	-1%	35	+4%
Bus	2.5	-8%	9	-7%

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?

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 $= \int_0^L r\theta(P_c - dPr)\,dr$

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

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
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

Start date	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	2	5	1	8	28
1961-1980	4	17	12	33	61
1981-2000	3	4	12	19	80
In Construction	1	7	5	13	93
TOTALS	14	47	32		

B. Light Rail Systems

	N. America	Europe	Rest of World	Total
Total Systems	21	50	15	86

Capital Costs

In US:

- $11.4 billion in capital costs in 2001

By type:

- 35% for vehicles
- 55% for infrastructure and facilities
- 10% other

By mode:

- 33% for bus projects
- 31% for metro projects
- 20% for commuter rail projects
- 13% for light rail project
- 3% other

Capital Costs by Type and by Mode

	Bus	Metro	Commuter Rail	Light Rail	Other
Vehicles	55%	28%	21%	17%	67%
Infrastructure, facilities, and other	44%	72%	79%	83%	33%
Total ($ bill)	3.7	3.5	2.3	1.4	0.5

- Infrastructure, facilities and systems capital costs dominate for rail modes
- Vehicular capital costs represent more than half of all capital costs for bus

Infrastructure Costs

Key factors:

- type of construction
  - -- at grade (least expensive)
  - -- elevated
  - -- subway: shallow tunnel, deep tunnel (most expensive)
- land acquisition and clearance
- number, size, complexity, and length of stations
- systems complexity

Typical Capital Costs

Metro:

	System cost (includes stations and vehicles) ($ billion)	Cost/km ($ million)
Tren Urbano: new system (2002) Phase I: 17 km, 16 stations 50% at grade, 40% elevated, 10% subway	2.0	118
MBTA Red Line Alewife Station Extension (1984) 5 km, 4 stations: 100% subway	0.6	120
LA MTA: new system (late 1980s) 7 km: subway	1.2	180
WMATA: new system (late 1970s-early 1990s) Multiple phases 100 km, 70 stations (partial system) Mix of subway, elevated, and at grade	6.4	60

Kain (mid-1990s) estimate of average metro capital costs:
$80 million/km

Typical Capital Costs (cont'd)

<u>LRT</u>:

	System cost (includes stations and vehicles) ($ million)	Cost/km ($ million)
LA MTA (late 1980s): 30 km, at grade	690	23
Buffalo (late 1980s): 10 km, subway	529	53
Santa Clara (late 1980s): 30 km, at grade	498	16
Portland: 22 km, at grade	214	10

Kain (mid-1990s) estimate of average LRT capital costs:
$25 million/km

Typical Capital Costs (cont'd)

Busways:

	System cost (includes stations and vehicles) ($ million)	Cost/km ($ million)
MBTA South Boston Transitway (2002): 2 km, bus tunnel	606	11
Bogotá Transmilenio (2001): 36 km, at grade	200*	5
Seattle (mid 1980s): 2 km, bus tunnel	319*	160
Pittsburgh (mid 1980s): 10 km, at grade	113*	11
Houston (early 1980s): 35 km, at grade	290*	8

* excluding vehicles

Vehicle Capital Costs

		MBTA most recent order
Rail Car (Metro or LRV)	$1.5-2.5 mill	Breda $1.985 mill 100 vehicles (LRT)
Standard 40' bus - CNG	$0.3-0.35 mill	NABI $0.31, $0.32 mill 300 vehicles
Standard 40' trolley	$1 mill	Neoplan $0.943 mill 28 vehicles
Articulated 60' bus - CNG	$0.5-0.7 mill	Neoplan $0.614 mill 44 vehicles
Articulated dual-mode 60' bus		Neoplan $1.6 mill 32 vehicles

Typical Capital Costs on Per Passenger Mile Basis

Vehicle cost per passenger mile:
$0.05-0.10 for all modes

Infrastructure cost per passenger mile:
$0.01-1.00

Operating Costs

In US:

- $23.5 billion in operating costs in 2001

By type:

- 44% for vehicle operations
- 18% for vehicle maintenance
- 10% for man-vehicle maintenance
- 15% for administration
- 13% for purchased transportation

By mode:

- 57% for buses
- 18% for metro
- 12% for commuter rail
- 3% for light rail
- 10% for other modes

Productivity

- US transit industry has 2.7 employees per active vehicle
- Bus/rail comparison for NYCT
  (from Pushkarev and Zupan in 1970s)
  (employees/vehicle):

	Veh. Ops.	Veh. Maint.	Manage & Control	Fare Coll.	Way Maint.	Total
Bus	2.2	0.8	0.5	--	--	3.5
Rail	1.0	0.8	0.8	0.6	1.2	4.4

- Metro productivity is 3-4 times average bus productivity measured in pass. miles/RVH