Evaluation Methods for Different Modes of Transportation

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Topic Overview

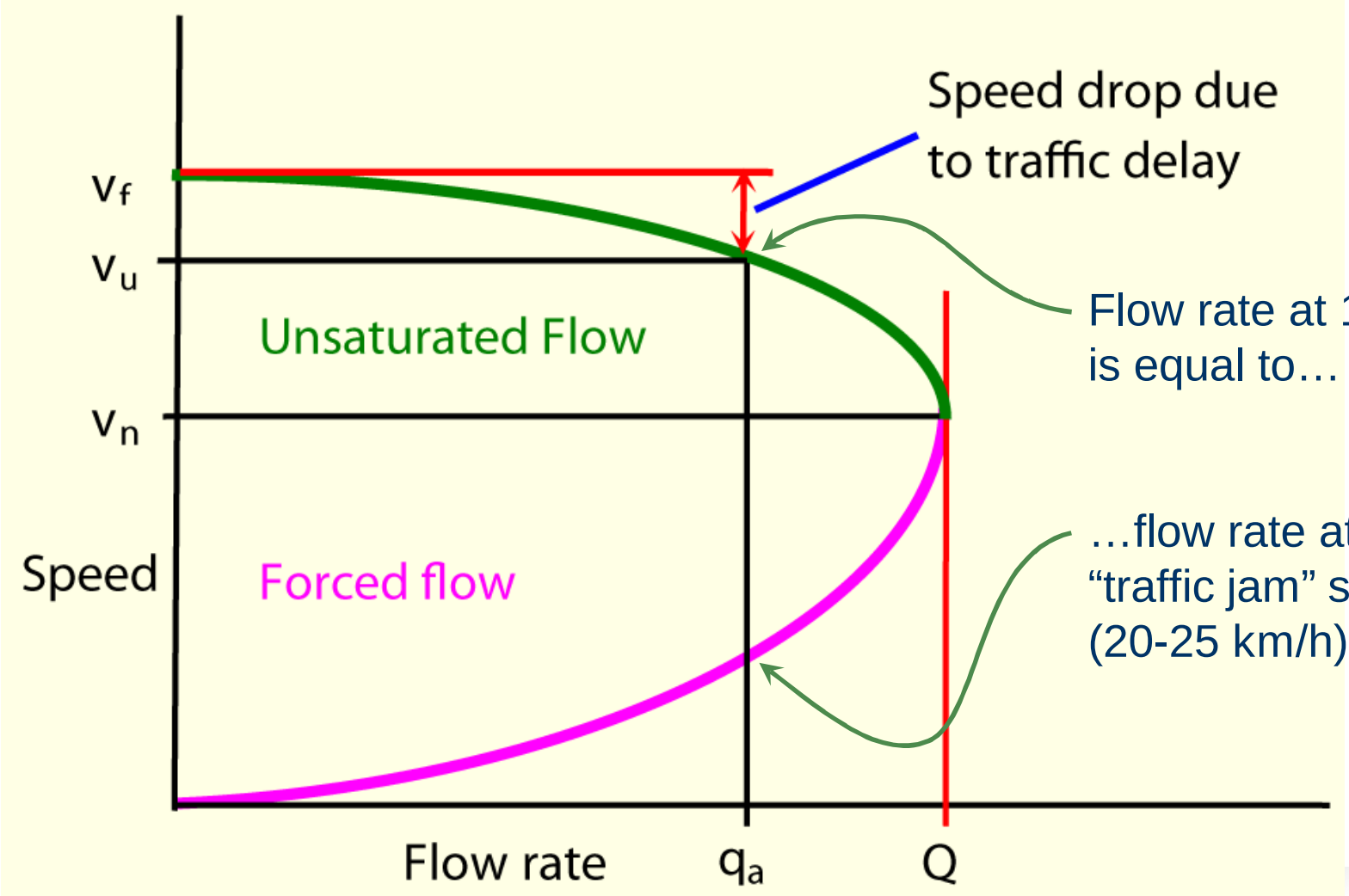
- ***Problem:*** *Many evaluation criteria which may be applicable to highway studies are not well suited for transit studies*

- ***To Learn:*** *Criteria commonly used in evaluation of alternatives related to transit and other multimodal projects*

Problem

- Traditional Capacity Measure provides some insight but can be misleading

Highway Flow Rate



Transit Flow Rate

- Light Rail Example

Light Rail Vehicle with 3-Car Trains	
Average Speed (including Dwell Time):	32 km/h
Headway	2 minutes
Passenger/Train Unit Maximum	450
Peak Hour Factor	0.87
Maximum Passenger Loading per Hour	**11,700**
Travel Time for 8km Trip	15 minutes

Transit Flow Rate

- Rapid Transit (Subway or Elevated) Example

Rapid Transit Vehicles with 6-Car Trains	
Average Speed (including Dwell Time):	64 km/h
Headway	4 minutes
Passenger/Train Unit Maximum	900
Peak Hour Factor	0.87
Maximum Passenger Loading per Hour	**11,700**
Travel Time for 8km Trip	7.5 minutes

Transit Flow Rate

- Streetcar Example

Streetcar "Conga Line"		
Average Speed (including Dwell Time):	16	km/h
Headway	48	seconds
Passenger/Tram	178	
Peak Hour Factor	0.87	
Maximum Passenger Loading per Hour	**11,700**	
Travel Time for 8km Trip	30.0	minutes

Transit Flow Rate

- Comparison

Capacity per Hour of Transit Options	
LRT – 2 minute headways	**11,700**
Rapid Transit – 4 minute headways	**11,700**
Streetcar – 2 streetcars every 90 seconds	**11,700**

Problem

- Perception of “Level of Service” for roadways versus transit is different
  - With roadways, if opening year V/C is 0.90 to greater than 1.00, the design would be a colossal failure!

  - With transit, if the opening year V/C is 0.55 (level of service “C” for roadways), transit is perceived as a failure!

Problem

- How do you evaluate whether the investment is worthwhile?

Examples

- Cost to save 30 seconds of travel time = $500,000
- Cost to save 3 minutes of travel time = $30,000,000

- Cost to save 2 minutes of travel time = $2 Billion

“Cost Effectiveness”

- Used extensively in the U.S. in evaluation of transit alternatives
- Basically, the cost per hour of travel time saved

$$\frac{\text{Annualized Capital Cost + Annual O\&M Cost}}{\text{Annual Travel Time Savings}}$$

Example – LRT vs. Rapid Transit

8 km LRT (Complex Urban)			
Capital Cost:	$	512	Million
O&M:	$	19	Million/year
Annualized Cost:	$	60	Million/year
Daily Ridership:		80,000	
Avg. Time Savings:		7	minutes
Annual Hours Saved:		2,600,000	hours
Cost Effectiveness:	$	23	/hour

8 km Rapid Transit (Subway)			
Capital Cost:	$	3,200	Million
O&M:	$	58	Million/year
Annualized Cost:	$	314	Million/year
Daily Ridership:		110,000	
Avg. Time Savings:		12	minutes
Annual Hours Saved:		6,200,000	hours
Cost Effectiveness:	$		/hour

Example – Ferry vs. Bridge

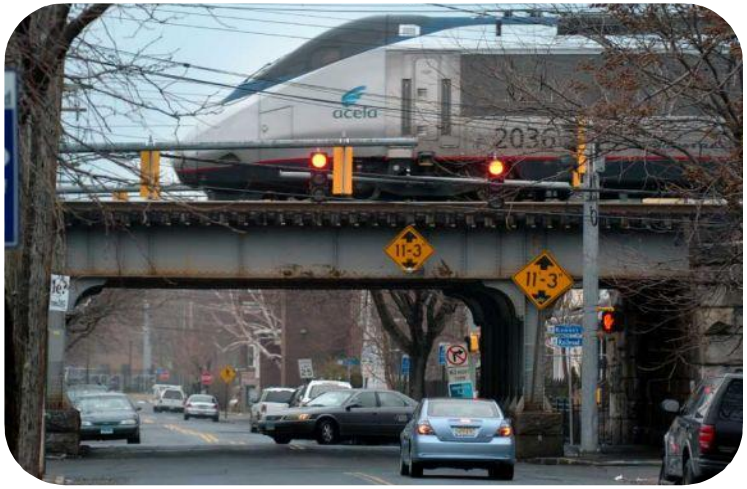
Ferry			
Capital Cost:	$	60	Million
O&M:	$	8	Million/year
Annualized Cost:	$	14	Million/year
Hours of Delay/Year:		50,400	hours

New Bridge			
Capital Cost	$	280	Million
Maintenance:	$	1	Million/year
Annualized:	$	23	Million/year
Added Time:		10,800	hours

Added time is trip for pedestrians and cyclists

Comparison	
Difference in Annual Cost:	Million/year
Difference is Reduce Delay:	Hours/year
Cost per Hour Saved:	/hour

Example – BRT Dedicated Lane



- Proposed Dedicated BRT Lanes cannot fit through existing railroad viaduct
- Opinion of Capital Cost to replace and add BRT lanes: $56 million
- Annualized Capital Cost: $4.3 million/year

- Delay due to BRT in mixed traffic (compared to dedicated lanes): 3.5 minutes
- Projected daily passenger loading in this link: 8,700
- Annual hours of delay if all passengers experience delay: 142,000
- Cost effectiveness = $30/hr

Ultimate System Capacity

There are some cases where ultimate system capacity can be a helpful criteria.

Cycling track		
Average Speed:	19	km/h
Saturation Flow Rate for 1.5 m Cycle Lane	1,500	
Travel Time for 4km Trip	12.5	minutes

Would need storage for cycles at destination

Streetcar Option		
Average Speed (including Dwell Time):	16	km/h
Headway	6	minutes
Passenger/Tram	178	
Peak Hour Factor	0.87	
Maximum Passenger Loading per Hour (per direction)	1,500	
Travel Time for 4 km Trip	15.0	minutes
Average 2012 Capital Cost	$ 20	Million/km

Ultimate Lane Capacity

Measure in persons per hour (as opposed to vehicles per hour).

BRT (18.5 m Articulated, Dedicated Lane)	
Buses per hour (*120 second signal cycle*)	30
"Comfortable" Passenger Loading (59 seated + 21 standing)	80
Peak Hour Factor	0.84
Passenger Loading per Hour	2,000

BRT (18.5 m Articulated, Dedicated Lane)	
Buses per hour (*90 second signal cycle*)	20
"Comfortable" Passenger Loading	80
Peak Hour Factor	0.84
Passenger Loading per Hour	1,340

Automobile (3.3 m Lane)	
Vehicles per lane per hour (arterial)	900
Passengers per vehicle (average)	1.2
Passengers per hour	1,080

Cycle Lanes (Two 1.5 m Lanes)	
Cyclists per hour (Two 1.5 m cycle lanes)	3,000
Available Green Time at Signals	0.5
Cyclist Capacity per Hour	1,500

Health Benefits

- From an October 2011 Study, health benefits for mode shift (auto to cycle) were included at $330/year per commuter who changed modes.

Year	Safety Benefit	Health Benefit	Total Benefits	7% Discount Rate
0	$ -	$ -	$ -	$ -
1	$ 483,000	$ 89,100	$ 572,100	$ 535,000
2	$ 483,000	$ 133,650	$ 616,650	$ 539,000
3	$ 483,000	$ 178,200	$ 661,200	$ 540,000
4	$ 483,000	$ 222,750	$ 705,750	$ [illegible]
5	$ 483,000	300	$ 750,300	
[illegible]		[illegible]		
[illegible]	[illegible]	$ [illegible]	[illegible]	$ 348,000
13	$ 483,000	$ 300,713	$ 783,713	$ 325,000
14	$ 483,000	$ 300,713	$ 783,713	$ 304,000
15	$ 483,000	$ 300,713	$ 783,713	$ 284,000
16	$ 483,000	$ 300,713	$ 783,713	$ 265,000
17	$ 483,000	$ 300,713	$ 783,713	$ 248,000
18	$ 483,000	$ 300,713	$ 783,713	$ 232,000
19	$ 483,000	$ 300,713	$ 783,713	$ 217,000
20	$ 483,000	$ 300,713	$ 783,713	$ 203,000

Total Benefits (Present Value): $7,775,000

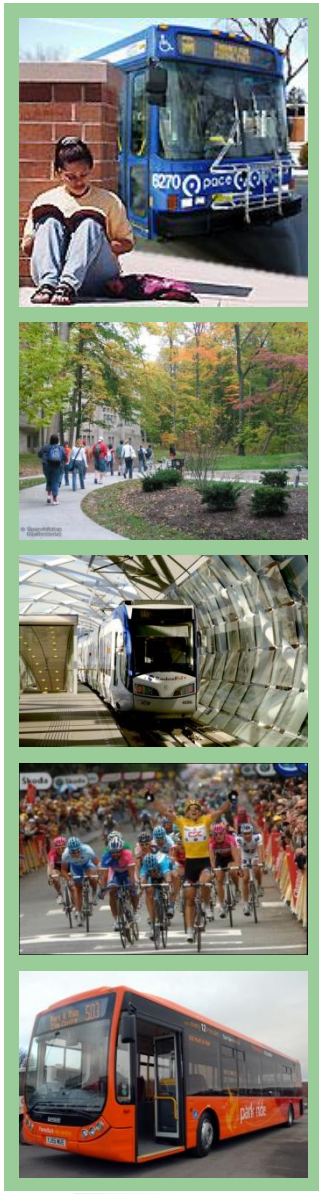
Capital Cost of Commuter Cycle Track: $5,616,000

Summary

- With transit, but take into account the operating and maintenance (O&M) costs as well as capital costs. Converting to an overall annualized cost is preferable.
- “Cost Effectiveness” is the cost per hour of travel time savings. Can be compared against a base case, or can be compared using incremental changes.
- For capacity, compare persons per hour rather than vehicles per hour. Purpose of passenger transportation is to move people, not automobiles.

Summary (continued)

- Cycling and pedestrian project benefits may include:
  - Health benefits
  - Safety improvements
- Transit and non-motorized project benefits may also include:
  - Decrease in automobile usage costs
  - Decrease in parking demand (and need for parking facilities), or shift in parking demand location



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