Transport Modes and Technologies

A Walking Tour on Capacity, LOS...

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Urban Transportation Planning
MIT Course 1.252j/11.380j
Fall 2006

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Transport Modes and Technologies

- Private Transport: The automobile
- Collective Transport
  - Bus
  - Light Rail
  - Rapid Transit
  - Taxi, CarSharing...
- Non Motorized Modes
  - Walking
  - Biking

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The Automobile - Infrastructure

- Road system:
  - Hierarchical system:
    - From turnpike to local street
    - From unimpeded movement to access to properties *(Mobility vs Accessibility in their lingo)*
  - Uninterrupted segments:
    - Turnpike with access control
  - Interrupted segments:
    - Traffic signals, stops...

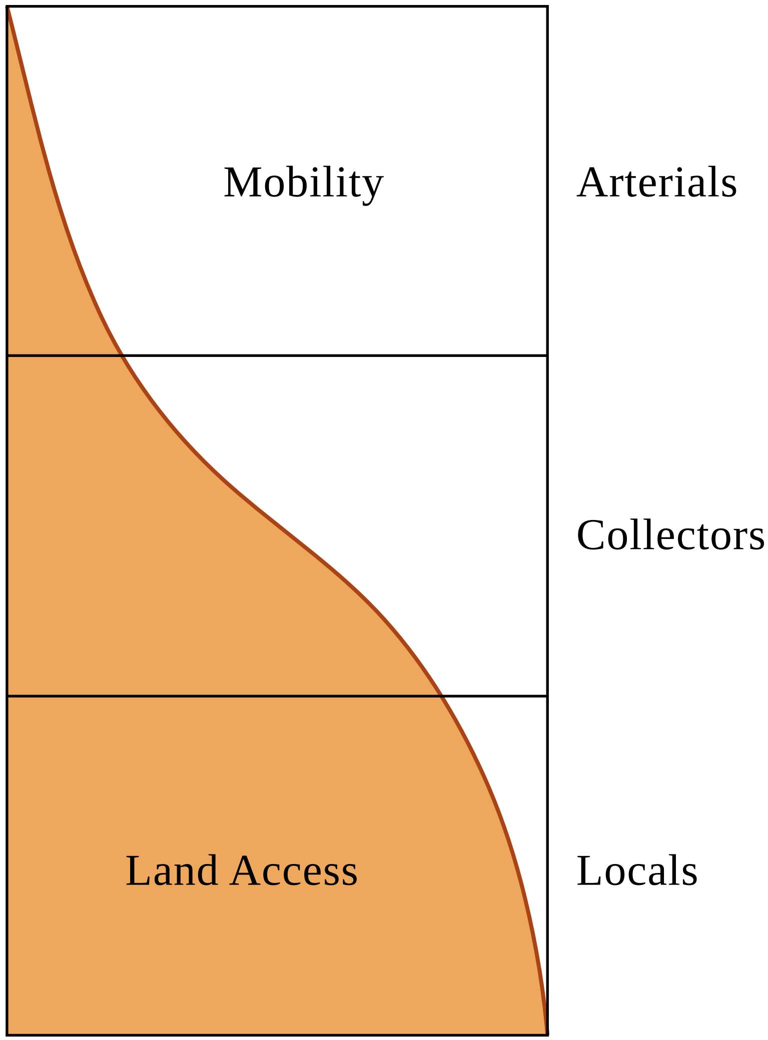

Figure by MIT OCW.

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The Automobile – Capacity

- The capacity of a facility is the maximum hourly rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, traffic, and control conditions

Highway Capacity Manual
Transportation Research Board (TRB)
HCM2000

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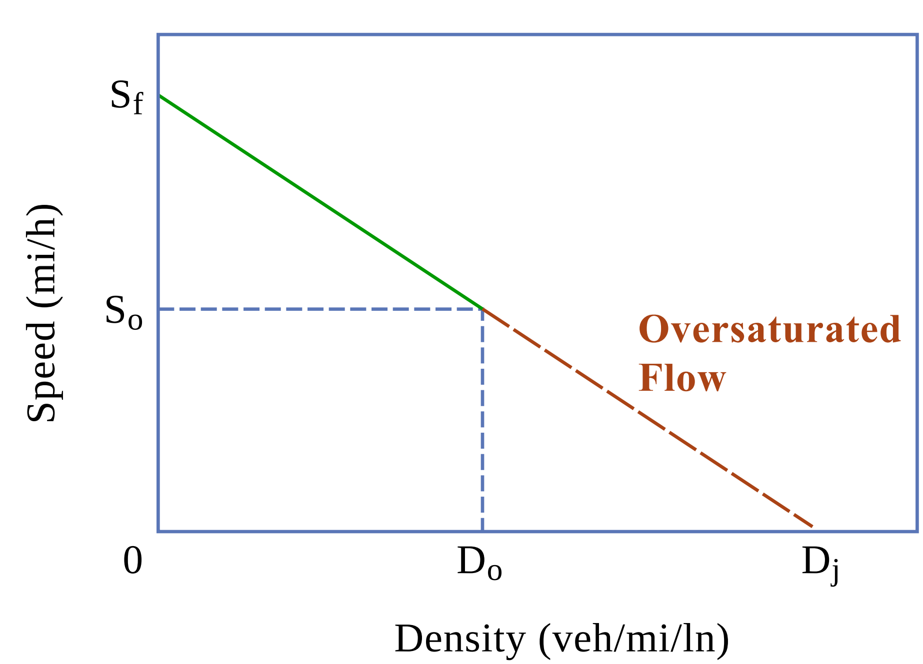
Density Speed Relationship

- S_f=Free flow speed
- S_o=Optimum speed

- D_o=Optimum density
- D_j= Jam density



Speed-Density

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

Speed-Flow Relationship

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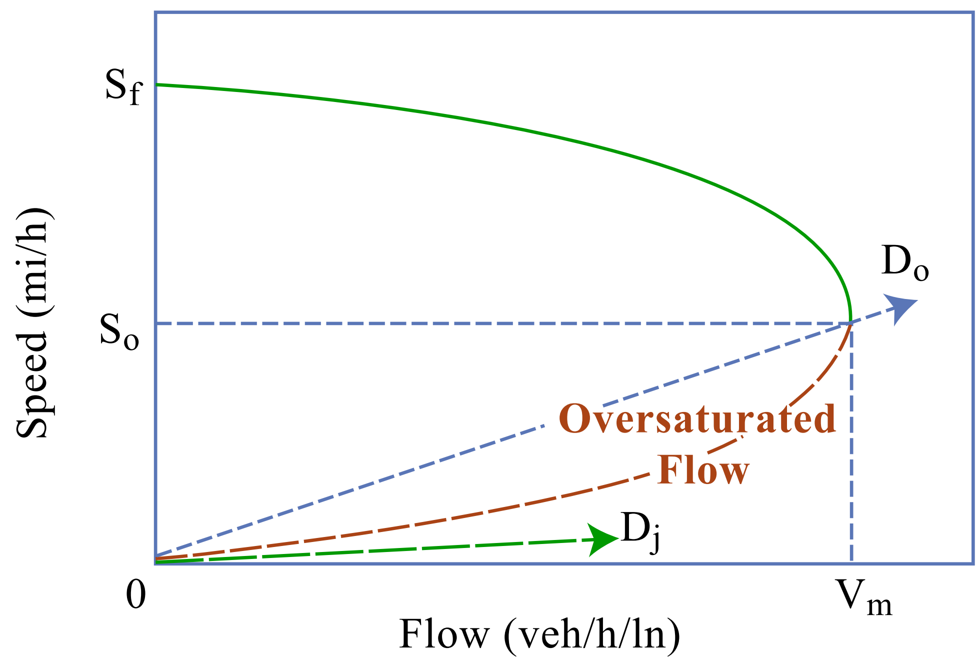
- S_f=Free flow speed
- S_o=Optimum speed

- D_o=Optimum density
- D_j= Jam density

- V_m= Maximum Flow



Speed-Flow

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

Flow-Density Relationship

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- S_f=Free flow speed
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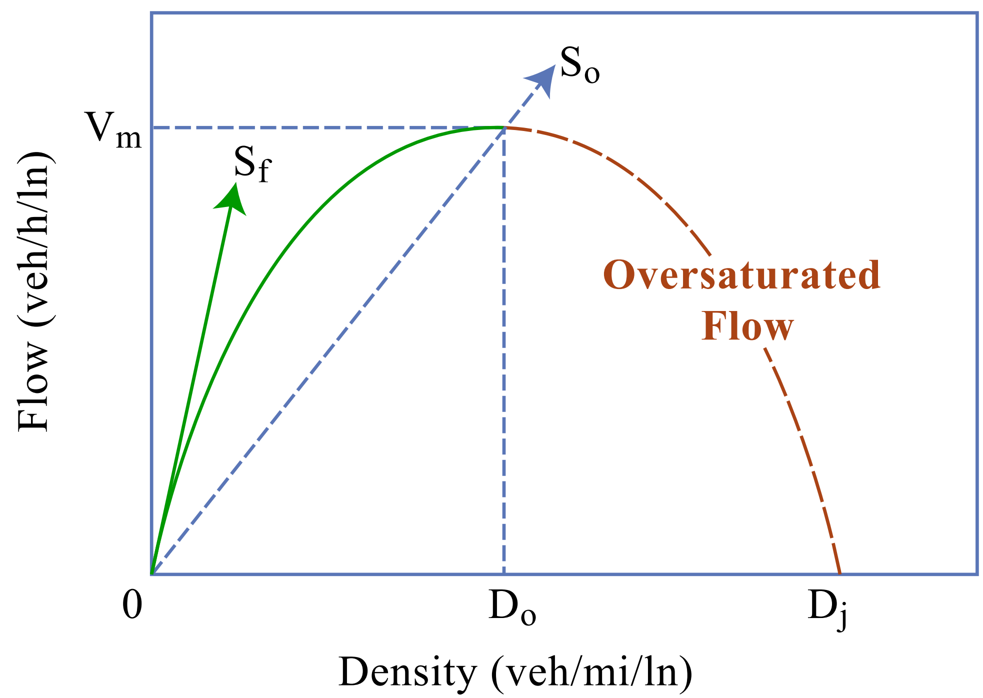

Flow-Density

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

Speed-Flow-Density Relationship

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- S_f=Free flow speed
- S_o=Optimum speed
- D_o=Optimum density
- D_j= Jam density
- V_m= Maximum Flow

D=v/S

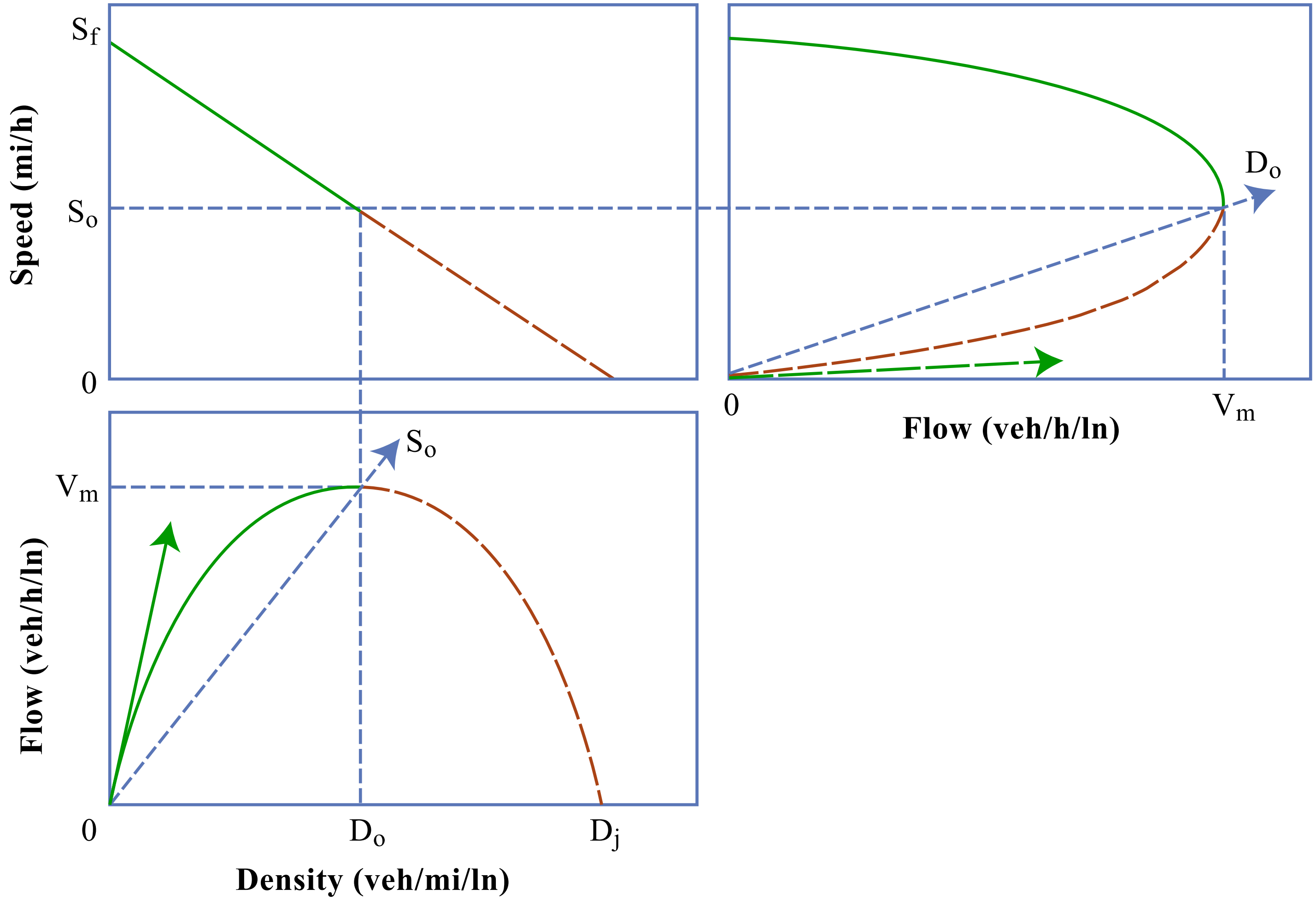

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

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The Automobile – Capacity

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- Vehicle throughput in uninterrupted flow:
  - Speed-density curves

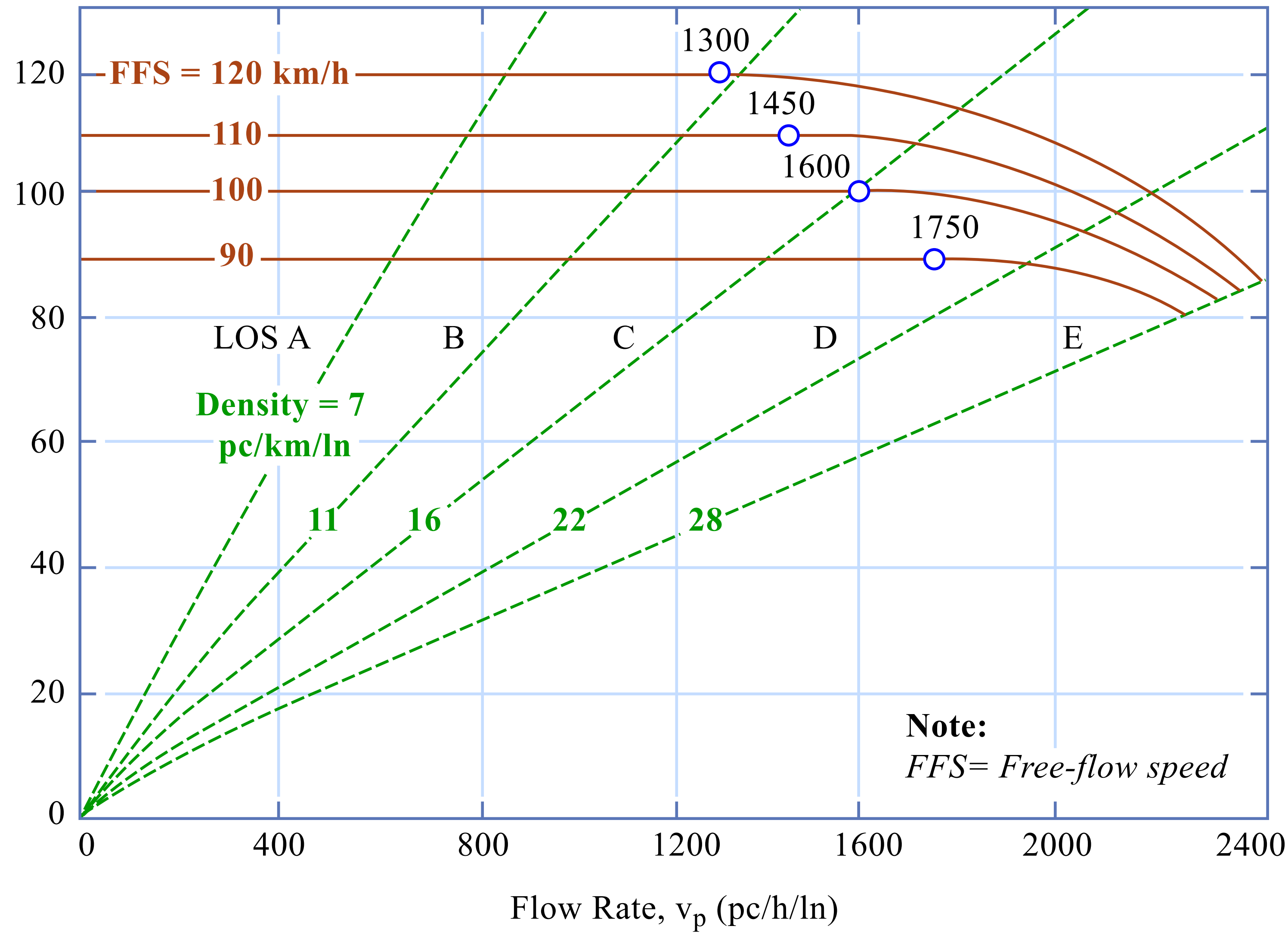

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

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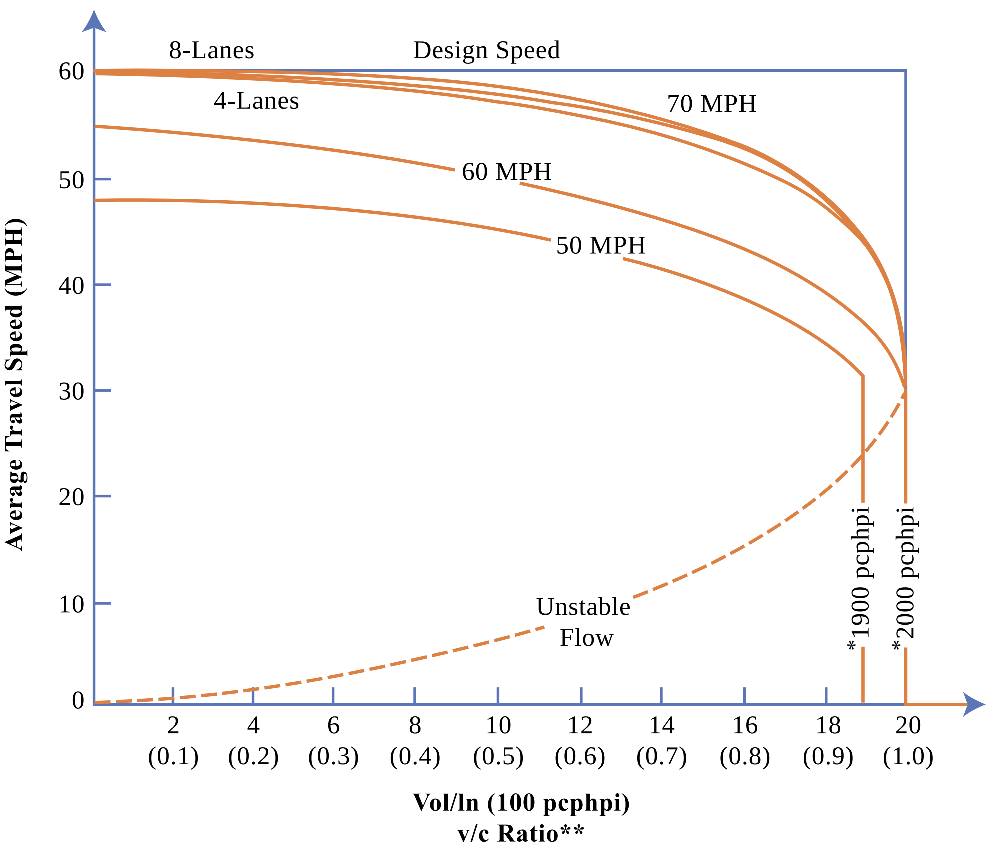
Speed-Flow Curves:

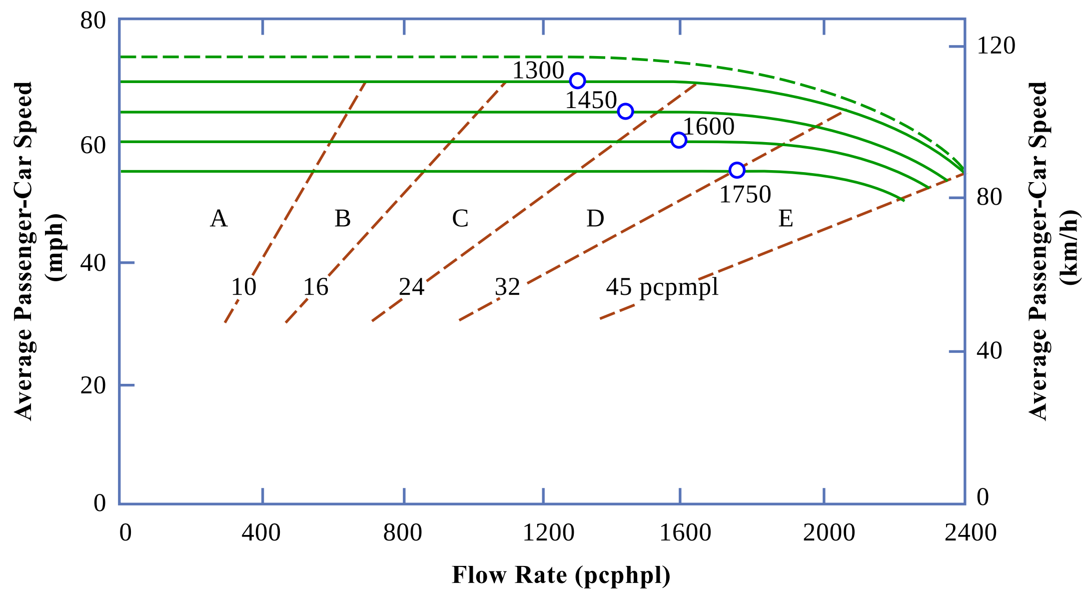
HCM speed-flow curve, before and after:

- Human adaptation to driving in congested conditions
- The original dream of ITS

BASE FREEWAY SEGMENT



*capacity
**v/c ratio based on 2000 pcphpi valid only for 60- and 70-MPH design speeds



Flow-Flow Speed (mph)	Capacity (pcphpl)
≥ 70	2400
65	2350
60	2300
55	2250

Note: Capacity varies by free-flow speed.

Figures by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

Speed-Flow Curves

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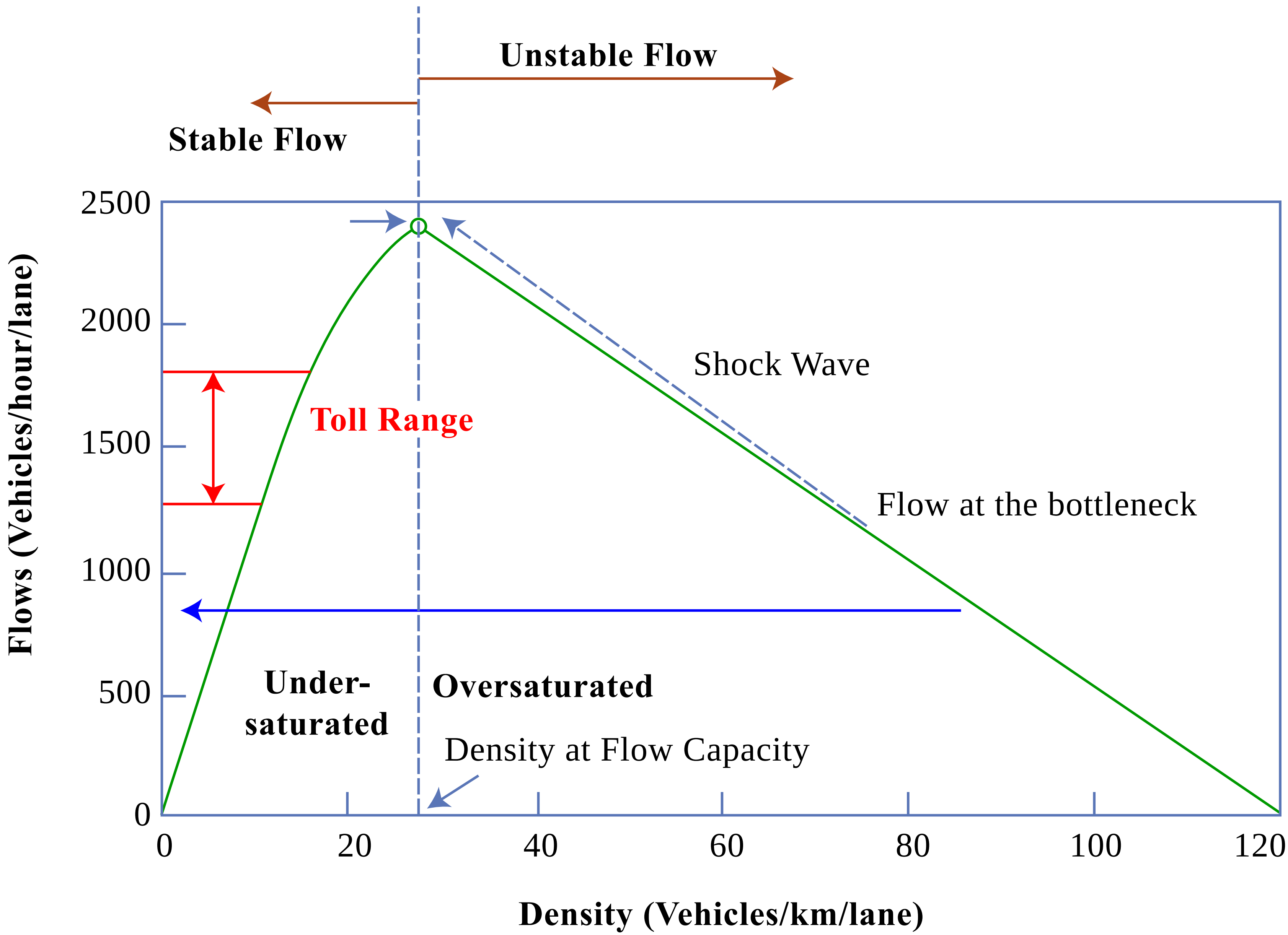

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

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From ideal capacity to...

- Different vehicles have different power to weight ratios, therefore...
- Different gaps in front or behind some vehicle types
- Plus:
  - Gradients
  - Widths
  - Weather
  - ......

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From ideal capacity to...

- Even in uninterrupted flow sections, some movements may reduce the ideal capacity, such as:
  - Merging
  - Diverging
  - Weaving
  - ....

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Capacity under interrupted conditions...

- Traffic signals, roundabouts, all-stops...
- Automobiles and trucks – reaction times
- Saturation, blocking intersections (gridlock??)

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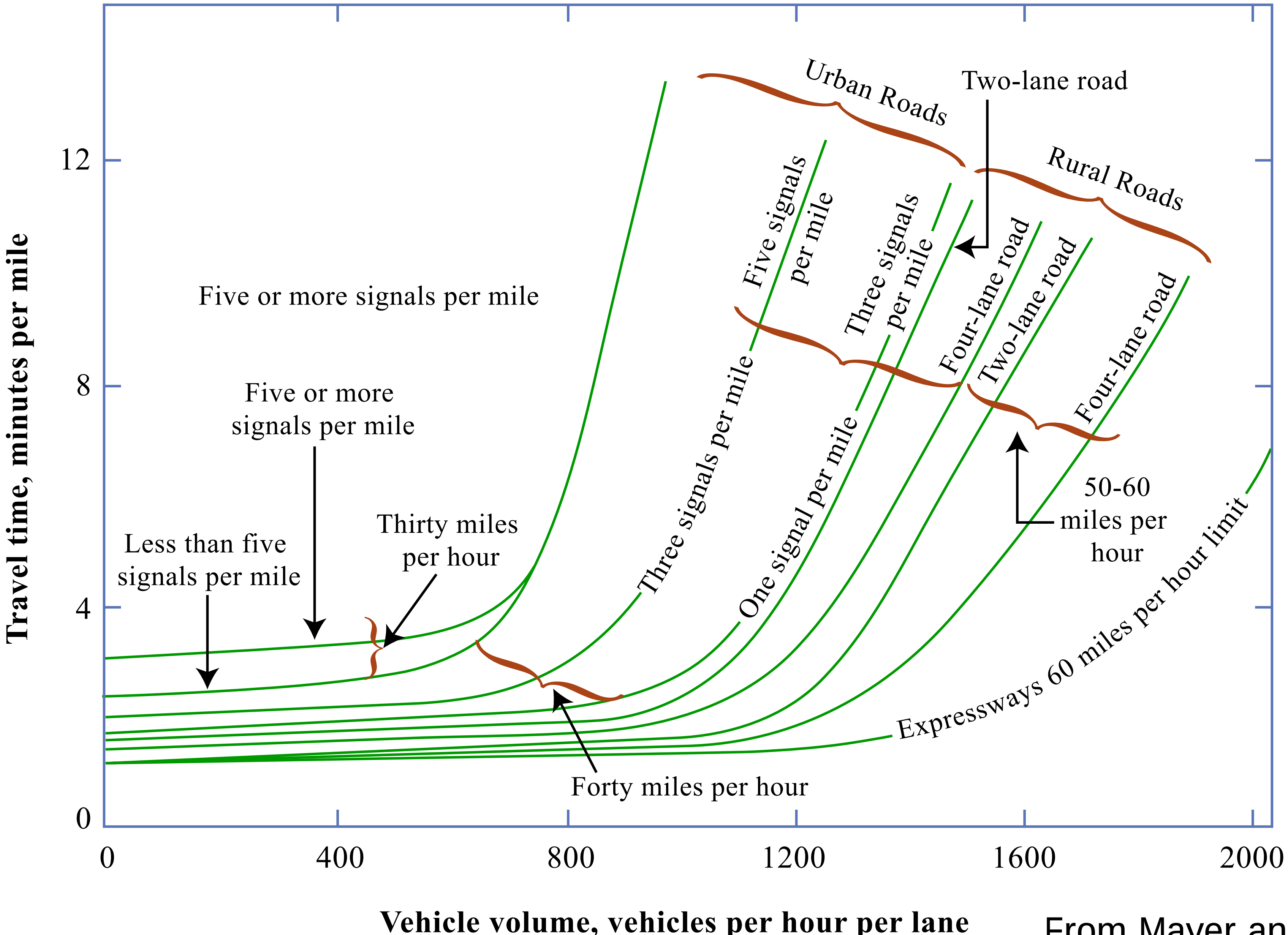
The Automobile – Capacity



Little nos
Vs
Fancy nos

Figure by MIT OCW.

From Mayer and Miller

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The Automobile – Capacity

- PEOPLE throughput :
  - Vehicle throughput times OCCUPANCY
  - Auto-occupancy (a non-technical issue)
    - HBW... 1.1
    - HBO-shop... 1.4
    - HBO-social... 1.7
    - NHB...... 1.6

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The Automobile – Levels-Of-Service

- The power of A to F
- From spot values to travel times
- Living under saturated conditions

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The Automobile – Costs

- Fixed Costs:
  - Vehicle purchase
  - Insurance
  - A parking spot/garage
  - ....
- Variables Costs:
  - Gasoline
  - Oil and maintenance
  - Parking
  - Tolls
  - ....

- **Ratio between Fixed and Variable Costs?**

- **Why this is important?**

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The Automobile – Costs

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- Social costs:
  - Road construction, maintenance
  - Management of road system
- Environmental costs:
  - Accidents
  - Health impacts
  - Noise (pedestrian areas)
  - Air pollution: cold-start, f(speed)
  - Land consumed
  - Energy
  - Segregation
  - ....

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Transit - Capacity

- People throughput:
  - Vehicle size
  - Headway (and fleet size)
  - Commercial speed

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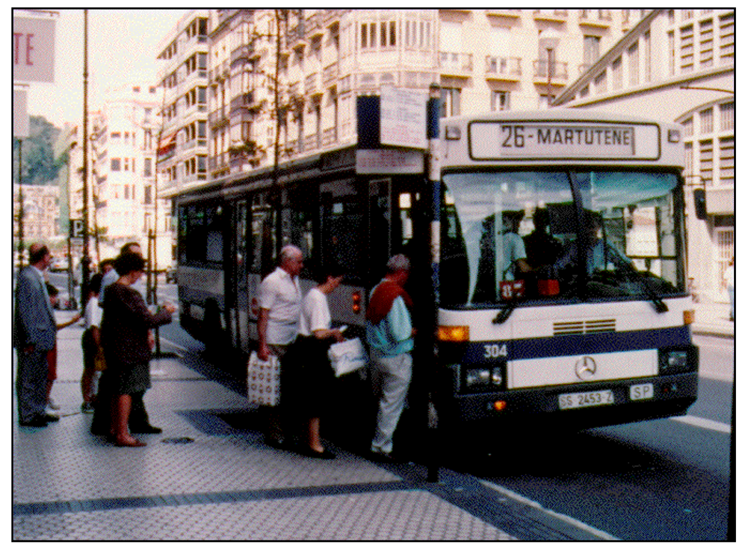
Buses - Capacity

- Bus type and size:
  - No of seated spaces and no of standees

- Access and ticketing:
  - No of doors
  - Easy access and egress
  - Access by the front door, other doors
  - Egress by one or two doors
  - Low floor
  - Ticket validation:
    - By the bus driver
    - On other machines on board
    - On the bus stops

Buses - Capacity

- Capacity (Cont'd):
  - Headway: Peak-hour and off-peak
  - Commercial speed:
    - Mixed traffic
    - Bus lanes
    - Signal priority



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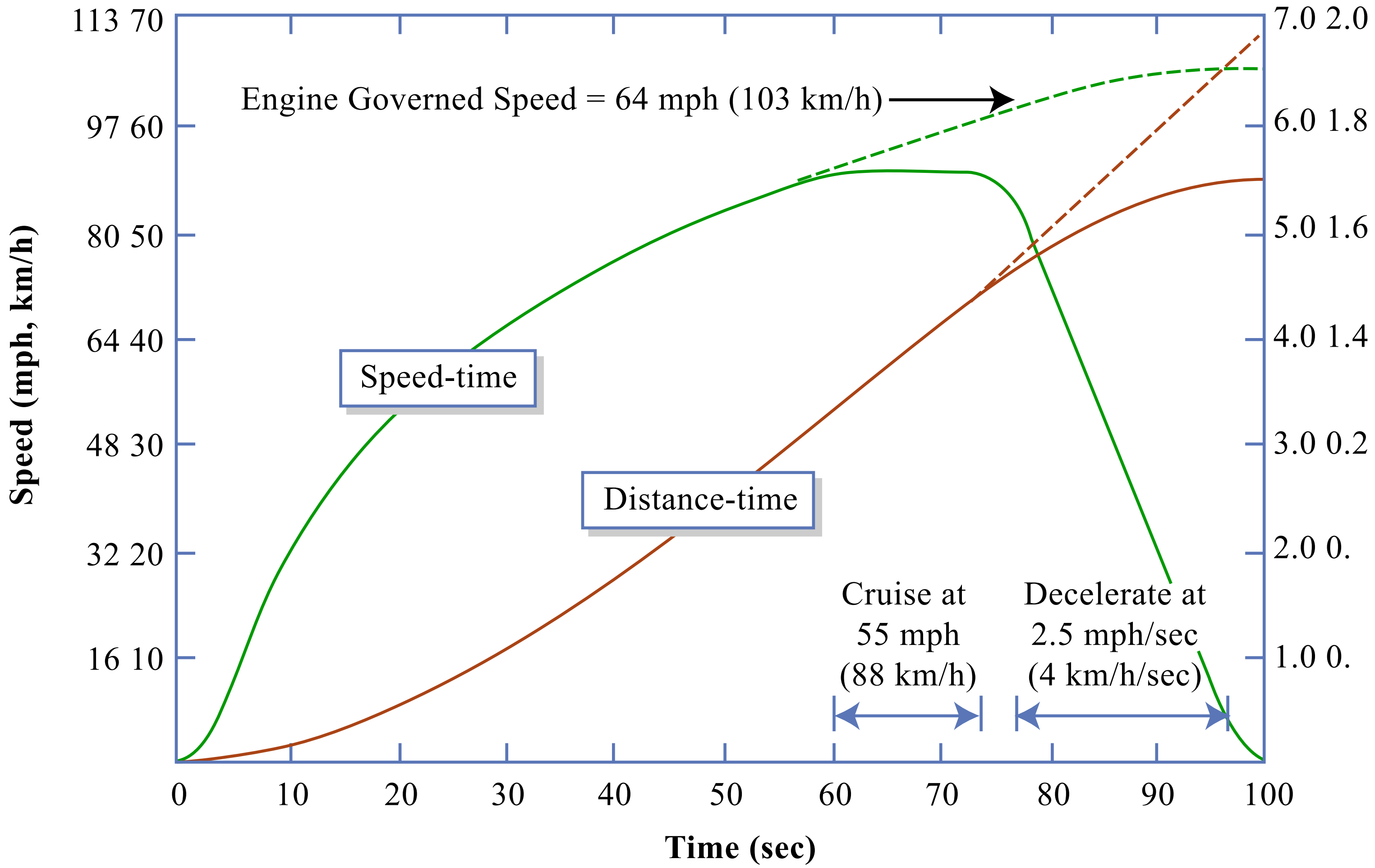
Rail-based systems capacity

Speed profiles between stations



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Rail-based systems capacity

- Time-Space Diagrams

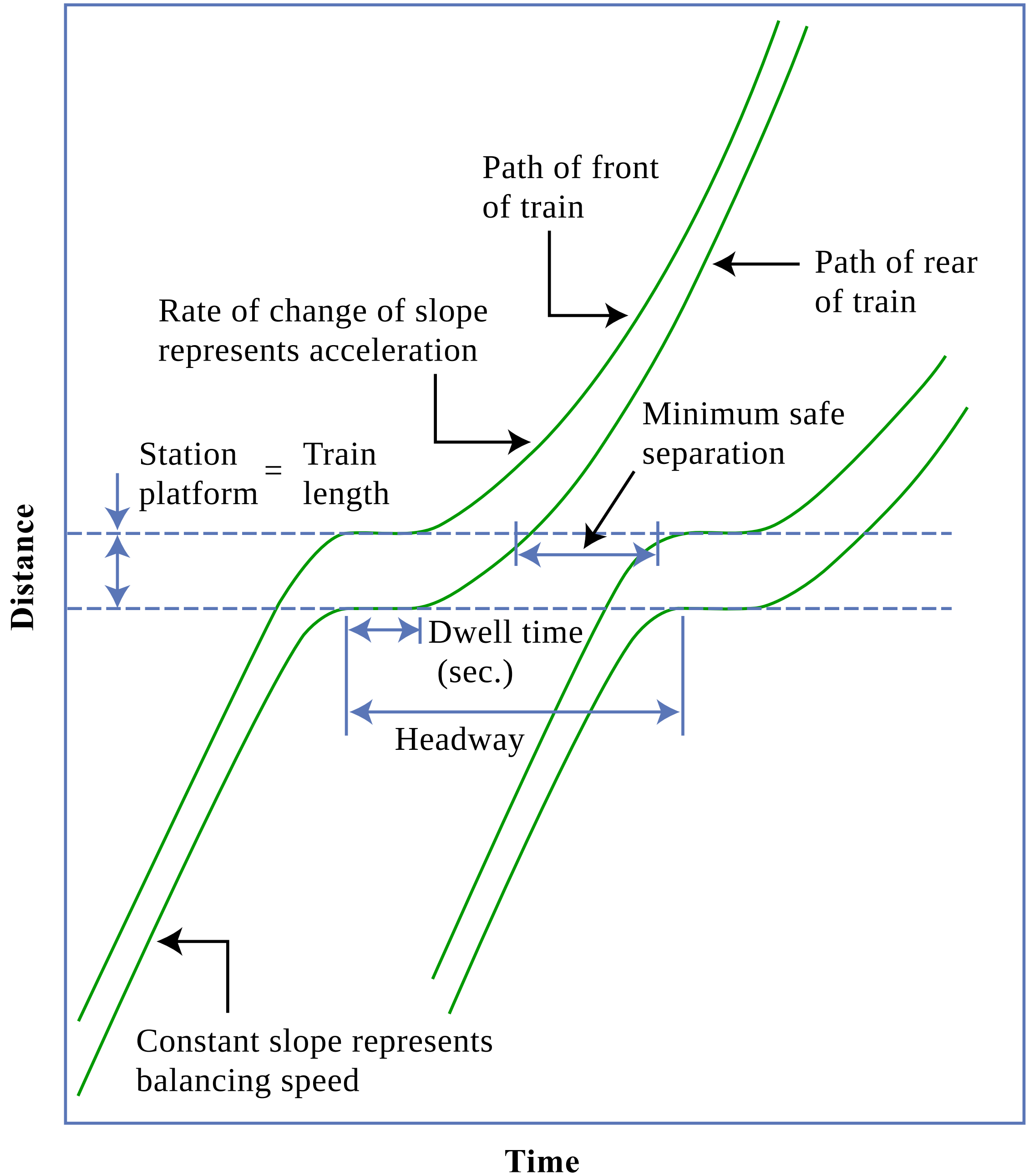

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

Transit – LOS

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- HBW represents > 50%
- Peak hours
- Peak directional flows

Easy to accept overcrowding at peak to justify service during off-peak hours

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Transit - LOS

Originally, just density as for automobiles!!

LOS	BUS		RAIL		COMMENTS
	ft^2/p	*p/seat**	*ft^2/p*	*p/seat**	
A	>12.9	0.00-0.50	>19.9	0.00-0.50	No passenger need sit next to another
B	8.6-12.9	0.51-0.75	14.0-19.9	0.51-0.75	Passengers can choose where to sit
C	6.5-8.5	0.76-1.00	10.2-13.9	0.76-1.00	All passengers can sit
D	5.4-6.4	1.01-1.25	5.4-10.1	1.01-2.00	Comfortable standee load for design
E	4.3-5.3	1.26-1.50	3.2-5.3	2.01-3.00	Maximum schedule load
F	<4.3	>1.50	<3.2	>3.00	Crush loads

*Approximate values for comparison LOS is based on area per passenger.

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

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Transit - LOS

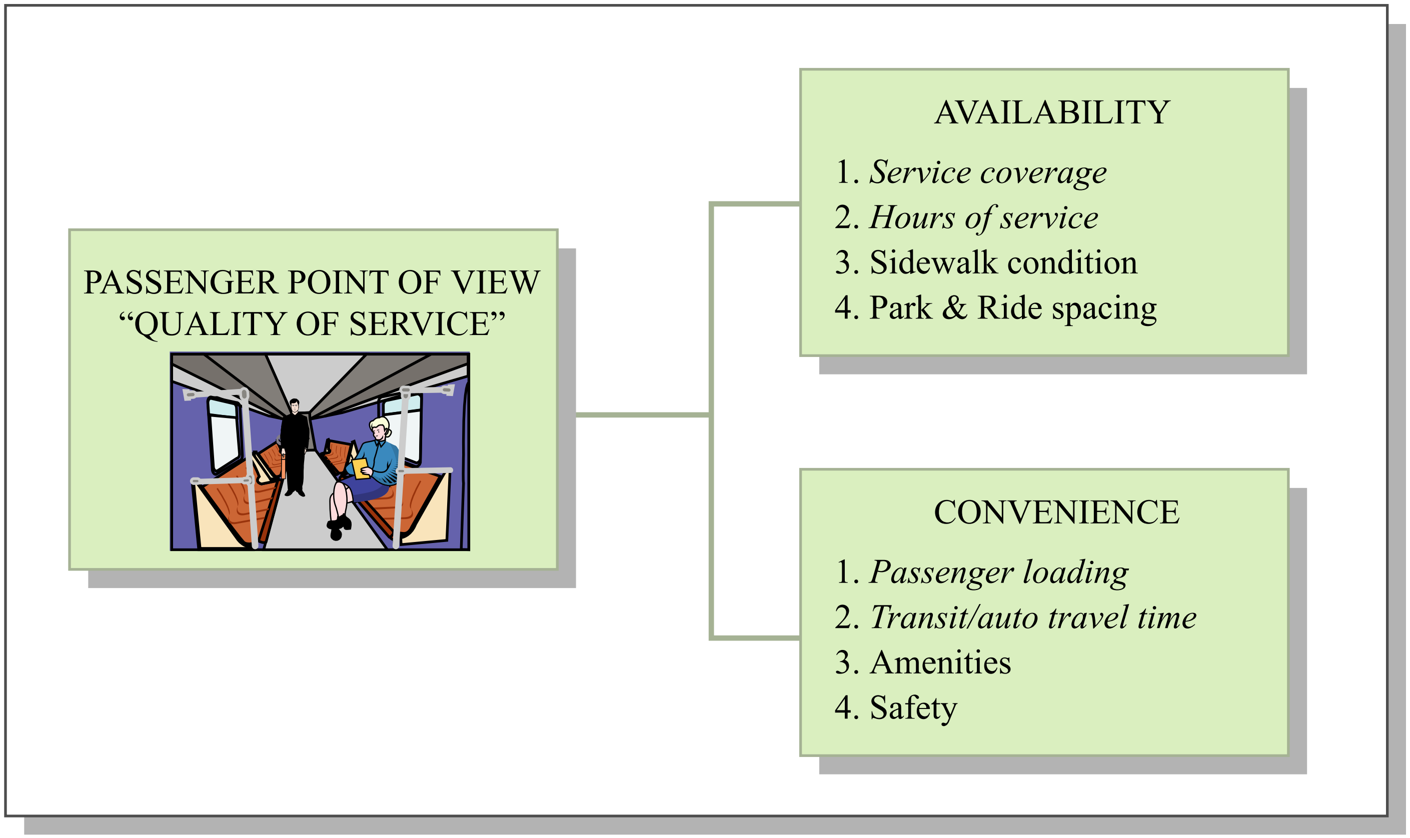

Figure by MIT OCW.

Transit - LOS

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Category	Service & Performance Measures		
	Transit Stop	Route Segment	System
Availability	Frequency* Accessibility Passenger loads	Hours of service* Accessibility	Service coverage % person-minutes served
Comfort and Convenience	Passenger loads* Amenities Reliability	Reliability* Travel speed Transit/auto travel time	Transit/auto travel time Travel time Safety

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

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Transit - LOS

Different points of view to judge LOS:

TRANSIT/AUTO TRAVEL TIME LOS

LOS	*Travel Time Difference (min)*	*Comments*
A	≤ 0	Faster by transit than by automobile
B	1-15	About as fast by transit as by automobile
C	16-30	Tolerable for choice riders
D	31-45	Round-trip at least an hour longer by transit
E	46-60	Tedious for all riders; may be best possible in small cities
F	>60	Unacceptable to most riders

Open to many interpretations:

- Times door-to-door?
- Weight factors applied to the different time segments?

Figure by MIT OCW, adapted from the Transportation Research Board, "Highway Capacity Manual 2000".

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Transit - Cost

- Capital Costs:
  - >50-75 years horizon (infrastructure)
  - Usually not included in fare-box recovery ratio for operating costs
  - 12-40 years for vehicles (buses or trains)
- Operating Costs:
  - $C_{op}=C_d$*veh-miles $+C_t$*veh-hr + C_s*fleet

    (with variations for peak and off-peak)
- Environmental Costs:
  - Accident rate
  - Noise, soot...

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Buses

- Flexibility for route adjustments
- Closer stop spacing
- In search of higher quality:
  - Low floor buses for an aging population
  - Bus stops:
    - Real time info on arrivals (and eventually downstream)
    - Maps, transfers, info on ticketing and validation

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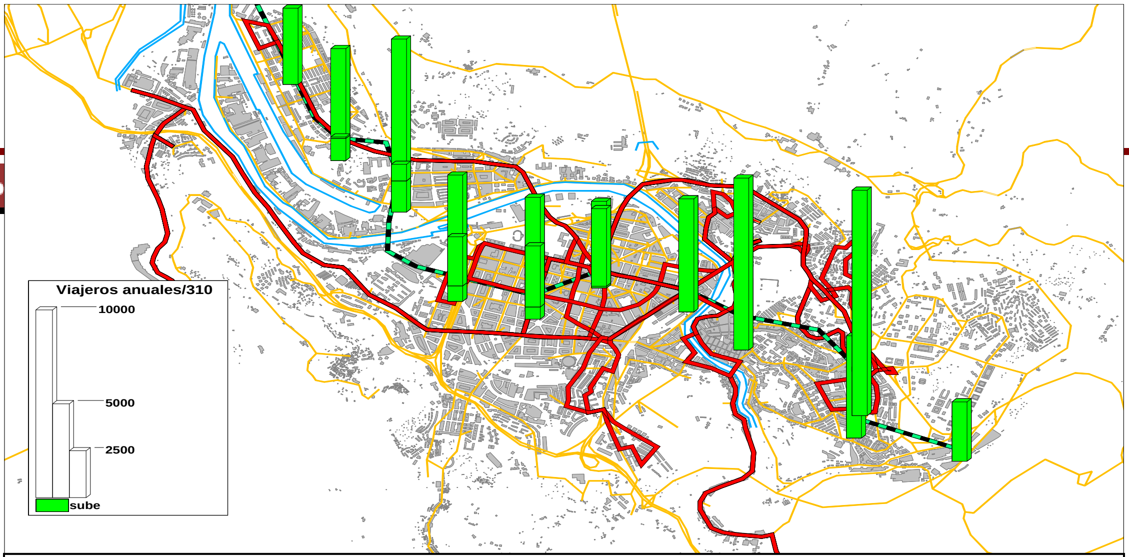
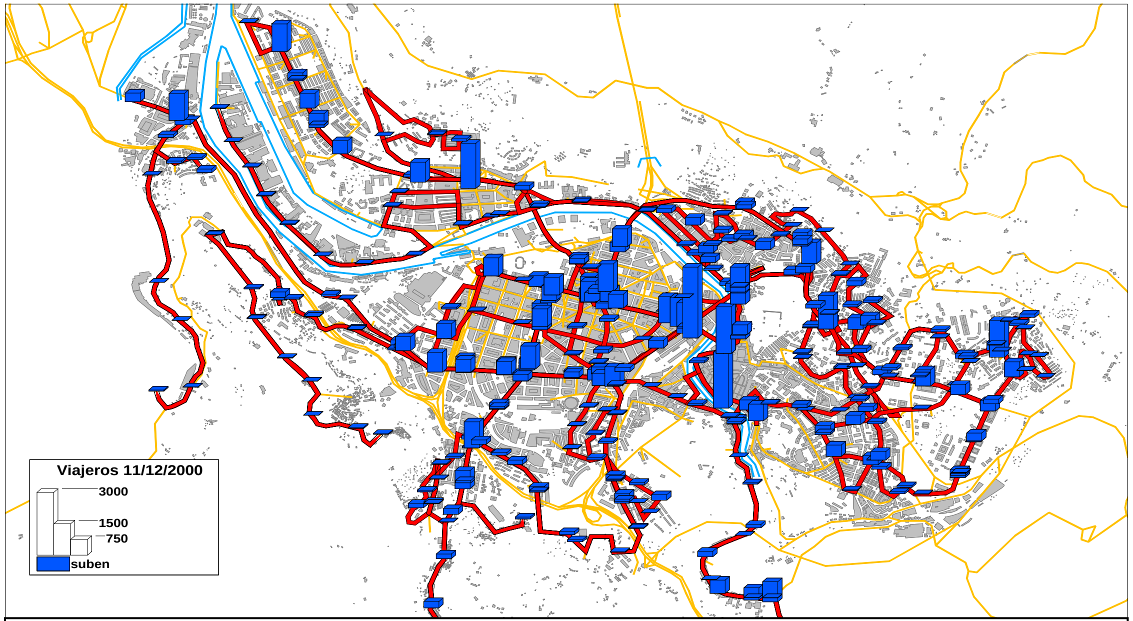
Rail vs Bus



Metro 90,000 viajeros en 11 estaciones



BilboBus 90,000 viajeros en >180 paradas

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Light Rail

- From Rapid Rail Transit to Light Rail:
  - Lower investments
  - But more *exciting* than buses
  - Mixed traffic segments
  - Easier to garner support for priority
  - Attracts local development

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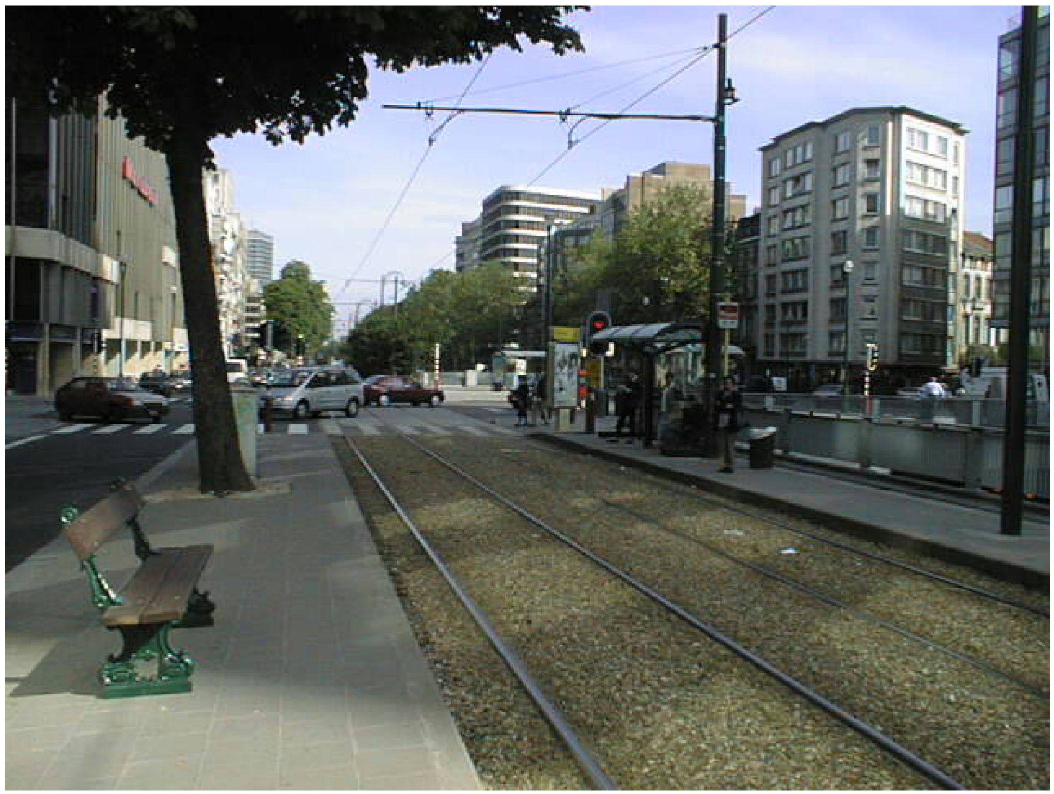
Light Rail

- Full reserved ROW or mixed traffic



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Light Rail

- Priority easily awarded...

From Public Transport to Collective Transport

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Rethinking transit:

- Jitney service
- Taxi-Bus
- Dial-a-Ride
- Taxi
- Car Sharing
- …….??

Some comparative *little* numbers

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	Car on city streets	Car on Freeway	Bus LRT on Mixed Traffic	Semi Rapid Transit	Rapid Transit
Vehicle occupancy	1.2	1.2	40-300	40-600	140-2,200
Speed (km/hr)	**20-50**	**60-120**	**5-20**	**15-45**	**25-70**
Veh/hr	600-800	1500-2200	60-80	40-90	10-40
Capacity (pers/hr)	**720 to 1,050**	**1,800 to 2,600**	**2,400 to 20,000**	**4,000 to 20,000**	**10,000 to 72,000**

Walking – See LOS C and E per HCM

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- Capacity and LOS
  - Moving and
  - Waiting

- **Is it enough??**

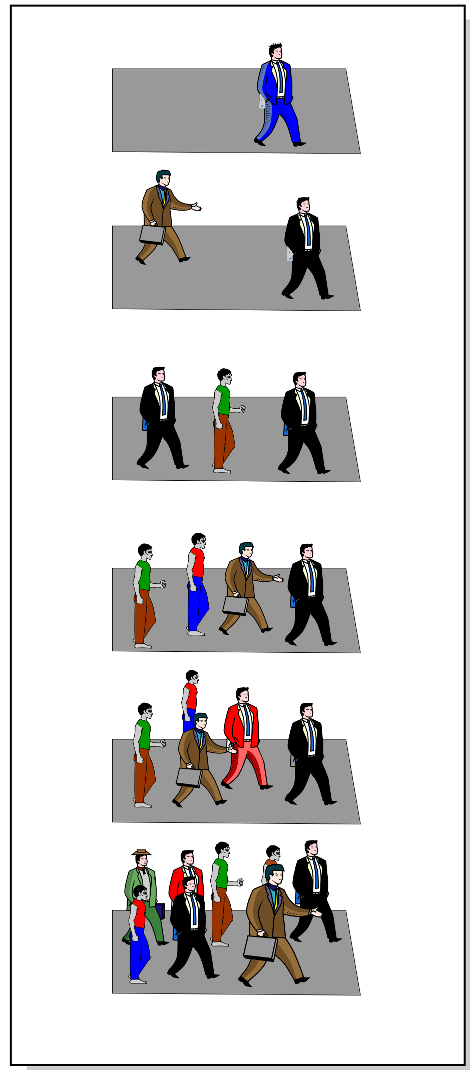

Figure by MIT OCW.

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Walking – How to define LOS?

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What else should come into the picture?

- Comfort and safety
- Protection from weather
- Direct lines of sight
- Direct routing
- “Live” facades
- Conviviality
- ....???

The *Tube* Platforms

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Biking – L.O.S.

- The power of a can of paint
- Safety first and foremost

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Biking- LOS

- Again, LOS based on throughput whether it is one-way or two-way

- Other concepts to be included in LOS?
  - Inclines
  - safety issues
  - continuity
  - drainage
  - wet leaves
  - ....?

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Biking: A process

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