INTRODUCTION (ECI 256)  
Traffic Flow, Traffic Control and a Case Study

Yi-Ru Chen
Fall 2011
How many cars on earth?
Where are bottlenecks?

- **Google Map Traffic**: up-to-date traffic conditions to help you plan your routes. http://maps.google.com
- **Performance Measurement System** http://pems.dot.ca.gov
Why does congestion occur?

Demand > Capacity

FLOW RATE

Demand

Capacity

Observed flow

8 am  5 pm  t
Flow(veh/hr), Density(veh/mile), and Speed(mile/hr)

Flow (Veh/Hour)
864 Lane Points (6% Observed)
Mainline VDS 318067 - W of CR 105d - 180-E
Fri 10/07/2011 00:00:00 to Fri 10/07/2011 23:59:59

Lane 1 Flow (Veh/Hour)  
Lane 2 Flow (Veh/Hour)  
Lane 3 Flow (Veh/Hour)

EB Off to Dmle  
EB Off to West
Flow (veh/hr), Density (veh/mile), and Speed (mile/hr)
Flow (veh/hr), Density (veh/mile), and Speed (mile/hr)
The Concept of Highway Capacity (Field Observations)
Approximate Relations

\[ q(\rho) \]

\[ q(\rho) \]

\[ q(\rho) \]

\[ q(\rho) \]

\[ v(\rho) \]

\[ v(\rho) \]

\[ v(\rho) \]

\[ q_{\text{max}} \]

\[ K_c \]

\[ K_{\text{jam}} \]

\[ u_f \]
Capacity

The capacity of a transportation system:
The maximum number of vehicles/passengers “per unit time” that can be accommodated under given conditions w/ a reasonable expectation of occurrence.

– Capacity is independent of demand
– Capacity depends on traffic composition
– Capacity is a probabilistic measure; an acceptable expectation of occurrence.
Ideal capacity

• Maximum hourly flow rate under ideal conditions
  – Lane width (>= 12FT)
  – Lateral clearance (>=6FT)
  – Number of lanes (>= 5/DIR)
  – Interchange density(<=0.5/MILE)
  – All passenger cars
  – Familiar drivers
  – Good weather conditions
### Exhibit 2-1

**LEVELS OF SERVICE (LOS) FOR FREEWAY SEGMENTS**

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>Flow Conditions</th>
<th>Operating Speed</th>
<th>Delay</th>
<th>Service Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Highest quality of service. Free traffic flow, with low volumes and densities. Little or no restriction on maneuverability or speed.</td>
<td>55+</td>
<td>None</td>
<td>Good</td>
</tr>
<tr>
<td>B</td>
<td>Stable traffic flow, speed becoming slightly restricted. Low restriction on maneuverability.</td>
<td>50</td>
<td>None</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>Stable traffic flow, but less freedom to select speed, change lanes, or pass. Density increasing.</td>
<td>45</td>
<td>Minimal</td>
<td>Adequate</td>
</tr>
<tr>
<td>D</td>
<td>Approaching unstable flow. Speeds tolerable, but subject to sudden and considerable variation. Less maneuverability and driver comfort.</td>
<td>40</td>
<td>Minimal</td>
<td>Adequate</td>
</tr>
<tr>
<td>E</td>
<td>Unstable traffic flow with rapidly fluctuating speeds and flow rates. Short headways, low maneuverability, and low driver comfort.</td>
<td>35</td>
<td>Significant</td>
<td>Poor</td>
</tr>
<tr>
<td>F</td>
<td>Forced traffic flow. Speed and flow may drop to zero with high densities.</td>
<td>20</td>
<td>Considerable</td>
<td>Poor</td>
</tr>
</tbody>
</table>
Figure 3-4. LOS Criteria

Note: Capacity varies by free-flow speed.

<table>
<thead>
<tr>
<th>Free-Flow Speed (mph)</th>
<th>Capacity (pcphpl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 70</td>
<td>2400</td>
</tr>
<tr>
<td>65</td>
<td>2350</td>
</tr>
<tr>
<td>60</td>
<td>2300</td>
</tr>
<tr>
<td>55</td>
<td>2250</td>
</tr>
</tbody>
</table>
CONTROL OF URBAN ARTERIALS

1. No control (e.g., roundabouts)
2. Stop/Yield control
3. Signal control
Roundabouts

Roundabout design for SR 542/Smith Road intersection - June 2010

By WSDOT ★ Favorite 1 comment
Stop/Yield controlled intersections
Signal controlled intersections
“Warrants”

Does the situation warrant a signal?
MUTCD (Manual on Uniform Traffic Control Devices)

Warrant 1, Eight-Hour Vehicular Volume.
Warrant 2, Four-Hour Vehicular Volume.
Warrant 3, Peak Hour.
Warrant 4, Pedestrian Volume.
Warrant 5, School Crossing.
Warrant 6, Coordinated Signal System.
Warrant 7, Crash Experience.
Warrant 8, Roadway Network.
Traffic Signal Control: NEMA (National Electrical Manufacturers Association) diagram, phases
Signal Control Operations

• Pre-timed or fixed-time
  – Cycle length, phase sequences, green times, offsets are all pre-determined and fixed for a period of time (such as morning peak)
  – Generally needs no sensors
  – Mostly found on downtown streets, or streets with fixed traffic demand patterns.

• Semi-actuated
  – Sensors are installed on minor street to detect vehicle presence. Green rest on main street until a vehicle call from minor street
  – Responsive to traffic demand changes
  – Usually found on major/minor street intersections
  – Cycle length and phase sequences are variable

• Fully-actuated
  – Sensors are installed on all approaches
  – Responsive to changes in traffic demand
  – Cycle length and phase sequences are variable
The Italian Job

http://www.youtube.com/watch?v=hvj9vhA8ixY
Controllers (solid-state)

Econolite 2070

Eagle 2070

Inside a controller cabinet
Actuated signals

• A signal that is actuated by the arrival of individual vehicles on one or more approaches. The phases and green times vary from cycle to cycle. Cycle length can also change in response to traffic
Signal coordination

FOR GOOD PROGRESSION AND LESS DELAY

Coordination for NB Traffic

$t_{offset} = \text{block length} / \text{progression speed}

= L / S$
## Level of Service

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>Control Delay per Vehicle (sec/veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤ 10</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 10-20</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 20-35</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 35-55</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 55-80</td>
</tr>
<tr>
<td>F</td>
<td>&gt; 80</td>
</tr>
</tbody>
</table>

CASE STUDY: FIX I-5 Project
CHANGES IN FREEWAY FLOW PATTERNS
Volume Changes
Detour Routes

Hourly Traffic Flow on US50 EB–Capitol Ave. (313780)

- Before
- NB Closure
- SB Closure
- open
- After

Time of Day

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Hourly Traffic Flow

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23

31
Unaffected Routes

Hourly Traffic Flow on SR99 NB – 12th Ave (312562)

Before

Traffic Flow

Time of Day

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23