

CE454 Urban Transportation Systems

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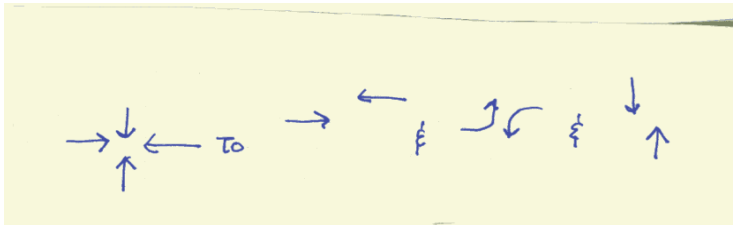


Announcements

- The Asphalt Pavement Association of Oregon (APAO) scholarships to Civil and Construction engineering students at Oregon Universities with a demonstrated interest in transportation engineering and/or heavy highway construction. More details on the program and applications can be viewed on line at the following link; <http://www.apao.org/scholaroverview.shtml> The deadline for applications is November 3rd, 2006.
- ASCE Welcome Back BBQ Noon 10/11 Outside EB
- STEP Group 1st Meeting 4:30 PM 10/11 Room 350
- Proposals Due 10/12, Sandeep TA to collect
- Dr Monsere out 10/12, Bill Kloos COP Guest Lecture

Why build a traffic signal?

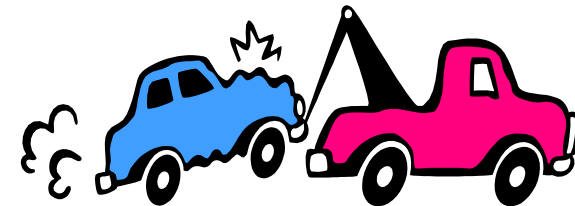
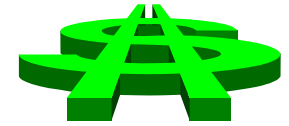
- Reduce frequency of certain crash types, especially right-angle
- Effect orderly traffic movement

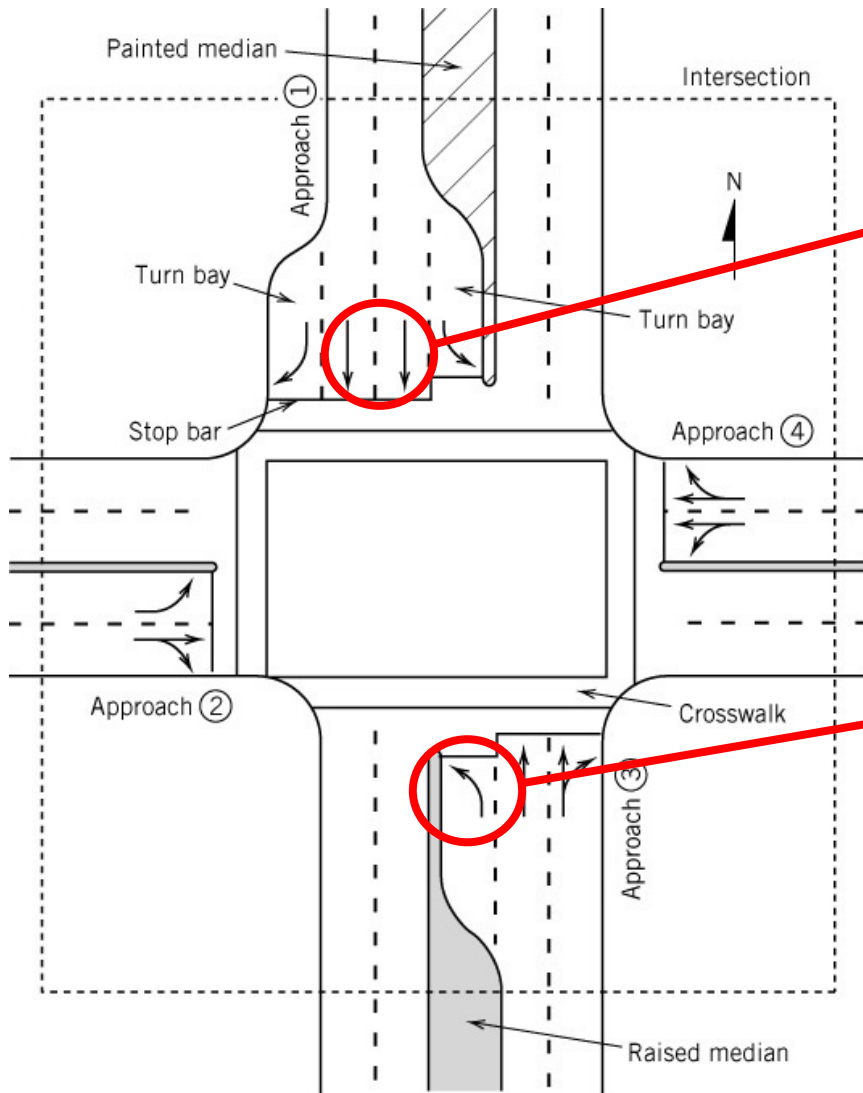


- Provide for continuous flow - work with system
- Allow vehicles, peds and bikes to cross traffic stream

Drawbacks

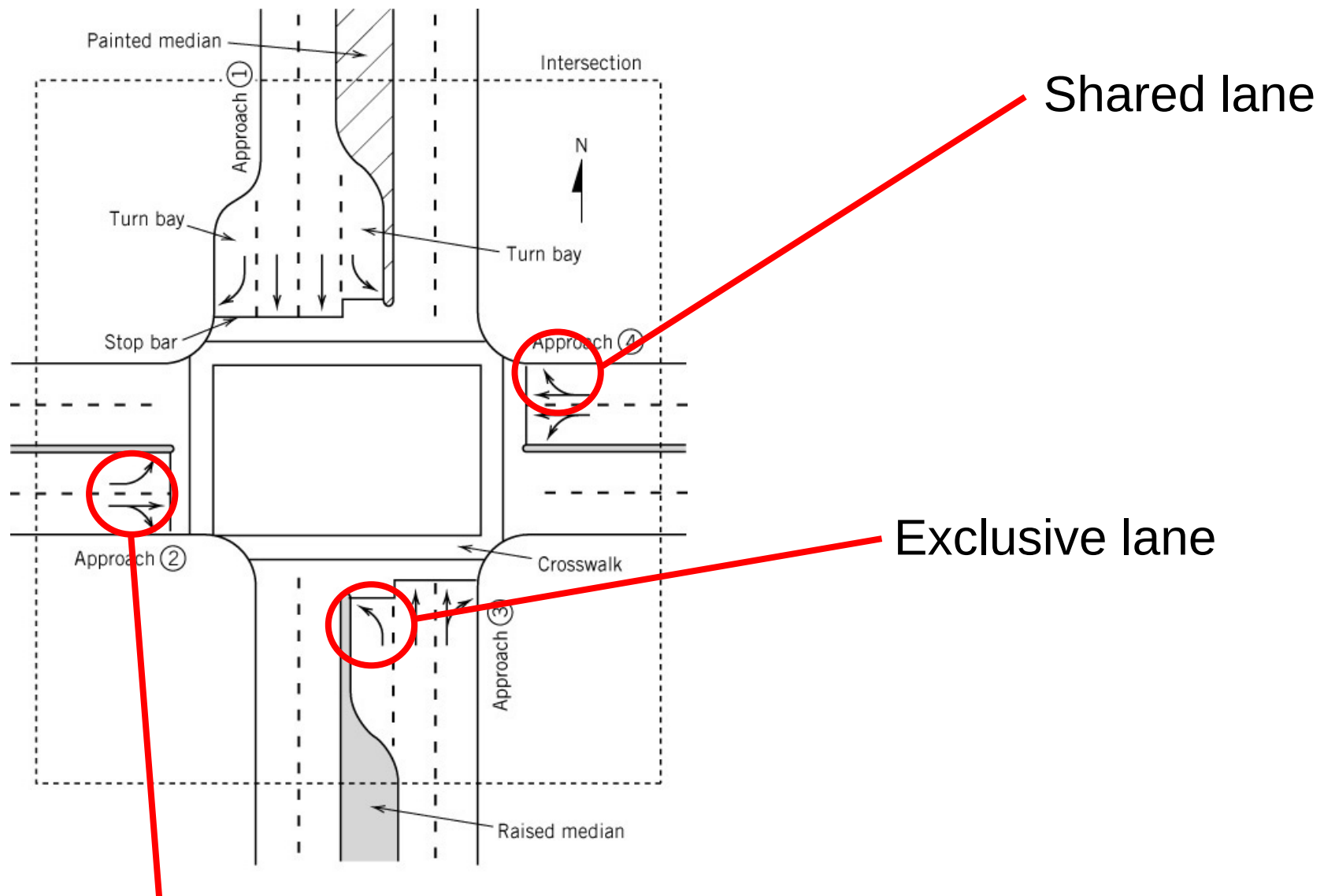
- Expensive- \$120,000+ for equipment
- Ongoing maintenance - \$4,000 per year
- Someone still has to stop
- Increase of certain crash types
- People may disregard





Thru movement

Left-turn movement

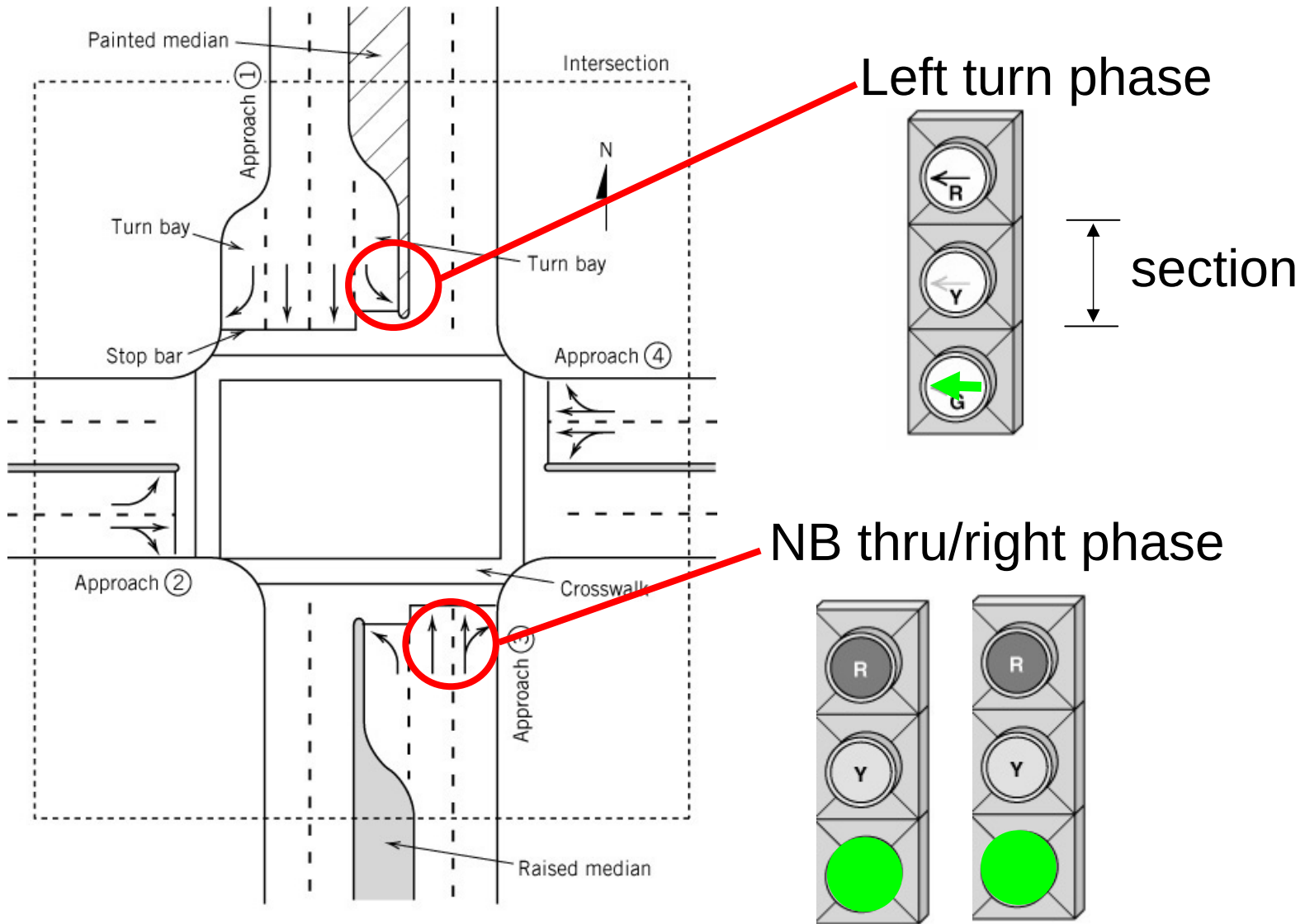


Eastbound approach (traffic traveling east)

Terminology

- Indication
- Interval
 - “Yellow interval” shown in image





Left-turn Phasing

- Permitted Left Turn
 - Turning vehicles must yield the right-of-way to opposing traffic flows. Left-turns must wait for gaps
 - Can also apply to right turns



Left-turn Phasing

- Protected Left Turn
 - Exclusive movement for that phase
 - Can be before thru “leading” or after thru “lagging”

3 Section Arrow Head



Left-turn Phasing

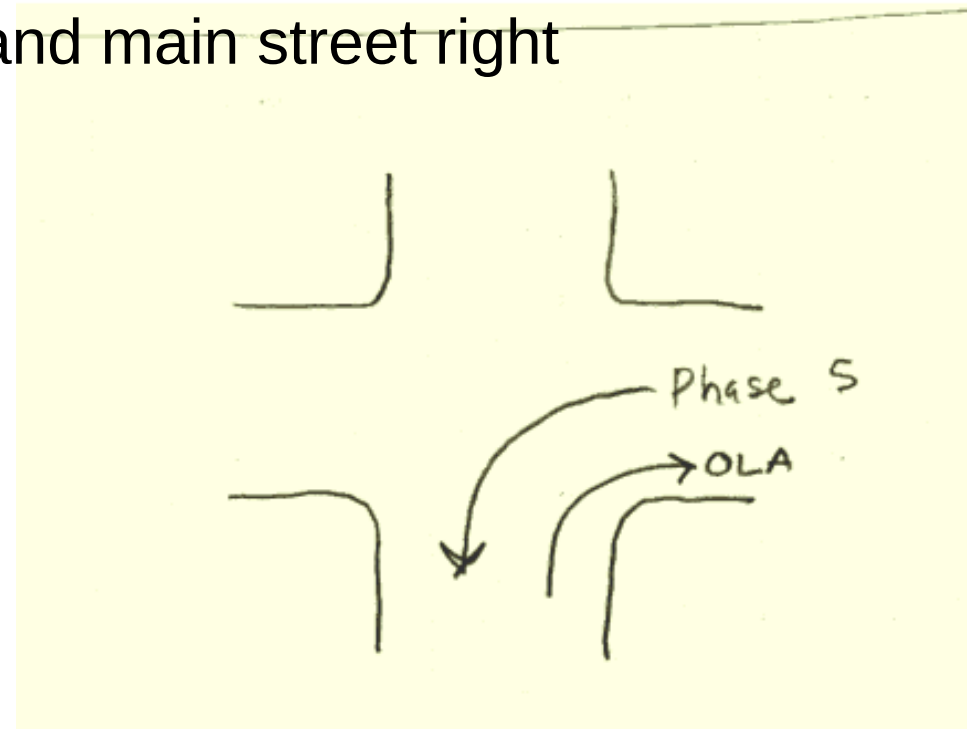
- Protected/Permitted Left Turn
 - Has protected movement, then permissive



5 Section Head

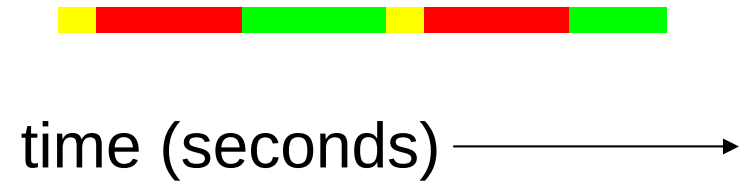
Phase Overlaps

- What is an Overlap?
 - Operation of phases that are on conflicting legs of intersection
 - Often a side street left and main street right
- Why use Overlaps
 - More capacity
 - Better intx utilization



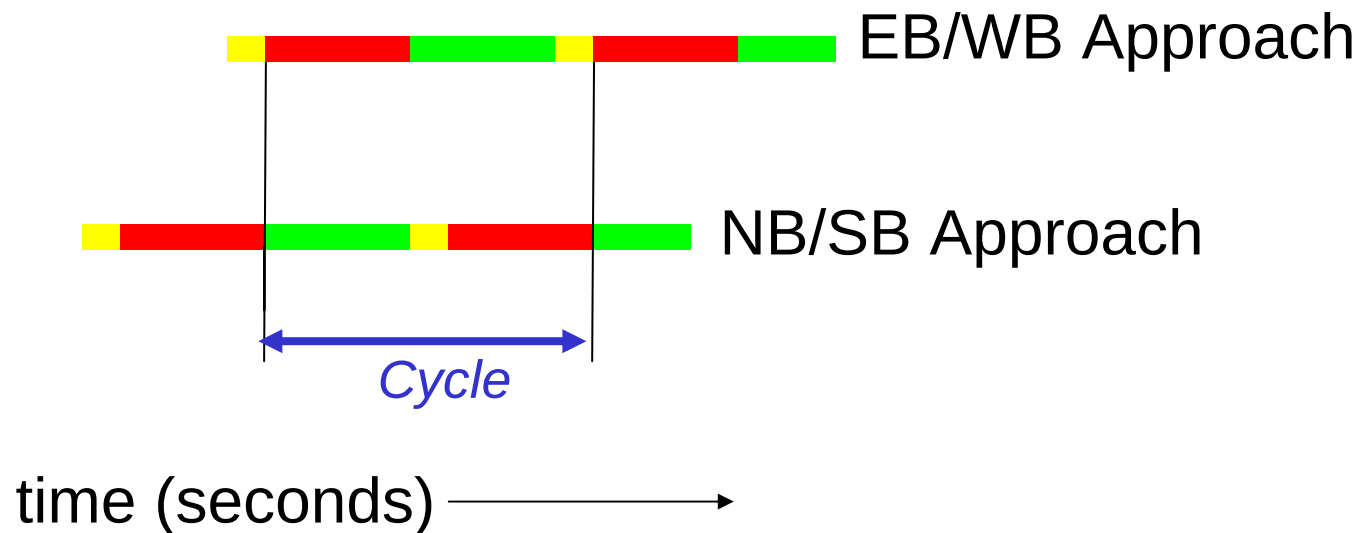
Times (Intervals)

- Green interval
- Clearance interval
 - Yellow (amber) time
 - All-red time
- Red interval



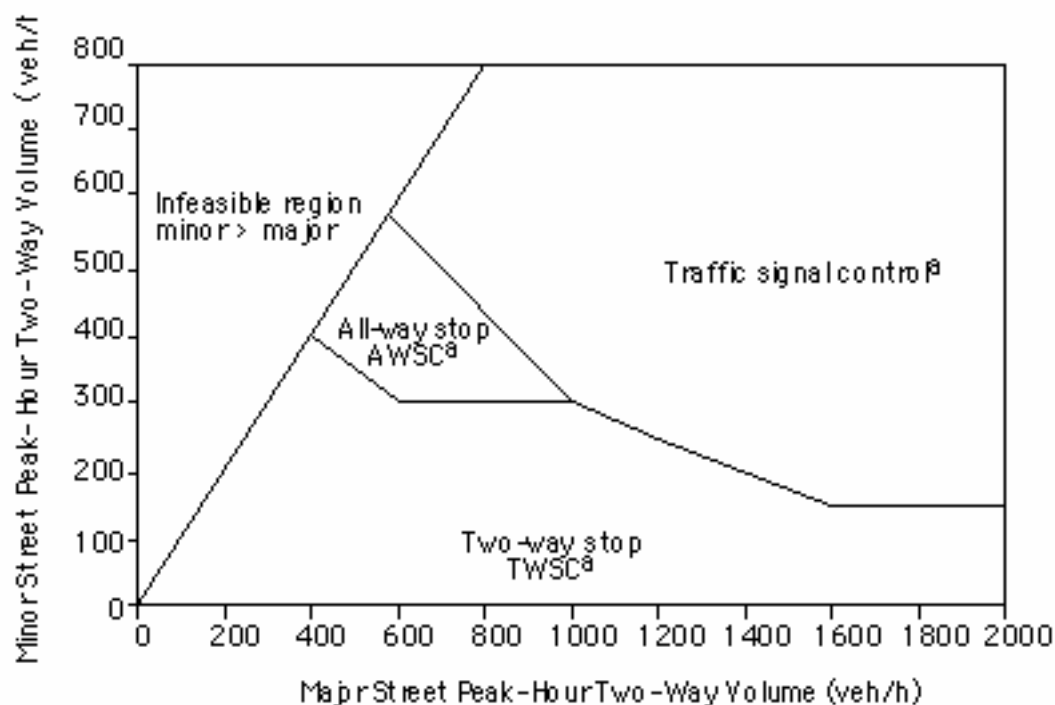
Terminology

- Cycle
 - measured from a consistent point, time needed for one complete sequence of indications for all approaches



When to choose types of intersection control

EXHIBIT 10-15. INTERSECTION CONTROL TYPE AND PEAK-HOUR VOLUMES
(SEE FOOTNOTE FOR ASSUMED VALUES)



Notes

a. Roundabouts may be appropriate within portion of these ranges.

Source: Adapted from *Traffic Control Devices Handbook* (8, pp. 4-18) - peak-direction, 8-h warrants converted to two-way peak-hour volumes assuming ADT equals twice the 8-h volume and peak hour is 10 percent of daily. Two-way volumes assumed to be 150 percent of peak-direction volume.

Warrants – Do we need?

- There are 8 Traffic Signal Warrants in the 2003 Manual of Uniform Traffic Control Devices
 - 1. Eight-hour vehicle volume
 - 2. Four hour vehicle volume
 - 3. Peak hour
 - 4. Pedestrian volume
 - 5. School crossing
 - 6. Coordinated signal system
 - 7. Crash experience
 - 8. Roadway network

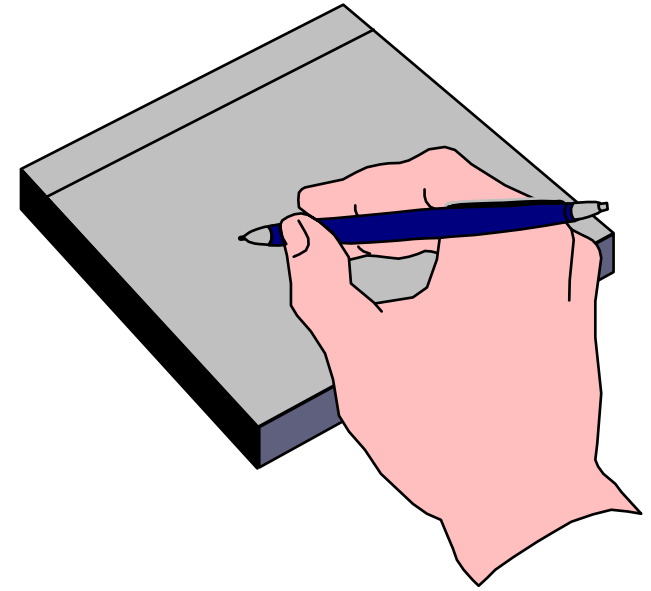
Warrants 1, 2 & 3 most commonly examined

Traffic Signal Design Elements - Operations

- Level-of-service (LOS) analysis (delay)
- Number of lanes (delay + safety)
- Traffic signal phasing (delay + safety)
- Level of protection for left-turns (delay + safety)
- Overlaps (delay)
- Pedestrians and bikes (safety)

Traffic Signal Design Elements - Physical

- Signal controller
- Signal poles & foundations
- Signal heads
- Pedestrian signals
- Illumination
- Wiring & vehicle detection



Signal Poles

- Three types
 - Pedestal pole
 - Mast arm poles
 - Span wire poles
- Considerations
 - Signal visibility
 - Maintenance
 - Location for poles
 - Area (Downtown/Other)

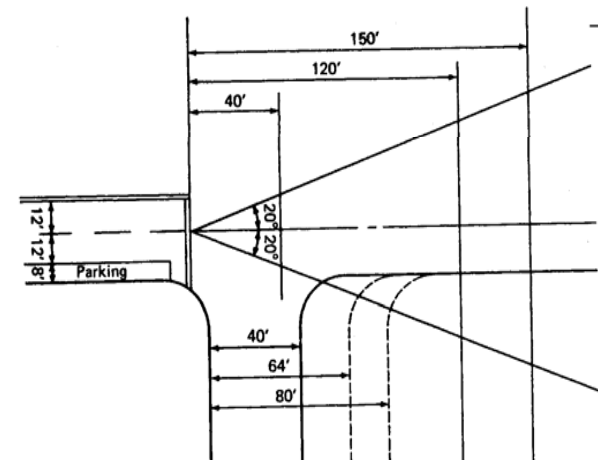


Signal Visibility

- Head visibility distance
 - Approaching vehicle
 - Two heads visible
- Cone of vision
 - At stop bar
 - Minimum one head visible

TABLE 5-1
Minimum Visibility Distances

85-Percentile Speed, mph	Minimum Visibility Distance, Feet	Desirable Distance Feet
20	175	265
25	215	325
30	270	405
35	325	480
40	390	570
45	460	660
50	540	760
55	625	870
60	715'	980



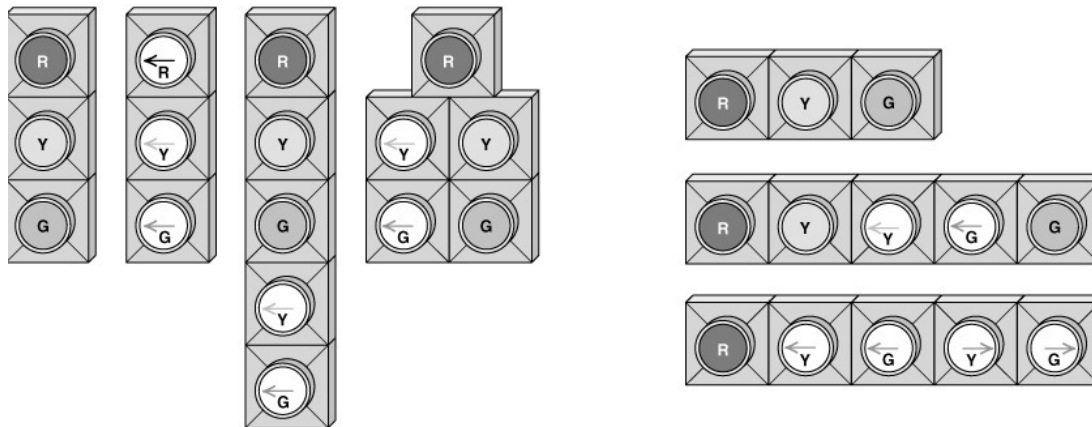
Pole Foundations

- There is a lot of weight blowing around in the wind on a mast arm!
- Foundation dimensions vary with pole design
- Steel reinforcing cage
- Big bolts!



Signal heads

- Size specified in MUTCD, standards
- Typical 12"
- LED vs Incandescent bulbs
- Configurations vary
- Clearance to bottom of signal heads = 15'
- Heads no higher than 25.6'



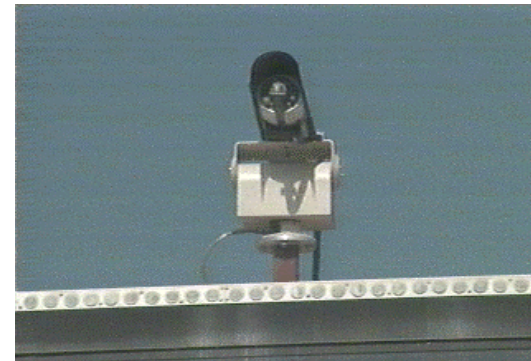
Pedestrian Signals

- Accommodate pedestrians
- Ped pushbuttons need to be accessible
- Consideration of crossing times
- ADA Ramps



Vehicle Detection

- What are we detecting?
 - Vehicles, bikes
- Inductive loops
- Video detection
- Microwave (radar)



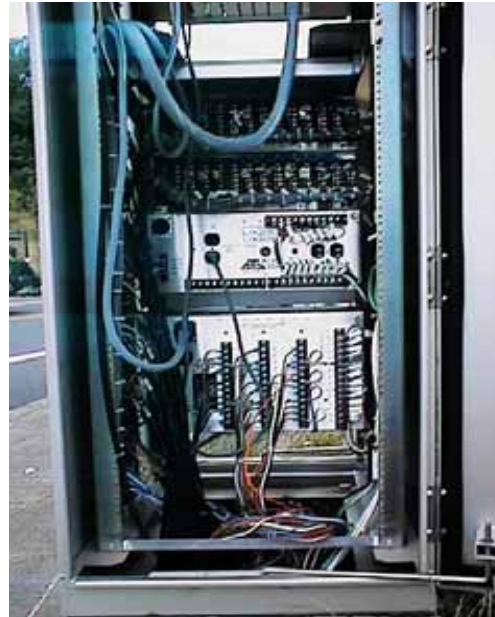
Conduits

- Separate conduits
 - Low voltage
 - High voltage
 - Communications



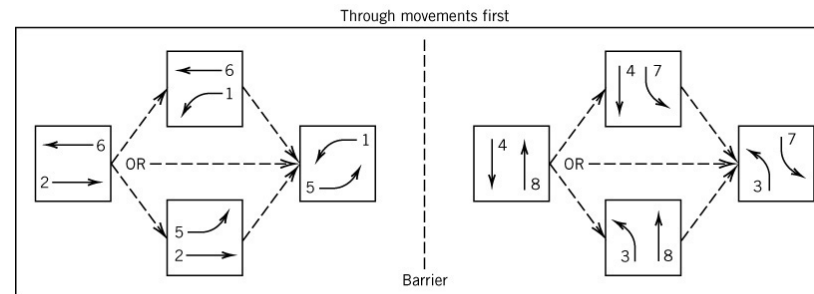
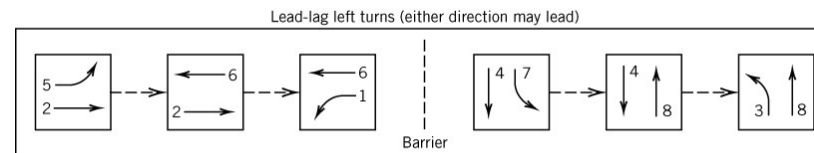
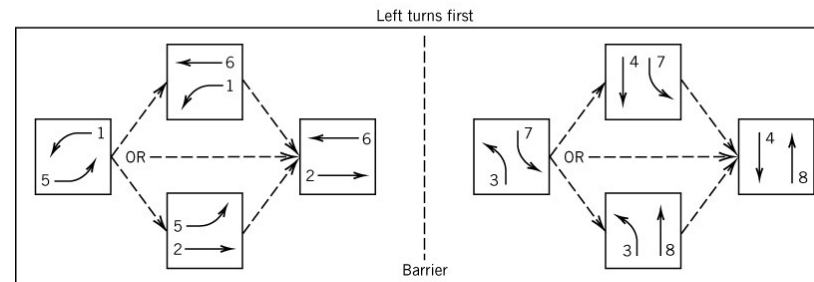
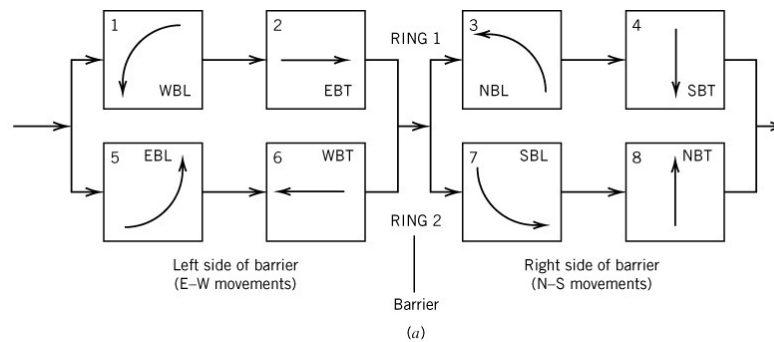
Traffic Signal Controller

- Every device needs power - signal is made up of many devices
- Result - many wires!
- Need power to run signal
- Different types of wires for different jobs



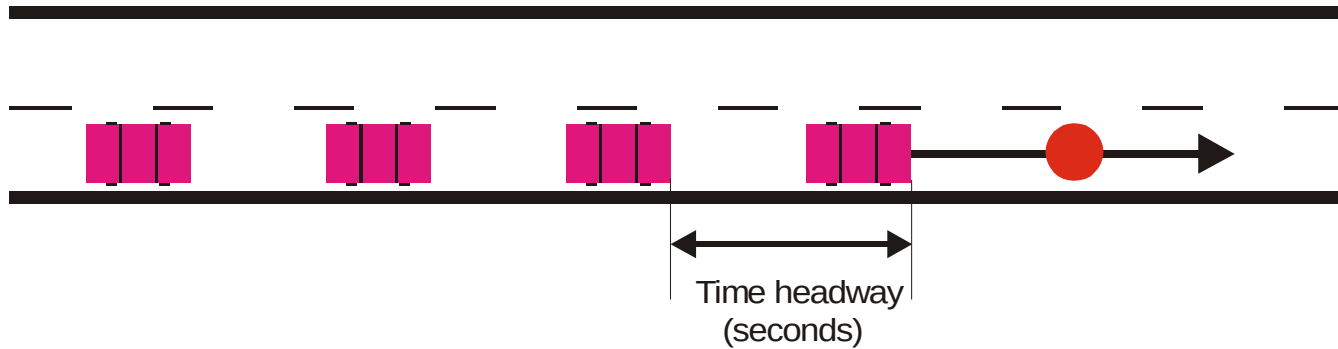
Types of Signal Controller Operation

- Pretimed
 - set plan based on volumes
 - does not change over specific time periods
 - no detection
- Semi-actuated
 - Detection on some, but not all approaches
 - Phase length and order may be modified
 - Usually with minor low volume
- Fully-actuated
 - Detection on all approaches
 - Timing plans may vary



(b)

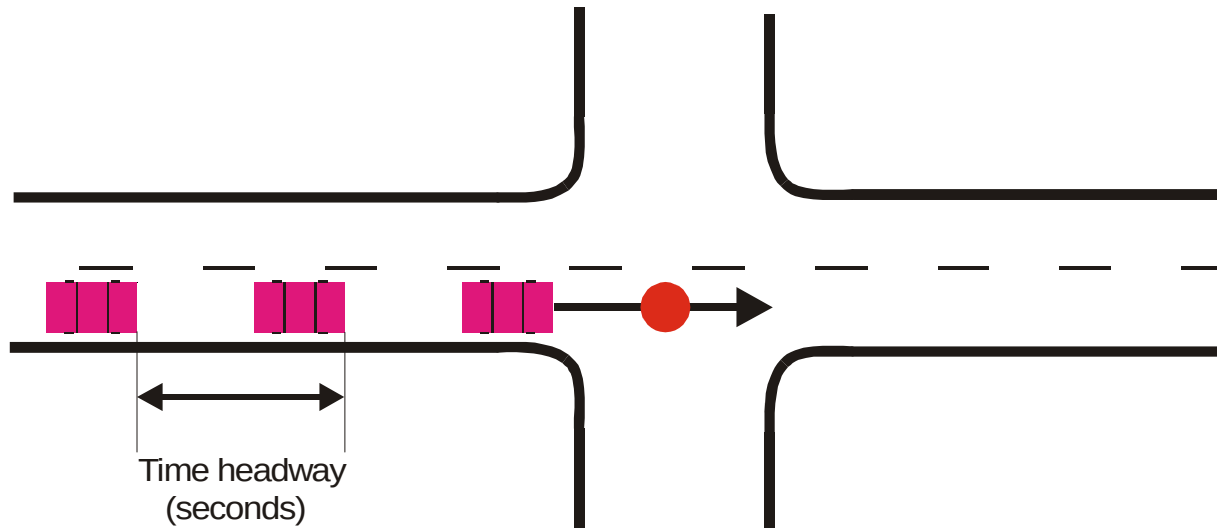
What is the capacity of the point?



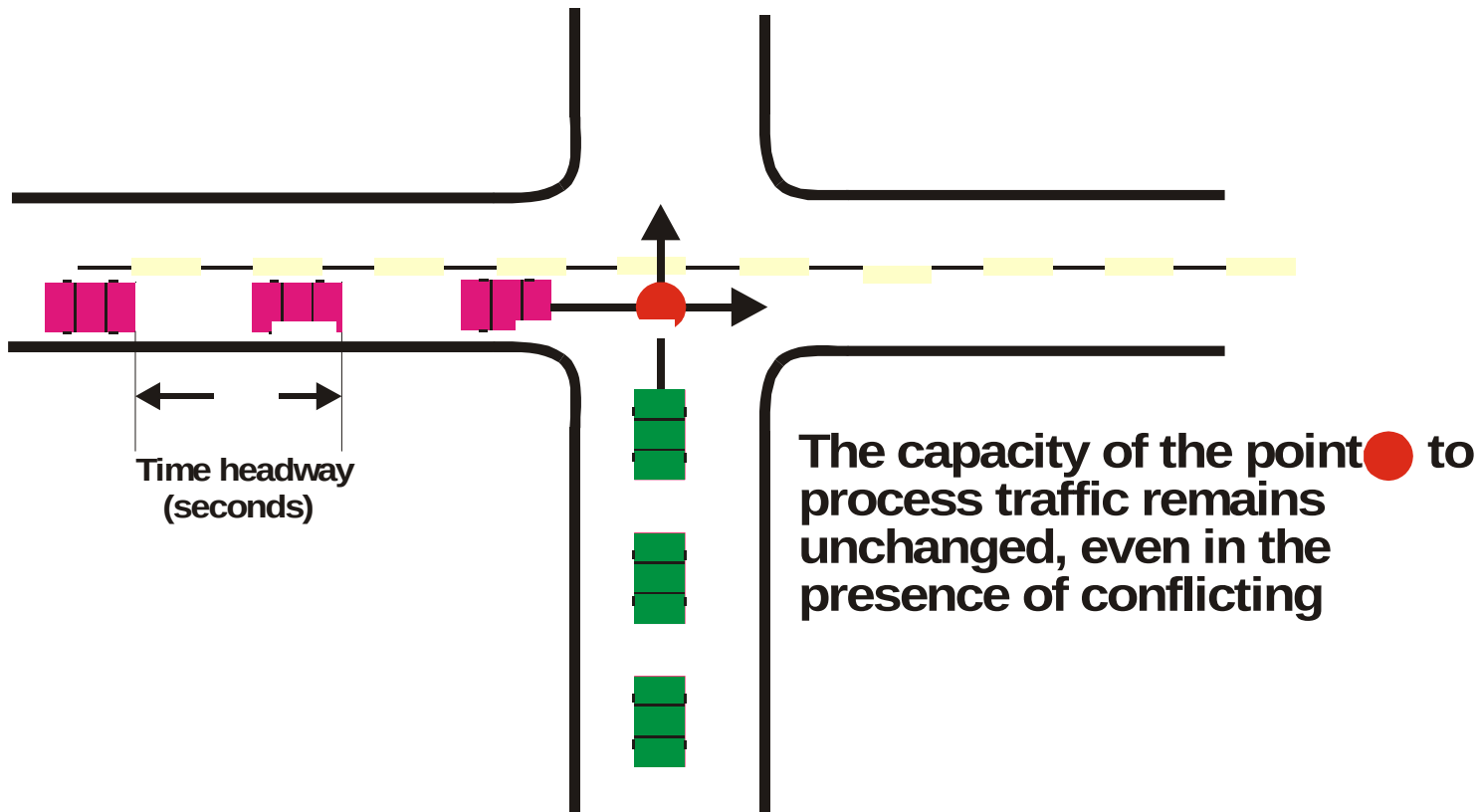
What is the capacity of the point ● ?

capacity = vehicles/per hour/per lane = $1 / \text{minimum headway}$
demand = vehicles needing to be served

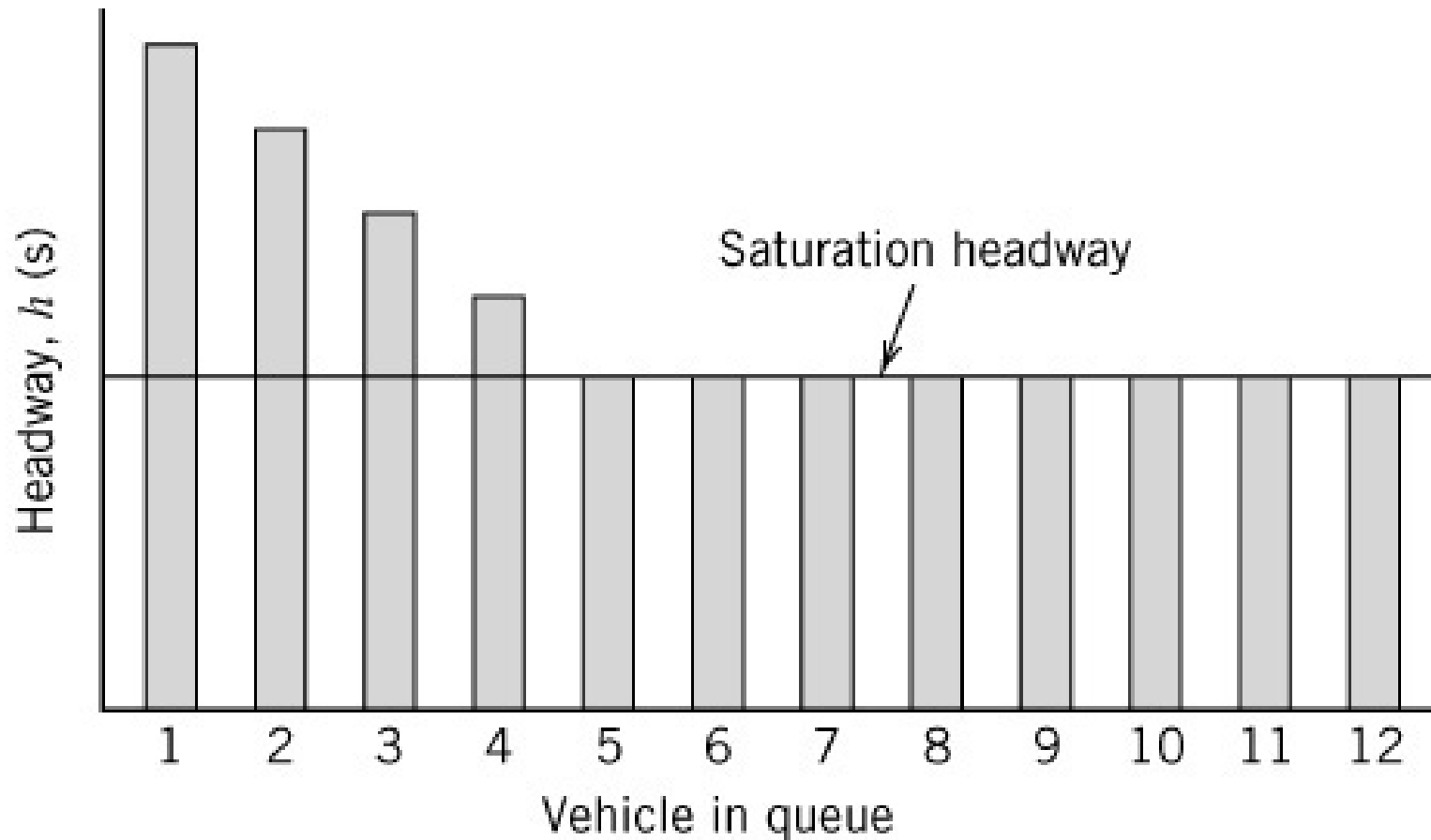
What is the capacity of the point?



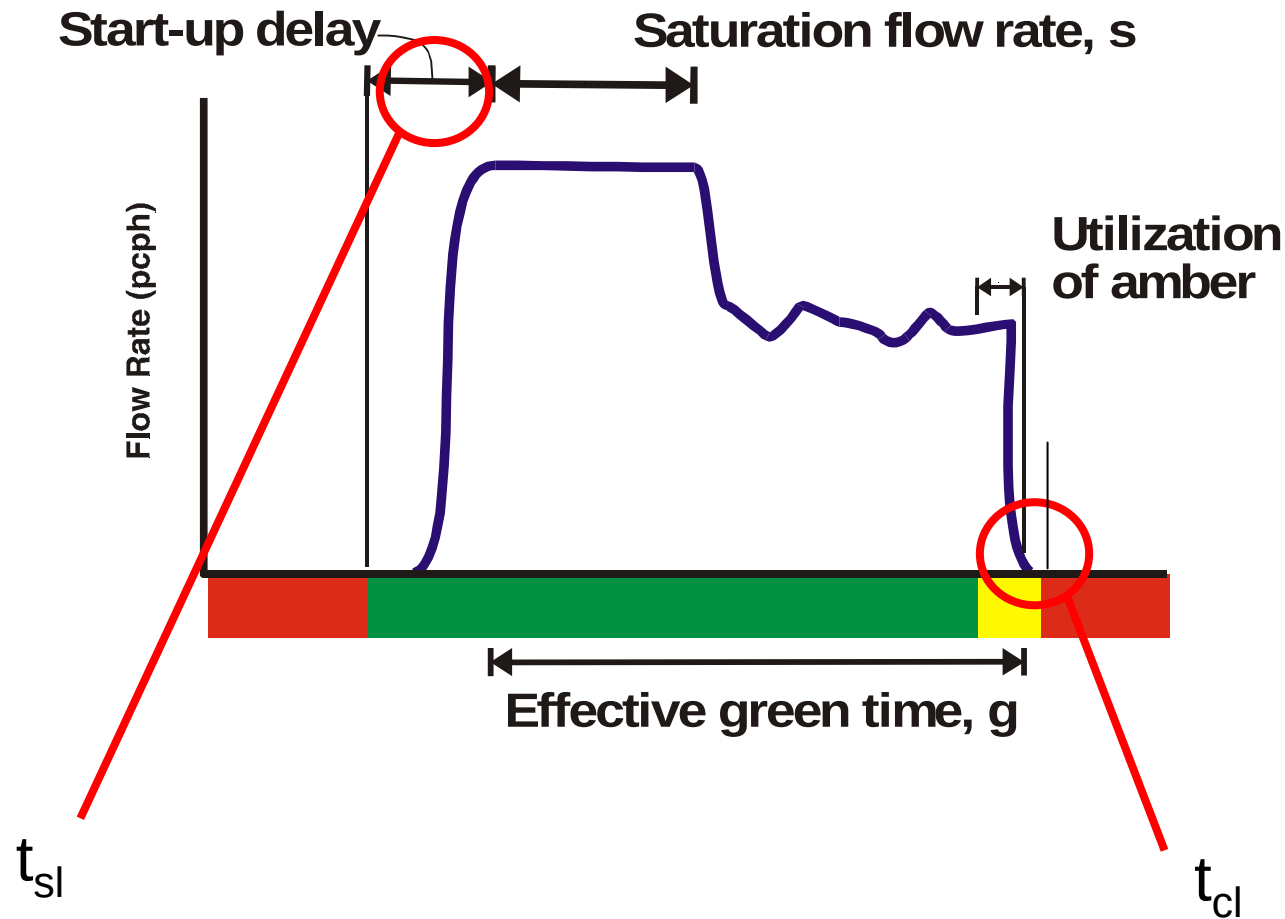
Conflicting traffic doesn't change point capacity



Saturation Flow

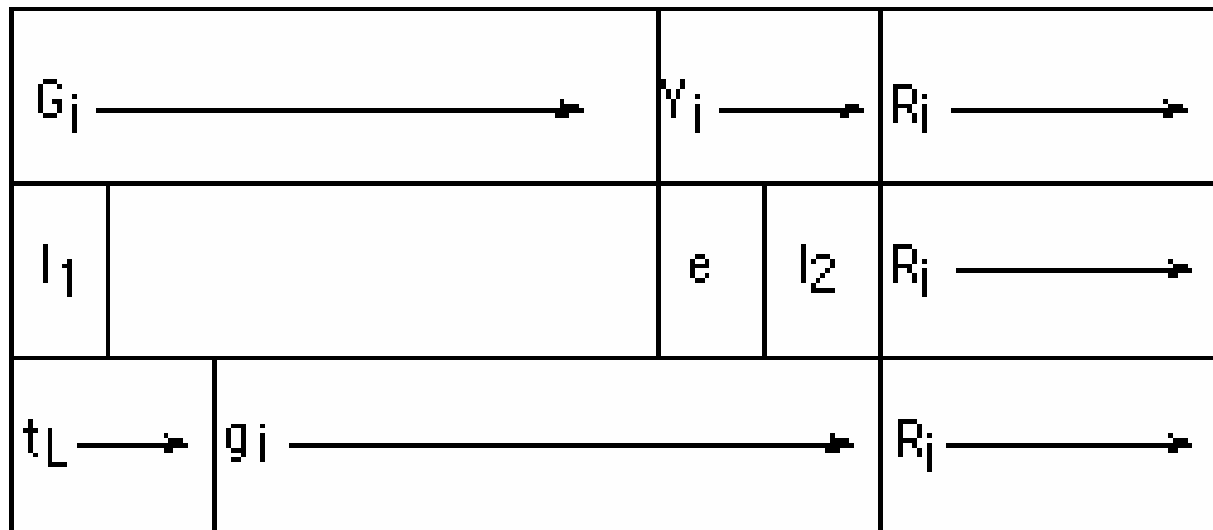


Traffic flow at a signalized intersection



Relationship between effective green and red

EXHIBIT 10-10. RELATIONSHIP AMONG ACTUAL GREEN, LOST-TIME ELEMENTS, EXTENSION OF EFFECTIVE GREEN, AND EFFECTIVE GREEN



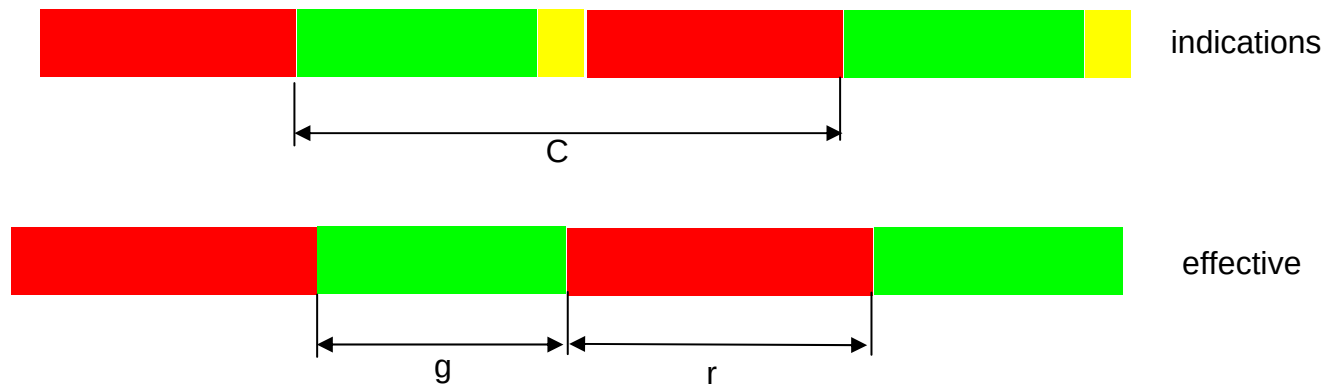
$$g = G + Y + AR - t_L \quad r = R + t_L$$

Wow! Lets watch video

- See video

Example - simple 2 phase signal

- NB/SB approach
 - $G = 35$ sec , $R = 40$ sec, $Y + AR = 4$ sec, $t_L = 2$ sec



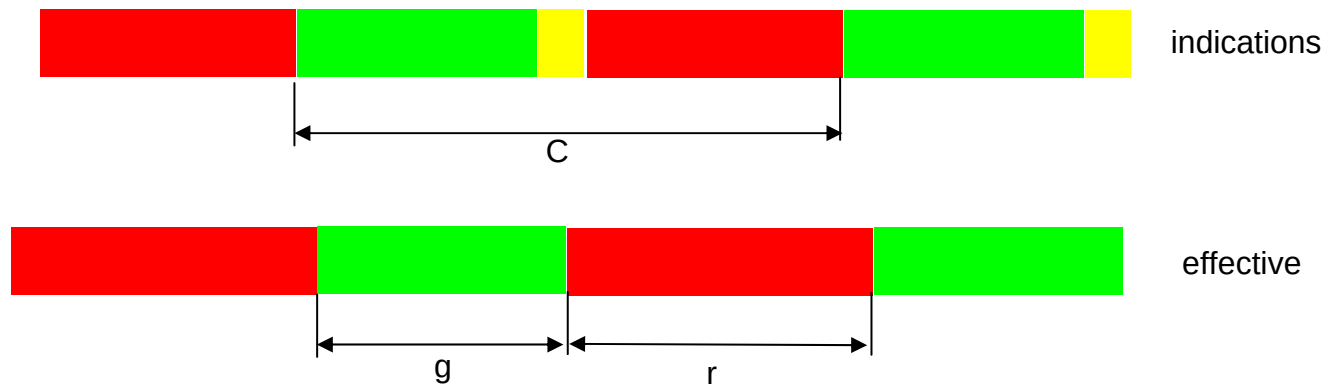
$$C = G + R + Y + AR = 35 + 40 + 4 = 79 \text{ secs}$$

$$g = G + Y + AR - t_L = 35 + 4 - 2 = 37 \text{ secs}$$

$$r = C - g = 79 - 37 = 42 \text{ secs}$$

Example - simple 2 phase signal

- EB/WB approach
 - $G = 40$ sec , $R = 35$ sec, $Y + AR = 4$ sec, $t_L = 2$ sec



$$C = G + R + Y + AR = 40 + 35 + 4 = 79 \text{ secs}$$

$$g = G + Y + AR - t_L = 40 + 4 - 2 = 42 \text{ secs}$$

$$r = C - g = 79 - 42 = 37 \text{ secs}$$

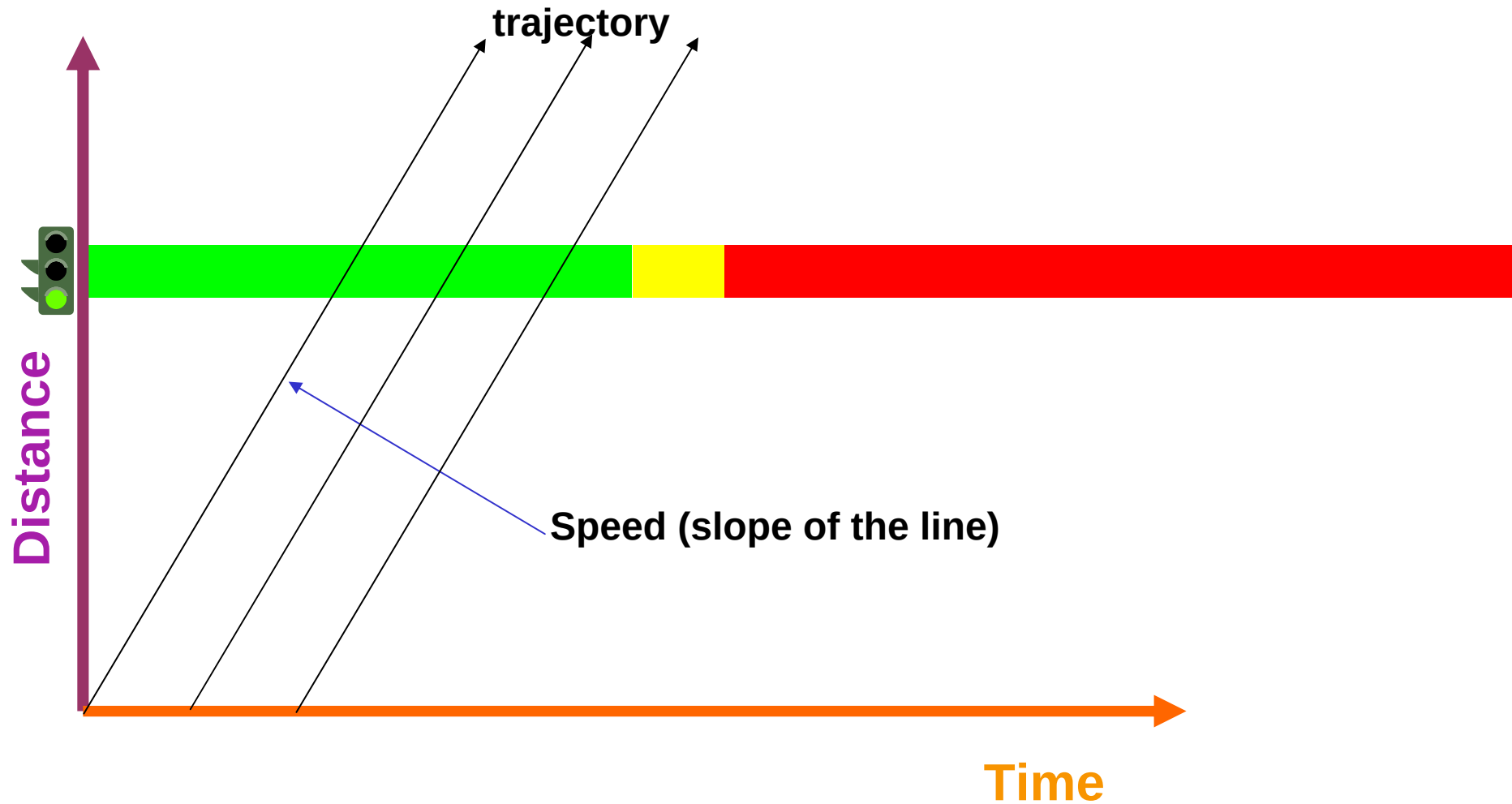
Lost time

- Note that lost time accumulates per phase or every time we stop/start traffic
- How much does this accumulate?
 - $(3600 \text{ sec / hr}) / (79 \text{ sec / cycle}) = 46 \text{ cycles / hr}$
 - $4 \text{ secs / cycle lost time} = 184 \text{ secs tl / hr}$
 - Assume 4 peak hours, $= (184 * 4) / 60 = 12 \text{ mins lost}$

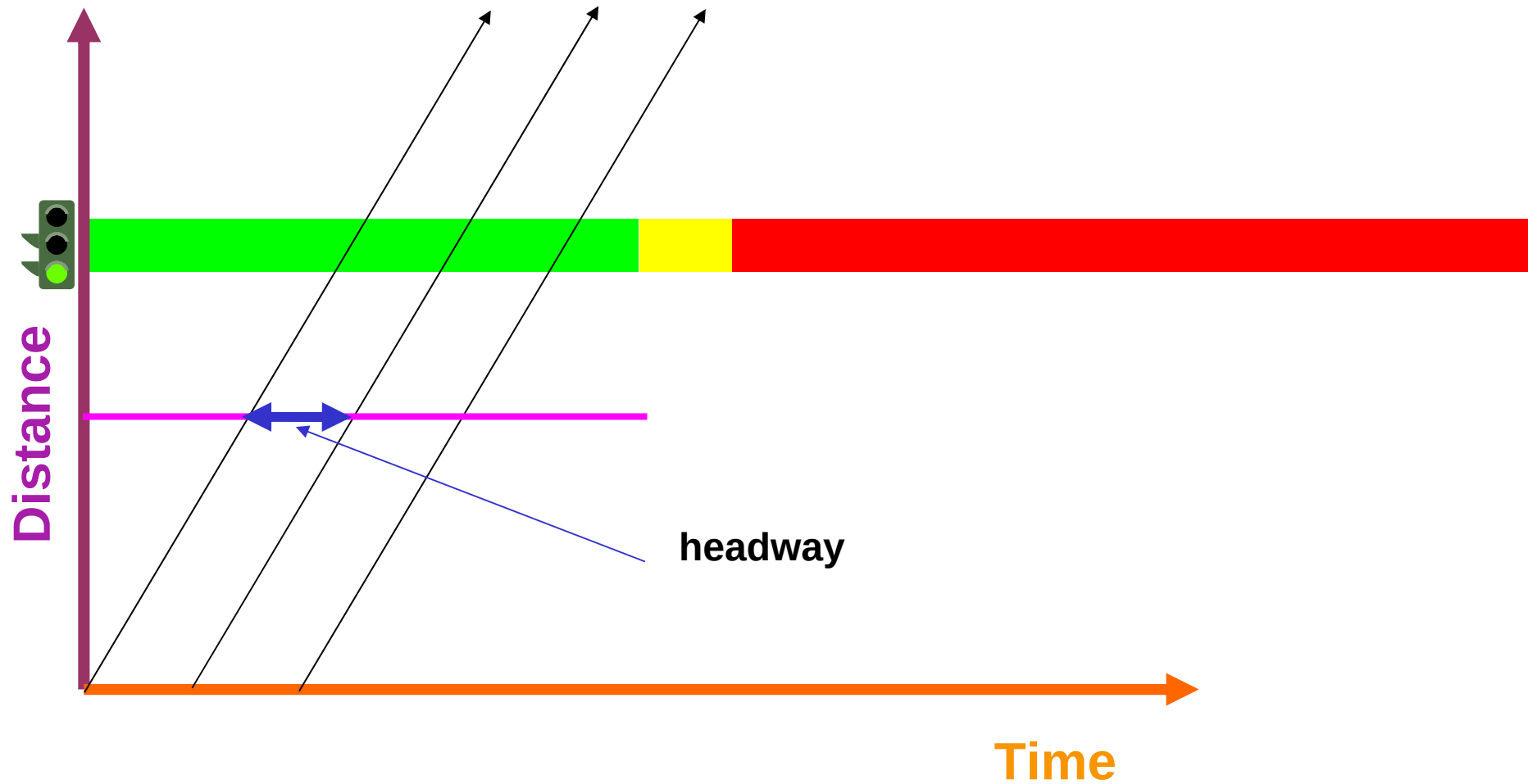
Capacity means “max”

- estimated per approach since each approach only gets so much green time
- capacity = saturation flow * (g / C)
 - in words, the maximum hourly volume that can be accommodated under prevailing traffic conditions
- Note that the saturation flow rate is in passenger cars per lane per hour of green (pcplphg) and is not always observed (remember video)

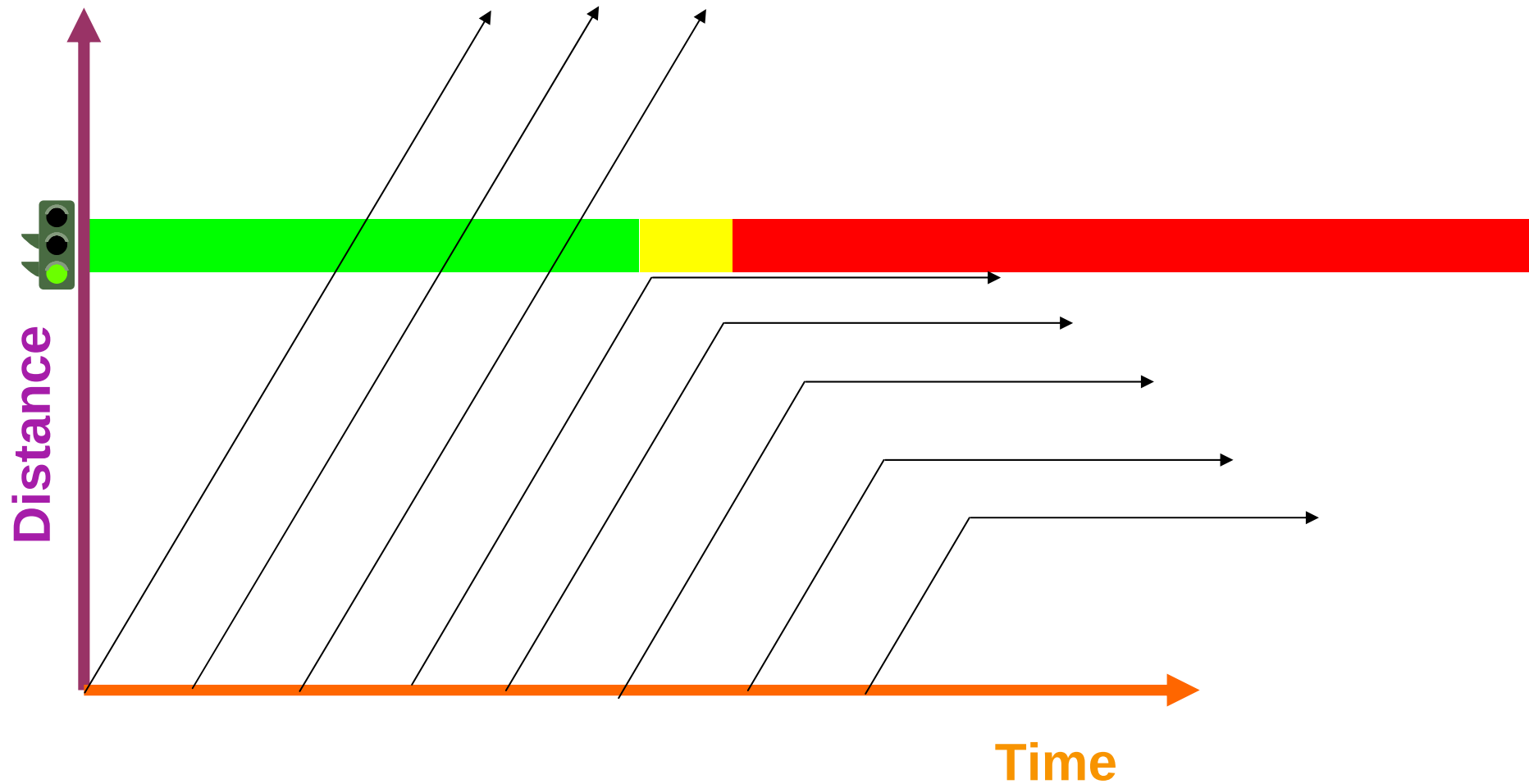
Time-Space Diagram Concepts

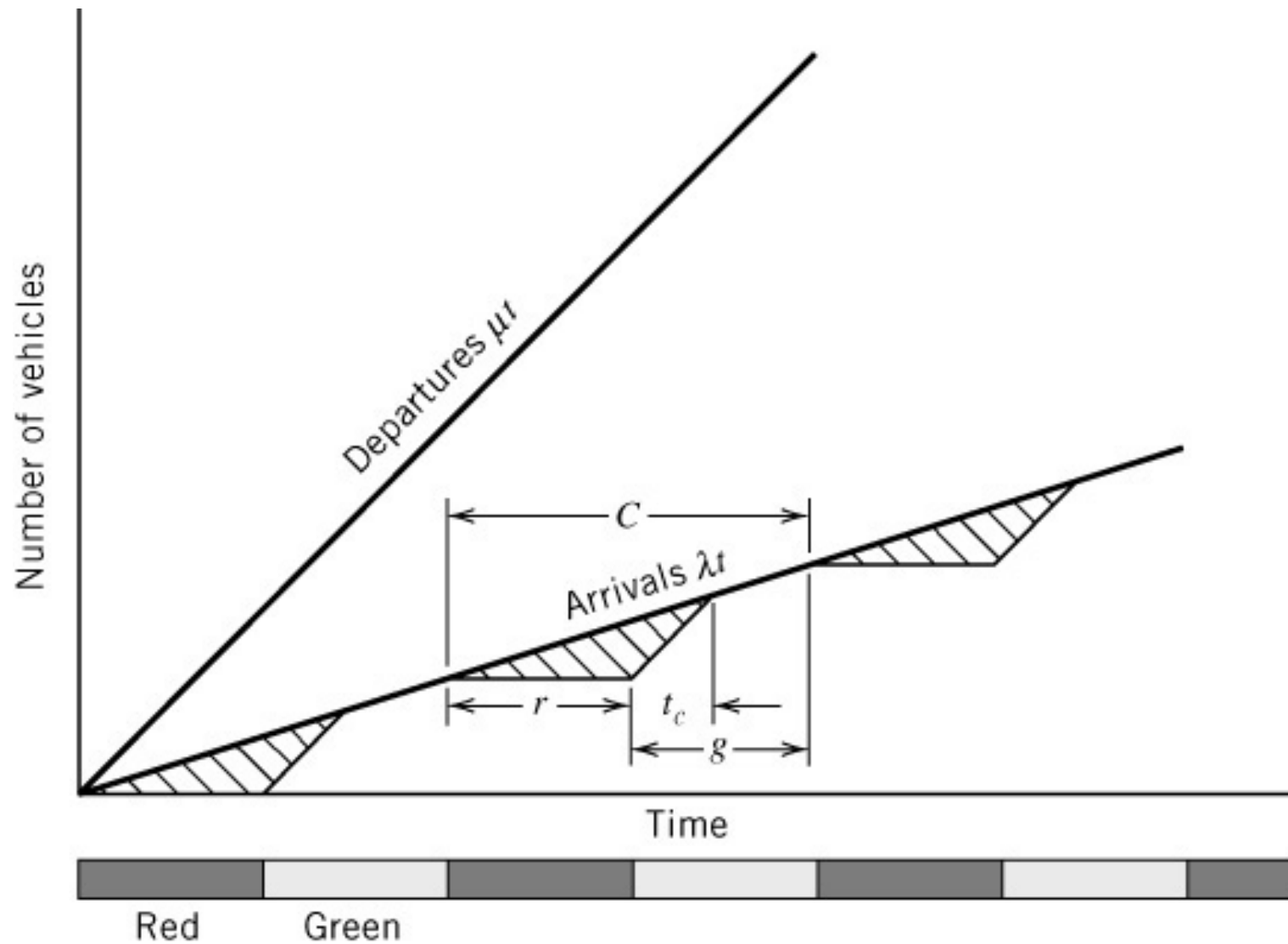


Time-Space Diagram Concepts



Time-Space Diagram Concepts





queue does
not clear,
vertical height
is the # of
vehicles left
in the queue

