Section 2

Basic Understanding of Traffic Control at Intersections

A. Signs

1

Intersections…

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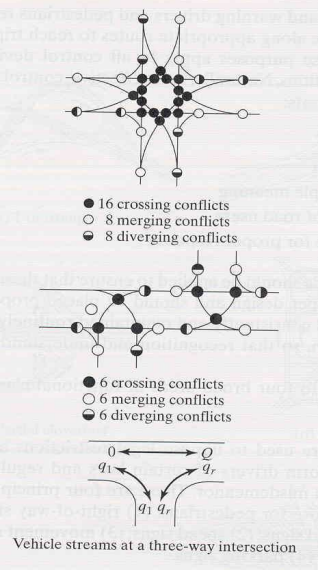
- Reduce ***conflicts*** between road users
- Improve efficiency and safety
- Consider
  - Human factors
  - Traffic
  - Geometrics
  - Economics



Vehicle streams at a three-way intersection

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Requirements

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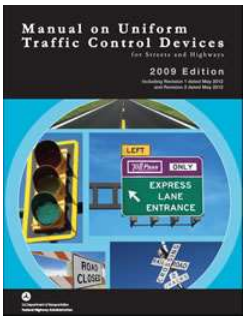
- To be effective, a traffic control device should meet five basic requirements:
  - Fulfill a need;
  - Command attention;
  - Convey a clear, simple meaning;
  - Command respect from road users;
  - Give adequate time for proper response.

- *National Standard*
- *Legal Document*



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Signs

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- Traffic signs convey information through their shape, color, message, and placement.
- Standard sign shapes:
  - Octagon -- Exclusively for STOP signs
  - Equilateral Triangle, Point Down -- Exclusively for YIELD signs
  - Circle -- Exclusively for Railroad Advance Warning and Civil Defense Evacuation Route marker
  - Pennant -- Exclusively for NO PASSING ZONE signs

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Signs

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- Standard Sign Shapes
  - Diamond -- Used for warning signs
  - Rectangle, Longer Dimension Vertical -- Used for regulatory signs
  - Rectangle, Longer Dimension Horizontal -- Used for guide signs

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Signs

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- Other Traffic Signs
  - Trapezoid -- Used for recreational area guide signs
  - Pentagon -- Used for school advance warning signs
  - Crossbuck -- Used for railroad crossing signs
  - Other shapes -- Used for route marker signs

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Sign Colors

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- Red

- Black

- White

- Orange

- Yellow

- Brown

- Green

- Blue

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Sign Colors

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- **Fluorescent Yellow-Green** -- Now approved for pedestrian, bicycle, and school crossing warning signs
- **Fluorescent Pink** – Incident Management Signs
- **Purple** -- Reserved for future use
- **Light Blue** -- Reserved for future use
- **Coral** -- Reserved for future use

Figure 6I-1. Examples of Traffic Incident Management Area Signs

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Section 2

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Basic Principles of Traffic Control

B. Markings

- See PART III of the MUTCD
  - Pavement lines and symbols
  - Object Markers
  - Delineators

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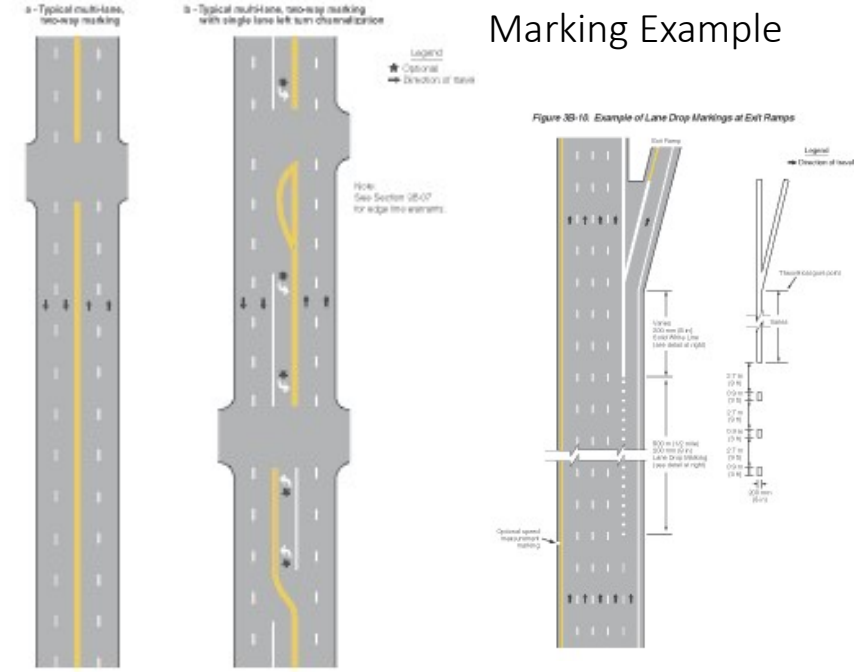
Marking Example



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Other Types?

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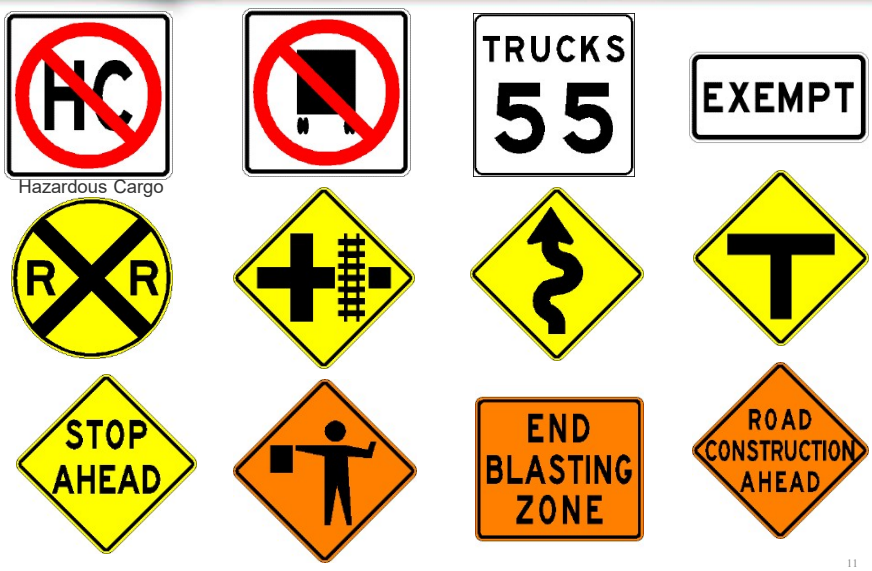

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Section 2

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Basic Understanding of Traffic Control at Intersections

C. Signalization

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Traffic Signals

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- **The MUTCD defines nine types of traffic signals**
  - Traffic control signals
  - Pedestrian signals
  - Emergency vehicle traffic signals
  - Traffic contrail signals for one-lane, two-way facilities
  - Traffic control signals for freeway entrance facilities (ramp metering)
  - Traffic control signals for movable bridges
  - Lane-use control signals
  - Flashing beacons
  - In-roadway light

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Traffic Signals

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- **How do we decide if needed ?**
  - ✓ Traffic Engineering Studies
  - ✓ Warrants
- **Traffic signals advantages**
  - ✓ Provide for the orderly movement of traffic
  - ✓ Increase capacity
  - ✓ Improve safety (reduce certain crash types)
  - ✓ Coordinate traffic flow for continuous movement
  - ✓ Introduce gaps

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Traffic Signals

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- **However, traffic signals are not the solution to all urban intersection problems!!**
- **Traffic signals disadvantages**
  - Add delay
  - Encourage disobedience
  - Send volume to other routes
  - Increase certain types of crashes
  - Safety

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Terminology and Definitions

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- Cycle: One complete sequence of signal indications (C).
- Cycle length: Time (sec) to complete one full cycle.
- Phase: Part of a cycle allocated to any combination of traffic movements receiving the right of way (R/W) simultaneously during one or more intervals.
- Interval: a period of time during which none of the signal indications change.
- Green Time/Interval: Green indication time.
- Change Interval: The yellow indication for a given movement
- Clearance Interval: The “all-red” indication for a given movement.
- Lost Time: Time during which the intersection is not effectively used by any movement; Start-up (l_1), Clearance (l_2).

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Capacity of a Signalized Approach

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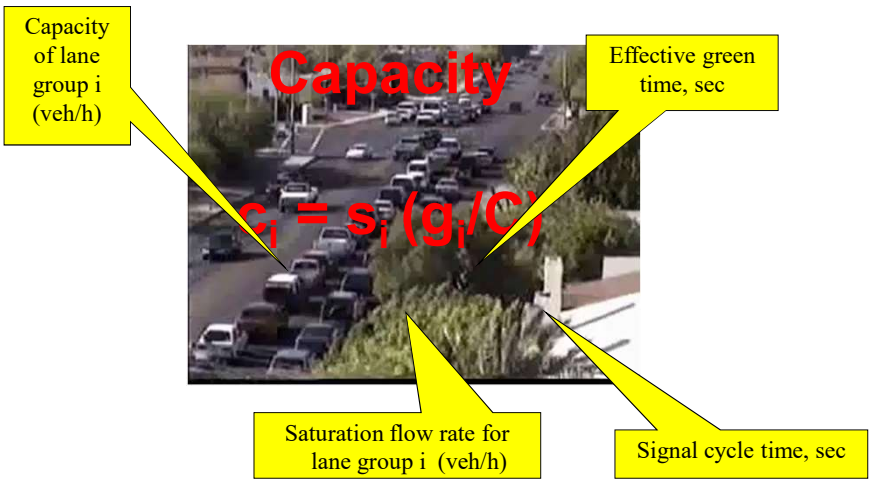

g_i/C = "green ratio" = actual time available

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Saturation Flow Rate & Lost Time

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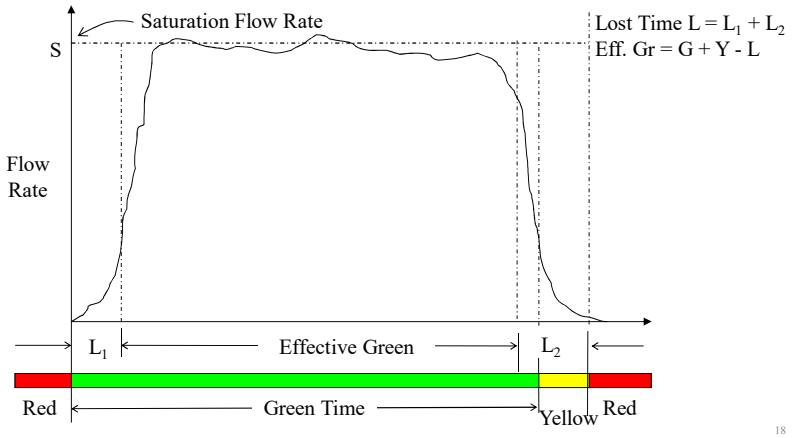
The maximum number of vehicles from a lane group that would pass through the intersection in one hour under the prevailing traffic and roadway conditions if the lane group was given a continuous green signal for that hour.



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Saturation Flow Rate Defined in Highway Capacity Manual

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Ideal saturation flow:
2000veh/h/ln for metropolitan areas; otherwise 1900 veh/h/ln

$$s = s_0 N f_w f_{HV} f_g f_p f_a f_{bb} f_{Lu} f_{RT} f_{LT} f_{Lpb} f_{Rpb}$$

# of lanes; lane width; heavy vehicles; approach grade; parking lane; area type; bus blocking; lane utilization; right turn; left turn; ped for left turn; ped for right turn

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Capacity of a Signalized Approach

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- **Example:** Given a signalized intersection:
  Saturation headway for EB approach (two lanes), h = 2.2 sec; Cycle length, C = 80 sec; Green time for EB approach, G_i = 37 sec; Start-up lost time, l_1 = 2 sec; Clearance lost time l_2 = 1 sec; Yellow time = 3.5 sec.
  Capacity of EB approach = ?
- **Solution:**
  Saturation flow rate of EB, s_i = 3600/h = 3600/2.2 = 1636 veh/hr/ln
  Total lost time/phase $t_{Li} = l_1 + l_2$ = 2.0 + 1.0 = 3 sec
  Effective green time $g_i = G_i + Y_i - t_{Li}$ = 37.0 + 3.5 – 3.0 = 37.5 sec
  Capacity of EB approach, c_i (veh/hr/ln)

  veh/ln/hr

  For the two-lane approach: c = 767*2 = 1534 veh/hr

$$c_i = s_i \frac{g_i}{C} = 1636 \frac{37.5}{80} = 767$$

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Saturation Flow Rate

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Table 20.2: Saturation Flow Rates from a Nationwide Survey

Item	Single-Lane Approaches	Two-Lane Approaches
Number of Approaches	14	26
Number of 15-Minute Periods	101	156
Saturation Flow Rates		
Average	1,280 veh/hg/ln	1,337 veh/hg/ln
Minimum	636 veh/hg/ln	748 veh/hg/ln
Maximum	1,705 veh/hg/ln	1,969 veh/hg/ln
Saturation Headways		
Average	2.81 s/veh	2.69 s/veh
Minimum	2.11 s/veh	1.83 s/veh
Maximum	5.66 s/veh	4.81 s/veh

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Start-Up Lost Time and Discharge Headway

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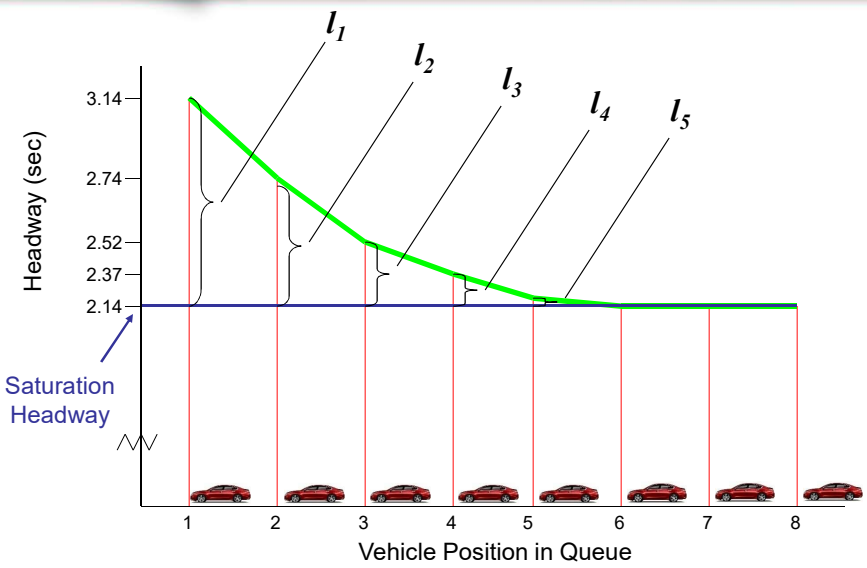

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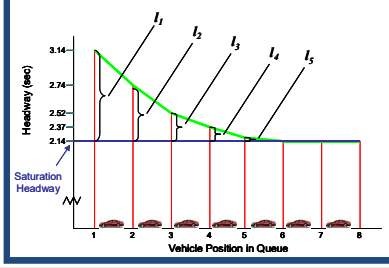
Queue Position	Observed Avg. Headway	Estimated Sat. Headway	Difference (Obs.-Est.)
1	3.14	2.14	1.00
2	2.74	2.14	0.50
3	2.52	2.14	0.38
4	2.37	2.14	0.23
5	2.21	2.14	0.07
>5	2.14	2.14	0.00
Start-up Lost Time			2.18



Example of Start-up Lost Time Computation

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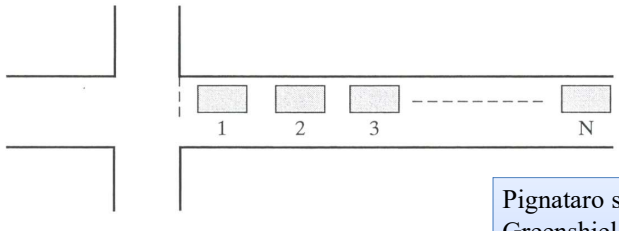
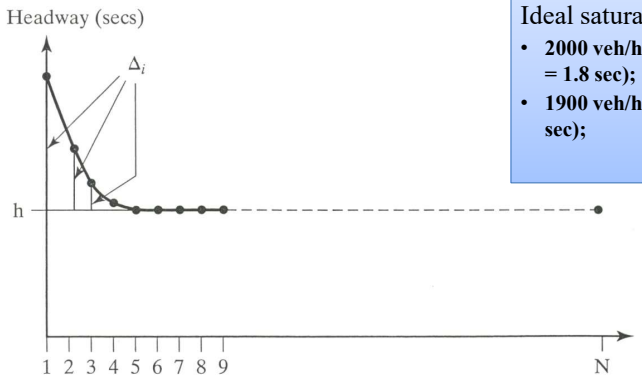


(a) Vehicles in an Intersection Queue

Pignataro suggested 3.7 seconds from Greenshield's starting delay values: 3.8, 3.1, 2.7, 2.4, 2.2, 2.1, ……

Ideal saturation flow:

- **2000 veh/h/ln for metropolitan areas (h_{min} = 1.8 sec);**
- **1900 veh/h/ln for other areas (h_{min} = 1.9 sec);**



(b) Average Headways Departing Signal

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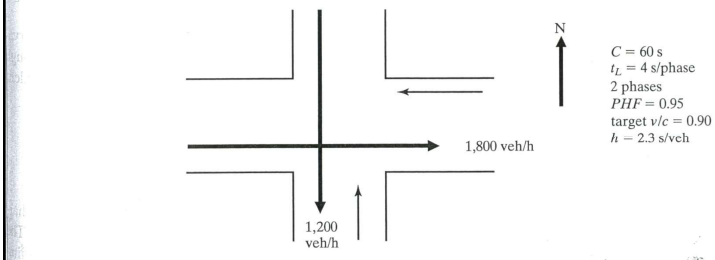

Figure 20.5: Sample Problem Using the Time-Budget and Critical-Lane Concepts

Critical-lane flow rate

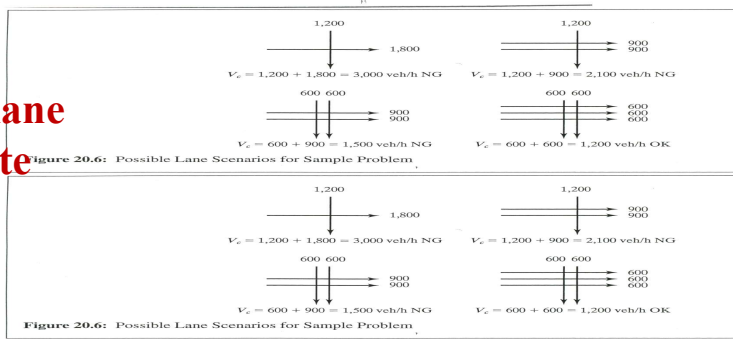

Figure 20.6: Possible Lane Scenarios for Sample Problem

Figure 20.6: Possible Lane Scenarios for Sample Problem

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Capacity of a Signalized Intersection

- Critical Volume: the largest movement among all movements within a lane group.
- Steps to determine the capacity:
  - Step 1: calculate total lost time per cycle: $L = N*t_L$
    - N = # of phases in the cycle; t_L = total lost time/phase
  - Step 2: calculate total lost time in one hour, L_H
    - $L_H = N*t_L * (3600/C)$
  - Step 3: calculate green time allocation, T_G
    - $T_G = 3600 - L_H = 3600 - N*t_L*(3600/C)$
  - Step 4: determine capacity V_c given saturation headway, h, and a phase plan
    - $V_c = (3600 - L_H)/h = 1/h[3600 - N*t_L*(3600/C)]$

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Capacity of a Signalized Intersection

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- **Example:** a signalized intersection with 3 phases
  Cycle length, C = 90 sec
  Lost time per phase t_L = 3.5 sec
  Saturation headway, h = 2 sec
  Steps to determine the capacity (as shown in last slide)
- Solution:
  V_c = (3600 - L_H)/h = 1/h[3600 – N*t_L*(3600/C)] =
  ½[3600 – 3*3.5*(3600/90)] = 1590 veh/hr

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Left-Turn (and Right-Turn) Equivalent

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- A left-urn vehicle will consume more effective green time traversing the intersection than a similar through vehicle.
- Example: It was observed that the effective green time allows 11 through vehicles to pass the intersection. One observation suggests that 5 through vehicles plus 2 left-turn vehicles passed the intersection during the effective green time (shown by the following figure), what's the left-turn equivalent factor?

  Solution: 11 = 5+ 2E_{LT} → E_{LT} = (11-5)/2 = 3.0. that means, 1 left-turn vehicle 's passage time at an intersection allows 3 through vehicles to pass the intersection.

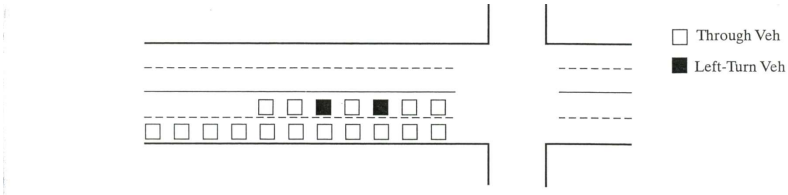

Figure 20.7: Sample Equivalence Observation on a Signalized Intersection Approach

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