CIVL - 7904/8904

TRAFFIC FLOW THEORY

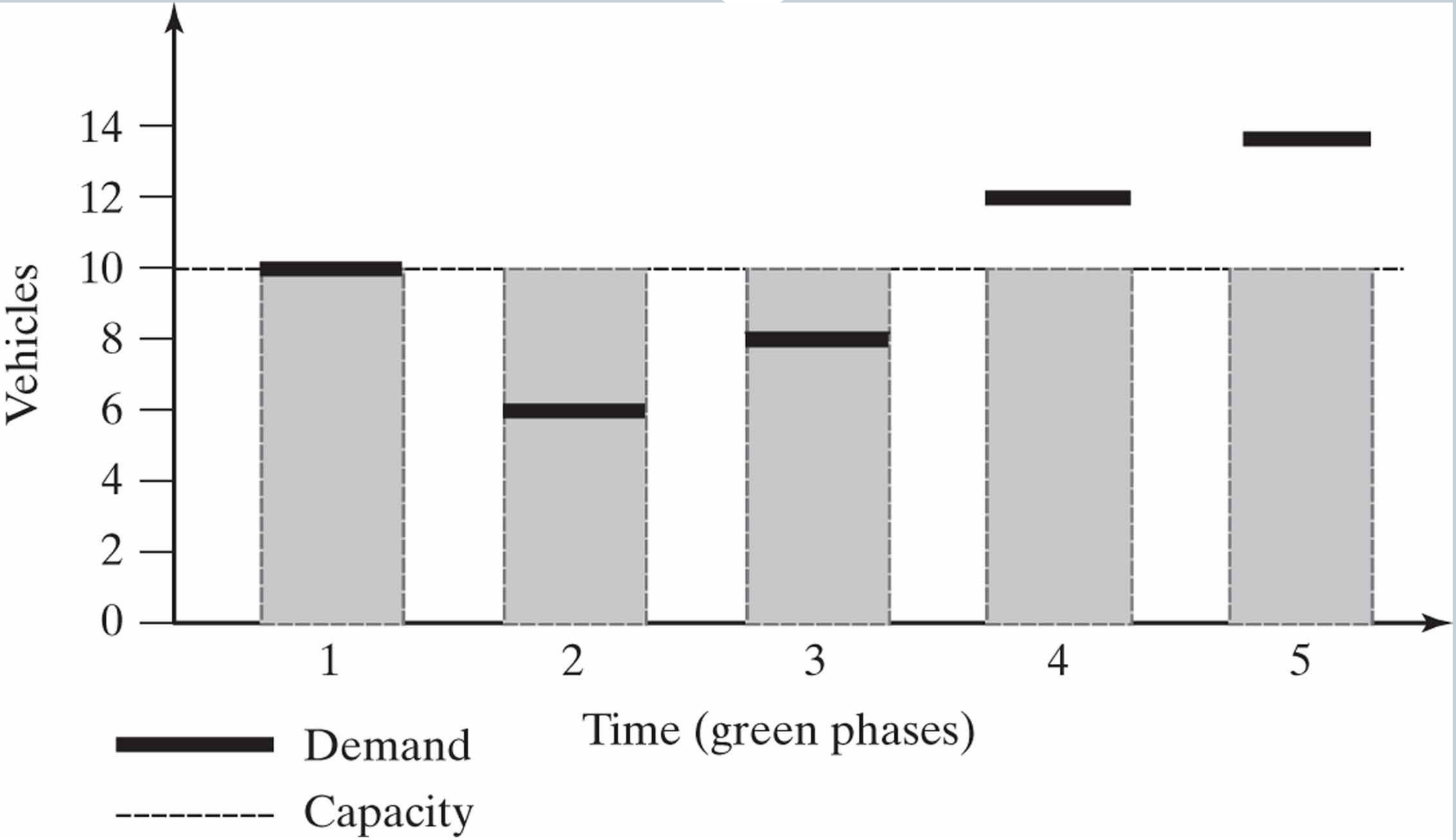
LECTURE -17

Actuated Signal Control and Detection

By the end of this chapter the student will be able to:

- Explain terms related to actuated signals
- Explain why and where actuated signals are used
- Determine detector locations given traffic conditions
    - Explain how semi-,full-actuated, volume-density signals work
- Explain how presence and passage detectors work

Demand Variation



Variation in arrival demand

- Pretimed signals operate with constant cycle lengths, phase sequence, and interval timings ➔ Capacity with a pretimed controller is constant.

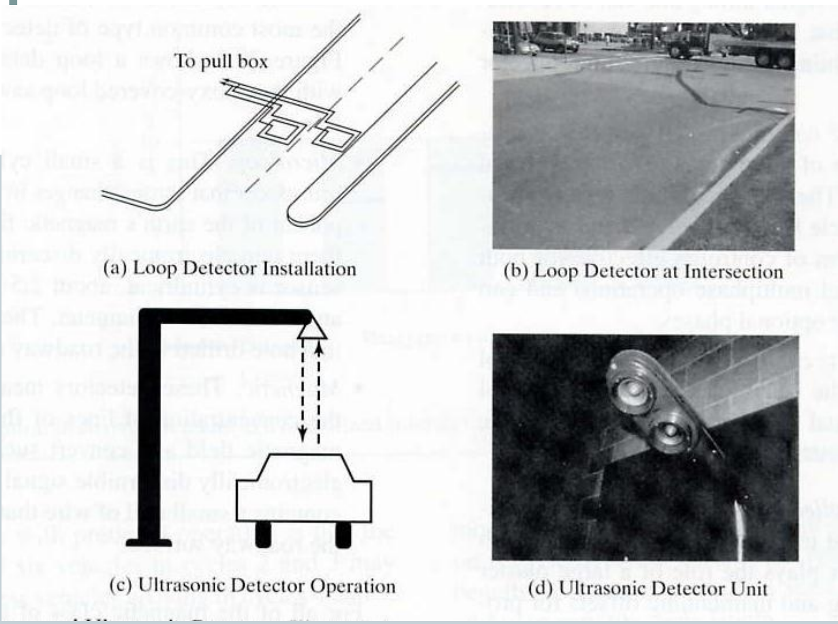
- When demand varies significantly from time to time, either green time is wasted or queue forms.
- In a coordinated system, however, all signals must operate on a single fixed cycle length to maintain offsets and progression patterns ➔ Actuated controllers are not good for such cases

Types of Actuated Control

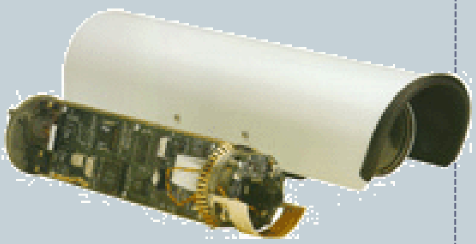
- The cycle length, phase splits, even the phase sequence may vary from cycle to cycle.

Semi-actuated control	Detection only on minor side-street approaches; green remain on the main until a “call” for service on the side street is registered. When warrant 1b (interruption of main traffic) is used.
Full-actuated control	All approaches have detectors; equal importance of the direction of traffic; for relatively isolated intersections;
Volume-density control	Basically functions like full-actuated control; good for high-speed approaches (>= 45 mph); Has extra features to adjust initial timing and reduce the gap extension during green extension time

Detectors and Detection

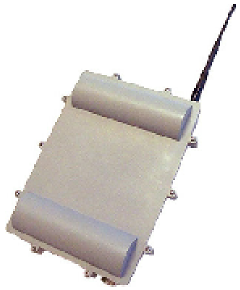


Area sensing



Imaging and virtual detectors

SmartSensor Makes Roadways More Intelligent



October 1, 2001 (Provo, UT, USA)-Wavetronix, LLC announces the product release of SmartSensor with Digital Wave Radar technology that will change the way that traffic information is gathered, analyzed and reported.

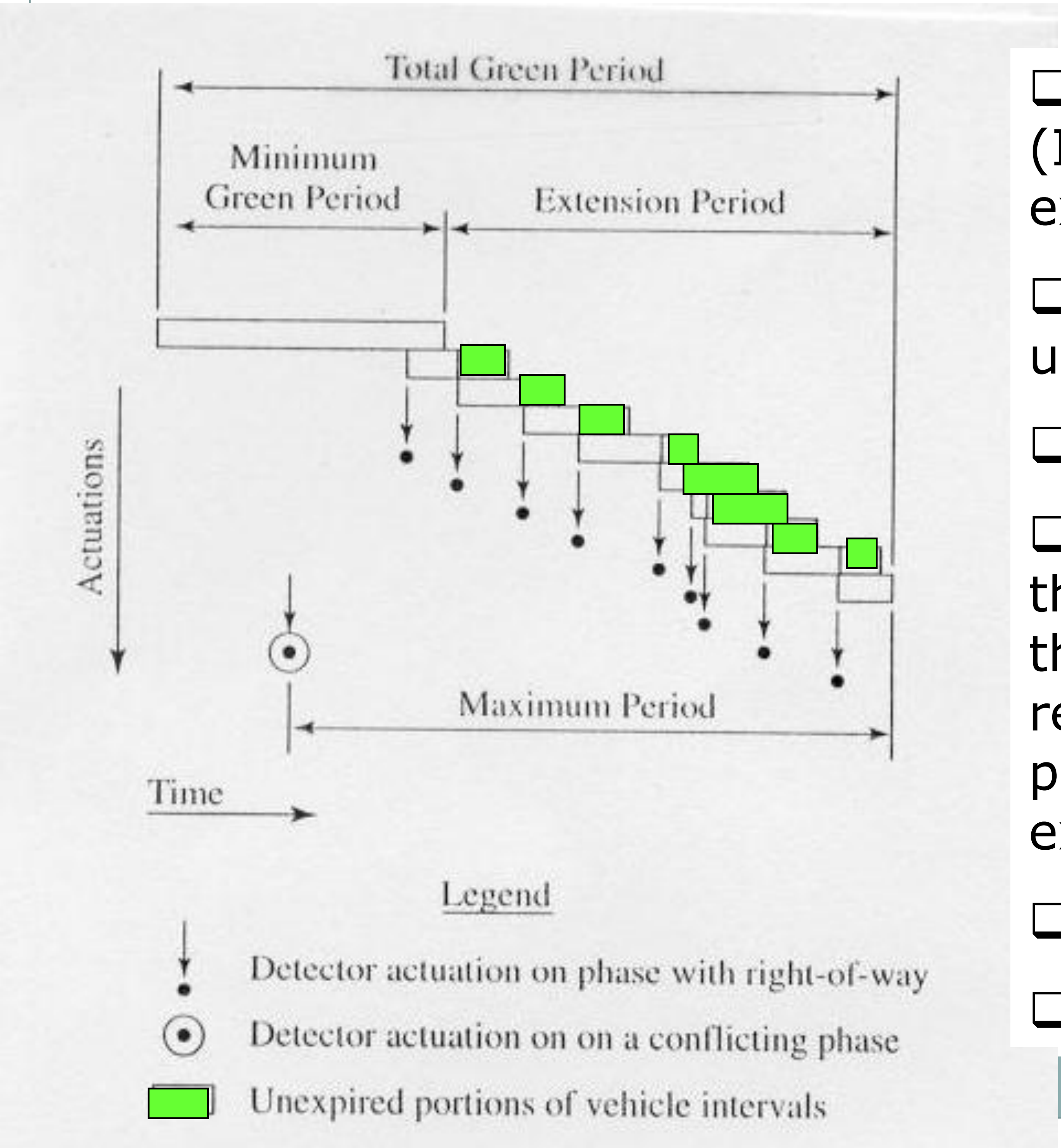
SmartSensor is the only above ground traffic sensor with the capability to detect up to 12 lanes of traffic and report lane by lane speed, volume, occupancy and trends. SmartSensor will automatically adapt and reconfigure if lanes change due to weather, construction, lane closures or other incidents. By collecting all this

Microwave sensing

Detection type

Point detection ("passage" type)	❑ A single detector is placed for each approach lane to be actuated. ❑ The detector relays information as to whether a vehicle has passed over the detector.
Area detection ("presence" type)	❑ Generally used in conjunction with volume-density controllers. ❑ The importance is placed on the existence of a vehicle (s) in the detection area. ❑ They "count" the number of vehicles stored in the detection area.

Actuated Control Features and Operations

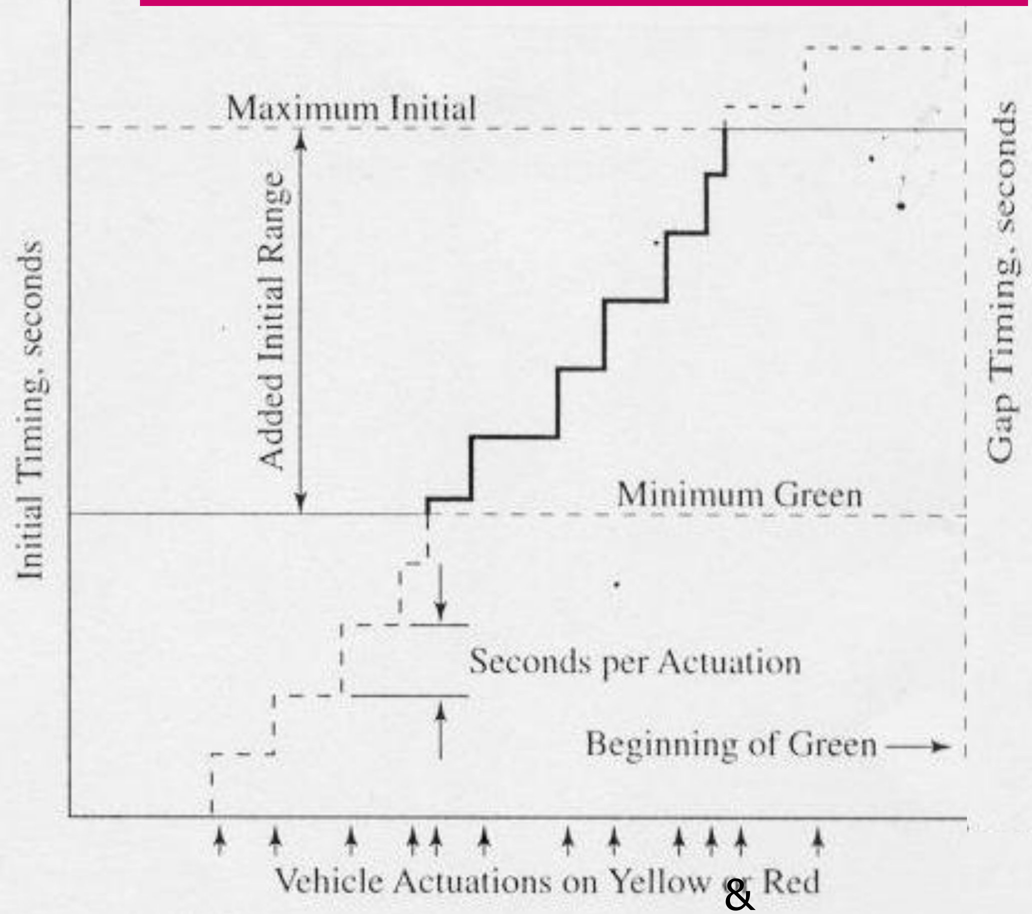


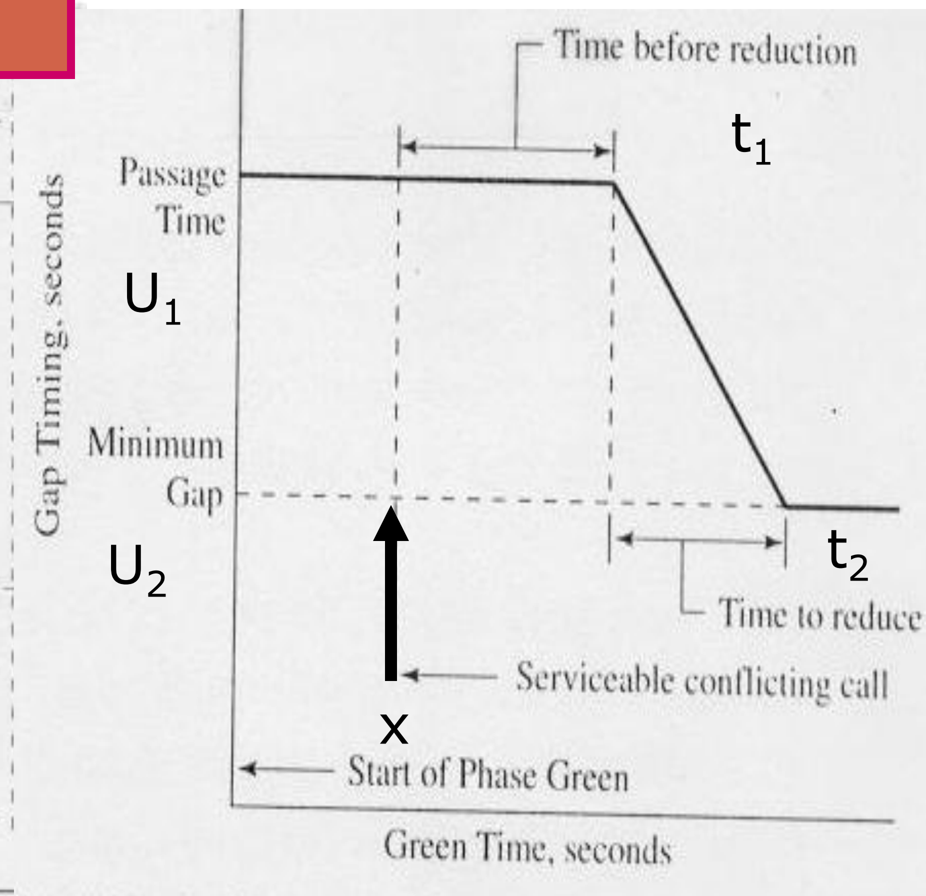
- ❑ Minimum green time (Initial green + unit extension)
- ❑ Passage time interval, unit or vehicle extension
- ❑ Maximum green time
- ❑ Recall switch (unless the subsequent phase has the recall “on” green remains to the previous phase unless demand exists)
- ❑ Yellow and all red
- ❑ Peds signal intervals

Additional features of the volume-density controller

Gap reduction (to make it more difficult to retain green on a particular phase as the phase gets longer.)

Variable initial timing (useful because detectors can memorize the number of queued vehicles.)



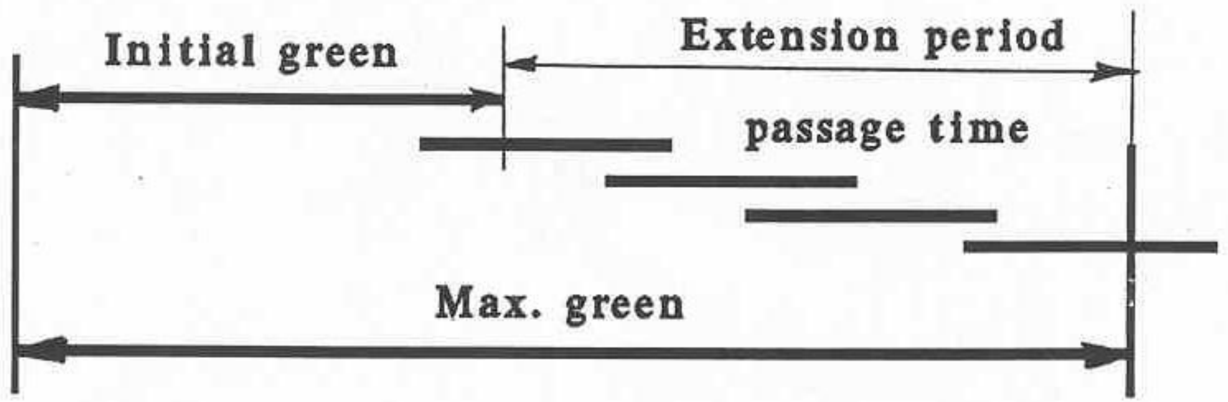


How the maximum green time works

* **How the MAXIMUM green time works:**

Semi-actuated:

The MAX green starts right when the minor street receives green

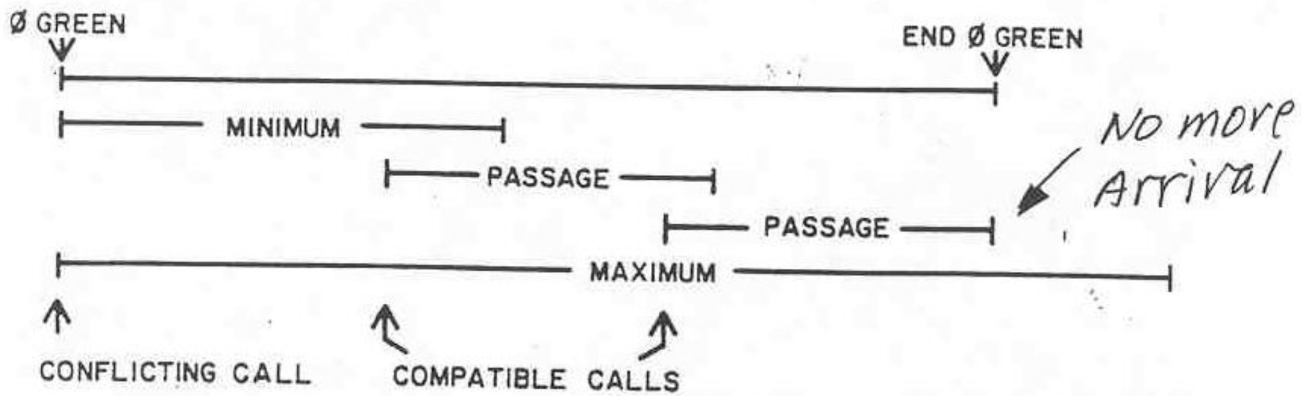


How the maximum green time works (cont)

Fully-actuated

The MAX green does not start ticking until there is a serviceable call on an apposing phase

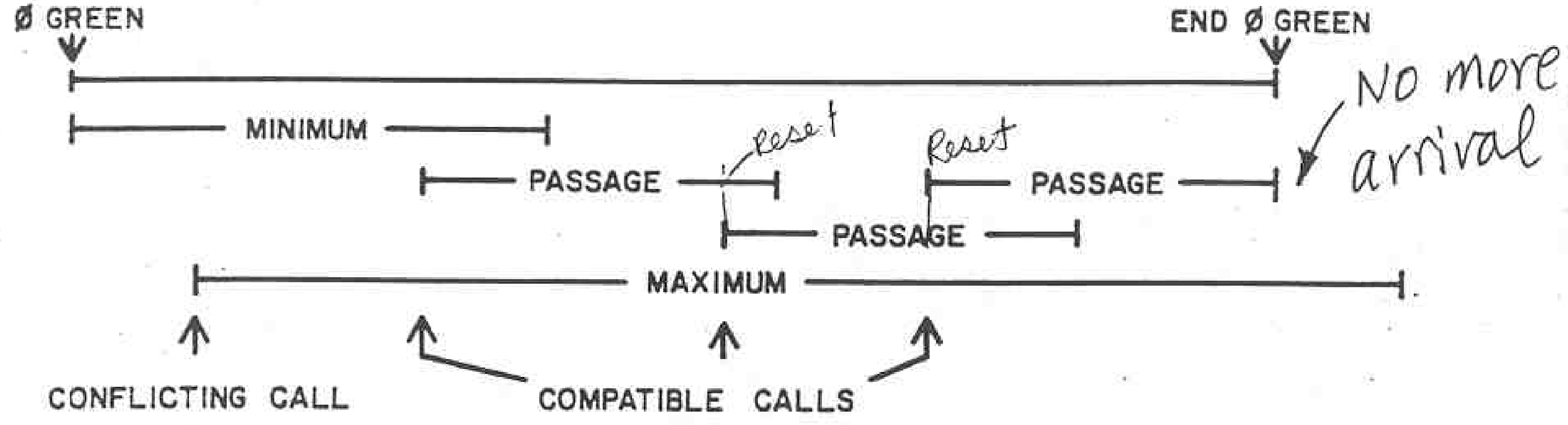
a) Conflicting call at BEGIN of initial; MAX exceeds the phase green



How the maximum green time works (cont)

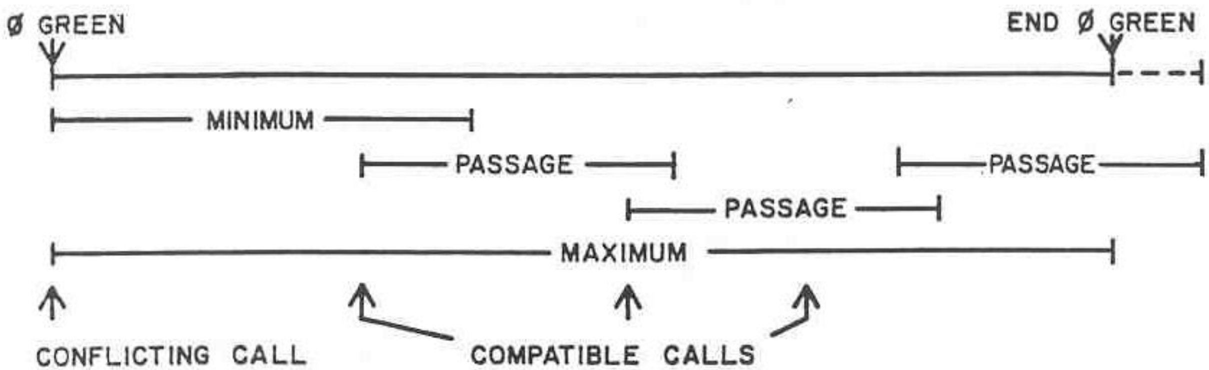
Fully-actuated (cont)

b) Conflicting call during initial; MAX exceeds phase green

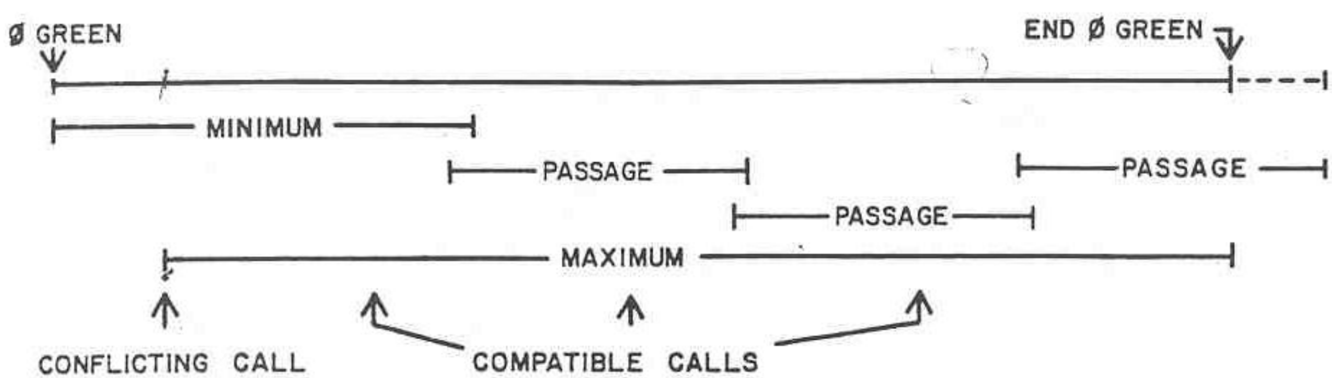


How the maximum green time works (cont)

c) Conflicting call at BEGIN of initial; MAX cuts the phase green short



d) Conflicting call during initial; MAX cuts the phase green short



Actuated Signal Timing and Design

Minimum green time:

"Minimum green times must be set for each phase in an actuated signalization, including the nonactuated phase of a semi-actuated controller.

Point or passage detectors:

$$G_{\min} = l_1 + 2 * Int\left(\frac{d}{20}\right)$$

(d/20) the number of vehicles between the stop bar and the detector.

Area or presence detectors:

$$G_{\min} = l_1 + 2n$$

n = the number of vehicles queued at the beginning of green.

Gmin = minimum green time, s

l_1 = start-up lost time, s

D = distance between detector and STOP line, ft

20 = assumed head-to-head spacing between vehicles in queue, ft

2 = 2 sec headway

Unit or vehicle extension

The unit or vehicle extension serves multiple purposes. In terms of signal operation, it serves as both the minimum allowable gap to retain a green signal and as the amount of green time added when an additional actuation is detected within the minimum allowable gap. The unit extension is selected with two criteria in mind:

- Should be long enough such that a subsequent vehicle operating in dense traffic at a safe headway will be able to retain a green signal (assuming the maximum green has not yet been reached.
- Should not be so long that straggling vehicles may retain the green or that excessive time is added to the green (beyond what one vehicle reasonably requires to cross the STOP line on green.

For all types of controllers, however, the unit extension must be equal to or more than the passage time.

$$U \geq P = \frac{d}{1.47S_{15}}$$

Detector location strategies

- Strategy 1. Place the detector to achieve a desired minimum green time
- Strategy 2. Place the detector such that passage time to the STOP line is equal to the unit extension.

Strategy 1:

Keep minimum green times as low as possible to minimize unused greens and frustration by the driver. A practical minimum limit is the assumed start-up lost time plus 2 seconds ($l_1 + 2.0$) – usually between 4 to 6 seconds, long enough to process a single vehicle.

$$G_{\min} = 6\_\sec = 4 + 2 * Int\left(\frac{d}{20}\right)$$

$$Int\left(\frac{d}{20}\right) = \frac{6.0 - 4.0}{2} = 1$$

Assuming you round up to get an integer, d can be $0 < d \leq 20$ ft.

d to the front (leading end = upstream end) of the detector.

Strategy 2:

Place the detector to equalize the unit extension and the passage time.

Example: unit extension 3.5 sec, 15th percentile speed = 40 mph.

$$U = 3.5\_\sec = \frac{d}{1.47*40}$$

$$d = 3.5*1.47*40 = 205.8\,ft$$

Advantage: A vehicle arriving when there is no other demand present but the signal is red, could cross the detector and have the light turn green just as the vehicle arrives at the STOP line.

Disadvantage: Leads to a very long minimum green time.

$$G_{\min} = 4.0 + 2*Int\left(\frac{205.8}{20}\right) = 4 + 22 = 26\sec$$

Strategy 2 (continued):

- Longer setbacks result in a long minimum green; hence, longer setbacks in which the unit extension and passage time are equal are generally used only where presence or area detectors are in place, allowing for a variable minimum green assignment.
- Practical limitations for point detectors:
  - The detectors must be placed such that no vehicle can arrive at the STOP line without having crossed a detector. This means that no detector can be placed where a vehicle can enter the traffic stream from driveway or curb parking space located between the detector and the STOP line. ➔ This requires that the detector be located quite close to the STOP line. ➔ Area detectors are better for this case. They can detect vehicles entering the detection area from the side. Thus it is only the location of the front (leading end) of the area detector that is limited

Maximum green times and the critical cycle

(2.4.5 Yellow and AR intervals

- The critical cycle for a full actuated signal is one in which <u>each phase reaches its maximum green time</u>.
- For semi-actuated signals, the critical cycle involves <u>the max green time for the side street and the minimum green time for the major street</u>, which has no detectors.

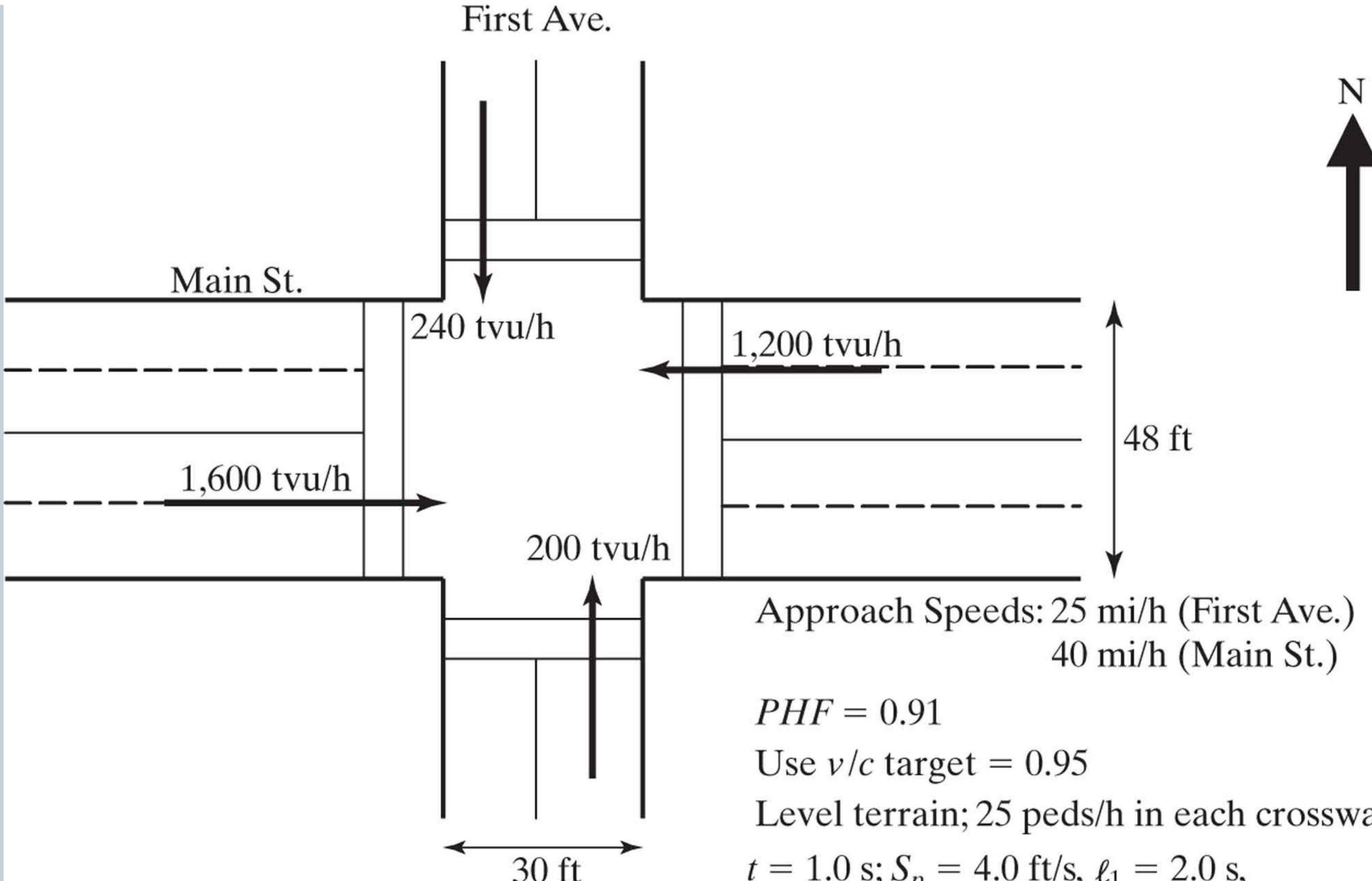
Maximum green times for actuated phases and/or the minimum green time for the major street with semi-actuated signalization are found by determining a cycle length and initial green split based on average demands during the peak analysis period.:

Signal Times

$$C_{des} = \frac{3N}{1 - \frac{V_c}{1615PHF(v/c)}} \quad g_i = (C - L) * \frac{V_{ci}}{V_C}$$

Then, multiply the green times thus computed by a factor of between 1.25 and 1.5 for perturbations occurring during the peak 15 minutes..

Example



Approach Speeds: 25 mi/h (First Ave.)
40 mi/h (Main St.)

$PHF = 0.91$

Use v/c target $= 0.95$

Level terrain; 25 peds/h in each crosswalk

$t = 1.0$ s; $S_p = 4.0$ ft/s, $\ell_1 = 2.0$ s,
$e = 2.0$ s, $a = 10$ ft/s^2, $L = 20$ ft.