VEHICLE DETECTION

Traffic control signals are usually described as pre-timed or vehicle actuated. Vehicle actuated controllers can be *semi-actuated* with detectors on the side street only and in which right-of-way is relinquished only when a call is received for the actuated phase, or *full-actuated* which requires detectors on all approaches and in which right-of-way does not automatically go to a designated phase unless it is recalled by a function on the controller. The type of vehicle detection system used for actuated signal control depends on the operational requirements of the intersection in terms of type and use of data needed by the controller to operate efficiently and the design's cost effectiveness.

Controllers have three modes for detection memory: lock, non-lock and recall. The **lock** feature means that a vehicle call is held by the controller (even after the vehicle has left the detection area) until the call has been satisfied. This type of detection memory is usually associated with point detection such as one 1.8 m X 1.8 m (6' X 6') loop or a magnetometer. It has the advantage of minimizing detection costs, but is incapable of screening out false calls.

In the **non-lock** mode of memory, a waiting call is dropped by the controller as soon as the vehicle leaves the detection area. Non-lock detection memory is associated with large areas of detection at the stop line. This type of operation can reduce delay by screening out false calls, but has greater installation costs due to the large areas of detection needed.

The **recall** feature of a controller is a function that causes the automatic return of the right-of-way to a street regardless of actuation on that street. Minimum recall returns to the selected phase for the minimum amount of green time for that phase. Maximum recall returns to the selected phase for the maximum of green time for that phase. The maximum recall feature is used primarily for fixed time advances and the artery phase of signals in a signal system. Minimum recall is used primarily for the artery phase of a full actuated signal not in a system and for the phase in which the signal is expected to rest.

Traffic **detectors** are used to sense pedestrian or vehicular demand. The demand information is then provided to the controller. There are many types of detectors available. A brief description of some of the most common types follows:

Detector Types

Push button	Push buttons are commonly used to detect pedestrian demand. Push button detection is not extendible.
Loop	Loop detectors consist of an amplifier located in the controller cabinet and coiled wires in the pavement, which create an electrical field. It is the most widely used type of vehicle detection because of the flexibility of design. Loop detectors can be used to sense vehicle presence, passage, lane occupancy, speed and volume.

Preformed Loop	Similar to a loop detector described above, but not imbedded in the pavement. They can be considered for use on bridge decks.
Magnetic	There are four types of magnetic detectors; the standard magnetic detector, directional magnetic detector (no longer available), magnetometer, and self-powered vehicle detector (SPVD). The standard magnetic detector cannot sense vehicles moving less that 5 mph; therefore, cannot provide presence detection. The SPVD is similar to the magnetometer; however, it does not require cable to connect the sensor to the amplifier. The magnetometer and SPVD can provide either pulse or presence detection.
Pressure	Vehicle pressure detectors are activated by the weight of a vehicle and consist of a metal frame and plates installed in the roadway. They were very reliable, but their use is now very limited due to high installation costs and resulting adverse pavement conditions.
Radar	Radar detection is a speed-based detector that transmits speed data to the host when vehicles pass through the cone of detection. These detectors normally use doppler technology to provide speed data. They can provide volume and occupancy data along with speed data, depending on the manufacturer. Use of radar detectors requires an FCC license by the manufacturer. It is used primarily for flow monitoring of the limited access highway system by Highway Operations.
Microwave	Microwave detectors are mounted above the ground and beam a cone shaped area to an approaching vehicle which reflects some of the microwave energy back to the detector thereby providing a momentary contact closure (pulse) to indicate that a vehicle has been detected. This type of detection can be considered in areas where detector pavement installation is not possible, i.e., pavement is in poor condition or right-of-way is limited.
High Intensity Light	This type of detection system consists of a high intensity light emitter mounted on a vehicle and a receiver mounted at or near the signal. It is used primarily for priority control or pre-emption for emergency vehicles.
Video	Video detection is an image processor. It consists of a microprocessor-base CPU and software that analyzes video images. Using a mouse and interactive graphics, the user places virtual "detectors" on the video image displayed on a monitor. Each detection zone emulates an inductive loop.

Vehicle detectors have two modes of operation, pulse and presence. **Pulse** mode is used to describe a detector which detects the passage of a vehicle by motion only (point detection). In most cases, this type of detector mode is associated with locking memory on the controller. **Presence** mode is used for large areas of detection to register a vehicle's presence in a detection zone. The controller may be set for either lock or non-lock memory with presence mode.

Loop Vehicle detector **amplifiers** have extend and delay features available. By using the delay feature the call is output to the controller only if a vehicle is continuously detected beyond a preset time period (e.g. 8"). By using the extend feature the call is held at a preset time after the vehicle leaves the detection zone. In the design of detection systems for actuated control it is necessary to select controller memory operation, detector type and detector function.

The following information has been developed to assist the engineer in the design of loop detectors for actuated traffic signal control. They are guidelines only, each intersection should be designed for its specific characteristics.

Loop Installation Guidelines

Controller phase mode **NON-LOCK** - Detector mode **Presence**

1. Consider using non-lock:

   a. where there are moderate to heavy right turns.

   b. where there are permissive left turns.

   c. where it would reduce false calls.

   d. where it would not cause long clearance lost time.

2. Provide a detection zone:

   a. for through lanes, single lane approaches and right turn lanes, beginning no closer than 3 m (10') from the adjacent road's curb line extension and ending not less than 7.5 m (25') from the stop line.

   b. for left-turn lanes the detection zone should begin 1.5 m (5') in front of the stop line unless there is an island or median in which case it should begin at the nose of the island or median and end not less than 7.5 m (25') from the stop line.

   c. by using segmented loops, they should be square or rectangular with one dimension equal to 1.8 m (6') and the other dimension should be a minimum of 1.8 m (6') and a maximum of 7.5 m (25') with 2.4 m (8’) between detectors..

3. Where there are two or more separate detection areas on an approach, set the vehicle extension to allow a vehicle to travel from one detector to the next detector.

4. Use no more than three segmented loops per lane.

5. When the stop line is located such that a detector should not be in front of it, consider using only two loops.

6. Detector locations on the main line are dictated by speed with consideration given to the dilemma zone. (Refer to Page 34)

7. Consider using delay features (even in systems) when:

    a. it will reduce false calls.

    b. there is an exclusive right turn lane.

    c. right turns are the predominant movement.

Controller phase mode **LOCK** - Detector mode **Presence**

1. Consider using lock:

    a. where No Turn On Red exists.

    b. where stop lines are set back from the extended curb line.

    c. where non-lock, presence detection cannot be designed within the guidelines.

    d. where left turn by-pass capability exists for through vehicles to extend the phase (detector set back should normally be such that the vehicle extension is 3" to 4").

    e. at an isolated location on a minor street with a two lane approach, one left lane detector can be placed 7.5 m (25 ft.) back from the stop line and multiple detectors can be placed in the right lane with a delay feature for the right lane detectors.

    f. where there is an exclusive left turn lane with an exclusive phase.

    g. when the predominant move on the side street phases indicates a heavy left and/or straight through movement.

2. Install one loop in the center of the lane 0.9 m (3') off the edge of travel way and 0.9 m (3') off the centerline. The detector should be located 7.5 m (25') from the stop line.

3. Set the vehicle extension time based on detector set back, between 2" and 5".

4. Care in placement of the detectors must be given when poor turning radii and/or narrow streets make turning maneuvers difficult and increase the potential for false calls.

5. Be especially aware of parked vehicles and driveway locations as vehicles exiting the drive may not be detected and vehicles entering the drive or parked may place false calls.

Controller phase mode **RECALL** - Detector mode **Presence**

1. Recall is used to return the right-of-way to a street regardless of actuation on that street.

    a. Minimum recall is used for the artery phase of full-actuated signals.

    b. Maximum recall is used primarily for fixed time advances and the artery phase of signals in a system. Refer to controller specifications.

    c. Minimum recall may be used for side street phases of signals in systems when that feature is needed for the desired operation.

2. Place a detector approximately at the approach edge of the dilemma zone (farthest from the stop line) centered in the lane(s), 0.9 m (3') off the edge line(s).

3. The vehicle extension time should be set such that once a vehicle leaves the detector it has sufficient time to leave the dilemma zone.

4. Use variable initial when the minimum green time is less than that needed to clear all vehicles between the stop line and the detector.

5. Use an additional detector between the stop line and the first detector when it is desirable to reduce the vehicle extension or to detect a vehicle exiting a drive.

6. Phase modes set on max-recall do not normally require detectors.

Miscellaneous

1. The rear loop of a multi loop approach may be used as a system detector to obtain volume counts in a closed loop system; however, the length must be 1.8 m (6').

2. Installation of detectors in crosswalks should be avoided.

3. Consider using gap reduction at isolated intersections with relatively equal volumes on all approaches and where capacity is of concern.

4. Loop detectors are the most commonly used type of detector. They should be square or rectangular with one dimension equal to 1.8 m (6') and the other dimension should be a minimum of 1.8 m (6') and a maximum of 7.5 m (25'). The dimensioning of loop detectors must be shown on signal plans as width X length.

5. Consider installing the loop in a diamond configuration for R.T.O.R. when the throat is wider than 4 m (13').

6. Engineers should be familiar with Chapter 5 "Detectors" in the Traffic Control Systems Handbook (reference 14), prior to determining the phase mode and detector location.

7. Detector numbers and signal face numbers should correspond to the appropriate phase where possible.

Microwave Detector Guidelines

1. The traffic engineer should define the area of detection.

2. The Microwave detector Must be fixed-mounted and located so that there is unobstructed line of sight to the area of detection.

3. The Microwave detector should be located so that the cone of detection is aimed at the approach that requires detection. The detector should be oriented along an axis which is parallel (or nearly parallel) to the approach being detected. The minimum detection speed is normally 5 to 5-1/2 mph.

4. Since microwave detectors cannot provide for presence, the phase must be on lock.

General:

If a Microwave detector is to be used in conjunction with loops on an opposing street, the traffic engineer may want to use a dummy phase to allow the loops to work in non-lock mode. If this is the case, the parent phase can be in non-lock, the dummy phase will be in lock with the following Technical Notes:

1. Phase 5 (the dummy phase) check to call Phase 4 (the parent phase), but not extend.

2. Detector D-5 (microwave detector) to call Phase 5 and Phase 4.

DILEMMA ZONE

It has been our practice when designing a full-actuated signal to consider "dilemma zone" for isolated applications. A commonly utilized technology is to locate the arterial detector 5 seconds from the stop bar based on the 85th percentile speeds. Vehicle extension is based on the time necessary for a vehicle at the posted speed limit to travel from the arterial detector to the stop bar. This method of design was developed to ensure that vehicles traveling at the posted speed limit will not be "trapped" within the dilemma zone. It can create, however, inappropriately high vehicle extension timing and initial settings. The designer should consider techniques to reduce these settings, such as variable initial or design utilizing two approach detectors.

Dilemma Zone is defined as the range of distances from the stop bar, where the percentage of vehicles which will stop is between 10% and 90% (10% being the lower limit and 90% the higher limit). The standard method for avoiding trapped vehicles is to place a detector at the 90% point, allowing these vehicles to extend the interval sufficiently enough to ensure that they pass the lower 10% limit.

The following table is from the Traffic Control Devices Handbook listing those distances at which 10% and 90% of approaching vehicles are expected to stop for various speeds.

	Distance (Feet) Probability of Stopping	
Speed (MPH)	10%	90%
35	102	254
40	122	284
45	152	327
50	172	353
55	234	386

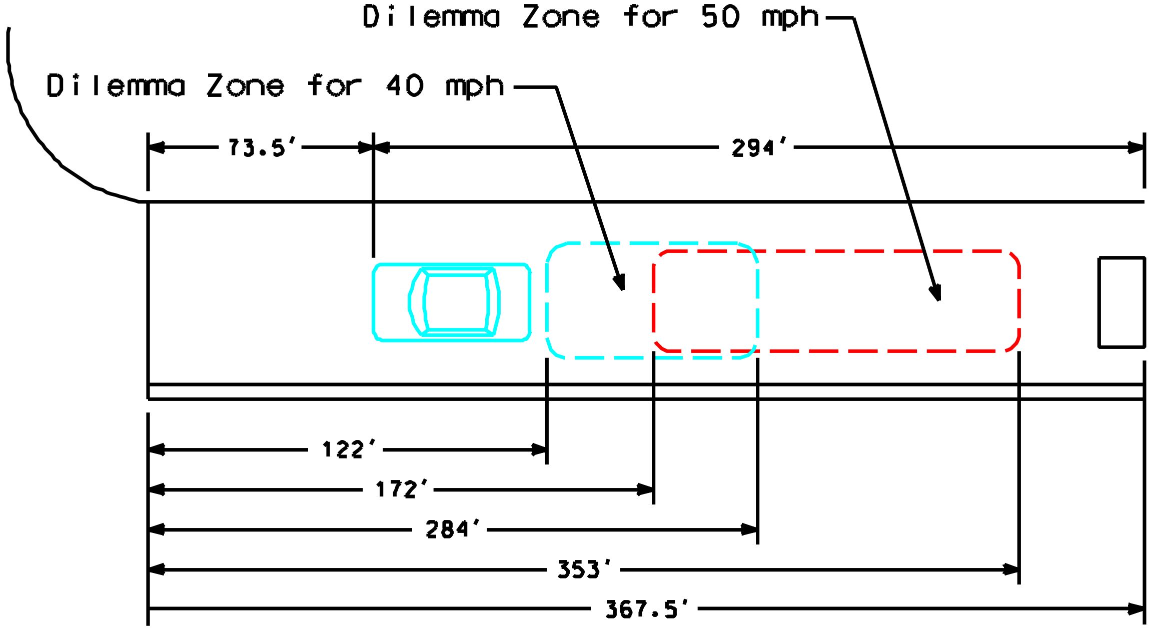
Note that the 90% point for all speeds is approximately 5 seconds. To ensure that vehicles are detected before they enter the dilemma zone, 5 seconds should always be used in determining the arterial detector setback regardless of speed.

The following guidelines can be used to ensure dilemma zone protection:

1. Arterial detectors should be located 5 seconds from the stop bar based on the 85th percentile speeds with a 5 second vehicle extension for the artery phase.

2. Perform a "trap check" to ensure vehicles traveling the speed limit will not be within the dilemma zone upon termination of artery green. This is determined by subtracting the distance a vehicle traveling the speed limit will cover during the extension time (5 seconds) from the setback distance calculated for the 85% speeds. The difference should be less than the lower dilemma zone limit (see table) at the speed limit. Generally, slower vehicles will not be trapped if the posted and 85% speeds are within 15 mph of each other.

Example : posted - 40 mph
85th% - 50 mph



Setback at 85% = (5sec) (73.5 ft/sec) = 367.5'

Trap check = (5sec) (58.8 ft/sec) = 294'

367.5' - 294' = 73.5

73.5' is less than 122' : therefore ok.

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