The method of advance detection design must be compatible with the actual gap and duration of maximum green incorporated into the design. Detector placement strategies which require high values of allowable gap may be incompatible with safety and efficiency. Furthermore, under heavy traffic conditions, a long allowable gap may cause unnecessary delay to waiting vehicles or routinely extend the controller to maximum green even under moderate traffic.

Depending on vehicle speeds and roadway geometrics, advance detection may be augmented by the placement of intermediate and/or stop-line detection. Additional near detection is commonly used on low-volume side-street approaches and main street approaches not using recall.

There are a variety of strategies that can be employed for advance detection. However, primarily there are two which provide the most efficient and safe operation. These are single-point detection and dilemma-zone detection.

**SINGLE-POINT DETECTION**

Single-point detection consists of a single loop, normally 6’ x 6,’ in each through lane, or one loop covering all approach lanes (e.g. 6’ x 20’ or 6’ x 18’ for two lanes), located two to five seconds of travel time in advance of the stop line. Single-point detection is typically used where vehicle speeds are ≤35 mph or if the opposing volumes are such that it is inefficient to extend the green for sporadic arrivals.

Signal timing for this type of detector application is based on the distance from the stop line to the advance detection. The minimum green time is commonly set for approximately 6 to 10 seconds. The variable initial time may add green time beyond the minimum green to allow additional vehicles in the queue to enter the intersection. The variable green time can be determined several ways; one method is to divide the time for all vehicles to enter the intersection by the total number of vehicles in the queue.
(assume a queue extending from the stop line to the point detection). The passage time or allowable gap is established by determining the time it takes to travel from the advance detection to the intersection at the selected design speed. While this type of detection can also be used for higher speeds, ≥35 mph, it is recommended that the second type, dilemma zone detection, be employed where speeds exceed 35 mph. Figure 1 illustrates two commonly used layouts.

Figure 1
Advance-Detection Loop Layout

DILEMMA ZONE DETECTION

The dilemma zone is defined as that portion of the roadway in advance of the intersection within which a driver is indecisive regarding stopping prior to the stop line or proceeding into or through the intersection. Detection designed to minimize driver decisions in this area is called dilemma zone detection. This type of detector application is intended for high-speed approaches (>35 mph) where decision distances and stopping distances are critical and not fully accounted for in single-point detector applications. Although there are different methods used for dilemma zone detection, all methods utilize multiple-loop-detector configurations. The difference among methods is the number, placement, and loop size for a particular configuration.

The two primary dilemma zone detection methods are: (1) green extension system; (2) extended call detector system.

GREEN EXTENSION SYSTEM

The green extension system utilizes two loops per lane. The concept is to detect a vehicle as it enters the dilemma zone and then extend the green until the vehicle clears
the dilemma zone. The advance loop (S₁) acts to extend the green time for a vehicle to reach the near loop (S₂). The near loop maintains the green time long enough to allow the vehicle to enter or clear the intersection. This method is best used where speeds are relatively consistent and the posted speed limit is ≥ 45 mph. The loop locations are governed by the percentile speed chosen by the designer. The 85th-percentile speed is commonly used; however, a higher percentile speed can be designed. Figure 2 illustrates the green extension system loop layouts.

It *should* be noted that regardless of the method employed, vehicles *may* still be caught in the dilemma zone if traffic conditions or timing parameters cause the respective phase to max out.'
EXTENDED-CALL SYSTEM

The extended-call detector system also utilizes two loops. However, under this method a long loop or series of long loops is placed at the stop line for presence detection, and a single extended-call detector loop is placed upstream of the stop line. The advance loop (S1), located at the beginning of the dilemma zone, extends the green time, allowing a vehicle to reach the stop line loop (S2) (i.e. travel through the dilemma zone). The stopline loop (presence loop) ensures that vehicles queued at the intersection can enter the intersection without triggering a premature gapout when there are not subsequent calls from vehicles on the advance loops. The extended call system is best used where speeds are in the range of 35 mph to 50 mph and the vehicle volumes are relatively high. Figure 3 illustrates the extended-call detector system layout.

It should be noted that regardless of the method employed, vehicles might still be caught in the dilemma zone if traffic conditions or timing parameters cause the respective phase to max out.

![Figure 3](image.png)

Extended-Call Detector System

There have been several tables published regarding the dilemma zone location for various design speeds. For the purpose of providing guidance, Chart 1 and Table 1 have been reprinted from a Northwestern University Traffic Institute course manual. Table 1 shows the dilemma zone response curves by vehicle speed and distance from intersection. The 90% Go and 90% Stop probability ranges have been marked for reference during design. Table 1 shows passage distances based on speed and time. The numbers shown in Table 1 are directly related to the curves shown in Chart 1. Chart 2 has been reprinted from the Federal Highway Administration Detector Manual. This chart shows various dilemma zone response curves by vehicle based on vehicle speed and percentage probability of stopping. The 90% and 10% probability ranges
have been identified for reference during design. Chart 3 *may* be used to determine passage times for advance detection. Using the design speed and proposed passage distance, the passage time can be determined. It is the responsibility of the signal designer to determine the appropriate passage distance. The passage time *should* allow the vehicle to enter into the intersection; however, each case *should* be evaluated separately.

These tables and charts are provided only as a reference. In all cases the signal designer is responsible for selecting the appropriate design speed, passage time, and percentage probability of stopping.

ADVANCE DETECTION FOR EXTENSION

The same loop layout concept shown for point detection *may* be used for extending the green time for an approach, including left-turn lanes. If extend-only detection is installed without recall, it must be supplemented with near detection. This is required since extend-only detection will not place a call from a passing vehicle when a red phase is being timed. See TSDM Subject 8-1-6 for details on near detection.
Chart 1
Dilemma Zone Response Curves

Table 1
Dilemma Zone Values
Chart 2
Dilemma Zone Response Curves
CHART 3
Speed Vs.
Distance Traveled Curves
For Various Time Intervals

APPRAOCH SPEED - M.P.H.

DISTANCE - FEET

(From detector A to detector B or from detector to Stop Line)