Signal Progression

The objective of a signal system is to provide continuous movement of vehicles and/or minimize the delay along an arterial or throughout a network of major streets. This requires:

- coordination among the signal controllers
- signal timing plan
- compatible equipment
- typically, equal cycle times
- adequate and appropriate signalized intersection spacing.

I. COORDINATION

There are a number of traffic signal control systems that can provide the necessary coordination to achieve signal progression.

A. Non-interconnected system. This is the simplest system control of all. Appropriate offsets of the beginning of green phrases for the sequence of signals can be measured and set with a stop-watch.

B. Time-based Coordinated System. Non-interconnected controllers are coordinated using “time-based coordinators,” which are devices that employ the power company supplied frequency to keep time accurately. Coordination of signal timing plans can be achieved accurately.

C. Interconnected Pretimed System. The signal controllers of the signalized intersections on the facility are hard wired to a master controller, which is one of the intersections controllers.

D. Traffic Responsive System. An interconnected system that responds to the information at some traffic detectors to determine which cycle lengths are used.

E. Digital computer Signal Control System. A central computer facility receives, analyzes and develops the appropriate signal turning patterns with cycle times, offsets, and phasing. It then communicates them to the local controllers.

II. DEFINITIONS

These definitions are shown graphically in Figure 1.

A. System cycle - a specified cycle length is imposed throughout the system under the timing plan.

B. Split - the proportion of the cycle that is green for the arterial at each intersection.

C. Offset - the time that the green phase at an intersection begins after the beginning of green of the major control intersection or the reference signal.

D. Band width - the width of the green through band in seconds, which indicates the amount of green time where traffic can flow with progression.

E. Band speed - the slope of the green through band on the time space diagram is the speed of progression for the platoon.

III. SIGNAL SYSTEM TIMING

A. A. Simple System

These are primarily used with signals that are pretimed.

1. Simultaneous- All signals show the same indication at the same time.

    - Provides inefficient timing
    - Increases speeds
    - Reduces capacity

Best suited to very short (300-500 ft.) or very long blocks, and locations where major street can have most of the green time. See Figure 2.

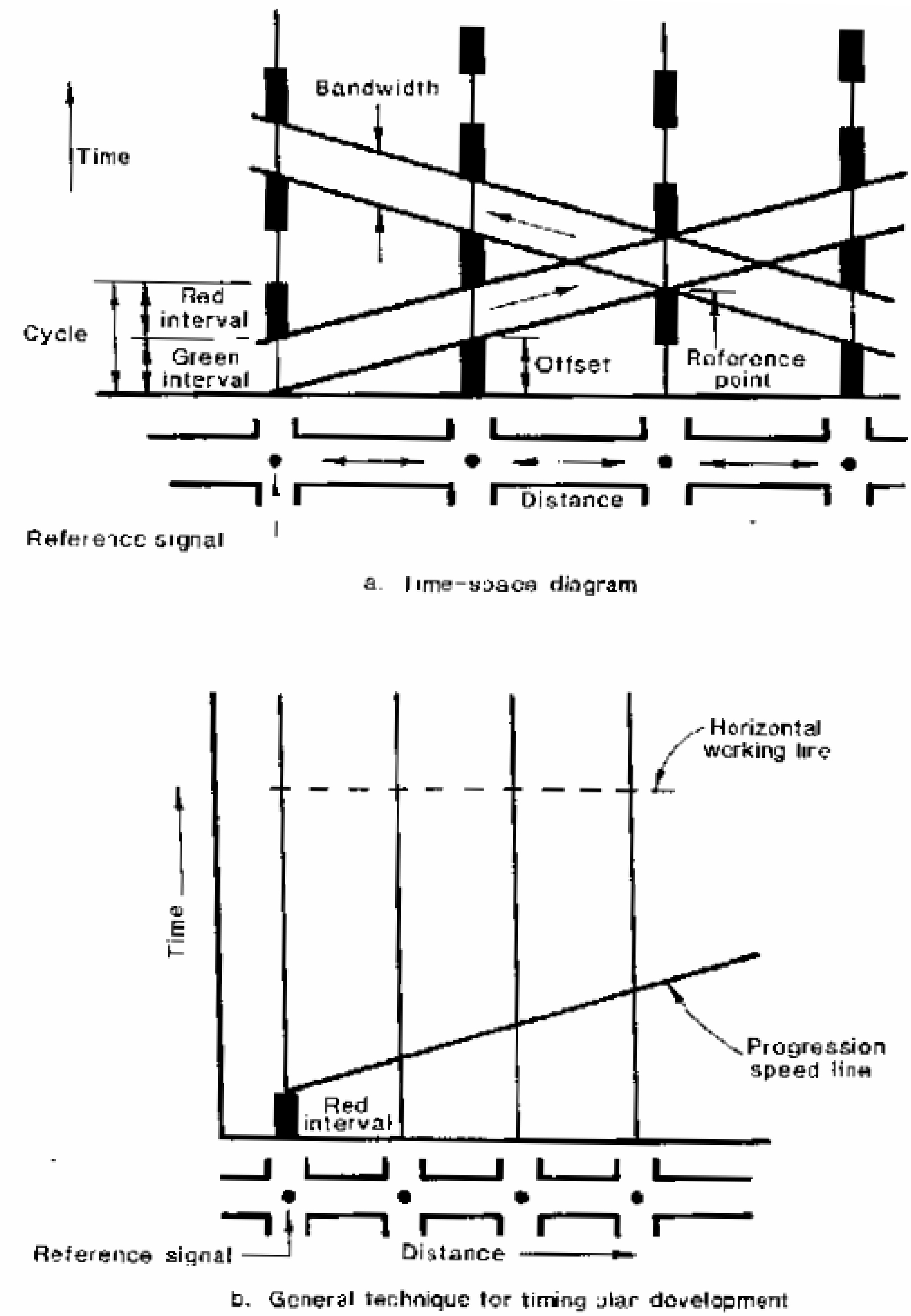


Figure 1. Time-Space Diagram and Graphic Technique

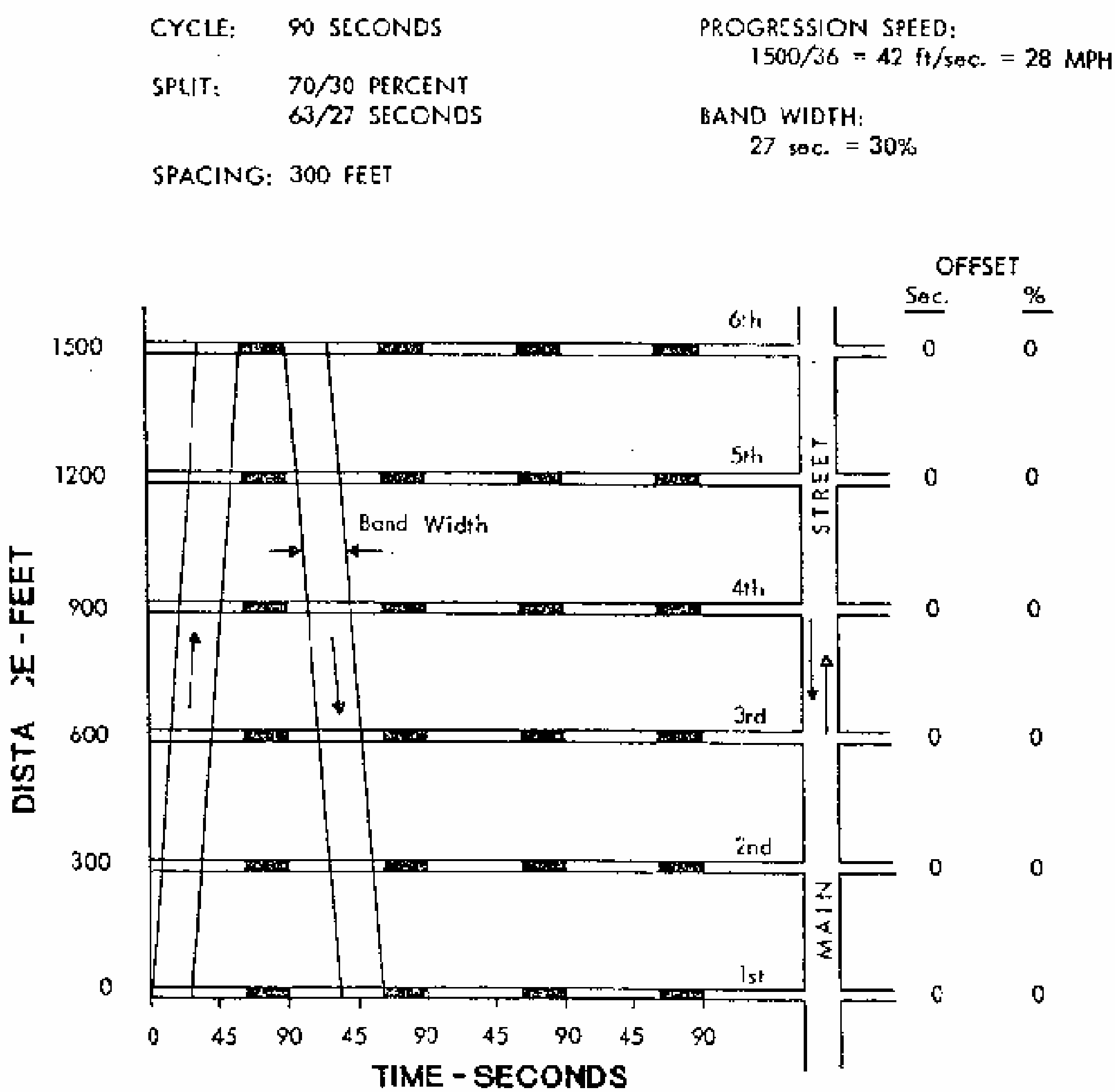


Figure 2. Simultaneous System Zero Offset

2. Alternate System

a. Single Alternate. Every other signal shows the same indication.

b. Double Alternate. Every other pair of signals shows the same indication.

c. Requires 50-50% cycle split.

d. Not well-suited for unequal block spacing.

e. Double alternate reduces the through band width by 50%.

f. Best suited for downtown areas with square blocks and low speeds.

g. Timing

1) Select desired speed

2) Compute time required to travel one block

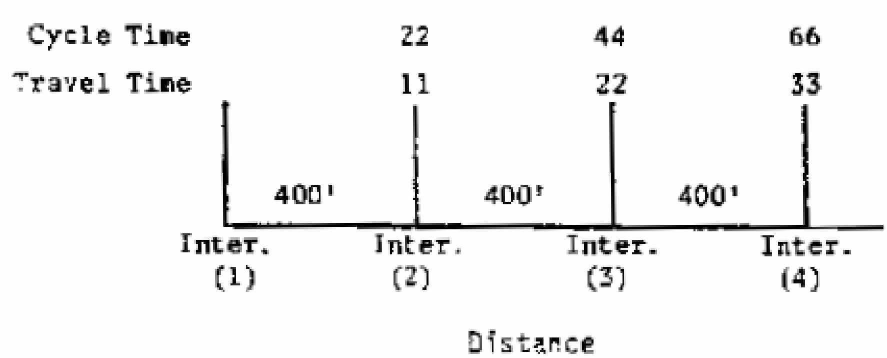
$$TT = \frac{\text{Block length}}{V\ (\text{fps})}$$

3) Select signal system and cycle time based on round trip time.

- Single alternate - round trip to second intersection
- Double alternate - round trip to third intersection
- Triple alternate - round trip to fourth intersection

Example: 400 ft. long blocks; 25 mph

$$TT = \frac{400}{36.7} = 10.9 \text{ sec., say } 11 \text{ sec.}$$



3. Progressive Systems

A signal system in which the vehicles receive a green indication as they arrive at the intersection.

a. One-way street progressive systems can provide a band width of 100% of green regardless of the block spacings (see Fig. 3).

b. Two-way street progressive systems can provide progression in both directions with equal block spacings, as shown with single alternate and double alternate systems (see Figs. 4 and 5).

c. Two-way streets with unequal block spacing may not be able to achieve progression in both directions, or it may be inefficient with poor speeds of progression on small band widths.

IV. Optional Signalized Intersection Spacing

The optimum spacing for the signals that dictate the progression speed and band width can be determined based on these concepts. As has been discussed the distance between intersections is a critical variable in determining the amount of progression band width and the speed of progression.

A. Signal Spacing. Signalized intersections should be spaced to minimize delays and disruptions to through traffic. The optimum spacing of signals is dependent on the speed, cycle length, traffic volumes and efficiency of signal progression. Extensive research has been performed to determine the relationship among speed, cycle length and signal spacing, using the computer simulation package PASSERII. Figure 4 shows the results of that work.

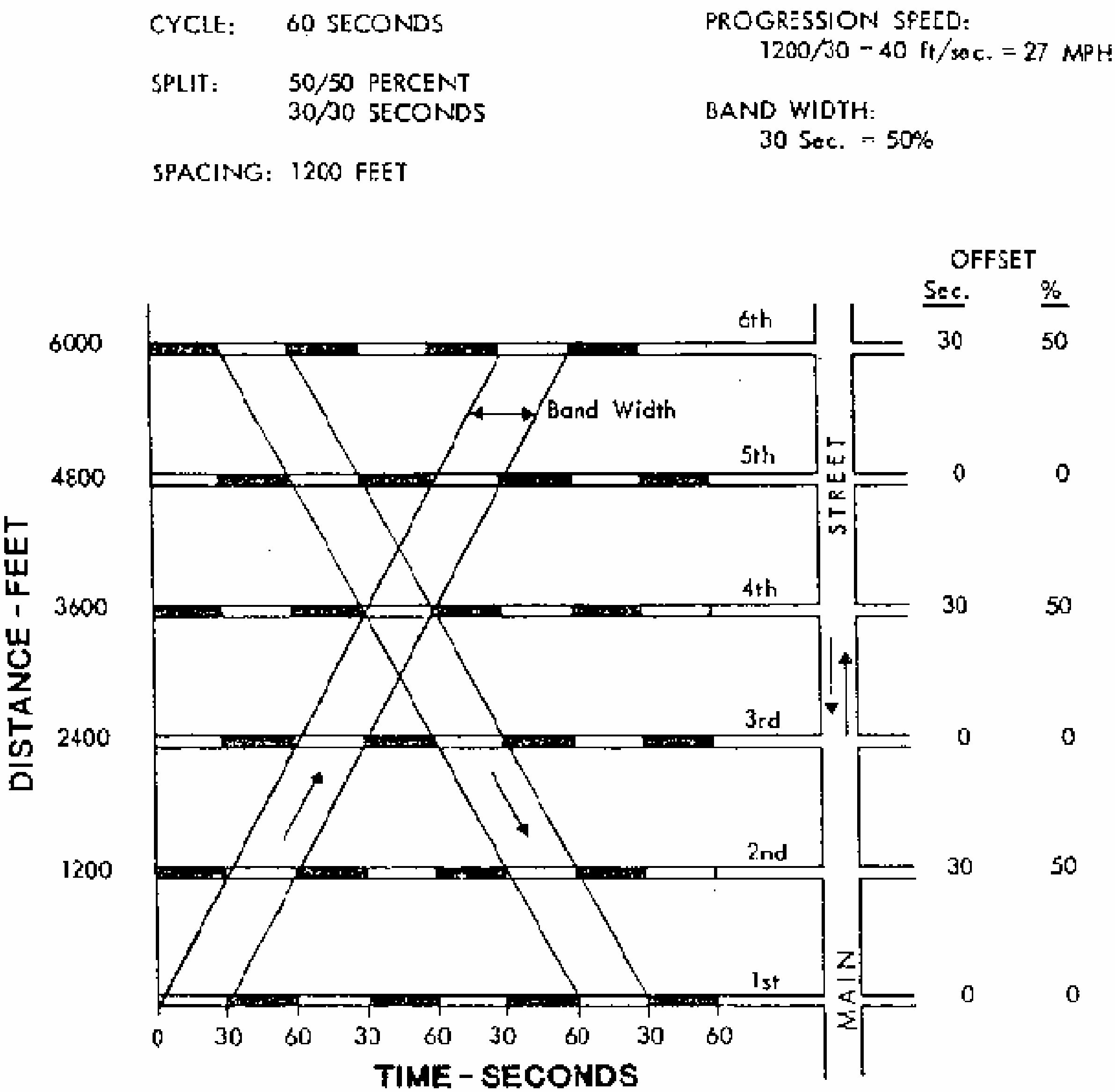


Figure 3. Single Alternate System One-Half Cycle Offset

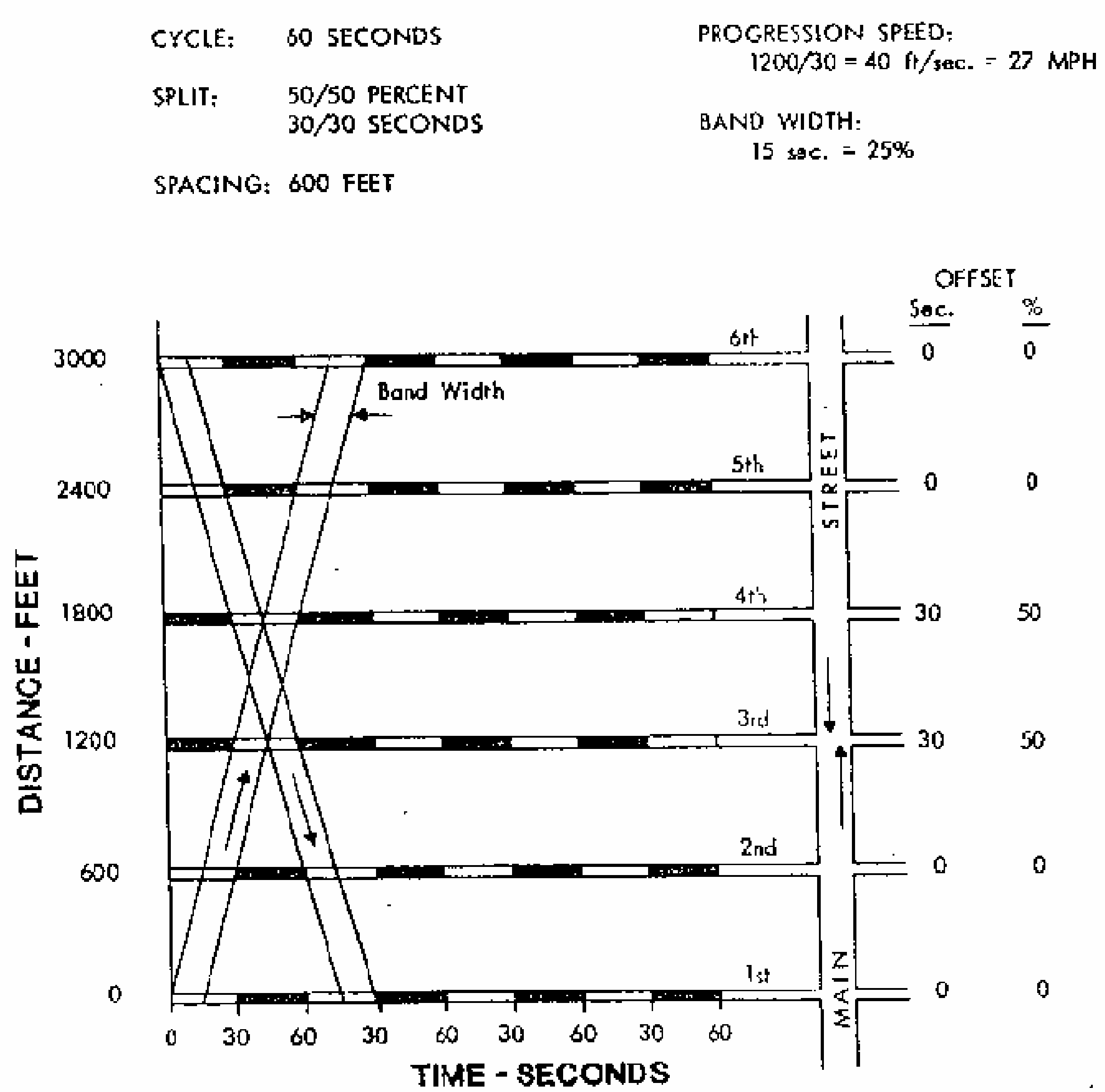


Figure 4. Double Alternate System

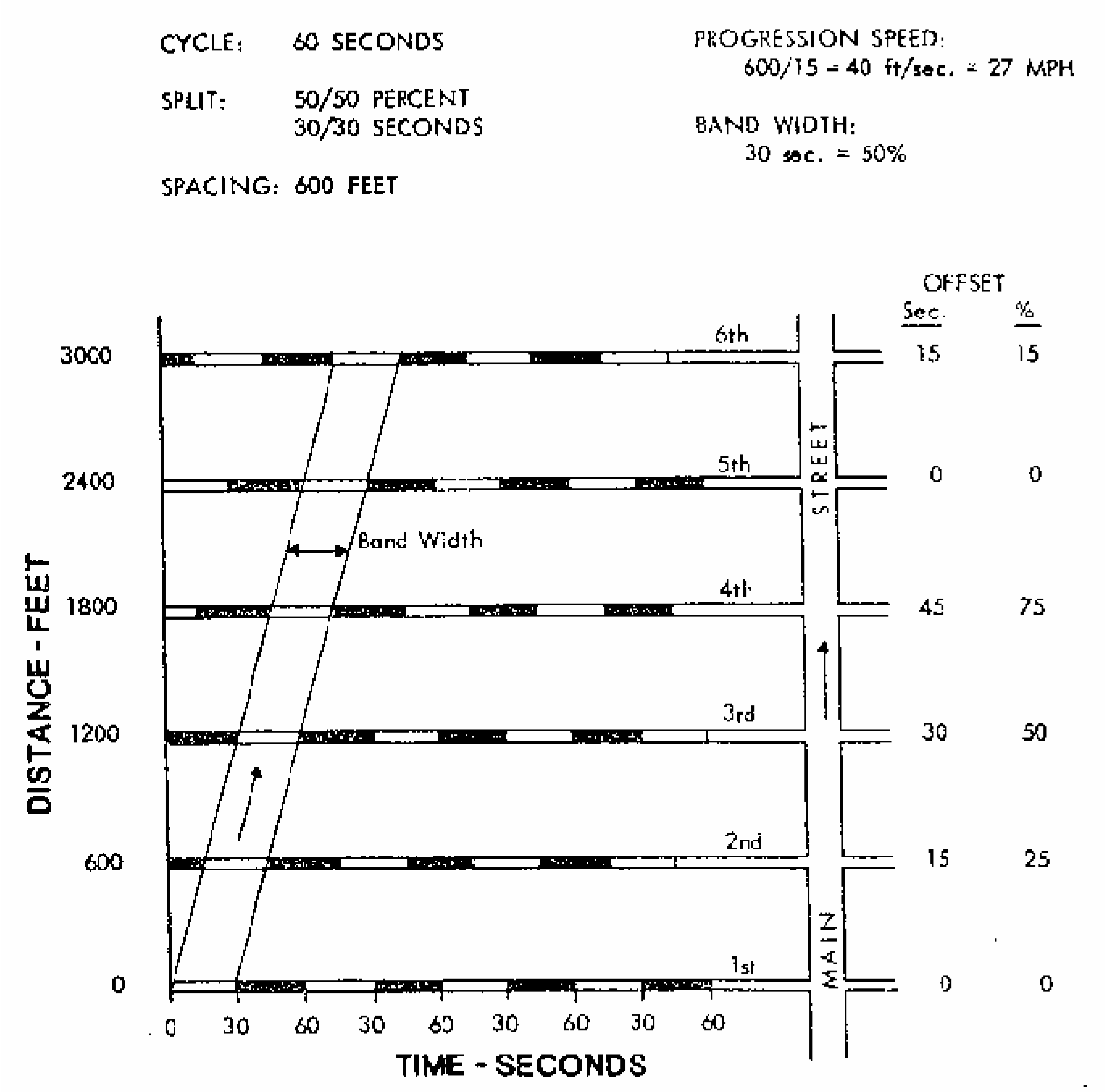


Figure 6. Quarter Cycle System

The volumes on urban arterials during morning and afternoon peak periods are high, requiring long cycle lengths of 120-150 seconds on major urban arterials. Since the concern for access management is greatest when the local land use is at maximum build out, and consequently with high demand volumes and the greatest level of conflict, a 120-150 second cycle should be adopted for urban areas to determine the signal spacing. Further, as facility speeds increase, the signal spacings must also increase. However, allowable speeds on arterials reduce as an area becomes more urbanized. The figure shown below may be used to determine the appropriate signal spacing. Typical values for cycle lengths are:

120-150 sec - urban major arterials with speeds of 30-45 mph

90 sec - suburban arterials with speeds of 40-50 mph

60 sec - rural arterials with speeds of 45-55 mph

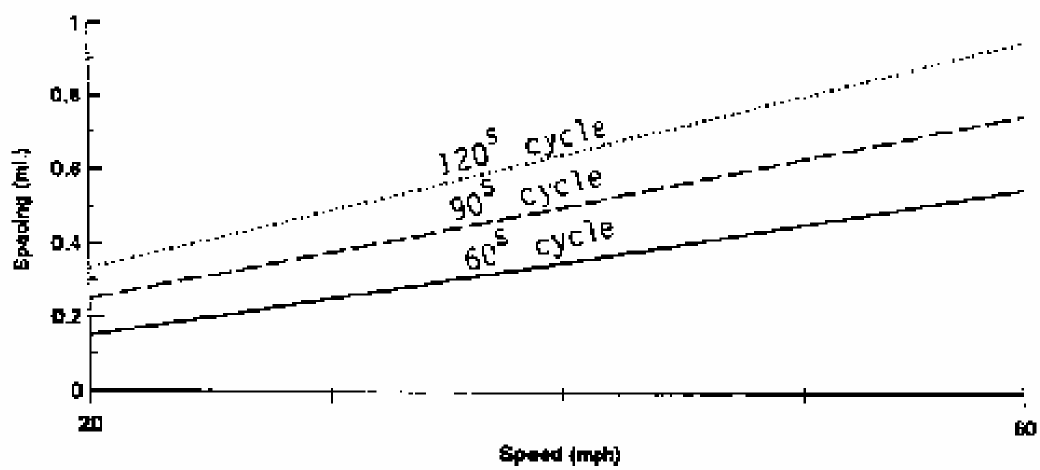


Figure 6. Signal Spacing vs. Speed

As a rural area becomes more urbanized and peak hour volumes increase, the cycle times increase from 50-60 seconds to about 120-150 seconds. Also, as the area becomes urbanized, the speeds of operation reduce from 55 mph typical of rural areas to 35-45 mph in an urbanized area. In general, from the figure, note that the most appropriate signal spacing for rural or suburban access is 1/2 mile.

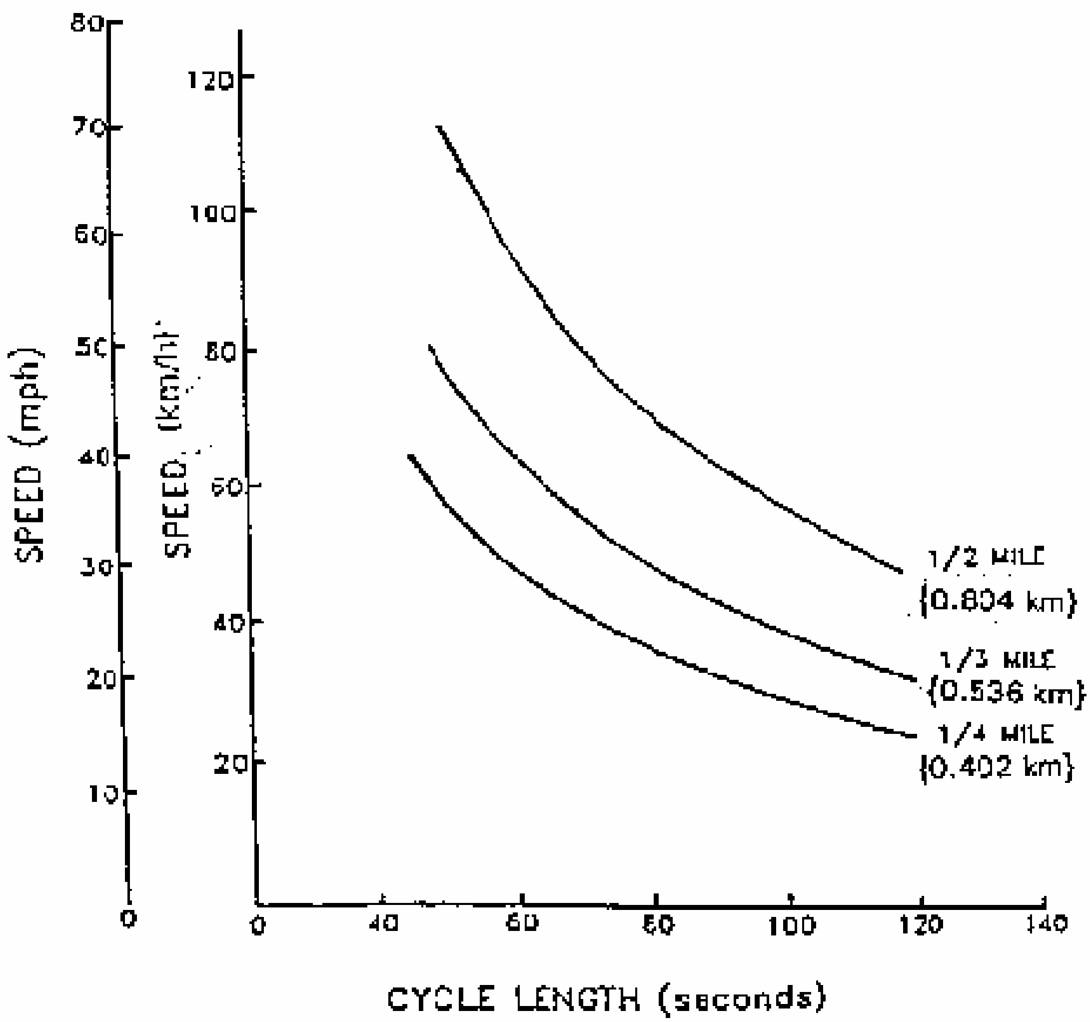


Figure 8. Relationship between Speed, Cycle Length and Signal Spacing