DESIGN CRITERIA MANUAL

CHAPTER 6 TRAFFIC CONTROL

MUNICIPALITY OF ANCHORAGE

PROJECT MANAGEMENT & ENGINEERING DEPARTMENT AND TRAFFIC DEPARTMENT

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DESIGN CRITERIA MANUAL
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Chapter 6 – Traffic Control

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Acronyms and Abbreviations

AASHTO .... American Association of State Highway & Transportation Officials
ADAAG .... Americans with Disabilities Act Accessibility Guidelines
ADOT&PF .... Alaska Department of Transportation and Public Facilities
CBD .... Central Business District
HCM .... Highway Capacity Manual
ITE .... Institute of Transportation Engineers
LOS .... level of service
M.A.S.S. .... Municipality of Anchorage Standard Specifications
MUTCD .... Manual on Uniform Traffic Control Devices
OS&HP .... Official Streets & Highways Plan
RTOR .... Right Turn on Red
TCD .... traffic control devices

SECTION 6.1 TRAFFIC CONTROL

When development occurs in urban areas, an increase in traffic volume is experienced. The service supplied by existing roadway facilities is often decreased to undesirable or unacceptable levels. The traffic control devices (TCD's) discussed in this Chapter provides assistance in maintaining or improving service levels. TCD's include traffic islands, medians, signs, pavement markings, signals, and detector loops. Specific guidelines regarding design criteria, traffic analysis requirements, and design policies are provided. The designer shall meet these standards as well as those of the American Association of State Highway and Transportation Officials (AASHTO). Information on the preparation of plans and specifications is provided in Chapter 7.

END OF SECTION 6.1

SECTION 6.2 INFORMATION

In the development of traffic control designs, the identification of specific traffic congestion problems is critical. Because of this, the designer shall collect the appropriate data for performing an operational analysis and developing the design. Types of information required include survey, soil investigation, existing TCD's, posted speed, traffic volumes, bus routes, adjacent land uses, crash records, and nearby railroad facilities.

Information on survey and soils standards are included in Chapter 1 of this manual. Additional information about other types of required data follows:

1. Operational Data

   b) Phasing and timings;

   c) Signal displays;

   d) Type of controller;

   c) Detection methodology, and

   e) Signal system interconnect requirements.

2. Traffic Data

   a) Counts and projected volumes;

   b) Speed limit and speed study;

   c) Crash history and diagrams; and

   d) Pedestrian volumes and patterns.

3. Miscellaneous Data

   a.) Bus stops and routes;

   b) Adjacent land uses;

   c) Proximity of railroad crossings;

   d) Proximity of emergency vehicle sources; and.

   e) Other construction in progress in the area.

Information on existing topographic features can be obtained from existing plans or maps and from field survey. Operational and traffic data may be available from the Municipality's Traffic Engineering Section, but may need to be supplemented. The designer shall coordinate with Traffic Engineering for specific requirements of each project.

END OF SECTION 6.2

SECTION 6.3 INTERSECTION DESIGN

In most intersection projects, an evaluation of the intersection should precede the design work. The purpose of the analysis is to document the information, assumptions, and procedures used to develop the conceptual design, and to affirm that the design level of service will be provided through the design year. The designer shall contact Traffic Engineering to determine if studies are required. If traffic modeling software is used, the designer shall submit computer input and output files, as specified by Traffic Engineering. In general, a ten-year design should be used for the intersection design study.

6.3 A Design Study Considerations

The intersection design study shall consider an analysis of the intersection traffic operation and level of service for the peak hours for each of the following conditions. The peak hours analyzed shall generally be the A.M. and P.M. peak hours for a typical weekday. However, special circumstances such as heavy shopping traffic, sporting events and school traffic may require additional analysis.

1. Existing traffic and geometric conditions.

2. Projected traffic and proposed geometric conditions in the design year, analyzed as a signalized intersection.

3. Projected traffic and proposed geometric conditions in the design year, analyzed as an unsignalized intersection.

4. Projected traffic and proposed geometric conditions at project completion, including projections of any new traffic due to trip diversions and/or known new trip generation with traffic signals in operation.

5. Projected traffic and proposed geometric conditions at project completion, analyzed as an unsignalized intersection.

6. Projected traffic and proposed geometric conditions in the intermediate year, if specified by Traffic Engineering, with traffic signals in operation.

7. Projected traffic and proposed geometric conditions in the intermediate year, if specified by Traffic Engineering, analyzed as an unsignalized intersection.

6.3 B Method of Analysis

For an isolated intersection, the level of service for both signalized and unsignalized conditions shall be determined in accordance with the procedures defined in the currently approved version of the Highway Capacity Manual (HCM)(17).

If the intersection will be part of a signal system, a more detailed analysis to determine the effects of signal spacing and impacts to progressive traffic flow may be required, using software such as PASSER II (18), TRANSYT 7F (19) or Synchro (24). Preprocessing software such as TEAPAC may be used. A detailed progressive flow analysis should include time-space diagrams. The designer is directed to contact Traffic Engineering to determine if these studies are required. The physical boundaries of the system and the conditions to be analyzed shall be defined by Traffic Engineering. If MOA has plans for signalizing additional unsignalized intersections within the system boundaries, then these intersections should be treated as signalized intersections during the analysis.

Optimal and uniform signal spacing is essential for achieving efficient progression and appropriate speeds on arterial streets. Variation from optimal and uniform spacing greatly increases driver delay and can have significant negative impacts on crash rates along a major route. The desired uniform signal spacing on arterial streets is ½ mile for arterial with operating speeds of 40 mph or greater, and 1/3 mile if operating speeds are less than 40 mph. If a signal is proposed on an arterial street and spacing deviates by more than 250 feet from the desired spacing, then the analysis must show that negative effects on progressive traffic flow are acceptable or within acceptable limits.

The designer shall develop an efficient timing plan for each set of conditions in which signalized intersection operations are to be analyzed, including existing conditions, for either isolated intersection or signal system analysis. Actual existing signal timing shall not be replaced by computer-optimized timing plans when analyzing future conditions, unless the same optimization process has been used to improve the existing timing plans.

The designer shall also use the same signal cycle length for both existing and future conditions, when analyzing signal operations for a specific time of day, unless directed otherwise by Traffic Engineering.

1. Required Level of Service

   The intersection level of service and level of service for critical movements to be provided in the design year shall be level of service D or better. The level of service (LOS) provided in the year halfway between project completion and the design year shall be C or better.

2. Application Method – Isolated Intersection

   The HCM operational and design application of level of service analysis is used for the project completion year and any intermediate year.

3. Application Method – Signal System

   The system shall be analyzed using network analysis software and methodologies approved by Traffic Engineering such as Synchro (24), or PASSERII-90 (18) and TRANSYT-7F (19) along with appropriate preprocessing software, to determine the impacts to progressive traffic flow. The designer shall contact Traffic Engineering to determine which traffic engineering software packages are acceptable. Intersection and approach LOS should be determined based on the delay in seconds per vehicle calculated by the software. An analysis of LOS based on the signalized intersection procedures in the Highway Capacity Manual is not required for alternatives that are analyzed by other approved software during the system analysis.

   Special care should be taken so that software that allows modeling of actuated control, such as Transyt 7F or Synchro, calculates results reasonably consistent with Highway Capacity Manual.

4. Traffic Modeling Parameters

   Timing parameters used when modeling traffic flow shall conform to Traffic Engineering standard operational procedures. The following parameters shall be used unless otherwise approved by the traffic engineer.

   a) Cycle Lengths

      The cycle lengths to be used shall be specified by the traffic engineer. Cycle lengths can not violate minimum pedestrian or vehicular phase times.

   b) Pedestrian Intervals

      Minimum pedestrian clearance times shall be determined using the Manual on Uniform Traffic Control Devices (MUTCD) (15) guidelines, including the Alaska Supplement, with a 4 fps walking speed from the face of curb to face of curb or median. The yellow clearance interval can be subtracted from the ped clearance time, but not the all-red. The minimum walk interval shall be 7 seconds. The walk and walk clearance intervals may need to be increased at some locations, to provide special consideration for slower pedestrians such as the elderly and small children.

   c) Minimum Phase Times

      Minimum split times of 15 seconds for left-turn phases, 20 seconds for side street through or right-turn phases, and 25 seconds for main street through phases shall be used for traffic modeling. Minimum pedestrian phase times do not generally need to be used in traffic modeling unless the intersection is fixed time such as in the Central Business District (CBD), or if a traffic actuated intersection experiences significant volumes of pedestrian traffic.

d) Lost Times

A total lost time of 4 seconds per phase shall be used, including 2 seconds of start-up lost time and 2 seconds of clearance interval lost time.

e) Yellow and All-Red Times

MOA uses yellow and all-red times at all intersections, which are based on ITE guidelines (20), using a 10 foot per second squared deceleration rate. The yellow interval is based on approach speed, and the all-red interval is calculated to allow a vehicle that enters the intersection at the end of the yellow to clear the intersection, from the first crosswalk line or stop bar to far-side curb reference line plus 20 feet, during the red interval. Actual yellow and red times shall be used in traffic modeling.

f) Default Internal Program Modules and Procedures

Traffic modeling software packages come with default procedures, or modules, that are used to model permitted turning behavior, estimate stops and delays, calculate operating costs, and perform other functions. The programs often provide alternate procedures and equations to be used for performing these functions, and allow the designer to change the default procedures. The designer shall not change the default modules used internally by traffic modeling software, unless directed otherwise by Traffic Engineering.

g) Traffic Speeds

When modeling traffic flow in a system, the speed limit should generally be used as the travel speed between intersections, unless otherwise directed by Traffic Engineering.

h) Right Turns on Red (RTOR)

The number of Right Turns on Red in a shared through and right-turn lane can be estimated by multiplying the number of cycles per hour by the percentage of right turns in the shared lane. For an exclusive right-turn lane, right-turns on red can be increased.

Some types of software calculate saturation flow rates for right turns on red. However, accuracy can vary widely. For existing intersections, right turns on red from exclusive lanes should be verified using manual counts, especially if they are critical to the intersection level of service. In no case shall the RTOR saturation flow rate exceed 1,000 pcplph.

i) Lead/Lag Phasing

Care must be taken when using lead/lag phasing. Lead/lag phasing can be used to improve progression, but shall not be used when both opposing left-turn phases are protected-permissive.

When a left-turn phase experiences heavy congestion during peak hours that may cause queue spill-over into the through lanes, it is generally not acceptable to lag the left-turn phase, because spill-over vehicles must be cleared before the start of the through phase to allow through vehicles to move after they receive a green indication. However, if opposing through traffic is light under these conditions, the left-turn phase may still be lagged.

In general, the protected portion of a protected-permissive left turn shall never lag if the opposing left turn allows permissive turns at any point. However, if no opposing left-turn phase exists, such as at a ramp intersection, lagging the protected portion of a protected-permissive left-turn phase is acceptable.

A left-turn phase should not be lagged when there is a high volume of opposing through traffic flow, because in lagging left-turn phases a single left-turn call will cause the phase to hold until the end of a simultaneous coordinated phase, which will steal needed time from the opposing coordinated through phase.

Lead/lag phasing on main streets should only be used when there is a significant demonstrated advantage for progressive traffic flow, and if used, signal sequences should not be changed too frequently during normal daily operations, as this can be confusing to drivers.

Left turns on side streets can also be lagged for progression purposes, according to the constraints listed above. Furthermore, there are instances when side street left turns can be lagged for non-progression reasons such as to compensate for the pedestrian actuation and passing of time. Under normal semi-actuated control, leading side street left-turn phases can not pick up any passed time. In addition, side street through phases must often be programmed with relatively long split times in signal controllers to allow for pedestrian actuations. If there is heavy traffic on a side street left-turn phase, and its opposing through phase is not as heavy, it is sometimes beneficial to lag the side street left-turn phase so it can pick up unused time from the opposing through phase. This can be very useful when attempting to keep cycle lengths low at especially wide intersections, as heavy side street left-turn phases can be allocated minimum vehicular split values and allowed to pick up additional time from the opposing through phase.

j) Changes in Procedures

Procedures for evaluating progressive traffic flow may change, as available traffic engineering software is frequently upgraded, and new software is developed. Traffic Engineering has final approval on the procedures to be used, and may change or update these procedures.

5. Saturation Flow Rates and Traffic Volumes

Continuous count data taken in Anchorage show that summer traffic volumes are usually higher than winter traffic volumes. In addition, studies have shown that winter saturation flow rates are significantly lower than summer saturation flow rates.

Many agencies model traffic using average yearly traffic volumes and normal summer saturation flow rates. This does not accurately represent driving conditions in Anchorage, because when traffic volumes decrease, the saturation flow rate decreases also, due to reduced lane widths resulting from snow build-up between lanes, blurred lane lines, slick conditions, decreasing hours of daylight, and other factors.

To address the differences between summer and winter driving conditions in Anchorage, summer traffic volumes and normal summer ideal saturation flow rates should be used in traffic modeling. Traffic counts taken during the summer should not be adjusted downward to reflect average driving conditions unless saturation flow rates are reduced as well. Studies by MOA have shown that the average ideal saturation flow rate is lower than the standard of 1900 passenger cars per hour per 12-foot lane given in the Highway Capacity Manual. A value of 1850 pcphpl should be used for summer driving conditions, unless field studies are performed that indicate otherwise.

In some cases when an intersection or signal system is located near large winter activity centers such as schools and shopping centers, traffic volumes may actually be higher during winter. In these instances winter driving conditions are more critical and should be analyzed instead of summer conditions. Studies conducted in Anchorage and in Fairbanks, Alaska (21) indicate that saturation flow rates should be reduced by 15% to represent average winter driving conditions, and that total lost times of 4 seconds per phase are adequate for both summer and winter conditions.

6. Queue Lengths

When designing turn lanes at signalized intersections, there shall be at least a 95% probability of storing all left-turn vehicles in a left-turn lane during the peak hour. The designer shall be aware of the differences in queue length calculations provided by different software. Some software provides queue lengths based only on arrivals during the red phase, while others account for vehicles joining a queue after the signal has turned green. A worst case scenario must be considered for design purposes.

6.3 C Lane Configurations

The operational level of service analysis is used to determine the required through lanes and auxiliary lanes (left- and/or right-turn lanes) needed to provide the necessary intersection level of service and to provide for minimal degradation of main street traffic flow.

1. Exclusive Right-turn Lanes

Single and double right-turn lanes shall be considered as a means of achieving the desired level of service where the specific turning volumes are high.

Exclusive right-turn lanes shall be constructed on all main street approaches at any signalized or unsignalized intersection constructed on a roadway classified as an arterial in the Municipality of Anchorage's Official Streets and Highways Plan (OS&HP).

Driveway entrances with a projected right-turn traffic volume of greater than 20 vph during the peak hours shall also provide for an exclusive right-turn lane on the arterial approach. Other driveway entrances along an arterial shall provide for efficient or tapered entrances so as to reduce friction to traffic traveling along the arterial. Excluding right-turn lanes at any intersection, including driveways, causes excessive friction and platoon dispersion along the arterial resulting in break downs in travel speed and signal coordination.

Exclusive right-turn lanes shall also be installed on side street approaches at intersections where signals are constructed, or it is anticipated that signal warrants will be met within the design year. Exclusive right-turn lanes at side street approaches to signalized intersections provide for efficient operation. Where these lanes are not provided, right turn on red (RTOR) vehicles will be detected and put in false calls to the controller. This results in stopping main street traffic to service RTOR vehicles that have already left the intersection, causing unnecessary intersection delay and down grading arterial operations.

Right-turn lanes on side street approaches also provide for improved level of service at unsignalized intersections, and can forestall the need for a traffic signal at intersections where traffic volumes are close to satisfying signal warrants. Exclusive right-turn lanes on side street approaches allow for efficient movement of right-turn vehicles, which can often move unimpeded. Where these right-turn lanes exist, right-turn volumes should be excluded when performing traffic signal warrant analyses if the movement can be made with minimal conflict. Refer to the MUTCD (15).

2. Exclusive Left-Turn Lanes

   Left-turn lanes greatly improved the operation of signalized intersections. In areas such as the central business district, where speeds are low and right-of-way is not always available or feasible, the benefits of left-turn lanes may be outweighed by the costs.

   Exclusive left-turn lanes shall be provided on main street approaches to all traffic signals constructed outside of the downtown area. Exclusive left-turn lanes should also be constructed on all side street approaches at signalized intersections on streets classified as arterials in the Official Streets and Highways Plan.

   Over designing side street approaches at signalized intersections greatly improves arterial service, even when the impacts that additional lanes have on intersection level of service are small. Additional lanes on side street approaches reduce the amount of time needed to service the side street traffic, thereby increasing the arterial through bandwidth. This is especially important where signal spacing is poor. For each 1% that signal spacing deviates from the desired uniform spacing, arterial through band width is decreased by 1%. Over designing the side street can help to compensate for poor spacing, to an extent.

6.3 D Signal Phasing

Traffic conditions which warrant signalization can vary significantly. For example, substantial left-turn volumes may occur in one location and not another. Because of this, flexibility in adapting signals to specific site concerns is important. Listed below are several signal phasing alternatives.

1. Permissive Left Turns

   Permissive-only left turns (no separate signal phase displayed) shall be used unless more restrictive left-turn phasing is required. Unnecessary left-turn phases decrease signal efficiency and increase travel delay.

2. Protected/Permissive Left-Turn Phasing

   Protected/permissive left-turn phases are required when any one of the following criteria is met:

   a) They are needed to achieve the required level of service; or

   b) The product of the left-turn peak hour volume and the sum of opposing through and right-turn peak hour volumes exceeds 50,000 for one opposing lane and 100,000 for two or more opposing lanes.

   Protected/permissive phasing shall always include a feature to prevent a lagging left turn, except where the opposing left turn is prohibited. Protected/permissive phasing and protected-only phasing shall not be mixed on opposing left-turn phases.

3. Protected Left-Turn Phases

   Protected-only left-turn phases shall be used when any one of the following criteria is met in addition to Item 2 above:

   a) If dual left-turn lanes are being used.

   b) If there are 4 or more opposing through lanes, or if the 85th percentile speed of opposing traffic is 55 mph or greater.

   c) If there is inadequate sight distance for the left-turn driver and the on-coming vehicle to detect each other.

This situation includes the case where sight-distance may be limited by an opposing left-turn vehicle. Left-turning sight distance shall be calculated in accordance with AASHTO standards (3), as discussed in section 6.4 C of this manual. Both stopping sight distance for the opposing through traffic and crossing maneuver sight distance for the left-turning vehicles should be checked.

d) If lead-lag left-turn phasing is to be used to improve traffic progression.

e) If crash records indicate there are 5 or more left-turn crashes per year, and protected / permissive left-turn phasing has been installed.

f) If the opposing left turn requires protected only phasing.

g) Additionally, the designer is directed to analyze the following risk factors.

(1) 85% speed of opposing traffic greater then 45 mph.

(2) 3 or more opposing through lanes.

(3) Peak hour left-turn volume greater than 300 vph.

(4) The product of left-turn and opposing through- and right-turn traffic exceeds 150,000 for one opposing lane, or 3000,000 for two or more opposing lanes.

(5) Opposing through traffic approaches the intersection along a significant horizontal curve.

If three or more of these risk factors exist, then protected only phasing shall be used. If one or less exist, then protected-permissive phasing may be used. If two of these factors exist, and are only marginally satisfied, then protected-permissive phasing may be used with the approval of the traffic engineer, and crash rates should be tracked after implementation to insure they do not rise above unacceptable levels.

4. Split Phasing

Split phasing is defined as separating two opposing directions of traffic such that the compatible through and protected left-turn movements receive the right-of-way simultaneously. This phasing shall only be used if one of the following conditions exists:

a) The opposing approaches are offset to the extent that simultaneous left turns in opposing directions would cause a high number of conflicts, resulting in a high collision potential.

b) Multiple left-turn lanes are used in one or both directions and the turning radii are not sufficient to allow simultaneous -s without conflicts between opposing left-turn traffic.

c) The left-turn volume is extremely heavy on an approach that does not allow the construction of a separate or additional left-turn lane.

d) Left-turn volumes are extremely heavy on opposing approaches and both are nearly equal to the adjacent through movement critical lane volume (a check is required to determine that the design hour level of service will be significantly improved and that there will not be substantial decreases in level of service during other hours of the day).

e) The critical lane volumes are lowest when drivers are permitted to turn left from more than one lane, and are also permitted to use the right-most left-turn lane as a through lane.

f) If the intersection is an interconnected system and the coordination phase would be improved by splitting the phases.

5. Right-Turn Arrows Displayed with Congruent Left-Turn Arrows

An example of this operation is when a left-turn arrow on a main street approach is displayed simultaneously with a right-turn arrow on the side street approach. This type of overlap is only to be used where there is a right-turn lane and all of the following criteria are met:

a) There are 250 or more right turns during a peak hour.

b) There are 200 or more corresponding left turns during the same hour.

c) The per lane through volume for the same approach is approximately equal to, or less than, the right-turn volume.

d) There are no pedestrian conflicts.

e) U-turns for the congruent left-turn phase are not required to provide adequate access for local businesses.

6. Overlaps

Overlaps are encouraged where feasible.

6.3 E Traffic Controller Type

All controllers shall be compatible with the existing Anchorage traffic control system and contain necessary internal communication.

END OF SECTION 6.3

SECTION 6.4 GEOMETRIC DESIGN ELEMENTS

If construction of geometric changes in the roadway are required, the work shall be done in accordance with Chapter 1 of this manual, AASHTO, and the following criteria.

6.4 A Design Speed

The design speed for a roadway is the anticipated 85th percentile speed plus five mph, or as directed by the Traffic Engineer.

6.4 B Design Vehicle

The design vehicle is generally a WB-50 (AASHTO), or as directed. However, for signalized intersections or intersections where signals are anticipated in the future, the right-turn movements shall be designed for a CITY-BUS (AASHTO) design vehicle, if buses are the largest vehicles expected to frequently turn in to or out of the side street, and there are no known commercial developments requiring frequent access of larger vehicles located within the area served by the signal. Figure 6-1 illustrates a typical minimum design for this case.

6.4 C Auxiliary Lane Design

The type of left-turn protection to be used shall be determined using the requirements in Section 6.3 D of this manual. Sight distance for left-turning vehicles shall be calculated in accordance with AASHTO Case III A - Crossing Maneuvers (3), with the following minimum parameters:

1. J Value of 2.0 seconds

2. Normal acceleration, passenger car

3. Passenger car in opposing left-turn lane

4. Clearance of the lanes in which the oncoming vehicles are traveling

If the 85th percentile speed of opposing traffic is 45 miles per hour or greater, or 40 mph or greater with three or more opposing through lanes, the sight distance requirements listed in Table 6-1 must also be met for permitted or protected/permitted operation (from reference 22). The intent is that permitted left turns on high speed multi-lane facilities should only be allowed if sight distances significantly greater than AASHTO minimums are provided.

TABLE 6-1
SIGHT DISTANCE REQUIRED FOR A HIGH SPEED PERMITTED LEFT TURN

Operating Speed (mph)	Required Sight Distance (feet)	
	2 Opposing Thru Lanes	3 Opposing Thru Lanes
40		560
45	590	630
50	650	700

The length of the left- or right-turn lanes are determined using AASHTO standards or as directed by Traffic Engineering. The minimum auxiliary lane length is 150 feet unless restricted by other factors. The maximum left-turn lane length should be 400 feet. If the expected queue storage length exceeds 400 feet, a dual left-turn lane shall be considered. Additional information on horizontal sight distance at intersections is provided in Section 1.6 E of this manual. Auxiliary lane widths shall be in accordance with AASHTO.

When designing permissive or protected-permissive left-turn lanes on streets with medians, the designer shall take into account the negative impact of increasing median width. Wider medians create a greater negative offset between opposing left-turn vehicles, which results in the sight distance for a left-turn vehicle being obstructed by a left-turn vehicle on the opposing approach. The designer should attempt to either:

Provide a positive offset of 2 feet between opposing left-turn lanes, or

Provide a minimum width median in the proximity of the intersection (2 feet), and increase left-turn lane width to 14 feet so that vehicles can offset positively to improve sight distance.

6.4 D Tapers

All approach taper ratios shall conform with AASHTO standards.

6.4 E Islands

Traffic islands are intended to provide separation at intersections for traffic going in opposing directions. Island sizes and dimensions shall meet AASHTO standards. Curb and gutter types listed in Section 1.6 F are to be used.

6.4 F Medians

Medians shall be constructed on all approaches carrying two-way traffic at signalized intersections and anticipated future signalized intersections. Medians prevent turning traffic from driving over detection on the cross street when executing their turning maneuvers. Where medians are absent at signalized intersections, turning vehicles continually drive across cross street detection and enter false calls to the signal controller. This significantly degrades intersection efficiency, resulting in signal phases being served when no vehicles are present.

Medians differ from islands in that they are not limited to intersections. Medians often extend the full length of a road and provide separation for traffic going in opposite directions as well as left-turn restriction. Median design considerations are:

1. The minimum width of a raised median is two (2) feet from back of curb to back of curb. A six-foot width shall be considered where dual left-turn lane is opposed by three or more right and through lanes to provide pedestrian storage.

2. Raised medians are to be constructed of mountable curbs. The first four feet of each nose shall be constructed with a ramped approach. A standard detail for medians is found in MASS.

3. Raised medians separating a left-turn lane from the opposing traffic should extend upstream to the beginning of the full width left-turn pocket.

4. Both vehicle and pedestrian characteristics shall be considered in the location of the median noses.

6.4 G Bus Turnouts

1. Bus turnouts shall conform with MOA standard details. For further information refer to Design Criteria Manual Chapter 7 Public Transportation. If bus stops are located on the approach to a signalized intersection and within the operational area of the intersection, then turnouts shall be provided. The operational area is the distance between the back of the 95% queue and the stop bar or crosswalk.

2. Far-side turnouts are preferred, but near-side may be necessary from on occasion. Factors to be considered include the traffic movement patterns, transfer opportunities, available right-of-way and other geometrics. Approval from Traffic Engineering is required for near-side turn-out installations.

6.4 H Bike Trails

At intersections, all pathways are to be designed to match up with the pedestrian crosswalks. For further information, refer to Chapter 4 of this manual.

6.4 I Pedestrian Landings

At intersection corners without sidewalks, where traffic signal poles are to be installed, a pedestrian landing shall conform with MASS standard details and the Americans with Disabilities Act Accessibility Guideline (ADAAG).

6.4 J Landscaping

1. The designer will assure landscaping and vegetation do not obstruct the visibility of side mounted signal heads, overhead signal heads or post-mounted signs. Required visibility of signal heads is given in section 6.6 A. Allowance shall be made for future growth of newly planted vegetation.

2. Landscaping, vegetation, planters, fences, or other appurtenances shall not be placed such as to interfere with cabinet access, opening of the cabinet door, load center access, or junction box opening and access.

3. At signals, landscaping and other appurtenances shall not be placed so as to obstruct the sight distance of conflicting vehicles for RTOR vehicles, using AASHTO sight distance requirements. Sight distance shall be determined using the procedures for stop control on the minor approach, with the drivers eye located at least 14.4 feet, and preferably 20 feet, from the edge of the traveled way. A drivers eye height of 3.5 feet above the roadway surface, and an object height of 3.5 feet above the surface of the intersecting road shall be assumed.

4. For the purpose of this section fully matured landscaping shall be used as a basis in determining sight distances.

6.4 K Driveways

Poorly spaced or under-designed driveways significantly degrade arterial through traffic operations, cause excessive delay to drivers exiting the driveways, and can result in increased crash rates along an arterial. Table 6-2 lists the minimum driveway spacing for arterial streets

TABLE 6-2 MINIMUM DRIVEWAY SPACING ON ARTERIAL STREETS

85th percentile through traffic speed (mph)	Minimum Driveway spacing (feet)	Desirable Driveway spacing (feet)
30	185	210
35	245	300
40	300	420
45	350	550
50	425	690

Refer to the Traffic Departments Driveway Standards when constructing driveways on an arterial for any type of commercial development The designer shall meet the spacing requirements of Table 6-2, including existing signalized or unsignalized intersections in the vicinity of the new driveway. When existing driveways are already poorly spaced or have sub-standard design, the designer shall attempt to combine or move driveways to the extent feasible without creating a need for a signal at an undesirable location. Driveways on opposite sides of the arterial should be aligned with each other and not staggered, unless separated by a median.

In addition to the spacing requirements in Table 6-2, driveways for commercial developments shall not be constructed within the operational area of a signalized intersection, where it will cause side street vehicles to cross through queues of vehicles stopped at the signal. It is also important to meet spacing requirements on the downstream side of the signal, where vehicles slowing to turn after driving through the signal degrade signal capacity.

Driveways for any type of commercial development on arterials meet the requirements for auxiliary lanes given in Section 6.3 C. If the commercial development is large enough to justify a signal, or it is possible that a signal may be justified in the future, then throat length is crucial. The unobstructed minimum throat length shall be 250 feet, or the 95% back of queue, which ever is greater. No intersecting driveways will be allowed within this distance on the approach to the signal.

END OF SECTION 6.4

SECTION 6.5 PAVEMENT MARKINGS

Pavement marking locations act as guides in the placement of signal heads and detector loops. Therefore, these markings shall be identified prior to signal design. Pavement markings are provided on a standard detail sheet available at the Traffic Department. Pavement markings shall conform to requirements of the State of Alaska's Traffic Manual, MASS, the Alaska Department of Transportation and the MUTCD, and the following guidelines.

6.5 A Materials

1. Pavement markings as specified in the MASS shall be used for all lane lines, island markings, and cross hatching on new paving and existing pavement within project limits.

6.5 B Lane Lines

1. Lane lines shall align with corresponding lane lines on the opposite side of the intersection when practicable. Offsets are acceptable only if approved by the Traffic Engineer.

2. Lane lines are to terminate at the crosswalk or stop bar if one is used.

3. All lane lines shall be in conformance with the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD, 15).

4. When skip striping is used, stripes shall be 10 feet long with 30 foot spaces in between.

5. Dotted lines extending through the intersection are required for dual left or right-turn lanes. This striping should be installed such that the left-turn lane nearest the median or right lane nearest the curb are guided into the nearest available lane on the intersecting street. It shall consist of 8-inch by 12-inch rectangles, with 3 foot spaces in between. The use of methylmethacrylate or thermoplastic materials shall be in accordance with Section 6.5 A or as directed by the Traffic Engineer.

6.5 C Crosswalks

1. Crosswalks shall be installed across <u>signalized</u> approaches except where pedestrians are prohibited from crossing. Crosswalks shall provide access to all corners of an intersection.

2. Crosswalk lines shall be 24-inch wide painted lines and be ten feet from inside of line to inside of line

3. Crosswalks shall align with ADA curb ramps, but not necessarily centered.

4. Crosswalks shall align with pedestrian signal indications.

5. At signalized intersections, crosswalks should be placed as perpendicular to the street as possible to minimize pedestrian crossing time, minimize pedestrian exposure time, and increase timing efficiency.

6. At signals where split phasing is used, only one pedestrian crosswalk should be used for the two split phases. This crossing should correspond with the phase that has the heaviest through-traffic volumes, unless conditions such as pedestrian traffic characteristics, adjacent trails, or heavy conflicting right-turn traffic require installing the crosswalk on the least heaviest phase.

7. Pedestrian crosswalks should not cross multiple permissive left-turn movements, unless pedestrian phases can be separated from the vehicular phase.

6.5 D Stop Bars

1. Stop bars are required at all traffic signal and stop sign locations which do not have a crosswalk.

2. Where a stop bar is used, it shall be 24-inches wide, white, and extend from the curb to the median (or solid double

yellow line). It shall be located in accordance with the Alaska Traffic Manual.

6.5 E Turn Arrows and Legends

1. "Arrow-Only" combinations shall be located four feet from the stop bar or crosswalk in each left- (right-) turn lane. Another combination shall be provided 200 feet from the first if the turn lane pocket is of sufficient length.

2. Arrows in through lanes are not permitted unless specifically approved by the Traffic Engineer.

6.5 F Approach to Obstruction

If the intersection involves a state highway, raised medians shall have pavement markings on the approach to the median in accordance with ADOT/PF standard drawings.

END OF SECTION 6.5

SECTION 6.6 HARDWARE DESIGN

Traffic signal hardware shall be designed in accordance with the Alaska Traffic Manual, MASS, and the criteria listed in this section. Signal locations, whether near-side or far-side, shall conform with MUTCD. Design standards are provided for traffic signal heads, pedestrian signal heads, signal head relocations, mast arm assemblies, and poles. A sample hardware schedule sheet is provided in in Design Criteria Manual Chapter 8.

6.6 A Vehicle Signal Heads

1. The number and location of required signal heads is provided in Figure 6-2.

2. Sizes and configurations shall meet the following criteria:

   a) All heads shall be oriented in a vertical alignment;

   b) All sections of vehicle signal indications shall be 12 inches except in the CBD where they may be 8 inches;

   c) All sections of heads containing arrow indications shall be 12 inches;

   d) Protective/permissive overhead left-turn signal heads shall have a cluster configuration as shown in Figure 6-3.

3. Signal Mounting Height

   The bottom of a signal housing suspended over a roadway shall not be less than 18 feet above the road surface immediately below the signal. For overhead signals located 53 feet or more horizontally from the stop bar, the top of the housing shall not exceed 25.6 feet above the road surface. If signals are less than 53 feet from the stop bar, the maximum mounting height shall be determined using the MUTCD.

4. Type of Signal Head

   a). Optically programmed signal heads shall only be used whenever the indications can be viewed by two or more conflicting movements of traffic at skewed intersections, or at closely spaced intersections, where vehicles can be drawn through an intersection by the signals at a farther downstream intersection. This will eliminate signal projection to those for which the signal does not apply.

   b. Bi-modal indication signal sections are not acceptable unless prior approval is obtained from the Traffic Engineer

   c. All traffic signal heads shall be equipped with a tunnel visor. This will block signal viewing to those which the signal does not apply while minimizing snow buildup in front of the lens.

   d. Full circle or cut-away visors will not be allowed.

5. Type of Mounting

   a. All holes in mast arms shall be field drilled to ensure proper location of signal heads with respect to traffic lanes.

   b. Top of pole signal heads shall be mounted with a slip-fitter as shown in MASS.

   c. Sidemount signal heads should be mounted on the side of the pole away from vehicular traffic using terminal compartments.

   d. Sidemount terminal boxes shall not be attached to more than 2 heads and shall not have more than 1 head mounted per side.

   e. Pole and post mounts should be avoided in medians. Signal poles that are placed in the medians should be fixed base with crash cushions or other approved protection devices. .

f. When two heads of different lengths are attached to the same terminal box, then the mounting shall have 5 elbows, as shown in M.A.S.S.

6. Back plates

All signal heads shall be equipped with back plates. Louvered back plates are not allowed. Signal heads with only eight-inch sections shall have a five-inch back plate. Signal heads with 12-inch sections shall have five-inch back plates.

7. Wiring Holes

The specifications shall include the requirement that signal mast arms be drilled for wire accesses after installation of the pole base. The intent is to order mast arms with no holes or nipples and drill holes on site after the pole location is certain. The wire hole locations shall be centered on the mounting bracket on the signal head side of the mast arm.

8. Identification Scheme

Each signal head shall be identified on the plan sheet by a two-digit number. The left-most digit represents the phase number which the signal head serves. See Section 6.7 B for proper phase designations. The right-most digit represents the signal head number for the given phase with the heads being numbered in sequence from 1 to N starting with the signal head on or closest to the far right pole and numbering to the left, or counter clockwise around the intersection. This is illustrated in the sample signal plan sheet provided in DCM Chapter 8. Figures 6-4 and 6-5 depict the proper identification scheme for N/S and E/W main streets.

Protected and protected/permissive left-turn heads shall be numbered with the appropriate turn phase.

9. Signal visibility

Two signal heads for the major movement on each approach shall be visible for the minimum distance from the intersection provided in Table 6-3 from all travel lanes on the approach:

TABLE 6-3 SIGNAL VISIBILITY

85^{th} Percentile Speed (mph)	Minimum Signal Visibility Distance (feet)
25	270
30	325
35	390
40	460
45	540
50	625
55	715
60	820
65	900

6.6 B Pedestrian Signal Heads

1. The type and number of pedestrian signal heads required is determined as follows:

   a) Pedestrian signal heads shall be installed wherever crosswalks are provided;

   b) Pedestrian heads shall be installed at each end of the crosswalk being controlled; and

   c) Pedestrian signal heads shall be in conformance with MASS.

2. Legend

All pedestrian signal heads shall have international symbol messages consisting of a Portland orange hand and a lunar white walking man.

3. Location

Pedestrian signal heads shall be located as nearly in line with the crosswalk as possible. If the mast arm pole is located where the pedestrian signal will be blocked by stopped vehicles, or if it is more than 20 feet outside of the crosswalk lines extended, then an alternative means of mounting shall be designed. Pedestrian heads shall be mounted 7.5 feet (to the bottom of the head) above the walking surface on the side of the pole away from vehicular traffic.

4. Identification Scheme

   Each pedestrian signal head shall be identified on the plan sheet by a two-digit number. The left-most digit represents the vehicular phase number with which the pedestrian movement is compatible. See Section 6.7 B of this manual for the proper phase designations. The right-most digit for each pair of pedestrian signal heads shall be eight for the far-side signal head and nine for the near-side head when facing the direction of the compatible vehicular phase. If there are median pedestrian heads, then the right-most digit shall be seven if there is one head, and the right-most digits shall be six and seven if there are two heads. This is illustrated in Figures 6-4 and 6-5.

6.6 C Relocating Signal Heads

Signal heads shall be relocated only when they are in good condition and no modifications are necessary. LED heads shall be replaced if over 3 years old, and may be reused or relocated if less than 3 years old.

6.6 D Signal Poles and Mast Arm Assemblies

A standard detail sheet for pole and mast arm assemblies can be obtained from Traffic Engineering.

1. Pole Placement

   a) Poles shall be located at least six feet behind the back of the curb line extended on curbed streets with speeds of 35 MPH or less. They shall be at least four feet from the curb in curb return areas.

   b) On streets without curbs or with speeds greater than 35 MPH, poles shall be located a minimum of ten feet behind the edge of pavement or two feet behind the edge of the shoulder, whichever is greater. They shall be located 15 feet from the edge of the through-traffic lanes extended.

   c) Signal poles shall be aligned with pedestrian crosswalks when practical.

   d) Signal poles shall be located as close to the sidewalk or pedestrian landing as possible for pedestrian push-button access without encroaching into the pedestrian access route. Push-buttons shall be accessible to the handicapped and shall conform to the Americans with Disabilities Act (ADA) requirements, for new construction. However, locations shall still meet the guidelines for distance from the curb, pathway, or traveled way. If poles can not be located to provide push-button access that conforms with ADA, then auxiliary push-button poles are required.

   e) Pole locations shall not impact the usability of walkways and trails.

   f) Poles that have mast arms that exceed 56 feet in length shall be avoided. The geometric design of the intersection should not require excessive mast arm lengths. The designer shall consider median poles if necessary.

2. Mast Arm Lengths

   a) Mast arms longer than 56 feet in length require an evaluation of the foundation to be used and approval of the Municipal Traffic Engineer.

   b) Mast arm lengths shall allow for probable future modifications to the signal. If a left-turn lane exists, the arm shall extend six feet beyond the lane lines separating the left-turn and through lanes, even if no separate left-turn phase is being designed.

c) The centerline of the mast arm shall be at 90 degrees to the centerline of the approach it is serving unless required otherwise.

d) Mast arms shall not exceed 65 feet in length.

3. Clearances from Utilities

Poles shall be located so that all portions of the poles and attached equipment have clearances from overhead utilities in accordance with the requirements of the local utility and the National Electrical Safety Code (NESC). All clearances shall be clearly marked in the design plans.

4. Material

Materials shall conform with MASS or as directed by the Traffic Engineer.

5. Delivery Time

Typical delivery time for mast arm poles is 18 to 24 weeks from the approval of the manufacturer's shop drawings. The number of working days specified in the contract shall allow for the long delivery time.

6. Luminaire Extension and Arm on Signal Mast Arms

When used, luminaire extensions on mast arm poles shall provide for a luminaire mounting height of 40 feet, unless otherwise specified. Luminaire mounting height shall be coordinated with other roadway lighting.

7. Identification Scheme

Traffic signal poles shall be identified on the traffic signal plan sheet by numbering them in sequence, beginning with the pole on the northwest corner and continuing in a clockwise direction around the intersection. Luminaire poles shall be numbered beginning with the next higher number from the last traffic signal pole numbered. The numbering shall begin with the pole nearest to signal pole #1 and continue away from the corner for luminaries in that quadrant of the intersection. This scheme shall continue with all poles on the same quadrant as signal pole #2, pole #3, and then #4.

6.6 E Luminaires

1. All intersection lighting located on traffic signal poles shall be 240V.

2. At signalized intersections, a luminaire should be placed above each crosswalk, unless pole location, overhead utility conflicts, or other circumstances prevent doing so. Luminaire arms should be on the far right pole paralleled with the signal arm to be viewed by the driver, as vehicles approach the intersection.

3. The desired luminaire arm length is 15 feet. Luminaire arm length varies, depending on pole setback.

4. Specific criteria on street lighting are provided in Chapter 5.

END OF SECTION 6.6

SECTION 6.7 CONTROLLER DESIGN

6.7 A Controller Types

Materials and construction shall conform with M.A.S.S. A standard detail sheet on controllers can be obtained from Traffic Engineering.

6.7 B Phasing

1. The sequence of operations shall be shown by a phasing sequence diagram for each intersection on the plan sheet. A sample plan sheet showing format is provided in DCM Chapter 8. Permissive movements shall not be indicated unless part of a protected/permissive sequence. All phasing for pedestrian movements shall be shown.

2. Phases shall be designated on the traffic signal plan sheet in accordance with the standard phase designations. In addition, the phases shall be assigned as follows:

   Phase 2 - main street, northbound or westbound

   Phase 6 - main street, southbound or eastbound

   Phase 4 - side street, westbound or northbound

   Phase 8 - side street, eastbound or southbound

6.7 C Controller Cabinet Location

The controller cabinet should be located to minimize the probability of being hit by a vehicle and outside of intersection visibility triangles. Visibility triangles are identified in Section 1.6 F of this manual. Additionally, cabinets shall be located as to not obstruct the sight distance of conflicting traffic for RTOR vehicles, using AASHTO sight distance requirements for intersections with stop control on the minor approach, and with the drivers eye located at least 14.4 feet, out preferably 20 feet, from the edge of the traveled way. It should be assumed that the driver’s eye height is 3.5 feet above the roadway surface, and that the object height is 3.5 feet above the surface of the intersecting road.

1. Locations particularly susceptible to crash damage are:

   a. The far corner (apex) for a dual left-turn or right-turn movement where the crossing street does not have a raised median;

   b. The far corner (apex) for a heavy left-turn movement; and

   c. The far-right corner of a high-speed approach where a right-angle collision can knock a car into the controller.

2. The controller shall be located upstream on the heaviest approach and/or back from the corner on the minor approach if there is a significant difference in approach volumes or speeds.

   Consideration shall be given to locating the controller where it is protected by a non-breakaway pole or guard posts.

3. The controller should be located on the same corner as the power supply. Special care shall be taken that the load center is not separated from the controller by a wide, high-speed or high-volume street.

4. Areas subject to flooding shall be avoided.

5. Cabinets shall be positioned to prevent splash-back from the roadway gutters into the opened cabinet door, and should be positioned so that maintenance personnel have a clear view of the intersection and the inside of the cabinet simultaneously. The cabinet shall be positioned so that the door opens counter clockwise (right-handed). After the cabinet location has been determined, the positioning of the cabinet shall be approved by Signal Maintenance.

6. A clear area for parking maintenance vehicles should be left in the corner of the intersection where the cabinet is located. This area should be located so that the parked vehicle will not impede maintenance personnel's view of the intersection, obstruct driver sight distance, or block pedestrian pathways.

7. The cabinet should not be located where addition of right-turn lanes at a future time would require relocating the cabinet.

6.7 D Load Centers

Signalization systems shall be served by meters which are located on load centers. The designer shall carefully evaluate whether all electrical loads in a particular area should be fed from one meter. This is because one municipal department pays for lighting or signalization energy and another pays for thaw-wire energy. If the same agency is paying for all energy, only one load center should be installed whenever economically feasible. It is the designer's responsibility, working through the project manager, to determine whether a single meter is allowable or whether multiple meters are required.

It is also the designer's responsibility to coordinate with street lighting and/or thaw wire design personnel to insure that a common meter location is satisfactory to serve all loads. The designer shall also coordinate multiple meter locations so as to minimize visual clutter and the expense of connecting utility service to the meters.

Once the required number of meters is determined, the designer shall contact the servicing utility to coordinate meter base location and determine hook-up procedure. Obtaining written approval of the location from the utility is recommended. The submission of any required utility applications for hook-up is the responsibility of the designer, in coordination with the project engineer.

MASS requires the contractor to obtain electrical permits and inspections. The contractor shall also be required to advise the utility when the system is ready for hookup.

Load center locations shall conform to section 6.7 C., except for item number 5.

END OF SECTION 6.7

SECTION 6.8 DETECTOR LOOP DESIGN

6.8 A Controller Types

The purpose of detector loops is to detect traffic and communicate that information to the signal controller. Detector loops shall be installed at intersections where traffic warrants and as directed by the Traffic Engineer. Municipal design guidelines and criteria are provided in this section. MASS provides standard loop specifications and a standard detail sheet for detector loops can be obtained from Traffic Engineering.

The "home run" and the "home run loop wires" are defined as the pair of wires and encasing conduit from the loop in the traveled lane to the nearest junction box. The "lead-in" or "lead-in cable" is defined as the shielded twisted pair cable from the junction box to the controller cabinet.

Except where noted otherwise, dimensions for detector loop setbacks shall be referenced from the extension of the curb line or edge of traveled way on the right-hand side of the approach which is referred to as the "detector reference line" (Figure 6-6). The detector reference line should be curved if needed to follow the alignment of the cross street.

The following subsections define standard loop placement. Traffic Engineering may require changes to standard loop placement, if warranted by special conditions or traffic engineering experience. Plans shall be delivered well before construction begins, to allow Traffic Engineering adequate time for review of loop placement.

6.8 B Identification Theme

1. Detector loops shall be identified by a three-digit number. The left-most digit will represent the phase which the detector will call. If a left-turn lane has detector loops, the left-turn lane loops shall be identified by the appropriate left-turn phase number even if there is no left-turn phase. If the opposing through movements are assigned to the same controller phase, the loops must still be numbered according to the phase they would serve if the movements were on separate phases.

2. The second digit identifies the lane associated with that phase. Multiple lanes shall be numbered from left to right when facing the same direction as traffic for that approach. Left-turn lanes shall be numbered separately from through lanes; right-turn lanes numbered as a through lane.

3. The right-most digit of the identification number shall be assigned sequentially to the loops associated with that lane. The numbering shall begin with "1" assigned to the loop furthest from the intersection and continue toward the intersection.

6.8 C High-Speed Approaches

High-speed approaches are those where the posted speed is greater than 30 MPH.

1. Location

   a) For high-speed approaches, two loop detectors for each through lane of traffic shall be located according to the information in Table 6-4, unless otherwise directed by Traffic Engineering. Note that the location of these loops is based on the posted speed or 85th percentile speed, which may be different than the geometric design speed of the roadway.

   b) In addition to the advance detectors, two stop bar loops shall be placed near the crosswalk in each lane. One detector loop shall be placed 14 feet back of the reference line and the second placed an additional ten feet upstream of the back edge of the first detector. However, for main street approaches where it is anticipated that the main street green indications will be operated with minimum phase recalls and locking detection, Traffic Engineering may require only one stop bar detector in each lane, 20 feet upstream of the detector reference line.

In addition, on State Roads, the ADOT&PF may require the use of three stop bar detectors instead of two, with the third detector placed 10 feet upstream of the back of the second.

At locations involving skewed intersections, or other extenuating circumstances, the loop positions may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. Care shall be taken to not leave too much undetected space immediately upstream of the crosswalk. The intent of the loop placement is to prevent the smallest passenger cars, motorcycles, and bicycles from being caught in an undetected area. If adjusted, the distances between the two stop bar detector loops shall remain constant.

TABLE 6-4 DETECTOR LOOP SPACING ON HIGH SPEED APPROACHES

Posted Speed* (mph)	Advanced Loop Setback from Reference Line (feet)	Intermediate Loop Setback from Reference Line (feet)	Passage Time (sec.)
55	385	255	2.2
50	355	235	2.5
45	330	210	2.5
40	285	190	2.0
35**	255	170	2.0

* Or 85th percentile speed, whichever is less.
**Presence detection is to be used for side street approaches if the higher through phase critical lane volume for the side street is less than one-half the critical lane volume of the higher volume main street through phase.

2. Detector Lead-ins and Home-Runs

a) The upstream and intermediate detector loops for the dilemma zone protection shall be on separate detector amplifier channels, for approaches with single through lanes, and the upstream and intermediate loops shall be common to a single 7-pair lead-in cable (Figure 6-7a).

b) If there is more than one through lane, adjacent intermediate loops shall be placed on separate amplifiers without connection to any other loop. Adjacent upstream detector loops shall be spliced in series at the cabinet and connected to the same detector amplifier channel.

c) One stop bar loop in each lane shall be connected to its own amplifier channel for counting purposes, and all remaining stop bar loops shall be connected in series at the cabinet to a single detector amplifier channel.

d) If there is more than one through lane, the adjacent pairs of stop bar loops shall be connected in series with each other at the cabinet and connected to the same detector amplifier channel. However, no more than four loops will be connected in series.

e) If there are two through lanes, the upstream and intermediate loop lead-ins shall be common to one 7-pair lead-in cable; the stop bar loop lead-ins shall be common to a second 7-pair lead-in cable (Figure 6-7b).

f) If there are three or more through lanes, all upstream loop lead-ins shall be common to a single 7-pair lead-in cable and all intermediate loop lead-ins shall be common to a separate 7-pair lead-in cable (Figure 6-7e).

g) The upstream and intermediate loop home runs shall be routed to the nearest junction box along a path perpendicular to the direction of travel. Home-runs for adjacent loops, less than 16 feet apart, shall be routed to the nearest junction box in the same trench to minimize excavation of the pavement.

h) The stop bar loop home runs shall generally be routed to the same junction box. All the home runs shall be routed parallel and adjacent to each other along a path perpendicular to the direction of travel. A path parallel to the direction of travel may be needed from the individual loop to the common perpendicular routing.

i) Each 7-pair lead-in cable should have two, but in no case less than one spare pair. Lead-in cables should not contain more than one vehicle phase wherever possible.

j) Route all home-run conduits to Type IA junction boxes. Home-run conduits shall be limited to a maximum of 6 per junction box.

3. Amplifier and Controller Settings

   Amplifier and controller settings shall be as specified in M.A.S.S.

6.8 D Low-Speed Approaches

Low-speed approaches are those where the anticipated 85th percentile or posted speed is 30 MPH or less, or 35 MPH or less for side street approaches where the higher through phase critical lane volume is less than one-half the critical lane volume of the highest volume main street through phase.

1. Location

   a) Presence detection shall be used on these approaches. In general, it shall consist of five detector loops placed in each lane near the crosswalk. One detector loop shall be placed fourteen feet back from the curb reference line, measured parallel to the lane lie from near point to near point. A second detector loop shall be placed ten feet upstream of the back of the first detector, a third detector loop shall be placed 10 feet upstream of the back of the second detector, a fourth shall be placed ten feet upstream of the third detector, and a fifth shall be placed ten feet upstream of the fourth detector.

      Under special circumstances, Traffic Engineering may require alterations to the standard loop placement described above. This may involve moving the fifth detector further from the intersection. The designer is directed to contact Traffic Engineering prior to final loop design to determine if special considerations apply.

   b) At locations involving skewed intersections, or other extenuating circumstances, the loop positions may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. Care shall be taken to not leave too much undetected space immediately upstream of the crosswalk. The intent of the loop placement is to prevent the smallest passenger cars, motorcycles, and bicycles from being caught in an undetected area. If adjusted, the distances between the four detector loops shall remain constant.

2. Detector Lead-Ins and Home Runs

   a) The four detector loops closest to the reference line in each lane shall be connected in series at the controller cabinet. The farthest upstream loop shall be on a separate detector amplifier channel.

   b) Typical loop assignments to the lead-in cable should be as shown in Figure 6-7a through 6-7f.

   c) When there are 1 or 2 lanes of presence detection, home runs for the three loops closest to the intersection shall be routed to the same junction box along a parallel and adjacent path that is perpendicular to the direction of travel. Home-runs for adjacent loops shall be routed to the nearest junction box in the same trench to the extent possible to minimize excavation of the pavement. A path parallel to the direction of travel may be needed from the individual loop to the common perpendicular routing. Home runs for the two loops furthest from the intersection shall be routed to a second junction box in a like manner.

d) When there are three lanes of presence detection, home runs for the two loops closest to the intersection in all lanes shall be routed to the same junction box along a parallel and adjacent path that is perpendicular to the direction of travel. The next two loops closest to the intersection in all lanes shall be routed to a second junction box in a similar manner, and the farthest loop in all lanes shall share a third junction box.

3. Amplifier and Controller Settings

Amplifiers shall have the capabilities described in M.A.S.S.

6.8 E Left-Turn Lane Detection

1. Location

Left-turn lane detection shall be designed according to Section 6.8 D, Low-Speed Approaches.

2. Detector Lead-Ins and Home Runs

a. Where medians are constructed adjacent to left-turn lanes, the home runs shall not be routed to a junction box in the median. The home run shall be routed along a path perpendicular to the direction of travel and be along the shortest path to the curb. The home run shall then be routed to the nearest junction box.

b. The upstream most loop shall be connected to its own amplifier channel and to the appropriate left-turn or through phase. The remaining loops shall be connected in series with each other at the cabinet and connected to the appropriate phase.

c. If there are two left-turn lanes, all the loops in one lane shall be connected in a like manner as described in paragraph b above. All loops in a lane shall be connected to lead-in pairs common to the same 7-pair lead-in cable; one cable used for each lane.

6.8 F Right-Turn Lanes

1. Location

For exclusive right-turn lanes on main street approaches at intersections where the main street phases will always be recalled, a single detection loop shall be located 60 feet upstream of the detector reference line. If dual exclusive right-turn lanes are used, the detection in the innermost right-turn lane shall be designed according to Section 6.8.D., Low Speed Approaches.

For exclusive right-turn lanes on side street approaches a three-loop presence detection layout shall be used. One detector loop shall be placed fourteen feet back from the curb reference line, a second detector shall be placed ten feet upstream from the back of the first detector, and a third detector shall be place ten feet upstream from the back of the second detector.

2. Detector Lead-Ins and Home Runs

For a single right-turn loop layout, the detector lead-in for a single right-turn lane shall be connected to it's own delay amplifier channel and connected to the through phase at the cabinet. If there are dual right-turn lanes, then the farthest upstream loop in the innermost lane shall be connected to it's own amplifier channel, and the four loops closest to the intersection shall be connected in series at the cabinet and connected to the through phase.

For a right-turn presence detection layout, the farthest upstream loop shall be connected to its own delay amplifier channel, and the two detector loops closest to the reference line shall be connected in series at the controller cabinet and shall be on a separate delay amplifier channel. If there are dual right-turn lanes, then the detection for the inner most lane shall be connected as described in item a.

c. The home runs shall be routed to a junction box along a path that is perpendicular to the direction of travel.

6.8 G Construction of Inductive Loops

See M.A.S.S. for standard details and specifications for inductive loop construction guidelines.

6.8 H Count Detector Loops

The intent of singling out upstream loops into their own amplifier channel is to allow the detector loops to be used for counting traffic. Additional downstream loops or through/right loops may be added for counting purposes, at the direction of Traffic Engineering.

END OF SECTION 6.8

SECTION 6.9 UNDERGROUND COMPONENTS

Traffic control devices (TCDs) have many components which shall be located underground. This section provides discussion and design criteria for conduit, junction boxes, electric cable, signal cable, and interconnect cable.

6.9 A Conduit

Discussion on conduit design criteria includes conduit types, installation methods, conduit sizing, conduit lengths, spare conduits, conduit separation, and conduit locations.

1. Type of Conduit

   a) Conduit used for encasing detector loops shall be rigid non-metallic conduit as specified in MASS.

   b) All other conduit shall be galvanized rigid metal conduit as specified in MASS.

2. Installation

   Conduit shall be installed according to MASS. Requirements for depth below finish grade shall be strictly adhered to.

   The consultant, in conjunction with the municipality, shall determine if conduit crossing paved streets should be shown as open cut or bored and jacked. The specifications shall require an alternate bid option of both methods to allow for unforeseen factors.

   In general, conduit runs crossing the street may be open cut if traffic will not be unduly interrupted.

TABLE 6-5 CONDUIT CAPACITY

Trade Size (in.)	Internal Diameter (in.)	Internal Area (sq. in.)	26% Fill (sq.in.)	40% Fill (sq.in.)
2	2.067	3.36	0.87	1.34
3	3.068	7.38	1.92	2.95

Source: National Electrical Code; Chapter 9, Table 4

3. Conduit Sizing

   a) Conduits shall be sized according to minimum allowed sizes and conduit fill.

   b) Conduit in foundations for ground rods shall be 3/4 inch.

   c) All other conduit shall be either two-inch or three-inch diameter. Multiple adjacent conduit runs in the same trench shall be used if additional space is required.

   d) New conduit shall have a maximum conductor fill of 26 percent. When a spare conduit is provided in a new run, the used conduits may have a 40 percent fill. When adding conductors to existing conduit, the maximum fill is 40 percent (see Figure 6-5).

   e) When crossing the street with one interconnect cable, a separate two inch conduit shall be used.

   f) When running two interconnect cables in a conduit, the minimum size shall be three inches.

4. Length of Conduit Run

   Conduit runs shall be limited to 190 feet between structures where the cable is reasonably accessible for pulling. If the conduit run is very straight with no more than 180 degrees of bend and contains only a single cable, the run may be extended to about 250 feet. For interconnect cable only, the run may be extended to 400 feet if the conduit run is very straight with no more than 180 degrees of bend and contains only a single cable.

5. Spare Conduits

   a) A spare two-inch, 90-degree conduit sweep shall be installed in each signal pole foundation, terminating in the nearest junction box.

   b) A spare three-inch, 90-degree conduit sweep shall be installed in each controller foundation, terminating in the nearest junction box.

   c) A spare two-inch conduit run shall be installed for each street crossing except if the intersection is piped in a "U" layout, then the street crossing at the bottom of the "U" shall have a spare three inch conduit run.

6. Separation of Signal, Illumination, and Interconnect Systems

   Traffic signal, intersection illumination, and interconnect circuits shall not occupy common conduit. Each of the three types of circuits shall have its own conduit run. However, the circuits may share common junction boxes. Roadway (non-intersection) illumination circuits shall not share common junction boxes with traffic signal, intersection illumination or interconnect circuits.

7. Location of Conduit Runs

   a) If new sidewalk is part of the construction, conduit runs should generally be located behind the new sidewalk, with junction boxes behind the sidewalk and two inches below grade. If conduits must be located under the new sidewalk because of utility conflicts or right-of-way constraints, the junction boxes shall be constructed flush with the sidewalk.

   b) If the sidewalk is existing, and a planting strip exists between the curb and the sidewalk, the conduit and junction boxes shall be located either in the planting strip or on the other side of the sidewalk (right-of-way permitting), whichever has fewer utility conflicts, and should be two inches below grade.

   c) If there is no curb and gutter, the conduit and junction boxes shall be located one to two feet beyond the outside edge of the shoulder, and should be two inches below grade.

   d) Conduit runs shall be located away from drainage collection points whenever possible.

6.9 B Junction Boxes

Discussion of junction boxes includes sizing and placement. In general, junction boxes should not be located in medians.

1. Sizing

   a) Type IA junction boxes shall be used if the total of all conduit diameters entering the box is less than 12 inches and if only loop detector cables are in the junction box.

   b) Type II junction boxes shall be used if the total of all conduit diameters entering the box is more than 12 inches or less than 25 inches.

   c) Type III junction boxes shall be used if the total of all conduit diameters is 25 inches or more.

2. Placement

   a) For high-speed approaches, a junction box shall be located near each set of adjacent upstream loops and a second shall be located near each set of intermediate loops. They shall be located to allow for the most direct detector home run path between the loop and the junction box. A third junction box shall be located midway between the two stop bar loops near the crosswalk.

   b) For low-speed approach and turn-lane detectors, a junction box shall be located midway between the two loops closest to the intersection. A second junction box shall be located midway between the two loops furthest from the intersection.

c) Only type IA junction boxes shall be used for detector loop home runs. The maximum quantity of home-runs into a type IA junction box shall be six.

d) Each quadrant of the intersection shall have a Type II (or larger) junction box that is within 30 feet of the traffic signal pole. This junction box should service the traffic signal pole and the conduit crossing the street. It shall be located to allow the most direct path for the conduit crossing the street.

e) On the quadrant where the controller cabinet is located, there should generally be a type II junction box, which services the traffic signal pole.

f) Where feasible, the type III junction box servicing the controller should be located directly in front of the controller cabinet door where it can serve as a pad for maintenance personnel. If not feasible, then a separate concrete pad shall be constructed in front of the controller cabinet door.

g) Where additional luminaire poles are required away from the intersection, a junction box shall be provided for each pole. These junction boxes shall be placed behind the poles to protect them from snowplows.

h) For interconnect runs between intersections, junction boxes shall be provided at appropriate intervals as required by Section 6.9 A.

6.9 C Electrical Cable

Discussion on electric cables include detector lead-in cable, power cable, illumination cable, and signal cable.

1. Detector Lead-In Cable

   a) Detector lead-in cable shall be 7-pair, #18 (7pr-#18) shielded cable meeting the requirements of the MASS.

   b) All detector lead-ins shall be continuous runs from the splice with the loop home run wires to the controller cabinet terminal strip.

   c) Each loop shall be individually brought back to the cabinet on a separate shielded cable pair. Series connections may be made at the cabinet terminal strip.

2. Power Cable

   Power cable to the traffic signal controller shall be a 3-conductor, 6 AWG cable (3c-#6 AWG) meeting the requirements of MASS and NEC. A bare copper #6 ground wire shall be provided from the load center ground rod to the controller ground. All conductors shall be continuous runs from the load center to the controller cabinet without any splices.

3. Illumination Cable

   Cable for the illumination circuits shall be the appropriate gauge of three conductor cable meeting the requirements of the ADOT&PF and NEC standard specifications. Intersection illumination circuits can share junction boxes with signal circuits when necessary. All splices for the luminaries shall be made in the handhole at the base of the pole.

   Cable for the photocell circuit shall be a 5 conductor, 14 AWG stranded cable.

6.9 D Signal Cable

1. Each traffic signal vehicle head shall be serviced by its own, separate 7-

conductor, 14 AWG (7c-#14 AWG) stranded cable in all cases and shall meet the requirements of MASS. The cable serving a traffic signal head shall not be spliced with any other cable.

2. Pedestrian signal heads shall be serviced by their own 5 conductor, 14 AWG (5c-#14 AWG) stranded cable with no splices to other heads in accordance with MASS.

3. Each pedestrian push-button shall be serviced by a 3 conductor, 14 AWG (3c-#14 AWG) cable in accordance with MASS.

4. Illuminated sign cabinets shall be serviced by a 3 conductor, 14 AWG (3c-#14 AWG) stranded cable in accordance with MASS.

5. Each traffic signal preemption detector shall be serviced by one 3 conductor, 20 AWG (3c-#20 AWG) preemption cable and one 3 conductor, 14 AWG (3c-#14 AWG) confirmation light cable in accordance with M.A.S.S.

6.9 E Spare Cables

Where future pedestrian movements or left-turn signal heads are anticipated, spare electric cables shall be routed from the controller cabinet to the junction box nearest the pole on which they would be installed. For future signal heads at the end of a mast arm pole, the cable shall also be routed to the end of the pole and secured to the inside of the arm with a cable grip fastened to a set screw. In all cases, sufficient spare cable shall be provided to connect to the future location of the equipment.

6.9 F Signal Interconnect Cable

Signal interconnect cable is usually routed adjacent to illumination cable, and is often added when illumination is brought into an area. Traffic Engineering has information regarding future interconnect needs. The designer shall contact Traffic Engineering early in the design process to determine interconnect requirements.

END OF SECTION 6.9

SECTION 6.10 SIGNS

In many situations, signs are the most appropriate traffic control device. Discussion in this section provides mounting parameters for street name signs, overhead lane use signs, median and island signs, pedestrian signs, and internally illuminated signs. A standard detail sheet on signal signing can be obtained from Traffic Engineering.

6.10 A Street Name Signs

1. Mounted on Mast Arm

   a) A street name sign for each approach shall be installed on the mast arm between the pole and the first signal head. The distance from the pole shall be shown on the pole schedule. Where possible, the right-hand edge of the D3-1B should be as close as possible to the signal pole while maintaining the signs visibility from the roadway.

   b) The legend on the overhead street name sign shall be eight inches upper case and six inches lower case. The sign blank must be 18 inches high and of sufficient length for the street name. Roadway designations such as street, avenue, drive, etc., shall be abbreviated.

   c) If the two legs of the cross street have different names, a sign (D3-2B, 30” high) with both street names shall be used. The name of the street to the right of the intersection shall be placed above name of the street to the left.

2. Mounted on Side-of-Pole

   a) Street name signs (D3-1) shall be mounted on poles to provide near right and far left indications for each approach, only when address numbers are used.

   b) The signs shall be mounted on the back side of the poles between the pedestrian signal and the side-of-pole mounted traffic signal by using cantilever mounting brackets.

6.10 B Overhead Lane Use Control Signs

1. Left-Turn Lane Without Left-Turn Signal

   a) An R10-100 lane use control sign shall be installed at the end of the mast arm, centered over the turn lane.

   b) If an existing mast arm is being used, the sign may be up to two feet short of the center of the lane.

2. Left-Turn Lane with Protected/ Permissive Left-Turn Signal

   a. An R10-100 lane use control sign shall be installed at the end of the mast arm, centered over the turn lane.

   b. If an existing arm is being used, the sign may be up to two feet short of the center of the lane, but shall be left of the signal.

3. On a left-turn and through lane with protected/permissive turn signals, an R10-12 lane use control sign shall be installed at the end of the mast arm.

4. On a single left-turn lane with a protected-only left-turn signal, no sign is required. For multiple left-turn lanes, an R3-5L sign shall be centered overhead on each left-turn lane.

5. If an exclusive right-turn phase is overlapped with a left-turn phase, the left-turn lane shall have a no U-turn sign, type R3-4, mounted in the median or overhead centered on the left-turn lane.

6. On exclusive right-turn lanes, an R3-5R shall be centered overhead on each lane.

7. For shared through- and left-turn lanes with protected phasing, an R3-6 sign shall be located overhead, centered on the lane.

8. Two R3-8 signs should be ground mounted on the right side of each multi-lane signal approach with one sign located in advance of the turn lane, and another near the stop bar.

9. At signalized intersections with one-way streets, R6-1 signs shall be placed on the signal poles in the near right and far left corners of the intersection facing traffic entering or crossing the one-way streets. Additionally, an R6-2 sign shall be placed overhead, near the overhead signal indications. If a right turn can not be made an R3-1 shall also be installed on the near right.

6.10 C Median and Island Approaches

1. Median approaches shall have an R4-7 Keep Right sign (symbol only) mounted at the nose of the median with two OM-1Y Type I markers mounted back to back underneath.

2. Island approaches, with same directional traffic on both sides, shall have a W12-1 Double Arrow sign mounted at the nose of the island with two OM-1Y Type I markers mounted back to back underneath.

6.10 D Pedestrian Signs

Pedestrian push-button signs shall be R10-3B (L or R). An R9-3A sign with plaque shall be installed on the mast arm pole at each side of an approach where no pedestrian signals or crosswalks are used.

6.10 E Internally Illuminates Signs

In general, internally illuminated signs should not be used. If approved, the signs shall be LED and controlled by the illumination photocell. The electric cable serving the internally illuminated sign shall be routed from the sign to the load center without passing through the controller cabinet.

END OF SECTION 6.10

SECTION 6.11 REFERENCES

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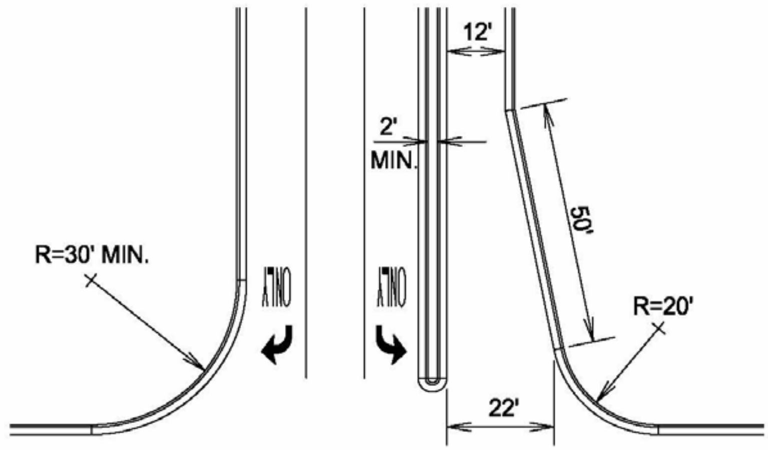
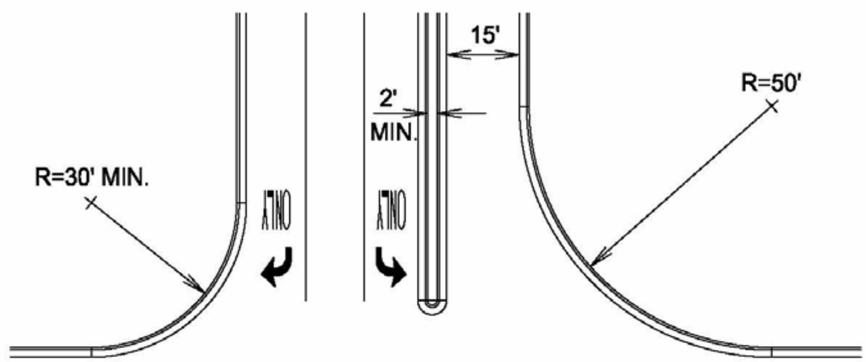


SIDE STREET APPROACH-
RESIDENTIAL INTERSECTIONS
(CITY-BUS DESIGN VEHICLE)



SIDE STREET APPROACH-
ALL MUNICIPAL INTERSECTIONS EXCLUDING RESIDENTIAL
INTERSECTIONS (WB-50 DESIGN VEHICLE)

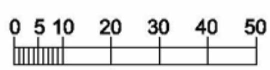


Figure 6-1

01-14-02

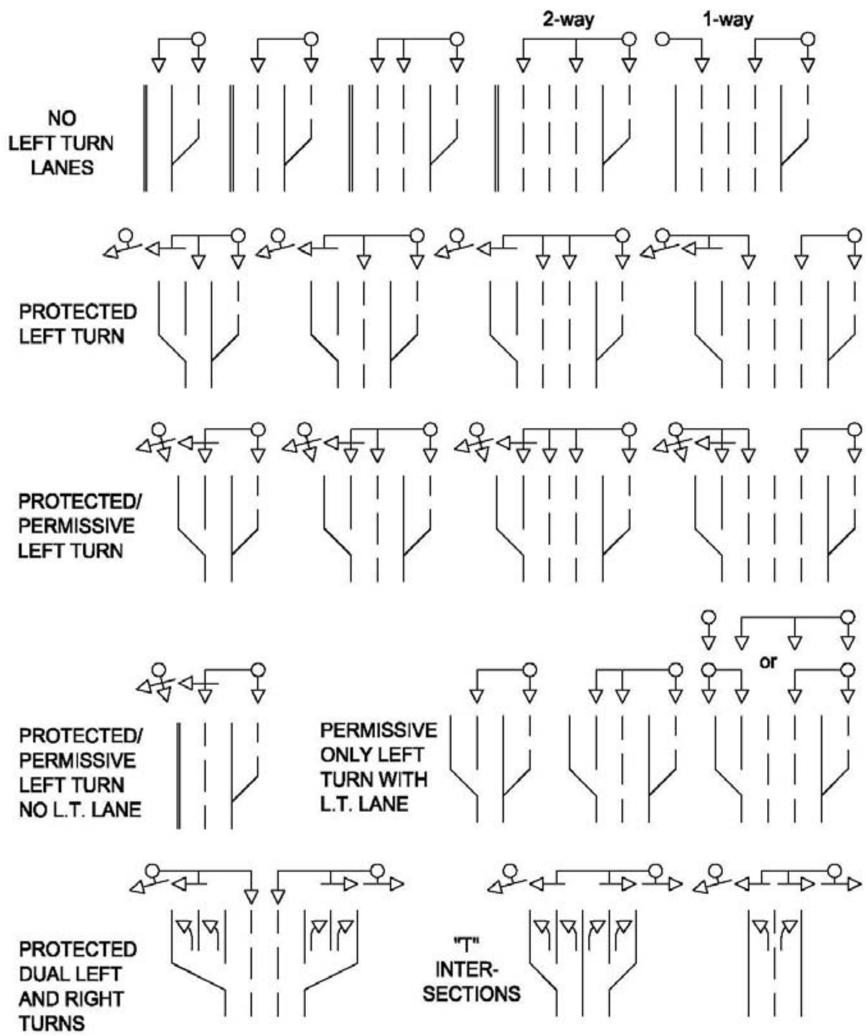


Figure 6-2
SIGNAL HEAD LOCATIONS

01-14-02

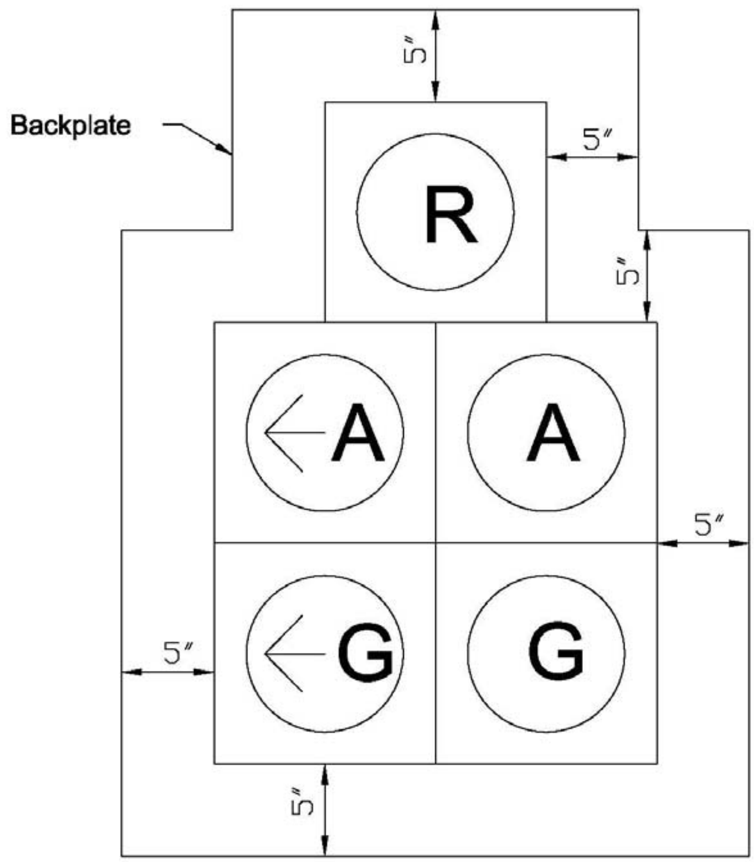


Figure 6-3
5-SECTION SIGNAL CLUSTER
HEAD CONFIGURATION

01-14-02

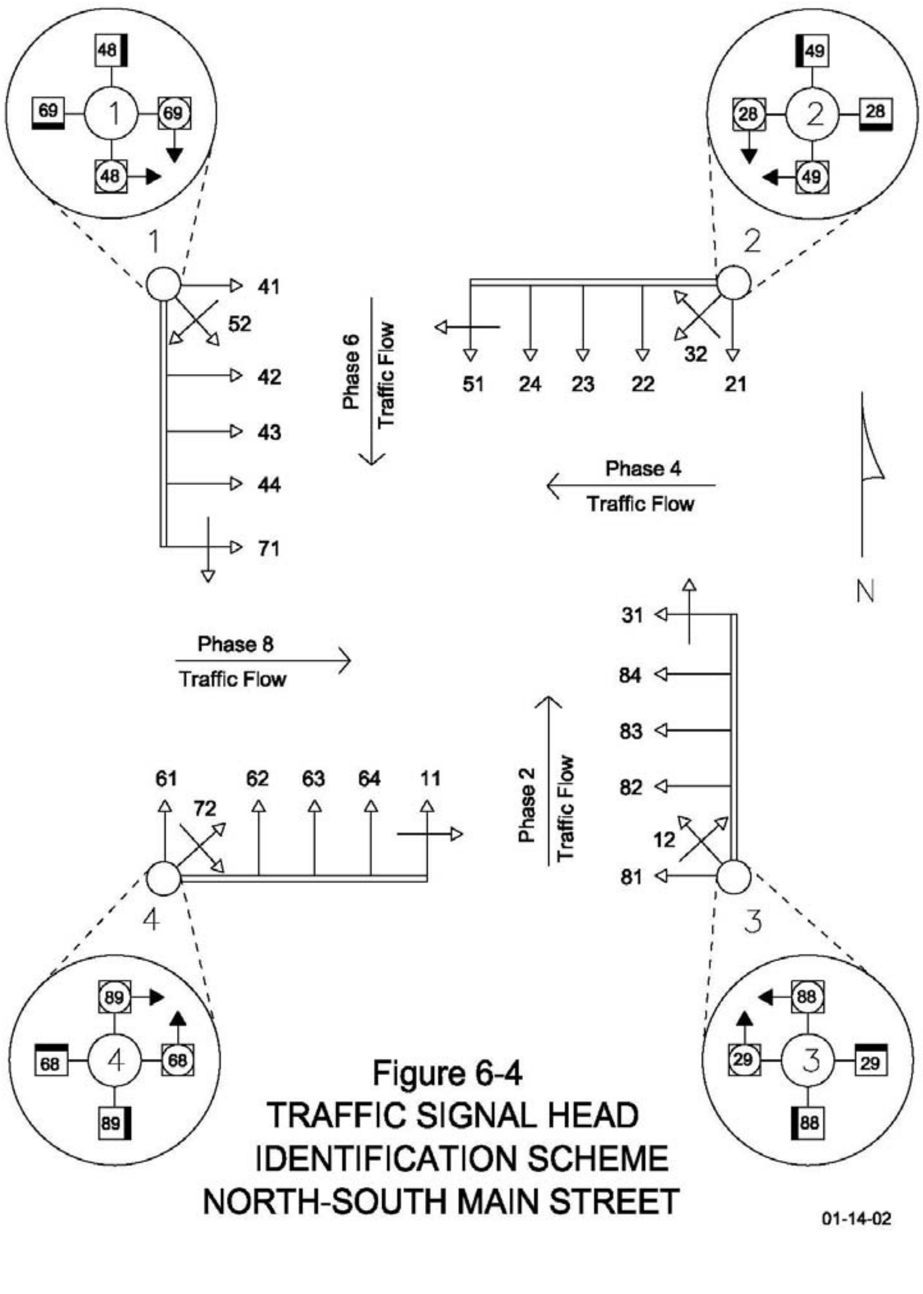


Figure 6-4
TRAFFIC SIGNAL HEAD
IDENTIFICATION SCHEME
NORTH-SOUTH MAIN STREET

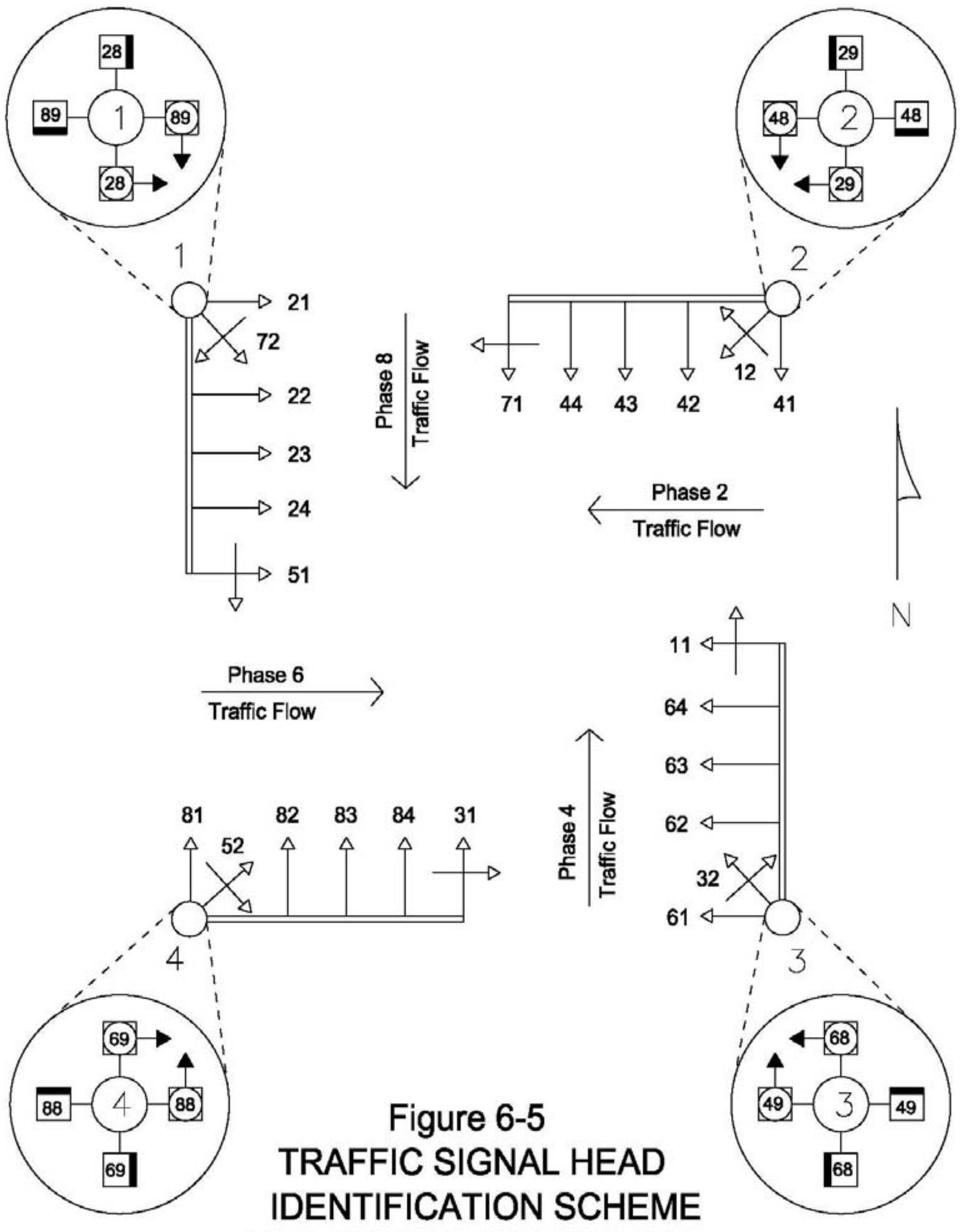


Figure 6-5
TRAFFIC SIGNAL HEAD
IDENTIFICATION SCHEME
EAST-WEST MAIN STREET

01-14-02

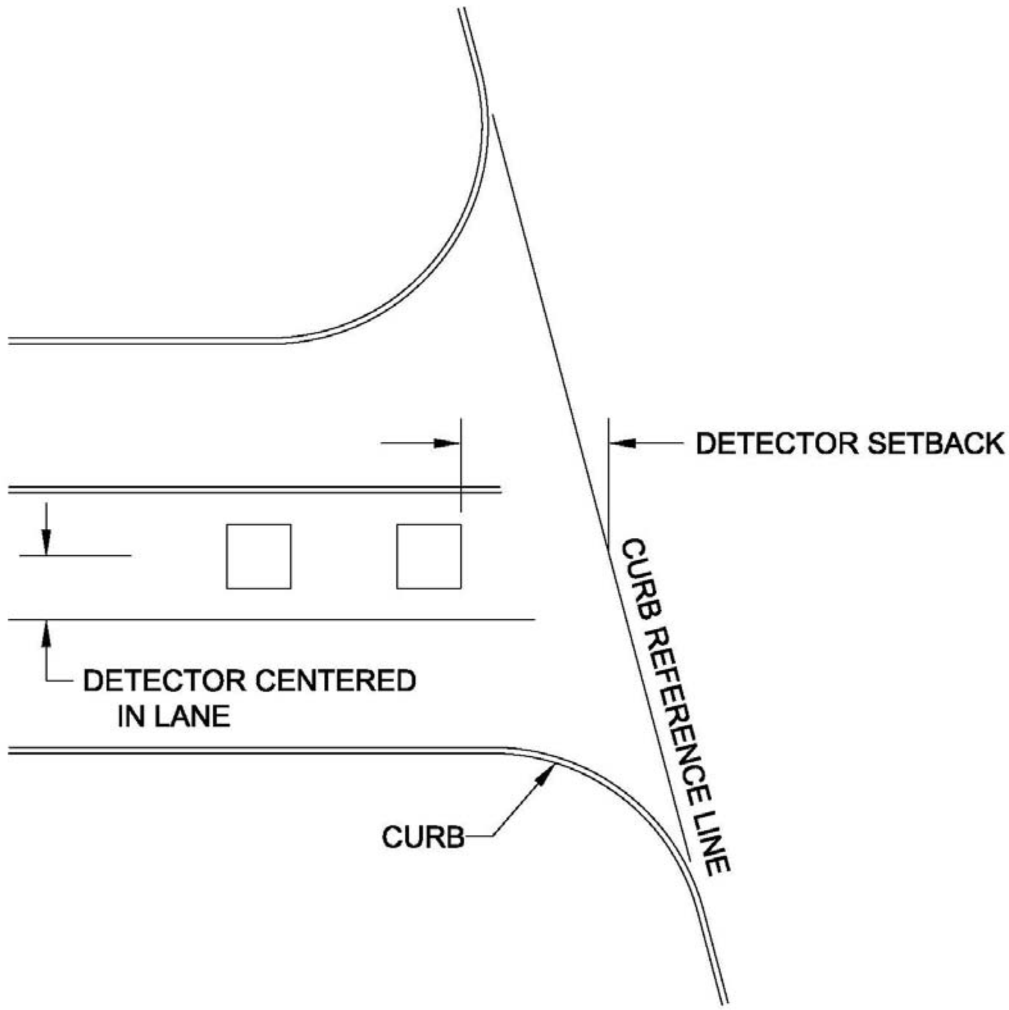
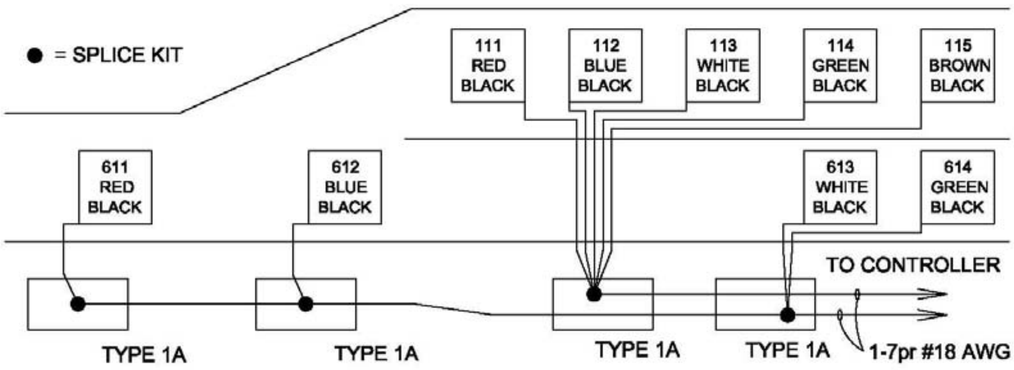
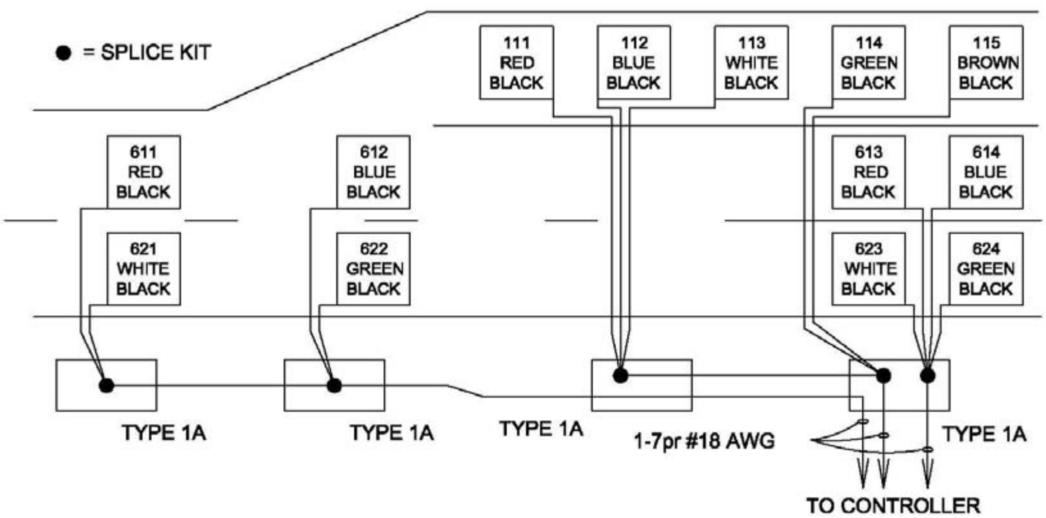


Figure 6-6
DETECTOR PLACEMENT

01-14-02

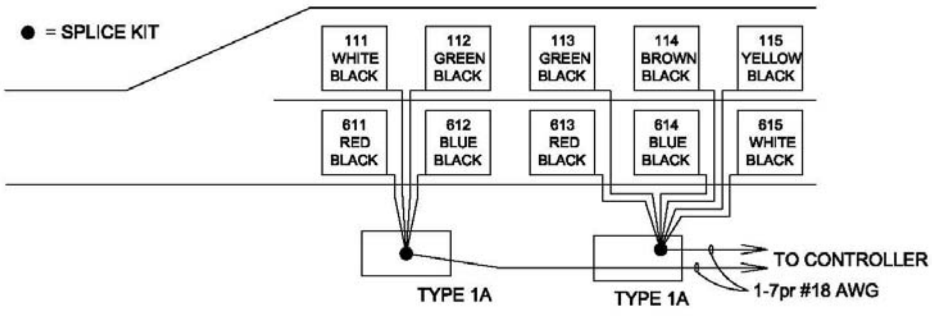


TYPICAL LOOP LAYOUT FIG. 6-7a

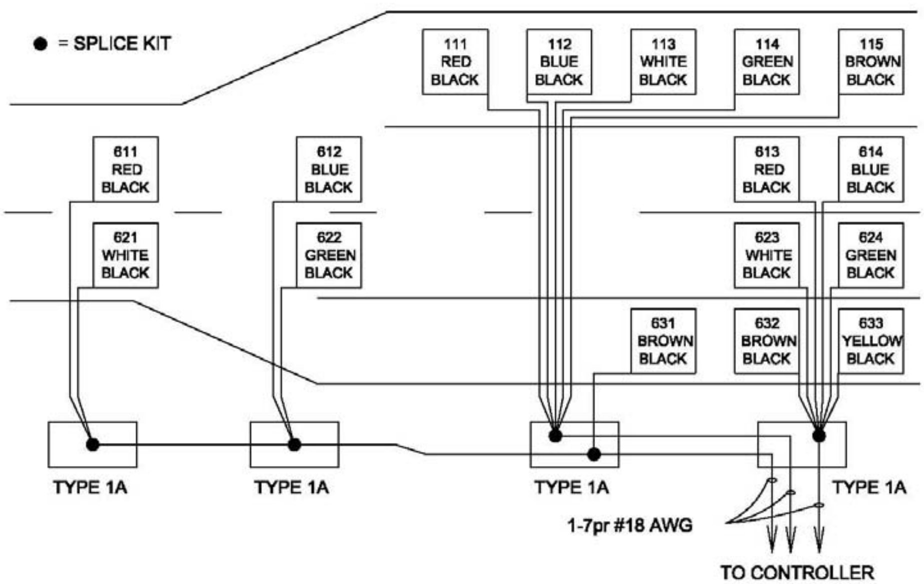


TYPICAL LOOP LAYOUT FIG. 6-7b

01-14-02

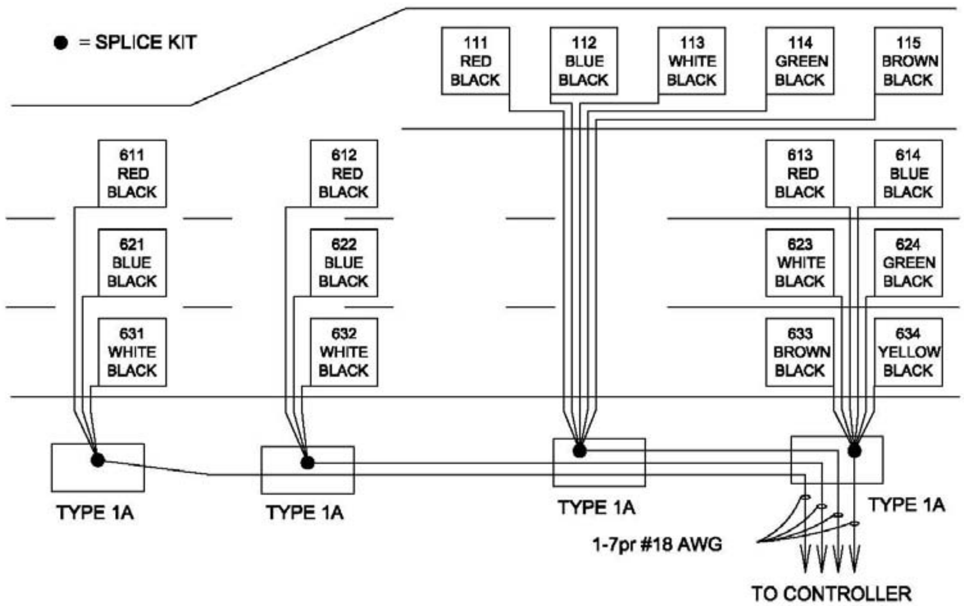


TYPICAL LOOP LAYOUT FIG. 6-7c

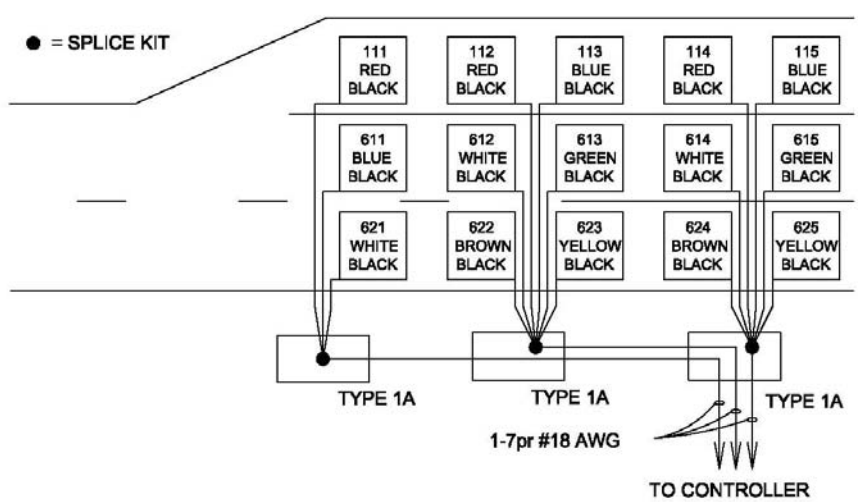


TYPICAL LOOP LAYOUT FIG. 6-7d

01-14-02



TYPICAL LOOP LAYOUT FIG. 6-7e



TYPICAL LOOP LAYOUT FIG. 6-7f

01-14-02

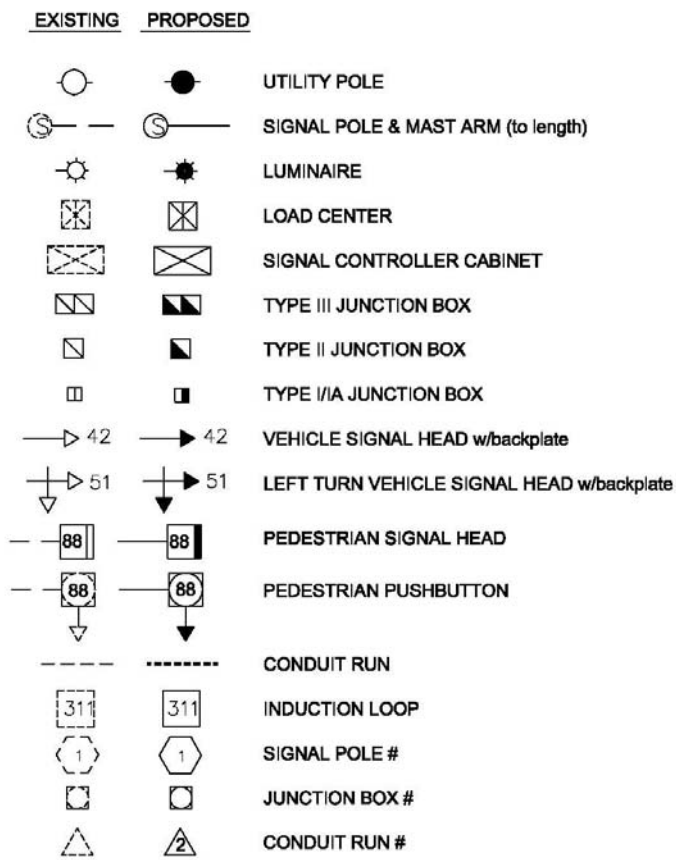


Figure 6-8

LEGEND FOR TRAFFIC SIGNAL PLAN SHEETS

01-14-02