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### 3.7 SIGNAL DESIGN PROCEDURE

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An intersection should provide for the safe and efficient movement of road traffic when crossing or turning, where there is conflict with another traffic stream. The type of intersection selected depends on many factors and ranges from an intersection with no controls, at a low volume road, to a complex signalised intersection.

Intersections generally require the use of the following Major Traffic-Control Items for the control of moving traffic.
- Give Way/Stop signs
- Roundabout signs
- Traffic signals

Road Rules - Victoria, Parts 6, 7, 8 and 9, contains the rules applicable at traffic-control signals and signs including the rules of precedence at unsignalised intersections.

The STATCON Program was established to provide the most appropriate type of control at every intersection in the state. Most of the intersections have been treated with either give way signs/stop signs, roundabout signs or traffic signals. The remaining unsigned or unsignalised intersections are controlled by the terminating road rule (T-Junction) without the need for signing.

The following references should be used with this manual:
- AUSTROADS “Guide to Traffic Engineering Practice”
  - Part 5: Intersections at Grade
  - Part 6: Roundabouts
  - Part 7: Traffic Signals
- Australian Standard 1742, Manual of uniform traffic-control devices,
  - Part 2: Traffic-control devices for General Use and
  - Part 14: Traffic signals

Other references:
- Traffic Engineering and Management, Dept of Civil Engineering, Monash University, edited by K W Ogden & S Y Taylor.
- ARRB Transport Research Ltd, SIDRA, (Signalised Intersection Design and Research Aid)

Table 3.1 is a guide to the selection of intersection treatments. Such matters as capacity, safety and level of service for all road users will require consideration before deciding upon a suitable format for the intersection and the choice of Major Traffic Control Item.

Councils may seek advice regarding detailed intersection design standards from their local VicRoads Region.
<table>
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<th>Secondary Arterial</th>
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<td>U</td>
<td>U</td>
<td></td>
<td>●</td>
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<td>Traffic Signals</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- ● Most likely to be the appropriate treatment
- ○ May be an appropriate treatment
- U Unlikely to be an appropriate treatment, except on low volume roads
- X Inappropriate treatment

**Table 3.1: Appropriate Intersection Controls for Different Intersecting Road Classifications**
3.2.1 Roundabouts

The Road Rules covering Roundabouts are in Part 9 of Road Rules - Victoria.

A roundabout is defined in the Rule 109 as an intersection with:-
(a) one or more marked lanes, or lines of traffic, all of which are for the use of vehicles travelling in the same direction around a central traffic island; and
(b) a "roundabout sign" at each entrance.

"roundabout sign" means a sign similar to that illustrated in Rule 109 of Road Rules - Victoria.

The regulatory roundabout sign shall be installed to face approaching motorists on each approach to a roundabout. The sign is a Major Traffic Control Item and approval is delegated to Council on certain roads.

The AUSTROADS publication “Guide To Traffic Engineering Practice, Part 6, 1993. Roundabouts” is to be referred to for the design guidelines for this type of intersection treatment. Roundabouts should be considered at locations experiencing a poor accident record.

When determining the appropriateness of a roundabout for an intersection, consideration should be given to the functional classification of the intersecting roads - refer Table 3.1.

When designing a roundabout, consideration should be given to:-
- type of vehicle expected to use the intersection. (If the roundabout is on a public commercial passenger vehicle route and is under Council delegation, the bus company's written agreement is required. The needs of Ultra Low Floor buses must also be considered where appropriate.)
- the needs and safety of pedestrians crossing at the intersection.
- access requirements of emergency and service vehicles.

Where the roundabout cannot provide for all vehicle movements in the normal manner, the design should allow emergency vehicles to mount the centre island or pass to the right of the central island when turning right, and to cross splitter islands (if provided) when turning left.

Vehicles should be guided into the roundabout at a safe speed and in a manner to avoid impact with the central island.

3.2.2 Give Way Sign And Stop Sign Controls

Give way and stop signs are Major Traffic Control Items and approval is delegated to Council on certain roads.

Unsignalised intersections with 4 or more legs shall have a Giveway Sign (AS1742.4, Section 2.5).

The Road Rules covering Give Way and Stop conditions are in Part 7, Division 1 of Road Rules - Victoria.

Give way signs and stop signs provide intersection control by allocating precedence to vehicles on one road over vehicles on an intersecting road. The signs are generally erected on the road of lesser importance. That is, the signs will be erected on the road of lesser traffic flow unless it is intended to change the priority to meet specific traffic management objectives. However, this should only be considered where the total traffic using the intersection will be less than 1000 vpd and the ratio of major flow to minor flow shall not exceed 2:1.
Where available sight distances fall below those specified in Table 3.2 a Stop sign shall be used in lieu of a Give Way sign.

**Guidelines for the use of Stop signs**

The intent of these guidelines is to ensure that a Stop sign is **only** to be used where it is necessary for a driver entering the intersection to be stationary when seeking a safe gap in the intersecting traffic.

Where available sight distances fall **below** those specified in Table 3.2, a Stop sign may be used. Where the available sight distances are **equal** or **exceed** those specified, a Give Way sign is to be used.

Where visibility exceeds the values in Table 3.2, a Stop sign may still be appropriate in rare cases. VicRoads approval is required in these cases as it is outside VicRoads guidelines.

A history of accidents may prompt requests for Stop signs. However, not all accidents can be overcome by Stop signs. For example, right angle accidents caused by minor road traffic “overshooting”, may be more effectively addressed by marking a holding line, relocating a Give Way sign, using a larger Give Way sign, duplicating a Give Way sign, using a Give Way Ahead sign, or building a central island. Consistency in the application of the guidelines will maintain the credibility of Stop signs and provide consistent driver expectations.

**Procedure for assessing visibility at major/minor intersections**

1. Determine which road is to be controlled (the Minor Road) and which road is to have priority through the intersection (the Major Road), taking account of traffic volumes and functional road classification.

2. Assess the major road traffic speed and identify the major road speed limit. Choose the appropriate value of 'Y' in Table 3.2.

3. Measure back along the minor road 3 m from the edge of seal or kerb line of the major road (or 4.5 m where the minor road is an arterial road). This is point 'M'. This measurement is to be made along the centreline, or for a one-way road, along the edge of the island, median, kerb or edgeline.

4. Measure to the right along the major road, from the minor road centreline (or equivalent) the distance obtained from Table 3.2. This is point ‘A’. This measurement is to be made along the nearest edge of the road on which a vehicle could travel (assume no parking). This is usually the kerb line or edge of seal.

5. Looking across the corner, carefully observe whether an object 1.15 m above the ground level at point 'A' is visible from a height 1.15 m above ground level at point 'M'. Ignore any single tree, utility pole or similar “narrow” item and any parked vehicles. Record whether visibility is obstructed by a permanent obstruction or not. Removable obstructions (vegetation, foliage etc.) should be noted for remedial action and should be ignored in determining the appropriate control sign.

6. Repeat Step 4 for the left approach on the major road. The measurement from the minor road centreline (or equivalent) to point 'B' is to be made along the major road centreline or separation line for a two way major road. For an approaching one-way major road the measurement is to be made along the near edge of the road.

7. Repeat Step 5 for the view between point 'M' and point 'B'.

8. At purely local cross roads, where a permanent obstruction is assessed to be blocking visibility, reassess the intersection with the major and minor road classification reversed.
9. Where the visibility in Step 5 or 7 is obscured by a permanent obstruction, the visibility warrant for a Stop sign is considered to be met.

Where the visibility limitation is due to vegetation, an earth bank or some other removable obstruction, steps should be taken, where practicable, to restore visibility by removing the obstruction rather than installing a Stop sign.

\[
\begin{align*}
\text{Major Road Speed} & \quad \text{X: Distance along Minor Road (m)} & \quad \text{Y: Distance along Major Road (m)} \\
40 & \quad 3 & \quad 20 \\
50 & \quad 3 & \quad 30 \\
60 & \quad 3 & \quad 40 \\
70 & \quad 3 & \quad 55 \\
80 & \quad 3 & \quad 65 \\
90 & \quad 3 & \quad 80 \\
100 & \quad 3 & \quad 95 \\
110 & \quad 3 & \quad 115 \\
120 & \quad 3 & \quad 150
\end{align*}
\]

**Table 3.2**

*From AS1742.2 - 1994 Fig 2.2*

**NOTES:**

1. For Major Road Speed, use the posted speed limit, except where the 85th percentile speed is significantly greater than the Major Road Speed Limit. In this case use the higher value.

2. Where the minor road approach is an arterial road, use X = 4.5 m for all speeds.

### 3.2.3 T-Intersections

*A T intersection is defined in Road Rules - Victoria as: “an intersection where 2 roads meet (whether or not at right angles) and one of the roads ends”. It may include an intersection where more than 2 roads meet but only one continues.*

The road rule for giving way at an unsignalised T intersection is Rule 73 of Road Rules - Victoria. This includes giving way at a modified T intersection.

In the Road Rules - Victoria the end of a road at a T intersection ends a speed limit applicable on that road.
Examples are shown in Figure 3.1. The Rules covering 'T'-intersections provide a form of major/minor intersection control without the use of control signs. The 'T'-intersection rule is an alternative to the use of a Give Way sign or a Give Way line on the terminating road at a conventional T-intersection.

Figure 3.1: Examples of 'T' Intersections

At T-intersections where visibility falls below the values in Table 3.2 a Stop sign may be installed.

At T-intersections, where a Stop sign is not required, a Give Way sign shall be installed after VicRoads written consent, where:-
- the major road is classified as an Arterial road,
- site conditions (such as a substantial proportion of turning vehicles, or road widths varying through the intersection) lead to significant numbers of turning drivers failing to give way. However, in this case an alternative treatment may be to use Give Way markings only, on the terminating road,
- the traffic volume on the major road exceeds 5000 vpd.

When considering applicability of the 'T' Intersection rule, correct identification of intersections as either T-junction or cross-roads is essential. See Figure 3.2.

Figure 3.2: T-Intersections Vs Cross-roads
3.2.4 Modified Intersections

A modified 'T' intersection is defined as a 'T' intersection at which signs, traffic islands or road markings indicate that:

(a) one road continues through the intersection around a bend;
(b) the other road ends.

The Regulation covering modified intersections is Rule 73 of Road Rules - Victoria.

Examples of modified intersections are shown in Figure 3.3. In all cases, modified intersections require control by either Give Way or Stop signs on one or more approaches, together with the associated marking and shall have exactly two uncontrolled legs which together form the major road through the intersection. Road works to reinforce priority should be carried out where practical to ensure satisfactory operation.

Figure 3.3: Some Typical Modified Intersections
Caution should be exercised when designing modified T-intersections as traffic management treatments. Experience indicates that where an intersection has been modified to form the layout shown in Figure 3.1 (b) motorists are more likely to negotiate the intersection (particularly the right turn from the continuing road) more safely than the layout shown in Figure 3.1 (a). This may be due to the motorist perspective on approaching the intersection. That is, the motorist proposing a right turn from the continuing road in Figure 3.1 (b) observes a similar perspective to a T-intersection terminating road. Here the requirement for a right turning vehicle to give way is well understood.

The motorist proposing a right turn from the continuing road in Figure 3.1 (a) can see “through” the intersection to his destination and may not realise that he must give way to a vehicle which is approaching on his left.

Therefore, the layout in Figure 3.3 (a) may be more appropriate for use in low speed low volume environment only while the layout in Figure 3.3 (b) may also be used in locations with higher speed and volumes.

### 3.2.5 Give Way To Right

The Give Way to Right rule (Rule 72 of Road Rules - Victoria) applies at an intersection where other forms of control are not present. It cannot apply at a terminating intersection. It is inappropriate as a form of permanent intersection control and is reserved for application in emergencies such as traffic-control signal failures at cross-roads, or where vehicle volumes are less than 50 vehicles per day in each road.

In general, this means that all cross-roads shall be controlled, and that within complex intersections, the Give Way to Right rule is not required for resolution of conflicts.

The use of the ‘Give Way to the Right’ sign is not provided for in Road Rules - Victoria and such signs existing should be removed and replaced with a Give Way or Stop sign.

### 3.2.6 A Single Flashing Red Light At Or Near An Intersection

A single flashing red light is used to supplement a stop sign at an intersection and is rarely used. The following guidelines must be followed before installing a single flashing light.

- The site has a high accident record and other counter measures have not reduced the number of accidents.
- Only used to supplement a stop sign and no other sign.
- A submission justifying the use of the single flashing red light must be made to the VicRoads Manager - Traffic Management Services for approval to erect the light(s).

A single flashing red light at or near an intersection is a MTCI and is not delegated to Councils.

### 3.2.7 Linemarking At Unsignalised Intersections

Refer to the Traffic Engineering Manual Volume 2 for details of line marking at unsignalised intersections.
3.3.1 Introduction

The primary aims of signal control are:

- to reduce traffic conflicts and delays,
- to reduce accidents.

The optimum information transfer from the traffic signal control system to the road user occurs if the traffic light system, comprising signals, signs and linemarking can be easily seen and identified.

Traffic-control signals are a MTCI and are not delegated to Councils.

*The Rules covering traffic signals are given in Part 6 of Road Rules - Victoria.*

Under Section 16(1)(c) of the Transport Act 1983, a function of VicRoads is to "purchase, design, construct, erect, install, maintain and operate traffic signals and other traffic facilities for the purpose of traffic management and control".

3.3.2 Guidelines for new traffic signal installations

Traffic signals are predominantly used where other less expensive forms of treatment are found to be unsatisfactory operationally or have a high accident rate. Traffic signals involve not only an initial installation cost but also continuing maintenance costs.

Table 3.1 lists the intersecting road types where traffic signals may be appropriate. Table 3.1 alone does not necessarily indicate that traffic signals will be the most appropriate form of treatment.

The traffic volumes given below are a guide for the consideration of traffic signals, however intersection analysis (eg. using ‘Sidra’) should be used to determine the level of service of unsignalised and proposed signalised intersections. The road network and the actual operation of the roads should also be taken into account when considering traffic signals.

A detailed intersection analysis should be undertaken and a traffic assessment report with SIDRA / or similar input and output files of the various cases should be submitted to the local VicRoads Regional office demonstrating the need for traffic signals.

**Traffic Volume:**

Traffic signals may be considered subject to detailed analysis; when the major road carries at least 600 vehicles/hour (two way) and the minor road concurrently carries at least 200 vehicles/hour (one way) on one approach over any 4 hours of an average day.

Where the 85th percentile speed on the major road exceeds 80 km/h or in isolated communities of less than 10,000 population, the minimum vehicular volumes given above may be lowered to 420 and 140 vehicles per hour respectively.

Predicted and/or actual traffic volumes are considered with other factors such as directional flows, turning movements, conflict points, operating speeds and whether the major road is a divided or undivided road.

**Continuous traffic:**

Where traffic on the major road is sufficient to cause undue delay or hazard for traffic on a minor road, traffic signals may be considered when the major road carries at least 900 vehicles/hour (two way) and the minor road concurrently carries at least 100 vehicles/hour (one way) on one approach, over any 4 hours of an average day.
However the signals should not be provided if an existing signalised intersection can be easily reached and has spare capacity, or if the traffic signal would disrupt the progressive flow of traffic on the major road, or if additional access points could be provided within a new subdivision.

**Pedestrians:**
Refer to Chapter 4.5.

**Accidents:**
To reduce accidents, signals may be considered if there is an average of 5 or more reported casualty accidents over 5 years which may be eliminated or reduced by traffic-control signals and the traffic volume is at least 0.8 times the volume guidelines given above. Signals should only be installed if a more simple device will not effectively reduce the accident rate or a roundabout is not suitable.

Accidents which may be eliminated or reduced by the provision of traffic signals generally include only vehicle to vehicle right angle collisions, right turn against opposing flow and certain collisions involving pedestrians or cyclists (ie. Definition for Classifying Accidents - DCA - codes 110 to 119 inclusive and 100, 101, 102).

**Combined Factors:**
In exceptional cases, signals may occasionally be justified where no single guideline is satisfied but where two or more of the volume guidelines above are satisfied to the extent of 0.8 times or more of the stated value. Traffic signals are rarely installed in 100 km/h speed zones.

**Within Co-ordinated Signal systems:**
Traffic signals may be occasionally justified at intersections within or near a co-ordinated traffic signal system where operation of the intersection without traffic signals causes significant interference to the progression of traffic to or from nearby traffic signals. Such signals will be appropriate only where it is possible for them to be co-ordinated with nearby signals.

**Traffic Management Plans:**
Traffic signals may occasionally be justified as forming an essential part of an overall traffic management plan for an area to promote use of the road network in accordance with the objectives of the plan. However, caution needs to be exercised that through traffic problems are not created on the local road network in the area. Other factors which may need to be taken into consideration include bus routes and principal bicycle routes in the area.

### 3.3.3 Remodelling Of Intersection Traffic Signals

The need for remodelling of traffic signals may arise as a result of one or more of the following:
- changes in the volume distribution of traffic or pedestrians using the intersection (eg. need for right turn phase).
- proposed roadworks.
- need for safety improvements.
- need to modernise the equipment.
- need for signal linking.
- need for public transport priority features.

### 3.3.4 Externally Funded Traffic Signal Installation

Externally funded works can be either installations or signal remodels to suit a change in the road layout. A Council narrowing a road requiring the relocation of a signal pedestal is an example.
The Region has the responsibility for ensuring that agreements are transacted between VicRoads and the relevant Council or developer regarding the signals works and a commitment from the Council or developer to pay full costs. An advance payment of full estimated cost of installation, design and maintenance *(for ten years)* where applicable is required before works will proceed.

In general, charge only for VicRoads works. When other authorities carry out works it is preferable to inform these authorities that they must recover their own costs.


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<th>Pedestrian Signals With SCRAM</th>
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<tr>
<td>10 Year Cost</td>
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<td>$49,200</td>
<td>$33,100</td>
<td>$24,600</td>
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The total maintenance cost over 10 years is calculated on an annual basis by the Team Leader - Installation and Maintenance of VicRoads. Regions should contact the Team Leader for the total 10 year or periods less than 10 years, for the costs of a particular traffic signal installation to be recovered.

When payment has been received the Regions should advise the Signal Installation Section that the installation work can be scheduled.

### 3.3.5 Emergency Vehicle Signals

To enable safe and efficient movement of emergency vehicles from their depot, traffic-control signals may be installed at the cost of the emergency vehicle authority. Where the emergency vehicle facility is located at an intersection controlled by traffic signals an all red phase is usually incorporated and this is called from within the emergency vehicle depot.

Where the emergency vehicle facility is located near an intersection controlled by traffic signals, emergency vehicle signals are installed at the emergency depot and connected to the adjacent signalised intersection. An emergency clearance phase is also incorporated at the signalised intersection.

Usually emergency vehicle signals are considered when:
- the depot is located on a primary or secondary arterial, or
- there have been two or more accidents between exiting emergency vehicles and road traffic in the past 5 years, or
- at least 6000 vpd use the road and
- an average of 20 emergency departures are made each week.

VicRoads has moved away from the double flashing red lights as, at some sites, not all vehicles stopped when the signals operated.

Standard three aspect displays are used which operate as follows:
- the signals are blank,
- a call is made from a button in the premises or vehicle,
- the signals switch on to 10 sec green for the road,
- the signals change to standard yellow time for the road speed,
- the signals change to red for the road,
- a white E display is shown to the emergency premises,
3.3.6 Portable Traffic Signals

Portable traffic signals are used for the control of vehicular traffic at roadwork sites. The signals can be used to control traffic on a single lane used alternatively by traffic from opposite directions or to control plant crossing a road. Portable traffic signals for use at roadwork sites are available in either handcart or tripod format. Guidelines for the operation of portable traffic signals are contained in OPS NOTE 006.92 issued by the VicRoads Regional Services Department. The Guidelines contain a form for applying for a Memorandum of Consent to operate the portable signals and other Major Traffic-Control Items on worksites.

Note: these Guidelines do not apply to fixed temporary traffic signal installations as these require specific design details as set out in this chapter.
3.3.7 Red Light Camera Site

(Guidelines to be developed)
A traffic signal system is made up of system components, eg. detectors, controller and lanterns. This system transforms traffic demands (as sensed through vehicle detectors, pedestrian push buttons and external data supplied from area control master and traffic engineers) in a manner determined by the controller design and optimum settings into a sequence of signal displays.

The components of a traffic signal system are described in the AUSTROADS Guide to Traffic Engineering Practice Part 7, Traffic Signals, Section 4. Figure 3.4 of this manual shows the major signal components.

### 3.4.1 Signal Displays

The display elements of a traffic signal system are described in the AUSTROADS Guide to Traffic Engineering Practice Part 7, Traffic Signals, Section 4. Figure 3.5 of this manual shows the standard lantern displays and Figure 3.6 shows the VicRoads lantern configurations.

The Rules covering traffic signal displays are given in Part 6 of Road Rules - Victoria.

The location of signal displays are described in the AUSTROADS Guide to Traffic Engineering Practice Part 7, Traffic Signals, Section 9. The location of primary, secondary and tertiary lanterns are shown on Figure 3.6 of this manual.

### 3.4.2 Signal Lantern Mounting

**Mounting heights**

The AUSTROADS Guide for Design of Traffic Signal Installations, Section 9.5.4 states that “where possible all vehicle lanterns mounting heights, to the top of the lantern body, should be 4.1 metres except where the lantern is required to be visible from within 20 metres”.

The 4.1 m mounting height for primary lanterns provides visibility above cars parked along the kerb and also allows for the appropriate stopping sight distances bearing in mind a driver's cone of vision in respect to currently designated speed zones. For some starting or manoeuvring lanterns the mounting height may be reduced to 3 m for all lanterns in that display.

VicRoads uses signal pedestals designated 2B for 4.1 m primary lanterns and 2A for 3.25 secondary and tertiary lanterns. Standard drawing 85 4056 shows the dimensions for 2B and 2A pedestals and the mounting of primary, secondary and tertiary lanterns.

For reductions in mounting height in order to clear obstructions such as verandahs, the minimum clearance of 2 m must be maintained. For pedestrian lanterns mounting height should be 3 m. Standard drawing 85 4065 shows lantern mountings under verandahs. (See page 3-60 for a list of standard drawings.)

**Joint use poles**

Multi purpose poles are available to reduce the number of poles as follows:

- **Joint use poles (JUP’s)** - to support traffic signals and street lighting lamps available in 8, 9, 10, 11 and 13.5 metre heights.

- **Joint use mast arms (JUMA)** - to support traffic signals and street lighting lamps. Available 5.5 m clearance height, 2.5 m, 3.7 m and 5.5 m length of outreach, and 8 to 13.5 m street lighting pole heights.

- **Multi purpose poles/mast arms (JUPTC)** - that will support traffic signals, street lighting, Tram Operator overhead cables, power lines.

Often existing Electricity Supply Authority and tramway poles can be used to support traffic signal hardware, however only the newer type tramway poles can support mast arm outreaches.
3.4.3 Guidelines For The Use Of Mast Arms

Mast arms have been designed to fulfil two objectives:
- to support a lantern over or to the side of an obstruction which is inhibiting the visibility of the primary lantern.
- to reduce the offset of the primary lantern from the driver’s line of sight (desirable maximum offset 7.5 m).

The general geometric requirements for mast arm installation are shown in Figure 3.7.
### Size of Mast Arms

To achieve the above objectives mast arms are available with **four** outreach lengths:

<table>
<thead>
<tr>
<th>Mast Arm Type</th>
<th>Outreach Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini mast arms</td>
<td>1.4 m</td>
</tr>
<tr>
<td>Standard Mast Arms</td>
<td>2.5 m</td>
</tr>
<tr>
<td></td>
<td>3.7 m</td>
</tr>
<tr>
<td></td>
<td>5.5 m</td>
</tr>
</tbody>
</table>

The lantern on the outreach of a mast arm is over the road pavement and must be at a sufficient height so that vehicles do not collide with it. Therefore the mast has been designed to provide a 5.5 m clearance from the road pavement.

Because of the need to provide electrical clearance between mast arm and overhead electricity cable (see Figures 3.7 and 3.8), mast arms should normally be installed in the median strips on divided road. This location also ensures that:
- the overhead lantern is nearest to fastest moving vehicles;
- if an indented right turn lane exists, there is a lantern clearly visible above the through lane.

#### Mini Mast Arm (1.4 m outreach)

VicRoads standard Plan 85 4018 shows the Mini Mast Arm to be of one size only - 5.5 m high with a 1.4 m outreach. At this height it cannot be used under 240 v power lines, which are generally hung 7.0 m above ground level, as the ESA clearance would be violated. Clearance to powerlines for all hardware is shown in Figure 3.7.

However, the mini mast arm can have its height reduced by 600 mm to 4.9 m where it is to be installed under 240 v power lines. Clearance of 4.9 m for all non over dimensional vehicles will still be maintained.

Therefore, where necessary design plans may specify the mini mast arm as 4.9 x 1.4 m MA, although 5.5 m x 1.5 m MA should be specified whenever possible. The Signal Installation Department will arrange for the shortening of the pedestal when required.

<table>
<thead>
<tr>
<th>Mast Arm Type</th>
<th>Vertical Clearance m</th>
<th>Outreach m</th>
<th>Pole Height m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint Use Pole (JUP)</td>
<td>-</td>
<td>-</td>
<td>8, 9, 10, 11, 13.5 -</td>
</tr>
<tr>
<td>Mini Mast Arm (Mini MA)</td>
<td>4.9 to 5.5</td>
<td>1.4</td>
<td>-</td>
</tr>
<tr>
<td>Mast Arm (MA)</td>
<td>5.5</td>
<td>2.5, 3.7, 5.5</td>
<td>-</td>
</tr>
<tr>
<td>Joint Use Mast Arm (JUMA)</td>
<td>5.5</td>
<td>2.5, 3.7, 5.5</td>
<td>8, 9, 10, 11, 13.5</td>
</tr>
</tbody>
</table>

NB: Mounting height of a street lighting lantern is 1.5 m above pole height. 

| **Table 3.3** |
Figure 3.4: Traffic Signal Components

- Joint Use Light Column (JUP)
- Combination Mast Arm Street Light (JUMA)
- Mast Arm (MA)
- Traffic Signal Post (2B or 2A)
- Mini Mast Arm (Mini MA)
Figure 3.5: Standard Lantern Aspects

CIRCULAR (Red, yellow or green)
ARROW (Red, yellow or green)
U-TURN (Red, yellow or green)

SPECIAL VEHICLE
(Emergency vehicle) (White)
SPECIAL VEHICLE
(Trams) (Red, yellow or white)
SPECIAL VEHICLE
(Buses) (Red, yellow or white)
SPECIAL VEHICLE
(Bicycle) (Red, yellow or green)

PEDESTRIAN
DON'T WALK (Red only)
PEDESTRIAN
WALK (Green only)

OVERHEAD LANE SIGNAL
(White only)
Note: Permissible lantern displays are shown in the AUSTROADS Guide Part 7, figure 5.17.

**Figure 3.6: Lantern Displays**

- **R** - Red
- **G** - Green
- **Y** - Yellow
- **W** - White

Note: The letters **K**, **L**, & **M** are used for special lantern displays.
3.4.4 Public lighting facilities on joint use poles

Although liaison occurs between VicRoads, the municipal council, and the electricity supply authority, the final traffic signal design plan only identifies the physical location of the JUP and JUMA’s which are to be supplied by VicRoads as part of the signal works. There is no indication of any other works other than conduits which may be necessary to supplement the provision of public lighting.

Standard drawings for JUP and JUMA foundations provide for a 63 mm conduit to be cast in the base to enable underground entry of the mains supply cable for the public lighting.

There has been tacit agreement with a number of the public lighting authorities that they would be prepared to put their cables through our conduit junction pits provided that they were not sharing our underground conduits. Hence, if the point from which the public lighting at a site was to be supplied was established, a network of separate 63 mm conduits utilising our conduit junction pits should be established and subsequently used for public lighting.

During the design phase, the supply point for the public lighting and a suitable network of conduiting for public lighting should be shown on the signal design plan.

Permanent reinstatement after signal works or other roadworks should not be completed before the public lighting is fitted to the joint use poles and mast arms.

**Figure 3.7: Signal Hardware Clearance Required Under Electricity and Tram Operator Lines**
**Figure 3.8: Mast Arm and Detector Loop Locations**

- **3 Standup Lanes No Median**
- **3 Standup Lanes With Median**
  - Use mast arm where there is a visibility problem
- **4 or More Standup Lanes**

**Legend:**
- ○ Primary Pedestal
- ← 200 mm Dia Lantern
- → Mast Arm
- Optional right turn loop location (stop line, 6 m or 12 m) depending on the degree of control or encouragement of the right hand turn movements (See also Figure 3.13)
- Stop line loop
3.4.5 Conduits, Pits and Cables

The conduit junction pits are connected by one 100 mm diameter conduit and one 100 mm diameter conduit (public lighting) in a ring circuit configuration as shown in Figure 3.9. From the controller a 50 mm diameter conduit is provided to the point of supply and two 100 mm diameter conduits to the nearest junction pit. A 32 mm diameter conduit is provided from the controller to the nearest telephone cable pit. A 100 mm diameter conduit is run from the point of supply to the nearest junction pit for public lighting.

The traffic signal pedestal is joined to the conduit pit by a 100 mm diameter conduit and each detector pit by a 50 mm conduit to the junction pit. These conduits are not shown on the plan but are detailed in the specification prepared by Traffic System Operation Department.

The cover required over conduits is 1200 mm under declared roads, tramways and railways. For local road crossings 600 mm cover is required.

The conduit junction pits are 600 mm diameter and 1000 mm deep and are usually placed between pairs of pedestals so that the pit is no further than 10 m from each pedestal.

**Figure 3.9: Typical Conduit Layout**
3.4.6 Detection

Traffic and other detection is described in the AUSTROADS Guide to Traffic Engineering Practice Part 7, Traffic Signals, Section 7.

For vehicle actuated systems to be effective, full information regarding the traffic is required. Therefore detectors are used to determine:

- if vehicles are waiting during the red period,
- their location,
- if they have moved (i.e. filtered),
- their direction (for right or left turn phases),
- if vehicles are still approaching during the green period.

Furthermore, for the SCATS co-ordinated signal system, individual detection loops in each lane are required for measurement of vehicle volumes and degree of saturation to provide the basis for adjusting the intersection signal timings and co-ordination offsets.

Consequently loops are placed in each lane with the leading edge of the loop 2.5 m behind the centreline of the stop line (see Figure 3.8).

Exceptions to this are:-

- In an exclusive right turn lane where the right turn movement is serviced by a leading, partially controlled right turn phase, the loop may be located at 2.5 m, 6 m or 12 m behind the stop line depending on the level of encouragement desired for the right turn vehicles. In most cases 6 m is adopted. If 12 m is chosen, a stop line loop at 1.5 m will generally be required to collect SCATS data. (See also Figure 3.13.)

- Loops may be omitted from some lanes if there is no requirement for calling or extending phases, or collecting SCATS data.

- Multilane loops (transverse loops) may be installed where there is only a need for calling or extending a signal phase. This type is more commonly used in rural townships and cities where SCATS strategic data is not required such as minor road approaches to intersection signals.
Two types of vehicle detectors are used:

- A passage detector produces a brief pulse as each vehicle enters the detection zone. A passage detector places a locking call for a phase which is only cancelled when the phase runs. Additional pulses extend the phase, however, if slow moving or stationary traffic occupies the detection zone, the passage detector will not provide further pulses.

- A presence detector provides a continuous output while part of a vehicle is within the detection zone. A presence detector can place either a locking call or a non-locking call (whilst a vehicle is over it) for a phase. Non-locking calls are normally used for partially controlled right turn phases. If a vehicle filters, the demand for the right turn phase is cancelled.

3.4.7 “Stop here on Red Signal” and “Stop here on Red Arrow” Signs

Where these signs are erected adjacent to a traffic-control signal a driver must not proceed beyond the traffic-control signal while it is displaying a red circle or arrow to face the driver.

The use of these signs is confined to situations where, due to some unusual feature of the traffic-control signal layout, drivers may have some difficulty in appreciating the need to stop, or the location at which they should stop (eg. a wide median when turning right).

Wherever the use of these signs is considered necessary it will be included in the traffic signal design.

In general, however, use of these signs will be kept to an absolute minimum consistent with safety, so as to maintain its effectiveness at locations where the need for the sign is greatest.

A stop here on red signal or arrow sign is a MTCI and is not delegated to Councils.

Road Rule 56 of Road Rules - Victoria covers stopping for a red signal or arrow.

3.4.8 A “Right Turn From Left” Sign (Hook Turns)

Right turn from the left (hook turn) signs are used extensively in the Melbourne Central Activities District, on streets where trams operate, to assist the movement of traffic and provide for safe right turns. Traffic flow is heavy, road widths are restricted and right turn phases are not practical. Provision is made in the intersection layout to allow right turn vehicles to store on the left of the intersection clear of the through traffic lanes, allowing better traffic movement through the intersection.

In city areas with high pedestrian volumes, conventional right turn operation may lead to the situation where both traffic lanes are held up, blocked respectively by a right turn vehicle in the right lane and a left turn vehicle in the kerb lane waiting for pedestrians to clear the pedestrian crosswalk. It may only need one turning vehicle in each lane to hold up all the through vehicles.

Hook turns can be used on one road and conventional right turns on the other road but hook turns and conventional turns should not be used together on the same road at an intersection.

Hook turns are safer for pedestrians, as the right turning traffic can only move off in the next part of the traffic signal cycle in conjunction with the adjacent (or side street) traffic, rather than turning through pedestrians on the pedestrian crossing.
Right turn from the left signs are restricted to signalised intersections and their use should be restricted to the Melbourne Central Activities District.

The right turn from the left sign is a Major Traffic Control Item and is not delegated to Council.

The Rules for a 'right turn from the left sign' (Hook Turn) is given in Rules 34, 35 & 36 of Road Rules - Victoria.

### 3.4.9 A Single Flashing Yellow Light

A single flashing yellow light occurs when intersection traffic-control signals stop normal operation. The Regulations state that a display by a traffic-control signal of intermittent single yellow flashes is an instruction that a driver must approach, enter and pass through the intersection with caution.

At a signalised pedestrian crossing displaying a single flashing yellow light, the driver of a vehicle must give way to a pedestrian on the marked cross-walk. This type of operation is called a Pelican crossing, refer to Chapter 4.

A single flashing yellow light is a MTCI and is not delegated to Councils.

Rules 63, 64 and 65 of Road Rules - Victoria cover a single yellow flashing light (including a flashing yellow arrow signal).

A single flashing yellow light may also be used as a conspicuity device at a time-based school zone speed limit, see Section 7.9.2.

### 3.4.10 Minor Traffic Control Items at a Traffic Control Signal

Where minor traffic-control items, as referred to in Road Rules - Victoria, are erected or displayed at or near a traffic control signal they become Major Traffic Control Items. (See item 40 of Schedule 2 of Road Safety (Road Rules) Regulations 1999). An example of this is a 'No Right Turn' sign at a signalised intersection. A sign used in this situation is an MTCI and is not delegated to Councils.
3.5.1 Signal Phasing

Signal phasing covers the arrangements of separately controlled traffic movements (groups) into sequential and concurrent (overlapping) flows which comprise signal cycles.

- **Criteria**
  - maximum safety (minimise the number of potential conflict points).
  - maximum intersection performance (minimise overall delay and stops to traffic).

- **Basic Phasing**
  Two phases is the simplest system with two cross movements controlled by 3 aspect circular displays. It allows filter movements and parallel pedestrian movements. Other basic phasing systems are the three phase with a leading right turn movement and a split phase (see Figure 3.10).

**Figure 3.10: Basic Phasing**

- **Signal timing**
- **Vehicle Time**

  - Minimum green: Minimum time provided to allow one vehicle to pass through the intersection.
  - Extension Green: Usually a 3 seconds time added to the minimum green for each successive vehicle detection up to a maximum green.
  - Maximum Green: Predetermined maximum time allocated to each particular movement.
Intergreen Time
The intergreen time comprises two stages:

- a yellow time to warn drivers of the imminent termination of the phase
- an all red time to enable vehicles within the intersection to clear the controlled area. This time is calculated by using the speed of vehicles and the size of intersection.

<table>
<thead>
<tr>
<th>Design Speed (km/h)</th>
<th>Yellow Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>3.0</td>
</tr>
<tr>
<td>50</td>
<td>3.5</td>
</tr>
<tr>
<td>60</td>
<td>4.0</td>
</tr>
<tr>
<td>70</td>
<td>4.5</td>
</tr>
<tr>
<td>80</td>
<td>4.5</td>
</tr>
<tr>
<td>90</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Note: Traffic-control signals are rarely installed in 100 km/h speed zones.

<table>
<thead>
<tr>
<th>R = 3.6W/V</th>
<th>Where R = All red time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W = width of intersection (m)</td>
<td></td>
</tr>
<tr>
<td>V = posted vehicle speed (km/h)</td>
<td></td>
</tr>
</tbody>
</table>

The minimum all red setting is one second.

Pedestrian Time
The time for pedestrians to cross the road at a signalised crossing comprises two time periods:

- a walk time (Green Person Display) indicates to pedestrians to start their crossing.

\[ W = 2 + \frac{d}{1.2} \]

Where

\[ W = \text{walk time in seconds.} \]

\[ 2 = \text{reaction time in sec.} \]

\[ d = \text{crossing distance in m (as defined below).} \]

\[ 1.2 = \text{Australian standard walking speed, m/sec.} \]

On undivided roads a standard 8 seconds walk is used unless formula yields a lower figure, with a minimum of 4 seconds.

On divided roads, the walk time is calculated using the above formula where 'd' is the distance of the widest road plus median plus one metre past the median.

- a clearance time (Flashing Red Person Display) sufficient to enable a pedestrian, who has started to cross at the end of the walk time, to reach the far kerb or median.

\[ C = \frac{d}{1.5} \]

Where

\[ C = \text{clearance time in seconds} \]

\[ d = \text{crossing distance in m} \]

\[ 1.5 = \text{Australian standard clearance speed, m/sec} \]

For ease of use a graph has been prepared in determining the above times (see Figure 3.11).

'd' is the crossing distance of one road measured from kerb to kerb. It is assumed that pedestrian walking speed is faster during Clearance than during Walk due to greater urgency to complete the crossing.

### Divided Road
**Central Median > 1.8 m**
- **Walk Time:**
  To enable Ped to clear widest road & step 1 m onto other road. (Graph 1)
- **Clearance Time:**
  Provide enough time to clear widest road. (Graph 3)

**Central Median < 1.8 m**
- **Walk Time:**
  As for Central Median > 1.8 m.
- **Clearance Time:**
  Provide enough time to clear both roads. (Graph 3)

**Undivided Road**
- **Walk Time:**
  Calculated from Graph 2 using kerb-to-kerb distance.
- **Clearance Time:**
  Graph 3. Provide enough time to clear kerb-to-kerb.

---

**Figure 3.11: Pedestrian Time Settings**

**Note 1:** Pedestrian Situation Crowded
Add 2 seconds for each additional row of pedestrians.

**Note 2:** Supervised Crossing
Additional time may have to be added to allow supervisor to take up position.
In the case where the movement involves crossing more than one road, and a pedestrian refuge exists (eg. median) then ‘d’ refers to the widest road width.

If the median is not wide enough to store pedestrians ie. less than 1.8 m (between face of kerbs) or if there is no push button on the median, then the clearance time should be sufficient to clear the total road width.

- **Infirm or Aged Pedestrians**

  Where a pedestrian facility is provided for this class of pedestrian (eg. outside of hospitals), increasing the walk and clearance times may be appropriate. If wheelchair detection loops are provided the 'walk time' may also need to be increased.

### 3.5.2 Right Turn Movements

The AUSTROADS Guide to Traffic Engineering Practice, Part 7, Traffic Signals, Section 6.4.1 discusses the control of right turn movements.

VicRoads funded research by Monash University in 1991 into right turn control. The results were published in reports titled 'The Effect of Right Turn Phases at Signalised Intersections,

Report No. 20, Safety Performance by Bill Bui, Max Cameron and Foong Chee Wai

Report No. 21, Mobility Performance by MAP Taylor'

The results are summarised as follows:

- **Safety**
  
  The installation of partially controlled right turn passes had no beneficial effect on Right Through collisions.

  The installation of fully controlled right turn phases resulted in:
  
  - significant reduction in the incidence of Right Through crashes at signalised intersections,
  
  - mildly significant reduction in pedestrian casualty accidents,
  
  - significant increase in rear end accidents.

  There is no clear explanation in the report for the increase in rear end accidents however inadequate lengths of right turn lanes may have been a factor.

- **Mobility**

  The installation of right turn phases, for most conditions except some instances of peak period operation, resulted in a reduction in the level of performance of the intersection. Partially controlled right turn phases resulted in less of a reduction in performance than fully controlled right turn phases.

**Types of right turn control**

- **Filter**

  Green circle alone indicates that the driver can turn with care.

- **Partial Control**

  Green and yellow arrows are used to control this type of right turn phase. The green arrow indicates when the driver can turn unopposed but when extinguished the driver is still able to filter during the green circle.

- **Full Control**

  Three aspect green, yellow and red arrows are used to indicate when the driver can turn unopposed and when the driver is not permitted to turn. Certain conditions necessitate the use of full control of right hand turns. Guidelines setting out these conditions are outlined in Table 3.5.
- **Split Phase**
  Single aspect green arrow is used in conjunction with green circle to indicate to all the vehicles on the approach including right turning vehicles all can run together unopposed (ie. no filter turns are permitted).

- **Right Turn Ban**
  A part or full time right turn ban may be appropriate for the following reasons:
  - to improve safety.
  - to improve capacity of critical movements.
  - to assist tram movements.
  - to support local traffic management strategies.
  - the right turn demand is low (ie. less than one car/cycle up to 30 vph).

- **Right turn phases can be provided for the following reasons:**
  - to encourage right turn movements at specific locations.
  - to provide a viable alternative to by-pass routes in residential streets.
  - to service a substantial right turn demand.
  - to discourage right turns by fully controlling the right turn and limiting the green time given to the movement.
  - to control right turn movements to improve tram operation.
  - to reduce the existing 'right turn against' accident occurrence.
  - to reduce the potential for right turn against accidents at new locations due to identifiable high risk characteristics which may have contributed to these accidents at existing locations.

Table 3.4 lists the strategies applicable to right turn control. Figure 3.13 shows how the location of the detector loop can be used for various right turn strategies.

Decisions regarding right turn control should be made with due consideration of both safety and operational performance objectives. Full control of the right turn may create a need for improved overall capacity or double right turn lanes.
<table>
<thead>
<tr>
<th>Objective</th>
<th>Strategy</th>
<th>Type of Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Management</td>
<td>Encourage</td>
<td>Partial control with stop line loop.</td>
</tr>
<tr>
<td></td>
<td>Discourage</td>
<td>Do not provide right turn phase even if demand exists.</td>
</tr>
<tr>
<td></td>
<td>Maintain</td>
<td>Fully controlled right turn phase with stop line loop but limit green time.</td>
</tr>
<tr>
<td></td>
<td>No specific requirements</td>
<td>Do not increase the current level of control for low turn movements.</td>
</tr>
<tr>
<td></td>
<td>Tram Priority</td>
<td>Provide a partial controlled right turn phase operated by a loop at 12 m if significant demand exists.</td>
</tr>
<tr>
<td>Safety</td>
<td>Reduce accident occurrence at existing signals</td>
<td>Partial control with stop line loop if accident occurrence occurrence is less than specified for full control in Table 3.5. Allow filter turns if no right-turn-against accidents have occurred in the last 3 years. Full control with stop line loop if accident potential meets criteria in Table 3.5. The right turn lane may need to be lengthened.</td>
</tr>
<tr>
<td></td>
<td>New or existing signals</td>
<td>Full control with stop line loop for 2 or more right turn lanes. Partial control with stop line loop for three opposing through lanes with a good accident record. Allow filter turns if there is a good accident record with only two opposing through lanes.</td>
</tr>
</tbody>
</table>

### Table 3.4: Method of Determining the Need and Type of Right Turn Control

#### Maintaining level of service
To assist the designer in maintaining an acceptable level of service the following facilities are available:
- restricting the time available to one or more movements.
- banning certain right turn movements.
- extensive parking restrictions, permanent parking bans or clearways.
- provision of five lane treatments with or without roadworks.
- reducing the lane widths consistent with the vehicle composition.
- roadworks to increase the number of lanes.

#### Fully controlled right turn phases
Right-turn-against accidents are the largest single accident type at intersection signals. They represent approximately one-third of all reported casualty accidents at signals.

Fully controlled (3-aspect) right turn phases are highly effective in reducing the incidence of right-turn-against accidents. The use of fully controlled right hand turn phases can have a detrimental effect on capacity but, when considered in economic terms, may be justified. Where major operational problems would result from the use of fully controlled right turn phases, an economic analysis should be carried out to assist with decision-making. This will clarify the relative worth of accident savings, travel time and other costs.
The ranking of the project for funding will need to be carried out using a benefit cost analysis contained in a spreadsheet operated by VicRoads Road Safety Department. Refer to the Road Safety Program, Blackspot and Route Treatment Projects, Guidelines for Site identification and project evaluation.

Note:
- recognise intersections which have operated safely over a number of years, despite the perceived potential for right-turn-against accidents.
- if a fully controlled right turn phase is to be provided then an exclusive right turn lane must be provided for the movement.
- where a fully controlled right turn phase is proposed, the length of the existing right turn lane should be compared with the results of the SIDRA intersection analysis package. If the existing right turn lane is inadequate, lengthening should be considered as part of the project to implement the fully controlled right turn phase.

In order to provide guidance in the use of fully controlled right turn phases, the following guidelines have been developed.

The criteria established are based on demonstrated right-turn-against accident problems and/or on the potential for such problems. Table 3.5 lists some basic criteria for considering a fully controlled right turn on intersection approach.

Accident histories apply to the total for the most recently available 3 year period. In marginal cases, 5 years of data should be examined, to check whether the annual accident frequency was similar over the longer period, and where the additional years of data have relevance to existing conditions.

Where an economic analysis, involving a consideration of accident savings, traffic operation and delay, indicates that full control is not an appropriate measure, partial right turn phase control, called by a stop line loop, should then be considered.
<table>
<thead>
<tr>
<th>EXISTING AND NEW SIGNALS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACCIDENT HISTORY</strong></td>
<td></td>
</tr>
<tr>
<td>DCA 121 Right turn against crashes</td>
<td>&gt; 3 Reported casualty accidents over a most recent 3 year period. Benefit Cost Ratio for funding ranking needs to be determined.</td>
</tr>
<tr>
<td>Pedestrian activity</td>
<td>Check on DCA 107 pedestrian accidents for right turning vehicles.</td>
</tr>
<tr>
<td><strong>TASK COMPLEXITY/GAP SELECTION</strong></td>
<td></td>
</tr>
<tr>
<td>Number of right turn lanes</td>
<td>&gt; 2 Lanes turning right.</td>
</tr>
<tr>
<td>Opposing multi-lane approaches</td>
<td>&gt; 3 through lanes.</td>
</tr>
<tr>
<td>High opposing speeds with 3 opposing through lanes</td>
<td>85th percentile speeds &gt; 80 kph.</td>
</tr>
<tr>
<td>Road cross section</td>
<td>Centre road with service roads continuous through the intersection (note service roads should normally be truncated where possible).</td>
</tr>
<tr>
<td><strong>SIGHT DISTANCE RESTRICTIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Horizontal and/or vertical alignment</td>
<td>Restricted sight distance.</td>
</tr>
<tr>
<td>Intersection layout</td>
<td>&gt; 2 Opposing right turn lanes.</td>
</tr>
</tbody>
</table>

*Table 3.5: Basic Criteria for Considering a Fully Controlled Right Turn*

*Figure 3.12: Right Turn Movements*
During the right turn movement phase, four additional movements are possible, these are:
- opposing right turns,
- parallel pedestrian movement,
- left turn overlap movement and
- through movement.

(See Figure 3.12.)
3.6.1 Data Collection

Information that must be gathered before designing a set of traffic signals is as follows:

- **Site Information**
  - All ground services within 20 m of intersection on each approach eg. pits, stop valves, fire hydrants, etc.
  - Point of electricity supply, Telephone pits and (existing) controller location.
  - Public lighting poles and lanterns, tramway poles, electricity poles, etc. If possible, height and location of overhead wires at the intersection.
  - Pram crossings within intersection area.
  - Parking poles, signs and type of restriction approximately 60 m along each approach or to end of restriction if possible.
  - Driveways approximately 60 m along each approach.
  - Kerb and channel type; ie. bluestone, concrete, etc.
  - Height of verandahs to underside and their thickness if possible.
  - All existing detector loops, detector pits and conduit pits.
  - Nature strips, footpaths and trees - establish whether trees require pruning.
  - All existing signals, lantern type and number, pedestal type, internally illuminated signs, pedestrian signals and push-buttons, audible pedestrian signals, etc.
  - Photographs of intersection from all approaches sufficient to give a drivers view which should show any obstructions or peculiarities, such as overhanging trees, poles, etc.
  - If photographs do not show all linemarking, locate and establish type of linemarking, eg. painted islands, double lines, continuity lines, lane lines, etc., by chainage and cross-section to tangent points, changes of direction and start and finish of such features.

- **Plan**
  A plan of the intersection or mid-block area at 1:250 scale. If no plan is available, a survey must be undertaken to determine:
  - the kerb and building lines,
  - all above and below ground features including poles, service pits, trees, verandahs, power lines, parking signs, side entry pits, pram crossings, overhead lighting, footpaths, bus and tram stops.

- **Traffic Volume**
  A peak hour turning movement traffic count carried out for a minimum of two hours in both peak periods. A count of pedestrians where appropriate.

- **Accident Data**
  An accident collision diagram may be required showing all accidents in the intersection or mid block area for a minimum of the previous five years.

- **Future Developments**
  Information on any known or likely future developments in the surrounding area, ie. shopping centre development, road widening or realignment, major sporting complexes, etc.

- **Traffic Management Strategy**
  Information regarding the particular strategy to be adopted to manage the traffic, ie. which movements should be encouraged, discouraged, banned or maintained, particularly public transport priorities.
3.6.2 Data Analysis

The data collected should be analysed in the following order:

- **Intersection/Mid Block Geometry**
  Initially the existing geometry should be checked to see that it conforms with current standards. Secondly the inclusion of medians, islands to create free left turn lanes and modified corner radii can improve the intersection definition, improve vehicle turning movements or slow down turning vehicles to improve pedestrian safety.

  Narrowing of lanes or flaring into medians can provide additional through or turning lanes to improve intersection capacity.

  Reducing the size of the intersection, particularly the ‘dead’ areas by kerb extensions, can substantially reduce pedestrian walk times.

- **Future Developments**
  The requirements of any future developments must be determined or estimated to determine their impact on the intersection geometry or phasing or installation of the signals.

- **Accident Analysis**
  An analysis of the collision diagram and if necessary the accident report forms is undertaken to determine if there are any geometric or special signal phases or other requirements such as line marking or street lighting necessary to improve the level of safety.

- **Strategy**
  As there are a number of measures (ie. geometric or signal phasing), available to encourage or discourage various movements, the most cost effective method must be determined.

- **Phasing and Capacity Analysis**
  Finally a draft geometric layout is determined and a capacity analysis is undertaken.

For this purpose an understanding of ARRB Transport Research Ltd, research report ARR 123, Traffic Signals: Capacity and Timing Analysis, R Akcelik 1989, is necessary. To make a capacity analysis easier, ARRB Transport Research has produced a computer program called SIDRA (Signalised Intersection Design and Research Aid). This computer program allows the traffic engineer to test a number of phasing systems, vary the levels of saturation, cycle times, saturation flows and other variables to determine the most efficient phasing system. Lane configuration, lane widths and lengths can also be varied to further improve the level of efficiency.

The output will also provide details of the degree of saturation, average delay (seconds) and average queue lengths for each vehicle movement.

The traffic engineer needs to analyse the design using the maximum linked cycle time if the intersection is going to be part of a linked system. The reason for using the linked cycle time is to ensure turn lanes are the appropriate length for maximising capacity under linked operation when all sites run the same cycle time.
3.6.3 Traffic signal hardware layout

Following the determination of an acceptable geometry, the number and type of vehicle lanes for each approach, signal phasing system and the traffic signal hardware can then be added to the plan as follows. (A typical signal layout plan is shown in Figure 3.25.)

- Pedestrian cross walk lines are drawn to:
  - minimise the pedestrian crossing distances and,
  - be as near as possible to pedestrian desire lines.

Pedestrian cross walk lines should be as near as possible to the corner to:
- ensure maximum visibility of pedestrians by turning motorists and,
- to minimise the distance from the stop line to the point where left turns conflict with the parallel pedestrian movement so that the speed of left turning vehicles at the conflict point is minimised, and
- minimise the distance from the stop line to the cross-walk on the far side of the intersection so that the time for through vehicles to clear the intersection is minimised.
- pedestrian walk lines should only be shown across left turn slip lanes where a signalised crossing is shown. See Section 3.6.4.

The above criteria are very important to ensure maximum level of pedestrian safety.

The relationship between the stop and pedestrian cross walk lines are shown in Figure 3.14 (for details of pedestrian operated signals, see Figure 4.3).

- Stop Lines
Stop lines are added as shown in Figure 3.14. In some circumstances particularly where trams turn left, the stop line is not always parallel to the pedestrian walk lines.

- Pedestals
Add traffic signal pedestals at intersection as shown in Figure 3.14 (for pedestrian operated signals, refer to Figures 4.7 and 4.8).

The criteria for pedestal locations are:
- desirable offset behind back of kerb one metre,
- primary pedestals located half way between stop line and pedestrian walk,
- tertiary pedestal in line with the departure side cross walk line.

![Figure 3.14: Typical Pedestal and Linemarking Arrangement](3-43)
There are a range of pedestal types available (see Figure 3.4).

Pedestal types should be chosen to ensure that the traffic signal lanterns are seen at required sight distances (see Figure 3.15) as follows:

- 110 m for 60 km/h speed zone
- 140 m for 70 km/h speed zone
- 170 m for 80 km/h speed zone
- 200 m for 90 km/h speed zone
- 240 m for 100 km/h speed zone.

**Figure 3.15: Sight Distance To Signal Lanterns**

**Pedestrian Lanterns**

A pedestrian lantern (with the symbolic red person and green person display) is located at each end of each cross-walk. On a divided road, additional lanterns are installed on the pedestal in the median. Where the total road width is less than 20 m, pedestrian lanterns may not be required on the median pedestal.

**Pedestrian Push Button Detectors**

Pedestrian push button detectors are shown on the same pedestals as the pedestrian lanterns at each end of the cross-walk. If the cross-walk passes over a median greater than 1.5 m, then a pedestrian detector is provided. If in some instances, it is necessary to locate the pedestrian detector away from the primary or secondary pedestals, then a type 3 pedestal (a one metre high pedestal) is used. The most frequent use of a type 3 pedestal is on safety zones.

Generally audio-tactile detectors (audible signals) should be specified for all new signal installations. Detectors with **constant** and **variable** sound output are available. Variable detectors adjust output according to ambient noise levels and should be used adjacent to residential properties.

There is an increasing practice of turning the audible signals off at night where residential properties are close to the pedestrian crossing and the audible signal causes disturbance. The operating times of the audible signal needs to be agreed with the local association of blind persons. The signal controller will need to be reprogrammed for the new operating times.

A note needs to be added to the traffic signal layout plan if audible signals are to be installed.
Figure 3.16: Location of Signal Displays, Undivided Roads

Figure 3.17: Location of Signal Displays, Divided Roads
Vehicle Displays
Vehicle displays are located as follows:
- a primary display is always provided on the left. Where a median exists or is proposed another lantern is located in the median as a second primary display.
- a secondary display is located on the departure side right to provide a display and starting signals for vehicles in the right lanes.
- a tertiary display is located on the departure side left and acts as a starting signal and a back-up to the primary display.

Desirably a minimum of three circular displays or two turn displays should be visible when approaching and two displays are visible when stopped.

The basic positions are shown in Figures 3.16 and 3.17.

Additional displays are then added for special purposes such as:
- tram and bus movements, and
- special displays, for left and right turn movements as shown in Figures 3.16, 3.17 and 3.6.

Bicycle Displays
See Chapter 5 for details on bicycle displays.

Street Lighting
After having determined the pedestal locations and types, a street lighting design must be obtained. Often joint use poles can be used to minimise the number of poles. Sometimes it may be necessary to slightly modify the pedestal locations so that a joint use pole can be used.

Parking Restrictions
Modify, increase, provide or ensure that the parking restrictions meet statutory requirements or capacity requirements. Add peak hour bans or clearways as required. Note the removal of any redundant signs and poles for inclusion in installation notes on the plan.

Joint use existing electricity poles where possible to minimise the number of poles.

Linemarking
Add lane markings, five lane treatments, chevron markings, RPM's or RRPM's as required to ensure the clear definition of vehicle paths particularly where there is misalignment through the intersection.

Add pavement arrows in turn lanes or lanes where vehicle movements are to be restricted.

Signs
Add any 'no right' turn or 'no left' turn sign (reflective or internally illuminated as required). Also add any keep left, hazard board or other signs as necessary.

Detectors
Add vehicle, tram, bus, wheelchair, queuing and red light camera loops as required.

Currently a loop is provided in each vehicle lane to detect or count vehicles and is located 2.5 m behind stop line.

Tram loops at the stop line are used to detect the presence of a tram so that a tram phase can be called, extended or introduced earlier in the cycle. The same applies to bus loops.

Advance tram loops can be installed approximately 200 m in advance of the stop line to detect approaching trams. Special tram phases can then be introduced to assist trams to reach stop line.
Installation/Remodel Notes
Specify all the works required by the various Authorities (Council, VicRoads and Signal Contractor).

Other Items
Other items that must also be added to the plan are:

Controller
A position is chosen where the controller lies:
- close to low voltage power source (240 volts) and a telephone cable pit.
- clear of running traffic on the protected side of roadside objects.
- at a prominent secure location where the maintenance vehicle can safely stop and park and there is a good view of all approaches.
- in shade or shelter.

Point of Supply
A suitable electricity supply authority pole which has 240 v supply available is selected for the supply point. In remote areas a transformer is required if only high voltage supply is available at the site.

Connection to Telephone Company
A nearby small telephone cable pit is selected as an initial first guess for an appropriate location to obtain connection to the SCRAM or DUST Systems. DUST is a dial up system for traffic that is widely used in VicRoads' rural regions and the City of Wyndham (Werribee). A 50 mm conduit is shown from this pit to the controller.

Cable pits and conduits
One cable pit is located on each corner for termination of the underground conduit for storage of a spare one metre loop of cable used in case of cable damage.

A 100 mm conduit (Category A PVC) is shown between each cable pit, to the controller and to point of supply. Sometimes on a large intersection twin, 100 mm conduits may be required to house the power and detector cables between the controller and the nearest cable pit.

Detector Pits
Add detector pits at back of kerb, 8 m from the stop line and in the median if required. A 50 mm conduit is installed from the detector pit to the nearest cable pit. This conduit is not shown on the plan but covered in the contract specification prepared by the Signal Installation Department. A maximum of three loops can be fed to each detector pit and if there are more than three lanes on a divided road, detector pits should be located both sides of the road.

3.6.4 Special Design Considerations

Single Left Turn Slip Lanes
The normal control for traffic entering the other road from the slip lane is a give way sign. Single lane slip lanes are generally not signalised for pedestrian movements. Various treatments may be considered depending on site conditions as follows:

- no special provision where pedestrian movements are light (do not mark walk lines),
- pedestrian crossing with two walking legs signs and zebra crossing linemarking for normal pedestrian activity (only use twin flashing yellow lights if there is a visibility problem),
- pedestrian signals should be considered where crossing would be hazardous for elderly, visually impaired or disabled pedestrians. Also consider signals if the crossing conditions are likely to be difficult due to high numbers of vehicle/pedestrian conflicts. See Section 4.5 for the warrants for pedestrian signals. (The stop line is positioned 6 m from the walk lines for pedestrian signals on a slip lane.)
The practice of not normally providing pedestrian signals on slip lanes has arisen because signalised left turn slip lanes are not well regarded by either drivers or pedestrians. Many pedestrians will cross the slip lane without pushing the button, or after pushing the button cross before the signals change. Thus, drivers are often faced with a red left turn arrow for no reason. All in all, if the signals do not have credibility with the users, a less restrictive control device should be used. Slip lanes should not be signalized unless there is a specific reason to do so. An example of where signalization could be used is where it has been demonstrated that visually impaired people regularly use the crossing and it has been recommended by an association for the visually impaired.

Double Left Turn Slip Lanes

Double left turn slip lanes should normally be provided for pedestrian signals. The normal control for vehicles entering the other road from the slip lane would be give way signs.

Slip Lanes and freeway incident management

There had been a perception that all freeway on ramp left turn slip lanes should be signalized for the purposes of ‘incident management’. The Incident Management Freeway Closure signs provided at each site will be satisfactory in the control of traffic during an incident, especially considering that the likelihood of an incident occurring which requires the closure of a left turn movement is very small - perhaps one or two occasions per year.

‘T’ Intersections

At ‘T’ intersections it is more hazardous for pedestrians to cross on the right hand side of the intersection because motorists turning right from the stem of the ‘T’ are unopposed and likely to turn more rapidly.

In the interests of efficiency of vehicle flows and overall safety, it is therefore preferable not to provide a cross walk on the right hand side of the intersection.

If this cross walk must be provided to service a very heavy pedestrian demand across this leg of the intersection, the following three basic phasing options should be considered:

Option (a)

Provide internally illuminated “Give Way to pedestrians” lantern facing the turning traffic. Also an early start to the pedestrian movement may be considered.

Option (b)

*Through movement does not run if pedestrian detector is operated

Option (c)

Separate pedestrian phase.

Figure 3.18

NB: Option (b) is only possible if there is an exclusive right turn lane.
Option (c) is not efficient for vehicle flows but may be appropriate where pedestrian volumes are high.
The basic principles in designing traffic signals at ‘T’ intersections are:
- Three vehicle lanterns to be visible to approaching motorists on all approaches.
- Desirable pedestal locations are shown in Figure 3.19.

**Figure 3.19: Desirable Pedestal Locations**

**Pedestrian Cross-Walks at Intersections**
Pedestrian cross-walks should be provided at all intersections on all legs, except at ‘T’ intersections as above and at rural intersections in totally undeveloped areas, or in other under developed areas such as freeway on/off ramps.

Wherever possible cross-walks should be perpendicular to the kerbline to assist the safe crossing of visually impaired pedestrians. See also the AUSTROADS Guide Part 13, Section 3.3.9, Tactile Paving and AS 1428.

**Phase Overlaps**
Whenever a right turn phase is provided, a corresponding left turn overlap phase should be provided if conditions allow because:
- left turning vehicles can turn without opposition by pedestrians thereby increasing pedestrian safety.
- through vehicle movement during the through phase can be increased as the incidence of left turning vehicles being blocked by pedestrians is significantly reduced.

**Five Lane Treatments**
Painted ‘five lane’ or three lane treatments should be considered whenever the kerb to kerb spacing is greater than 14.1 m or 8.7 m respectively (face of kerb measurements). Care should be taken to ensure adequate provision for truck turning movements, particularly left turns.

This type of treatment significantly increases intersection capacity particularly where there is a significant number of right turning/left turning vehicles on one approach where, if blocked by on-coming vehicles or pedestrians, there will be no vehicle flow until there is a gap in the on-coming vehicles or the pedestrians have completed their crossing.

**Railway Crossings**
If traffic or pedestrian signals are located close to a railway crossing, an interlink between the traffic-control signals and railway signals is often necessary. This link will ensure that the traffic signals will not cause any vehicles to store on the railway lines when a train is approaching.

Most traffic signals installed close to or across railway lines require a fairly complex phasing system to ensure that vehicles do not queue across the railway lines. For efficient operation careful consideration should be given to achieving the maximum road capacity (number of lanes, exclusive turn lanes) and the maximum use of complimentary (overlap) vehicle and pedestrian phases. Clearance phases are not used after train phases.

Roundabouts have been successfully used next to railway crossings even though the roundabout may be blocked during train movements.
Staggered ‘T’ Intersections
These type of intersections should be avoided because they operate very inefficiently when signalised. The reasons are that the cross streets usually require separate phases and rear end collisions often occur on the major road due to the closely spaced stop lines.

Location of stop lines and lane lines where trams turn
It has been general practice for stop lines to be set back where trams turn. The basis of this practice is to provide safe movement of trams around curves clear of adjacent vehicles. There are four points of conflict to be considered (see Figure 3.20).

1. Left turning tram crossing lane line near the stop line.
2. Right turning tram crossing centre line on approach.
3. Right turning tram crossing centre line on departure.
4. Right turning tram rear end swinging wide near tangent point.

The design of stop line positions should reflect the need to avoid these conflicts. To achieve the optimum position for the stop line there are a number of modifications which may be incorporated:

- For conflict point 1 (Figure 3.20) the lane line may be marked so that it diverges to the left. The taper must start no closer than 4 m prior to the tangent point. Minimum lane width may limit the stop line position (see Figure 3.21).

- For conflict point 2 the tram will need to stop before it crosses the centre line or road markings. In some locations this may prevent effective use of signal priority. Marking a chevron area instead of a single line may allow the tram to move up further (see Figure 3.22).

- It is vital that vehicles waiting at the stop line do not block the turning trams. By marking a chevron area where trams overhang the centre line, the stop line may be moved closer to the intersection (see Figure 3.23).

- When a tram negotiates a curve the rear end of the tram will swing wide, even before the tram is fully on the curve. It is important that the lane line is marked so that the tram does not overhang it (see Figure 3.24).

When there is a tram safety zone, the end of the safety zone and the stop line may need to be set back to avoid tram patrons being trapped between the turning tram and the traffic signal pedestal. When the stop line and safety zone is moved back care should be take to ensure tram patrons can access the pedestrian crossing. Use a wide pedestrian crossing if necessary.

Agreement has been reached with the Tram Operators that the enclosed linemarking layout proposals are acceptable in principle for preparation of signal designs at sites where trams turn.

These layouts should only be used with care as they may produce a poor alignment for through traffic. In some situations it may be more appropriate to set the stop line back and provide a tram activated right turn phase.

Tram clearance should be maintained at the standard 0.9 m adjacent to straight track.
**Figure 3.20:** *Stop Lines Where Trams Turn*

**Figure 3.21:** *Lane Lines Where Trams Turn Left*
Figure 3.22: Lane lines where trams turn right using painted island

Figure 3.23: Lane lines where trams turn left using painted island
**Tram Auto Points**

At tram line junctions Yarra Trams or Swanston Trams (as the case may be) may install tram signal equipment and a controller to automatically switch the tram points. A connection is needed between the Tram and VicRoads controllers to allow the tram phases to be called. Also a back up push button is needed at a convenient location to allow the tram driver to call the tram phase if the Tram system fails.

The procedure for installing tram automatic points is that the relevant Tram Operator will send to the VicRoads Regional Manager a copy of the layout of the automatic points equipment showing the locations of the controller cabinet. The Regional Traffic Engineer arranges a signal remodel plan showing:

- the back up push button location,
- the tram cabinet location,
- the location of a 50 mm duct between the Tram controller and the nearest traffic signals conduit pit.

For a straightforward job, the draft stage may be skipped.

Send the signal layout plan to Signal Installation and Traffic Operations for installation. A quotation should be obtained if the job is not straightforward and the Tram Operator advised of the cost. The cost of all works is charged to the Tram Operator.
Figure 3.25: Typical Signal Layout
3.6.5 Specifying Site Works For Traffic Signal Plans

The Traffic Signals Department require that the remodel notes on signal layout plans be clear to avoid any misrepresentation by Signal Installation contractors. With this in mind the ‘Remodel/Installation Notes’ have been standardised as follows.

Installation/remodel notes

A. SIGNAL CONTRACTOR

NEW SITE
1. Install new hardware as shown.
2. Install meter box or switch box at point of supply.
   (See “general notes” for further notes required).

TOTAL REMODELS
1. Install new hardware as shown.
2. Install/replace meter box or switch box at point of supply.
3. Remove all existing above-ground hardware.
4. Remove all existing P.O.S, P.O.S.S, pedestrian crossing, school crossing, hardware on ............ approach.
   (See “general notes” for further notes required).

PARTIAL REMODELS
1. PEDESTAL ............
   - Relocate existing 2A, B, JUP, MA from .........................
   - Install new 2A, B, JUP, MA ..................
   - Install new lanterns as shown.
   - Install new ..... lanterns.
   - Remove ........ lanterns.
   - Replace ......... lantern with ........ lantern.
   - Relocate ....... lanterns from redundant pedestals.
2. Pedestal ............ Etc. (Repeat above applicable notes for all pedestals altered)
3. Remove ............ (List all items)
4. Install/replace meter box at point of supply.
5. A. Install 32 mm conduit, ............ conduit pits, new controller base and ........ detector pits as shown, or
   B. Install 32 mm conduit to telephone pit as shown.
6. Install ................ detector pits on ............ approach, 50 mm conduit to conduit pit and ........ feeder cables.
   (See general notes for further notes required).

GENERAL NOTES
1. Install parking sign poles and faces at .................
2. Remove parking sign poles and/or faces at ............
3. Relocate parking sign faces from ............ to ............
4. Install 10 pair communication cables as shown/from controller to fire station, ambulance, Tram Operator communication room.
5. Install audio tactile pedestrian detectors (constant or variable).
6. Reuse audio tactile pedestrian directors (constant or variable).
7. Additional cabling (approximately ........m) to be placed in pit near pedestal ........ to provide for relocation of pedestals due to future road widening.
8. Contractor to seal verandah roof / ceiling at pedestal
9. Cap pedestal ............ under verandah and fit junction box.
10. Install road signs where shown and remove redundant signs.
11. Provide for advance tram detection, see note
12. Relocate photo-violation camera and flash unit as shown.
13. Install 63 mm Public Lighting conduit as shown.
14. Install additional detector pit on ... (location)... for telephone (Telstra) connection.
B. COUNCIL
1. Construct roadworks as shown.
2. Install ................ pram crossings as shown.
3. Reinstate kerb at ................ pram crossings as shown.
4. Arrange for transfer/installation of public lighting and/or the removal of any redundant poles or equipment. See notes
5. Trim/remove trees as shown.
6. Construct pedestrian footpath as shown.
7. Install temporary kerbing as shown.
8. Install parking sign poles and/or faces at ....................
9. Remove parking sign poles and faces at ....................
10. Relocate parking sign faces from .......................... to ....................
11. A Linemark as shown and remove any redundant markings, or.
    B Repaint linemarking.
13. Install road signs where shown and remove redundant signs.

C. VicRoads REGION
1. Construct roadworks as shown.
2. Install ............. Pram crossings.
3. Reinstate kerb at ................ Pram crossings as shown.
4. Linemark as shown above and remove any redundant markings.
5. Install R.R.P.M.'S and R.P.M.'S as shown and remove any redundant markers.
6. Arrange for transfer/installation of public lighting to new joint use poles and the removal of any redundant poles or equipment. See notes
7. Install road signs where shown and remove redundant signs.
8. Install detector loops as shown.
9. Install new controller, or replace existing controller.
10. Linemark as shown and remove any redundant markings.
11. Install R.R.P.M.'S and R.P.M.'S as shown and remove any redundant markers.
12. Terminate communication cable as shown from controller to fire station, ambulance, met rail.
13. Program controller or

D. PUBLIC TRANSPORT CORPORATION
1. Install overhead detector cable on approaches.
2. Install safety zones as shown.
3. Relocate P.T.C. Poles as shown.
4. Relocate/remove /install tram stops/shelters as shown.

OTHER NOTES WHICH MAY BE REQUIRED ON THE PLAN
A. The following notes, as appropriate, are to be placed in the notes section.

1. Advance tram detection on:-
   (i) North approach - pit to base of P.T.C pole .......................(.........M), detector cable overhead at M pole
   (ii) South approach - pit to base of P.T.C pole .......................(.........M), detector cable overhead to M pole
   Or
   (i) North approach - use tram loop .......................(... M), at the intersection of ..........................(Drg no ).
   (ii) South approach - use tram loop .......................(.... M), at the intersection of ..........................(Drg no ).
   Or
   (iii) Tram loop ....................... to be used for transfer of demand to the intersection, pos/s at .......................... (Drg no ).

2. Audio tactile pedestrian detectors installed.
3. Base information from .................. Plan no ............... and VicRoads site inspection.

4. Public lighting notes,
   (i) Pedestal ................to be ........... M JUP, JUMA, mounting height ...............M, outreach M, with lights.
   (ii) Pole on corner of ............ to be ...........M JUP, mounting height ............... M, with lights.
   (iii) Tram Operator pole no .............. to be JUP, mounting height ...............M, outreach ...............M, with ............... lights.

5. Show speed zone.

B. The following notes are to be placed near phasing diagrams.
1. Tram priority phases not shown.
2. For full phasing details refer to phase selection drg no. .............. (Traffic Operations Section).

C. The following note to be placed under plan number.
1. Supersedes plan no............... Date

Display of signs on plans
Signs and their standard identification numbering should be shown on the signal layout plan.

For information regarding typical signing layout for various intersection types refer to Sections 29 and 30 of the Traffic Engineering Manual Volume 2.

If a sign is existing it will be shown for example as (E) and proposed signs are indicated on a sign schedule.

**Figure 3.26: Preliminary Plan Form**
### 3.6.6 Signal Installation Costs

The following lists may be used for estimating purposes. The rate will vary according to site location (ie. urban or rural) and year.

#### Supply and install new facilities (1999/2000)

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zebra ped. crossing</td>
<td>$19,000</td>
</tr>
<tr>
<td>Ped. operated signals, undivided road</td>
<td>$42,000</td>
</tr>
<tr>
<td>Ped. operated signals, divided road</td>
<td>$54,000</td>
</tr>
<tr>
<td>T intersection signals, undivided</td>
<td>$75,000</td>
</tr>
<tr>
<td>T intersection signals, divided main road</td>
<td>$85,000</td>
</tr>
<tr>
<td>Intersection, undivided</td>
<td>$95,000</td>
</tr>
<tr>
<td>Intersection, divided main road</td>
<td>$100,000</td>
</tr>
<tr>
<td>Intersection, all legs divided</td>
<td>$115,000</td>
</tr>
<tr>
<td>Red light camera</td>
<td>$10,000</td>
</tr>
</tbody>
</table>

#### Supply and install typical items for a remodel (1999/2000)

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestal with associated hardware</td>
<td>$3,300</td>
</tr>
<tr>
<td>Extra lantern</td>
<td>$750</td>
</tr>
<tr>
<td>Joint use pole with associated hardware</td>
<td>$6,800</td>
</tr>
<tr>
<td>Mast arm with associated hardware</td>
<td>$8,400</td>
</tr>
<tr>
<td>Joint use mast arm with associated hardware</td>
<td>$9,000</td>
</tr>
<tr>
<td>Controller 12 groups</td>
<td>$17,000</td>
</tr>
<tr>
<td>Controller ped signals</td>
<td>$13,000</td>
</tr>
<tr>
<td>Road crossing 25 m</td>
<td>$6,000</td>
</tr>
</tbody>
</table>
### 3.7.1 Summary

1. Obtain Base Plan (from files, Councils and/or Site survey).
2. Obtain
   - turning movement count for AM/PM peaks,
   - accident data,
   - information on any roadwork modifications.
3. Place signal hardware/roadwork changes on plan based on standard signal design.
4. Locate controller in position where it is “safe” and easily connected to telephone and power supply.
5. Check plan for all features/hardware.
6. Send copies of the preliminary plan and form (Figure 3.26) for comment to:
   - Signal Installation and Maintenance Section (VicRoads)
   - Traffic Operations Section (VicRoads)
   - Council(s)
   - Traffic System Implementation Section (VicRoads) for public lighting assessment.
   - VicRoads Construction Section if VicRoads is responsible for road works.
7. Collate comments and include on plan if appropriate.
8. Send copies of the plan to the following for agreement:
   - Council(s)
   - Operators of Private Company where a bus or tram route is affected.
9. Upon receipt of agreement send “final plan” form (Figure 3.28) and copies to:
   - Signal Installation and Maintenance Section
   - Traffic Operations Section
   - Traffic System Implementation Section (VicRoads) for public lighting assessment.
   - VicRoads Construction Section if VicRoads is responsible for road works.

The following documentation should also be forwarded to Signal Installation and Maintenance Section together with the final plan:
- written approval for major traffic control items.
-Parms job number.

Traffic count information should be forwarded to Traffic Operations Section together with the final layout plan.
3.7.2 VicRoads Standard Drawings for Traffic Signal Components; Approx Categories & Comments

The plans, if needed, are available from Traffic System Implementation Section.

List of Current Drawings in the TC- Series

<table>
<thead>
<tr>
<th>Dgn No.</th>
<th>Date approved or amended</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC-1001</td>
<td></td>
<td>Intersection Example</td>
</tr>
<tr>
<td>TC-1004</td>
<td></td>
<td>Pedestrian</td>
</tr>
<tr>
<td><strong>STREET LIGHTING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC-1060</td>
<td>11/09/96</td>
<td>Street Lighting Bracket Single and Double - Type 1.</td>
</tr>
<tr>
<td>384800</td>
<td></td>
<td>(Up to 4m outreach for 10.5 kg Luminaire; up to 3m outreach for 15 kg Luminaire)</td>
</tr>
<tr>
<td>TC-1061</td>
<td>11/09/96</td>
<td>Street Lighting Bracket Single and Double - Type 2.</td>
</tr>
<tr>
<td>384800</td>
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<td>(Up to 5m outreach for 10.5 kg Luminaire; up to 4.5m outreach for 15 kg Luminaire)</td>
</tr>
<tr>
<td>TC-1062</td>
<td>28/10/96</td>
<td>Street Lighting Distribution Box - Foundation Detail.</td>
</tr>
<tr>
<td>TC-1067</td>
<td>04/06/97</td>
<td>Street Lighting Bracket - Single &amp; Double, Type 1 &amp; 2 Stiffening Plate</td>
</tr>
<tr>
<td><strong>POLES (incl MA, JUP, JUMA, Brackets, Other Components etc.)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC-1101</td>
<td>Draft</td>
<td>Cable Pit - Installation Details</td>
</tr>
<tr>
<td>TC-1102</td>
<td>To Be Drafted</td>
<td>Signal Post - Upper Mounting Assembly</td>
</tr>
<tr>
<td>TC-1103</td>
<td>Draft</td>
<td>Mini Mastarm (Type 2D)</td>
</tr>
<tr>
<td>TC-1104</td>
<td>To Be Drafted</td>
<td>Pedestrian Crossing Post</td>
</tr>
<tr>
<td>TC-1105</td>
<td>Draft</td>
<td>Signal Mastarms, JUP &amp; JUMA - General Arrangements &amp; Nominal Dimensions</td>
</tr>
<tr>
<td>TC-1106</td>
<td>Draft</td>
<td>Traffic Signal Mastarms, JUP &amp; JUMA - Overhead Lantern Mounting Assembly</td>
</tr>
<tr>
<td>TC-1107</td>
<td>Draft</td>
<td>Traffic Signal Mastarms, JUP &amp; JUMA - Baseplate Detail</td>
</tr>
<tr>
<td>TC-1108</td>
<td>04/06/97</td>
<td>Weather Cap for Traffic Signals and Street Lighting</td>
</tr>
<tr>
<td>TC-1109</td>
<td>Draft</td>
<td>Traffic Signal Mastarms, JUP &amp; JUMA - Outreach Arm Clamping</td>
</tr>
<tr>
<td>TC-1110</td>
<td>Draft</td>
<td>Conduit Entry Detail</td>
</tr>
<tr>
<td>TC-1111</td>
<td>To Be Drafted</td>
<td>Traffic Signal Mastarms, JUP &amp; JUMA - Lighting Arm Mounting Spigot Detail</td>
</tr>
<tr>
<td>TC-1112</td>
<td>Draft</td>
<td>Typical 5.5m Mastarm Installation (2.5m Outreach)</td>
</tr>
<tr>
<td>TC-1113</td>
<td>To Be Drafted</td>
<td>Traffic Signal Mastarms, JUP &amp; JUMA - Column Lantern Fixing Detail</td>
</tr>
<tr>
<td>TC-1115</td>
<td>To Be Drafted</td>
<td>Signal Post - Lantern Orientation</td>
</tr>
<tr>
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<tr>
<td>TC-1116</td>
<td>To Be Drafted</td>
<td>Signal Post - Lantern Mounting Heights</td>
</tr>
<tr>
<td>85 4055/6</td>
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</tr>
<tr>
<td>TC-1117</td>
<td>To Be Drafted</td>
<td>Signal Post - Verandah Installations</td>
</tr>
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<td>85 4065</td>
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</tr>
<tr>
<td>TC-1118</td>
<td>Draft</td>
<td>Traffic Signal Mastarms, JUP &amp; JUMA - Door Opening &amp; Cable Termination Block Mounting Detail</td>
</tr>
<tr>
<td><strong>TRAFFIC SIGNALS - CIVIL &amp; ELECTRICAL</strong> (Includes foundations, pits, conduits, Point of Supply etc.)</td>
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</tr>
<tr>
<td>TC-1203</td>
<td>Draft</td>
<td>Traffic Signal Controller Details</td>
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<tr>
<td>TC-1210</td>
<td>21/12/95</td>
<td>Cable Pit Former - 600 mm Dia.</td>
</tr>
<tr>
<td>417192</td>
<td>85 4047</td>
<td>(For Electrical and Communication Pits)</td>
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<tr>
<td>TC-1220A</td>
<td>14/08/96</td>
<td>Cable Pit Access Cover &amp; Frame 600 mm Dia.</td>
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<td>417192</td>
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<tr>
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<td>22/08/96</td>
<td>Cable Pit - Installation Details.</td>
</tr>
<tr>
<td>85 4042</td>
<td>(For Electrical and Communication Pits)</td>
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</tbody>
</table>
**DETECTION (All Varieties)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Date</th>
<th>Description</th>
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<tbody>
<tr>
<td>TC-1300</td>
<td>Being Drafted</td>
<td>Loop Pattern and Installation Details - Symmetripole</td>
</tr>
<tr>
<td>TC-1301</td>
<td>To Be Drafted</td>
<td>Vehicle &amp; Tram Detector Loops along shared &amp; Exclusive Tram Lines</td>
</tr>
<tr>
<td>TC-1310</td>
<td>14/08/96</td>
<td>Detector Pit.</td>
</tr>
<tr>
<td></td>
<td>85 4064</td>
<td>(For Jointing Detector and Feeder Cables)</td>
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<tr>
<td>TC-1320A</td>
<td>22/08/96</td>
<td>Detector Pit - Installation Details.</td>
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<tr>
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<tr>
<td>TC-1320.spc</td>
<td>07/09/95</td>
<td>Detector Pit - Installation Specification</td>
</tr>
<tr>
<td>TC-1601</td>
<td>14/08/96</td>
<td>Rag Bolt Assembly - M24 CG and HS - 600 mm long x 350 mm PCD.</td>
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<tr>
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<td>85 4021</td>
<td>(For mid-hinge Camera Column and Help-phone post bases)</td>
</tr>
<tr>
<td>TC-1603A</td>
<td>22/08/96</td>
<td>Rag Bolt Assembly for Cabinet - M12 - 600 x 460 x 255 mm.</td>
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<tr>
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<td>85 5065</td>
<td>(For Camera Control Cabinet)</td>
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**TRAFFIC INFORMATION SYSTEM - GENERAL SERIES (2001 - 2010)**

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
<td>TC-2001</td>
<td>21/12/95</td>
<td>Trunk Conduit System - Incident Detection - Typical Layout.</td>
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<tr>
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<td>(Includes a trunk separation system for bridges)</td>
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<tr>
<td>TC-2002</td>
<td>21/12/95</td>
<td>Cabinet - Installation Details.</td>
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<td>TC-2003</td>
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<td>Cabinet.</td>
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<tr>
<td>TC-2011A</td>
<td>07/06/97</td>
<td>Camera Site - Typical Layout.</td>
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<tr>
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<td>417195</td>
<td>(Column Details excluded)</td>
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<tr>
<td>TC-2012</td>
<td>21/12/95</td>
<td>Camera Column - 10 m Mid-hinge</td>
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<tr>
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<td>417195</td>
<td>(With Site Details relocated to TC-2011).</td>
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<tr>
<td>TC-2013</td>
<td>14/08/96</td>
<td>Camera Column - Bored Pile Foundation - Installation Details.</td>
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<td>417200</td>
<td>(Includes Reinforcement Cages)</td>
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**TRAFFIC INFORMATION SYSTEM - PHONE SERIES (2021 - 2030)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Date</th>
<th>Description</th>
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<tbody>
<tr>
<td>TC-2021</td>
<td>21/12/95</td>
<td>Help-phone Site - Typical Layout.</td>
</tr>
<tr>
<td></td>
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<td>(Installation Details excluded)</td>
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<tr>
<td></td>
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<td>(Adaptation of original design - galvanised finish)</td>
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<tr>
<td>TC-2023</td>
<td>21/12/95</td>
<td>Help-phone - Installation Details.</td>
</tr>
<tr>
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<td>417196</td>
<td>(Site Details have been relocated to TC-2021)</td>
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<tr>
<td>TC-2024</td>
<td>Under review.</td>
<td>Help-phone - Taper Details for 3.0 m extended shoulder</td>
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<td>417201</td>
<td>(To suit Urban conditions)</td>
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<tr>
<td>TC-2025</td>
<td>Under review.</td>
<td>Help-phone - Indented Bay for Rural Sites</td>
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<tr>
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<tr>
<td>TC-2026</td>
<td>21/12/95</td>
<td>Help-phone - Termination Pillar</td>
</tr>
<tr>
<td>TC-2027</td>
<td>21/12/95</td>
<td>Help-phone - Termination Pillar - Installation Details</td>
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</table>

**TRAFFIC INFORMATION SYSTEM - DETECTION SERIES (2031 - 2040)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Date</th>
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<tbody>
<tr>
<td>TC-2031</td>
<td>21/12/95</td>
<td>Detection Site - Typical Layout.</td>
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<td>417199</td>
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<td>23/02/96</td>
<td>TC-2032a.spc: Detector Loop - Installation Specification.</td>
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<td>TC-2032</td>
<td>21/12/95</td>
<td>Loop Installation - Incident Detection.</td>
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<td>TC-2033</td>
<td>21/12/95</td>
<td>Loop Pattern - Incident Detection.</td>
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<tr>
<td>TC-2034</td>
<td>21/12/95</td>
<td>Loop Pattern - Incident Detection - Retro Installed in Open Grade Course.</td>
</tr>
</tbody>
</table>