Chapter 5
Freeway Traffic Data
5.1. Traffic Data Quality and Availability

The key to effective management of a freeway is reliable and accurate traffic data at appropriate locations. The traffic detection system needs to be dependable to obtain information for a range of uses.

5.1.1. Real Time Traffic Data

Real time traffic data of actual traffic conditions is essential for the effective dynamic management of freeway flow, i.e., ‘If you can’t measure it, you can’t manage it.’

Real time data enables:

- Proactive management of the freeway to prevent flow breakdown
- Reactive responses to incidents or other factors that may be beyond the control of the system or operator
- Provision of traveller information, particularly for travel time and congestion.

5.1.2. Historical Traffic Data

Analysis of historical traffic data provides an understanding of traffic flow efficiency and operational problems. Evaluation of data can also assist in project development.

Historical traffic data facilitates analysis relating to:

- Traffic performance over an extended period
- Identification and evaluation of traffic problems
- Targeting and developing improvements
- Evaluation of benefits for recommended improvements
- Preparing a business case to justify funding, i.e., ‘If you can’t measure it, you can’t justify it.’

5.2. Freeway Data Stations

5.2.1. Data Station Locations

The following principles for locating data stations should be applied to urban freeways to facilitate historical and/or real time use of data. On freeways where ramp metering is not provided, the appropriate positioning of data stations, generally as shown in Figure 5.2, can facilitate retrofitting at a later date.

Data stations should be installed on the mainline to cover the full length of the freeway with detectors provided in all lanes at each point. This would generally include the following locations:

a) Near Entry Ramps:

- At the end of the ramp merge, generally 320m downstream of the nose for a single lane merge. This is the primary mainline site for ramp metering control
- Just upstream of the ramp nose with separate detectors for the ramp and mainline traffic.

b) Near Exit Ramps:

- Just downstream of the exit ramp nose, with separate detectors for ramp and mainline traffic.

c) At Other Mainline Locations:

- Potential bottleneck locations where traffic flow needs to be managed, such as just downstream of lane drops, on steep upgrades, tight curves and carriageway narrowing, e.g., no shoulder, narrow lanes or at bridges
- Remaining locations typically to ensure not more than 500m spacing along the full length of the freeway.

Power supply and communications are required at data station locations and the preferred arrangement is to provide longitudinal conduits for power and optical fibre. Alternatively, solar power and radio communications are options that can be considered.
5.2.2. Detector Accuracy and Reliability

Reliable and accurate freeway traffic data needs to be collected from the roadway. This is to provide general traffic information, to drive numerous real time traffic management systems and to provide detailed traffic information for analysis and reporting of road system performance. Because of the numerous end-users of historical data, (e.g., Austroads performance measures, network planning, road design, pavement design, traffic control and traveller information), it is important to ensure that the source data is fit for end-user purposes.

Coordinated Ramp Metering, for example, has very stringent requirements for the Vehicle Occupancy measurement in order to precisely control the freeway performance near critical flows. Therefore an absolute error greater than ±5% in a 20 second period, cannot be tolerated in the vehicle occupancy measure for effective motorway control.

Freeway traffic data comprising speed, volume and vehicle occupancy must be suitable to provide for system operation. Real time operations of managed freeways currently require vehicle data to be delivered at 20 second intervals and possibly at lower intervals in the future. Vehicle classification information is also important.

These source traffic data requirements are independent of the end-to-end service delivery and availability requirements, which for managed freeways, travel time and TMC functions, should be 95% or higher to enable automated system response capabilities. This availability also means that motorists can be provided with optimum capacity and day to day reliability.

Source data types e.g., speed, volume, occupancy (SVO) and vehicle classification, and their accuracy need to meet basic requirements to support VicRoads business needs. Source traffic data performance requirements for vehicle detection are as follows.

- Measure all freeway lanes and ramps for speed, volume, occupancy and length classification with a variation of accuracy between all lanes not more than ±2%.
- Transmit the traffic data to control systems at interval no greater than 20 seconds.
- Record vehicle by vehicle data for volume and length classification.
- Traffic flow fundamental diagrams should be reproducible from the SVO data. This is possible from existing in-pavement technologies e.g., loop and stud technologies, however, alternate technologies may need to include vehicle classification data in their calculations as vehicle length significantly affects lane occupancy.
- Measure accurately during all weather and light conditions applicable to the route/location, e.g., tunnels, and tested in wet weather and at night to confirm ground truth, e.g., manual counting from video.
- Undertake vehicle volume counts with an accuracy of ±2% measured over 24 hours and ±3% during peak periods when lane flows are above 1,800 vehicles per lane; measured against ground truth, e.g., manual counting from video.
- Accurately measure individual vehicles under congested conditions or queuing at vehicle spacing in the order of 7 metres (gaps as low as 3 metres), e.g., when mainline vehicles are closely spaced during flow breakdown or in slow moving ramp queues.
- Undertake speed measurements in km/h with an accuracy of ±3% for speeds between 0 and 160 km/h.
- Measure vehicle length in metres with an accuracy of ±5% and logging into 4 length user-defined classification bins, for example as follows:
  - > 0 - < 6m
  - > 6 - <12.5m
  - > 12.5 - < 17.5
  - > 17.5 m.
- Measure vehicle occupancy per traffic lane with an accuracy of ±5%; vehicle occupancy must respond to changes in vehicle length.
5.2.3. Wireless Vehicle Detectors

Wireless vehicle detectors provide accurate and reliable data for presence and movement of traffic and are suitable for mainline detection and for ramps. Data transmission from the battery powered detector to a field processor occurs via an access point within 50m of the detector or, for distances up to 300 metres, by relay to the access point using a battery powered repeater point.

Installation is less intrusive compared with loops as the detector and repeater point devices do not require saw cutting, conduits/pits or cabling. The detectors, which are approximately 75mm x 75mm x 50mm in size, are installed in the pavement with a 100mm hole cutting machine and then covered with epoxy as shown in Figure 5.1.

Details of the detector layout for a wireless data station are shown on Standard Drawing No. 541701 in Figure 5.2. Prior to installation each detector is pre-configured for a specific lane and location. The detector footprint has a default setting of 600mm x 1200mm but is variable in the software and can be changed after installation. The ability to set a small footprint overcomes problems of undercounting by loops mentioned in the Note below.

Figure 5.1: Wireless Vehicle Detector Installation
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Figure 5.1: Wireless Vehicle Detector Installation

Figure 5.2: Freeway Data Station using Wireless Vehicle Detectors

* Distance of stop line detectors from nose is subject to location of stop line
2. Distance of lane line detectors from nose subject to the number of lanes at the nose and overall merging distance
3. Refer to ramp signals standard drawings 60a, 60/-77, 60/-75, 60/-79 and 60/-76
5.2.4. Detector Loops

The data station loops are installed by saw cutting the pavement. The detector includes a double loop arrangement in each lane of the freeway or ramp. Details of the loop layouts are shown on Standard Drawing TC-2033 in Figure 5.5.

![Freeway Data Station Loops](image)

**Figure 5.3: Freeway Data Station Loops**

**Note:**

VicRoads current practice is to use wireless vehicle detectors on ramps for queue management as part of the HERO system. The initial installation of ramp meters on Melbourne’s freeways used SCATS loops on the entry ramps. These loops which are 4.5 metres long were found to lack accuracy at low speeds as shown in Figure 5.4. The accuracy problem of SCATS loops has previously been identified by Akcelik et al (1999) where it was recommended that consideration be given to using 3.5 metre loops for through lanes and 3.0 metre loops for right turn lanes.

![Undercounting due to slow moving queue](image)

**Figure 5.4: Example of Undercounting by SCATS Loops on an Entry Ramp**
Figure 5.5: Freeway Data Station using Loop Vehicle Detectors

Table: Freeway Traffic Data

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NOTES:
1. LOOPS ARE DESIGNED TO BE DOWNHILL FROM LEADING TO PREVENT WATER POOLING
2. LOOPS MUST BE PLACED IN THE CENTRE OF THE LANE
5.2.5. Traffic Data to be Collected

The principal types of data available from data detectors are:

- Flow (traffic volume)
- Speed, and
- Lane occupancy.

The data stations collect the data using a 20 second sampling period. Generally, this data is then aggregated into 1, 5 or 15 minute periods for analysis. The density of traffic (vehicles/km) can be calculated from the flow and speed data as shown in Appendix E. The lane occupancy data is generally used as a surrogate for density in relation to operational performance as it is easier to measure.

The data stations are also able to provide information related to vehicle length for vehicle classification studies. Loop detectors collect the data when activated for a specific survey. Wireless vehicle detectors are capable of collecting vehicle length data continuously.

5.3. Data Analysis Tools

5.3.1. Freeway Analysis Tool (FAT)

The VicRoads Freeway Analysis Tool (FAT) has been developed to facilitate assessment of the data from the freeway data stations. Lane data may be analysed in individual lanes or aggregated. An example of output is shown in Figure 5.6.

Figure 5.6: Example of Chart from Freeway Analysis Tool
5.3.2. F1RM Tool

The F1RM Tool developed by VicRoads is a versatile tool to facilitate the analysis of 1 minute freeway flow data. Examples are shown in Figure 5.7 to Figure 5.11. Other examples are used throughout the Handbook to demonstrate various traffic flow characteristics.

Figure 5.7: Contour Plot (Time / Distance / Speed) along a Route showing 6 weeks of Peak Period Speed Data to Compare Flow from Day to Day

Figure 5.8: Contour Plot (Time / Distance / Speed) of Flow along a Route on a Specific Day
Figure 5.9: Flow Characteristics at a Specific Site

Figure 5.10: Fundamental Diagrams at a Specific Site. The Data may be Viewed in Short Time Slices to Observe the Sequence of Events
Figure 5.11: Data Station Report to Audit Detector Accuracy along a Route

5.3.3. STREAMS Data Outputs

The STREAMS system that forms the platform for VicRoads freeway management system provides a number of outputs to view data and facilitate analysis. An example is shown in Figure 5.12.

Figure 5.12: Bar Graphs of Operation in Real Time (Speed, Flow or Occupancy)

5.3.4. Spreadsheet and Charts

Data may be exported from the database and used in a spreadsheet for specific analyses, e.g., to plot a three minute moving average trend line. Examples of spreadsheet analyses are shown in Figure 5.13 and Figure 5.14.
Figure 5.13: Examples of Analysis with Raw (20 sec) Flow Data and smoothed 15 minute average
5.4. Data Analysis and Interpretation
The correct interpretation of data is essential in properly identifying the location and nature of traffic problems and in understanding the differences between symptoms and causes. A correct appreciation of the issues is also necessary to identify appropriate improvement actions. The examples provided throughout this handbook endeavour to provide guidance in data interpretation as well as appropriate analyses.

The appropriate collection and use of data for fine tuning and ongoing operation of a freeway ramp metering system is also essential for efficient, effective operation.