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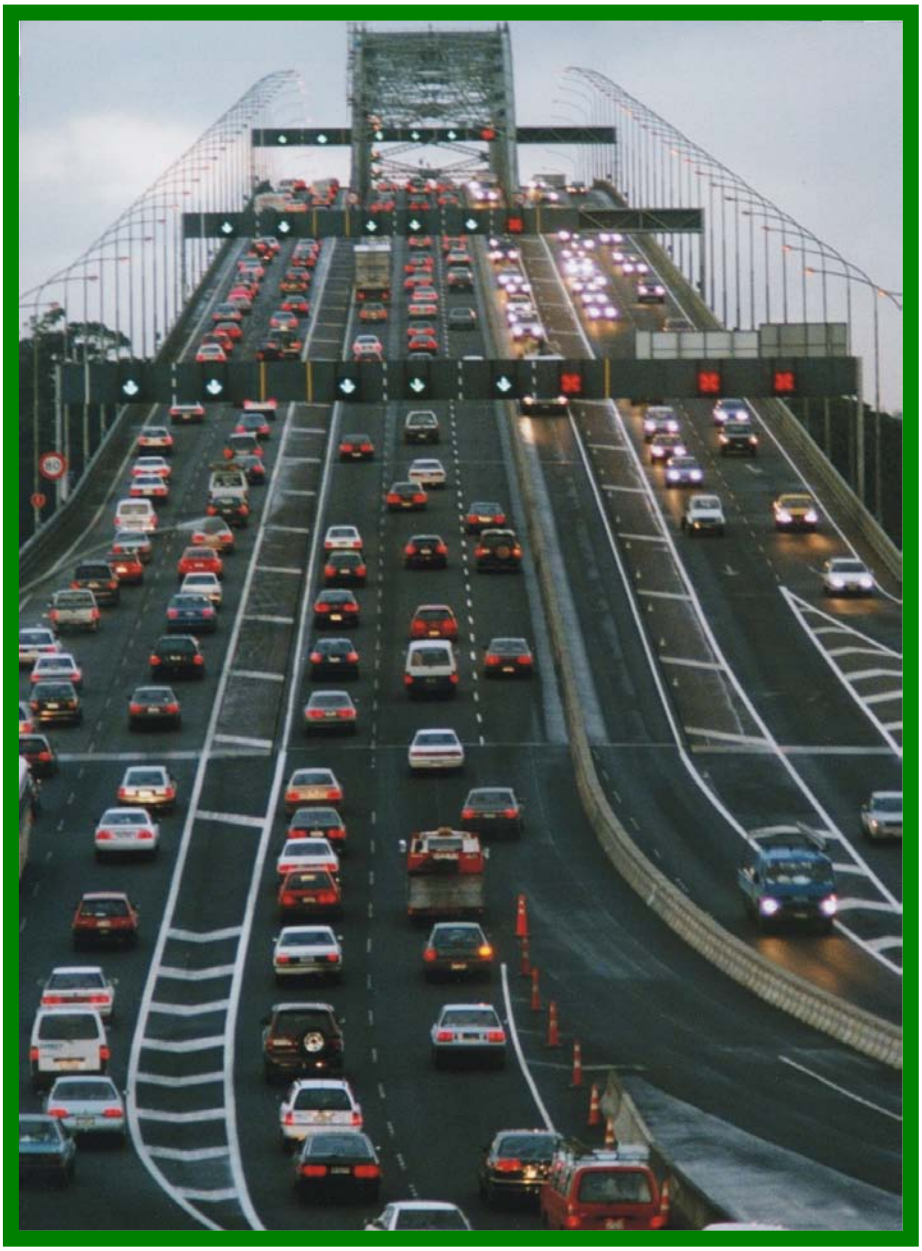

Traffic Monitoring for State Highways

TRAFFIC MONITORING FOR STATE HIGHWAYS

Manual Number: SM 052

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Transit New Zealand

TRAFFIC MONITORING FOR
STATE HIGHWAYS

Issued May 2004

State Highway Management Division **Date of issue: May 2004**

Manual Management Plan for Traffic Monitoring for State Highways

Manual Owner: Chris Parkman (Asset Management Information Manager)

Sponsor Endorsement: Dave Bates (National Operations Manager)

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1. Purpose

This is the Manual Management Plan for the above SHMD Manual.
[In accordance with Transits ISO 9001 Quality System, Manual Owners are expected to complete this form for all manuals]

2. Document Information

Manual Name	Traffic Monitoring for State Highways Manual
Manual No.	SM 052
Regional Champion	Regional Asset Manager
Review Team Members	Dave Bates Mark Owen Dave Robertson Roger McLeay

3. Amendment and Review Strategy

All Corrective Action/Improvement Requests (CAIRs) suggesting changes will be acknowledged by manual owners.

	Comments	Frequency
Amendments (of a region nature)	To be forwarded to Manual Owner	Annually
Review (major changes)	Reviewed in March	Annually

Foreword

Transit New Zealand is committed to planning, developing and maintaining the state highway system in a way that contributes to an integrated, safe, responsive and sustainable land transport system for New Zealand.

To achieve this mission, Transit must have reliable information about the road users in terms of traffic volumes, vehicle mix and traffic loading.

This manual describes the current methodology for traffic monitoring, the technology involved, conventions, survey guidelines, calculations and on overview of the software system. It also describes the current strategy for what data will be collected, where and how often. The expectation is that this strategy will be updated: as data is collected and analysed, as the strategic direction is developed and, as other related systems such as weight enforcement.

As with all information systems, there is scope for improvement, but the implementation of the Traffic Monitoring System, and supporting contracts, has resulted in Transit realising the goal of a consistent supported traffic collection and storage system.

The future in traffic monitoring holds challenges in: technology, congestion, data management systems and fundamental philosophies e.g. classifications, Weigh in Motion. The Traffic Monitoring System provides an excellent base on which all traffic data from around New Zealand could be held.

Rick van Barneveld
Chief Executive (Acting)

Document Status

This document has the status of a guideline (G) as defined in Transit New Zealand's ***Standards and Guidelines Manual***.

The objectives of the manual are to set out Transit New Zealand's policies and procedures for traffic monitoring for the state highway network in a manner that meets Transit New Zealand's goals.

The content is based on Transit New Zealand's current practices and those developed in the past from experience in traffic monitoring.

While all care has been taken in compiling this document, the Transit New Zealand Authority accepts no responsibility for failure in any way related to the application of this guide or any reference documents noted in it. There is a need to apply judgement to each particular set of circumstances.

Amendment Procedures

The next amendment will be issued to manual holders in the form of a reissue, if necessary.

Amendments will be distributed to all organisations and individuals on the list of registered manual holders. If you wish to check that you are on this list, or change the number of copies that are sent to your organisation, please contact:

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Record of Manual Amendments

No.	Pages Amended	Description	Effective Date	Updated by
1	v, vi, vii, and viii	Amendment procedure update	2/7/2004	N Beckett
2	i, vi and A.1	The contact phone number and vehicle classification scheme update	1/11/2011	G Wen

AMENDMENT LIST REGISTRATION FORM

[Note: this form must be returned to ensure receipt of amendments]

To: Asset Information Manager
Transit New Zealand
PO Box 5084
WELLINGTON

Please change/add/delete (indicate which) my address for the amendment list for the Transit New Zealand **Traffic Monitoring for State Highways SM 052**.

Current Address:

Title:

New Address:

Title:

Email Address:

Contents

Glossary of Terms

3G Third Generation

AADT Annual Average Daily Traffic (vehicles/day)

ATMS Advanced Traffic Management System

CVIU Commercial Vehicle Investigation Unit

ESA Equivalent Standard Axles

GPS Global Position Systems

LRMS Location Referencing Management System

RAMM Road Assessment and Maintenance Management

TMS Traffic Monitoring System (the software database)

VKT Vehicle Kilometres Travelled (sum of the products of AADT and Link Length)

WiM Weigh in Motion

RUC Road User Charges

TRAFFIC MONITORING FOR STATE HIGHWAYS

A robust Traffic Monitoring Method is an essential part of any transportation management system. It primarily relies on accurate data collection procedures and an efficient means of storing that data for subsequent retrieval and analysis. Transit New Zealand has been developing its Traffic Monitoring Method over the past 10 years and this document provides an overview, including details of the objectives, principles, procedures and applications.

1. INTRODUCTION

The following document describes Transit New Zealand's Traffic Monitoring Method, detailing the objectives, principles, procedures and applications of the strategy, and stems from an aggregation of initiatives originally recommended by Transit's Traffic Monitoring Group in 1993. These and other initiatives now implemented include:

- A means of representing the entire state highway roadway system in terms of nodes and links
- An appropriate vehicle classification scheme for the vehicle fleet using the state highway system
- The Traffic Monitoring System (TMS) software facility
- Contracts for regional traffic data collection

These are explained in greater detail in subsequent sections of this document. Additionally it should be noted that this is a 'living' document and will continue to be developed as a result of information and experience gained from the use and ongoing progressive development of the system, along with other advances gleaned from research being carried out by Transit and the transport industry in general.

2. BACKGROUND

Transit New Zealand was created by the Transit New Zealand Act 1989, which came into effect on 1 October 1989. In the forty years prior to that date, control of New Zealand's roads progressed through the Main Highways Board, the National Roads Board and the Ministry of Transport. Through these various bodies, Transit New Zealand inherited the Traffic Monitoring infrastructure and systems, which exist today.

In 1989 the Vogel Computer Centre supplied the computing resources required to manage the entire system as part of the Ministry of Works and Development. When the Vogel Computer Centre was privatised in 1993, it became necessary to investigate alternative resources to handle Transit's computing requirements.

Transit's Computer Services Division was commissioned to carry out investigations of what was required in terms of computing resources and report on the options available. Stage 1 of the investigations involved carrying out a comprehensive User Requirement Survey and the findings of this survey were disseminated in 1994. Based upon those findings, it was estimated that a prototype computer system that would encompass what the majority of what users thought was needed would cost in the order of two million dollars. Additionally the survey highlighted the issue that the data collection infrastructure then in place was not capable of delivering all that was actually needed.

Subsequently it was recognised that a formal long-term strategy plan for Traffic Monitoring was required to be established before committing to expensive inappropriate computer systems. Accordingly, in 1996, a project was commissioned to address the development of a robust mechanism to achieve this.

The first phase of the project involved the investigation of the feasibility of the node/link network concept for the state highway road system. The outcome of the investigations from this first stage was that the node/link methodology was adopted, and contracts to install loop count stations were awarded in 1998/1999. In this regard, the first contract dealt with the Napier, Wanganui and Wellington regions, followed by a contract for the entire South Island and finally one for the Auckland and Hamilton regions.

A subsequent phase for the project investigated a convenient method for categorising vehicles based on the composition of the New Zealand vehicle fleet and from this the Transit New Zealand Vehicle Classification Scheme 1999, was developed and is currently in use. A copy of this scheme is shown in Appendix A.

The next important phase involved the development of a comprehensive computer system for managing all the traffic count data from the various data collection sites. This system was implemented in 2000.

3. OBJECTIVES

A reliable estimate of state highway road usage is vital to the routine management and future planning of the highway infrastructure and other transport systems associated with it.

A system that delivers this information effectively and efficiently will ensure that appropriate decisions concerning the road network are made in accordance with the best business practices. This is in line with Transit's overall mission "To plan, develop and maintain the state highway system in a way that contributes to an integrated, safe, responsive and sustainable land transport system for New Zealand".

4. BASIC COMPONENTS OF THE METHODOLOGY

Transit's Traffic Monitoring Method essentially comprises the following key elements:

- A node/link network
- Traffic sampling method (Managed Regionally by Regional contracts)
- Continuous Telemetry monitoring system (Managed Nationally by contract)
- Traffic Monitoring System (TMS) Database to share and manage traffic data.

All these are described in greater detail in the following sections of this document.

4.1 Node/Link Network

The core component of the Traffic Monitoring Method is the node/link network model. In general terms, this network provides a convenient means of representing the entire state highway roadway system in a discrete manner, such that an appropriate traffic monitoring regime can be easily applied and managed. Each link in the network is defined as having reasonably consistent traffic volumes and composition (vehicle mix) travelling along its length. Additionally, in association with each link are two nodes, which define the start and end of the link.

In the development of the network model, certain rules were devised for the location of nodes and they can be listed as follows:

- based on the change in estimated AADT values in the RAMM database, that is where:
- the AADT changed by more than 10% and 3,000 vpd, or
- the AADT changed by more than 15% and 1,500 vpd, or
- the AADT changed by greater than 25% and 750 vpd , or
- the AADT changed by greater than 40% and 350 vpd
- based on the locations of Reference Stations along the state highways, although nodes were not assigned to every Reference Station
- based on urban and rural transition boundaries (as identified by 50km/hr and 70km/hr speed restrictions) except in situations where the resultant link was less than 1km in length
- based on the locations of interchanges or intersections on motorway routes and roads with divided carriageways in 100km/hr zones
- based on start and end points of all State highways and State highway junctions.

Additionally, and except for a small number of low volume roads in the South Island, the maximum link length was set at 50km.

Further refinement of the model was achieved through consultation with the Transit regional offices and resulted in the adjustment of node locations such that they coincided with actual points of traffic inflow/outflow, generally at intersections with major arterial roads or other state highways.

A description of the current node/link network can be obtained from the TMS (see Section 6.3).

In 2000 there were approximately 800 links defined in the network model. In 2001 a further 300 links were added to include data obtained from the Advanced Traffic Management System (ATMS) being progressively installed along the Motorway network in Auckland.

In 2002 recognition was also made of the fact that the RAMM database considers divided carriageway sections of road as having separate links for each direction of travel. Therefore directional links were inserted into TMS for these divided carriageway sections to facilitate the smooth export of traffic data from TMS into RAMM.

In terms of data collection, one traffic count station is assigned to each link. The exact location of the count station along the link is fixed and should not be changed except for reasons of safety, data reliability or changes made to the node/link network. Link volumes on some high capacity motorways are calculated rather than directly surveyed and is achieved by measuring on or off-ramp traffic and incrementally adding or subtracting volumes to the known or calculated volumes on the immediately adjacent links.

In other places where there are short lengths of divided carriageway, “Virtual” sites have been created based on adjoining count station sites in order to provide a count value for these links. This also applies across Regional boundaries where a node point is required at the boundary. One count station applies to both links on each side of the boundary, so a “Virtual” site (Based on the actual count station) is created to ensure both links have their own unique count station.

4.2 Traffic Sampling Strategy

The statistical processes required for determining an appropriate and robust sampling method for traffic monitoring are complex given the large number of variables involved. It was decided that a ratio of continuous to non-continuous sites of 1:10 would be adequate to provide the level of accuracy required, at least until a full statistical audit can be carried out.

The data gathered at these continuous sites are used to factor the counts obtained at non-continuous sites so that seasonal variations in traffic volumes can be accounted for. Central to this rationale is the relationship of traffic flow patterns between the continuous and non-continuous sites.

The frequency of monitoring non-continuous sites is primarily determined as follows:

Volume	AADT	Minimum number of 7 day periods per year
Low	<1,000	Two
Medium	1,000 to 10,000	Four
High	10,000 >	At least Four

The fundamental objective of the traffic sampling method is to improve and optimise the sampling regime based upon a detailed statistical analysis of the data collected from all sites over a three year period.

4.2.1 *Telemetry Monitoring System*

The term "telemetry" denotes the 70 (approximate) continuous traffic monitoring stations located around the country, of which 4 are WiM sites, from which data is remotely downloaded via modem on a routine basis. These telemetry stations operate continuously throughout the year and provide a good indication of the variations in traffic volumes over the months of a year. The variations in traffic volume at these telemetry sites are used to adjust traffic counts from sites that are monitored less frequently.

Currently all telemetry sites are managed centrally by a National Telemetry Network Management Contract administered by Transit's National Office.

There are essentially two types of telemetry stations:

- Count/classification stations
- Weigh in Motion (WiM) stations

At telemetry count/classification stations a rough breakdown of traffic mix is recorded based upon approximate vehicle lengths. These are then separated into four categories, 0.5 to 5.5m, 5.5 to 11.0m, 11.0 to 17.0m and 17.0 to 35.0m. Typically, the heavy vehicle proportion is calculated as being the sum of vehicles in the greater than 11.0m categories plus half of the vehicles in the 5.5 to 11.0m category.

At the WiM (or Weigh-In-Motion) stations the approximate axle loads of individual vehicles can be recorded.

Data is downloaded and checked on a regular basis. In the event of a fault being detected, the National Telemetry Network Management Contractor is required to carry out the necessary repairs to malfunctioning equipment. In order to maintain the integrity of the overall monitoring system and ensure usefulness of the data collected at these continuous sites, the maximum length of downtime for a telemetry station should be no more than 7 days (or 2% of a year).

Listings of count/classification telemetry stations and WiM stations are provided in Appendices B and C respectively.

4.2.2 *Regional Traffic Monitoring Contracts*

All of the traffic monitoring at non-continuous count stations is managed by the Transit Regional Offices. In this respect, a standard pro-forma contract has been developed to ensure that the contracts are consistent throughout the country.

The contracts specify that traffic data is to be collected on lane-by-lane basis, at 15 minute intervals for a continuous 7 day period up to four times a year. The types of data collected are vehicle counts and vehicle classifications. Transit's vehicle classification scheme based on vehicle length was developed in 1999 to reflect the composition of the New Zealand vehicle fleet.

Contracts are designed such that the contractor is responsible for ensuring the integrity of the data recorded. The Transit Regional offices are required to audit this data and carry out random field checks to ensure the contractor meets Transit's requirements and the data collected is valid.

4.3 TMS (Traffic Monitoring System)

The heart of the Traffic Monitoring Method is the TMS software database. This is an internet-based Oracle database system, which stores all traffic data routinely collected on the entire state highway network. Access to the system is restricted by Transit and can only be accessed by users with a valid username and password.

The system has been specifically designed so that data can be readily loaded into the system and then be extracted from the system in summarised format by any authorised person via a computer equipped with an internet connection. A description of how to use the system is continually being updated as new advancements to the software are developed. The most recent version of the TMS User Guide is available from the TMS internet site: http://tms.transit.govt.nz. It is expected that all authorised users should be thoroughly familiar with the contents of this guide.

Data is uploaded into the system by the regional traffic monitoring contractor /consultant via a secure internet connection. It is the responsibility of the respective traffic monitoring consultants to ensure the integrity and reliability of the data before the uploading process. The software system is capable of performing a number of basic validation checks on the information uploaded and warns consultants of data anomalies subsequent to the uploading process.

Under certain circumstances and when errors are detected, the system will reject particular datasets. When data is rejected in this manner, both the consultant and the TMS regional administrator are notified and it is then the responsibility of the consultant to recheck the data and provide a reasonable explanation to the administrator as to why the data has failed the system checks. If the Regional TMS Administrator is satisfied with the contractors explanation the loadset can be accepted by the Regional TMS Administrator. However, if a satisfactory explanation is unable to be provided, the data for that particular count is to be rejected and a new count survey for the site is required under the terms of the traffic monitoring contract. A flowchart illustrating the process is provided in Appendix D.

The software system is capable of manipulating the raw data to calculate summarised data such as, AADTs, vehicle composition and ESAs for each count site. These summaries are then readily available to end users through the TMS internet site. Calculated and summary data can also be transferred to other transportation systems such as the RAMM system and for this reason, consistency in terms of location referencing of count sites, nodes and links is a fundamental requirement of the system.

5. IDENTIFICATION OF COUNT STATIONS

A special system for identifying count stations has been developed for use with TMS. Each count station is required to have at least the following details:

- route position number
- unique site reference number
- Transit region
- description of the site
- status of the site (active or obsolete or virtual)
- site type (continuous or non-continuous)
- lane information (for each lane)
- related control site (where applicable).
- whether or not the count data is exported to RAMM
- if "Virtual" details of where the count data is obtained

Additional site or locality information can also be supplied if necessary. All information stored against a particular site enables it to be readily and efficiently identified and located within the state highway network.

5.1 Site Numbering

As noted earlier, each count station is required to have a unique site reference number assigned to it. In TMS, this takes the form of an eight character alphanumeric identifier in the format "sssdnnnn" where:

- sss is a three character code that identifies the state highway on which the count station is located
- d is a direction code, a number between 0 and 6, defined as follows:
  - 0 = both directions
  - 1 = increasing direction
  - 2 = decreasing direction
  - 3 = increasing on ramp
  - 4 = decreasing off ramp
  - 5 = decreasing on ramp
  - 6 = increasing off ramp
- nnnn is a four digit code which provides the approximate running distance to the count site and is determined by adding the previous reference station number and the displacement in kilometres from the reference station.

By way of example, the site "00220937" represents the count site on State Highway 2, measuring volumes in the decreasing direction, at a location approximately 937 kilometres from the start of State Highway 2.

6. TRAFFIC MONITORING TECHNOLOGY

The various technological components within the system can be broadly separated into three categories as follows:

6.1 Data Communications

This refers to the method of extracting the data that has been recorded by the roadside equipment. Data extraction can be carried on site (via laptop computer and data cables) or remotely by using a modem and telecommunications.

6.2 Data Logging Equipment

The data logging equipment is an electronic device or computer which collects, processes and stores the data recorded from the vehicle sensors/detectors.

6.3 Vehicle sensors/detectors

Sensors/detectors are the devices, which are connected to the data logging equipment in order to detect the presence of a vehicle or axle and thereby obtain a count of the number of vehicles passing the data collection point. They can be separated into two distinct categories:

- Vehicle Presence

  Video imaging
  Infra red
  Radar
  Laser
  Inductive Loop

- Axle

  Pneumatic tube
  Treadle
  Piezoelectric cables
  Laser
  Fibre optic
  Capacitance strip

- There are also special types of axle detectors, which are capable of measuring axle loads while vehicles are in motion. These include bending plate detectors and load cell detectors.

All these detectors can be used in various combinations or configurations depending on the type of roadside equipment they are connected to and the type of information required.

Some examples of the types of detectors used in New Zealand include:

- Video imaging as used on the Auckland and Wellington ATMS
- Infra red technology as used on the Auckland Harbour Bridge telemetry site
- Radar technology as used on the ACC/Police Speed trailer
- Inductive loops as used for traffic signals and many of Transit's count sites
- Pneumatic tubes of the kind commonly used throughout New Zealand by all Road Controlling Authorities
- Piezoelectric cables as used on fixed speed camera sites and the Pukerua Bay telemetry site
- Bending plate/load cell detectors as used at the WiM sites and CVIU enforcement stations

The most common of these in terms of Transit's traffic monitoring system are the pneumatic tube, piezoelectric cable, inductive loop and bending plate detectors. The following sections detail the way each of these work.

6.3.1 Pneumatic Tube

This technology relies on a flexible tube being laid across a roadway and attached to data logging equipment on the side of the road. The impact of a wheel on the flexible tube generates a pressure pulse, which is detected by an air switch and recorded in the memory bank within the data logging equipment. Extraneous pulses or bounces are filtered out by electronics or software within the data logging equipment itself.

In its simplest configuration, with one tube laid across a roadway, axle counts can be collected. Axle counts are simple to obtain and only require one tube per lane. However it requires the application of an "axle factor" to convert axle counts into vehicle counts. For example, if all vehicles were "2-axled" then the axle factor would be 2, such that the total number of vehicles passing the count site would be the total axle count divided by 2. Where there are many multi-axled vehicles passing the site, the axle factor would accordingly be higher. Derivation of an appropriate axle factor is paramount to the accuracy of the vehicle count at a particular site.

Please note: Transit New Zealand 's contract specifications do not permit the use of single tube axle detectors in the normal traffic counting programme. Two-tube classifiers are to be used at all count sample sites where traffic volumes are being surveyed in order to obtain vehicle counts, classes, direction of travel, intervals and speed data.. The additional cost of laying two tubes across the traffic lanes compared to one is minimal since the greatest cost is getting the equipment to and from the site. The greater accuracy and level of information collected with two-tube classifiers is far greater than any time saved on site by using a single tube axle detector and calculating an axle factor to get vehicle counts.

With the use of only one length of tube, the lane in which the vehicle is travelling or the direction of travel cannot be determined. In order to obtain that level of information, two tubes are required. If the equipment is placed at the side of the road, directional traffic data can be collected from a maximum of two lanes. If the equipment is placed in the middle of a road, such as on a raised median, then data from up to four lanes can be recorded.

The diagram illustrating possible tube layout configurations is shown in Appendix E.

The biggest advantage of pneumatic tube detectors is their relatively low cost, and the fact that the tubes can be re-used for several surveys as they are only temporarily nailed to the road surface each time.

The disadvantages of pneumatic tube detectors are that the tubes, while re-usable, eventually do wear out. Additionally, the tubes are prone to vandalism and detachment from the road surface or data logging equipment especially in urban areas. For this reason, Transit New Zealand has a policy of installing loop traffic detectors in urban areas and where vandalism has been a problem. Loop detectors also provide greater safety for the field staff collecting traffic data as the are only required to go onto the traffic lanes for one count every three years when they do a classified count at the site.

6.3.2 Piezoelectric Cable

These detectors can be configured in the same manner as the pneumatic tube detectors and can be used on multiple lanes. The number of lanes that can be counted is dependant on what can be handled by the equipment. The equipment is placed on the side of the road.

This technology relies on the impact of a wheel on the cable creating a small change in cross-sectional shape of the crystals embedded within the cable. This in turn generates a small voltage, which can easily be measured and used to determine the passage of vehicles.

The disadvantages of piezoelectric cables are primarily their high cost. They are also difficult to maintain, especially when installed in flexible, chip-seal pavement environments. Additionally they are very sensitive and even small vibrations can generate electronic signals, which can be falsely interpreted as wheel activations.

6.3.3 Inductive Loop

This technology requires the use of an inductive loop, either installed permanently within the road pavement or temporarily affixed on the surface of the road, to detect the passage of vehicles travelling along the road. An inductive loop is essentially a wire wrapped round in a continuous loop in the centre af the traffic lane to form an inductor. The inductance of this loop depends upon the loop area and the number of turns of the wire. A small electrical current is passed through the loop at a specified frequency in order to produce an electronic field. When a vehicle passes over the loop the inductance changes and an electronic signal is generated which can be measured, registering a 'count' in the roadside data logging equipment.

As noted earlier, the loops can be installed permanently within the road pavement or temporarily on the road surface, although the latter method can be difficult, as it requires the use of sticky bituminous tape.

Permanent loops have an estimated lifespan of at least 10 years and can be set up at a particular location to record data continuously (as for telemetry sites) or connected to data logging equipment to collect data when required. However it should be noted that the adoption of this technology requires substantial forward planning as the costs associated with installation and maintenance are relatively high.

Inductance loops can be configured, depending on the data logging equipment used, to collect vehicle counts only or a combination of counts and classification (either length or speed). For the latter, two loops per lane would be required. Possible configurations for inductance loops are shown in Appendix E.

6.3.4 Bending Plate

Bending plate technology incorporates a steel or rubber plate with strain gauges (or sensors) attached to its underside. As the axle of a vehicle passes over the plate, the strain gauges generate an electronic signal proportional to the plate deflection to the roadside data logging equipment. The magnitude of the signal is then used to determine the applied load.

Bending plate technology in conjunction with inductive loop technology can be used to determine the presence and speed of a vehicle, the axle spacing and the axle load applied. This is the basic principle governing Transit's Weigh-in-Motion sites.

7. MONITORING HIERARCHY AND CONVENTIONS

Historically, Transit New Zealand have measured the total vehicle counts on all sites; at some of these sites the vehicles will be classified; and at some of these sites weigh-in-motion data will be collected. Hence, there is a hierarchy of traffic data collection.

For each monitoring site, data is generally collected on a lane-by-lane basis at 15 minute intervals.

Additionally, it is vital that the equipment clocks are synchronised and maintained to within five seconds of the Industrial Research Limited's Talking clock, accessible on 0900 45678 so that consistency is maintained across all sites.

7.1 Vehicle Counts

This is simply the total number of vehicles recorded over each lane at a particular location within a specified period of time.

Individual surveys should be carried out over a period of 7 contiguous days, taking care to avoid daylight saving start/end times and public holiday periods. In some instances however, collecting data during public holiday periods may be useful, especially in respect of summer and winter vacationing locales, and it is left to the discretion of individual Transit regional offices as to whether counts in these areas are warranted.

If a number of 7-day counts are required for a particular site then the data collection should be spread evenly throughout the year. For example, if four 7-day counts are required during the year then each count should be carried out at three monthly intervals.

Inductive loop technology is used on highways where traffic volumes are in excess of 4000 vehicles/day so that the hazards of placing pneumatic tubes in areas of high traffic flow are avoided in the interests of safety.

As noted earlier vehicle counts are carried out on a continual basis throughout the year at Transit's telemetry sites. These counts are obtained on a directional basis and are separated into Transit's four standard length classes.

7.2 Vehicle Classifications

Supplementing the basic vehicle counts are counts in which the vehicle flow travelling past the monitoring location is disaggregated into 14 separate classifications based on a combination of the number of axles and spacing. Transit developed a standard Vehicle Classification Scheme in 1999 and as noted earlier, a copy of this scheme is provided in Appendix A.

The rules regarding frequency of count and days where counts are to be avoided are the same as for the standard vehicle counts outlined in the previous sub-section.

It is expected that a classified count is to be undertaken at every rural and non-motorway monitoring site at least once every 3 years.

7.3 Weigh In Motion

As noted earlier, there are 4 WiM monitoring sites located throughout the country in current operation. At each WiM site, the weight of every passing vehicle is determined dynamically, that is while they are in motion. If this weight exceeds 3.5 tonnes, which is a convenient means of defining a "heavy vehicle", then various details pertaining to this vehicle are stored in the memory banks of the roadside data logging equipment. These details include:

- The date and time that the vehicle passed the site
- Which lane the vehicle was travelling in
- The overall length of the vehicle (measured by loops)
- Speed of the vehicle
- Spacing between each axle
- Weight associated with each axle.

From the last two items, the overall wheelbase (sum of axle spacings) and the gross weight (sum of axle weights) are also calculated and stored within the data logging equipment. In addition to all the details noted above, the WiM site also performs the same function as the conventional telemetry classifier by recording traffic counts in the standard four Transit length bins described in Section 4.2.1 of this Guide.

8. TYPICAL SURVEY SPECIFICATION

This section is included to assist the count contractor with carrying out traffic counts at the non-continuous monitoring site locations. The success of the entire Traffic Monitoring System relies entirely on the quality of the data obtained and all efforts must be directed towards ensuring that data collection procedures and equipment are of the best possible standards.

8.1 Site Selection Criteria

The choice of site is extremely important to the quality of the count data obtained. In this regard, sites must be located a reasonable distance away from intersections and other turning traffic. It is desirable to have at least 20 metres of straight road on either side of the survey site. If tubes are used, they should be secured perpendicular to the lane.

Factors such as: lane discipline within the survey area, areas where overtaking is prevalent, and areas where acceleration or deceleration is common, should be taken into account when choosing a suitable survey site. Additionally, on-street parking can pose a problem when the wheel of a vehicle is parked directly over a tube thereby inhibiting the operation of the counting equipment. Furthermore, the noise generated from the wheels of vehicles travelling over the tubes can create an unacceptable nuisance in residential areas. Multiple tubes can compound the problem. Vandalism and interference with counting equipment also is a potential problem at urban sites. Careful consideration is required in these circumstances. These are among the reasons Transit New Zealand prefers all regular urban count sites to be set up with permanent traffic detection loops.

8.2 General Guidelines for Tube Surveys

Tube survey equipment should be limited to obtaining data for one or two lanes. If a solid raised median is available to accommodate the data logger then basic axle counts from up to four lanes can be collected with relative ease.

Two types of information can be collected depending upon the tube configuration and type of equipment used at the monitoring site. This data can be either axle counts or classified counts (based on vehicle length and speed). Classified counts require the use of two tubes. In high traffic volume situations, where coincident traffic in each direction may confuse the data logger, one recorder for each direction may be required.

In both types of survey, a visual assessment over a period of at least 15 minutes, must be carried out and documented in order to confirm the integrity of the collected data. The visual survey would also be used to determine the axle factor for the site if necessary.

The correct operation of tube equipment is generally described in the specific equipment operation manuals. It is important that the field operators in charge of placing the equipment on the site are fully conversant with the details provided in the equipment manuals.

Additional important points to note with regard to the placement of data counting equipment are as follows:

- For vehicle classifications it is necessary for both tubes to be of the same length and stretched to the same tension
- Tubes should be checked thoroughly on a regular basis as they have a tendency to deteriorate over time. Air escaping from punctures in tubes and water getting into tubes can cause serious recording errors
- It is good practice to blow compressed air through the tubes regularly to check they have no moisture in them and they are not punctured.
- Vandalism is a constant issue, especially in areas of relatively high pedestrian activity. Avoidance of these areas where possible and frequent inspection of the equipment are measures which can be employed to minimise the problems associated with vandalism
- Data logging equipment should be securely chained to fixed roadside objects such as power poles, signs, fence posts, trees or housed in purpose built cabinets
- Tubes must be securely affixed to the road surface in such a way as to prevent the tube from bouncing, which can send false signals to the data logger

Adherence to the points noted above will assist in ensuring the success of the data collection process.

8.3 Safety Issues

As with all matters relating to working on the road, extreme caution is required to be exercised to ensure that the laying and retrieval of equipment is carried out in the safest manner possible, with respect to both the contractor and other road users.

Transit New Zealand has developed a Code of Practice for Temporary Traffic Management to assist people working in the road environment in carrying out their necessary tasks safely and efficiently. Additionally the Road Controlling Authorities in various regions have their own specific requirements in regard to working on the roads. Both the Code of Practice and the relevant Road Controlling Authority must be consulted prior to undertaking any surveys and guidelines adhered to when setting out or removing equipment.

If a tube is required to traverse a footpath, then appropriate safety precautions should be observed for pedestrians. Tubes should be covered by a plate, or at the very least, sprayed with a bright coloured paint so that they are visible in poor light conditions. In this respect, placing the equipment near a street light can be advantageous.

When fastening tubes to the surface of the carriageway special care needs to be taken to ensure nails or spikes do not come loose and create a hazard likely to puncture the tyres of vehicles passing over the tubes.

9. DATA CALCULATION

Once the data is collected from a particular site it can be used to calculate a variety of outputs, such as AADT, VKT or ESA. As referred to in the preceding section, calculations are reliant on an accurate representation of the base data.

The TMS database software has been specially developed to carry out all the necessary calculations on the collected data as noted earlier in Section 4.3. The software continues to be developed as requirements of users change over time and as technological advances necessitate. The particular outputs from the TMS are discussed in a later chapter.

9.1 Data Accuracy

Accuracy can be described in two basic terms, confidence limits (or levels) and target (or desired) range. Confidence limits relate to the degree of certainty, such that a confidence limit of 95% indicates an assurance "95% of the time". The 95% limits or thresholds originate from the properties of the normal distribution where the true mean lies within two standard deviations of the sample mean.

Therefore, an accuracy specification of 95% ± 10% indicates that 95% of the time the measured value, for example AADT, will lie within 10% of the true value.

Variables affecting accuracy include the type of equipment used and the type of survey conducted, the duration of the survey and the frequency of the survey. Acceptable recording errors are within plus or minus 5%.

More statistical analysis work is to be conducted at the conclusion of the current three year contract cycle.

9.2 Calculated Values

9.2.1 Average Annual Daily Traffic (AADT)

The most common computation carried out on the collected data is to calculate the AADT for a particular survey site. At a continuous site, this is simply the sum of the daily totals divided by the number of days. The level of accuracy is dependent on the number of days for which a complete 24 hour count is available, ideally every day of a given year. The ratio of the flow measured on a particular day and the true overall AADT is a value which can be defined as a "Daily Flow Factor". This factor is used to scale the traffic counts obtained from non-continuous count sites associated with the continuous site, in order to take account of seasonal variations in traffic flow which occurs throughout a typical year. The average of the scaled daily totals at the non-continuous sites is the derived AADT for that site.

AADTs can be subdivided by lane and vehicle composition. When quoting AADTs, they should be rounded to the nearest multiple of ten.

9.2.2 Vehicle Kilometres Travelled (VKT)

VKT is the product of the AADT and the length of the roadway link within which the count was obtained. Link VKTs can be summed as desired such that a total VKT over a State Highway or Region can be obtained. The annual change in VKT over the entire network provides an indication of the growth in traffic volumes throughout the state highway network.

9.2.3 Equivalent Standard Axles (ESA)

ESA's are determined from measurements of vehicle axle loadings, either from WiM stations, Police Commercial Vehicle Investigation Unit (CVIU) sites or other commercial vehicle weighing installations. The precise details of these calculations are provided in the Pavement Design Manual and are not included here as subtle changes may be made to the formulae in the future.

10. TRAFFIC MONITORING SYSTEM (TMS) OPERATION

The key to the whole Traffic Monitoring Method lies within the TMS database software, which fulfils the functions of being a central repository for the collected data, a data manipulator and a reporting tool to produce the necessary summaries of data to assist with infrastructure planning. Since the software is internet-based it is easily accessible by authorised end users throughout the country. The internet site has its own on-line help which includes a comprehensive User Guide for the system.

The internet site comprises a number of menus and sub-menus which can be accessed by the end user to either load data or provide data outputs. At its most basic level there are five separate areas within the internet site and these are summarised below.

10.1 Operational Data

This area of the internet site allows the user to view details of the various counter sites within the network and the basic components of the node/link network as described in Section 4.1.

10.2 Traffic Data

Through this area of the internet site, the regional traffic monitoring consultants can load raw data into the system. After the data is loaded, the TMS carries out a validation check of the data and notifies the consultants of any apparent anomalies. The consultant is also able to delete loaded data through this area.

10.3 Reports

10.3.1 Recorded Data

The reports produced in this area show the actual count data uploaded into the TMS prior to the application of any seasonal adjustments or internal TMS calculations.

Reports that can be output include:

- hourly volumes for all days of a month
- hourly volumes over a week
- 15 minute volumes for the peak hours (6am to 10am, 3pm to 7pm) for all days of a week, including a 5-day average and a moving hour average for all 5 weekdays
- actual count data by day, week, month, quarter or year
- counts in the increasing, decreasing directions and combined flows for each of the four Transit length bin classes
- an un-summarised display of actual counter data

These reports are useful for easily obtaining an overview of the counts measured in the field and are useful for detecting any obvious anomalies within the data.

10.3.2 Summarised Data

These reports show the adjusted count data, which have been factored to take account of Daily Flow Factors, reclassifications and motorway on/off ramp adjustments.

Reports can be obtained which show:

- summary data for a particular site, such as AADT, Daily Flow, Flow Factor and VKT
- the AADTs for all sites in a region
- all the calculated Daily Flow Factors
- a 7 day ADT for actual and reclassified data
- the trend in AADTs for a range of years
- the annual VKT for a site, highway or region
- the AADT outputs as per the State Highways Traffic Volumes publication produced by Transit on an annual basis
- the calculations relating to reconciling traffic volumes along a motorway system which uses counts measured at certain locations and a system of adding or subtracting on-ramp and off-ramp counts respectively
- the AADT statistics in a format suitable for export to the RAMM system

These reports are ultimately used as a basis for highway asset infrastructure forward planning.

10.3.3 Site Details

The reports within this area deal with the various count sites as opposed to the traffic data itself.

The reports produced here can show:

- details of the site, including location, and lane information
- availability of data at a particular site (complete, incomplete or missing data)
- days where there is missing data for a control (parent) site but data available for the non-continuous (child) site
- number of days counted for specified sites
- all the sets of data loaded against a site, including the status and date range of each dataset.

These reports can be used to assess the various data issues associated with the various monitoring sites.

10.3.4 Weigh-in-Motion

The reports produced here are primarily related to the data collected at the Weigh-in-Motion stations along the road network. These include tabulations of:

- ESA statistics for the 4 axle groups defined in the Austroads Pavement Design Guide, New Zealand Supplement
- ESA statistics for vehicles classified according to the number of axles
- Axle load distributions for the 4 axle groups as defined in the Austroads Pavement Design Guide, New Zealand Supplement
- Heavy motor vehicle distributions according to PAT type, a scheme that classifies vehicles according to number of axles and axle configuration.

This summarised data can be used to assist assessing the activity of heavy vehicles using the road network and planning the necessary alterations to the network to accommodate these vehicles.

10.4 User Administration

This area of the internet site is available to carry out any administrative tasks which may be required by the end user. At this stage there is only one facility available that allows end users to change their TMS access passwords.

10.5 Help

The final area on the internet site deals with the online help. The items included here are:

- the general User and Administrator guides
- a quick reference guide which can be downloaded and printed
- a document outlining lane numbering conventions for Traffic Monitoring purposes
- a template document for use in requesting changes to TMS operation or reporting. Once filled in this can easily be emailed to the TMS System administrator or the TMS regional administrator for consideration.

All documents are provided in Microsoft Word format and can be easily downloaded and printed for future reference. The documents are also amended from time to time and the internet site is updated accordingly.

11. LINKS TO OTHER SYSTEMS

At present TMS is able to directly interface with the RAMM system via a simple mechanism. However this interface relies on the Site ID and link nodes within both systems being entirely consistent.

In the future it is expected that TMS will be fully compatible with other road asset systems such as the new Location Referencing Management System (LRMS).

12. THE FUTURE

As time progresses and new technological breakthroughs in the transportation field are discovered, Transit's Traffic Monitoring Strategy and associated systems should be sufficiently robust to cope with the changes. Already, the ATMS systems in Auckland and Wellington demonstrate the potential for what can be achieved in terms of data collection. Additionally as transportation applications for new technological advances such as GPS and 3G Communications are developed, it is likely that the accuracy of data and efficiency of data retrieval will be enhanced notably.

Overall, given the improvements the future of Transit's Traffic Monitoring Method looks bright, allowing better forecasting of state highway use in the future and subsequently more efficient allocation of resources to ensure *"a safe and efficient state highway system which meets the needs of road users and the communities it serves."*

APPENDIX A

TRANSIT NEW ZEALAND VEHICLE CLASSIFICATION SCHEME

Vehicle Classification Scheme (NZTA 2011)

NZTA Axel Class	Vehicle Types in Class	Axles	Groups	Criteria	Maximum axle spacing < 10m			Length Range (WIM data)	NZTA EEM Class	Light or Heavy	NZTA Length Class	Austroads 1994 Class
					AS1 - 2	AS2 - 3	AS3 - 4					
1	oo (very short 2 ax veh = motorbike)	2	1	2 ax, AS 1 criterion	>=0.5, <1.75	-	-	>1.5 - 2.5	(PC)	Light	VS	1
2	o-o (short 2 axle vehicle = car)	2	2	2 ax, AS 1 criterion	>=1.75, < 3.2	-	-	2.5-5.5 (4-6)	PC & LCV	Light	S	1
	o-o--o (car towing 1 axle trailer)	3	3	3 ax, AS 1,2 criteria	>2.1, < 3.2	>2.1	-	7 -11			M	2
3	o-o--oo (car towing tandem trailer)	4	3	4 ax, AS 1,3 criteria	>2.1, < 3.2	>2.1	<=1.0	8 -13	PC & LCV	Light	M	2
	o-o--o-o (car towing car)	4	4	4 ax, AS 1,2,3 criteria	>2.1, < 3.2	>2.1	>2.1	10 -15			M	2
	o----o (truck or bus)	2	2	2ax AS 1criterion	> =3.2m			5 - 12			M	3
4	o--o--o (truck towing light trailer)	3	3	3 ax, AS 1,2 criteria	>=3.2m	>2.1, <=6.8	-	8 -16	Bus & MCV		L	6
	o--o--oo (truck tow light 2 ax trailer)	4	3	4 ax, AS 1,3 criteria	>=3.2m	>2.1	<=1.0	9 -17			L	7
	o--oo (truck or bus/coach)	3	2	3 axles, 2 groups	>=3.2m	<=2.1	-	7 -12			M	4
	o--oo (tractor without semi-trailer)	3	2	3 axles, 2 groups	>2.1, < 3.2	<=2.1	-	6 -8			M	4
5	oo--o (twin steer truck)	3	2	3 axles, 2 groups	<=2.1	-	-	7 -12	Bus & HCV1	Heavy	M	4
	o--o-----o (artic e.g. bread truck)	3	3	3 ax, AS 1,2 criteria	>=3.2m	>6.8	-	11 -17			L	6
	o--oo---o (truck tow light 1 ax trailer)	4	3	4 ax, AS 1,2,3 criteria	>=3.2m	<=2.1	>2.1	10 -17			L	7
	oo--o---o (twin steer tow 1 ax trailer)	4	3	4 ax, AS 1,3 criteria	<=2.1	-	>2.1	10 -17			L	7
	oo--oo (heavy truck)	4	2		<=2.1	-	>1.0, <=2.1	7 - 13			M	5
6	o--ooo (heavy truck)	4	2	4,5 axles, 2 groups	>2.1	<=2.1	>1.0, <=2.1	7 -11	HCV1	Heavy	M	5
	oo--ooo (heavy truck)	5	2		-	-	-	8 -13			M	5
	o--o--oo (artic A112)	4	3	4 ax, AS 1,2,3 criteria	>2.1	>2.1	>1.0, <=2.1	12 -18			L	7
7	o--oo--o (artic A121)	4	3	4 ax, AS 1,2,3 criteria	>2.1,<3.2	<=2.1	>2.1	12 -18	HCV1	Heavy	L	7
	o--o--o--o (truck tow heavy trailer)	4	4	4 axles, 4 groups	>=3.2	>2.1	> 2.1	13 -17			VL	7
	o--oo--oo (truck tow light trailer)	5	3		-	-	-	10-18			VL	8
	o--oo--oo (artic)	5	3	5 axles	-	-	-	12-17			L	8
8	o--o-----ooo (artic)	5	3		-	-	-	12 -17	HCV2	Heavy	L	8
	o--oo--o--o (T+T)	5	4	3,4,5 groups	-	-	-	13 -18			VL	8
	o-o-o-o-o (mobile crane)	5	5		-	-	-	10 -13			L	8
	o--oo--ooo (artic)	6	3			-	>2.2,<12.0	13 -18			L	9
	oo--oo--oo (artic)	6	3		-	-	-	13 -18			L	9
	o--ooo--ooo (artic)	7	3	6-8 axles	-	-	-	> 16			L	9
9	o--oo--oooo (artic)	7	3	3 groups	-	-	-	> 17	HCV2	Heavy	L	9
	oo--oo--ooo (artic)	7	3		-	-	-				L	9
	oo--oo--oooo (artic)	8	3		-	-	-				L	9
	o--ooo--oooo (artic)	8	3		-	-	-				L	9
	o--oo--o-oo (T+T)	6	4		-	-	-				VL	10
	oo--o--o-oo (T+T)	6	4		-	-	-				VL	10
10	oo--oo--o--o (T+T)	6	4	6 axles	-	-	-		HCV2	Heavy	VL	10
	o--oo--o-o-o (T+T)	6	5	4,5 groups	-	-	-				VL	11
	o--o--oo--o-o (A train)	6	5		-	-	-				VL	11
	o--oo--o--o-o (A train)	6	5		-	-	-				VL	11
	o--oo--oo-oo (T+T)	7	4		>2.2m	-	-				VL	10
11	o--oo--oo--oo (B train)	7	4	7 axles, not twin steer	>2.2m	-	-		HCV2	Heavy	VL	10
	o--oo--oo--o-o (A train)	7	5	(AS 1 criterion)	>2.2m	-	-				VL	11
	oo--oo--o-oo (T+T)	7	4		<=2.2m	-	-				VL	10
	oo--o--oo--oo (T+T)	7	4		<=2.2m						VL	10
	oo--oo--oo-oo (T+T)	8	4		<=2.2m	-	-				VL	10
	oo--oo--oo-ooo (T+T)	9	4	7-11 axles	<=2.2m	-	-				VL	10
12	oo--oo--ooo-oo (T+T)	9	4	twin steer	<=2.2m	-	-		HCV2	Heavy	VL	10
	oo--oo--ooo-ooo (T+T)	10	4	(AS 1 criterion)	<=2.2m	-	-				VL	10
	oo--ooo--oo--ooo (T+T)	10	4		<=2.2m						VL	10
	oo--oo--ooo-oooo (T+T)	11	4		<=2.2m	-	-				VL	10
	various (twin steer A train)	7-11	5		<=2.2m	-	-				VL	11
	o--oo--ooo-oo (B train)	8	4		>2.2m	-	-				VL	10
	o--oo--oo--ooo (B train)	8	4		>2.2m	-	-				VL	10
	o--oo--ooo-ooo (B train)	9	4		>2.2m	-	-				VL	10
13	o--oo--ooo-oooo (B train)	10	4	8-11 axles	>2.2m	-	-		HCV2	Heavy	VL	10
	o--oo--oo--o-oo (A train)	8	5	not twin steer	>2.2m	-	-				VL	11
	o--oo--ooo--o-o (A train)	8	5	(AS 1 criterion)	>2.2m	-	-				VL	11
	o--oo--ooo--o-oo (A train)	8	5		>2.2m	-	-				VL	11
14		any	-	Everything else	-	-	-					

NZTA Length Class: VS= 0.5 - 2.0m S=2.0 - 5.5m M=5.5 - 11m L=11 - 17m VL>17m
Axles: Number of axles
Groups: Number of axle groups (an axle group is where axles are less then 2.1m apart.
AS1 - 2: Distance between first and second axle
AS2 - 3: Distance between second third axle
AS3 - 4: Distance between third and fourth axle

APPENDIX B

TELEMETRY STATION SITES

Telemetry Station sites (by Transit Region and State Highway)

North Island

NORTH ISLAND		
Transit Region	**SH**	**Locality**
1 – Northland	1N	Kawakawa
		Wellsford
2 – Auckland	1N	Hadfields Beach
		Auckland Harbour Bridge
		Ellerslie
		Panama Rd
		Drury
		Bombay
3 – Waikato	1N	Taupiri
		Karapiro
		Lichfield
		Hallets Bay
	2	Mangatawhiri
		Waihi
	3	Te Kuiti
	25A	Hikuae
	27	Kaihere
	32	West Lake Taupo
4 - Bay of Plenty	2	Te Puna
		Onhinepanea
	5	Tarukenga
		Waipa
	29	Kaimai
	30	TeNgae (Rotorua)
		Lake Rotoma
	33	Paengaroa
5 – Gisborne	2	Ormond
6 - Hawkes Bay	2	Tangoio
	5	Te Pohue
	50	Napier South
7 – Taranaki	3	Tongaporutu
		Tariki
		Waitotara
	45	Hawera
8 – Manawatu-Wanganui	1N	Hihitahi
		Sanson
		Ohau
	2	Norsewood
	3	Manawatu Gorge
	4	Horopito
		Upokongaro
9 – Wellington	1N	Pukerua Bay
		Ngauranga Gorge
	2	Clareville
		Rimutaka
		Ngauranga Gorge
	58	Pauatahunui

Telemetry Station sites (by Transit Region and State Highway)

South Island

SOUTH ISLAND		
Region	**SH**	**Locality**
10 - Nelson-Marlborough	6	Hira
		Stoke
		Murchison
11 – Canterbury	1S	Kaikoura
		Dunsandel
		Timaru
		St Andrews
	7	Lewis Pass
	73	Springfield
	74	Cranford St Chch
12 – West Coast	6	Punakaiki
		Chesterfield
	7	Ahaura
13 - Otago	1S	Green Island
		Milton
	8	Alexandra
14 - Southland	1S	Gore
		Invercargill
	6	Winton

APPENDIX C

WEIGH-IN-MOTION SITES

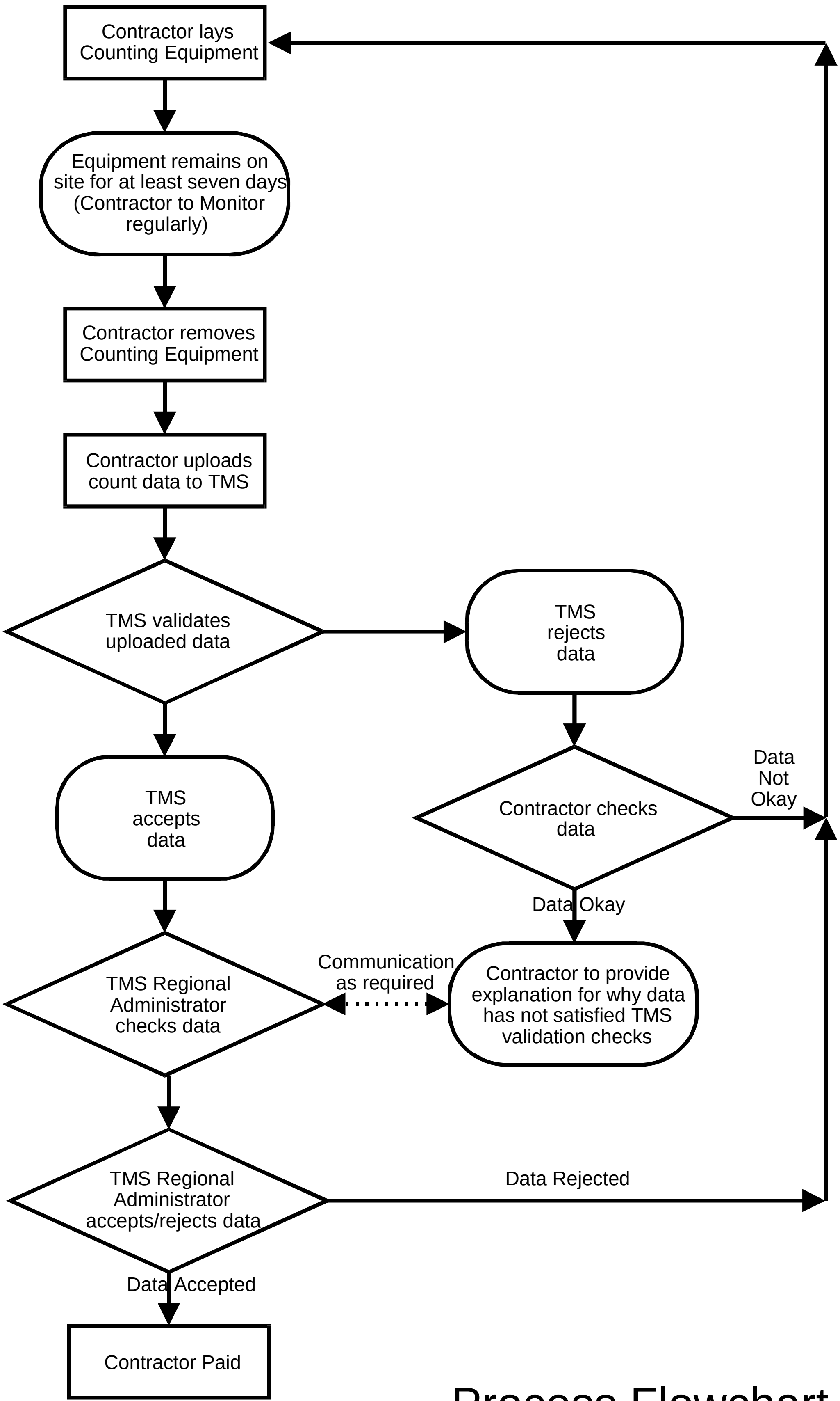
Weigh in Motion Sites

NORTH ISLAND		
Transit Region	**SH**	**Locality**
2 - Auckland	1N	Auckland Southern Motorway, Drury
3 - Waikato	1N	Tokoroa
4 - Bay of Plenty	2	Te Puke

SOUTH ISLAND		
Transit Region	**SH**	**Locality**
11 - Canterbury	1S	Waipara

APPENDIX D

PROCESS FLOWCHART

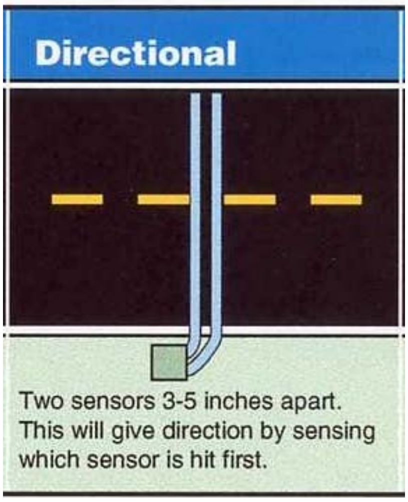


Process Flowchart

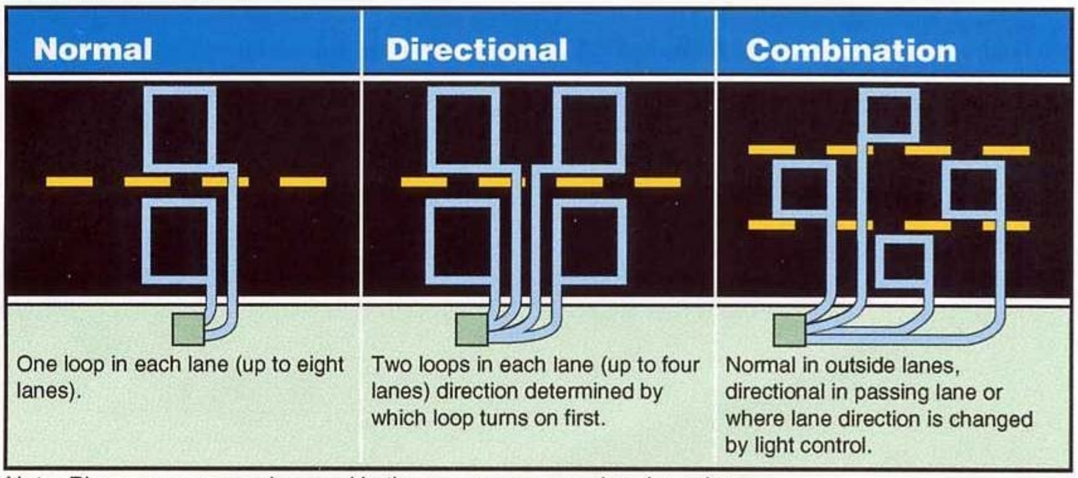
APPENDIX E

POSSIBLE TUBE AND LOOP LAYOUT CONFIGURATIONS

Counts (axle sensors)



Counts (loop detectors)



Note: Piezo sensors can be used in the same arrays as the above loops.

Sensor Arrays for Classification

Axle (road tube / piezo / resistive)