Control Specialists Company
Traffic Systems Since 1965

TIRTL

Product Overview

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1 Introduction

The Infra-Red Traffic Logger (TIRTL) (Figure 1) is a traffic surveillance system that is non-intrusive and capable of highly advanced functionality with features making it the most flexible ITS product in the world today.

TIRTL counts, classifies, determines the lane and speed of passing vehicles using a novel light-based technology. As a single noninvasive system, TIRTL operates in installations involving uni-directional and bi-directional, multi-lane traffic.

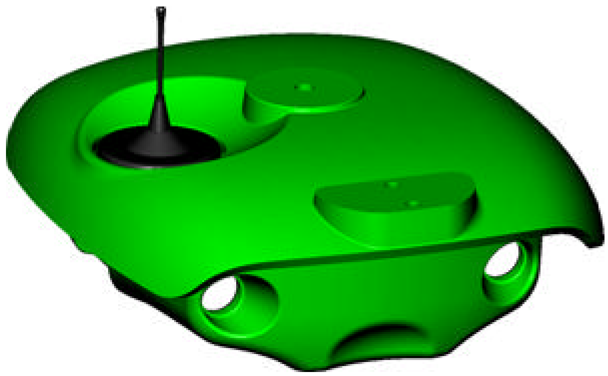

Figure 1 –TIRTL receiver incorporating GPS/GSM option.

Features

The features of TIRTL include:

- Infrared light detection system.
- Portable unit with fast and easy installation during day or night.
- Temporary or permanent installation.
- Multilane, bi-directional traffic monitoring with a single TIRTL system.
- Noninvasive installation hidden from passing vehicles.
- Vehicle classification system based on axle counts, axle separation, wheel widths and wheel size ratios.
- Speed measurement based on parallel beam breaks (1% @ 120 mph).
- For vehicles traveling at an average speed of 60 mph and an average separation of 3 seconds from each other, the vehicle classification accuracy of TIRTL is typically better than 98% (2 lanes), 97% (3 lanes) and 96% (4 lanes).
- Vehicle counting, classification, location, lane identification and speed measurement for multilane, bi-directional roadways.
- Capable of vehicle counting and classification at a constant rate of 125 vehicles per second in a multilane environment.
- Classification to FHWA13 and user defined schemes.
- Date and time stamped traffic data logging, including vehicle count, classification, speed, direction, lane and wheelbase measurement.
- Ultra-low power consumption for battery (7 days alkaline, 10 days lithium) or fixed power installation.
- Remote operation, monitoring and data log transfer via a GSM (900/1800MHz or 900/1900MHz) mobile modem or fixed line modem.
- Optional Global Positioning System (GPS) provides location.
- Excellent environmental performance and capable of reliable operation in all weather conditions (-40°F to +185°F, IP67 rated enclosure).
- User-friendly Graphic User Interface for Personal Computer (Windows 98, Windows 2000 or Windows XP) or Palm Handheld PDA. Communication to TIRTL for the GUI is via an RS232 connection.
- Secondary serial port may connect to an image camera for speed law enforcement, variable message signs or other ITS products.

TITRL consists of transmitter and receiver units on opposite sides of a highway (Figure 2). TIRTL uses two parallel and two cross beams at below axle height to measure and classify passing vehicles. The system has a speed measurement accuracy of 1% @ 120 mph and precisely measures the number of axles, axle separation, wheel width and the front to back wheel width ratio to classify vehicles.

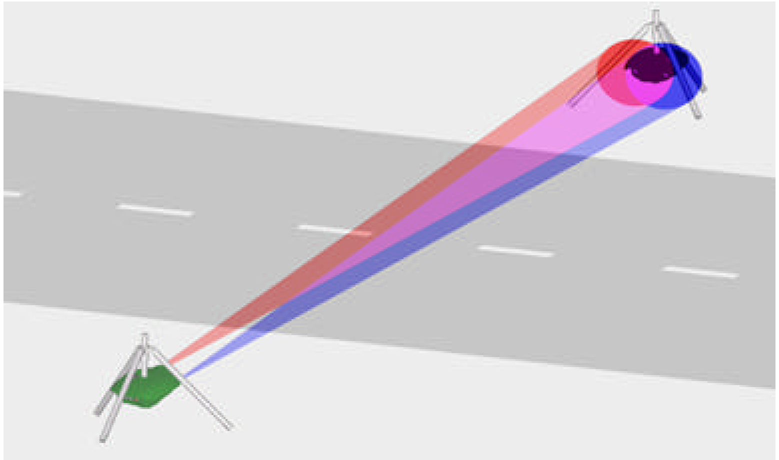

Figure 2 - Deployed TIRTL

The non-intrusive measurement techniques employed by TIRTL reduces time and costs for installation, maintenance and road repair. TIRTL is easily hidden from the view of oncoming traffic and as TIRTL is installed off the main highway there is no need for lane closures improving the safety for the public and service personnel.

TIRTL is designed to operate under extreme temperature conditions of -40°F to +185°F and is resistant to sunlight, rain, hail, dust and fog. The main TIRTL enclosure and associated connectors are rated to IP67.

TIRTL has a large data logging memory to record vehicle information in a time and date stamped format. The data log may be downloaded at any time either locally or remotely via a variety of modem options.

The system is web-enabled, it incorporates GPS functionality and communicates with a mobile modem or a fixed line modem to provide real time and historic traffic data from a remote installation.

TIRTL has an RS232 interface to facilitate the connection of a sophisticated Graphic User Interface known as TIRTL*soft*. A version of TIRTL*soft* is available for both a personal computer running under the Windows operating system and a Palm Handheld PDA. Using TIRTL*soft* the user can easily configure, monitor and exchange information to and from TIRTL. Communication uses an ASCII protocol and can be connected to a camera to enable traffic law enforcement, to an electronic variable message sign, to a WIM controller and to a wide range of ITS products.

The ultra-low power consumption enables TIRTL to operate from fixed power, solar power or internal batteries.

TIRTL can be easily installed during the day or night and remain hidden from passing traffic.

The many features and ease of use make TIRTL the most flexible ITS product in the world today.

Applications

A single TIRTL may be installed in place of a number of different traffic surveillance products. Additionally, TIRTL may be used in ways not previously contemplated. Applications include:

- Advanced traffic detection including non-intrusive vehicle counting, classification and speed measurement.
- Speed and red-light enforcement when connected with a standard image camera.
- Point-to-point speed and travel time law enforcement.
- Tolling as the primary and secondary count and classification unit.
- Over height vehicle detection.
- WIM system support providing vehicle count and classification data, communications and data logging.
- Remote monitoring of rural highways for vehicle statistics and oversized vehicle detection.
- Traffic density monitoring for real-time applications.
- Closed roads, airstrips and track monitoring.

2 Theory of Operation

A TIRTL consists of a transmitter and receiver pair. The transmitter is the source of infrared beams used to detect traffic. The receiver detects disturbances in the infrared beams caused by passing tires, and uses intelligent software to produce vehicle classifications based upon the relative timing of those events.

2.1 Vehicle Detection using "Beam Events"

The transmitter emits a beam of infrared light from each forward facing lens. These light beams overlap at the receiver, such that the light from each falls over both of the receiver's lenses. This beam overlap yields four different paths of light from the transmitter to the lenses of the receiver, two parallel beams and two crossed beams as illustrated in Figure 3. As a vehicle passes between the receiver and transmitter, each wheel interrupts each of the four beam pathways.

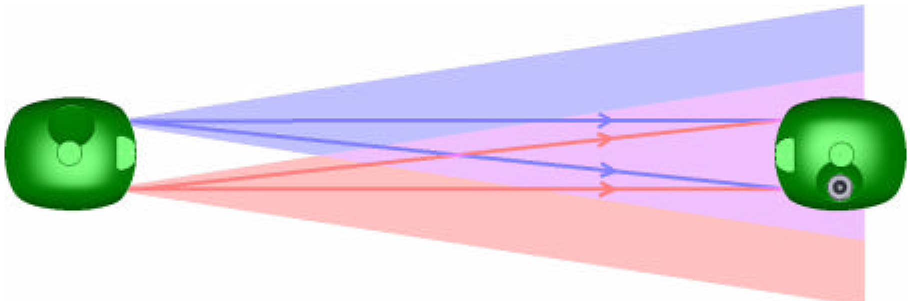

Figure 3 – TIRTL beam configuration.

Breaking of a beam is known as a "Break Beam Event" while the re-establishment of a given beam's continuity is defined as a "Make Beam Event". In this way with passing of each vehicle wheel a set of 8, time-stamped, Beam Events are generated from the 4 beam pathways at the TIRTL receiver. Detecting the precise time of each Beam Event allows the receiver to compute for example the velocity and lane of each vehicle wheel as it passes.

It is important to note that the alignment of the transmitter and receiver units is critical and that the beams traversing the highway are set at as low a point as possible. This allows effective detection without interference from mud-flaps and other features hanging from the main body of the vehicles. By use of the specialized TIRTL Optical Sights accurate alignment during the day or night is easily achieved.

Figure 4 shows the tripod installation of TIRTL receiver. This TIRTL receiver features the GPS/GSM modem option as evidenced by the antenna rod attached to the top of the unit. Figure 4 also shows the positioning of the Optical Sight on the top of the unit used during the alignment process of the TIRTL system.

Figure 4 - Temporary Tripod of TIRTL Receiver

2.2 Speed and Vehicle Direction Detection

Figure 5 illustrates a TIRTL installation on a bidirectional roadway as viewed from above. As the wheels of the vehicles interact with the 4 beam pathways "Make and Break" Beam Events are generated. The speed of a vehicle is determined by the time interval measured (t1 or t2) between like Beam Events on the parallel beam pathways, A and B.

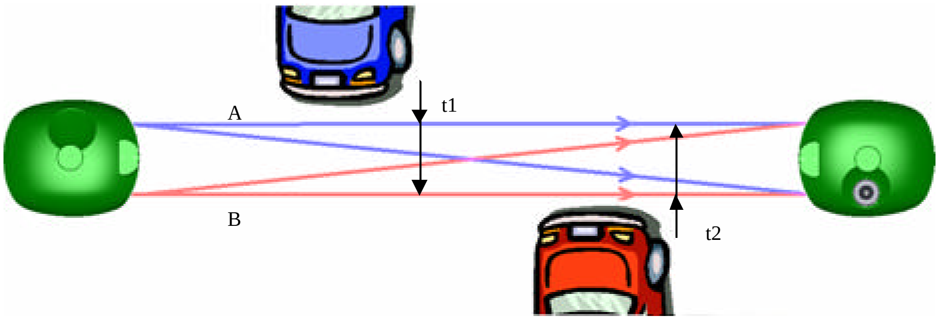

Figure 5 - Speed and Vehicle Direction Detection

The direction of travel of a vehicle on the monitored roadway is determined by the order in which Beam Events occur. In Figure 5 A to B represents Southbound traffic and B to A represents Northbound vehicles.

A number of redundant Beam Events are recorded in TIRTL installations. The redundant information is used to discard invalid measurement in multilane installation where passing traffic obscures or distorts a Beam Event associated with the target vehicle.

2.3 Lane Detection

Figure 6 illustrates the principles of lane detection as implemented in TIRTL. As each wheel of the vehicle interacts with infrared light pathway A, Ax, B and Bx "Beam Events" are generated. For each class of Beam Event, Make or Break, time intervals are measured. "t1" and "t2" are defined as the time interval between Beam Events on beams "A" and "Ax". "t3" and "t4" are similarly defined as the time interval between Beam Events on beam "A" and "Bx". Figure 6 illustrates that there exists a quantized time difference between time interval "t1" and "t2" used by the intelligent software of the TIRTL receiver to learn the lane positions of the installation. The measured time intervals are normalized to the vehicle speed to provide a ratio metric measurement of vehicle position. Time intervals "t3" and "t4" represent an example of redundant measurement information, which may be employed when passing traffic in multilane deployments invalidates one interval measurement or another.

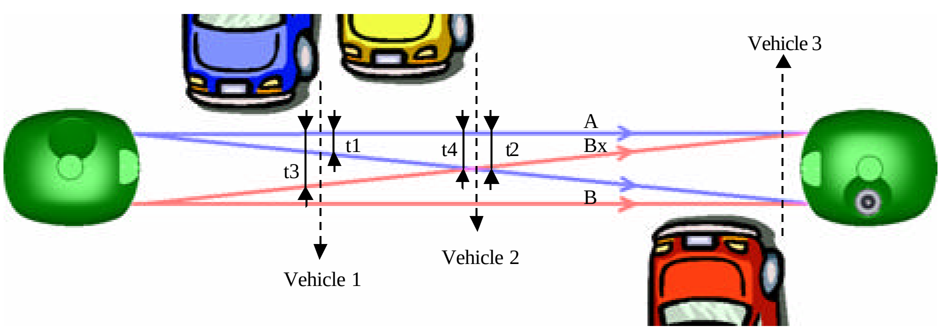

Figure 6 - Lane Detection

2.4 Axle, Axle Groups, Vehicle Detection and Wheel Size Measurement

Figure 7 illustrates in more detail the process of Make and Break Beam Events. The combination of a Break Beam Event followed by Make Beam Event of the same beam occurring within a single vehicle lane constitutes the detection of an axle. Detection of axles is the first stage in the important process of vehicle classification.

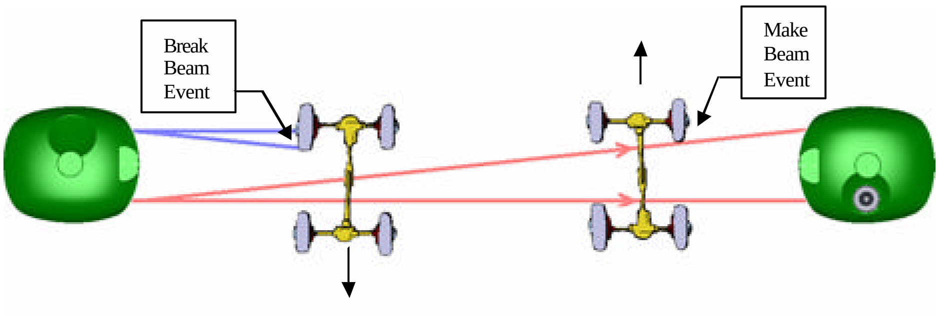

Figure 7 – Axle, Axle Groups and Vehicle Detection

An "Axle Group" is defined by TIRTL as a collection of axles separated by a user defined maximum distance. The distance between axles is measured by knowing the speed of the vehicle, the vehicles lane location and the time taken to traverse the 4 beam pathways. For example, the maximum distance between axles for a vehicle type is user defined as 2.1m. If a distance between 2 axles was measured at less than 2.1m TIRTL would consider a vehicle had been detected. In the vehicles illustrated in Figure 7 each of the Axle Groups consists of 1 axle; however, for multi-wheel vehicles such as semi-trailers Axle Groups can consist of more than one axle (see Figure 9).

A vehicle is detected when the number of axles and the distance between Axle Groups are within user-defined limits.

The Wheel Size of a particular vehicle class is necessarily a TIRTL learned parameter. It is necessary that this parameter be learned as the height of the beams above the road varies between TIRTL installations. Each of the infrared beam pathways between the transmitter and receiver effectively scribes a chord across the circle of the passing wheel (see Figure 8). With the speed measurement of the vehicle, the time between the Break and Make Beam Event and the traveling lane a measure of the tire width is obtained. This measurement may be ratio metrically used to discriminate between vehicle classes where the vehicles have very similar wheelbases based upon percentage wheel size variances.

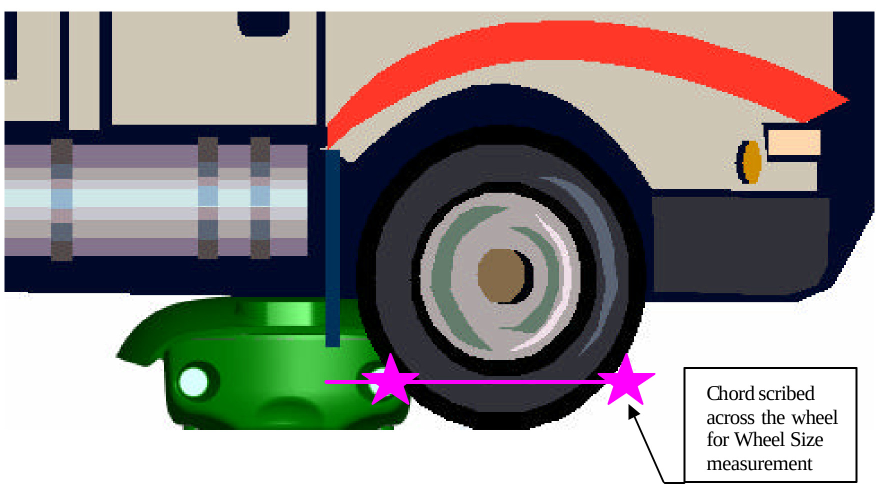

Figure 8 - Wheel Size Measurement

2.5 Classification of Vehicles

There are a number of different features of the wheelbase of road vehicles that may be used by the intelligent TIRTL software to classify vehicles.

Figure 9 illustrates these features. The user using the Classification Editor function of the TIRTLsoft GUI builds up classification Schemes based upon these features

A Classification Scheme contains a series of patterns based upon parameters associated with vehicle axles. Each pattern contains a number of parameters that uniquely describe a vehicle class. Generally the Classification Scheme moves toward finer and finer detail for the parameters of a particular vehicle class.

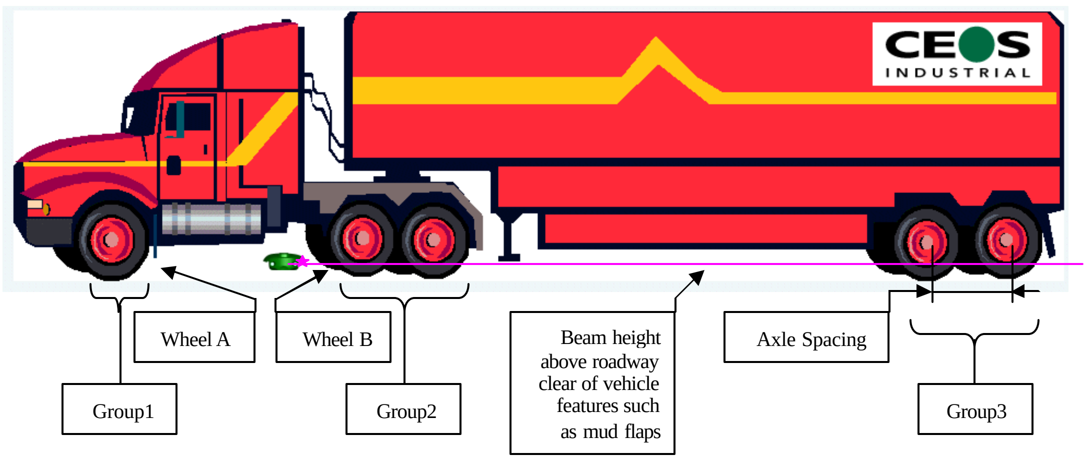

Figure 9 – Features of road vehicles.

A definition of the parameters associated with a user defined Classification Scheme is provided in the following paragraphs.

Axle Count – The number of Beam Events allows a count of the number of axles in a given vehicle. This is useful for discriminating between standard cars and trucks.

Axle Groups – The frequency of beam events allows an assessment of groups of axles. This is useful for discriminating between vehicles with the same axle count. Figure 9 illustrates 3 axle groups; the first group includes a single axle while groups 2 and 3 include double axles.

Axle Spacing – The duration between beam events allows a measurement of axle spacing providing discrimination between vehicles with the same axle count.

Wheel Size – This is a fine discrimination that allows vehicles with very similar axle profiles to be further categorized by ratio metric wheel size variations. The absolute wheel size within TIRTL is a learned parameter, the average of which is normalized to 1 within the current wheelbase class. This modifiable parameter gives the user the ability of differentiating wheel sizes measurably outside the average for this wheelbase. For example, by specifying a minimum normalized wheel size of 0.97 and a maximum of 1.03 all vehicles with a wheel size greater than ±3% will not be classified within this class.

Wheel Ratio – This is a ratio metric measurement of the leading wheel size measurement (wheel A in Figure 9) divided by the trailing wheel size measurement (wheel B in Figure 9). This is a fine discrimination that allows vehicles with different wheels front and back to be categorized.

3 Graphical User Interface.

TIRTL*soft* provides an intuitive GUI to TIRTL. The GUI has a clear and comprehensive presentation that allows a real time view of traffic events. TIRTL*soft* runs under Windows or Palm Handheld operating systems. The Windows version provides a comprehensive, fully featured, real time overview of traffic events. The Palm Handheld version combines the advantages of portability with an effective user interface suited to the smaller display size of the Palm.

3.1 PC Based TIRTL*soft*.

The PC based version of TIRTL*soft* runs under Windows 98, Windows 2000 and Windows XP. Figure 10 gives a broad view of the TIRTL*soft* GUI for Windows. A brief description of some of the features of the GUI is given in the following paragraphs.

Configuration Editor

The configuration editor, located at the left hand side of the figure, is used for the creation and editing of the structured files used to configure the operation of TIRTL receiver. There are two tabs associated with the Configuration Editor window, namely "Site Information" and "Classification Scheme". Figure 10 illustrates the view of the Configuration Editor with the Classification Scheme tab selected.

Status

The Status panel, located in the top right hand side of the figure, shows the operational status of TIRTL. The panel is segmented into four different tabs, General, Alarms, Logging and Modules. Figure 10 illustrates the view of the Status panel with the "General" tab selected. General status includes, time, date, serial numbers, unit temperature, battery status and the infrared beam intensity levels. "Alarms" gives a view of active and inactive alarms within TIRTL. "Modules" provides status and control of optionally fitted TIRTL modules including, GSM/GPRS, POTS Modem and GPS modules. "Logging" provides control of the logging options within TIRTL.

Traffic

The Traffic panel, located in the center right-hand section of the figure, provides a real time scrolling list of the classified traffic. It is intended to be used to verify correct operation of TIRTL after set up. In addition to displaying real-time classification, a vehicle counter is provided to aid traffic volume measurement.

Task Log

The Task Log window, located in the bottom right hand side of the figure, contains a history of system activities that have occurred since TIRTL*soft* application was started.

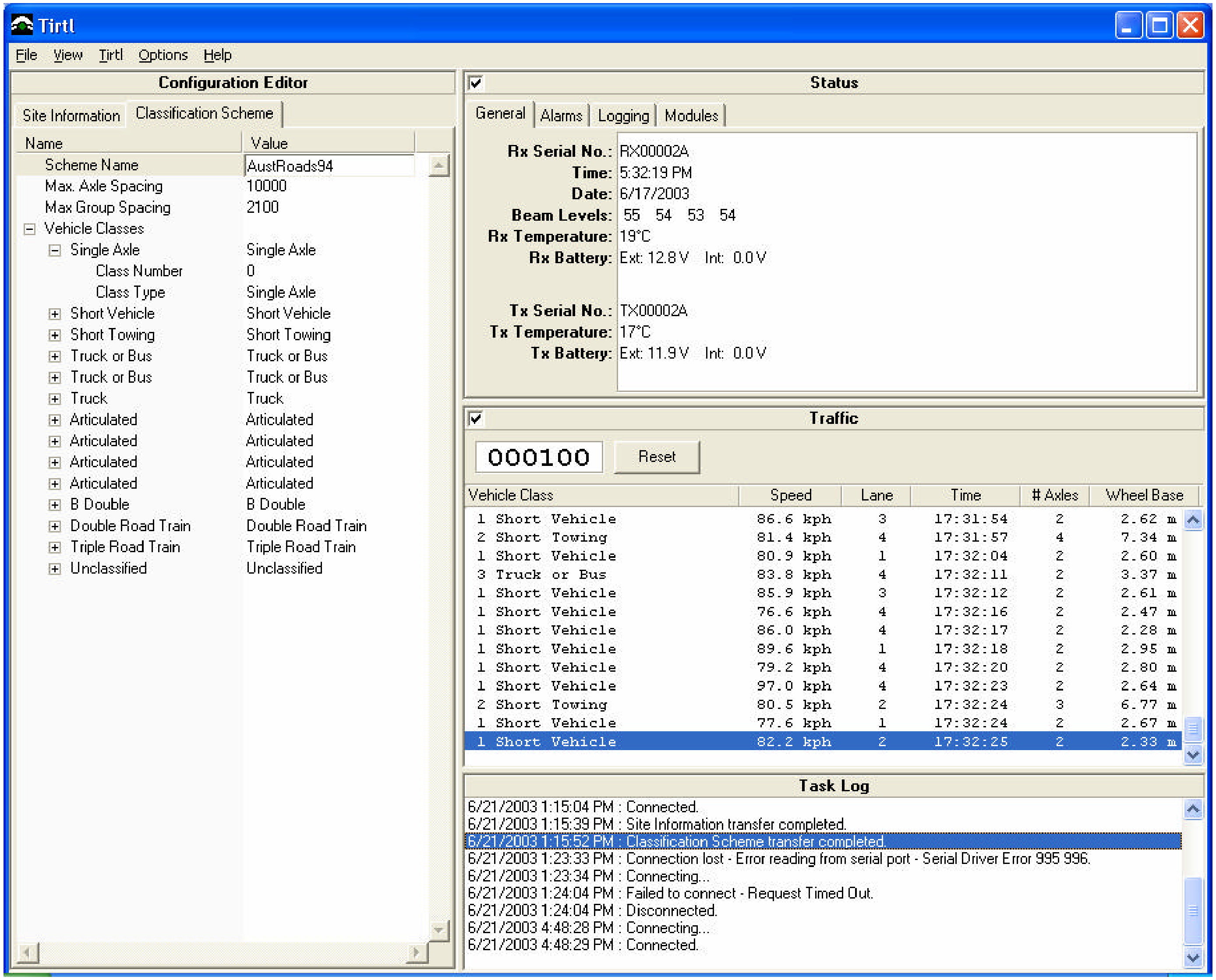

Figure 10 – Broad view of TIRTL*soft.*

3.2 Palm Handheld Based TIRTL*soft*.

Figure 11 illustrates a view of the GUI first encountered by the user when first starting TIRTL*soft* application on the Palm Handheld. When a connection is established to TIRTL the Main Menu allows access to the following sub-menus:

- General Status – This view gives information on TIRTL receiver/transmitter pair including operational temperature, battery status and serial numbers.
- Alarm Status – A view of active and inactive alarms within TIRTL.
- Module Status – Monitoring and control of optionally fitted TIRTL modules, including GSM/GPRS, POTS Modem and GPS modules.
- Logging Status – Control of the logging options within TIRTL including, Vehicle, Alarms, Beam Events and System.
- Alignment – Graphically display of the quality of the beam alignment and intensity.
- Traffic – A table view of all classified traffic events, useful for confirming classification accuracy.
- File Manager – Allows the manipulation and verification of information regarding TIRTL installation. Details include Site Information, Classification Scheme and Logs.

Navigation of the menus of the Palm Handheld version of TIRTL*soft* is achieved by tapping context sensitive buttons with the Palm Handheld stylus.

Figure 11 – Palm Main Menu view.

4 Specifications

Speed measurement accuracy:	±1% (0 – 120 mph)
Maximum number left-bound lanes:	9
Maximum number right -bound lanes:	9
Max. Tx/Rx separation distance:	328 ft.
Max Tx/Rx separation (long-range optic)	656 ft.
Operating temperature range:	-40 to +185ºF
Environmental rating:	IP67 (Main body) IP66 (Battery compartment)
Internal C -cell battery operating time:	7 days (alkaline) 10 days (lithium)
External power input:	10V to 16V dc
Avg Rx Power Consumption at 25°C:	680 mW (no traffic) 770 mW (dense traffic)
Peak Rx Power Consumption at 25°C:	1800 mW
Avg Tx Power Consumption at 25°C:	640 mW
Processor:	x486, 33 MHz
Operating System:	Linux (kernel 2.2)
On Board RAM:	8MB - 16MB
On Board ROM:	8MB - 64MB
Compact Flash Storage (log storage):	16MB - 1,024MB (~ 100,000 – 7M vehicles)
Communication Interfaces:	2 x RS232 serial ports PSTN modem (optional) GSM/GPRS modem (optional) CDMA modem (future)
Optional modules:	GSM/GPRS unit GPS unit PSTN modem CDMA modem (future) Larger Memory.

5 Abbreviations

Reference	Description
DC	Direct Current
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
GUI	Graphical User Interface
ITS	Intelligent Traffic System
PDA	Personal Digital Assistant
POTS	Plain Old Telephone System
TIRTL	The Infra-Red Traffic Logger
WIM	Weigh In Motion

Table 1 - Abbreviations