Automatic Traffic Counter and Classifier Using TIRTL Technology

1. Background

The Infra-Red Traffic Logger (TIRTL) 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.

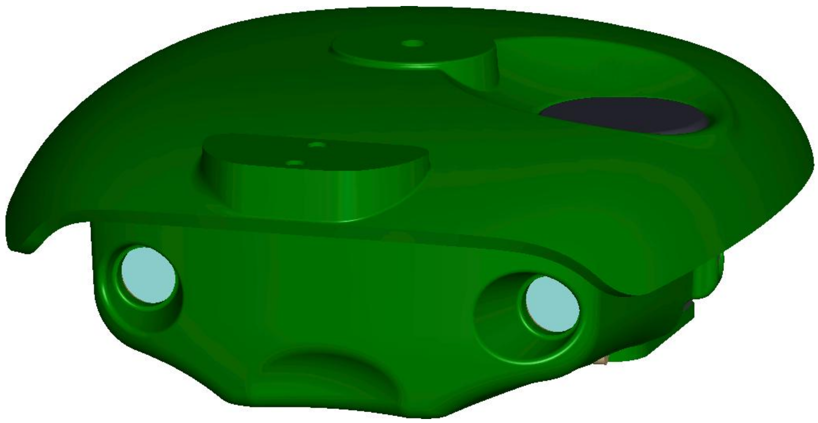

Figure 1 – TIRTL Receiver with portable sunshield

2. Purpose

This manual describes the theory of operation of a TIRTL system. It describes permanent and portable technical details.

3. Theory of Operation

A TIRTL installation consists of a transmitter and receiver pair located on opposite sides of the road. The transmitter is the source of infra-red beams used to detect traffic. The receiver detects disturbances in the infra-red beams caused by the wheels of passing vehicles, and uses intelligent software to analyse the timings of the light pulses to produce vehicle classifications.

3.1 Vehicle Detection using "Beam Events"

The transmitter emits a beam of infra-red 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 2. As a vehicle passes between the receiver and transmitter, each wheel interrupts each of the four beam pathways.

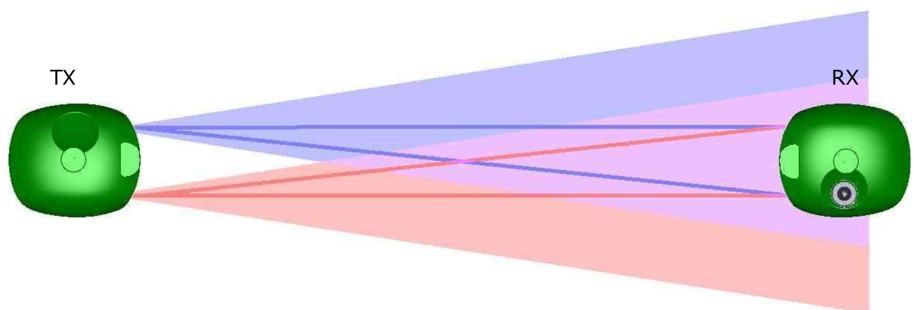

Figure 2 – TIRTL Beam Configuration

Breaking of a beam is known as a "Break Beam Event" while the re-establishment of a given beam is defined as a "Make Beam Event". In this way, with the passing of each vehicle wheel, a set of eight 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 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 roadway are set to within defined limits. This allows effective detection of vehicles without interference from mud -flaps and other features hanging from the main body of the vehicles. By use of the specialised TIRTL Optical Sights and the intelligent setup software, accurate alignment during the day or night is easily achieved.

3.2 Speed and Vehicle Direction Detection

Figure 3 illustrates a TIRTL installation on a bi-directional 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 beams, A and B.

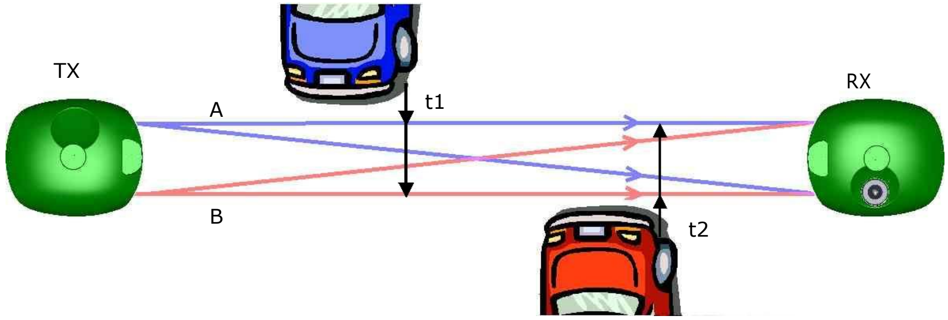

Figure 3 – Speed and Vehicle Direction Detection

The direction of travel of a vehicle on the monitored roadway is determined by the order in which Beam Events occur. In Figure 3, A to B represents South bound traffic and B to A represents North bound traffic.

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

3.3 Vehicle Direction Convention

The convention for vehicle direction movement is:

When viewed from the rear of the TIRTL receiver positive velocity signed traffic always moves from left to right of the unit (see Figure 4).

This is only true if the correct installation information is entered into the *Site Information* details. The *Site Information* must accurately reflect the orientation of the TIRTL units. Non-inverted operation is defined as when the TIRTL is mounted underneath a tripod. Inverted operation is typical for permanent installations.

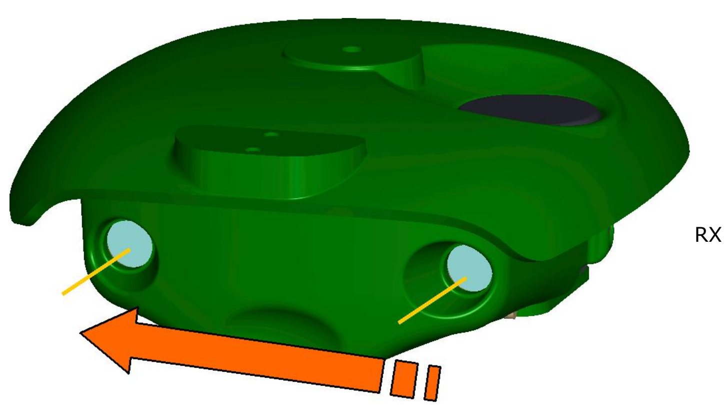

Figure 4 – Standing behind receiver: Positive velocity for cars travelling left to right

3.4 Lane Detection

Figure 5 illustrates the principles of lane detection as implemented in TIRTL. As each wheel of the vehicle interacts with infra -red 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 5 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 to verify vehicle information on a multi-lane installation.

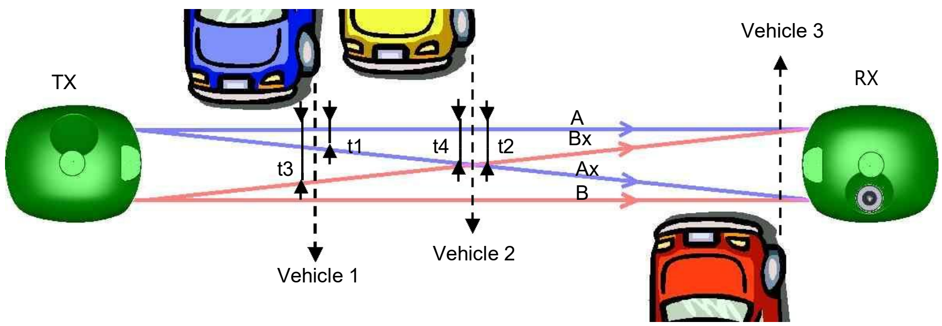

Figure 5 – Lane Detection

3.5 Axle, Axle Groups, Vehicle Detection and Wheel Size

Figure 6 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.

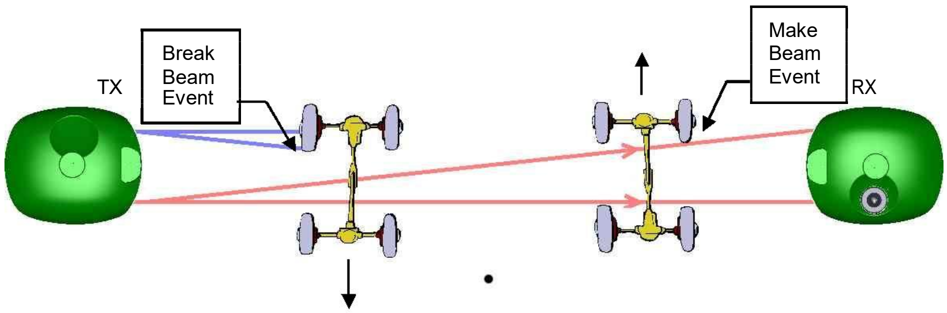

Figure 6 – Axle, Axle Groups and Vehicle Detection

An "Axle Group" is defined by TIRTL as a collection of axles separated by less than 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 as less than 2.1m, the TIRTL would consider a vehicle had been detected. In the vehicles illustrated in Figure 6, 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 8).

The wheel size of a particular vehicle class is necessarily a TIRTL learned parameter. It is necessary that this parameter is learned as the height of the beams above the road varies between TIRTL installations. Each of the infra-red beam pathways between the transmitter and receiver effectively scribes a chord across the circle of the passing wheel (see Figure 7). With the speed measurement of the vehicle, the time between the Break and Make Beam Event and the travelling lane a measure of the wheel width is obtained. This measurement can be ratio metrically used to discriminate between vehicle classes, where the vehicles have very similar wheel bases, based upon percentage wheel size variances.

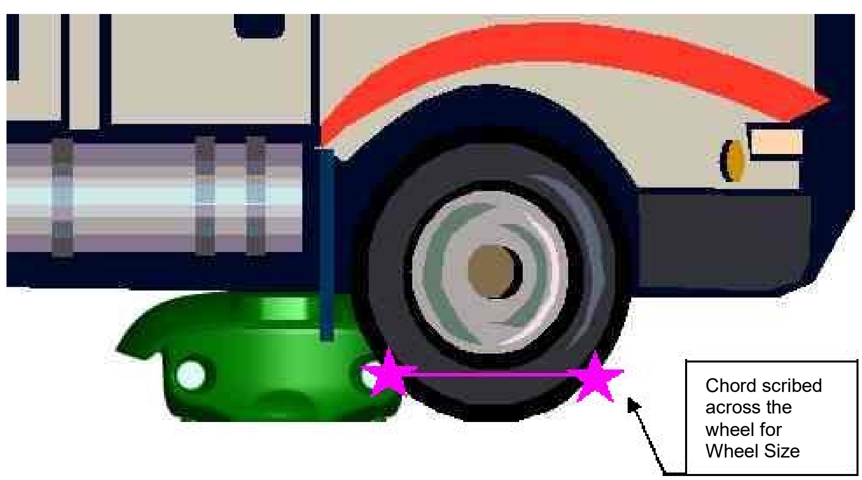

Figure 7 – Wheel Size Measurement