

Traffic Counting Primer

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1. What is Traffic Counting?

Traffic Counting is a discipline and methodology that provides the most basic measurement required by traffic engineers for any design, plan or control of traffic. Its resulting data is used for many and diverse applications, among them:

- Planning of roads construction/widening
- Statistical analysis of road use
- Origin/Destination matrix generation
- ITS systems design
- Designing signal control timing plans
- Funding states for road repair
- Toll highway audit
- Parking facilities control

Each application has its own requirements in terms of:

- Location of counting stations
- Type of additional data besides volume (e.g. Speed, Classification)
- Length of counting period
- Accuracy requirements
- Type and format of reporting

Among the Counting data analyses and reports generated are:

- peak hours
- peak hour flow rate
- average volume and speed v. day of week
- peak hour factor
- flow rate v. time
- traffic density v. time
- Speed v. Volume and Speed v. flow
- Headway v. time
- directional distribution
- lane use distribution
- Classification distribution
- AADT (Annual Average Daily Traffic)
- Nth day of highest traffic within the period
- Vehicles/day by class v. day of the week
- % of DT v. time of day
- ADT as %AADT v. month
- DT as %Total weekly traffic v. day of week
- Hourly volume threshold (in %AADT) v. the Number of hours exceeded
- Turning movement and Origin/Destination reports

2. Technologies in use

To meet the various requirements, for these Counting applications, several detection technologies are used, as listed in the table below:

Intrusive devices	Technology	Prime use
	Inductive loop detectors	General purpose
	Pneumatic tubes	Temporary in-city counting
	Piezo sensors	Classification and WIM
	Magnetometer	Temporary and permanent
Non-intrusive		
	Microwave radar	General purpose
	Doppler motion detector	Low-traffic rural roads
	Infra-Red	
	Ultrasonic	
	Laser fixed beam	Classification
	Laser scanning beam	Precise classification
	Video detector	

A brief explanation of the technologies and their applicability to Counting follows:

1. **Inductive Loop detectors** are widely used for both permanent and temporary counting on highways. Many Traffic Counters and reporting software are available. Single loops are sufficient for Volume counting, while dual-loop speed-traps are required for Speed and Classification data. Loop detectors have sufficient accuracy in all weather but they require a good pavement and are very costly to maintain, not only because of their short life but due to the closing of traffic lanes during the repair. Their cost-effectiveness is particularly low in temporary counting use as their deterioration continues between counts.
2. **Pneumatic tubes** are suitable only for temporary counts in urban areas (and not on highways). Many low cost counters are available with the required air-switches to allow counting, measuring speed and classifications by axle spacing. Although not as intrusive as loops, they can only be installed when there is no traffic on the road. They cannot be used for permanent count stations or on highways because the rubber tubes get torn or damaged after a certain number of vehicles, and they cannot take the tire friction typical to high speed highway traffic. Per-lane and speed/classification requires a very complex installation of many tubes.
3. **Piezo sensors** are rods that are installed in the road for permanent counting and classification. They must have a solid foundation in order to last and are generally expensive to install and maintain. Two spaced rods can do a very good job of speed and classification by axle spacing. The amplitude of their pulses is proportional to the axle weight that produces them, so they find their main application in WIM (Weigh In Motion) stations.

4. **Magnetometer** sensors come in two types; For temporary counting, they can be obtained with installed battery, ready to be nailed to the road to be picked up later. They are not suitable for highway counting because of the high friction. In permanent counting, they are installed in the pavement with large batteries for longer life, as well as a separate wireless Access Point. While they are fairly accurate in flowing traffic, they are difficult to install and retrieve in the road and show accuracy problems in congested traffic due to wireless problems and others.
5. **Microwave radar** presence detectors are non-intrusive detectors that combine detection quality comparable with loops in all weather and lighting conditions, with the additional advantage of covering multiple lanes individually from the side of road, allowing installation with no road closures. They have a significantly higher reliability and can operate on any road regardless of surface quality. Data includes Speed and Classification by length and can be provided to counters in both contact closure and serial data saved in sensor memory. They are therefore applicable to both permanent and temporary detection in both highway and urban applications.
6. **Doppler Motion** detectors operate on the Doppler principle. They do not perform ranging as Microwave radars do. These detectors cannot detect vehicles moving at very low speeds (usually below 15 Km/h). They can perform all weather counting and separate two directions but do not separate lanes, so if any direction consists of more than one lane, two vehicles going side by side will be counted as one vehicle. They are useful for low volume traffic counting on narrow rural roads but not for highways or urban roads. They cannot perform accurate classification or speed measurement either for the same reason.
7. **PIR (Passive Infra Red) detectors** are low cost single lane detectors that must be installed above each traffic lane on an overpass or sign-bridge. For a multi-lane road, in addition to the PIR sensor heads, a separate data storage unit is required on the side of road. The installation cost is high because in addition to the cost of material because traffic on the road need to be stopped. PIR detectors cannot detect well during heavy rain and snow. They can perform speed and classification by length when provided with dual beams but are not very useful for counting.
8. **Ultrasonic** detectors are low cost single lane detectors, similarly to PIR installed above the lane of travel. They are operating well in bad weather and can provide presence detection but not Speed or Classification.
9. **Multiple Technologies detectors** combine multiple detectors in one package; e.g. ASIM combines PIR detector with Ultrasonic detector, but because it still cannot measure speed in rain, they added a Doppler motion sensor into the same unit, resulting in an improved single-lane detector. It has the installation limitation as above and the complexity of the hardware and an additional storage unit results in a semi non-intrusive solution of limited functionality and high cost.

10. **Laser fixed beam detectors** are single-lane detectors for high accuracy classification by shape. They consist of a narrow fixed beam LIDAR (Laser Radar) that measures the distance to the spot it illuminates on the ground. When vehicles pass underneath, it can generate from multiple range readings the vertical profile of the vehicle. To deal with vehicles not centered on the lane, three laser sensors are covering not only the center but also the sides of the lane. Two such sets of triple sensors allow measuring the speed of the vehicle as well. This is an expensive sensor with high installation cost, and is suitable for precise classification such as for shadow-tolling.
11. **Laser scanning beam detectors** are single-lane detectors for high accuracy classification by shape. They consist of a narrow fixed beam LIDAR (Laser Radar) that measures the distance to the spot it illuminates on the ground. When vehicles pass underneath, it can generate from multiple range readings the vertical profile of the vehicle. Because their beam is moving in a fan-shaped scan across the lane, they can produce highly accurate classification by shape. The high cost makes this detector useful only for shadow-tolling applications.
12. **Video Image Processing (VIP) detectors** are non-intrusive detectors capable of multiple lanes operation but are prone to large errors in rain, snow, and windy nights. They have a difficulty in performing classification because they do not always see the whole bodies of vehicles. In addition they require sufficient lighting which is not always available on the road. They are also vulnerable to sun-glare from windshield and are therefore not very useful for counting applications.

The RTMS microwave radar has great advantages over all other counting technologies:

Intrusive devices	Technology	Comparative RTMS advantages/ limitations
	Inductive loop detector	Low (1/3) installation cost, (1/20) maintenance; fits any road; fits temporary counting
	Pneumatic tubes	No lane closure in temporary in-city counting; Classification not as good in stop/go traffic
	Piezo sensors	Higher cost savings than in loop comparison. Cannot do axle Classification and WIM
	Magnetometer	Lower cost, better performance and no lane closures in either temporary or permanent
Non-intrusive		
	Doppler motion detector	Per lane detection in any speed, Classification
	Infra-Red	Multi-lane all weather operation; no lane closure
	Ultrasonic	Multi-lane all-features operation; no lane closure
	Laser fixed beam	Multi-lane; Low cost operation; no lane closure Cannot perform classification by shape
	Laser scanning beam	Multi-lane; Low cost operation; no lane closure Cannot perform classification by shape
	Video detector	All-weather and light level accurate operation; side-fired installation on low poles

3. Who needs what?

Every Counting operation has its own requirements and sometimes these dictate the Counter technology. Here is a brief sample of typical cases:

- Highway traffic counting is used for trend analyses for planning purposes, e.g. to determine when the road should be widened or to study the impact of adding an interchange. For this applications Volume and Speed data may be sufficient and per-lane data may not be required. Reports lane aggregation is allowed and typically 1 hour time aggregation.
- Other Highway counting, such as used to generate reports to federal government about road use (e.g. for purpose of obtaining repair funds) require full classification capability to 13 classes. (most of the 13 US FHWA classes define different axle configurations on long semi-trailer trucks). Such classifications require intrusive detectors such as Piezo. The reporting will likely require per lane information but time aggregation could be 1 day. Permanent counting stations must be maintained for this purpose.
- Most urban traffic counting are temporary (for one week) and used as input to off-line simulators in order to produce optimized timing plans for signal controllers. Many of these require only Volume, and not necessarily segregated by lane and require 5 or 15 minutes time aggregated reports. Some (depending on the sophistication of the Traffic Control system) require speed and perhaps classification between busses and all the rest of the vehicles.
- Other urban counting are very demanding, such as turning-movements counts which report for each approach the number of vehicles that turn left, turn right and go through. Because these decisions in many cases are taken by the driver right at the stop-bar, where traffic is standing half the time, no detector technology has proven to be accurate enough for this application and it is currently done by video recording of the entire intersection and manual counting based on the recorded video.

4. Operational Considerations

Counting operations require more than mere detectors. They must be based upon an integrated wide-area network of Counting stations, each powered uninterruptedly and able to send its accumulated data to a data collection center for archiving and report generation.

Counting operators generate their reports using familiar software in a specific format often dictated by national standards. Therefore they have two choices of implementing non-intrusive Counting stations:

- Use a detector that can emulate Inductive loop detections by producing contact closures together with a standard Traffic Counter that is designed for inductive loops. The advantage of this approach is the simple interface with already available legacy equipment and software with no need for any changes.
- Use a detector that provides the required data on its own, by internally storing time-stamped data messages and transmitting the data to the Center when requested. This scheme requires a means of feeding the retrieved data to a modified report generating software; however it does not restrict the overall performance by the limitations of legacy equipment.

The RTMS radar is suitable to both methods:

- It produces multiple contact closures that can be fed into existing counters. Either one contact per lane or dual contacts per lane can be provided (in the form of speed-trap emulation) directly from the RTMS to the Traffic Counter.
- It also has an internal memory and a serial communications interface that allows this data to be transmitted to a center by phone line, radio modem or Ethernet.

Other considerations in selecting the Counting station technology are:

- Temporary counting is invariably battery-powered, so low power consumption is a requirement. Because they are continually torn down and set up elsewhere, fast setup is very important. As well, a simple installation that can be done by one person and does not require heavy equipment or trucks is important.
- Permanent counting requires very high reliability and durability to reduce the occurrence and amount of data loss. Either UPS or Solar solutions are attractive for power supply. All weather accurate operation and ease of maintenance is very important as well as full-features: per-lane data, including classification. Remote download of stored data is essential.
- Urban traffic counting solutions require zero or very low setback requirements because most likely installation will be on existing poles that are very close to the curb. At the same time classification is usually not required. 120VAC power is very useful as well as remote download of the data.

5. RTMS in permanent Counting application

The RTMS low cost of ownership is due to:

- Ease of deployment on existing roadside poles on any road without lane closures
- Cost of procurement spread over the multiple lanes of coverage
- High reliability, easy maintenance and ease in accommodating road changes
- Low power consumption which makes Solar power feasible
- Internal memory for data storage and direct download access via RF modem
- Automated cost-saving operations using the Traffic Reporter software

These features made the RTMS an attractive replacement to other technologies, for highway traffic data collection. Other operational advantages are due to:

- The Traffic Reporter automates the data collection as well as the report generation, allowing many counting stations to be easily maintained over a wide area.
- The use of solar power and cellular modems for communication frees the designer of location limitations.

These RTMS features are attractive to customers seeking simple and smooth operations, with minimal data losses and gaps.

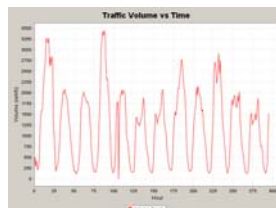
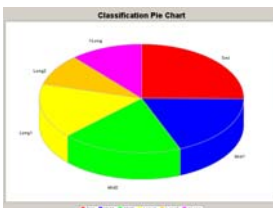
Hundreds of RTMS-based permanent counting stations were installed along highways and mid-block urban locations across Russian federal roads, across Canada, in Dubai and Malaysia as well as in various states in the US.

Traffic Reporter software is used to automatically retrieve data stored in the RTMS memory by dialing up to a Count Station at a prescheduled time (e.g. every Midnight Saturday). Traffic Reporter can also segregate the Count stations into groups that share the same report format, and to automatically generate traffic reports in the prescribed format for all Stations in each group. The reports are exportable to MS Excel.

An additional Traffic Reporter Analyzer can produce a variety of reports graphically and numerically.



RTMS Permanent Counting Stations
Traffic Reporter outputs



6. RTMS in Temporary Counting application

Temporary Counting is useful in both highway and urban applications.

RTMS has great advantages for this application in both environments:

- Ease of installation by single person due to forgiving aiming requirements and Wizard-automated setup.
- deployment using existing roadside poles on any road without lane closures
- Cost of procurement spread over the multiple lanes of coverage
- Low power consumption which makes batteries last longer
- Internal Flash memory for data storage and direct download access
- 12-lane coverage and zero setback capability

Pictures below show how RTMS can be installed with battery power by attaching a thin pole to a more sturdy structure and aiming by a single person.

