Chapter 8

Automated Traffic Measurement

8.1 Introduction

This present paper offers a review on some of the latest automated traffic data collection technologies. This automated technology briefly summarizes as two methods. The first technology is in-situ technology and second one is in vehicle technology. Broadly speaking, "in-situ" technologies refer to traffic data measured by the means of detectors located along the roadside. Generally, traffic count technologies can be split into two categories: the intrusive and non-intrusive methods. The intrusive methods basically consist of a data recorder and a sensor placing on or in the road. Non-intrusive techniques are based on remote observations. Then the next order automated traffic data technology is floating car data (FCD). FCD is an alternative or rather complement source of high quality data to existing technologies. They will help improve safety, efficiency and reliability of the transportation system. They are becoming crucial in the development of new Intelligent Transportation Systems (ITS). Then finally discussed travel time prediction by these technologies.

8.1.1 General

The vehicular traffic is increasing tremendously in today's/this world, simultaneously congestion also increases. In order to prevent congestion, one option is to increase the capacity by increasing the number of existing transportation system. A second option is to develop alternatives that increase capacity by improving the efficiency of the existing transportation system. The later focuses on building fewer lane-miles, while investing in Intelligent Transportation Systems (ITS) infrastructure. The goals of ITS include the following:

1. Enhance public safety;
2. Reduce congestion;
3. Improved access to travel and transit information;

4. Generate cost savings to motor carriers, transit operators, toll authorities, and government agencies; and

5. Reduce detrimental environmental impacts.

Intelligence requires information, and information requires data, which is generated by surveillance. ITS include sensor, communication, and traffic control technologies. These technologies assist states, cities, and towns nationwide, meeting the increasing demands on surface transportation system. Vehicle detection and surveillance technologies are an integral part of ITS, since they gather all or part of the data that is used in ITS. So a wide range of data is required for ITS to manage:

1. Volume Count

2. Vehicle Classification

3. Vehicle Occupancy

4. Travel Time

5. Delay

8.1.2 Volume Count

Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. These data helps to identify critical flow time periods, determining the influence of large vehicles or pedestrians on vehicular traffic flow. The length of sampling period depends on the type of count being taken and the intended use of recorded data. Two methods are available for conducting traffic volume counts: (1) manual and (2) automatic. Manual counts are typically used to gather data for determination of vehicle classification, turning movements, direction of travel, and vehicle occupancy.

Manual Count Method

Most applications of manual counts require small samples of data at any given location. Manual counts are rarely used when the effort and expense of automated equipment are not justified. Manual counts are necessary when automated equipment is not available. Manual counts are typically used for period of less than a day. Normal intervals for a manual count are 5, 10, or 15 minutes. Traffic counts during a rush hour of Monday morning and Friday evening rush hours shows exceptionally high volumes and is not normally used in analysis; therefore, counts are usually conducted on Tuesday, Wednesday, or Thursday.

Automatic Count Method

The automatic count method provides a means for gathering large amounts of traffic data. Automatic counts are usually taken in 1-hour interval for each 24-hour period. The counts extend for a week, month, or year. When the counts are recorded for each 24-hour time period, the peak flow period can be identified. Automatic counts are recorded using one of three methods: portable counters, permanent counters, and videotape.

8.1.3 Vehicle Classification

Traffic volumes vary over time on all roads. Traffic volumes also vary dramatically from one road to another. These variations in traffic volume are even more apparent when volumes for specific vehicle types (classification) are analyzed. Consequently, the vehicle classification data collection program must gather sufficient data on traffic patterns of important vehicle types to accurately quantify the truck traffic stream to meet the needs of users. These include; time of day, day of week, time of year, direction. Vehicle classification counts are used in establishing structural and geometric design criteria, computing expected highway user revenue, and computing capacity. If a high percentage of heavy trucks exist or if the vehicle mix at the crash site is suspected as contributing to the crash problem, then classification counts should be conducted. Typically cars, station wagons, pickup and panel trucks, and motorcycles are classified as passenger cars. The observer records the classification of vehicles and its direction of travel at the intersection.

Integration of Classification Count

The vehicle classification counts required should not be considered separate from the volume counts traditionally performed. Instead, they should be integrated with the traditional volume counts. Because classification counts provide both classification and total volume information, they can replace traditional volume counts reducing duplication and error. Traffic surveillance equipment is used as part of advanced traffic management systems (ATMS) or advanced traveler information systems (ATIS) can be used to supply both total volume and vehicle classification information. Intelligent transportation system (ITS) technology and its resulting data are often present at high profile locations as part of safety enhancement systems. These systems can supply useful, continuous traffic monitoring data. Coordinating these traffic monitoring activities can lead to significant improvements in the amount of data available to users, while at the same time reducing the cost of data collection.

Uses of Classification Data

Vehicle classification data are of considerable use to agencies involved in almost all aspects of transportation planning and engineering. The need for information on truck volumes and freight movements is growing with the recognition of role that freight mobility plays in the economy, and as highway engineers realize the importance of truck volume and operating characteristics on the geometric and structural design of roadways and bridges.

1. pavement design
2. pavement management
3. scheduling the resurfacing, reconditioning, and reconstruction of highways
4. prediction and planning for commodity flows and freight movements
5. development of weight enforcement strategies
6. vehicle crash record analysis
7. environmental impact analysis
8. analysis of alternative highway regulatory and investment policies.

8.1.4 Vehicle Occupancy

Vehicle occupancy measurement is an important part of transportation congestion management and it is used for evaluating the efficiency of road system, High Occupancy Vehicle (HOV) lanes or particular congestion reduction programs. The measure occupancy is a function of speed and length of individual vehicle and thus, it could consider the effects of varying vehicle length and speed. Hence, it can be considered as a logical substitute of density. In other words, occupancy, based on practical consideration, is defined as the percentage of time the detection zone is occupied by the vehicles. Therefore, occupancy measured using detectors depends on the length of detection zone, each detector type has a differing zone of influence (detector length) and the zone of influence is effectively added to vehicle length. Hence, the measured occupancy may be different for different detection zones even for the same site having identical traffic, depending on the size and nature of the detectors. Development of intelligent systems that extract traffic density and vehicle classification information from traffic surveillance systems is crucial in traffic management. It is important to know the traffic density of the roads real time especially in HOV lanes for effective traffic management. Time estimation of reaching from one location to another and recommendation of different route alternatives using real time traffic density information are very valuable for metropolitan city residents.

8.1.5 Travel Time

Travel time can be defined as the period of time to transverse a route between any two points of interest. It is a fundamental measure in transportation. Travel time is also one of the most readily understood and communicated measure indices used by a wide variety of users, including transportation engineers, planners, and consumers. Travel time data is useful for a wide range of transportation analyses including congestion management, transportation planning, and traveler information. Congestion management systems commonly use travel time-based performance measures to evaluate and monitor traffic congestion. In addition, some metropolitan areas provide real-time travel time prediction as part of their advanced traveler information systems (ATIS). Travel time data can be obtained through a number of methods. Some of the methods involve direct measures of travel times along with test vehicles, license plate matching technique, and ITS probe vehicles. Additionally, various sensors (e.g. inductance loop detectors, acoustic sensors) in ITS deployment collect a large amount of traffic data every day, especially in metropolitan areas. Such data can be used for travel time estimation for extensive applications when direct measurements of travel times are not available.

8.1.6 Delay

The delay defines as "The additional travel time experienced by a driver, passenger, or pedestrian". Delay is thus the difference between an "ideal" travel time and "actual" travel time. Since the definition of delay depends on a hypothetical "ideal travel time", delay is not always directly measurable in the field. If the ideal travel time is defined as off-peak travel time, then the measured delay is difference between the actual measured travel time during peak period, and the actual measured travel time during off-peak period. If the ideal travel time is defined as travel at the posted speed limit, then the delay cannot be directly measured in the field. It is estimated by subtracting the hypothetical travel time at the posted speed limit from the measured mean travel time in the field.

8.2 Detector technology

8.2.1 General

In traffic detector information is derived from technologies divided into two main groups, information collected via in-situ detectors, deployed at location of interests, or information from mobile technologies that are located within vehicles themselves. Over the last two decades, there has been an increase in the provision of services that are specific to vehicle types, as well as fleet or asset management and tracking, based on in-vehicle technologies. In-vehicle technologies have really come into realization through the advantage of satellite-based technologies, and are perceived as playing an increasing role in the future.Such technologies not only improve our ability to manage networks efficiently, but will also have a direct impact of the types of policy instruments available to authorities, the operation of so-called ITS.

8.2.2 In-Situ Technologies

In-situ traffic detector technologies are further divided into two categories: *Intrusive* technologies that are physically mounted at, or below, the road surface, installation of which causes potential disruption to traffic. Conversely, *non-intrusive* technologies are mounted at, or above the road surface, and their installation causes little or no disruption to traffic. Detectors of both types temporary or permanent nature, though sub-surface *intrusive* installations are, by necessity, usually permanent. All in-situ detectors will provide some measure of the volume of vehicle flow. Particular detector technologies will vary as to their reliability of the flow estimate, and their ability to provide accurate additional information on vehicle category or speed. A single sensor gives only flow or occupancy information. Two adjacent sensors are required for speed or classification assessment. The time-lag and separation distance between the onset of consecutive events at the sensors have been used to estimate vehicle speed. Classification information is derived either from vehicle length or through examination of the form of the profile generated as output from the sensor.

Intrusive Technologies

Typical examples of intrusive technologies, their sensor types and installation locations are shown in Fig. 8:1. The first types of units (Fig. 8:1, Type 1) are passive magnetic or magnetometer sensors that are either permanently mounted within holes in the road, or affixed to the road surface in some fashion. The unit communicates to a nearby base station processing unit using either wires buried in the road, or wireless communications. The sensor has a circular or

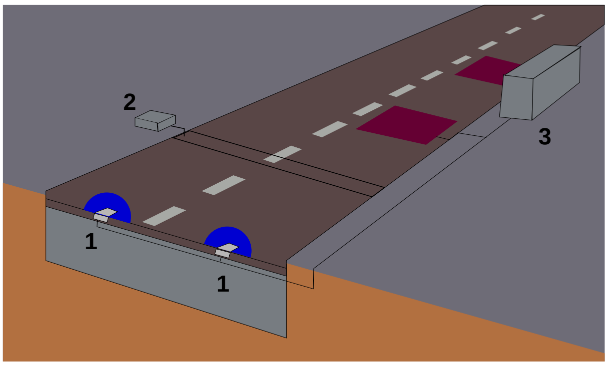

Figure 8:1: Typical intrusive detector configurations, Source: IMAGINE- Collection Methods for Additional Data

elliptically offset *zone of detection* (i.e., the blue area).

The second types of units (Fig. 8:1, Type 2) use pneumatic tubes that are stretched across the carriageway and affixed at the kerb side at both ends. Such systems are only be deployed on a temporary basis, due to the fragile nature of tubes, which are easily damaged or torn up by heavy or fast moving vehicles.

The third type (Fig. 8:1, Type 3) are inductive detector loops (IDL), consisting of coated wire coils buried in grooves cut in the road surface, sealed over with bituminous filler. A cable buried with the loop sends data to a roadside processing unit. The zone of detection for inductive loop sensors depends on the cut shape of the loop slots. The zones depending on the overall sensitivity of system not correspond precisely to the slot dimensions. IDLs are a cheap and mature technology. They are installed on both major roads and within urban areas, forming the backbone detector network for most traffic control systems.

The fourth type of intrusive system is Weigh-In-Motion (WIM) shown in Fig. 8:2, detectors that consist of a piezoelectric sensor (e.g. 'bending-plate' or fiber-optic) system laid in a channel across the road. These systems are relatively rare and are used in specific locations for enforcement or access control. They are usually coupled with other systems, either intrusive or non-intrusive, to provide additional cross-checks on collected data.

1. **Pneumatic Tube Detector**

   Pneumatic road tube sensors send a burst of air pressure along a rubber tube when a

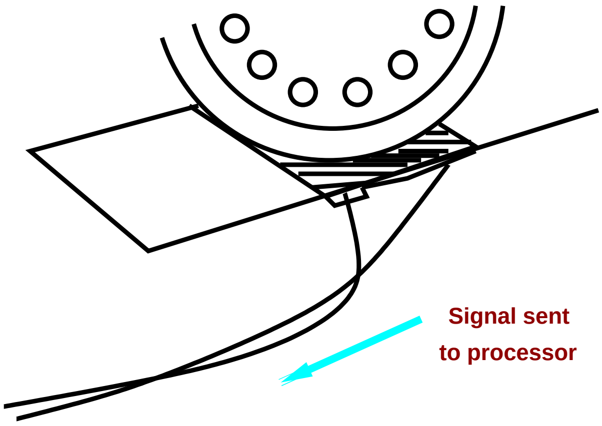

Figure 8:2: Weigh-In-Motion Detector system, Source

vehicles tire passes over the tube. The pulse of air pressure closes an air switch, producing an electrical signal that is transmitted to a counter or analysis software. The pneumatic road tube sensor is portable, using lead-acid, gel, or other rechargeable batteries as a power source. The road tube is installed perpendicular to the traffic flow direction and is commonly used for short-term traffic counting, vehicle classification by axle count and spacing. Some data to calculate vehicle gaps, intersection stop delay, stop sign delay, and saturation flow rate, spot speed as a function of vehicle class, and travel time when the counter is utilized in conjunction with a vehicle transmission sensor.

Advantages

(a) Cheap and self-contained, the easiest to deploy of all intrusive systems, recognized technology with acceptable accuracy for strategic traffic modeling purposes, hence very widely used.

(b) Axle-based classification appears attractive, given sub-vehicle categories are partially axle based.

Disadvantages

(a) Some units are not counted or classify vehicles.

(b) Tube installations are not durable, the life of tubes are less than one month only.

(c) The tube detectors are not suitable for high flow and high speed roads.

(d) Units should not be positioned where there is the possibility of vehicles parking on the tube.

(e) It cant detect the two wheelers.

2. **Inductive Detector Loop (IDL)**
Oscillating electrical signal is applied to the loop. The metal content of a moving vehicle chassis changes the electrical properties of circuit. Changes are detected at a roadside unit, triggering a vehicle event. A single loop system collects flow and occupancy. The speed can be calculated by the assumptions that are made for the mean length of vehicles. Two-loop systems collect flow, occupancy, vehicle length, and speed.

Advantages

(a) It is a very cheap technology. Almost every dynamic traffic control system in this world uses IDL data.

Disadvantages

(a) Loops are damaged by utility and street maintenance activities or penetration of water.
(b) IDLs with low sensitivity fail to detect vehicles with speed below a certain threshold, and miscount vehicles with complex or unusual chassis configurations, or vehicles with relatively low metal content (e.g. motorcycles).
(c) IDL data supplied to traffic control systems have a very low sample rate.
(d) Not suitable for mounting on metallic bridge decks.
(e) Some radio interference occurs between loops in close proximity with each other.

3. **Magneto-meters/Passive magnetic systems** Magneto-meters monitor for fluctuations in the relative strength of the Earths magnetic field, which is changed by the presence of a moving metal object i.e., a vehicle. A single passive magnetic system collects flow and occupancy. Two magneto-meter systems collect flow, occupancy, vehicle length, and speed.

Two types of magnetic field sensors are used for traffic flow parameter measurement. The first type, the two-axis flux gate magneto-meter, detects changes in vertical and horizontal components of the Earth s magnetic field produced by a ferrous metal vehicle. The two-axis flux gate magneto-meter contains a primary winding and two secondary sense winding on a coil surrounding high permeability soft magnetic material core. The second type of magnetic field sensor is the magnetic detector, more properly referred to

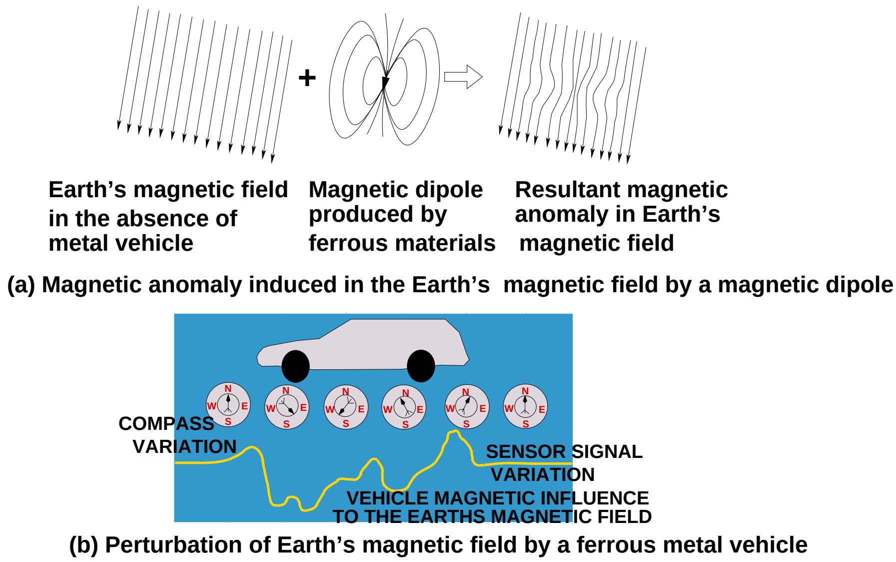

Figure 8:3: Weigh-In-Motion Detector system (Source: FHWA vehicle detection manual)

as an induction or search coil magneto-meter shown in Fig. 8:3. It detects the vehicle signature by measuring the change in the magnetic lines of flux caused by the change in field values produced by a moving ferrous metal vehicle. These devices contain a single coil winding around a permeable magnetic material rod core. However, most magnetic detectors cannot detect stopped vehicles, since they require a vehicle to be moving or otherwise changing its signature characteristics with respect to time.

Advantages

(a) More usually mounted in a small hole in road surface and hardwired to the processing unit.
Suitable for deployment on bridges.

Disadvantages

(a) Possibly damaged by utility maintenance activities, as with IDLs.

4. **Weigh-In-Motion (WIM) systems**

(a) Bending Plate
Bending plate WIM systems utilize plates with strain gauges bonded to the underside. The system records the strain measured by strain gauges and calculates

the dynamic load. Static load is estimated using the measured dynamic load and calibration parameters. Calibration parameters account for factors, such as vehicle speed and pavement or suspension dynamics that influence estimates of the static weight. The accuracy of bending plate WIM systems can be expressed as a function of the vehicle speed traversed over the plates, assuming the system is installed in a sound road structure and subject to normal traffic conditions.

Advantages
Bending plate WIM systems is used for traffic data collection as well as for weight enforcement purposes. The accuracy of these systems is higher than piezoelectric systems and their cost is lower than load cell systems. Bending plate WIM systems do not require complete replacement of the sensor.

Disadvantages
Bending plate WIM systems are not as accurate as load cell systems and are considerably more expensive than piezoelectric systems.

(b) Piezoelectric
Piezoelectric WIM systems contain one or more piezoelectric sensors that detect a change in voltage caused by pressure exerted on the sensor by an axle and thereby measure the axle s weight. As a vehicle passes over the piezoelectric sensor, the system records the sensor output voltage and calculates the dynamic load. With bending plate systems, the dynamic load provides an estimate of static load when the WIM system is properly calibrated.

The typical piezoelectric WIM system consists of at least one piezoelectric sensor and two ILDs. The piezoelectric sensor is placed in the travel lane perpendicular to the travel direction. The inductive loops are placed upstream and downstream of the piezoelectric sensor. The upstream loop detects vehicles and alerts the system to an approaching vehicle. The downstream loop provides data to determine vehicle speed and axle spacing based on the time it takes the vehicle to traverse the distance between the loops. Fig. 8:4 shows a full-lane width piezoelectric WIM system installation. In this example, two piezoelectric sensors are utilized on either side of the downstream loop.

Advantages

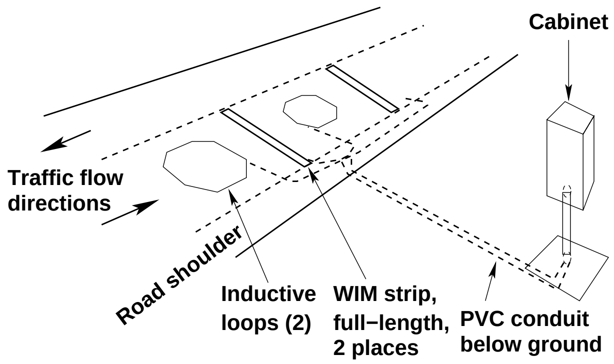

Figure 8:4: WIM installation with full-length piezoelectric sensors Source: FHWA vehicle detection manual

Typical piezoelectric WIM systems are among the least expensive systems in use today in terms of initial capital costs and life cycle maintenance costs. Piezoelectric WIM systems can be used at higher speed ranges (16 to 112 kmph) than other WIM systems. Piezoelectric WIM systems can be used to monitor up to four lanes.

Disadvantages
Typical piezoelectric systems are less accurate than load cell and bending plate WIM systems. Piezoelectric sensors for WIM systems must be replaced at least once every 3 years.

Non-Intrusive Technologies

Non-intrusive technologies include video data collection, passive or active infrared detectors, microwave radar detectors, ultrasonic detectors, passive acoustic detectors, laser detectors and aerial photography. All these technologies represent emergent fields that are expanding rapidly with continuing advances in signal processing. At present time such technologies are used to provide supplemental information for selected locations or for specific applications (e.g., queue detection at traffic signals). Most non-intrusive systems are operationally and somewhat visually similar, consisting of small electronics unit mounted in a weatherproof housing placed in various locations, as shown in Fig. 8:5.

The first type of non-invasive detectors are roadside mast-mounted. The detector possesses a field-of-regard covering an oblique area upstream or downstream of the unit. There are also multiple zones of detection defined within the overall field of regard, or the overall zone of detection same as the field of regard, depending on the specific detector type and technology.

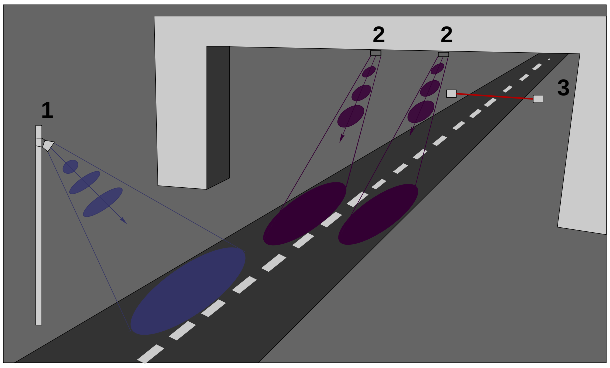

Figure 8:5: Typical non-intrusive technology configurations

Obscuration problems occur when high-sided vehicles screens lower vehicles from the detector or the field-of-view being too large, leading to detection of vehicles outside the desired lane. The second type of non-invasive detectors are mounted on gantries or bridge undersides, with field of regard directly below, or at a slight oblique to the unit. Finally, some units, such as open-path pollutant monitors are mounted road side at ground level, firing a beam across the road. Such units are subject to side-by-side masking and hence most suitable for only single lane, unidirectional flows.

1. **Video image detection (VID)** The traffic parameters are collected by frame-by-frame analysis of video images captured by roadside cameras. The following parameters are collected: Depending on the processing methodology almost all traffic parameters are captured from video analysis. Simple video systems often collect flow volume and occupancy. More complex systems allow the extraction of further parameters.

   Advantages
   Possibility to capture all desired traffic information, including some parameters that are not readily obtainable using other types of detectors Possibility of a permanent visual record of the traffic flow that reviewed and analyzed by a human operator.

   Disadvantages
   VID systems are susceptible to obscure issues, as with other non-intrusive detectors. Performance of VID systems might be degraded in bad weather or low light conditions.

2. **Infrared Sensors** The sensors are mounted overhead to view approaching or departing traffic or traffic from a side-looking configuration. Infrared sensors are used for signal

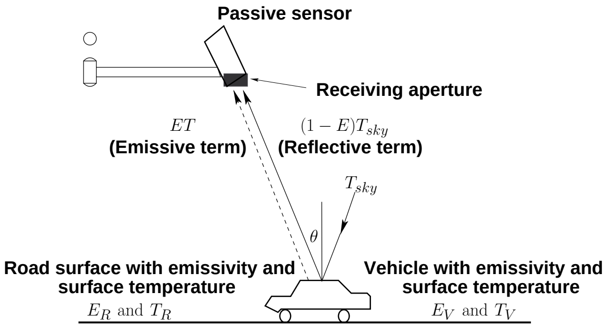

Figure 8:6: Emission and reflection of energy by vehicle and road surface. (Source: FHWA vehicle detection manual)

control; volume, speed, and class measurement, as well as detecting pedestrians in crosswalks. With infrared sensors, the word detector takes on another meaning, namely the light-sensitive element that converts the reflected or emitted energy into electrical signals. Real-time signal processing is used to analyze the received signals for the presence of a vehicle.

(a) Passive Infrared (PIR)
Detection of vehicle based on emission or reflection of infrared (electromagnetic radiation of frequency $10^{11} - 10^{14} Hz$) radiation from vehicle surface, as compared to ambient levels emitted or reflected from the road surface shown in Fig. 8:6. The PIR system collected following parameters: Flow volume, Vehicle presence, and detection zone occupancy. Speed with unit with multiple detection zones.

Advantages

i. Relatively long wavelength of light used in PIR systems makes them less susceptible to weather effects.

Disadvantages

i. Accuracy of speed information is poor with low resolution sensors. Vehicle length determination is highly problematic for the same reason.

(b) Active Infrared (AIR)/Laser Low power LED or laser diode fires a pulsed or continuous beam down to road surface as shown in Fig. 8:7. Time for reflection to return is measured. Presence of a vehicle lowers the time of reflection. High scanning rates provides a detailed profile for classification determination. Use of Doppler frequency shift from moving object allows for very accurate speed determination. The AIR system collected following parameters flow volume, speed, classification,

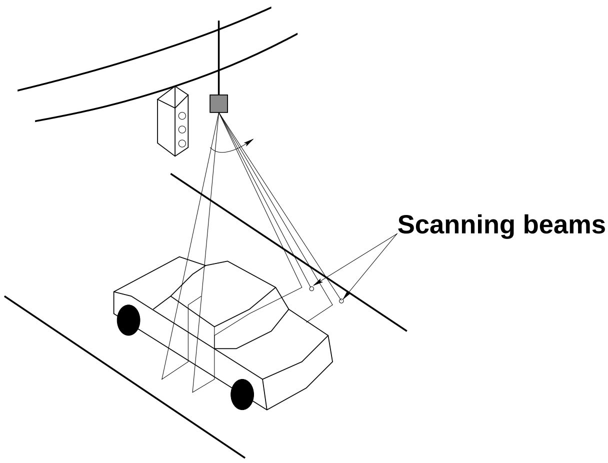

Figure 8:7: Laser radar beam geometry. (Source: FHWA vehicle detection manual)

vehicle presence, traffic density.

Advantages

i. Very accurate flow, speed and classifications possible.
ii. Laser systems work in day and night conditions.

Disadvantages

i. Active near-IR sensors adversely affected by weather conditions.
ii. Laser systems impeded by haze or smoke.
iii. Some problems with tracking small vehicles reported.
iv. Relatively high costs compared to other units. Precise, but limited zone of detection require additional units over other systems.

3. **Microwave - Doppler and Radar** Low energy microwave radiation (2.5 to 24 GHz) is transmitted into the detection zone. Objects within the zone reflect a portion of the radiation back to a receiver. Doppler units use the frequency shift of the return to calculate speed as shown in Fig. 8:8. It cant detect the stationary objects. The microwave system collected following parameters.

   Doppler - Flow volume and speed;
   Frequency-Modulated, Continuous Wave (FMCW) - Flow volume, speed and presence;
   Microwave - Flow volume, speed, presence, possibly classification;

   Advantages

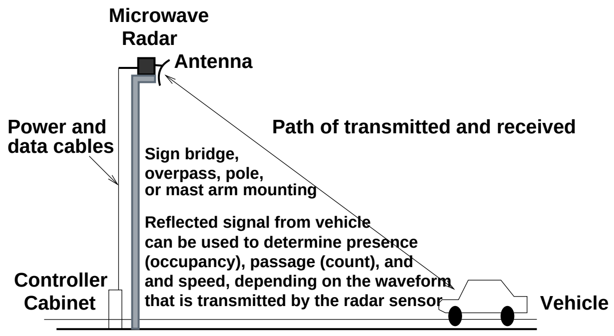

Figure 8:8: Microwave radar operation. Source

(a) Very accurate. Easy to install, long ranged.

(b) Multiple detection zones possible.

(c) Day or night operation.

Disadvantages

(a) Possible sensitivity to spurious returns from adjacent objects

(b) Restrictions on use due to electromagnetic interference with other electronics.

4. **Pulsed and Active Ultrasonic** Ultrasonic sensors transmit pressure waves of sound energy at a frequency between 25 and 50 KHz. Pulse waveforms measure distances to the road surface and vehicle surface by detecting the portion of the transmitted energy that is reflected towards the sensor from an area defined by the transmitters beam width. When a distance other than that to the background road surface is measured, the sensor interprets that measurement as the presence of a vehicle as shown in Fig. 8:9. The received ultrasonic energy is converted into electrical energy that is analyzed by signal processing electronics that is either collocated with the transducer or placed in a roadside controller. Vehicles flow and vehicular speed can be calculated by recording the time at which the vehicle crosses each beam.

   Advantages

   (a) Highly accurate.

   Disadvantages

   (a) Environmental effects affecting sound propagation degrade performance.

   (b) Pulsed units with low sampling rate miscount or misclassify fast moving vehicles.

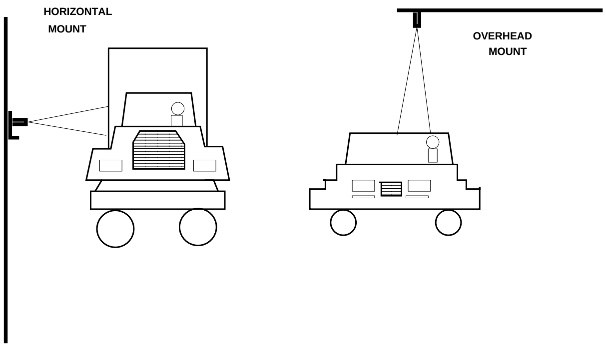

Figure 8:9: Ultrasonic range-measuring sensors, source

5. **Passive Acoustic Array Sensors**
   An array of microphones is used to detect the sound of an approaching vehicle above an ambient threshold level. Time lags and signal variations between microphone positions are used to determine vehicle location relative to the array as shown in Fig. 8:10. Further processing of signal yield to speed information and possibly engine type classification. It collected flow, speed, occupancy, possibly classification.

   Advantages

   (a) Completely passive system
   (b) Direct speed measurement.

   Disadvantages

   (a) Environmental effects affecting sound propagation degrade performance
   (b) Low accuracy in busy locations due to interference from adjacent sources.

8.2.3 In-Vehicle Technologies or Floating Car Data (FCD)

In addition to using in-situ technologies, many network management applications make use of in-vehicle devices, generically termed Automatic Vehicle Location (AVL) systems. AVL devices either provide positional information whenever a suitably equipped vehicle passes a certain point in the network, or continuous information as the vehicle travels through a network. The former system typically relies on appropriate vehicles being equipped with transponders which transmit and receive information from roadside units. The latter system uses vehicles equipped with Global Positioning System (GPS) technology.

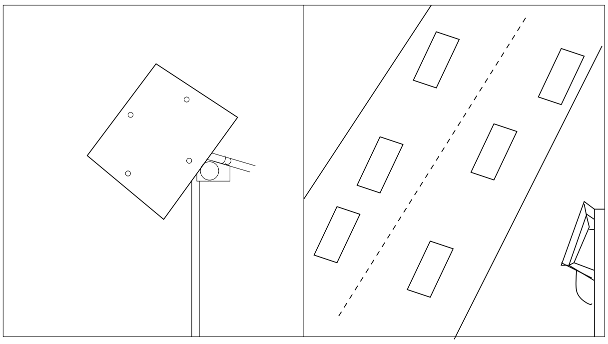

Figure 8:10: Acoustic array sensors, source

The principle of FCD is to collect real-time traffic data by locating the vehicle via mobile phones or GPS over the entire road network as shown in Fig. 8:11. It represents that all vehicles are equipped with mobile phone or GPS which will act as a sensor for the road network. Data such as car location, speed and direction of travel are sent anonymously to a central processing centre. After collecting and extracting, useful information such as status of traffic and alternative routes it can be redistributed to the drivers on the road. FCD is an alternative or rather complement source of high quality data to existing technologies. They will help improve safety, efficiency and reliability of the transportation system. They are becoming crucial in the development of ITS.

GPS-based FCD

GPS is becoming more and more useful and inexpensive; few cars had been equipped with GPS system and were made to pass a certain point in the network. The vehicle location precision was found to be relatively high, typically less than 30m. Generally, traffic data obtained from private vehicles or trucks are more suitable for motorways and rural areas.

Currently, GPS probe data are widely used as a source of real-time information by many service providers but it suffers from a limited number of vehicles equipped and high equipment costs compared to floating cellular data.

Radio-frequency identification (RFID) or Transponder Systems

Radio-frequency identification (RFID) is an automatic identification method, relying on storing and retrieving data from remote areas using devices called RFID tags or transponders. The technology requires some extent of cooperation of an RFID reader and an RFID tag. An RFID

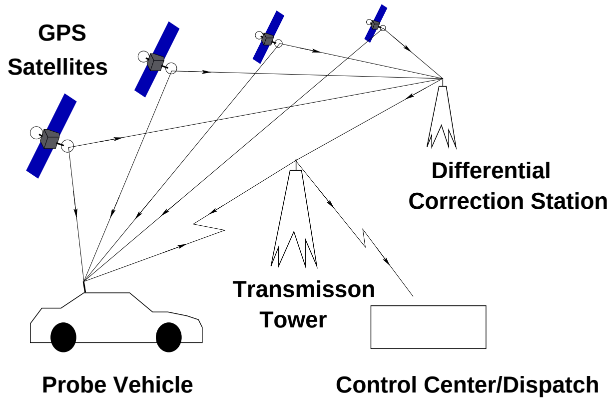

Figure 8:11: Communication from GPS, source

tag is an object that can be applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves. Some tags can be read from several meters away and beyond the line of sight of the reader.

A basic RFID system consists of three components

1. An antenna or coil
2. A transceiver (with decoder)
3. A transponder (RF tag)

An RFID tag is comprised of a microchip to collect information and an antenna that transmits this data wireless to a reader. At its most basic, the chip will contain a serialized identifier, or license plate number, that uniquely identifies that item. Typically, processed data would be used to provide revised scheduling and arrival time information to the general public, via variable information signs. Transponder systems are also used with Selective Vehicle Detection (SVD) systems which are designed to allow priority at traffic signals or cordon points for public transport or emergency service vehicles.

Typical Applications for RFID

1. Automatic Vehicle identification
2. Inventory Management
3. Work-in-Process

4. Container or Yard Management

5. Parking Management

Advantages

1. RFID tags can be read through materials without line of sight.

2. RFID tags can be read automatically when a tagged product comes past or near a reader.

Disadvantages

1. Reader collision occurs when the signals from two or more readers overlap.

2. The tag is unable to respond to simultaneous queries.

3. Tag collision occurs when many tags are present in a small are

8.3 Special applications

8.3.1 General

Travel time, or the time required to traverse a route between any two points of interest, is a fundamental measure in transportation. Travel time is a simple concept understood and communicated by a wide variety of applications for transportation engineers and planners. Several data collection techniques can be used to collect travel times. These techniques are designed to collect travel times and average speeds on designated roadway segments or links.

8.3.2 Travel Time Data collection Technique

Following are the different techniques available for the travel time data collection.

1. Test Vehicle Techniques

2. License Plate Matching Techniques

3. ITS Probe Vehicle Techniques

4. Emerging and Non-Traditional Techniques

Test Vehicle Techniques

Travel time data using active test vehicles in combination with varying levels of instrumentation: manual (clipboard and stopwatch), an electronic distance measuring instrument (DMI), or a global positioning system (GPS) receiver. It involves the use of data collection vehicle within which an observer records cumulative travel time at predefined checkpoints along a travel route. Then this information converted to travel time, speed, and delay for each segment along the survey route. There are several different methods for performing this type of data collection, depending upon the instrumentation used in the vehicle. These vehicles are instrumented and then sent into the field for travel time data collection, they are sometimes referred to as "active" test vehicles.

Advantages

1. Advanced test vehicle techniques (e.g., DMI or GPS use) result in detailed data.
2. Low initial cost.

Disadvantages

1. Sources of possible error from either human or electric sources that require adequate quality control,
2. Data storage difficulties.

License Plate Matching Techniques

Travel times by matching vehicle license plates between consecutive checkpoints with varying levels of instrumentation: tape recorders, video cameras, portable computers, or automatic license plate character recognition.

Advantages

1. Travel times from a large sample of motorists, very simple technique.
2. Provides a continuum of travel times during the data collection period.

Disadvantages

1. Travel time data limited to locations where observers or video cameras can be positioned;
2. Limited geographic coverage on a single day
3. Accuracy of license plate reading is an issue for manual and portable computer

ITS Probe Vehicle Techniques

Travel times using ITS components and passive probe vehicles in the traffic stream equipped with signpost-based transponders, automatic vehicle identification (AVI) transponders, ground-based radio navigation, cellular phones, or GPS receivers.

Some vehicles are equipped with dynamic route guidance (DRG) device which act as roving traffic detectors, a non-infrastructure based traffic monitoring system. Such vehicles, which are participating in the traffic flow and capable of determining experienced traffic conditions and transmitting these to a traffic center, are called probe vehicles. To determine its position and to register experienced traffic conditions, a probe vehicle is equipped with on-board electronics, such as a location and a communication device. By means of the location device, the probe vehicle keeps track of its own geographic position.

Through the communication device, the probe vehicle transmits its traffic experiences via a mobile communication link to a traffic center. For instance, each probe can transmit traffic messages once every time interval containing its location and its speed at the instant of transmission. In this traffic center the traffic data received from probe vehicles is gathered, and combined with data from the other monitoring sources, and processed into relevant traffic information. It is very useful for Advanced Traveler Information system (ATIS).

Advantages

1. Low cost per unit of data
2. Continuous data collection
3. Automated data collection
4. Data are in electronic format
5. No disruption of traffic

Disadvantages

1. High implementation cost
2. Fixed infrastructure constraints - Coverage area, including locations of antenna
3. Requires skilled software

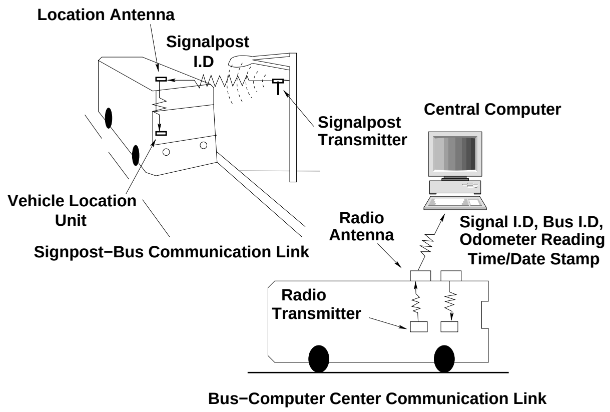

Figure 8:12: Signpost-Based AVL Communication Processes, Source: Travel Time Detection Hand Book

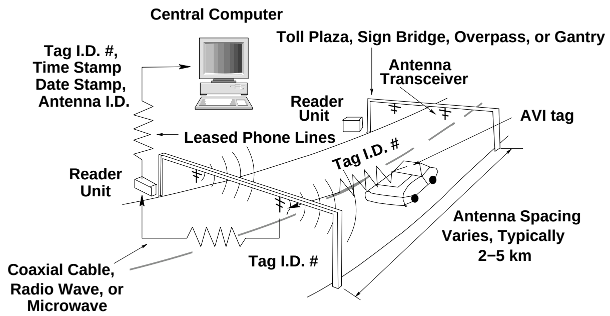

Figure 8:13: AVI Vehicle-to-Roadside Communication Process, Source: Travel Time Detection Hand Book

4. Not recommended for small scale data collection efforts

ITS probe vehicle data collection systems

1. **Signpost-Based Automatic Vehicle Location (AVL)** - This technique has mostly been used by transit agencies. Probe vehicles communicate with transmitters mounted on existing signpost structures shown in Fig. 8:12.

2. **Automatic Vehicle Identification (AVI)** - Probe vehicles are equipped with electronic tags. These tags communicate with roadside transceivers to identify unique vehicles shown in Fig. 8:13 and collect travel times between transceivers.

3. **Ground-Based Radio Navigation** - It is used for transit or commercial fleet management, this system is similar to the global positioning system (GPS). Data are collected

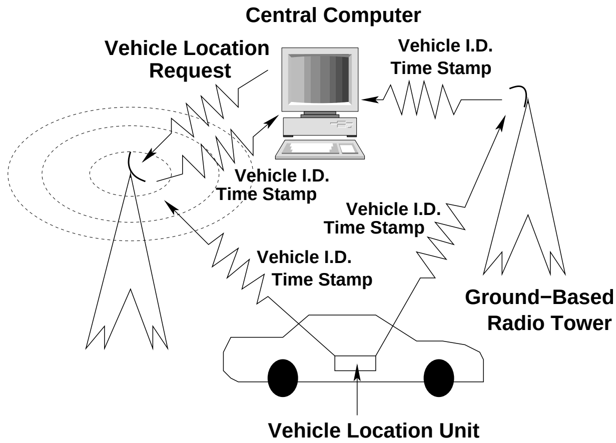

Figure 8:14: Ground-Based Radio Navigation Communication Process, Source: Travel Time Detection Hand Book

by communication between probe vehicles and a radio tower infrastructure as shown in Fig. 8:14.

4. **Cellular Geo-location** - This experimental technology can collect travel time data by discretely tracking cellular telephone call transmissions. Cellular telephones are also useful to collect travel time data. Two techniques have been applied using cellular technology: cellular telephone reporting and cellular geolocating.

   Cellular Telephone Reporting

   An operator at the central control facility records each drivers identification, location, and time, by monitoring the time between successive telephone calls, travel time or travel speed between reporting locations are determined. It is useful for assessment of current traffic conditions and for collecting travel time data during delays or accidents. The cellular telephone reporting method is recommended for short-term studies with low accuracy requirements.

   Cellular Geo-location

   The cellular geolocating methodology discreetly tracks cellular telephone calls to collect travel time data and monitor freeway conditions. This technique utilizes an existing cellular telephone network, vehicle locating devices, and a central control facility to collect travel time data. All vehicles equipped with cellular telephones are potential probe vehicles. The system automatically detects cellular telephone call initiations and locates the respective probe vehicle within a few seconds.

Advantages

(a) Driver recruitment not necessary

(b) No in-vehicle equipment to install

(c) Large potential sample

Disadvantages

(a) Low accuracy

(b) Privacy issues

(c) Infrastructure dependent

Numerical Example

1. If the vehicle 10% time occupied by loop M and 32% time occupied by loop N, the distance between two loops are 4.22 m find the spot speed of the vehicle. Also find the length of the vehicle if time occupancy for M - loop is 0.26sec and 0.32 for N-loop?

   Solution: Length is 4.22 m and occupancy times are 0.32 and 0.1.Therefore,the spot speed(v)is given by:

$$\begin{aligned} v &= \frac{l_{dist}}{t_2 - t_1}, \\ &= (4.22)/(0.32 - 0.1) = 19.18 \text{ m/sec.} \end{aligned}$$

   For length calculation, the speed is 19.18 m/sec and occupancy times are 0.26 and 0.32.

$$\begin{aligned} L_{vehicle} &= \frac{Speed(ot_2 + ot_1)}{2}, \\ &= \frac{19.18(0.26 + 0.32)}{2} = 5.56 \text{ m.} \end{aligned}$$

2. The average length of vehicle is 4.25 m and the length of loop detector zone is 1.85 m. The time occupancy in the loop is 32 percentages, find the spot speed of the vehicle?

   Solution: The average vehicle length is 4.25 and detector zone length is 1.85 m and t0 is 0.32.The spot speed(s)is given by:

$$
\begin{aligned}
s &= \frac{EVL}{t_o}, \\
&= \frac{4.25 + 1.85}{0.32} = 19.06 \text{ m/sec.}
\end{aligned}
$$

3. In freeway 1500 vehicles are observed during 120 sec interval. The lane occupancy is 65 percentage and the average length of vehicle observed as 6.55 m. Find the space mean speed on the freeway section?

   Solution: The number of vehicle N is 1500 vehicles; observation period is T= 120 sec. The lane occupancy O is 0.65 and average length is 6.55, so g is (40.9/6.55).The space mean speed(s) is given by:

$$
\begin{aligned}
s &= \frac{N}{T \times O \times g}, \\
&= \frac{1500 \times 6.55}{120 \times 0.65 \times (40.9)} \\
&= 3.08 \text{ m/sec.}
\end{aligned}
$$

8.4 Summary

ITS include sensor, communication, and traffic control technologies. Intelligence requires information, and information requires data, which is generated by surveillance. Vehicle detection and surveillance technologies are an integral part of ITS, since they gather all or part of the data that is used in ITS. A detailed introduction and importance of ITS and different types of data involved have been discussed in this chapter. Technology regarding the data collection techniques on conventional and non conventional methods has been presented in the following chapter.
A detailed different technology system, their principles, advantages, disadvantages and type of data collected by each system have been discussed in this chapter. Application part of travel time by probe vehicle and vehicle signature by some technologies has been presented.
Detailed travel time estimation by different techniques has been discussed in this chapter. Also travel time estimation by vehicle technology and emerging techniques such as vehicle signature have also been discussed in this chapter.

Each detector technology and particular device has its own limitations and individual capability. The successful application of detector technologies largely depends on proper device selection. Many factors impact detector selection, such as data type, data accuracy, ease of installation, cost and reliability. Vehicle technologies are well advanced compared to the in-situ technology detectors for travel time. A non- Intrusive technology is very effective compared to the Intrusive technologies. Pneumatic road tube sensors are more suitable for small sample and short duration period but it cant detect two wheelers. ILDs are flexible to satisfy different variety of applications, but installation requires pavement disturb. Magnetic sensors provide traffic measurements more accurate and more informative than loop detector measurements, but it cant detect the stopped vehicle.

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