Data Collection Methods

An analyst or agency can use a variety of data collection devices. These devices can be grouped into three categories, which for these purposes, are based on the location that the speed data collection device is installed:

- Manually-operated, handheld devices that are portable and can be used in most places (e.g., stopwatch, radar gun, and laser gun).
- In-road devices that are installed into or on top of the roadway surface (e.g.,pneumatic road tube).
- Out-of-road devices that are installed overhead or to the side of the roadway surface (e.g. radar recorders).

Each device has distinct advantages and disadvantages for collecting and analyzing data that may factor in determining the appropriate device to use for a particular location. The analyst or agency *should* make a concerted effort to use devices that incorporate the most advanced data collection technologies available to them. In doing so, a more accurate representation of vehicle speeds can be obtained while minimizing observer-related biases. Table 1 summarizes several common speed data collection techniques and the following section describes the methodologies and processes for each one.

Current Data Collection Methods

The following describes data collection methods that use current technologies to accurately collect speed data while minimizing driver awareness of the device and associated observer-related biases. When performing a speed study, it is recommended that the high-technology devices be considered first for deployment to capture vehicle speed data.

Radar Recorders

Methodology. Radar recorders use the Doppler principle to obtain vehicle speeds. This is performed by a module that emits radar or microwave energy that reflect off of moving vehicles. The device collects the returning waves and uses them to generate an instantaneous measurement of speed.

Equipment. Radar recorders typically are constructed as pole-mounted modules that are affixed to a signpost, utility pole, or overhead sign. In addition, law enforcement speed boards also use radar technology that can function as data collection devices; however, the speed limit visual display **shall** be turned off so motorists do not alter their speeds because of the speed board.

Process. The analyst secures the radar recorder to a fixed object outside the traveled way based on the device's user manual (for speed boards, it should be parked well off the traveled way to avoid motorist collision). The radar recorder is left to collect data for a predetermined period of time and then is collected from the field. Data collected by the recorder is downloaded to a computer for further analysis.

Table 1. Comparison of Data Collection Methods

Method	Data Collected	Labor Involvement	Equipment Costs [1]	Advantages	Disadvantages
Radar Recorders	Instantaneous speed, traffic volumes, vehicle class, traffic flow gaps [3]	Low	High	Little labor required to collect and tabulate data: Can collect data for long periods of time; Other traffic-related data may be collected at the same time; Can be used when snowplows may be present without risk of damage; Less visible to traveling public than road tubes	User cannot randomly select vehicles for data set; Some devices may not accurately collect data for multi-lane roadways and/or determine directionality of observed vehicles; Equipment-intensive method; Maintenance/calibration required
Pneumatic Road Tube	Instantaneous speed, traffic volumes, vehicle class, traffic flow gaps [3]	Low	Medium	Little labor required to collect and tabulate data; Can collect data for long periods of time; Other traffic-related data may be collected at the same time	Visible to traveling public which may change driver behavior; User cannot randomly select vehicles for data set; Use discouraged when snowplows may be present; Most equipment-intensive method; Maintenance/calibration required
Laser Gun	Instantaneous speed	Medium	High	Equipment is easily portable; User controls vehicles sampled as a more focused laser beam limits the number of readings for non-target vehicles as compared to radar	Cosine error limits horizontal/vertical deployment; Scopes and sights may not be user-friendly; Laser beams more sensitive to environmental variances than radar; Maintenance/calibration required
Radar Gun	Instantaneous speed	Medium	Medium	Equipment is easily portable; User controls vehicles sampled; Accurate data collection method; Widespread equipment availability has lowered its cost	Cosine error limits horizontal/vertical deployment; Closely-spaced and larger vehicles may create readings for non-targeted vehicles; Maintenance/calibration required
Stopwatch [2]	Travel time over a distance	High	Low	Little equipment to purchase and maintain; Easy to perform data collection process	Labor-intensive; Collects time data that needs to be converted to speed data; Typically low accuracy

1 Equipment costs reflect the initial purchasing costs of the equipment and not future maintenance and calibration costs
2 The stopwatch method **shall not** be utilized in State-sponsored studies or studies that involve roadways under the jurisdiction of WisDOT.
3 The amount of additional data collected varies for each device, please consult the device's user manual for a better understanding of its capabilities.

Advantages/disadvantages: Radar recorders provide the least labor-intensive method, only requiring a technician to install and remove the module or speed board. Because of this, many of the observer-related errors that may occur with other methods are eliminated. Radar recorders can collect data for long periods of time, and some recorders also include software that can tabulate traffic volumes and distinguish vehicle classes. Because radar recorders are installed outside of the traveled way, they are not readily noticeable to the traveling public (as previously mentioned, it is recommended that the visual display of a radar speed board be turned off to increase its inconspicuousness). Radar recorders measure speed data for all vehicles that pass through the capture zone, which may include vehicles that are not traveling at free-flow speeds. Dependent on the device, some radar recording devices cannot accurately collect speed data along multi-lane roadways due to device limitations. Furthermore, some radar recorders are unable to distinguish directionality of observed vehicles. Because radar recorders rely on equipment to perform the data collection task, they require more maintenance and calibration to uphold its accuracy.

Pneumatic Road Tube Method

Methodology. The pneumatic road tube method uses a set of pneumatic road tubesthat are attached to an electronic counter with air-sensitive switches. When a vehicle passes over a road tube, the pressure created in the tube actuates a switch in the counter. The amount of time it takes to receive actuations from the twotubes is then converted into an instantaneous speed measurement.

Equipment. The pneumatic road tube method is performed using two road tubes and a recorder, devices to attach and secure the road tubes to the roadway and the counter to a fixed object for security, and a measuring tape.

Process. The analyst installs the road tubes on the roadway surface, spaced at a specified length based on the counter's user manual. The road tubes are then attached to the counter and the counter is secured to a fixed object (e.g. tree, sign post, or light pole) so it will not be tampered with or stolen. The counter and road tubes are left to collect data for a predetermined period of time and then are collected from the field. Data collected by the counter is downloaded to a computer for further analysis.

Advantages/disadvantages: The pneumatic road tube method possesses many of the same advantages and disadvantages that can be found by using radar recorder devices. Pneumatic road tubes require little labor to collect speed data, eliminating observer-related errors. Pneumatic road tubes can collect data for longperiods of time, and some traffic counters also include software that can tabulate traffic volumes and distinguish vehicle classes. Pneumatic road tubes measure speed data for all vehicles that pass over them, which may include vehicles that are not traveling at free-flow speeds. This method also relies on equipment to perform the data collection task and, therefore, requires more maintenance and calibration to uphold its accuracy.

Unlike radar recorders, though, some pneumatic road tube traffic counters can be configured to collect the directionality of observed vehicles with only one device, provided a median is present to store the traffic counter. In addition, some traffic counters can be configured to collect data along multi-lane roadways. However,

pneumatic road tubes are more visible to the traveling public, which could influence driver behavior as they cross them. Pneumatic road tubes are also discouraged for winter-time use due to the affect of cold weather on counter performance and the potential for snow plows to damage the road tubes and/or counter. Installation and removal of the pneumatic road tubes requires the analyst to work within the traveled way, raising safety concerns and potentially conflicting with the traveling public.

Other Data Collection Methods

Other data collection methods are also available for use in collecting vehicle speeds. These methods range from labor-intensive because they require an observer to collect the data (i.e., Laser Gun, Radar Gun, or Stopwatch) to more technologically advanced (e.g., devices that emit microwave or infrared beams). The labor-intensive methods may be more viable for agencies with limited resources to purchase or borrow radar recorder or pneumatic tube technologies, or with limited resources to hire outside data collection services.

Laser Gun Method

Methodology. The laser gun technology uses laser beams to obtain vehicle speeds. Similar to the radar gun, a handheld device (or 'gun') emits a laser beam that reflects off of moving vehicles. The device collects the returning beams and converts the amount of time for the beam to emit and return into an instantaneous speed measurement.

Equipment. The laser gun method is performed using a laser gun, a mounting device (if applicable), and data collection forms.

Process. An observer 'shoots' the laser gun at approaching vehicles and records the speed data transmitted by the laser gun on the data collection form. The speed data is then processed for further analysis.

Advantages/disadvantages. The laser gun possesses many of the advantages for use like the radar gun; however, unlike the radar gun, the laser gun emits a concentrated beam of light, which enables the observer to target exactly those vehicles he/she wishes to collect speed data and not inadvertently receiving speed data from non-targeted vehicles. The laser gun also possesses many of the limitations of the radar gun, such as tolerance, maintenance, and calibration.

Because the laser gun uses laser beams to collect data, the observer must target vehicles using a scope and sights attached to the device, which may not be as user-friendly as radar guns. Furthermore, laser-light beams are more sensitive to climate conditions, such as precipitation and humidity, which may interfere with readings.

Radar Gun Method

Methodology. The radar gun method uses the Doppler principle to obtain vehicle speeds. This is performed by a handheld device (typically called a 'gun') that emits radar or microwave energy that reflect off of moving vehicles. The device collects the returning waves and uses them to generate an instantaneous measurement of speed.

Equipment. The radar gun method is performed using a radar gun, a mounting device (if applicable), and data collection forms.

Process. An observer 'shoots' the radar gun at approaching vehicles and records the speed data transmitted by the radar gun on the data collection form. The speeddata is then processed for further analysis.

Advantages/disadvantages. Technologically, the radar gun method is one of the most accurate ways to measure vehicle speeds. The radar gun is portable and can be mounted to a vehicle or tripod for use. Radar guns allow the observer to collect and distinguish speed data from vehicles traveling in both directions of the roadway. The observer *should* consult the reference manual of the radar gun before application to determine the device's effective range and tolerance. One particular tolerance, known as cosine error, limits the horizontal and verticallocation an observer can be positioned relative to the roadway. Because beams from the gun are emitted in the shape of an inverse funnel, the speeds of non- targeted vehicles may be transmitted due to the distance of non-targeted vehicles and the targeted vehicle as well as the amount of reflective surface each vehicle possesses. As with most data collection devices, the radar gun requires maintenance and calibration to ensure accuracy.

Stopwatch Method

Methodology. The stopwatch method measures the time a vehicles takes to pass between two points of a known distance. From the time data collected, speed can be calculated.

Equipment. The stopwatch method is performed using a stopwatch (or similar time-measuring device, such as certain electronic traffic count boards), a measuring tape or wheel, a data collection form, and posts or other objects to use as starting and ending reference points (if necessary).

Process. The observer first uses the measuring tape or wheel to establish a known length of roadway. The start and end points of this roadway section are then delineated using posts or other objects placed away from the traveled lanes that can be identified by the observer (existing objects in the field such as pavement cracks, utility poles, and trees can suffice as well). The observer then measuresthe amount of time vehicles take to travel from the start to end points and records it on the data collection form. After a sufficient number of time data records have been collected, the analyst converts the time data into speed data for further analysis.

Advantages/disadvantages: The stopwatch method can usually be performed without purchasing additional equipment, reducing costs for the purchase and maintenance of speed-collecting devices. While the stopwatch method is relatively simple to perform, it is also the most labor-intensive to conduct due to the setup of the study area and conversion of time data into speed data. The stopwatch method includes numerous factors that must be considered to ensure accurate data collection.

Additional Technologies

Speed data collection may be performed using other methods. The "floating car" or "pacing" method relies on an observer physically driving through the study area while following random vehicles, noting speed or time data of the random vehicle. This technique is more commonly used for travel time and delay studies where space-mean

speeds are of greater concern. Other methods gaining popularity in larger cities and state transportation agencies involve out-of-road devices that emit microwave or infrared beams to count and measure vehicle speeds. Finally, devices such as inductive loops can be installed under the roadway surface. When vehicles pass through the loop's electrical field, recorders note the speed of vehicles passing over them. This methodology requires extensive installation time and costs and is, therefore, not recommended for useon speed zone modification studies.

As previously mentioned, each device and technique has its distinct advantages and disadvantages for collecting and analyzing speed data, and it is up to the analyst or agency to select the most appropriate data collection method for a particular location. It is recommended that the analyst use the most technologically advanced data collection method available to them to gather an accurate representation of vehicle speeds. For state-sponsored speed studies and speed studies performed on a section of roadway that is part of the state trunk highway (STH) network, devices that use radar, laser, and microwave technology as well as pneumatic road tubes are appropriate data collection methods; the stopwatch method **shall** not be used to collect speed data for these particular studies. The stopwatch method may be used occasionally for speed studies on local roadways and streets by agencies that do not have access to more sophisticated data collection options.