SPOT SPEED STUDY WORKSHOP
INSTRUCTION MANUAL

Prepared for the
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INTRODUCTION

The intent of spot speed studies are to record speed characteristics under prevailing traffic conditions at a specific location along a roadway. The many applications of spot speed studies include, but are not limited to, the following:

- Determine existing roadway speeds, for potential use in speed zoning and prioritization of speed enforcement locations;
- Evaluate the effectiveness of speed enforcement programs;
- Identify the speed impact of roadway geometry, including horizontal and vertical alignment and general roadway features;
- Determine impact on speed of traffic control devices (traffic signs, pavement markings, signals); and
- Provide evidence to support/refute complaints of excessive speed.

This workbook provides an overview on conducting spot speed studies and includes information for each of the study steps listed below.

1. Organize Study Plan
2. Select Data Collection Technology
3. Select Appropriate Site and Collect Field Data
4. Reduce and Analyze Data
5. Interpret and Report Findings

It should be noted that this is workbook provides an overview and explanation of a methodology for conducting spot speed studies, and as a result, additional sources may provide further information for performing spot speed studies, or specific detector information. A glossary of terms is provided, which provides useful definitions for many of the terms commonly associated with spot speed studies.

Step 1: Organize Study Plan

Essential to this initial step is to identify the reason for conducting the study and nature of the problem to be evaluated. Other considerations for the study plan are the date(s) and time(s) during which the study should be completed, and the number of vehicles that should be observed as part of the study. The timing of the study should be consistent with the reason for conducting the study. For example, if the study is being completed to determine if speed complaints are valid during the evening rush hour, then the study should be completed during the evening rush hour. Literature suggests that speed data be collected for a minimum of one hour and observe at least 30 vehicles; however depending upon the type of technology used to complete the study, and the complexity of the study, sample sizes and durations can often include thousands of vehicles over multiple days (1). Once the plan is completed, the study can be carried out and the data can be evaluated as outlined in the steps below.
Step 2: Select Data Collection Technology

A wide variety of technologies exist for collecting traffic and/or speed information in addition to radar and LiDAR commonly used by law enforcement personnel. Each of these types of technology are associated with various advantages and disadvantages, which are commonly based upon ease of installation, cost, and accuracy. One basic difference in types of technology is whether they are in-road, which require placing equipment in or on the road, or out-of-road technologies, which can measure traffic from the roadside or above. Figure 1 provides an overview for various types of technology used in conducting spot speed studies. The attached appendix provides further details regarding the operating principle as well as some discussion of advantages and disadvantages (related to installation, cost, etc) for each type of technology listed in Figure 1.

![Detection Technologies](image)

**Figure 1. Overview of Detection Technologies.**
Step 3: Location Selection and Collect Field Data

The specific location of a study should be chosen carefully so that recorded speeds reflect how vehicles *typically* travel along unimpeded sections of the road under free flow conditions. Figure 2 below highlights some of the issues that should be considered as part of the site selection process. A sample field data collection sheet for use with a radar or LiDAR is presented in Figure 3. To complete the study simply place a tick mark each time a specific vehicle speed is observed as indicated by “A” in Figure 3.

**Things to Consider**

- Select roadway section with typical travel speed;
- Unless a specific requirement of the speed study, make an attempt to avoid the following, primarily to avoid accelerating/decelerating vehicles:
  - Traffic signals and other junctions
  - Intersections
  - Work zones
  - Curves
  - Parking zones
  - Active crosswalks
- Consider free flow vehicles only (those not impacted by speed of preceding vehicle, such as the first vehicle in a platoon);
- Consider date and time (consistent with Step 1)
  - Typical weekdays (Tues., Wed., Thur.) preferred
- Avoid unusual conditions, including:
  - Unique events
  - Inclement weather
  - Holidays
- If using Radar or LiDAR, consider:
  - the angle of measurement to assure accurate speeds
  - remain inconspicuous so as not to influence speeds (not from police cruiser or in uniform)
  - Record speeds
- **Remember safety first!!!**

**Figure 2. Things to Consider**
Figure 3. Sample Field Data Collection Sheet for use with radar or LiDAR
Step 4: Speed Data Reduction and Analysis

After the study is completed and the data have been tabulated the following steps may be considered as part of the typical data analysis. Specifically, the idea would be to identify key parameters associated with roadway speeds, which may include any or all of the following:

- **Mean Speed**: The average speed; calculated as the sum of all speeds divided by the number of speed observations (18).

- **85th Percentile Speed**: The speed at or below which 85 percent of a sample of free flowing vehicles is traveling; this is typically used as a baseline for establishing the speed (based on a spot speed study) (18).

- **95th Percentile Speed**: The speed at or below which 95 percent of a sample of free flowing vehicles is traveling (based on a spot speed study) (18).

- **Median (50th Percentile Speed)**: The speed that equally divides the distribution of spot speeds; 50 percent of observed speeds are higher than the median; 50 percent of observed speeds are lower than the median. (19).

- **Mode**: The number that occurs most frequently in a series of numbers (18).

- **Speed Variance**: The difference in travel speeds for vehicles on the road. Mathematically, variance is the average of the squares of the difference to the mean for each observed speed (18).

- **Pace**: A 10 mile-per-hour increment in speeds that encompasses the highest portion of observed speeds; often is the mean speed plus/minus five miles per hour (19).

Consider again the sample data presented previously in Figure 3. Logical next steps in the data reduction process would include the following:

- Count and record the total number of tick marks for each type of vehicle (marked by “2” in Figure 3)
- Count and record the total number of vehicles at each speed (marked by “C” in Figure 3)
- Count and record the total number of vehicles in the survey (marked by “D” in Figure 3).

At this stage of the analysis, it is already possible to calculate the mean speed, mode, and pace as demonstrated below.

- The mode is 29 mph as it is the observed speed that was most frequently observed, as it was observed for 26 vehicles.
- The median speed is calculated by using the following equation:
mean speed = $\bar{S} = \frac{\sum n_i S_i}{N}$

where:

$S_i$ is the observed speed group $i$,
$n_i$ is the number of observations for speed group $i$; and
$N =$ the number of observations recorded

For the example the mean speed (would be calculated as follows):

$$\frac{(19 * 2) + (20 * 6) + \ldots \ldots + (43 * 1)}{250} = \frac{7261}{250} = 29 \text{ mph}$$

The pace is determined as the 10 mph window that encompasses the highest number of observations. For the sample problem there are 179 recorded speeds between 25 and 34 mph, so the pace is reported as that range of speeds. Recall, that as a rule of thumb, the pace is typically the mean speed plus/minus 5 mph, which is indeed the case with the sample data.

Now consider Figure 4 on the following page, which presents the same sample data from Figure 3 in a spreadsheet format with cumulative values. The cumulative frequency (column 3 in Figure 4) represents the number of observed values at or below that speed. The cumulative percentage (column 4 in Figure 4) represents the percentage of speeds at or below the given speed, and is calculated as the cumulative frequency divided by the total number of observations (250). Note that the cumulative percentage increases from 0 to 100 percent.

Using the cumulative percentages in Figure 4, it is now possible to identify the median, 85th, and 95th percentile speeds. To determine each percentile speed move down the cumulative frequency column until you have gone past the desired percentile. Then move across to determine the corresponding speed. Again considering the sample problem data and Figure 4 the following approximate percentile speeds would be identified:

- Median (50th Percentile Speed) is equal to 29 mph;
- 85th Percentile Speed is equal to 34 mph; and,
- 95th Percentile Speed is equal to 37 mph.

It is important to note that a more precise estimation of the percentile speeds can be achieved by interpolating between speed values or using a cumulative frequency plot similar to that presented in Figure 5; however for most purposes the level of accuracy used in the sample problem is sufficient.
**Figure 4. Spreadsheet for Sample Problem with Cumulative Values.**

<table>
<thead>
<tr>
<th>Speed</th>
<th>Frequency of Vehicles</th>
<th>Cumulative Frequency</th>
<th>Cumulative percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>2</td>
<td>0.90%</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>10</td>
<td>3.20%</td>
</tr>
<tr>
<td>21</td>
<td>12</td>
<td>32</td>
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<td>19</td>
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</tr>
<tr>
<td>23</td>
<td>32</td>
<td>83</td>
<td>12.80%</td>
</tr>
<tr>
<td>24</td>
<td>40</td>
<td>123</td>
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</tr>
<tr>
<td>25</td>
<td>56</td>
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</tr>
<tr>
<td>27</td>
<td>92</td>
<td>343</td>
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</tr>
<tr>
<td>28</td>
<td>118</td>
<td>461</td>
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<tr>
<td>29</td>
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<tr>
<td>30</td>
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<tr>
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<td>4346</td>
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</tr>
</tbody>
</table>
Figure 6 Cumulative Frequency Distribution Plot for Sample Data.
Step 5: Interpret and Report Findings

Using the descriptive speed characteristics determined in Step 4, it is likely that there is now sufficient data to answer the primary questions for which the spot speed study was originally initiated. Consider some of the following examples:

- How do observed speeds compare with the posted or prima facie speed limit for the observed roadway?
- How does the distribution of speeds before compare with speeds during or after an enforcement campaign?
- If residents are complaining about excessive speeds in the afternoon rush hour, does your data support this claim?
- Are speeds on the approach to a high crash location higher than the roadway design speed?
- What is the speed variance? Are all vehicles traveling at approximately the same speed, or is there a wide range of observed speed values?
- How do average and percentile speeds compare with other roadways in town?
- Since the installation of a new SPEED LIMIT sign, how have roadway speeds changed?

As previously noted, the intent of this workbook was to provide introductory material for completing a spot speed study. It may be appropriate to consider additional resources for further details. Similarly, additional statistical support or study design may be required for some evaluations.

Once you have acquired the information and used it to answer some of the questions outlined above, it is important to consider how you can share this information with your community. Below is a list of possible opportunities for sharing the information you have gathered.

Presentations at Community Meetings: Create a powerpoint presentation or some other type of presentation materials (posters, for example) and help the community understand what information you have collected and how they can use it to think about speed in their own neighborhoods.

Educational Materials for Neighborhoods: Share your findings with the specific neighborhoods where you conducted your spot speed study. Creating informational handouts will help the residents understand why you were collecting the data and what you found. This information will be of special interest to them since the studies occurred on their roadways.

Information for Decision Makers: Present your information to your local policy makers such as a town council or traffic committee. This will help them understand the value of the study and
allow them to use your findings to make decisions about traffic rules that are relevant to your community based on the information you’ve collected.

For more information on speed management programs and other information that might be of interest to you regarding speed programming, consider these additional resources.

GLOSSARY OF RELEVANT SPOT SPEED TERMS

Headway (Gap): The distance (time) between two vehicles traveling the same direction (17).

Spot Speed Study: A measure of vehicle speed characteristics at a specific location under the traffic and environmental conditions at the time of the survey (1).

Control Location: An additional site used for comparison where what is being tested is absent (17).

85th Percentile Speed: The speed at or below which 85 percent of a sample of free flowing vehicles is traveling; this is typically used as the speed limit (based on a spot speed study) (18).

95th Percentile Speed: The speed at or below which 95 percent of a sample of free flowing vehicles is traveling (based on a spot speed study) (18).

Mean Speed: The average; the sum of all speeds divided by the number of speeds. (18).

Median: The speed that equally divides the distribution of spot speeds; 50 percent of observed speeds are higher than the median; 50 percent of observed speeds are lower than the median. (19).

Mode: The number that occurs most frequently in a series of numbers (18).

Speed Variance: The difference in travel speeds for vehicles on the road. Mathematically, variance is the average of the squares of the difference to the mean (18).

Traffic Counter Classifier: A device, which automatically counts and determines the type of passing vehicles (typically additional traffic information is collected) (20).

Pace: A 10 mile-per-hour increment in speeds that encompasses the highest portion of observed speeds (as compared to any other 10 mile-per-hour increment) (19).

Ball Bank Indicator: A curved level that measures the combined effect of the body roll angle, the centrifugal force, and the superelevation angle as a vehicle negotiates a horizontal curve at various speeds (16).

Free Flow Speed: There is no generally accepted definition of this term; However some have defined free flow speed as the condition where drivers are choosing their own speed, when vehicle interaction (congestion) and traffic control (signals or signs) are not an issue (21, 16).

Normal Distribution: A theoretical distribution with finite mean and variance, such as the speed of passing vehicles. Values are centered on an average, as you move away from the average the probability of a particular value decreases (i.e. a bell shaped curve as seen in Figure 1) (22). Most Speed distributions can be reasonably represented by a normal distribution (19).
**Cumulative Frequency Distribution:** A theoretical distribution, which is a count of the number of values less than or equal to x. For example the speed of cars passing a point with probability on the y-axis and speed on the x-axis would start at zero. The probability would cumulatively increase until the top speed, which has a probability of 100. The 85th percentile is calculated as the speed at the 85th percent of this graph at which 85 percent of the speeds are at or below this value (i.e. an S-shaped curve as seen in Figure 2) (22).
References


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