Chapter 14

TRAVEL TIME AND DELAY STUDY

14.1 PURPOSE

(1) The purpose of a Travel Time and Delay Study is to evaluate the quality of traffic movement along a route and determine the locations, types, and extent of traffic delays by using a moving test vehicle.

(2) This study method can be used to compare operational conditions before and after roadway or intersection improvements have been made. It can also be used as a tool to assist in prioritizing projects by comparing the magnitude of the operational deficiencies (such as delays and stops) for each project under consideration.

(3) The Travel Time and Delay Study can also be used by planners to monitor level of service for local government comprehensive plans.

(4) The methodology presented herein provides the engineer with quantitative information with which he can develop recommendations for improvements such as traffic signal retiming, safety improvements, turn lane additions, and channelization enhancements.

14.2 DEFINITIONS

Acceleration Noise (AN). Represents the degree of driver discomfort due to acceleration and deceleration. It is computed (approximately) as the root mean square value of acceleration (feet per second squared) considering each second of operation separately (The Theory of Road Traffic Flow). Stopped times (e.g., speeds less than 5 mph) are excluded from the computations.

Control Point (CP). A node at the beginning or end of a link, usually the stop line at a signalized intersection, but can be any physical feature, i.e., power pole. The stop line or physical feature selected within the intersection must be located in the same direction of travel. The control point may be different for each direction of travel. However, once a control point is chosen it shall be used for each run in that particular direction.

Delay (D). The elapsed time (in seconds) spent driving at a speed less than 5 mph.

Distance. The length of a link or the length of a run (feet for computerized method,
miles for manual method).

**Fuel Consumption Rate (FC).** The miles per U.S. gallon computed from a mathematical model which considers the length of the run, the total delay, and the effect of acceleration and deceleration *(NCHRP Report 111, Running Costs of Motor Vehicles as Affected by Road Design and Traffic).*

**Running Speed (RS).** The test vehicle’s average speed (in miles per hour) while the vehicle is in motion (does not include delay time) it can be calculated by the formula:

\[
RS = \frac{\text{Distance}}{TT - D}
\]

**Running Time (RT).** The elapsed time (in seconds) excluding delay spent driving a distance.

**Special Control Points (SCP).** Beginning and end points of the study route. They shall be located outside the influence of a signalized intersection or other highway feature which might cause delay. The vehicle must be at normal operating speed for the route when passing these points.

**Stop (S).** The average number of times per link or run that the test vehicle’s speed falls below 5 mph. After a stop, an additional stop will not be recorded unless the speed first exceeds 15 mph *(Institute of Transportation Engineers, Manual of Traffic Engineering Studies).*

**Travel Speed (TS) or Average Speed (AS).** The test vehicle’s average speed (in miles per hour) over a distance.

**Travel Time (TT).** The total elapsed time (in seconds) spent driving a specified distance.

### 14.3 APPLICATIONS

(1) The travel time and delay data enables the traffic engineer to define problem locations where design and operational improvements may be essential to increase operational efficiency and safety.

(2) Travel time and delay data will also enable the traffic analyst to monitor the roadway’s level of service for local government comprehensive plans.

### 14.3.1 Examples

(1) Determination of route operational efficiency or delay.
(2) Identification of congested locations such as driveways, entrances, etc., where a significant number of turning movements occur.

(3) Evaluation of the effectiveness of traffic engineering improvements using before and after studies on projects such as intersection retiming or the addition of turn lanes (*ITE Transportation and Traffic Engineering Handbook*).

(4) Determination of level of service from average travel speed data.

### 14.4 STUDY PROCEDURES

(1) To conduct a *Travel Time and Delay Study*, one must first define the study area by selecting all control points before beginning the study. The time periods recommended for studies are A.M. and P.M. peak hours as well as off peak hours in the direction of heaviest traffic movements (other times may be requested by the District Traffic Operations Engineer).

(2) These studies should be made during reasonably good weather so that unusual conditions do not influence the study. Also, since crashes or other unusual delays will produce erroneous results, any runs made during such an occurrence should be terminated and another run conducted. These studies should be conducted during average or typical weekday traffic conditions.

(3) When conducting a *Travel Time and Delay Study*, the floating car technique should be used. In using the floating car technique, the driver floats with traffic by passing as many vehicles as pass the test car. The idea is to emulate an average driver for each section of roadway.

(4) In order to determine the number of runs required for statistical significance, the engineer/analyst should use the following method:

(a) Estimate the number of runs required by using *Figure 14-1*.

(b) Conduct the runs.

(c) Calculate the average range in running speed (R) using the equation below.

(d) Using the average range in running speed as calculated, again use *Figure 14-1* to determine the number of runs required.

(e) Make additional runs if required.

(f) Engineering judgement should also be used in applying this procedure to fit the purpose of the study.

(5) To elaborate on (4)(c), after the first group of running speeds has been computed, the absolute differences between the first and second values, the
Approximate Minimum Sample Size Requirements for Travel Time and Delay Studies with Confidence Level of 95.0 Percent

<table>
<thead>
<tr>
<th>Average Range in Running Speed (mph)* R</th>
<th>Minimum Number of Runs for Specified Permitted Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>± 1.0 mph</td>
</tr>
<tr>
<td>2.5</td>
<td>4</td>
</tr>
<tr>
<td>5.0</td>
<td>8</td>
</tr>
<tr>
<td>10.0</td>
<td>21</td>
</tr>
<tr>
<td>15.0</td>
<td>38</td>
</tr>
<tr>
<td>20.0</td>
<td>59</td>
</tr>
</tbody>
</table>

*Interpolation should be used when R is other than the numbers shown in column 1.

Second and third values, etc., are obtained. These differences are summed and the total is divided by the number of differences (N-1) to provide the average range in running speed for the initial data.

\[ R = \frac{S}{N - 1} \]

Example:

<table>
<thead>
<tr>
<th>Run #</th>
<th>RS</th>
<th>Absolute Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>3</td>
</tr>
</tbody>
</table>

\[ R = \frac{S}{(N - 1)} = \frac{10}{(5 - 1)} = 2.5 \]
where \( RS \) = average running speed in mph
\( R \) = average range in running speed in mph
\( S \) = sum of absolute differences
\( N \) = number of completed test runs

(7) The approximate minimum sample size is selected from Figure 14-1 for the calculated average range in running speed and the desired permitted error. If the required sample size is greater than the number of runs made, then additional runs must be performed under similar traffic and environmental conditions to reach the minimum sample size.

(8) The specified permitted error for traffic operations studies involving efficiency (i.e., timing studies) should be ± 3.0 mph.

(9) The specified permitted error for before and after studies should be ± 3.0 mph for studies predominately involving efficiency, and ± 2.0 mph for studies predominately concerned with safety.

(10) Figure 14-1 also includes ranges for specified permitted errors of ± 4.0 mph, and ± 5.0 mph. This data are provided as background information for the traffic engineer. There may be special projects where the traffic engineer would deem it appropriate to use one of these other specified permitted errors. Any exceptions to the previously noted standards should be approved in writing by the District Traffic Operations Engineer on a project by project basis.

(11) Travel Time and Delay Studies shall be conducted using either the manual method or the computerized method which are explained in the following sections.

### 14.5 MANUAL METHOD

(1) The manual method requires a test vehicle, driver, observer, two stopwatches or one stopwatch with double sweep, distance measuring instrument, odometer, and two field forms.

(2) The Travel Time and Delay Study can be conducted manually by using the following procedures. There are two different areas of this study, the field form (Form No. 750-020-14) is used to collect field data and the field summary (Form No. 750-020-19) is used to perform the required calculations and analysis. The instructions noted below should be followed when completing this study.

(3) There are six runs per field form. The rows of run data are filled in from the left to right as the run is being conducted. If more than six control points are identified, at least two more field forms must be used. The first control point on Sheet Two
must be the same as the last control point on Sheet One, this will allow space for
the delays to be recorded.

(4) Sections 14.6 and 14.7 go into further detail on the completion of the Travel
Time and Delay Study.

14.6 TRAVEL TIME AND DELAY STUDY FIELD DATA FORM
(FIGURE 14-2 AND 14-3)

Roadway I.D.  Local name of roadway to be studied (include County Section
Number, State Road Number, U.S. Route Number).

Location  Enter begin and end intersection names or physical feature
(begin/end control points).

City  City where study is being conducted.

County  County where study is being conducted.

Date  Date of study.

Weather  General description of weather conditions during study.

Observer(s)  Name(s) of personnel conducting study.

Control Point  Describe each control point by intersection name or physical
feature.

Location  The cumulative distance of each control point from the begin
control point.

Milepost  If the actual milepost is unknown, the milepost for the begin control
point may be designated as 0.00.

14.7 RUN INFORMATION

(1) In the first space in the row for Run 1, under Time (first control point which
equals 0), write the clock time the run is started (i.e., 7:30 A.M.). This is the time
the first stopwatch is started.

(2) As each control point is passed, the cumulative time (in seconds) on the first
stopwatch should be written in the Time box above the dashed line. The box
below the dashed line is for the individual lapse time between control points and
can be calculated at the end of the runs.

(3) Between all control points, the delay should be noted in Seconds (time) and
Cause (see Delay Codes on field form). A second stopwatch or the second
sweep of a dual sweep stopwatch is used to collect the delay data. Delay should
be recorded when the test vehicle is travelling at speeds less than 5 mph.

(4) Each run is made from the Begin Point to the End Point, noting the times from
the first stopwatch and the delay between control points from the second
### Figure 14-2. Travel Time and Delay Study Field Data Form

<table>
<thead>
<tr>
<th>ROADWAY</th>
<th>CITY</th>
<th>DATE</th>
<th>WEATHER</th>
<th>DELAY</th>
<th>OTHER DELAY CODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>30th St.</td>
<td>Wausau</td>
<td>01/01/2000</td>
<td>Sunny</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Field Data Form

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>COUNTY</th>
<th>OBSERVERS</th>
<th>DEPART CODES</th>
<th>P-CAR PARKED</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd St.</td>
<td>Marathon</td>
<td>Rodgers and Delay</td>
<td>C</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Delay Codes

- **0**: No delay
- **1**: Delay due to traffic control
- **2**: Delay due to incident
- **3**: Delay due to stop sign
- **4**: Delay due to pedestrian

#### Time of Day

- **0**: 5:00 am
- **1**: 5:30 am
- **2**: 6:00 am
- **3**: 6:30 am
- **4**: 7:00 am
- **5**: 7:30 am

#### Run Number

<table>
<thead>
<tr>
<th>RUN NUMBER</th>
<th>PED = PEDESTRIANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Delay Data

<table>
<thead>
<tr>
<th>TIME</th>
<th>DELAY 0</th>
<th>DELAY 1</th>
<th>DELAY 2</th>
<th>DELAY 3</th>
<th>DELAY 4</th>
<th>DELAY 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5:30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6:00</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6:30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7:00</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 14-3. Travel Time and Delay Study Field Data Form (Sheet Two)

<table>
<thead>
<tr>
<th>ROADWAY ID: S.R. 690</th>
<th>CITY: Wausau</th>
<th>COUNTY: Washington</th>
<th>LOCATION: Miller Road to Irondale</th>
<th>OBSERVERS: Rodgers and Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE: 8/14/9998</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TS = TRAFFIC SIGNAL</th>
<th>SS = STOP SIGN</th>
<th>LT = LEFT TURNS</th>
<th>DL = DELAY</th>
<th>DELAY CODES</th>
<th>P = PARKING CARS</th>
<th>C = CONGESTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELAY</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MINIPOST</th>
<th>LOCATION</th>
<th>DELAY</th>
<th>CODE</th>
<th>DL = DELAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>4:39</td>
<td>5.39</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>5:38</td>
<td>6.07</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>4:30</td>
<td>5.49</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>4:17</td>
<td>6.07</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>4:14</td>
<td>6.07</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>4:11</td>
<td>6.07</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>RUN</th>
<th>DELAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>117</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>124</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>124</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>124</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>106</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>106</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER DELAY CODES</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>120</td>
</tr>
<tr>
<td>5</td>
<td>120</td>
</tr>
<tr>
<td>6</td>
<td>120</td>
</tr>
</tbody>
</table>
stopwatch. A space for delay codes not listed in the Delay Codes section is provided at the bottom of the field form.

### 14.8 TRAVEL TIME AND DELAY STUDY FIELD SUMMARY FORM (FIGURE 14-4)

The Travel Time and Delay Study Field Summary (Form No. 750-020-19) should be completed as follows:

- **Miles (M)**: Distance in miles from one control point to the next.
- **Travel Time (TT)**: Time in seconds from one control point to the next.
- **Delay (D)**: The time in seconds of delay experienced from one control point to the next.
- **Totals**: The miles, travel time, and delay are summed vertically and written in the Totals area.
- **Running Time (RT)**: Total travel time minus total delay for each run.

#### 14.8.1 Calculated Control Point to Control Point Averages (Right Side of Summary Sheet)

- **Average Travel Time (ATT)**: \[ \frac{\text{Sum of TT}}{\text{Total No. of Runs}} \]
- **Average Travel Speed (ATS)**: \[ \frac{\text{M} \times 3600 \text{ seconds per hour}}{\text{ATT}} \]
- **Average Delay (AD)**: \[ \frac{\text{Sum of D}}{\text{Total No. of Runs}} \]
- **Average Running Time (ART)**: \[ \text{ATT} - \text{AD} \]
- **Average Running Speed (ARS)**: \[ \frac{\text{M} \times 3600 \text{ seconds per hour}}{\text{ART}} \]

#### 14.8.2 Calculated Route Averages (Bottom of Summary Sheet)

- **Total Trip Length (TTL)**: Total distance between all control points (miles).
- **Travel Time Total (TTT)**: Sum of travel times between control points for an individual run.
- **Average Total Travel Time (ATTT)**: \[ \frac{\text{Sum of all TTT's}}{\text{Total No. of Runs}} \] = Sum of ATT's
### Figure 14-4. Travel Time and Delay Study Field Summary Form

<table>
<thead>
<tr>
<th>City</th>
<th>Date</th>
<th>Weather</th>
<th>Observer</th>
<th>Run Number</th>
<th>Traffic Time</th>
<th>Delay</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>5</td>
<td>23</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>6</td>
<td>21</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Reedsport</td>
<td>5-4-1983</td>
<td>Clear and Warm</td>
<td>Rodgers and Gates</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total:**

- **Running Time:** 312.00
- **Average Total Travel Time:** 312.00
- **Total Trip Delay:** 312.00
- **Average Total Running Speed:** 312.00
- **Average Delay:** 312.00
- **Average Travel Speed:** 312.00

**Average Delay:** 312.00

**Average Total Running Speed:** 312.00

**Average Total Travel Time:** 312.00

**Average Trip Delay:** 312.00

**Average Delay:** 312.00
Average Total Travel Speed (ATTS) = \(\frac{TTL \times 3600 \text{ seconds per hour}}{ATTT}\)

Average Total Trip Delay (ATTD) = \(\frac{\text{Sum of D Totals}}{\text{Total No. of Runs}} = \text{Sum of AD's}\)

Average Total Running Time (ATRT) = \(\frac{\text{Sum of RT's}}{\text{Total No. of Runs}} = \text{Sum of ART's}\)

Average Total Running Speed (ATRS) = \(\frac{TTL \times 3600 \text{ seconds per hour}}{ATRT}\)

Once this data is collected, the results must be analyzed to determine the appropriate corrective measures. Refer to Section 14.10 for further information.

### 14.9 COMPUTERIZED METHOD

1. The computerized method requires a test vehicle, driver, observer, DMI, field forms, and an approved computerized system, including data gathering and data analysis software. A computerized system has been developed for speed and delay data collection and analysis. A program was developed for a vehicular on-board microcomputer which allows the computer to be used to collect real time speed and delay data. A key is pressed on the microcomputer as the test vehicle crosses a control point. This is recorded by the program which also records the time from an internal clock.

2. The microcomputer is connected to a DMI in the vehicle. Thus the computer program has constant input for each foot traveled by the vehicles and the time required to travel the distance. All the above data is recorded by the microcomputer for data analysis and the printing of a report.

3. From this data an analysis program determines the time spent stopped and the speed at any time or distance. The program is thus able to calculate average speed, running speed, amount of delay, number of stops, distance and time between traffic signals, fuel consumption, and miles per gallon.

4. This program produces a Traffic System Performance Evaluation on letter size paper which may be included in a report, the data can also be used to produce a speed profile. This evaluation gives the average speed and its 95 percent confidence range for each 50 foot increment of roadway. The legend is at the bottom of the page and the scale (mph) is at both the top and bottom.

5. These outputs must then be analyzed, and engineering judgement should be applied to the numbers and graphs to determine if problem areas exist. If they do, then the appropriate corrective action must be determined.
14.10 ANALYSIS

(1) Once the information is tabulated and calculated, the results must be examined. Engineering judgement should be applied in order to analyze the results and to determine any actions that can be taken to reduce delay and improve operational efficiency.

(2) Things to look for include:

(a) More than one stop between intersections. This may indicate interference with the traffic flow from sources other than traffic signals, possibly caused by traffic generators.

(b) Travel speed (average speed) significantly less than running speed. This could be caused by delay at the traffic signal or accesses.

(c) Delay significantly higher during peak versus off-peak periods. This could be caused by heavy cross street traffic during a peak volume at an intersection exceeding or close to capacity, lack of left turn lane storage capacity, etc.

(3) Typical solutions for delays would include turn lanes, turnouts, traffic signal retiming, and restriction of certain movements responsible for delay. The engineer must determine the best solution for each particular problem.

14.11 APPROVED COMPONENT OF COMPUTERIZED TRAVEL TIME AND DELAY SYSTEMS

14.11.1 TA88/MVRAP

The software for this system was developed for the Department by the University of Florida Transportation Research Center (TRC). This program is Y2K compliant with date adjustments. The equipment and software include the following:

- PC-compatible laptop computer.
- Vehicle equipped with a DMI.
- TA88/MVRAP software available from McTRANS.

14.12 FORMS ACCESS

Reproducible copies of the Travel Time and Delay Study Field Data (Form No. 750-020-14) and the Travel Time and Delay Study Field Summary (Form No. 750-020-19) are in the Appendix. These forms are also available in the Department’s Forms Library.