Chapter 13 Presentation Script

Welcome

Welcome to the Manual on Uniform Traffic Studies, also called MUTS, computer-based training!

This training module will cover Chapter 13 – Travel Time and Delay Study.

This training contains audio, so please adjust your speakers accordingly.
An alternate version is available on the Resources page.
To begin select the start button or press Shift + N on your keyboard.

Introduction

During this training module, we will refer to two forms in excel format stored on the MUTS online library through the FDOT's Traffic Engineering and Operations Office website.

Before continuing the training, consider scanning the QR code using your phone camera which directs you to the online library shown in this slide.

The link to the forms is also provided in the resources page to this training.

Please open Forms number 750-020-14 and 750-020-19 as we will refer to them later in the module.

This training module will discuss the purpose of travel time and delay studies.

We will also cover key definitions, available methods, field procedures, and relevant forms to conduct a travel time and delay study.

The purpose of a travel time and delay study is to evaluate the quality of traffic movement and identify the extent and location of the delays.

The outcome of a travel time and delay study can be used to prioritize projects by comparing operational deficiencies.

The outcome can also be used to perform before and after studies on roadway and intersection improvements.

Definitions

The following section will walk through the key definitions used for a travel time and delay study.

The next slides provide definitions along with schematics to explain these key terms.

The purpose of a control point
is to define the limits of the travel time and delay study and individual link.

There are two types of control points, a special control point and a control point.

A special control point represents the beginning or end point of the study route.

Special control points must be located outside the influence of a signal
or other roadway feature that may cause delay.

When passing a special control point, the vehicle must be at the normal operating speed for the route.

Now let's discuss the control point.

The control point is a node that represents the beginning or end of a link.

A control point is usually located at the stop line of a signalized intersection,
but can be any physical feature that is easily identifiable.

The placement of control points should be as consistent as possible throughout the corridor.

The diagram shows a potential route configuration for a travel time and delay study.

The trip length, depicted from the special control points, is the total corridor distance in miles.

The trip length also equals the sum of each individual segment.

The distance, depicted by the brackets, is the length of a single link or segment.

Using the schematic, let's walk through stop and travel time.

A stop is the number of times that the test vehicle's speed falls below 5 miles per hour.

Stops can be categorized per link or per run.

Another stop is not recorded unless a vehicle reaches a minimum speed
defined by the Highway Capacity Manual 6th Edition.

Travel time is the total time elapsed along a specified distance.

In this example, the specified distance is the two special control points at the light poles.

As the vehicle travels down the roadway, it stops at both traffic signals.

The travel time includes the time stopped at a signal.

In this example, there are two stops, and the travel time is 18 seconds.

Delay is the additional travel time experienced by the user due to stops.

For the purposes of this chapter, delay is the length of time that a motorist has a travel speed between 0 and 5 miles per hour.

In this example, the car stops at the first light and the stopwatch begins to measure delay.

As the car accelerates from the stop, the stopwatch stops counting delay.

When the car stops at the next stop, the delay count is resumed.

In this case, the delay due to stops is 5 seconds.

The running time is the time it takes for the vehicle to travel and excludes delay.

Mathematically, it is calculated by subtracting the delay from the travel time.

It can also be calculated by using a stopwatch when the car is traveling above 5 miles per hour.

Once the car stops, the stopwatch is paused, and as the car continues again, the stopwatch is resumed.

In this example, the travel time is 18 seconds.

The fuel consumption rate is the miles per gallon of fuel that a car uses in a run.

This rate is determined by the length of the run, total delay, and the effects of acceleration and deceleration.

The fuel consumption rate calculation is computed using a mathematical model.

The travel speed or average speed represents the vehicle’s average speed over a distance.

This speed includes the delay.

The travel speed is calculated by dividing the distance by the travel time.

The running speed is the vehicle’s average speed while in motion and does not include delay time.

The running speed is calculated by dividing distance by running time.

Procedures

Now that we have defined the key terms,
let's take a look at the study procedures for a travel time and delay study.

There are three methods to conduct a travel time and delay study
which include the test vehicle method, vehicle observation, and probe data.

Before a study is conducted, the route should be selected.

First establish the study limits by selecting the special control points,
then select control points throughout the route in addition to the time period.

Generally, the A.M. or P.M. peak periods are used to conduct a travel time and delay study.

When conducting a travel time and delay study,
there should be no unusual conditions such as poor weather or crashes.

If these occur, then the run should be excluded from the data.

Let's compare the three data collection methods.

The test vehicle method drives the route and can record the most detailed travel time and speed data.

Both vehicle observation and probe data
require datasets or hardware from vendors or the Federal Highway Administration.

Both the vehicle observation and probe data will require pre- and post-processing of the data.

Detailed level stop data is unavailable using probe data.

Only overall travel time data is available to develop an understanding of the corridor.

Each method will be discussed in further detail later in the module.

The test vehicle method is one of the methods available to conduct a travel time and delay study.

The test vehicle method is widely used on arterial streets.

There is a minimum of 1-mile in total route length required to use the test vehicle method.

There are three possible techniques for the test vehicle method:
the average-car, floating-car, and maximum-car.

Let's take a closer look at these techniques.

Using the average-car method, the driver of the test vehicle
maintains a speed that is the average speed of the traffic stream.

Using the floating-car method, the test vehicle driver passes by as many vehicles
that pass the test vehicle.

The floating-car methods emulates the median driver for each section of roadway.

Using the maximum-car method, the driver travels the posted speed limit
unless impeded by safety considerations or observed traffic conditions.

When conducting a travel time and delay study, there are two data collections manual and automatic.

The equipment and personnel for the manual data collection method includes the following:

A test vehicle with a driver and an observer.

Form number 750-020-14 digitally or printed.

Two stopwatches.
One stopwatch to record overall travel time and the other stopwatch to record delay.

A distance measuring instrument or odometer.

Optional supplemental equipment includes a video camera or voice recorder.

Now let’s discuss performing manual data collection using a test vehicle.

Before using the manual data collection when conducting a travel time and delay study,
the practitioners must select the control points and measure the distance between them.

Then, a dry run of the study area should be conducted to practice the route.

As the study is conducted, the observer will record travel time and delay on the form.

We will go into detail about how to record data using the form later in the training module.

An alternate method to collect data using a test vehicle is the automatic data collection method.

The equipment and personnel for the automatic data collection method includes the following:
A test vehicle with a driver, a GPS system, any relevant field notes,
and an approved computer software.
[cont.]

Like with manual data collection,
a video camera or voice recorder can be used to supplement the data collection.

Now let's discuss using automatic data collection for a test vehicle run.

Before using automatic data collection, the control points using the GPS computer software should be selected, GPS should be calibrated, and a dry run should be conducted with the test vehicle and a driver.

During the travel time runs, computer software automatically calculates the relevant metrics such as travel time and delay.

The practitioner should always review and verify the outputs from the computer program against the field review notes.

Now we will discuss additional data collection methods.

The vehicle observation method is an alternative method to determine the travel time and delay.

There are multiple methods to conduct vehicle observation,
including the wireless technology method and the cellular telephone observation method.

The wireless technology method uses time and position data from GPS-enabled vehicles.

To use this method, a GPS dataset needs to be obtained.

Some pre-processing of the data may be required such as categorizing into days of the week.

The cellular telephone observation method collects Bluetooth and/or Wi-Fi addresses from readers.

To conduct this study, hardware needs to be obtained through vendors like BlueMac or BlueToad.

There is a minimum of two readers required,
and the analyst may need to filter the data depending on quality.

When using the cellular telephone observation method, only travel time will be the output,
stop delay or running time is typically unavailable.

For both studies, refer to MUTS Chapter 7 for the number of weeks of data required.

Using probe data is another alternate method to conduct a travel time and delay study.

The probe data is aggregated location data from commercial vendors. *[cont.]*

Roadways on the National Highway System have probe data available free of charge.

Since the data is aggregated, detailed vehicle movement like number of stops is unavailable.

When using the probe data, the relevant data should be filtered.

Data filtering can include day of the week and time of day.

The median travel time should be calculated.

This calculation can be completed in excel or another statistics program.

The median travel time is then converted to travel speeds.

This calculation, using travel time and distance traveled, helps reduce the effect of outliers and closely reflects the space-mean speed obtained via floating cars.

If free flow conditions are required,
15^{th} percentile travel time can be used to represent free-flow conditions.

The 15^{th} percentile travel time speed can be calculated in excel or another statistics program.

Please refer to MUTS Chapter 7 for the minimum data collection required.

When conducting travel time and delay studies, there is a minimum sample size requirement suggested by the ITE Manual of Transportation Engineering Studies 2^{nd} Edition.

The steps to determine the number of samples required are to estimate the number of initial test runs; followed by conducting the initial test runs and calculating the speed difference or “R-bar.”

After the speed differential is calculated, MUTS Figure 13-1 is used to determine if additional runs are required using the “R-bar” column along with the permitted error.

The permitted error is determined from the MUTS Table 13-1 based on the study’s context.

The following slides will walk through an example in determining the sample size.

There has recently been a new pavement treatment implemented on an arterial roadway.

We previously conducted a travel time and delay study before the pavement treatment was installed.

We will be conducting a travel time and delay study on the new pavement treatment with the purpose of comparing safety performance of the treatment.

In this case, what would the permitted error be?
[cont.]

Using the MUTS Table 13-1, the study purpose is a before and after study which means the permitted error is between plus or minus 1 to 3 miles per hour.

Looking at the table footnotes, a safety study has a permitted error of plus or minus 2 miles per hour, therefore the permitted error is plus or minus 2 miles per hour.

Now that we have the permitted error of plus or minus 2 miles per hour, we can determine the number of minimum runs.

For this example, the assumed confidence level is 95%.

From MUTS Figure 13-1, the lower end of the required samples with a permitted error of 2 miles per hour is around 4 to 6 runs.

Therefore, the initial number of runs should be between 4 and 6.

After the initial runs were completed, the maximum speed was determined to be 34 miles per hour and the minimum speed was 25 miles per hour.

The speed differential was calculated to be 9 miles per hour.

Now we have all the required variables to determine the minimum number of runs required.

Now we look at the column that has a permitted error of 2 miles per hour and the row that has an “R-bar” of 9 miles per hour.

Using the permitted error of 2 miles per hour and the speed differential of 9 miles per hour, the total runs required is 11.

The total number of runs include the initial runs already conducted.

Let’s take a look next at when the runs should be conducted.

Generally, the runs occur during the AM or PM peak periods.

Across all travel time runs the field conditions should remain consistent;
the sample runs represent a single set of conditions.

Depending on the number of runs required,
multiple observers conducting travel time runs may be necessary.

Ultimately, the number of observers will vary based on the project scope and length of the corridor.

The key takeaway is that all travel time runs must be conducted under consistent field conditions.

Forms and Examples

The slide shows a blank Form number 750-020-14,
consider scanning the QR code located on the top right corner
using your phone camera to access the online library to access a copy of the form.

Before conducting a travel time and delay study,
the relevant information should be filed out in the header.

Each location for a control point should be filled out in the corresponding fields.

During the travel time and delay study, there are different suggested delay codes shown in the form.

These codes should be used for the relevant delay that occurs in the field.

The cumulative travel time during each run should be filled out for the relevant control point
and the process should be repeated during each run.

The slide shows a blank Form number 750-020-19.

The first item to fill out in the form is the header.

After the travel time and delay study is completed using Form number 750-020-14,
the field data is transferred to this form.

The metrics to the right and bottom of Form number 750-020-19
are automatically calculated from the input data.

The following slides will demonstrate how the metrics are calculated.

As previously mentioned, Form number 750-020-19
automatically calculates metrics from the input cells.

This slide focuses on the metrics to the right of the form.

These metrics are control points averages over all the runs.

First the average travel time, or ATT,
is calculated by dividing the sum of travel time by the total number of runs.

The average travel speed, or ATS, is calculated by taking the segment length
multiplied by 3600 seconds per hour and dividing by the average travel time measured in seconds.

The average delay, or AD, is calculated by summing the delay
and dividing by the total number of runs.
[cont.]

The average running time, or ART, is calculated by subtracting the average delay
from the average travel time.

The average running speed, or ARS, is the segment length measured in miles
multiplied by 3600 seconds per hour divided by the average running time.

The speed metrics are output in miles per hour.

The same process will now be shown with the metrics at the bottom of the form.

These metrics are totals and averages across all control points and runs.

The total trip length, or TTL, is the sum of the distances between all control points measured in miles.

The total travel time, or TTT, is the sum of all travel times between control points for an individual run.

The average total travel time or, ATTT, is the sum of all total travel times
divided by the total number of runs.

It is equivalent to the sum of the average travel times.

The average total travel speed, or ATTS, is the total trip length multiplied by 3600 seconds per hour
divided by the average total travel time.

The average total trip delay, or ATTD, is the sum of the total delay over the total number of runs.

It is equivalent to the sum of average delays.

Average total running time, or ATRT, is the sum of running times, or RT,
over the total number of runs.

It is equivalent to the sum of all average running times.

The average total running speed, or ATRS, is the total trip length multiplied by 3600 seconds per hour and divided by the average total running time.

Now that we know the background calculations,
let’s walk through an example of a travel time and delay study.

Before conducting a travel time and delay study,
select and measure the distances between all the control points.

Input those measurements into Form number 750-020-14.

Then, conduct a travel time run.

Record the travel time and delay field data into Form number 750-020-14.
[cont.]

Repeat steps 3 and 4 until all runs are completed
which is determined by the sampling requirements previously explained.

After all runs are completed, summarize the data from Form number 750-020-14
to Form number 750-020-19 which will automatically calculate the metrics.

The image shown depicts the configuration
where we will complete the example travel time and delay study.

In total, we will have 4 control points.

Now, we need to measure the distance between the control points.

We calculate the respective milepost number of each control point by adding the distance the previous milepost value and these are recorded into Form number 750-020-14 which is shown below.

Now that we have the relevant distance measurements,
we are ready to conduct a travel time and delay study.

Be sure to input the control post mileposts into Form number 750-020-14
before conducting the study.

Now we will watch an animation of an example travel time and delay run in the eastbound direction.

Assume east is to the right of the slide.

The test vehicle is the vehicle in red headed east.

As the test vehicle passes control point 0, start the travel time stopwatch.

Once the vehicle stops due to a red light, start the delay stopwatch.

As the test vehicle crosses control point 1, record the travel time and delay.

The delay was caused by a traffic signal, so the code TS is used.

At the second intersection, the test vehicle stops for a leading eastbound

right-turning vehicle yielding to a pedestrian crossing

and the delay stopwatch is started.

Once control point 2 is passed, record the delay and travel time again

in the corresponding columns.

The delay was caused by a pedestrian, so the code “PED” is used.

When the vehicle passes control point 3,

only the travel time is recorded since no delay occurred on this segment.

We will now transfer the results from the travel time run
from Form number 750-020-14 into Form number 750-020-19.

First, we need to calculate the lapse to get the travel time between each control point.

The lapse is the time difference between control points calculated by the equation shown.

The lapse is calculated for each control point value.

Now we are ready to transfer the data into the Form number 750-020-19.

The results transferred are shown in the bottom table.

Note that the trip length between the control points is used and not the cumulative milepost value.

After inputting the results into the Form number 750-020-19 electronically,
we obtain the relevant metrics for our run.

These metrics are automatically calculated based on our inputs.

The average travel speed for the run overall was 26.9 miles per hour.

This concludes the travel time and delay example.

In this module, we discussed the purpose of a travel time and delay study and walked through key definitions.
We discussed the study procedures and different data collection methods which include the test vehicle method, vehicle observation, and probe data.
We also covered the different techniques and data collection methods for the test vehicle.

Lastly, we discussed the digital forms and provided an example for a travel time run application.

End of Lesson

This concludes the Manual on Uniform Traffic Studies computer based training, Chapter 13 - Travel Time and Delay Study.

[Web]

You will now be directed to a 10-question quiz to test your knowledge and understanding on the material presented in this computer-based training.

A passing grade of 70% is required to obtain the Certificate of Completion for the training.
[cont.]

If a grade below 70% is obtained, the trainees are required to re-take the full training until a passing grade of 70% or higher is obtained.

If you do not pass the quiz, please return to the Index page by selecting the Index button below and re-take this training.

Once you’ve received your certificate, please continue to the next chapter by selecting the “NEXT” button below this CBT.

On the next slide, please read the directions carefully before continuing to the quiz.

Thank you for your time and attention.

[LMS]

You will now take a 10-question quiz to test your knowledge and understanding on the material presented in this computer-based training.

A passing grade of 70% is required to obtain the Certificate of Completion for the training.

If a grade below 70% is obtained, the trainees are required to re-take the full training until a passing grade of 70% or higher is obtained.

If you do not pass the quiz, please return to the Course Content tab and re-take this training.

You will receive your certification after completing the full MUTS training and passing the quiz for each chapter.

Please continue to the next chapter by returning to the MUTS course content tab and selecting the next chapter in the training.

On the next slide, please read the directions carefully before continuing to the quiz.

Thank you for your time and attention.