Chapter 2 Presentation Script

Welcome to the Manual on Uniform Traffic Studies, also called MUTS computer based training! This training module will cover Chapter 2 - Traffic Signal Study Procedure.

The information in this chapter has been adopted from the Manual on Uniform Traffic Control Devices or MUTCD and the Intersection Control Evaluation, or ICE, Manual.

To get started, we will share more detail on the purpose of the Traffic Signal Study Procedure and the elements to consider in order to complete the study.

MUTS Chapter 2 provides an overview of the logical and systematic data collection procedure for investigating traffic signal requirements.
The data and procedure outlined in this chapter are designed to minimize the data collection effort and reduce the number of field reviews.

This chapter also provides guidance for determining the installation of a new traffic signal or the need for operational improvements of an existing traffic signal. When conducting these studies, make sure to download the latest excel available through the website.

Figure 2-1, found in the MUTS, provides an overview of the study procedure steps included in this chapter. Let's take a closer look into the different steps **through** this flow chart.

The procedure begins with an alleged problem that has been brought to the engineer.
The engineer should then conduct a field review to observe the problem
followed by a traffic Signal Warrant Analysis.
The next half of the flow chart will describe the report process once the Signal Warrant Analysis is completed.

If a signal is warranted, the engineer will conduct an Intersection Control Evaluation or ICE analysis which will include the conceptual design of the proposed solution. The proposed solution will then go through the traffic regulation approval process and the plans preparation process, simultaneously.

If approved, the solution will move into implementation
followed by the education/information dissemination process.
If a signal is not warranted, the procedure will move directly into the education/information dissemination process.

Let's take a closer look at the first step in the procedure: learning about the problem.

The first step is learning of an alleged problem.
When notified of a problem, the engineer is required to respond to the notice regardless of its source.

Once notified, the engineer should conduct a field review of the site to determine if a full-scale investigation is required.
Once an observation is conducted, the engineer should notify the reporting party of the action to be taken.

The next step in the process involves observation of problem symptoms.
Let's take a closer look at the intersection elements.

During the field review the engineer should observe and record the operational and geometric characteristics of the location as well as any unusual or significant circumstances. A condition diagram should be created or updated to record site characteristics.

Operation conditions should be observed and documented during the time that operational issues were reported to have occurred.
Photographs and video should be used to document observations.
Following the completion of the field review the engineer should determine if a real problem exists or if no further investigation is needed.
The engineer should notify relevant parties of the action to be taken.

The purpose of a Condition Diagram is to record relevant site information for analysis.
The Condition Diagram should include the location of existing traffic signal control devices, intersection geometry, and other physical features.
Further details on preparing a Condition Diagram are provided in MUTS Section 5.4.2.

Figure 2-2, found in the MUTS, provides greater detail into the study procedure.
We will break the chart down into three sections and discuss its content in detail in the following three slides.

Once a problem has been determined, the basic areas of concern should be established to understand the issues. These can include vehicle operations, pedestrians, and / or crashes.
Once the issues are understood, relevant data should be collected for evaluation.
This data can include but is not limited to turning movement counts, pedestrian demand, historical crash data, vehicular delay, and available gaps.
This step is followed by the Traffic Signal Study Report which contains the Traffic Signal Warrant Analysis.

If a traffic signal is warranted, the ICE analysis procedure should be applied.
The first step for the ICE analysis is to go through the ICE applicability criteria at the study intersection.

Under ICE Stage 1, the engineer will determine viable intersection improvement alternatives to advance to ICE Stage 2.
Signalized intersection improvement alternatives can include options such as the Restricted Crossing U-turn or R-CUT or the Median U-turn or MUT.

During ICE Stage 2 **the** engineer conducts a more detailed evaluation of the viable intersection alternatives which includes initial concept development.
Typically, the preferred alternative is selected during the ICE Stage 2 analysis.
At the conclusion of the ICE analysis, a preferred alternative conceptual design and report should be developed and submitted for review.

If the conceptual design and report are approved, the recommended solution should be moved into implementation.
As a final step, the engineer should evaluate the need to educate stakeholders, road users, and community members regarding the improvement being implemented.

We will now discuss and dive deeper into understanding how to establish the basic areas of concern for the study intersection.

When conducting a traffic signal study, there are three basic areas of concern: vehicle operations, pedestrians and bicyclists, and crashes.
It is important to recognize that the observed issue may be a result of more than one basic area of concern.

MUTS Chapter 3 provides additional detail on each of the traffic signal warrants.
Warrants relevant to vehicle volumes and operations are discussed MUTS Section 3.5, 3.6, and 3.7 regarding M-U-T-C-D signal warrants 1, 2 and 3.
MUTS Sections 3.8 and 3.11 discuss M-U-T-C-D signal warrants 4 and 7 relevant to pedestrian volumes and activity.
MUTS Section 3.11 discusses M-U-T-C-D signal warrant 7 relevant to crashes.

Let's take a closer look into vehicle operations as an area of concern.
Vehicle operations issues such as excessive queue lengths, slow queue dissipation rates, and substantial traffic volumes can usually be identified during a field investigation and data collection.

Typical data collected to determine the extent of a vehicle operations concern includes hourly approach volumes, distance to the nearest signal, intersection delay, and travel time and delay.

The second area of concern is pedestrian and bicycle issues.
Although pedestrian and bicycle issues can be identified during a field review, it is difficult to ascertain the severity of the issue without additional data collection.
Typical data collected to determine the extent of pedestrian and / or bicycle issue includes non-motorized volume studies, gap studies, distance to the nearest crosswalk or signalized intersection, pedestrian characteristics, and walking speed studies.

Walking speed studies, including procedures to evaluate and determine appropriate walking speeds, are further discussed in MUTS Section 9.6 as well as Section 3.11 as part of Traffic Signal Warrant 7: Crash Experience.

The third area of concern is crashes.
It is often difficult to determine an intersection's crash potential during a field review.
Nonetheless, engineers have to leverage the available data.
A review of historical crash records should be conducted to gain insight on potential crash frequency at the study intersection.

The number of years that are needed for review will be determined based on the existence of any recent projects at the site.
A minimum of five years of historical crash data should be reviewed, but engineering judgement should be used to determine the required number of years if a major change to the site has occurred.

There are many types of data that can help an engineer further define a crash problem.
The following are some types: historical records of recent projects or treatments,
as well as existing or proposed projects, hourly approach volumes,
crash records and / or crash rates, a collision diagram, pedestrian volume counts,
a vehicle spot speed study, intersection geometry including sight distances,
pavement conditions, roadside hazards,
existing guidance through signing and pavement marking, existing roadway lighting,
and a traffic conflict investigation.

It is important to understand the crash types that may be experienced at the study intersection.
Note that the typical crashes susceptible to correction by a signal include angle, left turn,
and sideswipe in some cases.

Some examples of remedial measures include advance warning signs
of unsignalized intersections and realigning available lanes.
Refer to MUTS Section 2.4.3 for additional guidance on resources for each of these elements.

Once the data is collected, the next step is data analysis and interpretation.

Following data collection, a traffic signal warrant analysis should be conducted to understand
if a traffic signal is warranted.
This analysis can be completed using Form Number 750-020-01,
Traffic Signal Warrant Summary.

The two captures shown are the input tab from this form;
MUTS Chapter 3 and its corresponding computer-based training
will cover in detail the application of this form and its features.
Once the warrant analysis has been completed, ideally using Form Number 750-020-01
or a similar tool, and a traffic signal is warranted,
engineering judgement should be used to determine if a traffic signal should be installed.

Consideration should be given to understand if a traffic signal would create greater problems than it would solve.
Considerations should include development of excessive queues, queue dissipation rates, spacing between adjacent signals, intersection geometry, public transportation, distance between pedestrian crossings, and signal timing.

Consider the situation at the intersection of Main Street and a commercial business driveway.
A relatively minor volume exits and enters the driveway,
but the volumes do meet the 70% threshold for Warrant 2 - Four-Hour Vehicular Volume.
A traffic signal is warranted due to meeting Warrant 2,
but the traffic signals adjacent to the driveway provide good platooning of vehicles on Main Street.

Due to the platooning, there are sufficient gaps in traffic and the delays for vehicles coming from the commercial business driveway are low.
In this case, engineering judgement should be applied to determine if the benefits for the relatively minor volume at the commercial business driveway outweigh the cost of delay increase for the major movement.

In another example, consider a new development that is being built along Main Street.
The phased development is approximately 30% built out.
The existing volumes do not meet warrants, but the projected future volumes at build out meet Warrant 1 and Warrant 2 for the 100% volume threshold.

The developer requested that a signal be installed based upon the projected future volumes.
In this case, engineering judgement should be applied to determine if a traffic signal should be installed when the existing volumes do not meet warrants and the development may never reach full build-out.

As a result, it is suggested to design the intersection to accommodate a signal in the future.
The construction of the signal would only happen if the future development occurs.

FDOT's Intersection Control Evaluation or ICE is a methodology developed
to evaluate control alternatives at intersections.
If signal warrants are met on a state roadway,
ICE is required to determine which kind of control is best for the intersection’s context.

The following list provides situations when ICE is required:
when new signalization is proposed, when an existing signalized intersection
undergoes major reconstruction such as adding exclusive left turns or adding intersection legs,
when converting from a directional or bi-directional median opening to a full median opening,
as part of driveway and connection permit applications for Category E, F, and G,
and when the District Design Engineer and District Traffic Operations Engineer
consider ICE to be a good fit for the project.

In contrast, ICE is not required for the following situations:
when work does not include substantive changes such as milling and resurfacing,
when an existing signalized intersection undergoes minor reconstruction
such as adding a right turn lane or signal phasing improvements,
or when work is being done on a local roadway.
ICE is not required but is recommended at ramp terminal intersections.

The purpose of ICE is to consistently consider multiple context-sensitive control strategies when planning a new or modified intersection.
The goal is to better inform FDOT's decision-making process to identify and select a control strategy meeting the project's purpose and need, fitting the intersection location's context classification, providing safe travel facilities for all road users, and reflecting the overall best value.
ICE is broken into three stages.

Stage 1 is a Screening process completed during a project's initial stage.
This stage reviews existing conditions and evaluates viable alternative intersection forms at a planning level.

There are two tools provided for this analysis.
For the operations analysis, Capacity Analysis for Planning Junctions or CAP-X is used.
For the safety analysis, Safety Performance for Intersection Control Evaluation or SPICE is used.

Stage 2 is a Preliminary Control Strategy Assessment completed following a project's initial stage when more detailed information is available.
This stage involves detailed operations and safety analysis to conduct a benefit-cost comparison of the viable alternative intersections.

The Analysis Guidance shown on this slide is the concept development of the Stage 2 control strategies to be included in preliminary construction and right-of-way cost estimates.

More detailed operations analysis is done using FDOT Synchro templates developed for the different control strategies.
SPICE is analyzed at a greater detail and uses existing crash history in the analysis.
The FDOT ICE Tool uses the operations and safety results for the benefits analysis and the construction, right-of-way, and operations & maintenance costs to conduct the benefit-cost and net present value analysis.
Typically, the ICE analysis will identify a preferred control strategy with the completion of Stage 2.
If not, Stage 3 is conducted.

Stage 3 is a detailed control strategy assessment completed to answer the reason why Stage 2 was not approved.

This stage is an extension of Stage 2, digging further into any necessary details and analysis to find the most viable solution.
There are no additional tools in Stage 3.

ICE trainings have been conducted for each FDOT district around the state.
Materials were developed for the trainings and have been made available on FDOT's website to aid engineers in learning the basics of the process.
Additionally, the corresponding ICE resources and tools can be obtained from the FDOT's Traffic Engineering and Operations Office website shown on the slide.

Preparation and Approval of Traffic Signal Study Report.
Many of the ICE control strategies may result in the installation of a traffic signal.
This report is required whether the ICE procedure's preferred alternative is a traffic signal, Restricted Crossing U-turn, Median U-turn,
or another control strategy requiring a traffic signal.

Proper documentation of all activities taking place from the initial allegation of a problem through the warrant analysis is required.
A traffic signal study report including the following elements should be prepared:
a cover and title page that is signed and sealed,
a description and aerial image of the study intersection,
and an Existing Conditions Diagram.

Additional report elements may include Crash Analysis and Collision Diagram, discussion of the Signal Warrant Analysis, and discussion of the ICE analysis including approved Stage 1 and Stage 2 ICE Forms
showing the traffic signal installation is the preferred alternative and the type of control strategy being a standard signalized intersection, Restricted Crossing U-turn, Median U-turn, or another control strategy requiring a traffic signal.

Discussion of the Traffic Operations Analysis conducted, recommendations, and all other relevant supplemental information are part of the preparation and approval of the study.

There are four potential outcomes of a traffic signal study.
Case one is that no problem exists and therefore no traffic signal is warranted.
Case two is that a problem exists, but the solution is not a traffic signal.
Case three is that a problem exists, and a traffic signal will correct or reduce the problem.
Case four is that a problem exists and a traffic signal in conjunction with other improvements will correct or reduce the problem.

If the outcome of the study is case one, no problem exists, the study should end and the party initiating the request should be notified.
If the outcome is case two, a problem exists, but a signal is not the solution, the study should end and another study should be initiated to resolve the problem.

If the outcome of the study is case three or case four,
a problem exists and a signal is the solution or a problem exists and a signal in conjunction with other improvements is the solution, the ICE process should be initiated to resolve the problem.
A new signal installation may change the intersection's control strategy to a different intersection form such as a Restricted Crossing U-turn or Median U-turn.

An example of case four could be an intersection that meets signal warrants and has high pedestrian crossing volumes along the segments adjacent to the study intersection. An alternative to a signalized intersection could be a Restricted Crossing U-Turn called a R-CUT. This alternative would provide the traffic signal at the main intersection as well as two signalized U-turn locations located on the segments adjacent to the main intersection.

The signalized U-turns can provide **signalized** pedestrian crossings to help meet the pedestrian crossing demand. Further, when the Restricted Crossing U-turn is the ICE preferred alternative, the traffic signal warrant analysis for the main intersection justifies signalization of the U-turn signals. No further signal warrant analysis is required.

The step to follow includes the development of conceptual design for the proposed improvements and signalization.

Once a new traffic signal or modifications of an existing signal have been justified, conceptual design should be completed. The following elements should be included in a traffic signal design conceptual report: data collection, alternatives development, alternatives evaluation, selection of the best alternative, and identification of the design improvement.

Each element is part of the ICE procedure. Stage 1 includes data collection and alternative development while the alternatives evaluation, selection of the best alternative, and identification of the design improvement are typically part of Stage 2.

The final step once data collection, analysis, and reporting are completed is the preparation and approval of a traffic signal conceptual design report.

Upon completion of the conceptual design process,
a traffic signal conceptual design report should be prepared.
At a minimum, the report should include: the elements of a traffic signal study report,
additional data collected, **a** description of alternatives, **a** description of analyses conducted,
and the engineer's recommendations.

Additionally, the report should include work to be performed, the maintaining agency,
the enforcement agency, copies of resolutions and agreements,
and approval of the recommended concept.

If ICE was conducted as part of the analysis the approved Stage 1 and Stage 2 ICE Forms
with the applicable supporting documentation should be included.
The report should be provided to the engineers responsible for the preparation
of the traffic signal plans and for conducting the necessary steps
of the traffic regulation approval process.

Consider the example intersection of US 1 and Reba Avenue.
This location met signal warrants 1, 2, 3, and 7; therefore, ICE was applied
to determine which intersection control type was most applicable for the existing characteristics.

Following the completion of ICE Stage 1 and Stage 2, the partial Median U-Turn
was selected as the preferred alternative based on safety and operations results.
Implementation of the partial median U-turn at US 1 and Reba Avenue
would provide an additional signalized pedestrian crossing at the signalized U-turn
located south of Reba Avenue.

It is important to note that the partial and full Median U-Turn
as well as the Restricted Crossing U-Turn do not require signal warrants
to signalize the U-turn intersections.

Implementation is the remaining step to complete the task and carry it through completion.

Implementation of the improvement should take place
as soon as possible after the project development and design report are completed.
Following implementation, the engineer should visit the site to determine if the traffic signal is operating as designed.
This evaluation may require additional data collection.

This concludes the Manual on Uniform Traffic Studies computer based training,
Chapter 2 - Traffic Signal Study Procedure.

[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.
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 enter your first and last name 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.
Once you've passed the quiz and received your certificate please continue to the next chapter by returning to the MUTS course content tab and selecting the next chapter in the training.
Please, continue to the quiz and thank you for your time and attention.

Chapter 3 Presentation Script

Welcome to the Manual on Uniform Traffic Studies, also called MUTS, computer-based training!
This training module will cover Chapter 3 - Traffic Signal Warrant Summary.

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.

During this training module, we will refer to one form 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 Q-R code using your phone camera which directs you to the online library pictured.
When conducting these studies,
make sure to download the latest excel form available through the website.

The link to the forms is also provided in the resources page to this training.
Please open Form number 750-020-01 as we will refer to this form later in the module.

The information in this chapter has been adopted from the Federal Highway Administration or FHWA Manual on Uniform Traffic Control Devices also known as MUTCD.

MUTS Chapter 3 presents a detailed guide of the procedure to complete a Traffic Signal Warrant analysis.

The chapter content covers what data is necessary to complete the analysis and how to use the summary spreadsheet for analysis documentation.

Traffic signals should not be installed unless one or more of the nine warrants are satisfied. Meeting one of the nine warrants is a minimum requirement and does not necessarily justify or mandate a traffic signal, engineering judgement should be applied.

A warrant is only effective when combined with knowledgeable judgement considering all pertinent facts. This is discussed in greater detail in MUTS Chapter 2, Traffic Signal Study Procedure.

The Traffic Signal Warrant Summary form provides a procedure to determine input into the decision of whether conditions at an intersection warrant the installation or the continued operation of a traffic signal.

A traffic signal warrant is a set of criteria used to define the relative need for, and appropriateness of a particular traffic control device.
Warrants are usually expressed in the form of numerical requirements, such as the volume of vehicular or pedestrian traffic.
A warrant normally carries with it a means of assigning priorities.

There are two fundamental concepts involved in this determination.
The first concept is that the most effective control device is the least restrictive while still accomplishing the intended purpose.
The second concept is that driver response to the influences of a traffic control device has been previously identified by observation, field experience, and laboratory tests under a variety of traffic and driver conditions.

A traffic signal warrant is a guideline and engineering judgement should be applied when determining if a traffic signal should be installed.
Refer to Section 1A.09 of the MUTCD for further detail.

Next, we will look at the Traffic Signal Warrant Summary, a tool developed to aid practitioners in completing a signal warrant analysis.

The nine traffic signal warrants include: Warrant 1 - Eight-Hour Vehicular Volume,
Warrant 2 - Four-Hour Vehicular Volume, Warrant 3 - Peak Hour,
Warrant 4 - Pedestrian Volume, Warrant 5 - School Crossing,
Warrant 6 - Coordinated Signal System, Warrant 7 - Crash Experience,
Warrant 8 - Roadway Network, and Warrant 9 - Intersection near a Grade Crossing.
We will discuss each of these warrants in greater detail during this training.

Form number 750-020-01 is recommended to be used to complete a traffic signal warrant analysis.
The first tab of the form is the Instructions & Input tab.

Throughout the form, two color cells are used to denote the following:
orange highlighted cells and checkboxes must be filled in by the user when highlighted in this color.
And blue highlighted cells denote user input has been completed
either manually filled in by the user or automatically populated from earlier data input by the user.

The Traffic Signal Warrant Summary updated form **includes** a column to input up to eight hours
of pedestrian crossing data, used for consideration in Warrant 7.

Throughout this training, we will use the unsignalized intersection of Main Street and 5th Avenue
as an example to work through the Traffic Signal Warrant Summary form.
The intersection of Main Street and 5th Avenue along with the associated intersection characteristics
have been generated for the purposes of this analysis as a hypothetical case.

For this example, we will assume there is a nearby school with students crossing Main Street
on the north leg of the intersection.
There is also an at grade railroad crossing on 5th Avenue on the east leg of the intersection.

To complete the signal warrant analysis, we begin with filling out the Instructions & Input tab.
Intersection general input data should be recorded at the top of the form
including location, number of major and minor street lanes,
and major and minor approach speeds with either the posted speed limit
or 85th percentile speeds.
Considering our intersection for today's training,
Main Street is the major street and 5th Avenue is the minor Street.

Main Street is a four-lane roadway with two through lanes in each direction.
5th Avenue is a two-lane two-way roadway with one through lane in each direction.
The posted speed limit on Main Street is 45 miles per hour and the posted speed limit
on 5th Avenue is 30 miles per hour.

The traffic volumes recorded on the form should be the actual Turning Movement Counts
taken for the highest 8 to 12 hours in an average day.
Data collection and time periods used will be discussed in further detail later in the presentation.
The highest eight hours of vehicle volume data should be recorded for Eight Hour Volumes,
Condition A, as well as Eight Hour Volumes, Condition B tables.
The 8 hours recorded in Condition A are not required
to be the same 8 hours recorded in Condition B.
On the minor street, the higher-volume minor street is not required to be the same approach
during each of the 8 hours.

The highest four-hour vehicle volume data should be recorded
in the Highest Four-Hour Vehicular Volumes table.
The highest one-hour of vehicle volume data should be recorded
in the Vehicular Peak Hour Volumes table.

The highest eight hours of pedestrian volume data should be recorded for Warrant 7
under the Condition A table.
The peak period of pedestrian volumes should be the highest four-hour pedestrian volume data
rather than vehicular peak period,
which should be recorded in the Highest Four Hour Pedestrian Volumes table.
The highest one-hour of pedestrian volume data should be recorded
in the Pedestrian Peak Hour Volumes table.

Let's take a closer look at how approach lanes should be considered in a signal warrant analysis.

The effects of the right-turn vehicles from the minor-street approaches should be carefully considered in the study. Engineering judgement should be applied to determine what, if any, portion of the right-turn traffic should be deducted from the minor street traffic count when evaluating the count against the traffic signal warrants.

Intersections with approaches consisting of one lane plus one right-turn or left-turn lane should be analyzed with the application of engineering judgement. Site-specific traffic characteristics will dictate whether an approach should be considered as a one lane approach or a two-lane approach. The following slides will review two examples. Refer to the MUTCD Section 4C.01, paragraphs 8, 9, and 10 for additional guidance on these considerations in addition to the following slides.

Site specific characteristics will dictate whether an approach should be considered as a one lane approach or a two-lane approach. For example, let’s take a look at a minor street approach with one shared through / right-turn lane and an exclusive left-turn lane with minor left-turning volume. In this case, engineering judgement would indicate that it should be considered as a one-lane approach.

In addition, engineering judgement would also indicate that only the volume in the shared through / right-turn lane should be considered for the minor street volume against the warrants.

In contrast, if the left-turn lane has sufficient length to accommodate left-turn vehicles and approximately half of the traffic on the approach turns left, the approach should be considered as a two-lane approach.

In another example, for a minor street approach with one shared through / left-turn lane and an exclusive right-turn lane with a heavy right turn volume, engineering judgement would indicate that the minor street should be considered as a two-lane approach.

In this case, engineering judgement would also indicate that the left-turn, through, and right-turn volume should be considered for the minor street volume in the warrant analysis.

The following factors should be considered when applying engineering judgement to determine the portion of right-turn volumes to include in the minor street volume: Number of lanes on the minor street approach, presence or absence of exclusive right-turn lane, presence or absence of free flow right turn, availability of gaps in major street traffic, sight distance available to right turning vehicles, percentage of minor street traffic which turns right, and pedestrian and bicyclist volumes.

Note that MUTS Chapter 8 - Gap Study and its corresponding computer-based training module provides detailed information on the data collection requirements and how to conduct gap studies.

In this section, we will discuss what traffic volume data is needed and how it should be used to complete a signal warrant analysis.

Traffic volumes are needed for evaluation of most signal warrants.
The traffic volumes used should be the actual turning movement counts
taken for the highest 8 to 12 hours in a typical weekday.
Turning movement counts are needed when the engineer is unsure if the right turning volume
from the minor street approach should be included in the total volume.

Approach counts should be conducted first to determine the need for turning movement counts
and the appropriate time periods for collecting turning movement counts.
If the volume from the approach counts is considered to be low,
then turning movement counts are not needed and approach counts
can be used in place of turning movement counts to complete a signal warrant analysis.
In all warrants where hourly volumes are entered, an hourly period may begin on any quarter hour
as long as there is no overlap among warranted hours.
Refer to MUTS Chapter 4, Intersection Turning Movements Counts,
for further details on the procedures for this data collection.

This slide will cover criteria to the volume warrants or Warrants 1, 2, 3 and 4.
If the posted, statutory, or 85th percentile speed on the major street exceeds 40 miles per hour,
or if the intersection lies within the built-up area of an isolated community having a population
of less than 10,000 people, the 70 percent volume thresholds may be used.

The form allows the engineer to document if these criteria are met,
and automatically checks the 70 percent threshold option when either criterion is marked as “Yes.”
When using the electronic form, the MAY checkbox must be checked
to use the 70 percent reduced volumes, this action will auto-populate the corresponding input
from the Instructions & Input tab.

The engineer should use engineering judgement to determine if it is appropriate to use the 70 percent volume threshold even when the criteria is met. Consider the situation when the posted speed on the major road is 45 miles per hour, but a target speed of 35 miles per hour has been set for the corridor. The engineer may choose to not use the 70 percent volume threshold given the unique conditions of the location.

Note that the speed threshold for Warrants 1, 2, and 3 is greater than 40 miles per hour.
While for Warrant 4, the criteria to use the 70 percent volume threshold
should be based on the posted, statutory, or 85th percentile speed on the major street
exceeding 35 miles per hour instead of 40 miles per hour.

We will now walk through how to complete each of the nine traffic signal warrants
using the example intersection of Main Street and 5th Avenue.

Warrant 1 is the Eight-Hour Vehicular Volume warrant.
The Minimum Vehicular Volume, Condition A is intended where large volume of intersecting traffic
is the principal reason to consider installing a traffic signal.
Refer to Section 4C.02 of the MUTCD for further detail.

If the posted speed, statutory, or 85th percentile speed on the major street exceeds 40 miles per hour,
or if the intersection lies within the built-up area of an isolated community
having a population of less than 10,000 people, the 70 percent volume threshold may be used.

For our example, a target speed has not been established for Main Street and it has a posted speed
of 45 miles per hour.

As a result, we can use the 70 percent volume threshold or volume reduction
due to the posted speed exceeding the 40 mile per hour criterion.
The MAY checkbox must be checked to use the 70 percent volume threshold.

This is an overview of the application of Warrant 1, Condition A.
The eight-hour vehicular volume data is auto-populated from the Instructions & Input tab.
As noted in the previous slide, the MAY checkbox must be checked
to use the 70 percent reduced volumes.

Warrant 1, Condition A is met if the major and minor street traffic volumes
meet the corresponding volume thresholds for eight hours based on number of approach lanes.
In our example there are two through lanes on Main Street and one shared left-right on 5th Avenue.
Warrant 1, Condition A is met based on the 70 percent volume thresholds
since all eight hours of major street volumes are greater than 420 vehicles per hour
and the minor street volumes are greater than 105 vehicles per hour.

The Interruption of Continuous Traffic, Condition B is intended where the traffic volume
on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay,
as determined by a gap study or conflict in entering or crossing the major street.
The information for Warrant 1, Condition B is available on Page 2 of the Warrant 1 tab
while Condition A is available on Page 1.
Refer to MUTS Chapter 8 - Gap Study for further details on gap studies.

This is an overview of the application of Warrant 1, Condition B.
The eight-hour vehicular volume data is auto-populated from the Instructions & Input tab.
The MAY checkbox must be checked to use the 70 percent reduced volumes.
Warrant 1, Condition B is met if the major and minor street traffic volumes
meet the appropriate thresholds for eight hours based on the corresponding number of approach lanes.

Warrant 1, Condition B would not be met based on the 70 percent volume thresholds
since not all eight hours of major street volumes are greater than 630 vehicles per hour.
The minor street volumes are greater than 53 vehicles per hour,
but the intersection should also meet the major street volume thresholds in order to meet the warrant.

Nonetheless, in our training example, Condition B is not applicable
due to already meeting Condition A.

Under circumstances where Conditions A or B for the 100 percent volumes are not satisfied,
the application of the Conditions A and B combination can be explored.
Both volume thresholds must be met by meeting the required vehicles per hour 80 percent thresholds,
total of both approaches for the major street and higher-volume approach for the minor street.
All other alternatives should be tried prior to using the 80 percent threshold.
Note that the 80 percent threshold influences the criteria under Warrant 7,
which will be discussed later in the training.

Warrant 2 is the **Four**-Hour Vehicular Volume warrant.
This warrant is intended to be applied where the volume of intersecting traffic
is the principal reason to consider installing a traffic control signal.
Refer to Section 4C.03 of the MUTCD for further details on completing Warrant 2.

This slide provides an overview of Warrant 2.
The 100 percent checkbox must be selected to auto populate the volumes
in the 100 percent volume level table and plotted on the chart.
Warrant 2 is met when the major and minor street traffic volumes meet the appropriate thresholds
on the 100 percent volume level chart for four hours.
If all four plotted points fell above the appropriate curve, the warrant would be met.

For our example, all four plotted points fall below the curve
for two or more lanes on the major street and one lane on the minor street.
Therefore, the 100 percent threshold is not met.
The next step is to check the 70 percent volume threshold.
The 70 percent checkbox as well as the MAY checkbox must be checked
to use the 70 percent reduced volumes.

Once we click the MAY checkbox to use the 70 percent reduced volumes
the spreadsheet auto populates the volumes in the 70 percent volume level table
and plots the volumes in the chart.
Warrant 2 is met when the major and minor street traffic volumes fall above the curve
in the 70 percent volume level chart for four hours.
In our example, all four points fall above the appropriate curve
for two or more lanes on the major street and one lane on the minor street,
therefore Warrant 2 is met.

Warrant 3 is the Peak Hour warrant.
The warrant is intended to be applied at a location where traffic conditions are such that for a minimum of one hour of an average day,
the minor street suffers undue delay when entering or crossing the major street.
This warrant should only be applied in unusual cases,
such as office complexes, manufacturing plants, industrial complexes,
or high-occupancy vehicle facilities attracting or discharging large numbers of vehicles over a short time.

If Warrant 3 is met, the location can operate in flashing mode
during the hours that the warrant is not met.
Refer to Section 4C.04 of the MUTCD for further detail on Warrant 3.

The following is an overview of how to complete Warrant 3.
Before applying Warrant 3, the unusual condition justification box
should be filled in to explain the circumstances justifying the use of the warrant.

The 100 percent checkbox must be selected to auto populate the volumes
in the 100 percent volume level table and chart.
Warrant 3 is met if the major and minor street traffic volumes meet the appropriate thresholds on the 100 percent volume level chart for the peak-hour.
For our example, the peak hour volumes do not meet the 100 percent threshold
as the plotted points fall below the curve for two or more lanes on the major street
and one lane on the minor street.

Warrant 3 is also met if all three criteria are fulfilled for the same one hour of an average day.
The three criteria that must be met are delay on the minor approach,
volume on the minor approach, and total intersection entering volume.
A delay study must be completed to evaluate the delay on the minor approach.
Refer to MUTS Chapter 7 - Intersection Delay Study
for the procedure to conduct an intersection delay study.
To meet the delay criteria, the minor approach must experience 4 vehicle-hours of delay
for a one-lane approach or 5 vehicle-hours for a two-lane approach.

The MAY checkbox must be checked to use the 70 percent reduced volumes.
Warrant 3 is met if the major and minor street traffic volumes meet the appropriate thresholds on the 70 percent volume level chart.
For our example, the plotted point falls below the appropriate curve for two or more lanes on the major street and one lane on the minor street, therefore Warrant 3 is not met.

Warrant 4 is the Pedestrian Volume warrant.
The warrant is intended to be applied where the traffic volumes on a major street are so heavy that pedestrians experience excessive delays in crossing the major street,
with determination of excessive delay being based upon a gap study.

Refer to MUTS Chapter 8 for further details on conducting a gap study.
The Warrant 4 Form consists of two pages which will be reviewed in the following slides.

Refer to MUTCD Section 4C.05 for further detail on completing Warrant 4.

The Pedestrian Volume warrant shall only be applied at locations
where the distance to the nearest traffic control signal or stop sign controlling the street
that pedestrians desire to cross is greater than 300 feet
unless the proposed traffic control signal will not restrict the progressive movement of traffic.

For additional FDOT guidance on pedestrian crossing treatment selection and placement,
refer to the FDOT Traffic Engineering Manual, also known as TEM.
Section 5.2 of the TEM contains information regarding Treatments for Pedestrian Crosswalks at Midblock and Unsignalized Intersections,
Criteria for Beacons and Signals, and **Beacons** and Signals.

Additional elements to be considered while considering the implementation of a traffic signal include signalization plans, pedestrian facilities design criteria, lighting, and speed management.
For guidance on these elements in addition to the TEM provisions,
visit the FDOT Design Manual also referred to as the FDM.

A traffic signal shall be considered using any four hours of an average day
and one hour of an average day.
These are not required to be consecutive hours.
MUTCD Figures 4C-5 and 4C-6, shown in Page 1 of the Warrant 4 tab,
should be used to evaluate the four hours of an average day
and MUTCD Figures 4C-7 and 4C-8, shown in Page 2 of the Warrant 4 tab,
should be used to evaluate the peak pedestrian hour of an average day.

Note that the pedestrian volume may be reduced by 50 percent
if a walking speed study has been conducted and shows that the 15^{th} percentile crossing speed
is less than 3.5 feet per second.

Refer to MUTS Chapter 9 - Non-Motorized Volume Studies for guidance
on how to conduct a walking speed study.

The 100 percent checkbox must be selected to auto populate the volumes
in the 100 percent volume level table and chart or MUTCD Figure 4C-5 or 4C-7.
Warrant 4 is met if the major street traffic volumes and pedestrian crossing volumes
meet the appropriate thresholds for the four-hour or peak hour on the 100 percent volume level charts.
The optional checkbox for the 50 percent pedestrian volume reduction is available
and must be checked to plot the reduced pedestrian volume curve.

The total pedestrians crossing the major street along with the major street traffic volume
should be plotted on MUTCD Figure 4C-5 or 4C-7 as explained in the previous slide.
If the posted, statutory, or 85^{th} percentile speed on the major street exceeds 35 miles per hour,
or if the intersection lies withing the built-up area of an isolated community
having a population of less than 10,000 people, Figures 4C-6 and 4C-8 may be used instead.

The MAY checkbox must be checked to use the 70 percent reduced volumes.
Warrant 4 is met if the major street traffic volumes and pedestrian crossing volumes
meet the appropriate thresholds for the four-hour
or peak hour on the 70 percent volume level charts.

For our example, a walking speed study was conducted
resulting in a 15th percentile crossing speed of 3.3 feet per second,
which meets the criteria to use the 50 percent reduction.
Using the 70 percent volume thresholds,
Warrant 4 is not met for either the four-hour or peak-hour volumes.

Warrant 5 is the School Crossing warrant.
The warrant is intended for application where the fact that school children cross the major street
is the principal reason to consider installing a traffic control signal.
Refer to MUTCD Section 4C.06 for further detail on completing Warrant 5.

The following is an overview of how to complete Warrant 5.
The warrant is satisfied if all three criteria are met.
The three criteria that must be met are a minimum number of students crossing the major street, fewer number of adequate gaps in the major street traffic during the period
when children are present than the number of minutes in the same period,
and the nearest traffic signal along the major street is located more than 300 feet away,
or the nearest signal is within 300 feet, but the proposed traffic signal
will not restrict the progressive movement.

A gap, as defined in MUTS Chapter 8.2 is the time duration between the rear bumper
and front bumper of two consecutive vehicles.
To simplify measurements in the field, a gap may be measured by the time duration
between consistent reference points of two consecutive vehicles.
A driver or non-motorist can accept or reject gaps.
Gap study procedures are described in further detail in MUTS Chapter 8 - Gap Study.

For our example, there are six students who cross Main Street to get to school during the highest hour,
which does not meet the criteria of 20 students.
Knowing one of the three required criteria is not met,
there is no need to check the remaining two criteria.
Therefore, we now know Warrant 5 is not met.

Warrant 6 is the Coordinated Signal System warrant.
The warrant is intended for application where the progressive movement
in a coordinated signal system sometimes necessitates installing traffic signals at intersections
where they are needed to maintain proper platooning.

The Coordinated Signal System warrant should not be applied
where the resultant spacing of traffic control signals would be less than 1,000 feet.
Refer to MUTCD Section 4C.07 for further detail on completing Warrant 6.

The following is an overview of how to complete Warrant 6.
The warrant is satisfied if either of the two criteria are met.
The two criteria are on a one-way street or a street that has traffic predominantly in one direction,
the adjacent signals are so far apart that they do not provide
the necessary degree of vehicle platooning, or on a two-way street,
adjacent signals do not provide the necessary degree of platooning,
and the proposed and adjacent signals will collectively provide a progressive operation.
For our example, Main Street is not part of a coordinated signal system
and so Warrant 6 is not applicable.

Warrant 7 is the Crash Experience warrant.
The warrant is intended for application where the severity and frequency of crashes
are the principal reasons to consider installing a traffic signal.
Refer to MUTCD Section 4C.08 for further detail on completing Warrant 7.

The following is an overview of how to complete Warrant 7.
The warrant is satisfied if all three criteria are met.
The first criterion requires that adequate trial of other remedial measures
to reduce crash frequency must have been tried and failed.

The second criterion requires that a minimum of five reported crashes
of types susceptible to correction by a traffic signal, such as angle, pedestrian, and left turn,
must have occurred within a 12-month period.
Local cities or counties may elect to use within their jurisdiction
MUTCD Interim Approval 19 subject to FHWA approval.
Note interim approval's application should not be done on the state highway system.

The third criterion has been updated in the Signal Warrant Summary Form to reflect Warrant 7
in the MUTCD more accurately.
This criterion requires that either Warrant 1 Condition A be met
for the 80 percent vehicular volume threshold or Warrant 1 Condition B be met
for the 80 percent vehicular volume threshold or requires Warrant 4 be met
for 8 hours for the 80 percent of the pedestrian volume threshold.

Eight hours of pedestrian volume data is needed to complete the pedestrian volume criteria
as part of Warrant 7.

The 8-hour pedestrian volume requirement may impact the level of effort required for data collection
if Warrant 7 is to be used.
For our example, criteria two and three are met,
but criteria one is not met as no remedial measure has been taken to date,
therefore Warrant 7 is not met.

Warrant 8 is the Roadway Network Warrant.
The warrant is intended to be applied where installing a traffic signal is needed
to encourage concentration and organization of traffic flow on a roadway network.
Refer to MUTCD Section 4C.09 for further detail on completing Warrant 8.

The following is an overview of how to complete Warrant 8.
The warrant is satisfied if at least one of the two criteria is fulfilled and if all intersecting routes have one or more of the Major Route characteristics listed.
Criterion one requires that the total entering volume is at least 1,000 vehicles per hour during a typical weekday peak hour and that five-year projected volumes satisfy one or more of Warrants 1, 2, or 3.

Criterion two requires that the total entering volume is at least 1,000 vehicles per hour for each of any five hours of a non-normal business day, such as Saturday or Sunday.

The three major route characteristics are as follows:
part of the street or highway system that serves as the principal roadway network for through traffic,
a rural or suburban highway outside of, entering, or traversing a city,
and if the roadways appear as major routes on an official plan.
For our example, Main Street is not part of a major route, so Warrant 8 is not applicable.

Warrant 9 is the Intersection Near a Grade Crossing Warrant.
The warrant is intended to be applied at intersections where a grade crossing exists on an intersection approach controlled by a STOP or YIELD sign and none of the other eight traffic signal warrants are met.

This signal warrant should only be applied after evaluating other alternatives and determining that the alternatives do not address safety concerns related to the grade crossing.
Refer to MUTCD Section 4C.10 for further detail on completing Warrant 9.
Warrant 9 consists of two pages.
The following slides provide an overview of how to complete Warrant 9.

Page 1 describes the two criteria which shall be fulfilled in order to meet the warrant.
The first criterion requires having an existing grade crossing on a STOP or YIELD controlled approach and the center of the track nearest to the intersection within 140 feet of the stop or yield line on the approach.

The second criterion requires that during the highest traffic volume hour
during which the rail uses the crossing,
the plotted point falls above the applicable curve for the existing combination of approach lanes over the track and the clear storage distance.
These figures are displayed on Page 2 of the Warrant 9 tab.
The clear storage distance is defined as D in the charts and is one of the inputs required under Page 1.

Percent of high occupancy buses and percentage of tractor-trailer trucks
on approach lane at track crossing as well as rail traffic occurrences per day
should be defined under Page 1.
Before moving to Page 2 of the tab, the analyst should determine which figure is applicable
for the study intersection based on the number of approach lanes crossing the track.

As previously noted, Page 2 of the Warrant 9 tab provides MUTCD Figures 4C-9 and 4C-10.
Figure 4C-9 should be used if there is one approach lane at the track crossing
while Figure 4C-10 should be used if there are two or more lanes at the track crossing.
Each figure shows an intersection schematic for the corresponding approach lane configurations.

The final inputs needed to evaluate the warrant are the major and minor road volumes.
These volumes should be recorded in the corresponding cells based on the number of lanes
on the minor road.

Note this is the only tab where volumes are a directly coded onto the Warrant analysis tab
as opposed to the Instructions & Input tab.
The form will auto-populate the adjusted volumes with the corresponding adjustment factors
coded by the engineer on Page 1 of the tab following MUTCD Tables 4C-2, 4C-3, and 4C-4.

Once the volumes have been recorded, the applicable factors will be applied to the volumes
and these will be plotted on the figure.
If the plotted point falls above the appropriate curve, the warrant is met.
For our example, Warrants 1 and 2 are met so Warrant 9 is not applicable.

To conclude the procedure, an overview of the Warrant Summary Checklist is provided.
Once all nine warrants have been evaluated and completed the checklist should be the final step.
This tab has been modified to allow the engineer to check boxes for each warrant
marking if the warrant is not applicable or if the warrant is or it is not met.

In our example, Warrants 6, 8, and 9 are not applicable, Warrants 1 and 2 are applicable and met,
and Warrants 3, 4, 5, and 7 are applicable and not met.
The engineer should now be ready to sign and seal the analysis.

This concludes the Manual on Uniform Traffic Studies computer based training,
Chapter 3 - Traffic Signal Warrant Summary.
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.
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 enter your first and last name before continuing to the quiz.
Thank you for your time and attention.

LMS:

This concludes the Manual on Uniform Traffic Studies computer based training,
Chapter 3 - Traffic Signal Warrant Summary.
You will now take a 10-question quiz to test your knowledge and understanding
on the material presented in this computer-based training.

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If you do not pass the quiz, please return to the Course Content tab, and re-take this training.
Once you’ve passed the quiz and received your certificate please continue to the next chapter
by returning to the MUTS course content tab and selecting the next chapter in the training.
Please, continue to the quiz and thank you for your time and attention

Chapter 4 Presentation Script

Welcome to the Manual on Uniform Traffic Studies, also called MUTS, computer based training!
This training module will cover Chapter 4 - Turning Movement Counts.

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.

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.

When conducting these studies, make sure to download the latest excel form available through the website.
The link to the form is also provided in the resources page to this training.
Please open Form numbers 750-020-02 and -03 as we will refer to these later in the module.

Intersection Turning Movement Counts, or TMCs,
are the bread-and-butter of traffic engineering.
Most traffic studies, from corridor plans to signal retiming,
require TMCs to understand current demand at study intersections.
More recently, TMCs are being used as an input to intersection control evaluations
to help practitioners select the right intersection type at a given location.
This training will share guidance on how to collect, process, and present TMCs.

To get started, we will share a little more detail on the purpose of TMCs
and the type of studies that these can inform.

At their core, TMCs are a summary of vehicle movements through an intersection.
In addition to vehicle movements, TMCs should also record non-motorist volumes like pedestrians and bicyclists.
While this training focuses on vehicular TMCs,

MUTS Chapter 9 discusses in depth how to conduct non-motorist volume studies.
If you are interested in learning more on the nuances for non-motorist counts, we encourage you to watch the computer-based training module for MUTS Chapter 9- Non-Motorized Volume Studies after completing this training.

As previously mentioned, TMCs can be used to make decisions for a wide range of studies, from planning to operations.
Some study types that typically need TMCs are listed on the right side of-this slide.
(listed on the slide: Geometric design, Capacity analysis, Intersection control type, Sign and signal installation, Signal timing, Pavement markings, Traffic circulation, Parking and loading and Vehicle classification)

Now that we know how TMCs are generally used, let's look at the most common types of counts out there.

There are three major types of TMCs: vehicle counts, path-based counts applicable to most alternative intersection designs, and counts at other alternative intersection counts.
We will start with "vehicle counts," where each individual vehicle is counted.

When counting vehicles at signalized intersections,
it is recommended that at least five signal cycles be captured within each interval;
intervals are typically 15-minutes long.
Pay extra attention when the intersection has permissive turning movements
or when right-on-red counting is necessary.
When additional information like this is needed,
additional resources may be required to complete the data collection.
Resources can include observers in the field or time during post processing of recordings.

Vehicle counts may be done manually or via automated means;
either method is often paired with the assistance of video cameras or drones.
Manual counts at signalized intersections typically require more than one observer,
as they are commonly done in the peak hour when the volume of traffic is highest.
When using video cameras to manually post-process the footage recordings,
the number of cameras and their placement will depend on the size
and configuration of the intersection.

Automated counts can include video image processing,
in-road tube or loop counters, and emerging technology such as cell phone location data.

In oversaturated conditions, the number of vehicles turning at an intersection
may not reflect the true demand. Let’s look at the analogy of the funnel to visualize this concept.
Water is being poured at a high rate from the pitcher into the funnel.
The funnel’s neck is too narrow to process all that water,
and so water builds up inside of the funnel.

If we were to count the three drops coming out of the funnel ,
we would undercount the amount of water that needs to make it through.
In essence, the water being held up inside the funnel is “unmet demand.”
In certain types of studies, such as signal warrant studies,
quantifying the overall intersection demand is critical to the analysis.

Note that MUTS Chapter 3 provides detailed information on the data collection requirements
to conduct a signal warrant study.
Let’s look into a solution to obtain the overall demand on the following slide.

The solution in these situations is to count the arrival and departure volumes
in addition to the turning movements.
Arrivals are counted as vehicles approach the intersection and join the queue.
Departures are counted as the vehicles cross the stop bar.
A detailed example of this type of counting is provided in the Institute of Transportation Engineers
or ITE Manual of Transportation Engineering Studies 2nd Edition referenced on this slide.

Now, let’s take look at the second major type of TMCs: "path-based counts.”

Some intersection configurations combine multiple movements into shared lanes,
such that the TMCs are dependent on the origin and destination of vehicles,
also known as the vehicle path.

Alternative intersection designs, such as roundabouts, jug-handles,
quadrant roadways or median U-turns, require this type of counting.

As an example, let’s take a look at how drivers complete their turning movements
at two different alternative intersection types: Restricted Crossing U-Turn or R-CUT
and Median U-Turns or MUT.

If we were to count only the primary intersections,
the associated turning demand would not be reflected in the count.
In our first example , you will notice that a motorist making a northbound through movement
at this R-CUT intersection needs to make a northbound right first, complete a U-turn,
and then make a westbound right.

Our second example shows a northbound left movement at a MUT, which shows up as a northbound right at the primary intersection, followed by a U-turn and the vehicle continues westbound through at the primary intersection. Because of movements like these, it is necessary to conduct path-based counts at intersections with these configurations.

There are three methods of obtaining path-based counts:
though manual observation, video tracking, and sampling.
The manual method works best for small roundabouts
where the observer can keep track of vehicle movements.

In heavier traffic or intersections with larger footprints,
video cameras or drone footage can be used to improve accuracy and vision.
Video tracking involves using machine vision to track and count vehicles
as they navigate the intersection.

Note that the sampling method involves gathering origin-destination
for only a subset of all the vehicles turning at the intersection.
Based on complementary counts of *all* vehicles using either manual or automated means,
the sampling method can then be extrapolated to a TMC estimate.

Finally, let’s take a look at other alternative intersection counts.

Other alternative intersection designs, including Single Point Urban Interchange and Displaced Left Turns or DLT generally do not require path-based counts as all movements can be observed in isolation at a single location. If not already, the observers should become familiar with the flow patterns at these intersection types before conducting the study.

Now that we have covered the broad types of TMCs, we will dive into the different methods for collecting the data.

As previously discussed, the primary distinction is between manual and automated methods. In the MUTS, we define manual collection methods as those where a human observer must manually tally the counts.

Automated counts reduce observer workload by using technology to perform the tallying without human input, although a person must still perform quality checks, review, and report.

Let's dive a little deeper into the differences between manual and automated data collection. Manual data collection is still the industry standard for TMCs, as it requires little setup and is flexible enough to work in a wide range of conditions, including poor lighting and weather.

It also has the added benefit of being able to capture other elements of the location at the same time, such as lane configuration, signal timing, queuing and more.

On the other hand, automated counts may be more cost efficient as the number of locations or the number of hours to capture goes up. It can also be the preferred alternative when counts are needed for a past date, as some automated methods can rely on archived data.

There are several tools that can aid during manual data collection and input.
The most basic of tools is simple paper and pencil,
using predetermined forms such as the ones included in this chapter.
We will describe these in more detail in later slides.

Another solution is electronic count boards, which can keep track of time while aiding in data entry.
As mentioned earlier, cameras may also be used to enable post-processing of counts
away from the count site.

Finally, mobile devices such as laptops, tablets,
and phones may be loaded with software that can help keep track of time,
aid in data entry, and summarize the data for delivery.

As to personnel needs, the number of observers will depend on the type of count,
the duration of the counting period, traffic levels, and number of lanes being observed.
Whether the counts are being done on the field or later based on video footage
will also affect personnel needs.

Breaks of 10 to 15 minutes are recommended at least every 2 hours,
or 30 to 45 minutes every 4 hours for data collection periods longer than 8 hours.

The first step when doing data collection fieldwork is to obtain and review a preparation checklist,
such as the one published by ITE in its Manual of Transportation Engineering Studies 2nd Edition.
It is important to identify good locations with unobstructed views of the intersection
ahead of time and arriving at least 15 minutes before the start of the data collection period to set up.
Safety vests and other personal protective equipment should be worn at all times.

If drones are being used for the data collection,
it is critical to prepare ahead of time as the Federal Aviation Administration
regulates the operation of drones.

Regulations include altitude restrictions or complete bans on flying drones.
All data collection should be researched in advance to comply with these regulations.

Drone video collection requires special personnel,
including having Federal Aviation Administration-one or more licensed drone pilots.
For short counts, a single drone or pilot may be sufficient.
Longer counts could benefit from more drones and pilots to ensure continuous filming
while batteries are being recharged.

A tethered drone plugged into a power source is recommended for extended periods.

Now that we have covered the different tools for manual data collection,
let's dive into the forms available with this chapter.
We will start with Form number 750-020-02: Summary of TMCs.

The heading of this form should be filled in completely.
Identify the location of the observer by marking the appropriate checkbox in the intersection diagram.
If more than one observer is used, name and number each and identify their location by number.
Briefly describe the weather if relevant and include any road conditions
which may influence the results of the data being collected under *Remarks*.
For example, a stalled vehicle that may temporarily restrict a vehicle movement
during a time period should be noted.

Enter the Street Name of each roadway and orient the intersection
by indicating north by directional arrow.
Enter the letters NB, EB, SB, or WB indicating the direction of approach
in the appropriate box of the intersection diagram.
In the box behind the movement indications, enter the number of lanes for each movement.
Note right turns can occur even if no exclusive right turn lanes are present.

For each time period to be counted, enter the Begin and End time.
Twenty rows are provided so that a total of 4 hours can be counted in 15-minute periods
and allow the user to enter hourly totals.
The intervals can be adjusted by the observer and these should be recorded accordingly in the form.
Enter the actual counts of vehicle movements in the appropriate time period and L, T, R column.

Finally, add up the counts and record in the "TOTAL" row below and "TOTAL ALL" column
to the right of the input cells.
Note that the spreadsheet will automatically add the counts into the total columns
if data is entered electronically, so practitioners do not need to compute totals manually
if the field data is recorded electronically into the spreadsheet directly.

This slide shows an example of how to fill out Form number 750-020-03:
Vehicle TMCs, which can be used for most intersections.
As with the previous form, the heading of the form should be filled out completely.

This form can be used to record the total number of passenger vehicles
and other vehicle classifications such as heavy vehicles for each movement within a peak hour
or analysis period.

Now that we have covered manual counts and the tools available,
let's take a look at the types of automated counts available.
There are three categories described in the MUTS chapter:
in-road counters, typically pneumatic tubes, or loop detectors;
video processing technologies; and the more recent and emerging,
probe data sources - these are typically from cell phone or connected vehicle datasets.

While in-road counters may not be useful for TMCs,
they could be used in conjunction with other methods described above
(such as the sampling method) to estimate TMCs.

When deploying in-road counters in the field,
start with obtaining and reviewing a preparation checklist.
Research ahead of time for a suitable location that will accomplish your study's goals.
In-road counters should be installed at right angles to the flow of vehicular traffic
as shown in this picture.
Areas to avoid include parking lanes, locations with frequent queuing, expansion joints,
sharp edges, and curves. Make sure to note in a sketch diagram
where the counter is ultimately placed.

Once the counter is in place, test it with a test vehicle to ensure it is working as intended.
Secure the sensor to the pavement and to a fixed object on the ground
such as a sign or tree to prevent vandalism.

Roll up any loose cables and tie down as short and compact as possible.
Finally, set the count interval to reset on the hour for ease of analysis and write down the start time.
Consider checking back periodically to ensure the sensor is still capturing data as intended.

Another type of automated counting relies on video image processing,
where a computer runs an algorithm to analyze an image and identify vehicles and their movement.
Video image processing can also be used to read license plates for use in the sampling method.

As with most automated technologies, there are some limitations.
If the footage has poor lighting or visibility,
the computer may not be able to pick up every vehicle in the frame.
It can also miss vehicles that are behind large objects, including trucks or buses.
As always, a human reviewer is needed to quality check the data and ensure its accuracy.

As noted earlier, the two forms available through this chapter,
Form number 750-020-02 and -03, have fields for various roadway elements.
This section summarizes these elements and the databases that can be used to obtain them.

The forms in this chapter ask for lane geometry, site layout, signal timing, and more *(listed on slide: location geometry, site layout, signal timing, equipment inventory, photographs of the site and equipment)*.

This information is often available from databases by FDOT or local agencies.
Three of the most common databases include the FDOT Roadway Characteristics Inventory or RCI database, the Florida Transportation Information or FTI,
and the Florida Traffic Online Web Application.

Let's look at key takeaways from this chapter and the forms.

TMCs are useful in a wide range of planning and operations studies.
They can be collected manually or through automated means,
with or without the assistance of video cameras.
If manual data collection is to be performed,
consider using some of the tools described in this training,
ranging from paper and pencil to drones and mobile devices.
If automated technology for data collection is to be employed instead,
the practitioner may need to plan for additional setup and review time,
as well as investigating potential limitations.

The two forms described earlier in this training can be accessed
by clicking the link on this slide or by scanning the QR code with a cellphone camera.

This concludes the Manual on Uniform Traffic Studies computer based training,
Chapter 4 - Turning Movement Counts.

[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.
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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.
To continue to the next chapter of this training please select the “NEXT” button below this CBT.
On the next slide, please enter your first and last name 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.
To continue to the next chapter of this training please go to the next chapter on the MUTS course content tab.
Please, continue to the quiz and thank you for your time and attention.

Chapter 5 Presentation Script

Welcome to the Manual on Uniform Traffic Studies,
also called MUTS, computer based training!
This training module will cover Chapter 5 –
Data Collection for Transportation Safety Studies.
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.

The purpose of this chapter is to provide guidance on the data collection requirements
for transportation safety studies on non-freeway roadway segments
and intersections data collection for conducting a transportation safety study.
The safety studies include those conducted through the application
of the Highway Safety Manual, or HSM,
and the Safety Performance for Intersection Control Evaluation tool, also called SPICE tool.

Let's take an initial look at the HSM Predictive Methods.
The HSM is organized by chapters and each of these shown on the slide
cover a different facility type.

Chapter 10 is for 2 lane rural roads and Chapter 11 is for rural multi-lane highways.
For urban and suburban facilities, Chapter 12 is for urban and suburban streets
between 2 and 5 lanes; NCHRP 17-58 is for urban and suburban streets
between 6 and 8 lanes and one-way streets.
NCHRP 17-70 covers roundabout analysis and **Restricted** Crossing U-Turn
also known as R CUT is covered through FDOT research.
We will revisit these resources later during this training -
it is helpful to have awareness of the sources, nonetheless,
it is crucial to understand the differences among the required data structure
and how these will impact our data collection and subsequently our analysis.
Remember MUTS Chapter 5 covers data collection only as opposed to any analysis.
If further HSM training is needed please visit the FDOT Roadway Design/Quality
Assurance/Training website for HSM webinars available on the resources page.

Let’s take a look at some safety studies basics.
The purpose of a transportation safety study is to identify potential hazards
and select possible safety countermeasures.
Transportation safety studies can be broadly classified as reactive to a given location's
crash history or **predictive** of a given location's potential crash frequency
based on its geometric and traffic characteristics.

During this training module, we will refer to sixteen data collection 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 resources page to this training.
Please open Forms 750-020-04 and 750-020-05a through 750-020-05o
as we will refer to them later in the module.

Before diving into the concepts, tools, and application,
we will go over the associated forms for this chapter.
These forms can be accessed by visiting the FDOT MUTS online library.
For purposes of this training, we will generalize the chapter forms in two bins:
one bin covers data collection forms for further transportation safety analysis
using HSM procedures while the second bin covers forms
for existing conditions reporting.
Let’s walk through each of these groups and forms.
We will begin with the data collection forms for safety analysis purposes.

We have four categories of roadway configuration:
Rural Two-Lane Roadway, Rural Multi-Lane Highway, Urban/Suburban Arterial for 2 to
5 lanes and Urban/Suburban Arterial for 6 to 8 lanes plus one-way roadways.
Each of these classifications has two data collection forms available:
one for segments and one for intersections.
Highlighted in red font are the forms associated to intersections only.
Lastly, we have data collection forms for safety analysis purposes
for Restricted Crossing U-Turn or RCUT**,** Roundabout, Oher Roadway Segments,
and Other Intersections.

Now let’s now discuss existing conditions forms for reporting purposes.

Under existing conditions reporting, we have four available forms:
one is for condition diagrams, the next one is for collision diagrams –
intersection and segment templates, and the last one is for crash summaries.
We will walk through these in more detail later in the chapter.

Here is a snapshot of the data collection process for Transportation Safety Studies
and the corresponding forms available.
As previously noted, we have two general form bins:
one for data collection in order to conduct transportation safety studies
and the second one for existing conditions reporting.
The Roundabout and RCUT data collection spreadsheets correspond
to the SPICE tool for analysis.
These forms can be accessed by visiting the FDOT MUTS website
or by scanning the QR code
on the top right corner of this slide with a cellphone camera.

The predictive method presented in the HSM -
Part C allows for the computation of the predicted average crash frequency
and the expected average crash frequency at a given location.
The predicted average crash frequency consists of three primary components,
the safety performance function, also called SPF,
predicts average crash frequency for base conditions,
the crash modification factors, also called CMFs,
provides for modifications to the base condition for given geometric
or traffic control features, and the local calibration factors.
The expected average crash frequency
combines the predicted average crash frequency with historical crash data.
MUTS Chapter 5 describes the data collection components
required for the implementation of the predictive method.

The data collection steps outlined in this chapter support the implementation of HSM predictive analysis methods and the SPICE tool.
These analyses can be implemented using spreadsheet tools built to support the predictive method. The four spreadsheet-based tools include:

Number 1, the HSM Chapter 10 tool for rural two-lane roadways.
Number 2, the HSM Chapter 11 tool for rural divided and undivided highways.
Number 3, the HSM Chapter 12 tool for urban and suburban arterials.
Number 4, the NCHRP 17-58 tool for 6 to 8 lane roadways and one-way streets.

Note that while each of these spreadsheet-based tools have two corresponding forms for data collection – one for segments and one for intersections,
the analysis tools are built to accommodate both, intersections, and segments,
on a single excel and the same tool should be used for analyzing either one.
The analysis forms are described in further detail under MUTS Chapter 14.
Refer to Forms 750-020-21a through 750-020-21d for specifics on application.
These forms are detailed in the next slide.
Lastly, Number 5, **the** SPICE tool,
which applies only to intersections and is built to evaluate
and compare alternatives, including alternative intersection types such as roundabouts,
restricted crossing U-turns, and median U-turn intersections as part
of the Intersection Control Evaluation or ICE analysis.

Here is a snapshot of the process and the corresponding forms available under MUTS Chapter 14 – Roadway Lighting Justification Procedure.
The form selection in Step 2 will vary based on the facility type being analyzed.
These forms can be accessed by visiting the FDOT MUTS website or by scanning
the Q-R code on the top right corner of this slide with a cellphone camera.

Further detail and description of the HSM predictive method is available
through recorded webinars and training provided by FDOT Roadway Design/Quality Assurance/Training and can be found through links on the resources page.
Predictive method **implementation** tools, SPICE and the HSM spreadsheets,
can also be found on the FDOT website through the resources page.

The facility types falling within the HSM predictive method
are classified by their location,
rural versus urban or suburban, as well as their geometric layout,
number of lanes for segments and type of control for intersections.
HSM Section 12.3.1 provides the definition of "urban"
and "rural" based on FHWA guidelines.
"Rural" areas are defined as places outside urban areas
where the population is less than 5,000 persons.
The HSM uses the term "suburban" to refer to outlying portions of an urban area,
but the predictive method does not distinguish between suburban and urban.
"Urban" areas are defined as places inside urban boundaries where the population
is greater than 5,000 persons.

In Florida, we consider the urban boundary plus the one-mile buffer
to be urban/suburban.
A link to maps depicting Florida's Urban Areas
plus a 1-mile buffer from those Urban Areas can be found on the resources page
and are an excellent source to obtain this information.

This slide provides a visual representation for two examples:
the image to the left was taken in an urban setting while the image to the right
was taken in a rural setting.
Urban or rural classification for HSM analysis
has nothing to do with the existing roadway typical section.
If the roadway pictured to the right was within the urban boundary or 1-mile buffer,
it should be analyzed a as an urban / suburban roadway.

Facility types are further classified as intersections or segments for safety analysis.
A segment is measured from the midpoint of one intersection to the midpoint
of the next intersection.
Crashes are assigned to segments and intersections based on the crash characteristics
and the crash location.
Crashes occurring within the extended curb lines of the intersection are usually
classified as intersection crashes, while crashes occurring on intersection approaches
can be classified as intersection crashes if the crash occurrence
was influenced by the intersection or as segment crashes if the crash
was not influenced by the intersection.

As we discussed, facility types can range from rural roadways
to urban/suburban arterials.
When conducting data collection for segments,
we need to look at some considerations common to all roadway segments
regardless of the facility type.

Segments must be homogeneous,
meaning that a new segment is designated
when there is a change in any of the roadway characteristics
affecting the calculated average crash frequency.
For each segment facility type, **data** collection includes elements
for the calculation of the base safety performance function
or SPF as well as the applicable crash modification factor or CMF.
Each data collection form **is** color coded based on entry type,
yellow indicates that manual data entry is needed,
and blue indicates that data is entered by selection from a drop-down menu.

Facility types in the HSM predictive method include roadway segments and
intersections on undivided rural two-lane roads,
divided and undivided 4-lane rural multilane highways,
undivided urban and suburban arterials from 2 to 6 lanes,
divided urban and suburban arterials from 4 to 8 lanes,
and one-way urban and suburban arterials from 2 to 4 lanes.
Stop control and signalized intersections on these roadways are included
in the HSM predictive method.
Facility types not included within the HSM,
but available for analysis with the SPICE tool
include RCUTs, roundabouts, and 3-leg signalized intersections on rural roadways.

The recent development of safety performance functions for these facilities
has been incorporated in SPICE and may be added to future editions of the HSM.
Note that a corridor analysis can be done using the segment and intersection tabs
in a single analysis spreadsheet.
Refer to MUTS Chapter 14 for additional guidance on how to conduct the analysis
using the corresponding spreadsheets.

Now that we have covered the basic concepts for the data collection
for Transportation Safety Studies, let’s dive into the chapter forms.
The forms have a consistent format through the data collection sheets.
The heading of this form should be filled in completely. Identify the roadway ID,
roadway name, segment limits, location, analysis year, and project number.
Review the corresponding form notes prior commencing the data collection.
For each facility type and roadway configuration, the forms provide AADT thresholds
which are auto populated on the form.
Finally, record the data input based on the roadway conditions.

We will now discuss the data entry requirements for predictive analysis.
Initially we will focus on **HSM** Chapter 10 - Rural Two-Lane Two-Way Roads
and discuss both the segment and intersection analyses.

The next training slides will follow the order per facility type shown on this graphic.
Note that the table of contents on the left-hand side of the screen for this training can be
used to navigate to a facility type of interest or to different sections.

Form 750-020-05a is used for the collection of data
on rural two-lane two-way roadway segments.
Data required for this form include the AADT and segment length,
to be used to compute the base crash prediction,
as well as data for the completion of 15 CMFs.
Note the segment length is always recorded in miles.

The required data for CMF calculations include:
lane width, shoulder width and shoulder type for both right and left shoulders,
the length of any present horizontal curve, as well as the radius of curvature,
presence of spiral curve transition, and curve superelevation variance, grade,
driveway density, presence of centerline rumble strips, number of passing lanes,
presence of two-way-left-turn lanes, roadside hazard rating, presence of lighting,
presence of automated speed enforcement, and the last is the calibration factor.
We will cover **five** of these CMFs in more detail in the next slide.

For horizontal curve related data, it is important to note that the length of the curve applies to the entirety of the curve, even if it extends outside of the segment limits.
The HSM states the base condition superelevation in a horizontal curve
is the amount of superelevation identified in the AASHTO Green Book.
The superelevation CMF is based upon the variation or the difference between the actual superelevation and the superelevation identified in the AASHTO Green Book.

When counting the number of driveways,
any driveways with at least once-daily use are to be counted.
Roadside Hazard Rating is determined on a 1 through 7 scale based on roadside design features such as side slope and clear zone width.
More detailed definitions of each rating and photographic examples
can be seen in the FHWA resource on the resources page.
Automated speed enforcement is currently not present for any roadway in Florida.

Let's take a look at an example for a two-lane two-way rural roadway.
This aerial shows a curved section of State Road 50 to be analyzed
to determine the safety effects of changing superelevation
and improving paved shoulders.
The data collection only focuses on the existing conditions.

First, we need to determine segmentation.
There are two unsignalized intersections:
one with County Road 755 and one with County Road 478A.
So, there will be **three** roadway segments from the beginning of study to the County Road 755 intersection as segment 1, between County Road 755 and County Road 478A intersections
as segment 2, and from the County Road 478A intersection to the end of study as segment 3. For this example, **we** will focus on segment 2.

It is important to understand where the data is going.
This slide shows the input tab in the analysis spreadsheet for rural two-lane,
two-way roadway segments.
This spreadsheet is known as the NCHRP 17-38 spreadsheet
and has three basic types of inputs.

First, for the SPF or safety performance function,
next for the CMF or crash modification factor and **the** last is the calibration factor.
We will address the calibration factors first which come from the FDOT Design Manual,
or FDM, Table 122.6.3 - HSM Calibration Factors for Florida.
The SPF and CMF inputs are the variables to be gathered
through the data collection effort for input in the analysis sheet.
Let's take a closer look at the HSM Calibration Factors for Florida.

FDM Table 122.6.3 provides a summary of the available HSM Calibration Factors
for Florida by facility type. Where a Florida specific Calibration Factor is not available,
the analyst should use a value of 1.
The table is broken down by **segment** calibration factors and **intersection** calibration factors.
Note there are currently no Calibration Factors for 6 to 8 lanes and one-way facilities.
Also, there are no calibration factors for roundabouts.

It is also important to understand CMFs have "base conditions" as shown here.
The rural, two-lane, two-way roadway segment CMFs
are listed here with the base condition.
When the existing roadway condition matches the base condition, the CMF is 1.00.
Data needs to be gathered either from existing plans or supplemental information,
review of current aerial photography,
a field review or all three to complete the data collection form.
Much of the information contained on this table was developed from existing plans.

So, let’s look at Form 750-020-05a which is for data collection for the elements
to be entered into the NCHRP 17-38 spreadsheet
for rural two-lane roadway segments.
The length of segment can be determined from the roadway stationing
and is expressed in miles. It is 0.281 miles. The AADT is 5,380.

These are the two functions needed for the **SPF** calculation.
The remainder of data collection is for the CMFs
and most of this is determined from plan's review.
The lane width is 12 feet.
The shoulder widths on both sides are 4 feet
and are composite being a combination of paved and grass stabilized.

As was seen in the aerial, there is a horizontal curve
which extends beyond this roadway segment.
The length of the curve is **0.3** miles and has a radius of 1,433 feet.
The curve does not have any spiral transition curves.
The AASHTO superelevation for this curve is 0.092 feet per foot
and the actual superelevation is 0.073 feet per foot so the superelevation variance
is 0.019 feet per foot. The grade is flat or 0.

There are no driveways in this segment, so this value is 0.
There are no centerline rumble strips,
no passing lane nor two-way left turn lanes present.
The roadside hazard rating is 3 meaning an approximate 10-foot clear zone
with a 3 to 1 side slope.

There is no **roadway** lighting or automated speed enforcement in this segment.
The calibration factor from FDM Table 122.6.3 - HSM Calibration Factors
for Florida is 1.00.

Data collection for rural two-lane roadway intersections uses Form 750-020-05e.
This form covers intersection types included in HSM Chapter 10,
which are 3-leg stop-controlled intersections, 4-leg stop-controlled intersections,
and 4-leg signalized intersections.
Analysis for other intersection types, including 3-leg signalized intersections
can be completed using the SPICE tool and its corresponding data collection form.
Data collected on this form includes **intersection** type and AADT
for the major and minor roadways, which are used for calculating the base SPF.

The intersection skew angle, number of signalized or uncontrolled approaches
with a left-turn lane, number of signalized or uncontrolled approaches
with a right-turn lane, **presence** of intersection lighting,
and calibration factor are also to be collected on this form.
Data required for this form will be used to compute the base crash prediction,
as well as data for the completion of four CMFs.
Let's take a closer look at **the** intersection skew angle CMF.

The intersection skew angle is measured as the deviation
of the intersection angle from 90 degrees.
If the skew angle differs for each minor road leg of a 4-leg stop-controlled intersection,
then a CMF is computed for each leg and then averaged together
to give a single CMF for the intersection.

Let's go back to the State Road 50 two lane example.
As you may recall, this roadway segment has two 3-leg, unsignalized intersections.
The one with County Road 478A was chosen for this example.
This intersection **has** single lane approaches on each of the 3-legs.

◦

Let's walk through completing Form 750-020-05e
for rural two-lane roadway intersection.
The intersection type being 3 or 4 leg stop control or 4 leg signalized
needs to be selected.
This is a 3 ST for 3 leg stop control intersection.

The major and minor roadway two-way AADTs are recorded as shown
on the corresponding fields.
If one leg has higher volumes than the opposite leg,
the higher volume is chosen.
The skew angle is entered, and this is 40 degrees.
The number of approaches with left or right turn lanes
can be determined from the aerial to be zero.
Intersection lighting is not present,
and the Florida Calibration Factor from FDM Table 122.6.3 is 1.27.
This completes the data collection for the rural two-lane roadway forms.

The next facility type we will cover is Rural Multilane Highway Segments
under HSM Chapter 11,
and we will discuss both the segment and intersection analyses.

Form 750-020-05b is used for the collection of data on rural multilane highway segments.
For the base SPF crash prediction, the roadway type - divided or undivided,
segment length and AADT are required.
Required data for CMF calculations include **lane** width, shoulder width and type,
median width, side slope, presence of lighting, presence of automated speed enforcement
and the last is the calibration factor.
We will cover three of these CMFs in more detail in the next slide.

Shoulder width and type refers to the right-side shoulder for divided highways,
and if shoulder width differs in each direction of travel, then the average should be used.
Possible shoulder types include paved, gravel, turf, or composite,
which is a combination of paved and turf.
Median width is not applicable to segments with median barriers,
as the CMF becomes 1 in this case.
The side slope measurement applies only to undivided highways and is recorded
as a ratio from 1-to-2 to 1-to-7.

Let’s look at another example on State Road 50 for widening the existing two-lane road
to a four-lane divided roadway.
The proposed **typical** section is shown in this graphic.

First, we select this to be a **divided** roadway.
The segment length is entered in miles to be 2.02 miles.
We also enter the AADT.
In this case, we are using a future AADT based upon the future four-lane widening.
The proposed typical section provides us the lane width and the shoulder width.
The lane width is proposed as 12 feet.
The typical section identifies a 5-foot paved shoulder
and a 7-foot grass shoulder.
Per HSM definitions, this is a composite shoulder.

A 10-foot shoulder width is the maximum allowed for HSM calculations
and this is entered.
The median width is 40-foot.
The form says the "side slopes" CMF is only applicable to undivided roadways,
so this is left blank.
The roadway does not have lighting nor automated speed enforcement,
so both are "Not Present". Per FDM Table 122.6.3 the calibration factor is 1.63.
These values are for proposed condition and would be used
in something like a Project Development and Environment or PD&E Study.

Data collection for rural multilane highway intersections is completed utilizing Form 750-020-05f. Similar to rural two-lane roadway intersections,
this form covers the intersection types included in HSM Chapter 11,
which are 3-leg stop-controlled intersections, 4-leg stop-controlled intersections,
and 4-leg signalized intersections.

Again, analysis for other facility types,
including 3-leg signalized intersections can be carried out
using the SPICE tool and its corresponding data collection form.
The data elements collected for rural multilane highway intersections
are identical to those previously discussed for rural two-lane roadway intersections.
Data required for this form will be used to compute the **base** crash prediction,
as well as data for the completion of four CMFs.

Let's continue the State Road 50 example
showing a rural 4-leg stop-controlled intersection
on the future 4-lane State Road 50.
This drawing is from the PD&E study to widen State Road 50
and shows the proposed intersection at Porter Gap Road.
There will be left turns off the major roadway in both directions.
No improvements are proposed on the minor leg approaches.
Also notice the minor approaches cross the intersection
at a skew angle which measures
to be 70 degrees.

In completing Form 750-020-05f for rural multi-lane highway intersection,
the intersection type is identified as 4-leg stop controlled or 4TH.
The AADTs from the PD&E study are entered as well as the 70-degree skew angle.
The number of left turn lanes are 2
and notice this is only for non-STOP controlled approaches.
There are no right turn lanes but again this is only applicable
to non-STOP controlled approaches.
Intersection lighting is not present, and the calibration factor
taken from FDM Table 122.6.3 is 1.64.
This completes the data collection for the rural multilane highway forms.

The next facility type we will cover is Urban Suburban Arterials for 2 to 5 lanes under HSM Chapter 12, and we will discuss both the segment and intersection analyses.

Data collection for Urban and Suburban Arterial segments uses Form 750-020-05c.
Corresponding with HSM Chapter 12, this applies to 2 lanes undivided roadways,
4-lane divided and undivided roadways, and 3 lane and 5 lane roadways
with a two-way left turn lane.
The roadway type, segment length,
and AADT are required roadway features to compute
the SPF for base crash prediction.

The urban and suburban roadway types that are eligible for this form are:
2U or 2-lane undivided,
3T or 3-lane including a center two-way left-turn lane,
4U or 4-lane undivided, 4D or 4-lane divided,
and 5T or 5-lane including a center two-way left-turn lane.

Data collected for CMF calculation incudes type of on-street parking,
proportion of curb-length with on-street parking,
median width, presence of lighting,
presence of automated speed enforcement,
driveway counts for major commercial,
minor commercial, major industrial, minor industrial,
major residential, minor residential,
and other driveway types, speed category, roadside fixed object density,
offset distance to roadside fixed objects, and calibration factor.
We will cover four of these CMFs in more detail in the next slide.

Median width is not applicable to segments with median barriers,
as the CMF becomes 1 in this case.
Major driveways are defined as those serving sites
with 50 or more parking spaces.
The speed category indicates if the posted speed limit
is greater than 30 miles per hour,
or 30 miles per hour or less.
Roadside fixed objects are counted only on the right side of the roadway,
not in the median.

Objects are counted if they are at least 4 inches in diameter
and do not have a breakaway design.
Objects that are continuous such as a fence and not behind other point objects
are counted as 1 object for each 70 feet of length.

Let's look at this example on Orange Avenue south of Orlando.
This is an existing 5-lane roadway being evaluated to become 4-lane divided.
We are to conduct a predictive safety analysis for the existing condition.
The aerial shows the analysis begins at Office Court and continues to Lancaster Road.
There are four signalized intersections at Office Court,
Perkins Road, Nela Avenue and Lancaster Road.
There are 3 segments between these intersections.
We will focus on Segment 2 which extends from Perkins Road to Nela Avenue
for the analysis application.
The review of existing aerial photography combined
with a field review reveals the input data shown in the table.
Let’s focus on completing Form 750-020-05c using this information.

We start Form 750-020-05c with completing the heading
and identifying the roadway type.
In this case we have a five-lane roadway with a two-way left turn lane or 5T.

The mileposts for Segment #2 are provided and were obtained
from the FDOT straight line diagram.

Always enter length of segment in miles in this case it is 0.261 miles.
The AADT is obtained and entered.

The remainder of the entries are based upon
a combination of aerial and field review.
There is no parking present along the corridor.
With the two-way left turn lane **there** is no median.

Further, there is no roadway lighting nor automated speed enforcement present.
The definition of major and minor driveways is provided in HSM Section 12.6.1
and says major driveways serve sites with 50 or more parking spaces.
Minor driveways are those serving less than 50 parking spaces.
These values are determined using aerial photography and are entered on the form.

The posted speed limit is 45 miles per hour being greater than 30 miles per hour.
The number of fixed objects is counted and converted to a per mile value
and the average offset is 18 feet.
The calibration factor from FDM Table 122.6.3 is 0.70.

Data collection for urban and suburban arterial intersections uses Form 750-020-05g.
This is applicable to intersections of roadways with 2 to 5 lanes on the major street.
Intersection type, AADT on the major and minor approaches,
the presence of lighting, and the calibration factor are collected for both
signalized and unsignalized intersections.
These are the input for the base crash prediction.

For unsignalized intersections, the number of major-road approaches
with left-turn lanes and the number of major-road approaches
with right-turn lanes is also collected.
For signalized intersections the following data elements are collected:
the number of approaches with left-turn lanes,
the number of approaches with right-turn lanes,
the number of approaches with left-turn signal phasing,
the type of left-turn signal phasing for each of those approaches,
the number of approaches with right-turn-on-red prohibition,
the presence of red-light cameras, the sum of all pedestrian crossing volumes,
the maximum number of lanes crossed by a pedestrian,
the number of bus stops within 1,000 feet, the number of schools within 1,000 feet,
and the number of alcohol sales establishments within 1,000 feet.

For the CMFs, there is a CMF whether intersection lighting is present
in addition to 2 CMFs for unsignalized intersections
and 14 CMFs for signalized intersections.
We will cover **four** of the signalized intersection CMFs in more detail in the next slide.

The sum of all pedestrian crossing volumes is measured
across all legs for the entire day,
this value can be measured or estimated based on activity level.
The maximum number of lanes crossed by a pedestrian includes
both turning and through lanes that must be crossed in a single crossing movement
without the use of a refuge island.

For the number of schools within 1,000 feet of the intersection,
schools are counted if any portion of the school grounds falls within 1,000 feet
of the intersection.
The number of alcohol sales establishments
within 1,000 feet of the intersection
counts any type of business that sells alcohol, including liquor stores,
bars, restaurants, convenience stores, or grocery stores.

Let's continue with the Orange Avenue example;
we selected Nela Avenue as it is signalized
and requires more data for the analysis.
The nearby railroad crossing is not a factor in this safety analysis,
and it is not addressed.

The Nela Avenue approaches are a single shared thru/right/left-turn lane
on the west approach and an exclusive left-turn lane
plus a shared thru/right-turn lane on the east approach.
A field review was conducted to obtain the remainder
of the data shown on this table.

The completion of Form 750-020-05g is similar to the other forms.
The heading along with other data such as **intersection** type which in this case is 4SG or 4-leg, signalized, major and minor approaches AADT, presence of intersection lighting and the calibration factor are entered.

The data for unsignalized intersection is left blank as this information is not applicable.
As previously noted, when evaluating a signalized intersection for urban and suburban arterials more information is required.

First regards intersection geometry and signal operation.
The number of approaches with left and right turn lanes are recorded.

We have 3 approaches with left turn lanes and no approaches with right turn lanes.
We also need to note the number of approaches with left turn signal phasing and the type of signal phasing per leg.
These are pull down menus and it is important for the type of left turn phasing to use those on the pull down to avoid any typing errors.

The number of approached with right turn on red prohibited is recorded, in this example is 0.
Next, the analyst should record whether red light cameras are present.
In our example, there are no red-light cameras.
Some of the other unique entry data is the sum of pedestrian crossing volumes being for all four approaches and being a daily volume.

It also requests the maximum number of lanes crossed by a pedestrian which in this case is on Orange Avenue and would be 5 lanes.
The number of bus stops within 1,000 feet of the intersection are recorded and there are two at the intersection and one north, totaling 3 bus stops.

There are no nearby schools.
There is one alcohol sales establishment within 1,000 feet of the intersection.

As previously noted, these are defined as any establishment selling alcohol to include grocery stores and convenience stores.
This completes the data collection for the urban suburban arterials for 2 to 5 lanes forms.

The next facility type we will cover is Urban Suburban Arterials for 6 to 8 lanes
and one-way streets completed through NCHRP 17-58,
and we will discuss both the segment and intersection analyses.

Data collection for Urban and Suburban Arterial segments uses Form 750-020-05L.
Corresponding with work completed through NCHRP 17-58, this applies to roadways
with 6 to 8 lanes and one-way streets.

The urban and suburban roadway types that are eligible for this data collection form are:
6U or 6-lane undivided, 6D or 6-lane divided,
7T or 7-lane including a center two-way left-turn lane, 8D or 8-lane divided,
2O or 2-lane one-way, 3O or 3-lane one-way, and 4O or 4-lane one-way.

Roadway type, segment length, and AADT are required roadway features
to compute the SPF for base crash prediction.
Data collected for CMF calculation includes the type of on-street parking,
proportion of curb-length with on-street parking, outside shoulder width, median width,
presence of median barriers, number of highway-rail grade crossings,
driveway counts for major commercial, major industrial, and minor driveways,
roadside fixed object density, offset distance to roadside fixed objects, and calibration
factor.

We will now look at the data collection requirements for a short section
of State Road 535 just south of Interstate 4.

As seen in this aerial this roadway is 6 lanes divided
and has a 22-foot-wide raised median.
It has 40 and 45 miles per hour posted speed limits
and the existing year AADT is 49,700 vehicles per day.
The roadway has curb and gutter with sidewalk at the back of curb on the east side.
Let's take a look at the data requirements shown on Form 750-020-05L.

The first requirement is to enter the roadway type
which is 6 lanes divided or 6D.
The roadway segment length is 0.21 miles which is from the center
of the I-4 intersection to the center of the signalized intersection
of Meadow Creek Drive and Lake Vining Drive to the south.
The AADT of 49,700 is entered.

The roadway does not have on-street parking, so none is selected from the pull-down menu. Since we selected none for parking the proportion of curb length is left blank.
The roadway is curb and gutter without a bike lane, so the outside shoulder width is 0 feet.
The median width is 22 feet and does not have a median barrier.
There are no highway rail grade crossings on this roadway.

The number of major commercial driveways being those serving 50 or more parking spaces is 3. Ski Holiday Drive being an unsignalized, right-in/right-out connection is considered
a major commercial driveway.
There are no major industrial driveways.
There are 5 additional minor driveways present.
There are 17 power poles in this 0.21-mile section or 81 fixed objects per mile.

The roadway has curb and gutter but there is overhead electrical along the eastern side about 16 feet from the edge of travel lane.
FDOT has not yet prepared calibration factors for these NCHRP SPFs
so the calibration factor would be 1.00.

Data collection Form 750-020-05m covers intersections
of urban and suburban arterials on roadways with either 6 to 8 lanes
on the major street or one-way streets.

Data collected for the entire intersection noted on the form as "Intersection Data"
include the area type, number of intersection legs, traffic control type,
presence of lighting, presence of red-light cameras,
daily pedestrian volume crossing all legs,
maximum number of lanes crossed by a pedestrian,
number of bus stops within 1,000 feet of the intersection,

presence of schools within 1,000 feet of the intersection,
and number of alcohol sales establishments within 1,000 feet of the intersection.

Data collected for each major and minor roadway
individually shown on the form as "Street Data" include the street configuration,
AADT, number of through lanes, number of approaches with left-turn lanes,
number of left-turn movements with protected phasing,
number of right-turn movements prohibited on red,
number of U-turn movements prohibited,
and the number of approaches with right-turn channelization.

These inputs are used to compute the SPF for base crash prediction,
and these values are used for the CMF calculation.
Let’s take a closer look at right turn channelization CMFs in the next slide.

An example of with and without right turn channelization are shown here.
It should be noted the channelization is only appropriate
for the major road approaches.

Right turn channelization is defined as having a marked or raised curb island
present to separate the right turn from the adjacent movements.

For this example, let’s go back to the State Road 535 corridor
and the signalized intersection with Meadow Creek Drive
and Lake Vining Drive at the southern end.

This intersection's major approaches have three through lanes and left turn lanes.
The southbound approach also has a right turn lane but does not meet the criteria
for right turn channelization as it is controlled by a stop bar
with no physical separation.

The minor street approaches have a left turn lane
and a shared through/right turn lane on Meadow Creek Drive
and a thorough/left turn lane plus a right turn slip lane on Lake Vining Drive.
The intersection also has pedestrian crosswalks on all four approaches.

In completing Form 750-020-05m,
the first is area type with urban and suburban selections.
The NCHRP 17-58 research defines urban where more than 50%
of the land use within 250 feet of the intersection is commercial.

Locations not meeting this criterion are considered to be suburban.
This intersection has apartments or residential in two intersection quadrants
and commercial development in the other two quadrants.
It is not more than 50% so the area type is defined as suburban.

The number of intersection legs is 4 and the traffic control type is signalized.
Intersection lighting is not present, and neither are red-light cameras.
The daily pedestrian volume is 50 persons and the maximum number of lanes
crossed by a pedestrian is 8 for the north intersection leg.
There are no bus stops nor schools within 1,000 feet of the intersection.
There are 7 alcohol sales establishments within 1,000 feet of the intersection.

The reporting of major and minor approach data is a bit different
than previous intersection analysis as it is separated into two columns.
For our example at State Road 535 and Meadow Creek Drive / Lake Vining Drive,
both the major and minor roadways are two-way.

The AADT for the major and minor approaches is entered
and remember this is the higher value from opposing legs.
The number of through lanes are entered and this is the total for both directions.
In this example it would be 6 lanes for the major street and 2 lanes for the minor street.

The number of approaches with left-turn lanes
is only for the major street approaches and will be 2.
The number of left-turn movements with protected phasing
only applies to State Road 535 approaches as both left turns have protected phasing.

Right turn on red is permitted at all approaches so it will be 0 for both major and minor.
U-turn movements are allowed so again it will be 0 for both approaches.
The major approaches do not have right turn channelization, so this is 0.

This completes the data collection for the urban suburban arterials
for 6 to 8 lanes and one-way streets forms.

The data collection forms we will cover next are those under SPICE
which focus on alternative intersection including roundabouts and RCUTs.

SPICE was developed to provide an easy-to-use tool
to automate the predictive safety analysis of intersections.
It is a component of the Intersection Control Evaluation procedure,
being used during both Stage 1 and Stage 2 analysis.

The SPICE tool includes analysis of the previously discussed facility types
covered in the HSM and NCHRP 17-58
as well as additional intersection configurations.
This tool can be downloaded from the FDOT Traffic Engineering
and Operations Office website shown on this slide.

To initiate the SPICE analysis, the upper part of the Control Strategy tab
must be completed with information common to all intersections.

This information is basic to all HSM Chapter 12 intersection analyses
and will not be discussed during this training.
The one thing the user should note from this tab which is common
to the data collection forms we will be covering is the analysis,
opening and design year.

SPICE looks at crashes over the project's life cycle.
Now let’s look at the two intersection forms evaluated in SPICE
and not previously discussed: RCUTs and roundabouts.

The first form we will cover today under SPICE
is the Restricted Crossing U-turn intersection also called RCUT.

Data collected at RCUT intersections for analysis in SPICE
can be collected using Form 750-020-05n.

Data recorded on this form include **the** number of U-turns,
number of major roadway lanes, **number** of minor roadway lanes,
total offset distance between center of intersection
and U-turns, number of driveways within RCUT footprint,
total U-turn deceleration length, total U-turn acceleration length,
number of left-turn lanes from major approach,
total median width, **maximum** median width, and major road speed limit.

Let’s look at an example to apply this form.

Most applications of the RCUT safety analysis will be as part
of the Intersection Control Evaluation or ICE process.
This example is for the proposed improvement of the State Road 44
and US 41 intersection in Citrus County.

In the ICE process the RCUT intersection
was evaluated and SPICE was used for the safety analysis.

The RCUT inputs are found in **SPICE’s** "At-Grade Inputs" tab.
Some of these input factors such as "Total Offset Distance"
and "Total Median Width" have pull down definitions to aid the user
in determining the value to be entered.

Here the **Total** Offset Distance is total distance
between the two U-turn intersections.
The Total Median Width is the sum of the median widths
at the two major street approaches.

Going back to our example and using the RCUT concept drawing,
let's complete Form 750-020-05n.
We see this intersection will have two U-turn locations on US 41.
Both the major and minor roadways have 2 through lanes
in each direction of travel.

The total offset distance is the distance between the two U-turn locations
which is 1,250 feet.
The number of driveways within the RCUT footprint
or between the U-turn locations is for both sides of US 41 and is 8 driveways.

The total U-turn deceleration length for the two U-turn locations is 400 feet.
The total U-turn acceleration length is only applicable
to unsignalized RCUTS and is left blank.
The number of left-turn lanes from major approach
is 2 for the US 41 southbound approach.
The total median width is for both major approaches which sums to 50 feet.

The maximum median width is for unsignalized RCUTs and is left blank.
The major road speed limit is 45 miles per hour.
This completes the data collection for the Restricted Crossing U-turn form.

Data collected for roundabout analysis using the SPICE tool
can be collected using Form 750-020-05o.
Data collected pertaining to the entire intersection includes the roundabout
configuration, location, and inscribed circle diameter.
For roundabout configuration, 31R means 3 legs and 1 circulating lane
and 42R means 4 legs and 2 circulating lanes.

Additional data is collected individually for each leg, including the entering AADT,
presence of a right-turn bypass, number of access points within 250 feet of the yield line
for single lane roundabouts only, entering width, number of entering lanes on the leg,
and **number** of circulating lanes at the leg.

Let’s take a closer look at three of these CMFs.

The inscribed circle diameter measures the diameter
of the circle making the outside edge of the circulating lanes.

The number of entering lanes is the total number of lanes on the given approach.
The number of circulating lanes is the total number of lanes
that an approach conflicts with upon entering the roundabout.

Let’s take a look at an example for application of the data collection for roundabouts.

Continuing with the ICE analysis of the State Road 44 and US 41 intersection
in Citrus County, let’s look at the roundabout option.
This concept drawing shows the roundabout lane requirements
based upon the operations analysis.

The concept has two right turn bypasses lanes,
and the circulating roadway is 2 lanes for all approaches
except for the US 41 northbound approach.

This is a two-lane roundabout.

The data collection requirements for SPICE analysis are shown on Form 750-020-05o.
The first is the roundabout configuration.
This is 42R being a four-leg, two-lane circulating roadway roundabout.
The location is within an urban service boundary, so it is urban/suburban.

The inscribed circle diameter is 150 feet.
The major leg and minor leg entering AADTs are carried forward
from the Control Strategy tab and the volumes are considered to be one-half
on each approach.
The next question is whether a right-turn bypass is present.

There is one on major leg #1 or northbound approach and minor leg #1
or the westbound approach so these are present and the other two legs are not present.

The number of access points within 250 feet of the yield line
is only applicable to single lane roundabouts and **is** left blank.

All approaches have two entering lanes and a 30-foot entering width.
All approaches except major leg #1 or the northbound approach
have two circulating lanes.

This completes the data collection for the roundabout form.

For data collection on segments or intersection that do not fit
into the previously discussed HSM, NCHRP 17-58, or SPICE facility types,
data can be collected using Form 750-020-05d and Form 750-020-05h, respectively.

Let's take a look at these two forms next.

Form 750-020-05d includes data elements from the previously discussed forms,
as well as a few unique elements, such as the presence of crosswalks,
school zones, and bike lanes.

Form 750-020-05h includes data elements from the previously discussed forms,
as well as crosswalk presence for each intersection leg.

We have now completed the overview of the Data Collection forms
for Transportation Safety Analysis.

Let's take a look at the four forms available for Existing Conditions Reporting.
We will begin with Condition Diagram.

A condition diagram is used to record existing field conditions
of the selected site and its surrounding area.

It can be used in conjunction with collision diagrams
to correlate existing conditions with crash history.

The condition diagram can be recorded
using Form 750-020-04 using the standard symbols provided
on the form or others approved by FDOT.

Alternatively, an annotated aerial may be used in the place of this form.
A sample condition diagram is shown on this slide.

The condition diagram should include information
such as intersection or roadway alignment; buildings, trees,
and other surroundings; lighting poles, fire hydrants, and other utilities;
traffic control devices; signal phasing; the number of lanes and lane use;
and the length of any turn lanes.

Let’s take a look at the forms to develop Collision Diagrams
at segments and intersections.

Collision diagrams provide a visual representation of historical crash patterns
and can help identify crash clusters by crash type.

This tool can used to define existing conditions safety concerns and crash patterns.
Collision diagrams can also aid in countermeasure identification.

Historical crash data is available through FDOT's Crash Analysis Reporting System
also known as CARS.
Automated software for creation of collision diagrams is available,
and if used, should be spot-checked for accuracy.

Form 750-020-05i should be used for collision diagrams along segments,
an example is provided on this slide.

A summary of the crashes should be provided.
The MUTS provides examples of collision diagrams
for segments and intersections.
Note bi-directional data is recorded on the using the legend shown on the form.

The data is summarized in the table below or on the Collision Summary.
This form uses a **legend** of crash types to record crashes,
this legend can be modified and adapted to the conditions
at the location under evaluation.

Form 750-020-05j should be used for collision diagrams at intersections.
Depending upon the number of intersection crashes,
a separate diagram may be needed
for each year of analysis.
Similar to the segment collision diagram,
this form uses a legend of crash types to record crashes.

For both, intersection, and segment collision diagrams,
the crash location is extremely important and may require reviewing crash reports
to accurately represent crash conditions.

If multiple crashes of the same crash type occur on the same approach,
the Collision Summary crash numbers
can be recorded on the collision diagram
to indicate multiple crashes and potentially link to more detailed data.

Let’s take a look at the form to develop a Crash Summary.

Form 750-020-05k can be used for the Collision Summary.
An example of a completed Collision Summary is shown on this slide and provides a detailed summary of the crash information displayed in the collision diagrams.

The data shown in the Collision Summary is typically available in FDOT CARS reports.
The bottom of the Collision Summary provides the opportunity to summarize the crashes by **severity**, **by** crash type and by contributing causes.

The HSM has provided new safety prediction methods for different roadway segment and intersections.

This chapter focused on the data collection requirements to conduct predictive safety analysis and existing conditions reporting for transportation safety studies.

[Web]

This concludes the Manual on Uniform Traffic Studies computer based training, Chapter 5 - Data Collection for Transportation Safety Studies.
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.
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]

This concludes the Manual on Uniform Traffic Studies computer based training, Chapter 5 - Data Collection for Transportation Safety Studies.
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.

Chapter 6 Presentation Script

Welcome

Welcome to the Manual on Uniform Traffic Studies,
also called MUTS, computer based training!
This training module will cover Chapter 6 - Data Collection
for Safety Analysis of Freeway Facilities.

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.

Form Access

During this training module, we will refer to three 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 form is also provided in the resources page to this training.
Please open Form numbers 750-020-06a, 750-020-06b and 750-020-06c
as we will refer to them later in the module.

Introduction

This chapter covers the data collection for transportation safety studies
on freeway facilities.
The goal of this chapter is to provide guidance on the data collection requirements
for conducting transportation safety studies on freeway facilities,
including the application of Highway Safety Manual
or HSM Chapters 18 and 19 methodologies
implemented using the Enhanced Interchange Safety Analysis Tool.
We will call this tool ISATe.

Safety Study Basics

Let's take a look at some safety studies basics.
The purpose of a transportation safety study is to identify potential hazards
and select possible safety countermeasures.
Transportation safety studies can be broadly classified
as reactive to a given location's crash history
or predictive of a given location's potential crash frequency
based on its geometric and traffic characteristics.
This chapter focuses on the data collection requirements
for the predictive safety studies.

HSM Background – Predictive Method Procedure

The predictive method presented in Part C of the HSM allows for the computation
of the predicted average crash frequency and the expected average crash frequency
at a given location.
The expected average crash frequency combines
the predicted average crash frequency with **recorded** historical crash data
using weighting factors.
Let's take a closer look at the components needed to calculate
the predicted crash frequency.

The predicted average crash frequency consists of three primary components,
the safety performance function, also called SPF,
which predicts average crash frequency for base conditions,
the crash modification factors also called CMFs
are for given geometric or traffic control features varying from the base conditions,
and **the** local calibration factor.

The calculation of the predicted average crash frequency is described in detail
in HSM Chapters 18 and 19.
This training focuses on the data collection activities
required to conduct this calculation.

FDOT has not yet developed local calibration factors for freeway
and ramp facilities so this will be 1.00 until these factors become available.
Refer to the FDOT Design Manual or FDM Chapter 122 for available calibration factors.
This training describes the data collection components required for the implementation
of the predictive method.

ISATe Tool & Resources

The ISATe Tool is a spreadsheet based on implementing
HSM Chapter 18 and Chapter 19 methodologies.
HSM Chapter 18 covers the predictive method for freeways and Chapter 19
covers the predictive method for freeway ramps.
This MUTS chapter will walk through the data collection needs for the ISATe Tool.

These data collection forms can also be used to record data for facility types
that are not currently covered under the methodologies
presented in HSM Chapters 18 and 19.
For further HSM training, visit the FDOT Roadway Design/Quality
Assurance/Training website.
The ISATe Tool and user manual can be accessed
through the Highway Safety Manual website at the provided link on the resources page.
Use the FDOT's Traffic Engineering and Operations Office website
as a resource to obtain a copy of the modified ISATe Tool
which have Florida based crash cost calculations capabilities.

Freeway Data Collection Needs

This chapter covers freeway data collection needs for three broad site types:
freeway segments, ramp segments, and ramp terminals.
While the traffic and geometric data collection needs are explained in detail,
further data collection information regarding **historical** crash data collection,
collision diagram development, and condition diagram development
can be seen in MUTS Chapter 5.

Freeway Segments

It is important to understand there are three basic segments
to the freeway – freeway, ramp, and crossroad which is the ramp terminal intersection.
Let's take a closer look at the freeway segment.

The freeway consists of the freeway segment and **the** speed-change lane.
The freeway segment is for both directions of travel and the number
of through lanes should reflect this.

The number of lanes should not include any high-occupancy vehicle or managed lanes.
The length should be measured in the increasing milepost direction
of travel after the 2-foot-wide marked gore point.
Let's take a closer look at the speed-change lane.

Freeway Segments: Speed Change Lanes

Speed change lanes should not be included in the freeway segment's length.
There are two types of speed change lanes - parallel and **taper**.
The speed change lane's length is defined as the roadway area
between where the marked gore is 2 feet wide and the taper point
of the ramp's merge or diverge area.

MUTS Chapter 6 Forms Overview

Before we dive into the data collection forms for Safety Analysis of Freeway Facilities,
it will be helpful to understand the resources available through the MUTS website.
Here is a snapshot of the process and the corresponding forms available.
The form selection varies based on the facility type being analyzed.
Let's start with HSM Chapter 18: Freeway Segments and its corresponding form.

These forms can be accessed by visiting the FDOT MUTS website
or by scanning the QR code on the slide with a cellphone camera.

Form No. 750-020-06a

Let's get started with the data collection requirements.
Form 750-020-06a is used for freeway segments.
The form is set up to match the data requirements of the ISATe Tool.
A separate form should be used for each freeway segment.
The data elements collected through this form contribute towards the computation of 13 CMFs for the freeway segment.

There is basic header information to be included on the form.
The form is two pages with six data collection sections.
These are **basic** roadway data, **horizontal** curve data, cross section data, roadside data, and **ramp** access data.

In addition to this roadway data, traffic and crash data will be required to conduct the predictive analysis but are not included in this data collection form.
Let's take a look at this form in greater detail.

Basic Roadway Data

After completing the header part, we will get into the Basic Roadway Data.
The first is Area Type. This uses rural versus urban guidance based on FHWA guidelines, which specifies that places within urban boundaries with a population greater than 5,000 are considered urban, and places outside urban areas with population less than 5,000 are considered rural.

The FDOT urban boundary maps are an excellent source for this information.
The next input is the number of through lanes which is again a bi-directional value.
The next value is segment length measured in miles.
This is typically the distance between speed change lanes, but other segmentation criteria provided in the HSM can be applied.

Horizontal Curve Data

The next data collection section is the presence of a horizontal curve on one or both roadbeds.
This is the first question and is answered “Yes” or “No.”
If a horizontal curve is present, then there are three needed data elements.
The first is the curve radius entered in feet.
This is generally obtained from roadway plans.
If the two roadbeds have different radius, then each are separately recorded.

The next is the length of curve measured in miles.
This is measured from the point where the curve begins or P.C. to the point where the curve ends or P.T.

The last element is the length of curve in the segment also measured in miles.
This is confined to the segment's boundaries so it cannot exceed the segment or curve length.

Cross Section Data – Part 1

The cross section data starts with the lane width in feet.
This is the average for all through lanes.
The shoulder width is the paved shoulder width and is reported separately for inside and outside shoulder.
Again, an average value should be used.

The median width, recorded in feet, is measured between edges of opposite direction travel lanes which includes the inside shoulders if present.
If there is a substantial change in median width, a new freeway segment should be created.

The presence of rumble strips on the outside and inside shoulders is a yes/no question.
If answered “Yes,” the length of rumble strips in miles for each direction of travel is to be recorded.

Cross Section Data – Part 2

Cross section data also includes the consideration for median barrier.
The first question asks if median barrier is present or not present.
If present, there may be multiple pieces of median barrier within a freeway segment.
Each piece of median barrier is measured, and its length is reported in miles.
The distance to the nearest travel lane in feet is also recorded.
Often this will vary as barrier tapers toward or away from the travel lane
and are reported as an average distance.

If a continuous median barrier is present, then report the barrier's width
and distance from the barrier to the nearest edge of the traveled way.

Roadside Data

The next data entry is for roadside data.
The first data element is the clear zone width in feet.
Then the presence of roadside barrier is reported as either none,
some or full using the dropdown menu.

If “Some” is selected, there are five entry points to provide the length of roadside barrier
in feet and **the** distance from the edge of travel lane to the barrier face.
If more than five entry points are needed,
consider using a second form to supplement the data collection.
Again, this is an average value for the barrier's length and is in feet.

If there is full barrier along both sides, then you only need to enter the values
at the bottom of the section for distance from edge of travel lane to the barrier's face.
This is done in two separate values for increasing and decreasing mileposts.

Ramp Access Data

The ramp access data takes a bit to understand, and we will take a few slides to cover.
First it is important to note that data collection is completed separately
for each direction of travel.

The form is set up for increasing milepost direction
followed by the decreasing milepost direction.
The methodology for these is the same.
Understanding two definitions is critical to entering the ramp access data.

These are Type B weave and the begin segment milepost related to the ramp gore points.
Let’s take a look at these data elements.

First, we will discuss the Type B weave.
This weaving section can have the following characteristics:
one of the two weaving movements can be made without making any lane changes,
the other weaving movement requires only one lane change,
and the entrance and exit ramps associated with the weaving section
are located on the freeway's right side.

Note that the weaving section length is measured
along the freeway's edge of travel lane from the gore point of the ramp entrance
to the gore point of the ramp exit.

Now, let’s take a look at how to locate any entrance and exit ramps
within or near the segment.
If there is no ramp within the segment or the ramp's gore point
is more than 0.5 miles from the segment,
there is no ramp, and the length is coded as 999.

The length is measured from the segment boundary to the ramp's gore point.
The images to the right provide two graphical representations
on the reference points to use when defining the begin mileposts
to measure the segment’s length.

For example, the length measured from the segment to the exit ramp gore point
for the exit ramps is shown in red.
In a similar fashion, the length measured from the entrance ramp gore point
to the segment is shown in blue.

Let's return to the ramp access data elements on the form.
The first data entry is whether there is an entrance or exit ramp in the segment.
The pull-down menu has *None, SC lanes or Speed change lanes* and *Add or drop a lane*.
Most ramps are speed-change lanes allowing traffic to accelerate
or decelerate for entrance or exit ramps, respectively.

When there is a speed change lane, you will need to enter the distance
from the begin milepost to the upstream entrance or exit ramp gore point in miles.
Again, the begin milepost is the milepost at the beginning of the segment.
There are three additional items of required information.
First is the length of ramp which is from the ramp's taper point
to the gore point measured in miles.
This was previously defined in the segmentation discussion as the speed change lane.
The next element is the length of ramp within the freeway segment.
For speed change lanes, you will also need to enter the roadway side
where the entrance or exit ramp is located.

The final part of the data entry regards whether there is a Type B weave in the segment.
If so, the length weaving section in miles as defined two slides ago and the length
of weaving section in segment are to be entered.

This completes the data entry requirements for Form 750-020-06a.
As previously noted, the analyst will need to collect two additional data requirements
for the freeway safety analysis: Traffic Data and Crash Data.
We will cover these next although these are not to be populated
under Form 750-020-06a.

Traffic Data

The values for bi-directional average annual daily traffic or AADT need to be entered.
Multiple years of AADTs both existing and future can be entered.
When entering the data into the ISATe Tool,
you will be asked the question of Proportion of AADT during high-volume hours.
This is defined as the proportion of a 24-hour day where the hourly volumes
exceed 1,000 vehicles per hour per lane.
The AADTs to be entered are freeway segment which are bi-directional volumes
in addition to each entrance and exit ramp volume.

ISATe: Traffic

Let's take a look at the ISATe Tool.
The bottom of the slide shows the available tabs within the tool.
The data input is arranged by facility type which includes:
freeway segments, ramp segments, and ramp terminals.
As shown on this screen capture, the traffic data is recorded by segment.
The AADT input should be entered for those years which data is available.
The tool will interpolate the missing years.

Within the Input Freeway Segments tab in the ISATe Tool,
the traffic data input is broken down as follows:
freeway segment data, entrance and exit ramp data for travel
in increasing milepost direction, entrance and exit ramp data for travel
in decreasing milepost direction.

Crash Data

The crash data is the final data requirement for the freeway segment analysis.
It is recommended five years of crash data be obtained
and each year can be entered into the ISATe Tool.
The crashes need to be broken into two broad categories
being Fatal and Injury Crashes and Property Damage Only or PDO crashes.
The freeway segment crashes need to be further categorized
as multiple and single vehicle crashes for both categories.
The ramp related crashes are those in the speed change lanes
for the entrance and exit ramps.

ISATe: Crash Data

Let's take a look at the ISATe Tool.
The data input for crashes within the tool is in the same tab as the traffic data or AADT.
For the Input Freeway Segments tab the crash data requirements
are broken down by Fatal and Injury crashes by year
and by Property Damage Only crashes by year.
For either severity level, the crashes are broken down by multiple-vehicle crashes, single-vehicle crashes, ramp-entrance-related crashes,
and ramp-exit-related crashes.

Freeway Segments: Example

This example is part of a comparative evaluation of different interchange forms considered for a proposed interchange.
This example is for a diamond interchange.
This example will be used throughout this training module.
While the alternatives will have different ramp configurations the freeway's mainline needs to be considered in the analysis.
The study area's limits are established to have a common begin and end point for all interchange alternatives.
The study area **begins** at milepost 5.41 and ends at milepost 6.75.
The two red circles are in the begin and end points of the study area.

Freeway Segmentation

The first step in the freeway analysis is the segmentation.
The ramp's speed-change lanes are used for the segmentation.
Freeway Segment 1 extends from the Begin Study Area at milepost 5.41 to the northern most part of the southbound on-ramp speed change lane at milepost 5.66.
The speed change lane for the northbound off-ramp is included in Freeway Segment 1.

Freeway Segment 2 begins at milepost 5.66 and continues to milepost 6.25 where the northbound on-ramp speed change lane starts.
This segment does not contain any speed change lanes.

Freeway Segment 3 starts at milepost 6.25 where the northbound on-ramp's speed change lane begins and continues to the End Study Area at milepost 6.75.
This segment also contains the southbound off-ramp speed change lane.

Basic Roadway Data

For our project example, we would need to complete three versions of Form 750-020-06a, one for each freeway segment.
For purposes of this training, we will complete the form for Segment 1 only as it contains two speed change lanes.
We will begin with the basic roadway data.
This project location is in a rural area, so the rural area type is selected.

The interstate has three through lanes in each direction
so the number of through lanes is six.
The segment length is the distance from milepost 5.41
to milepost 5.66 which is 0.25 miles.

You can also see additional data on the table
from developing the interchange preliminary plans for today's training.
We will focus on Segment 1 for the purpose of this training.

Horizontal Curve Data

The next part of the data collection form is the horizontal curve data.
There is no horizontal curve present so using the pull-down menu select "Not present."
No further data needs to be entered for our example.

Cross Section Data

Proceeding on to cross section data, we will use the information shown
in the table obtained from the preliminary plans.
The preliminary plans show this segment to have 12-foot-wide lanes
and 12-foot-wide inside and outside paved shoulders.
The median width is 40 feet.
Rumble strips are proposed for the inside and outside shoulders
throughout the project's length which is 0.25 miles.

The next part of the cross section data regards the presence of median barrier.
A continuous crossover median double-sided guardrail
is present at the northbound lanes edge of the paved shoulder.
This is entered in the pull-down menu for "presence of barrier in median" as "Offset".
The median barrier is present throughout the segment's length which is 0.25 miles.
The distance from the edge of traveled way to the median barrier face is 12 feet.
No further data needs to be entered for additional barrier lengths.
The last input we will record on this section is the median barrier.
The median barrier width is calculated from the median width, 40 feet,
minus the offset distance of 12 feet and guardrail average width of 2 feet.
The median width is recorded as 26 feet.

Roadside Data

There is also roadside data to be entered which is for outside the traveled way.
The clear zone width is 30 feet.
As indicated in the table there is 150 feet of roadside barrier
at 15 feet from the lane or traveled way.
Because there is only a short section of roadside barrier,
select "Some" from the pull-down menu.
The length of the roadside barrier, 150 feet,
needs to be entered into the table in miles which is 0.0284 miles.
Lastly, the distance from the edge of the traveled way
to the roadside barrier face is 15 feet as noted in the table.

Ramp Access Data

The ramp access data is entered first in increasing milepost direction
and then in decreasing milepost direction.
The increasing milepost direction has an exit ramp
so for "ramp entrance in segment" we answer “No” in the pull-down menu
and no further data is required until we get to "ramp exit in segment".
This is a speed change lane ramp, so we selected “SC Lane” from the pull-down menu.

The next data entry is for the distance from the begin milepost
to upstream exit ramp gore in miles.
This is from mile post 5.41 to milepost 5.64 or 0.23 miles.
The length of ramp exit is from milepost 5.59 to milepost 5.64 or 0.05 miles.
Since the entire length of ramp exit is in the segment this is also 0.05 miles.
The ramp is on the freeway's right side so “Right” is selected for exit side.
There is no weaving section so select “No” for Type B weave in segment.

We now move to entering the freeway in decreasing milepost direction
for the ramp access data.
There is an entrance ramp in this direction which is a speed change lane or SC lane.
The distance from the begin milepost at 5.41 to the upstream entrance ramp
gore milepost at 5.66 is 0.25 miles.

The length of ramp entrance is from the taper point at milepost 5.48
to the gore point at milepost 5.66 or 0.18 miles.
The ramp is on the freeway's right side so “Right” is selected for entrance side.
The segment does not contain an exit ramp so “No” is selected
for "ramp exit in segment.”

There is no weaving section so select “No” for Type B weave in segment.
This completes data requirements for Form 750-020-06a.
You will still need to enter the freeway and ramp AADTs
into the ISATe Tool and the freeway crash data for this segment.

MUTS Chapter 6 Forms Overview

Now let’s continue with **HSM** Chapter 19: Freeway Ramp Segments,
its data collection requirements, and its corresponding form.

Form No. 750-020-06b

The freeway ramp segments data collection is reported on Form 750-020-06b.
There is basic header information to be included on the form.
The form is two pages and has five basic sections to include basic roadway data,
horizontal alignment data, cross section data, roadside data, and ramp access data.

To conduct the analysis in ISATe both traffic and crash data
are needed but not included on the form.
The data elements in the five sections listed contribute towards 9 CMFs.
An individual form is required for each ramp segment.

Freeway Ramp Segments

Before we get into the ramp segments data collection,
let's discuss some basic definitions for ramps.
First, the number of through lanes can only be one lane for rural ramp segments
and not greater than two lanes for urban segments.
Turn bays and auxiliary lanes are not included.

We will use the graphic on the screen to walk through these concepts.
First, you will need to complete ramp segmentation.
For example, this ramp has three segments.
Segment 1 is from the gore point at the exit to the begin taper to add the second lane.
Segment 2 is from the taper to add the second lane to the taper to add the turn bay.
And Segment 3 is from the taper to add the turn bay to the crossroad.

The number of lanes for Segment 3 in this graphic is 2 lanes.

It is also important to understand the locations
where the ramps begin and end and how the ramp length is determined.
There are two critical ramp locations.
One is the 2-foot gore point which is the beginning of ramp for an exit ramp
and the end of ramp for the entrance ramp.

The other is at the crossroad where the reference line
intersects the crossroad's edge of travel lane.
This is the beginning of ramp for an entrance ramp
and the end of ramp for an exit ramp.
The ramp will have a reference line which is along the right edge
of the ramp's travel way.

The length of the reference line between the 2-foot gore point
and its intersection with the crossroad is the ramp's length.

Basic Roadway Data

The basic roadway data elements include the area type
which is given in the freeway segment and is unchanged.
The number of through lanes and ramp's segment length which were explained in the previous slides.
The average traffic speed on the freeway is for the non-peak hours during a typical travel day.
This speed is used to calculate the speed into any ramp curves.

The segment types include either an entrance or exit ramp
and if the ramp is a collector-distributor or CD road.
There is also a connector ramp which is for a ramp to a service interchange.
The type of control at crossroad ramp terminal can be signal,
stop control, yield, or none.
None is used when there is an add lane at the crossroad.

Horizontal Curve Data

The horizontal curve data in ramp segments is very similar to the data elements for the freeway segment.
Initially, you will need to note if a horizontal curve is or is not present.
If present, there is one minor difference from the freeway segment
as the ramp segment uses the ramp's reference line for the curve radius
and length of curve as previously described.
The curve radius is reported in feet.

The length of curve is measured along the reference line
from the point the curve begins or P.C. to the point where the curve ends,
and the tangent begins or P.T. and is reported in miles.
The length of curve may extend into multiple segments.
The length of the curve within this segment needs to be recorded and is also in miles.

Cross Section Data

The cross section data elements start with the lane width.
This is the average width of the through lanes reported in feet.
The right and left shoulder width is the average width of the paved shoulder for each side of the ramp.

The presence of lane add, or lane drop by taper is a pull-down menu with “No” being not present, a lane add or lane drop.
As previously noted, a new ramp segment is frequently created at the taper point for adding or dropping a lane.
If this occurs, then the length of taper within the segment is recorded in miles.

Roadside Data

The roadside data elements cover the barriers along the ramp.
The form initially has the right side of the roadway or ramp and the next section is for the left side of the roadway or ramp.
Within these sections are two basic data elements.

First is the length of barrier.
This can be for the barrier's entire length or divided into sections.
The illustration divides the barrier into 2 sections with two lengths of barrier $L_{rb\ 1}$ and $L_{rb\ 2}$.
Each of these barriers will have their own distance from the edge of traveled way to the barrier's face shown as $W_{off\ r\ 1}$ and $W_{off\ r\ 2}$.

This distance would be the second input for the form: distance from edge of the traveled way to the barrier face.
Please notice $W_{off\ r\ 1}$ is to the mid-point of the angled barrier representing the average offset distance.

Ramp Access Data

The ramp access data for ramp segments is only required
when there is a ramp entrance or ramp exit on the ramp.
If present, this is identified as a lane add or speed change or SC lane.
Note there are separate entries for a ramp entrance and a ramp exit.

The length of the speed-change lane is shown in the illustration
on the slide being either the ramp entrance length or the ramp exit length.
If the ramp entrance in the segment is a lane add,
you will need to answer if there is a collector-distributor road
and if it has a weave section.
If "Yes," the length of the weaving section and the length
of the weaving section in the segment need to be provided.

Traffic Data

The final data elements for freeway ramp segments
include the traffic and crash data.
Similar with other HSM data requirements, the annual average daily traffic or AADT
for the ramp segment is needed.
At a minimum, the existing year is needed, and future year projections are desirable.
Let's take a look at the ISATe Tool.

ISATe: Traffic Data

The bottom of the slide shows the available tabs within the tool.
The data input required for the Input Ramp Segment is only required
for the ramp segment.
As shown on the screen capture, the traffic data is recorded by segment.
The AADT input should be entered for those years which data is available.
The tool will interpolate the missing years.

Crash Data

Five years of crash data is desirable.
This should be divided into fatal and injury crashes
and property damage only or PDO crashes.
Also, these crashes should be further divided into multiple vehicle
and single vehicle crashes.
Let’s take a look at the ISATe Tool.

ISATe: Crash Data

The data input for crashes within the tool is in the same tab
as the traffic data or AADT.
Consistent with the Freeway Segments tab,
the Ramp Segments tab crash data requirements are broken down
by Fatal and Injury crashes by year and by Property Damage Only crashes by year.
For either severity level, the crashes are broken down by multiple-vehicle crashes
and single-vehicle crashes.

Freeway Ramp Segmentation

Going back into our example, we first need to see the ramp segmentation.
Again, this is when we have a taper to widen the ramp.
For this diamond interchange, each ramp has two segments as shown here.
Segment 1 is always the first segment in the direction of travel.
Segment 2 is the remainder length of the ramp.
For our example, we will use the northbound exit ramp circled in red.

Basic Roadway Data

First let's look at the segmentation.
From the graphic on the bottom right, we see the ramp is initially a single lane.
As it approaches the ramp terminal intersection, the ramp widens to have three lanes at the approach.
Northbound exit ramp Segment 1 is from the gore point to the beginning of the lane add taper which is 0.20 miles.
Segment 2 is from the taper to the ramp terminal intersection which is 0.12 miles.

We will complete this form for Segment 1.
The basic roadway data again starts with the area type which is rural.
For Segment 1 there is one through lane.
The segment length is 0.20 miles.
The average traffic speed on the freeway is 70 miles per hour.
The segment type is an exit ramp.
The type of traffic control at the crossroad ramp terminal is a traffic signal.

Horizontal Curve Data

There is a horizontal curve in ramp Segment 1.
In the pull-down menu select "In Seg" for in segment.
The curve radius is 1,600 feet.
The length of curve is 400 feet and needs to be converted into miles which is 0.0757 miles.

Since the entire curve is in the segment, the same is entered for this value.
There is only one horizontal curve in this ramp segment so select "No" for horizontal curve #2.

Cross Section Data

The cross section data is from the preliminary design and is shown in the table.
The lane width will be 15 feet, **the** right paved shoulder width is 4 feet, and the left paved shoulder width is 2 feet.
There is no lane add or lane drop by taper in this segment.
Note there would be a lane add in Segment 2.

Roadside Data

The roadside data regards the presence of barrier
on either the right or the left side of the ramp.
The preliminary design has not identified a need for barriers on either roadside,
so this has been left blank.

Ramp Access Data

Ramp access data regards when there is a ramp entering or exiting the ramp segment.
There are no ramps entering or exiting this proposed ramp
so the answer to these pull-down menus would be "No."
There is also no weaving section on the ramp so this would also be "No."

Form 750-020-06b is now complete for Segment 1.
This data collection process needs to be completed for the remaining ramp segments.
You will also need to enter the ramp AADTs into the ISATe Tool.
Since this is a proposed ramp, there is no existing crash data to be entered.

MUTS Chapter 6 Forms Overview

Let's take a look at Freeway Ramp Terminals, its data collection requirements,
and its corresponding form.

Form No. 750-020-06c

Freeway ramp terminals are the intersection of the ramp with the crossroad.
The HSM predictive method computes the ramp terminal's
predicted average crash frequency for the limits of the intersection
and the ramp or crossroad legs for crashes attributed to the intersection.

Form 750-020-06c is used to record the data elements to be used in the ISATe Tool.
These data collection sections include basic intersection data, alignment data,
traffic control, cross section data, and access data.
These elements contribute towards the computation of 11 CMFs
used in the predictive analysis.

Before we get into the ramp terminals data collection,
let's discuss some basic definitions for ramp terminals.
There are seven total configurations,
and these will be shown over the next two slides.

Freeway Ramp Terminals

The first element for basic intersection data is ramp terminal configurations.
The three configurations on this slide are for diagonal ramps
typical of what you may see at a full or half diamond interchange.
There is the diagonal, exit or type D3ex and **the** diagonal,
entrance or type D3en for 3 leg ramps.
The 4-leg diagonal ramp is Type D4.

Freeway Ramp Terminals

The other four types of ramp terminal configurations are for Parclo interchanges.
Parclo stands for partial cloverleaf and there is a Parclo A and a Parclo B.
The Parclo A is where the loop ramp is the entrance ramp.

Parclo B is where the loop ramp is the exit ramp.
There are parclo interchanges with ramps in two of the interchanges
four quadrants known as a 2-quad parclo.
If there are ramps in all four quadrants it is known as 4-quad parclo.

Basic Roadway Data

The freeway ramp terminal data collection starts with the basic roadway data.
Similar to the freeway mainline and ramps,
the first element is area type being urban or rural.
Then the selection of the ramp terminal configuration is done
using a pull-down menu.
The seven configurations discussed on the last two slides
are available through this drop-down menu.

The other data elements include the ramp terminal traffic control type
with the pull-down menu choices being signal, one stop and all-stop.
The last data element documents if the ramp terminal
is a non-ramp public street present at the terminal.
The answer to this is either “Yes” or” No.”

Alignment Data

The ramp terminal alignment data collection starts with **the** exit ramp skew angle.
This is measured as 90 degrees minus the intersection angle as shown in this graphic.
The intersection’s angle is measured between the crossroad
and the center of the vehicle at the stop bar.

For ramp terminals, the crossroad has inside and outside approaches
on the outside crossroad leg.
The inside approach is between ramp terminals while the outside approach
is in the opposite direction.

The next data element is the distance to the next public street intersection
on the outside approach in miles.
The final element is the distance to the adjacent ramp terminal
in miles measured between the inside approaches.

Traffic Control Data

The traffic control data elements are for signalized ramp terminals only
and looks at left-turn signal treatments.
The first data element is for the inside approach or between the ramp terminals.
Answer “Yes” or “No” if there is a left turn protected signal.
If it is a protected-permissive signal, this field should be answered as “No.”
Then do the same for the outside approach.
The exit ramp approach right turn movement traffic control type needs to be identified.
The pull-down menu choices are signal, stop, yield, merge or free.

Cross Section Data

The cross section data elements start with the crossroad median width in feet.
Next is the number of through lanes on the crossroad requiring three different entries.
First is the total number of through lanes for both approaches.
Then the number of inside through lanes at the approach must be entered.
This is followed by the number of through lanes at the outside approach.
For the number of lanes at the ramp exit approach this for all lanes, left, right and through.

Right turn channelization presence means there is a turning roadway
separated from the intersection by a triangular channelizing island
that can be painted or raised curb.
This field asks if right turn channelization is present
on the crossroad's inside and outside approaches and the ramp’s exit approach.

The cross section data also needs information about the left and right turn lanes on the crossroad.
The presence of an inside approach left turn lane and if so, the lane width.
This is the total pavement width.
If there are two 12-foot left turn lanes, then enter 24 feet.
The same applies to the outside approach.
The last data element to be collected is presence of a right turn lane.
For the right turn lane, you only need to note their presence for the inside and outside approaches.

Access Data

The access data pertains to the outside approach only.
The first question is the number of driveways on the outside crossroad leg.
This is within 250 feet of the approach's stop bar.
It is applied to both sides of the crossroad and is for active driveway being those with greater than 10 vehicles per day.
The second data element is the number of public street approaches within 250 feet of the ramp terminal intersection and on both sides of the road.

Traffic Data

The final data elements for freeway ramp segments include the traffic and crash data.
The traffic elements needed for this analysis are the inside and outside crossroad AADTs and the exit ramp AADT.
As previously noted, it is desirable to have both existing and future year AADTs.
Let's take a look at the ISATe Tool.

ISATe: Traffic Data

The bottom of the slide shows the available tabs within the tool.
As shown on the screen capture, the traffic data is recorded by terminal.
The AADT input should be entered for those years which data is available.
The tool will interpolate the missing years.

Within the Input Ramp Terminals tab in the ISATe Tool,
the traffic data input is broken down as follows:
Inside Crossroad Leg Data, Outside Crossroad Leg Data,
Exit Ramp Data and Entrance Ramp Data.

Crash Data

If you are evaluating an existing facility, intersection related crash data can be added.
Including 5 years of data is desirable.
The crash data needs to be divided into fatal and injury crashes
and property damage only crashes.
Let's take a look at the ISATe Tool.

The data input for crashes within the tool is in the same tab as the traffic data or AADT.
For the Input Ramp Terminals tab, the crash data requirements are broken down
by Fatal and Injury crashes by year and by Property Damage Only crashes by year,
note no further classification is needed for this data entry.
The crashes to be considered for the ramp terminal analysis
include the crashes associated with unsignalized driveway
or public street approach located within 250 feet of the crossroad terminal.

Freeway Ramp Terminals Example

Let's look at a ramp terminal example at our proposed interchange.
The two diamond interchange ramp terminals are shown on this slide
with intersection approach geometry.
We will continue to focus on the northbound ramp.

Basic Roadway Data

The basic roadway data elements include the area type
which is given in the freeway segment and ramp segment as rural
and has not changed.

The ramp terminal configuration is for a diamond interchange with four legs
at the ramp terminals or D4.
The ramp terminal traffic control is a signal,
and this is selected from the pull-down menu on the corresponding cell.

There is not a non-ramp public street at the ramp terminal and “Not Present” is selected.
The exit ramp intersects the crossroad at 90 degrees, so the skew angle is 0 degrees.
The distance to the next public street intersection on the outside approach is 0.5 miles.
The distance to the adjacent ramp terminal on the inside approach is 0.15 miles.

Traffic Control Data

Let’s zoom in into the ramp terminal configuration.
The ramp terminal is signalized so the traffic control data needs to be entered.
The crossroads inside approach is a dual left turn
with a protected movement so “Yes” is entered.

There is not an outside approach left turn movement
so this is selected as “No.”
The right turn movement at the exit ramp
is at the stop bar under signal control so “Signal” is selected.

Cross Section Data

The cross section data starts with the crossroad median width in feet
which is 22 feet obtained from the table.
The next three data elements regard crossroad through lanes.
The first is for both approaches which is 2 through lanes in each direction totaling 4 lanes.

The inside and outside approaches both have 2 through lanes.
The ramp exit has 2 left turn lanes and 1 right turn lane totaling 3 lanes.
There is not a separate right turn channelization present on any of the approaches,
so “Not present” for this data element was selected.
The next data elements regard the presence of a crossroad left turn lane.
The inside approach has 2 left turn lanes totaling 24 feet in lane width.
The outside approach does not have a left turn lane.
The final data element is whether a right turn lane is present
on the inside or outside approach.
The inside approach does not have a right turn lane and the outside approach
does have a right turn lane.

Access Data

Access data completes Form 750-020-06c.
This proposed interchange has limited access right-of-way
extending greater than 250 feet from the outside crossroad leg.
Therefore, there are no driveways or public approaches.
Both data elements are entered as “0”.

To prepare the ISATe Tool for analysis, **you** will need to enter the 2020 and 2039
inside and outside crossroad AADTs as well as the exit ramp AADT.
Since this is a proposed interchange, there is no crash history to be entered.

Summary and Forms

This training module covered the data collection requirements to use the ISATe Tool
for HSM analysis of freeway segments, ramp segment and ramp terminals.
The three forms described in this training can be accessed
by selecting the links on this resources page
or by scanning the QR code with a cellphone camera.

End of Lesson

[Web]

This concludes the Manual on Uniform Traffic Studies computer based training, Chapter 6- Data Collection for Safety Analysis of Freeway Facilities. 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. 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]

This concludes the Manual on Uniform Traffic Studies computer based training, Chapter 6- Data Collection for Safety Analysis of Freeway Facilities. 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.

Chapter 7 Presentation Script

Welcome to the Manual on Uniform Traffic Studies, also called MUTS, computer-based training! This training module will cover Chapter 7 - Intersection 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.

During this training module, we will refer to one form in excel format stored on the MUTS online library through the F-D-O-T's Traffic Engineering and Operations Office website. Before continuing the training, consider scanning the Q-R code using your phone camera. It will direct you to the online library shown in this slide. The link to the form is also provided in the resources page to this training. Please open Form number 750-020-07 as we will refer to it later in the module.

We will begin the training by describing the purpose of intersection delay studies.

Intersection delay studies measure the performance of intersections with respect to vehicular movement. These studies capture the experience of drivers as they pass through an intersection or use an intersection to turn onto another route. As a primary metric of intersection performance, delay studies are critical for several traffic engineering studies, including the ones shown on the right sidebar of this slide.

To inform this wide variety of studies, the delay measure can be categorized into various types.

The first type is time in queue delay, which is the time it takes a motorist to join the back of a queue, advance through it, and clear the intersection on the other end.

Control delay is the time difference between what a motorist experiences with the intersection and what the motorist would experience in an uncontrolled condition, without the intersection.

Geometric delay reflects the slowdowns experienced as motorists reduce their speed to navigate geometric features, such as curves.

Two other types of delay are described in the MUTS, which are aggregations of the three types discussed earlier.

Travel Time Delay is computed for segments, which can include one or more intersections. It is the time difference between what a motorist experiences traveling through the segment versus what the motorist would experience if the segment had no intersections and the motorist could simply continue traveling at its approach speed. Refer to Chapter 13 of the MUTS for additional guidance on Travel Time Delay Studies.

The Extra Travel Time Delay measure is a recent addition to the toolbox. It was included in the Highway Capacity Manual or HCM 6th Edition to better capture the delay associated with navigating alternative intersection designs, where motorists often have to travel out-of-direction followed by a U-turn to complete a movement.

This slide summarizes how the different types of delay relate to each other.

The time spent in queue plus the time it takes to decelerate and accelerate at an intersection constitute the control delay. In turn, when you add control delay to the geometric delay associated with traversing a segment with one or more intersections, you get the travel time delay. Finally, the new Extra Travel Time Delay adds the extra distance travel time associated with out-of-direction travel.

Now that we have an understanding of the purpose of intersection delay studies and the types of delay that can be measured, we will turn to the equipment you may use to conduct them.

Before we talk about measuring delay, it is important to talk about resources for gathering other data points that are often an input to intersection delay studies.

Intersection turning movement counts, also known as TMCs, are often required to conduct a delay study and to compute overall intersection delay. These counts may be collected through manual or automated means. MUTS Chapter 4 – Turning Movement Counts covers the available methods and procedures to collect TMCs. Refer to Chapter 4 for additional guidance on TMCs.

Secondly, intersection delay studies often rely on a comparison to free-flow approach speeds. MUTS Chapter 12 – Vehicle Spot Speed Study provides detailed information on the equipment, personnel, and procedures needed to obtain these speeds.

This slide focuses on the equipment that is often used to measure control delay, which you may recall is the time spent in the queue plus acceleration and deceleration delay. For additional reference, MUTS Table 7-1 contains a summary of commonly used equipment for intersection delay studies.

There are several tools that can aid during manual data collection and input. The most basic of tools is simple tally sheets, using forms such as the ones discussed in this chapter. We will describe those in more detail in later slides.

Another solution is electronic count boards, which can keep track of time while aiding in data entry. As mentioned earlier, cameras may also be used to enable post-processing of counts away from the count site. The cameras can be mounted to poles or on drones. Mobile devices such as laptops, tablets, and phones may be loaded with software that can help keep track of time, aid in data entry, and summarize the data for delivery.

To capture travel time delay, which is computed from point A to point B, different equipment is needed. Test vehicles (also known as floating cars) can be used with either manual timekeeping and recording or **with** assistance from GPS devices. Additional guidance on test vehicles is included in later slides. Refer to MUTS Chapter 13 – Travel Time and Delay Study for additional information on equipment and personnel needs for data collection.

There are also ways to estimate travel time delay with minimal field labor. A computer model can be built to simulate the performance of the intersection. Another way that has become commonplace in recent years is **the** use of probe data from cell phones or connected vehicles. We will share guidance on the use of probe data towards the end of this training.

Before we get into procedures and analyses of the data, it's important to cover the personnel and training requirements associated with intersection delay studies.

The number of observers needed will vary with the specifics of the study and the location, but is primarily based on the equipment being used, the duration of the counting period, the level of traffic, and the number of lanes being observed.

It's good practice to plan for breaks of 10-15 minutes every two hours, and 30-45 minutes every four hours for data collection periods longer than 8 hours.

When measuring delay on the field, it is recommended that the observers stand at about the midpoint of the maximum queue expected on the right sidewalk or shoulder, at a point where they have a clear view of the lanes being observed.

In general, a single observer can record queued vehicles for up to two lanes if the queues are under 25 vehicles per lane. A single observer could also record long queues on a single lane if they use an audio signal to mark the end of the count interval. The audio signal should also be used on two lanes if the queues are approaching 25 vehicles per lane. In other situations, two observers are usually required.

If drones are being used for the data collection, it is critical to prepare ahead of time as the Federal Aviation Administration regulates the operation of drones. Regulations include altitude restrictions or complete bans on flying drones. All data collection should be researched in advance to comply with these regulations. Refer to MUTS Chapter 4 – Turning Movement Counts for additional guidance on the use of drones for intersection data collection.

This next section covers the form in this chapter, which can be used to measure control delay in the field.

The basic process of measuring control delay involves repeatedly counting queued vehicles on an intersection approach every 10 to 20 seconds. The choice of count interval is up to the practitioner and should consider cycle length and signal actuation. At a signalized intersection, the signal's cycle length should not be divisible by the count interval. In other words, if the signal cycle is 90 seconds, the analyst should not pick 10 or 15 seconds as the count interval, but rather pick 14 or 20 seconds. This reduces bias associated with queues building up in a cyclical pattern.

This field-based approach is generally applicable when queues are up to 25 vehicles per lane but could be extended with more observers or video cameras.

The form included in this chapter can be helpful when performing these counts. As with other MUTS forms, the heading of the form should be filled out completely. Some general information such as date, time, intersection name, and area type could be filled out in advance of the field review.

Also, record the number of lanes, free-flow speed, cycle length, and the selected count interval as described in the previous slide. MUTS Chapter 12 - Vehicle Spot Speed Study provides guidance on collecting the free-flow approach speed.

The middle portion of the form is where the observer will record the queue counts based on field observations. A queued vehicle is considered as any vehicle traveling less than 3 miles per hour or two-three vehicle lengths from the vehicle that is queued in front of it.

Preferably, begin the counts at the start of a red phase when there are no remaining vehicles from the previous cycle. By starting the data collection before congestion builds up, it will be easier to find such a time.

For each survey count interval, record the number of vehicles in the queue. A vehicle must be counted more than once if it is stopped during more than one sampling interval. That is, a particular vehicle will continue to be counted in all intervals during which it remains stopped on the intersection approach.

Also record the approach volume, broken down by whether the vehicles stopped or did not stop. Vehicles stopping multiple times should only be counted once under the approach volume columns. This vehicle count is conducted for the entire study period.

There are three equations included in the bottom part of the chapter form, which are covered in MUTS Section 7.4. The first equation discussed in the MUTS summarizes the two components of control delay, which are time in queue delay and acceleration and deceleration delay. We will now show how to compute these two components using the other two equations.

The next equation discussed in the MUTS covers the acceleration and deceleration delay, which is calculated as the product of the fraction of vehicles stopping times a delay correction factor.

The fraction of vehicles stopping is equal to the number of vehicles stopping divided by the total number of vehicles. This is computed for each approach across the entire study period.

As an example, in this filled form the number of vehicles stopping was 223. The total number of vehicles on the approach was 530. Therefore, the fraction of vehicles stopping is 0.42.

Let's take a look at the second term in the equation or C-F.

The second term in the equation (C-F) is an empirical correction factor that can be looked up from MUTS Table 7-3, **which** is also included on the form itself.

To look up the C-F, you need to know two pieces of information: the first one is the number of vehicles stopping per lane per cycle, which can be obtained using the equation shown here. It is calculated using the number of vehicles stopping divided by the product of the number of cycles and the number of lanes. All these inputs are highlighted for our example form. In this example, there are 13.9 vehicles stopping per lane per cycle.

The second piece of information you need is the approach speed, also referred to as the free-flow speed in the form or shown in the green box here on our example. In this case, the approach speed is 45 miles per hour.

So, for this example, we can conclude that our C-F is +4.

Finally, taking the fraction of vehicles stopping from the previous slide (0.42) and the C-F, we obtain an acceleration/deceleration delay of 1.68 seconds per vehicle.

The final equation in this section is for time in queue delay. It multiplies an empirical factor (0.9) times the ratio of queued vehicles to all vehicles, and times the count interval in seconds.

On our example form, you will find the survey count interval here, the sum of all vehicles in queue here, and the total number of vehicles here. Once you plug in the values into the equation, we obtain a time in queue delay of 10.27 seconds.

Now that we have both the acceleration/deceleration delay and the time-in-queue delay, we can go back to the first equation and compute the total control delay for our example.

As we saw, the time-in-queue delay was 10.27 seconds. The acceleration/deceleration delay was 1.68 seconds. Adding those together results in a control delay of 11.95 or approximately 12 seconds.

If the analyst is using the Excel version of the form, this and other equations are automatically computed as the data is recorded electronically.

We will now cover the procedures for measuring travel time delay: manual test vehicle, **GPS**-assisted test vehicle, and **probe** data. Probe data may be obtained using Bluetooth or Wi-Fi readers or be purchased from commercial vendors that aggregate GPS and cell phone location data, such as INRIX, HERE, StreetLight Data, and others.

The test vehicle method also known as floating car is widely used on arterial streets. It requires a minimum one-mile route length and could be performed with three different techniques: average car, where the driver aims to keep to the average speed in the corridor; floating car, where the driver passes as many vehicles as pass the test car; and maximum car, where the driver drives at the speed limit unless impeded by traffic or safety considerations. Much more detail on the test vehicle method is available in MUTS Chapter 13 - Travel Time and Delay Study, refer to this chapter for additional guidance on the test vehicle method.

Recent advances in technology and wider availability of data are enabling the use of probe data to calculate intersection- and segment-level delays. However, because of typically low sample sizes, an extended data collection period is needed.

The duration of the data collection period for probe data will depend on the answer to four key questions:

How many motorists use the approach, intersection, or segment that you are studying?

What percentage of motorists are included in the sample you are collecting? This will vary depending on the specific technology being used and is usually available from the data or equipment vendor.

What is the inherent variability in what is being measured? If a roadway is typically at or near a fixed speed, then it follows that you don't need as many samples to confirm that.

Finally, how accurate does the estimate need to be? A planning study may require less precision than a traffic operations study.

For purposes of the MUTS Table 7-4 included in this chapter, these four questions are interpreted as the traffic volume or A-A-D-T, the capture rate, the speed range, and the confidence interval and permitted error. For the last one, MUTS Table 7-4 assumes a 95% confidence interval and a 1 mile per hour permitted error, which is in line with operational-level studies.

Out of those four items, the speed range is the one that the analyst may need to compute beforehand using readily available data, such as a spot speed study or a sample dataset. The speed range is defined as the difference between the maximum speed and the minimum speed observed during the study period.

If the maximum or minimum speeds are outliers and not representative of travel in the corridor, the analyst may select the 90th and 10th percentile instead.

An example of a spot speed study distribution is included on the right side of this slide. In this example, the maximum speed is 55 miles per hour and the minimum speed is 25 miles per hour, leading to a speed range of 30 miles per hour. Neither the maximum or the minimum speeds are outliers in this example, but if they were, the speed range would use the 90th and 10th percentiles shown in the distribution (47 and 29 miles per hour).

Here is a subset of MUTS Table 7-4, which shows the minimum number of weeks of probe data that must be collected for segment delays and for intersection delays, which are shown in parentheses. The user must first select the speed range closest to the one experienced in the facility.

Then, the user must look up the appropriate capture rate. This will vary depending on the source of the probe data and is generally available from the vendor.

Finally, the user must look up the segment A-A-D-T or the lower of the two A-A-D-Ts of intersecting roads at an intersection.

Regardless of which method is used to collect data, the travel time delay can be computed by **comparing** the travel time through the intersection against the unimpeded travel time. If probe data is being used, **unimpeded** travel time may be obtained by analyzing low-traffic hours, such as late night or early morning.

Note that probe data is usually summarized by short segments, often called traffic message channels. To compute travel time for a corridor, travel times for all traffic message channels in the corridor must be summed for each time period collected. In this example, **there** are three traffic message channels: a, b, and c. Together, they cover the study corridor **from** node number 1 to node number 2.

To obtain travel times for the study corridor, the individual traffic message channel travel times must be added. For example, for the first time period, the corridor travel time is 6 + 4 + 3 equal 13 minutes. Note that the second time period has missing data for one of the traffic messages channels, so we cannot compute a corridor travel time for that time period.

Let's now look at key takeaways from this chapter and how to access the forms.

Intersection delay is a primary performance measure used in a wide variety of traffic studies.

There are different types of delay and different methods of collecting it, either on the field or at the office using simulation and data.

Field collection for control delay can be suitable for intersections with queues up to 25 vehicles per lane but could be extended with additional observers and equipment.

The form included in this chapter and shown in this slide can help collect and analyze field-collected data. It can be accessed by clicking the link on this slide or by scanning the Q-R code with a cellphone camera.

Finally, probe data offers a convenient way of computing intersection and segment delays but requires weeks or months of data due to lower sample sizes. Guidance is included in this chapter to aid with collecting and computing travel time from probe data.

This concludes the Manual on Uniform Traffic Studies computer based training, Chapter 7 - Intersection 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. 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. To continue to the next chapter of this training please select the “NEXT” button below this CBT. On the next slide, please enter your first and last name 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. To continue to the next chapter of this training please go to the next chapter on the MUTS course content tab. Please, continue to the quiz and thank you for your time and attention.

Chapter 8 Presentation Script

Welcome

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

This training module will cover Chapter 8 - Gap 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.

Form Access

During this training module,
we will refer to two forms in excel format stored on the MUTS online library.

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

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

Please open forms number 750-020-08a and 750-020-08b,
as we will refer to them later in the module.

Introduction

This training module will define vehicle and pedestrian gap studies.

Through the slides, we will provide guidance for practitioners on how to conduct a gap study
and guidance on field data collection procedure.

A gap study determines the size and the number of gaps in the vehicular traffic stream.

This chapter will walkthrough calculations of the critical headway for both pedestrians and vehicles.

Gap studies are primarily used at unsignalized locations,
including two-way stop-controlled intersections, roundabouts, driveways,
or mid-block pedestrian crossings but can be conducted at other locations as well
depending on need.

Use of a Gap Study

Vehicular gap studies can be used for model calibration, conducting roadway capacity analysis,
and vehicular delay considerations.

The pedestrian gap study is commonly used in Traffic Signal Warrant 5.

For detailed information on the application of gap study results
for traffic signal warrant evaluation, refer to MUTS Chapter 3.

Definitions

The following section will walk through the definitions of key terms used for a gap study.

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

Key Definitions

The figure illustrates the difference between the gap and headway.

The gap is measured from the leading vehicle's back bumper to the following vehicle's front bumper.

On the other hand, the headway is measured from the front of both vehicles' bumper.

Both gap and headway are measured in seconds.

Gaps and headways should be measured consistently across vehicles.

Therefore, a reference point must be established.

A reference point is a predetermined spatial location to measure gaps or headways.

Typically, the reference point is the centerline of the minor roadway when conducting a gap study but can vary based on the project and the location characteristics.

The following slide will show an animation depicting the gap and headway.

Key Definitions

As the first vehicle crosses the reference point, the gap and headway can begin to be measured.

The headway is measured from the same point of the vehicles,
so the front of the first vehicle to the front of the second vehicle.

The gap is measured from the back of the first vehicle to the front of the second vehicle.

We will discuss how to measure the headway in the field in future slides.

Key Definitions

The critical gap or headway is the minimum gap, in seconds,
that the average vehicle or pedestrian would accept.

The following animation will show an example of the critical gap.

As shown in the animation turning right, the critical gap or headway
is the minimum amount of time between vehicles on the major street traffic stream
that an average turning vehicle or pedestrian is equally likely to accept or reject the gap.

Practically, this time will allow the entry of one vehicle on a minor movement or one pedestrian.

Key Definitions

Gap acceptance is the completion of a vehicle’s or pedestrians’ movement into a gap.

The following animation shows a rejected gap followed by an accepted gap.

As the first two vehicles travel rightward, they are too close together for the red vehicle on the minor street to make its turning movement.

The second gap is large enough for the vehicle on the side street to complete the turning movement.

We will discuss gap acceptances and rejections in further detail later in this training module.

Key Definitions

Lag is the time difference between when the minor street vehicle arrives to the stop bar and when the major traffic stream next vehicle’s front bumper crosses the side street vehicle at the stop bar.

Lag is also measured in seconds.

The following animation represents lag.

Once the side street vehicle approaches the stop bar, the lag is the time the black vehicle will reach the point the arrow is at.

Lag measurements are typically not included in gap studies.

Equipment and Personnel Needs

The following slides will describe the equipment and personnel needs to conduct a gap study.

Equipment Needs

The equipment used for a gap study can vary based on the equipment available to the engineer.

Equipment for a gap study can include electronic count boards, stopwatches, audio tapes, laptops, and video.

Not all this equipment is required simultaneously.

Electronic count boards, stopwatches, audio tapes, and video can be used individually or in combination to conduct a gap study depending on the capabilities of each device.

Stopwatches are typically used for manual data collection.

Audio tapes aid practitioners in the field as observers speak into the recording with field data collection information such as movements being completed.

Using laptops in the field is not required but can replace the need for printed forms.

If video is used alone, the majority of the equipment listed in this slide would not be required.

Supplementing manual data collection with video recordings allows review of any possible field errors but it is not required.

Personnel Needs

To conduct a gap study, the personnel should place themselves in a location with good visibility of the reference point.

The personnel should also locate themselves away from motorists' sight to not influence driver behavior or pedestrian behavior.

Typically, one observer is enough to record the gap data if no additional data needs to be recorded.

Field Procedure

Let's take a look at how to conduct a gap study in the field.

Field Procedures

To calculate the gap in the field, a stopwatch or other timing device is typically used.

The observer measures the headway between vehicles in seconds and records the headways on the Gap Study form.

For divided roadways that accommodate two stage vehicle or pedestrian crossings, the gap should be determined for each direction of travel.

Measuring the headway is the same for both vehicles and pedestrians, but a different reference point is likely used.

Like previously mentioned, the reference point for vehicles generally is the centerline of the minor roadway which is currently shown on the slide.

For pedestrians, the reference point may be at the center of a marked crosswalk.

If no marked crosswalk exists, the engineer should choose a reference point near where pedestrians are primarily crossing.

In this case, a light pole or a tree could provide a consistent reference point.

The practitioner should choose a reference point based on the field conditions.

The observers should locate themselves out of a vehicle's direct line of sight to not influence driver or pedestrian behavior.

The observer, represented by the person in orange, should not be located directly adjacent to the roadway.

Instead, the observers should locate themselves in an area with good visibility that is offset from the roadway.

The location of the observer will vary based on field conditions.

Field Procedures

In practice, measuring the gap between vehicles is more difficult than measuring the headway.

Therefore, we recommend measuring the headway when conducting a gap study.

Imagine you are the observer standing at location with a clear view of the reference point that avoids influencing driver behavior.

As the two vehicles follow each other, the observer begins the stopwatch once the front bumper of the first vehicle passes the reference point.

The observer stops the stopwatch when the front bumper of the second vehicle reaches the reference point.

In this example, the measured headway is two seconds.

Vehicular Gap Studies

Now that we know how to measure a headway in the field, let's discuss how to conduct a gap study using the applicable forms.

Vehicular Gap Study

A vehicular gap study can be used to evaluate an intersection's performance, calibrate a model, or determine vehicular delay.

The vehicular gap study uses form number 750-020-08b.

To estimate the critical vehicular gap, we will discuss the mean sampling method.

Alternative methodologies can be found in ITE Manual of Transportation Engineering Studies 2nd Edition, Chapter 6.

Form Access

Form number 750-020-08b is the Vehicular Gap Study form which is used in vehicular critical headway studies.

The form can be downloaded from the MUTS website or by scanning the QR code on this slide with a cellphone camera.

It is important to be aware that there are two tabs within this form.

We will take a closer look at these tabs in the next slides.

Form 750-020-08b

Form number 750-020-08b has two tabs the Field Data tab and Analysis tab.

The Analysis tab is automatically calculated using the inputs from the Field Data tab.

Form 750-020-08b: Field Data Tab

Before conducting a vehicular gap study, the header for the Field Data tab should be filled out.

The gap or headway data is recorded into bins with a predetermined time interval.

The applicable gap or headway size can be selected in the excel sheet
using the drop-down choice in excel.

The commonly used interval for most gap acceptance studies is 2 seconds.

Per the ITE Manual of Transportation Engineering Studies 2^{nd} Edition,
a suggested sample size of 200 accepted gaps for a 2-second bin interval is provided.

If a 1-second bin interval is used, a sample size of 500 accepted gaps is suggested.

If a computer is unavailable for the field, the Field Data tab can be printed,
and the results can be coded into the digital tab later.

Gap Study Example

The animation shows how the form would be filled out in the field.

As vehicles wait at the minor street stop bar, the size of accepted and rejected gaps is logged.

This process continues to be repeated throughout the sampling period.

If a computer is unavailable in the field, these tallies can later be transferred over
to the field data form electronically.

The Analysis tab, discussed in further detail later in the module,
will automatically calculate the critical gap from the inputs in the Field Data tab.

One Stage and Two Stage Crossings

When conducting a gap study, the way the headway is measured depends on field conditions.

A one stage crossing is represented on the left picture
where the vehicles and pedestrians look in both directions when accepting or rejecting a gap.

A two-stage crossing, pictured on the right, occurs when a large enough median
is available to store vehicles or pedestrians while these wait to find an acceptable gap
in the opposite traffic stream to complete the second stage of the crossing.

For two-stage crossings, the gap should be recorded for each direction of traffic which is made visible by the two reference points highlighted in blue and red on the right image.

Form 750-020-08b: Analysis Tab

The flowchart shown on this slide depicts the process that is followed to estimate the mean critical vehicular gap.

The form in the top right shows which section of the Analysis tab is completed through the 4 steps.

First, the accepted and rejected gap data is tallied into applicable bins in the Field Data tab and carried over automatically to the analysis tab.

Note the data collected in the field needs to be entered in the electronic format of the form in the Field Data tab to be able to automatically complete the calculations in the Analysis tab.

Form 750-020-08b: Analysis Tab

Then, we calculate the proportion of gaps for different critical gap times which we will show referring to this step as Table A.

Form 750-020-08b: Analysis Tab

Next, we calculate the number of accepted gaps for each critical gap time which requires inputs from Table A.

We will refer to this step as Table B and it will be used to calculate the number of accepted gaps.

Form 750-020-08b: Analysis Tab

Lastly, we calculate the critical gap percentage and estimate the mean critical gap.

All these calculations are automatically completed in Form 750-020-08b under the Analysis tab when the field data is entered in the form electronically.

Estimated Vehicular Critical Gap

We will now walk through the vehicular critical gap calculation to provide background into the Analysis tab.

If the engineer decides to conduct the calculations manually, these are the steps to be followed.

First, the accepted gaps are summarized into the applicable bins using the field data input which is automatically carried over from the Field Data tab.

The example we will walk through today uses a two-second bin size and shows the accepted and rejected gaps for each gap size for a total of 200 hundred measurements in the field.

The values seen in the table are sample values that will be used throughout the example.

The following slide will walk through a sample calculation for the proportion of accepted gaps.

The proportion of accepted gap formula is shown below.

The proportion should increase as the gap size increases as shown in our example.

Increasing Accepted Gap Proportion

Using the sample data presented on the previous slide,
this table shows the calculation of the proportion of accepted gaps.

For each column or bin size, the number of accepted gaps, shown in blue,
is divided by the number of accepted and rejected gaps, shown in red, and multiplied by 100.

The animation walks through each individual calculation.

As the gap size increases, so should the proportion of accepted gaps.

For the next step, we will use the number of accepted and rejected gaps
and transpose these values to populate the gap proportions for Table A.

Table A: Gap Proportion

The slide shows a blank Table A
that we will fill out based on the number of accepted and rejected gaps shown in the previous slide.

Table A: Gap Proportion

To calculate the gap proportion for each critical gap size, we start with a critical gap of zero.

The column that we will calculate first is highlighted in red.

The field data to the right shows the number of accepted and rejected gaps for each gap size.

We calculate the gap proportion of a critical gap of zero using the formula shown on this slide.

We divide the total number of accepted plus rejected gaps by the total sample size times 100 percent.

For example, for an accepted gap size of 1, the calculation is 60 divided by 200 multiplied by 100.

The same steps are taken for the remaining gap sizes.

Table A: Gap Proportion

After calculating the gap proportion of a critical gap of zero seconds,
we will calculate the weighted gap proportion for the remaining critical gap sizes.

The weighted gap proportion uses the formula shown on this slide.

Now, we will calculate the weighted critical gap proportion for a critical gap of 2 seconds.

First, we compare the accepted gap size to the critical gap.

If the accepted gap is less than the critical gap,
we assume that there will be no accepted gaps and all gaps will be rejected.

Because 1 second is less than the critical gap of 2 seconds,
all gaps of 1 second will be assumed to be rejected.

Now we use the rejected proportion at a critical gap of 0 seconds
to calculate the remaining gap proportions.

For an accepted gap size of 3 seconds, we divide 25 by 100 minus 30.

We repeat this same calculation across all accepted gap sizes.

It is important to note, the critical gap proportion calculations
use the 0 second critical gap proportions previously calculated
to complete the table as shown in the corresponding yellow and red colored boxes.

Table A: Gap Proportion

Now we repeat the same steps from the previous slide for a critical gap of 4 seconds.

First, we compare the accepted gap size to the critical gap.

In addition to 1 being less than 4, 3 is less than 4 as well.

Now we have two gap sizes that are rejected, 1 and 3 seconds.

To calculate the weighted gap proportion, we divide the percentage of accepted gaps by 100 minus 30 and 25 or 55 which represent the rejected gaps lower than the critical gap.

For a gap size of 5 seconds, the calculation is 22.5 divided by 100 minus 55.

The same steps are repeated for the rest of the accepted gap sizes.

Note that the critical gap proportion calculations
use the 0 second critical gap proportions initially calculated
to complete the table as shown in the corresponding yellow and red colored boxes.

Table A: Gap Proportion

We repeat the same steps for a critical gap of 6 seconds.

As we know from the previous slides, a gap of 1- or 3-seconds would be rejected,
and now a gap of 5 seconds is rejected as well.

The weighted gap proportion calculation is used for the remaining accepted gap sizes.

Note that the critical gap proportion calculations
use the 0 second critical gap proportions initially calculated
to complete the table as shown in the corresponding yellow and red colored boxes.

Table A: Gap Proportion

Now the only critical gap left is the one of 8 seconds.

All other accepted gap sizes are less than the critical gap size and are therefore rejected.

Using the weighted gap proportion equations, the weighted gap proportion for 9 seconds is 100%.

Note that the critical gap proportion calculations
use the 0 second critical gap proportions initially calculated
to complete the table as shown in the corresponding yellow and red colored boxes.

After all the columns are calculated, the results from Table A will be carried over
to calculate the values in Table B, mean critical gap, and critical gap proportion.

Table B: Number of Accepted Gaps

Now that we know the gap acceptance percentage for each critical gap from Table A,
we will use that information to calculate the number of accepted gaps in Table B shown on this slide.

Table B: Number of Accepted Gaps

First, we will calculate the total number of accepted gaps.

The Total column in Table B is the total number of accepted gaps recorded in the field.

These accepted gaps are the same values seen before.

Using the Field Data, we fill in the total column.

Table B: Number of Accepted Gaps

Now we will focus on the first row of Table B, or accepted gap of 3 seconds.

We know the total number of accepted gaps we can have is 5.

Now, we compare the accepted gap size to the critical gap size.

If the critical gap is greater than the accepted gap, then all gaps would be rejected.

In this case, all critical gaps greater than two seconds will be rejected.

The total number of accepted gaps must stay the same,
so we now know that the number of gaps accepted with a critical gap of 2 seconds
equals the total number of accepted gaps for 3 seconds which is 5.

Table B: Number of Accepted Gaps

Next, we will fill out the rest of the column for a critical gap of two seconds.

The first calculation we complete is to find the number of total gaps for a critical gap of two seconds.

The calculation will require data from Table A.

Table A and Table B

Using the same critical gap column from Table A and Table B of two seconds,
we will calculate the total critical gaps.

The equation shown on this slide shows how to calculate the number of gaps for a critical gap.

The critical gap total is equal to the number of accepted gaps times 100 divided by the proportion of accepted gaps for the corresponding accepted gap size.

This calculation will show how to calculate the total number of gaps accepted for a critical gap of 2 seconds.

The number of gaps is five and is multiplied by 100 and divided by the respective distribution of gaps from Table A.

In this case, the distribution is 35.7.

Following through with the calculation,
the total number of accepted gaps for a critical gap of 2 seconds is 14.

Table A and Table B

The number of accepted gaps for each accepted gap time uses the following equation.

The proportion of accepted gaps for each accepted gap time is multiplied by the total number of gaps for the corresponding critical gap.

For 5 seconds, this calculation is 32.1 multiplied by 14 divided by 100.

All calculations for the number of accepted gaps for a critical gap of two seconds are shown.

Now, the total accepted gaps and the number of accepted gaps with a critical gap of 2 seconds is known.

Table B: Number of Accepted Gaps

The remaining cells within the table need to be calculated in order to obtain the mean critical gap.

The next step is to calculate the number of accepted gaps for 5 seconds.

From previous calculations, we know the total number of accepted gaps and the number of accepted gaps with a critical gap of 2 seconds.

Following the same process, if the critical gap is greater than the accepted gap, the cell will equal 0.

For 5 seconds, the critical gap of 6 and 8 seconds will equal 0.

The number of accepted gaps for 4 seconds is calculated by subtracting the accepted gaps at 2 seconds or 4.5 from the total gaps for the accepted gap size which is 15.

The resulting equation is 15 minus 4.5 which equals 10.5.

Table A and Table B

After calculating the remaining number accepted gaps for 5 seconds which resulted in 10.5 gaps from the previous slide, the remaining number of accepted gaps for a critical gap of 4 seconds can be calculated.

First, the total number of accepted gaps
must be calculated using the formula on the right side of the slide.

In this case, the equation is 10.5 times 100 divided by 50 which equals 21.

The remaining rows for a critical gap of 4 seconds in Table B can now be calculated.

The remaining values are calculated using the equation at the bottom of the slide.

Using this equation, the number of accepted gaps for 7 and 9 seconds
equal to 9.3 and 1.2, respectively.

Table B

These steps are repeated for a critical gap of 6 and 8 seconds.

First, we must find the value that can be calculated using the total columns.

Then calculate the rest of the column using the methodology presented in the previous slides.

The animation shows the order these values would be calculated in.

The critical gap percentage and mean critical gap remain unknown.

Let’s now solve for these values.

Critical Gap Percent

The critical gap percent is calculated using the total number of gaps in each column
and dividing by the total number of accepted gaps which is 50 for our data set.

For a critical gap of 2 seconds the equation is the following:
14 divided by 50 multiplied by 100 equals 28 percent.

The calculation is repeated for the remaining gaps.

Mean Critical Gap Final Calculation

To calculate the mean critical gap, the total critical gap in seconds by critical gap bin size
is multiplied by the corresponding total accepted gaps in the column.

The data is then summed over all gaps and multiplied by the total gap.

The summation depicted in the formula is then divided by all the accepted gaps which is 50 for our data set.

For this example, the calculation is as follows:
2 times 14 plus 4 times 21 plus 6 times 13.1 plus 8 times 1.9 divided by 50.

This calculation equals 4.12.

The mean critical gap, rounded, is 4 seconds, which means based on the sample, the average vehicle will not accept a gap less than 4 seconds.

Table B

The final calculated values for Table B are shown on this slide.

The Analysis tab of Form 750-020-08b automatically calculates the critical gap proportions and mean critical gap using methodology just described.

Form 750-020-08b: Analysis Tab

The following images overview the top and bottom half of Form 750-020-08b: Analysis tab.

This form automatically calculates the gap proportions and mean critical gap from the field data recorded in the Field Data tab.

Note the results that we calculated step by step are the same results that the form automatically populates shown on this slide.

Pedestrian Critical Headway

Now that the vehicular gap methodology has been discussed, let's walk through the pedestrian gap study and how to calculate the pedestrian critical headway.

Pedestrian Gap Study

Typically, the purpose for a pedestrian gap study is related to pedestrian safety and behavior.

The outcome of a pedestrian gap study is commonly used for Traffic Signal Warrant 5.

Traffic Signal Warrant 5 determines whether a traffic signal is needed for a pedestrian school crossing.

For detailed information of the application of gap study results for signal warrants evaluation, refer to MUTS Chapter 3 - Traffic Signal Warrant Summary.

A pedestrian gap study is conducted usually at unsignalized intersections such as an unsignalized midblock crossing or a two-way stop-controlled intersection.

The critical pedestrian headway represents the minimum headway between vehicles that a pedestrian will accept while crossing the roadway.

Conducting a Pedestrian Gap Study

Conducting a pedestrian gap study is similar to a vehicular gap study.

The vehicle headways are tallied using a consistent reference point, and observers collect the data from a location that does not influence pedestrian or vehicular behavior.

Form 750-020-08a or 750-020-08b can be used.

Typically, form 750-020-08a would be sufficient for a pedestrian gap study related to Traffic Signal Warrant 5.

If using form 750-020-08a, the pedestrian headway will need to be calculated before data gathering.

Form 750-020-08b can calculate the mean critical headway based on accepted and rejected gaps.

The following slides will demonstrate the pedestrian critical headway calculations.

Pedestrian Gap Availability Study

Form number 750-020-08a is used to conduct a gap availability study.

For a gap availability study, all adequate gaps are logged.

Determining an adequate gap requires calculating the critical pedestrian headway before the field data collection is conducted.

The number of adequate gaps logged on Form 750-020-08a can be used to determine the outcome of Traffic Signal Warrant 5.

Now that we have an overview of a pedestrian gap study, let’s walk through an example calculation.

Pedestrian Critical Headway: Single Pedestrian

The estimated pedestrian critical headway is calculated using the following equation and default values.

A walking speed study may be required to adjust the default value of “S-p” depending on the presence and influence of people with disabilities, elderly, or children that would impact the average walking speeds at the study location.

For detailed information on how to conduct a walking speed study, refer to MUTS Chapter 9 - Non-Motorized Volume Studies.

Note that if a median refuge is provided, the field data collection and associated calculations should be conducted separately for each leg or crossing.

Single Pedestrian Example

In this example, the pedestrian crossing length is 60 feet,
and we will use the default values for walking speed and start up time.

The calculated critical headway is 20.1 seconds.

Gaps greater than 20.1 seconds are considered an adequate gap.

We will now use Form 750-020-08a and the critical headway we just calculated
to collect field data for a pedestrian gap availability study.

Form 750-020-08a

Form number 750-020-08a is the Gap Study form that allows practitioners to record adequate gaps over multiple time periods.

This form is available in an excel version on the MUTS online library
or by scanning the QR code on the top right corner with a cellphone camera.

Before beginning a gap study, the header of this form
should be filled out with the respective information for each item.

Form number 750-020-08a is designed to collect gaps over multiple time periods.

Once in the field, the engineer will begin to tally the total number of available gaps
for the specific time period.

Form 750-020-08a

Now that we have overviewed Form number 750-020-08a: Gap Study,
let's walkthrough how to conduct a study and use the form.

Remember, we recommend recording the headways between vehicles when conducting a gap study.

Since we are only recording adequate gaps, we will only record gaps greater than 20 seconds.

As the vehicles' front bumper passes the reference point, the observer begins the stopwatch.

As the next vehicle crosses the reference point, the observer stops the stopwatch or timing device and tallies that gap on the form under the corresponding bin.

Note that the pauses in the vehicle’s paths in the animation are only done for emphasis.

Vehicles in the field will continue moving.

The gaps are tallied throughout the time period filled out in the header.

This last gap in the animation is not recorded since it is less
than the pedestrian critical headway of 20 seconds.

Pedestrian Critical Headway

One caution with using the equation for calculating a pedestrian's critical headway
is that the default values present a conservative estimate for the critical pedestrian headway.

For example, the default walking speed represents the 15th percentile walking speed
which may overestimate the critical headway.

A walking speed study may be required to better represent the pedestrian critical headway.

For detailed information on how to conduct a walking speed study, refer to MUTS Chapter 9.

For most applications in Florida, the single pedestrian critical headway calculation is sufficient.

An adjustment is used to calculate group critical headways.

In Florida, groups of pedestrians which platoon while crossing may be seen at concerts,
sporting events, or other large events.

The following slides will walk through how to calculate the group pedestrian headway.

An alternative to calculating a single or group pedestrian critical headway and using assumptions
is to use to form 750-020-08b when conducting a pedestrian gap study.

Form 750-020-08b will calculate the mean critical headway using the methodology
previously discussed from the accepted and rejected gaps tallied in the sheet.

Group of Pedestrians

If there are a group of pedestrians, the critical group headway
is calculated using the following equation.

The spatial distribution of pedestrian is based on the data seen in the field.

"T-g" in the equation is the group critical gap, and the required inputs
include the single pedestrian critical headway, previously calculated,
and the spatial distribution of pedestrians.

If there are no platooning pedestrians, or pedestrians crossing behind one another, in the field,
the group critical headway is equal to the single pedestrian's critical headway.

In Florida, most applications of a pedestrian gap study
will only require a single pedestrian's critical headway.

Group of Pedestrians

The spatial distribution of pedestrians is calculated using the following equation.

The spatial distribution of pedestrians "N-p" requires the crosswalk width
and the number of pedestrians in the crossing platoon.

8.0 represents the default clear effective width
used by a single pedestrian to avoid interference when passing other pedestrians.

Group of Pedestrians

The number of pedestrians in the crossing platoon or "N-c" is calculated from the following equation and requires the pedestrian flow rate and vehicular flow rate which are determined by field conditions.

The single pedestrian critical headway is calculated per the equation on Slide 53.

The following example will walk through the critical headway calculations for a group of pedestrians.

Group Pedestrian Headway: Example

We will use the same scenario as the one for our single pedestrian headway calculations example.

From field observations, the pedestrian flow rate is determined to be 0.1 pedestrians per second and the vehicular flow rate is 0.25 vehicles per second.

The single pedestrian critical headway is 20.1 seconds per our last example.

Based on the example values and formula,
the number of pedestrians in the crossing platoon is equal to 43.57.

The crosswalk width is 10 feet.

The number of pedestrians in the platoon is input into the spatial distribution of pedestrian formula.

Inputting the relevant values, the spatial distribution of pedestrians is equal to 35 seconds.

The spatial distribution of pedestrians we just obtained will now be used
as an input into the pedestrian critical group headway.

Group Pedestrian Headway: Example

The individual critical pedestrian headway and spatial distribution
is input into the group critical headway equation shown.

By completing the calculations, the estimated group critical headway is 88.1 seconds.

While this value may seem high, this is for a group of 44 pedestrians in the crossing platoon.

The group critical headway is dependent upon field observations.

Gap Study Summary

The gap study is commonly used for roadway capacity analysis, vehicle delay considerations,
and Signal Warrant 5.

Conducting a gap study requires equipment such as a stopwatch or other timing device
and can be supplemented with video recordings.

Engineers conducting a gap study should find a location with good visibility and a reference point.

Additionally, the engineer should choose an observation location away from motorists' sight
to not influence driver or pedestrian behavior.

Typically, one observer is sufficient to conduct the study.

There are two sets of digital forms that can be used to conduct a gap study.

Form 750-020-08a is typically used for pedestrians and provides a means to record adequate gaps.

Form 750-020-08b is typically used for vehicular gap studies
but can also be applied to pedestrian gap studies.

The Analysis tab of Form 750-020-08b automatically calculates the mean critical gap.

Both forms are available digitally on the MUTS website or by scanning the Q-R code
on the top right corner of the slide with a cellphone camera.

Concludes

This concludes the Manual on Uniform Traffic Studies computer based training,
Chapter 8 – Gap 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.

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 enter your first and last name 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.

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

Once you've passed the quiz and received your certificate please continue to the next chapter by returning to the MUTS course content tab and selecting the next chapter in the training.

Please, continue to the quiz and thank you for your time and attention.