Chapter 14 Presentation Script

Welcome

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

This training module will cover Chapter 14 – Roadway Lighting Justification Procedure.

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 eight forms in excel format stored on the MUTS online library through the FDOT’s Traffic Engineering and Operations Office website.

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

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

Please open Form numbers 750-020-20, 750-020-15, 750-020-16, 750-020-17 and 750-020-21a, -21b, -21c, and -21d as we will refer to them later in the module.

Purpose

To get started, we will share more detail on what is covered in the Roadway Lighting Justification Procedure.

Overview of Lighting Justification Procedure

The roadway lighting justification procedure involves two steps.

Step 1 is the initial screening using the FHWA Lighting Handbook's form, modified for FDOT's use, called FDOT's Lighting Geometric and Operational Factors.

Step 2 is the computation of the benefit-cost ratio and net present value.

Step 2 provides a procedure for rural, suburban, and urban roadways and arterials to justify roadway lighting installation in the State of Florida.

The methods used in this chapter are based upon the methodologies contained in the Highway Safety Manual, also called HSM, - Part C for Two- to Five-Lane roadways, and National Cooperative Highway Research Program, or NCHRP, 17-58 Safety Prediction Models for Six, Seven and Eight-Lane and One-Way Urban and Suburban Arterials.

For introduction purposes, let's take an overview look at the process in Step 2.

Step 2: Benefit Cost and Net Present Value Analysis

The HSM safety performance functions, also called SPFs, in Part C and NCHRP 17-58 are used to predict crashes with and without roadway lighting by varying the crash modification factor, also called CMF.

This training will focus on the application of these SPFs and how they are used to conduct life cycle crash cost analysis with and without roadway lighting.

The chapter will also discuss the computation of a benefit-cost ratio and net present value for the lighting installation.

This training assumes the engineer has a basic understanding of conducting HSM analysis.

If further HSM training is needed, please visit the FDOT Roadway Design - Quality Assurance - Training website for HSM webinars.

A link to this is available on the resources page to this training.

Overview of Lighting Justification Procedure

By now, we should have a high-level understanding of the elements we will discuss in this training.

Let's begin with step one: Lighting Justification using the FHWA Lighting Handbook.

Step 1 – Initial Screening

FDOT's Lighting Geometric and Operational Factors form
is used for initial screening of collectors, major arterials, and local streets.

AASHTO Roadway Lighting Design Guide Warranting System
is used for freeways, bridges, and interchanges.

MUTS Chapter 14 covers collectors, major arterials, and local streets only
and today's training will be focusing on the roadway lighting analysis for these facilities.

Form No. 750-020-20: Overview

Form number 750-020-20 or FDOT's Lighting Geometric and Operational Factors form will be the main documentation resource for Step 1.

This form has four categories of factors –
Geometric Factors, Operational Factors, Environmental Factors and Collision Factors.

The bottom of the form provides a summary totaling all weighted factors
in addition to factor clarification notes.

Note that the form provides footnotes at the end of the page
which add clarification on the values and thresholds to be used for these factors.

Form No. 750-020-20 Overview

The form is set up to provide a 1 to 5 numerical rating for each factor
along with a corresponding default weight.

The rating factor times the default weight provides the score for a particular factor.

All the factors are summed and if the total is 60 or greater, the lighting analysis moves to Step 2.

Now let's discuss the individual factors in each of the four categories.

Form No. 750-020-20: Geometric Factors

There are eight geometric factors to be considered for the roadway's length being analyzed.

These include number of lanes, lane width, number of median openings per mile,
driveways and entrances per mile, horizontal curve radius in feet, vertical grades by percent grade,
sight distance and presence of parking.

Note that the highest weighted factor in the form is horizontal curve radius.

Form No. 750-020-20: Operational Factors

There are five operational factors to be considered for the Lighting Justification form.

The first is signalized intersections.

The percentages given on the form are based upon intersections with full median access.

For example, if the roadway being analyzed has 12 full access median openings and 7 of these are signalized, the percentage is 58% and the rating is 4.

The left turn lane factor applies to intersections with full access median openings and left turn lanes along the major roadway approaches.

The MUTS contains percentages for each category as shown on the bottom right hand of the slide. *[cont.]*

The Median Width, Posted Speed Limit, and Pedestrian and Bicycle Activity Level are the remaining operational factors.

Form No. 750-020-20: Environmental Factors

There are five environmental factors to be considered in the form.
The first is Percentage of Development Adjacent to the Road.
Development can be defined as commercial, industrial, or residential.
The rating increases with higher percentage of development.

The second factor is Area Classification with the classifications being rural, industrial, residential, commercial, and downtown.

The next factor is Distance from Development to Roadway.
The closer the development is to the roadway the higher the rating.
Ambient or off Roadway Lighting is the next factor.
The ratings for this factor range from “nil”, also known as “no lighting”, having the lowest rating to “intense” having the highest rating.

The last factor is Raised Curb Median.
“No curb” is the lowest rating and “At few intersections being less than or equal to 50% of intersections and median openings” is the highest rating.
Raised curb median can be either curb and gutter or concrete curb.
Analysts should refer to MUTS Chapter 14 for factors definitions and corresponding ratings.

Let’s take a closer look at Ambient (off Roadway) Lighting as an example in the next slide for the MUTS provided definition.
We will go over some examples of these definitions in the sample problem during this training.

Form No. 750-020-20: Environmental Factors - Ambient (off Roadway) Lighting

This table summarizes the definition for each of the ratings
available under the Ambient (off Roadway) Lighting Environmental Factor.

Sparse ambient lighting is typically found in rural highways
outside of city boundaries with some building lighting.

Moderate ambient lighting can be found in rural or urban roads
outside of commercial areas with some building lighting.

Distracting ambient lighting is typically found in downtown commercial areas
with well-lighted building exteriors adjacent to the roadway like gas stations.
[cont.]

Lastly, intense ambient lighting can generally be found in in both rural and urban areas
with large advertising signs and other intense light sources adjacent to the roadway.

This information, in addition to other factors rating definitions, can be obtained from MUTS Chapter 14.

Form No. 750-020-20: Collision Factors

The collision factor rating is based upon the ratio of night to day crashes.

Crashes reported as dawn or dusk are considered night crashes.

If the night to day crash ratio is 2:1 or greater,
lighting is automatically warranted regardless of the overall point score.

Be aware that the collision factor has the second highest weighting in the form
following Horizontal Curve Radius under the Geometric Factors.

Form No. 750-020-20 Results

The excel form will automatically total the warranting points as the form is completed.

A total score of 60 points or more is required to meet the lighting warranting condition
and advance to Step 2.

Project Example: SR 40 Background Information

Let’s look at an example to complete the FDOT Lighting Geometric and Operational Factors form.

This aerial shows a section of State Road 40 located west of I-95 in Volusia County.

The study section for this example extends from Tymber Creek Road
to the State Road 40 and I-95 interchange southbound ramps,
approximately three quarters of a mile in length.

The intersections with Tymber Creek Road and Booth Road are both signalized.

Project Example: SR 40 Geometric Factors

We will now begin to fill out the Geometric Factors in the form.

The first factors are the number of lanes and lane width.

State Road 40 is a 4-lane divided roadway with 12-foot lanes.

Both factors will be rated "1."

The total number of median openings is 4 which includes the signalized intersections; since this is a three-quarter mile-long corridor, the corresponding median openings per mile is 5.33 which corresponds to a rating factor of "2." *[cont.]*

The number of driveways and entrances in the corridor is 22; since this is a three-quarter mile-long corridor this means 29.33 openings per mile.

This is less than 32 openings per mile, so the rating is "1."

There is no horizontal curve present, which can be interpreted to have a radius extended to infinity, so this rating is "1."

The roadway is flat with no vertical curves, so this rating is "1."

With no horizontal or vertical curves, the sight distance is greater than 689 feet, so this rating is "1."

Lastly, parking is prohibited along this section of State Road 40, so this rating is "1."

The subtotal score for Geometric Factors is 11.2.

Note that any factor measured per mile needs to be weighted by the study segment length.

The Median Openings and Driveways and Entrances factors are a good example to revisit for this step.

Project Example: SR 40 Operational Factors

The second section of the form is Operational Factors.
The first operational factor is percent signalized intersections.

There are two signalized intersections out of four total median openings which is 50%.
This rating is "5."

Left turn lanes are located at all major or signalized intersections, so this rating is "1."
For definitions thresholds, the table shown provides a summary of the information available in MUTS Chapter 14 regarding Left Turn Lanes.

The median width varies between 40 feet to the west and 20 feet to the east which splits between the 1 and 2 ratings, so we use a worst-case scenario rating of "2."

The operating or posted speed is 50 miles per hour, so this factor has a rating of "5."
There are more than 10 pedestrians and bicyclists in the corridor in an hour, so this has a moderate rating of "4."

The total score for Operational Factors is 17.75.

Project Example: SR 40 Environmental Factors

As previously discussed, the Environmental Factors primarily focus on development adjacent to the roadway.

This section of State Road 40 has the Tomoka River in the middle with primarily residential and some commercial land use to the west and all commercial to the east of the river. *[cont.]*

Measuring using Google Earth, about 2/3 or 66% of the corridor has development adjacent to the roadway or a 4 rating.

As noted, the area classification is both residential and commercial and we provided a rating of 4 as the worst-case scenario.

The distance from the development to the roadway is, in many cases, between 50 and 100 feet, yielding a rating of 4.

In other locations, it is less than 50 feet yielding a rating of 5.

We provided a rating of 5 as a worst-case scenario.

The ambient lighting also varied with the three different sections of development being moderate to the west, sparse thru the river area, and distracting in the eastern part.

Let’s take a pause of the form and look at the conditions in the field.

SR 40 Ambient lighting conditions

We have moderate lighting towards the west end of the corridor near Tymber Creek Road with some building lighting.

Sparse lighting is observed in the vicinity of the river as we see in this capture.

And as we get closer to the eastern end of the corridor, we observe a level of distracting lighting due to the commercial uses such as gas stations.

These are images taken during field observations.

Project Example: SR 40 Environmental Factors

Let’s go back to completing the Lighting Justification form.
Based on the described field conditions,
we have a mixture of ambient lighting ranging from sparse to distracting.
We gave an overall rating of 4 as a worst-case scenario.
Finally, the raised curb median is only present east of Booth Road,
and fewer than 50% of the intersections have raised curb median.

The rating is 5.

The environmental factors overall rating is 9.22 points.

Project Example: SR 40 Collision Factors

Our review of the crash data shows that considering dawn and dusk crashes as night crashes yields a night-to-day collision ratio of 1.841.

The 4 rating is for ratios between 1.5 and 2.0.

Since the 1.841 ratio was much closer to 2.0 than 1.5,
we applied engineering judgement in this case and said the rating would be 4.5.

This gives us a collision factor score of 24.975.

Project Example: SR 40 Results

Sixty points are required to meet the warranting condition.

The total warranting points for our example is 63.145.

This analysis meets the warranting condition, leading to Step 2 in the analysis.

This form provides guidance to determine
whether a particular location should be considered for roadway lighting.

If we had the total warranting points just below the threshold of 60 points,
engineering judgement should be applied to determine if it is justifiable to continue with the analysis.

The key element to consider when applying engineering judgement
is to not miss an opportunity to light a critically needed roadway.

Overview of Lighting Justification Procedure

If warranted, the Step 2 procedure is used to justify a lighting project.

Step 2 consists of quantifying the safety benefits vs the cost of construction,
maintenance, and operation.

The safety benefits are quantified using HSM predictive method procedures.

While this training assumes the student has working knowledge of HSM procedures,
we will provide a few clarifications.

Overview of HSM Predictive Methods

First, 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 roads.

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.

If further HSM training is needed please visit
the FDOT Roadway Design - Quality Assurance - Training website for HSM webinars
available on the resources page to this training.

MUTS Chapter 14 Forms Overview

Before we dive into the Step 2 process for Roadway Lighting Justification,
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 in Step 2 will vary based on the facility type being analyzed.

Until now, we have covered the Step 1 form: 750-020-20.

The rest of this training will walk through the Step 2 process
and show how to use the corresponding form for the State Road 40 example previously described.

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.

HSM Definition of Rural, Suburban, and Urban

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.

You can access maps depicting Florida’s Urban Areas plus a 1-mile buffer from those Urban Areas
on FDOT’s Roadway website.

A link to this site is available on the resources page to this training.

Urban Boundary: SR 40 Example

As described in our Step 1 project example for this training,
State Road 40 is shown to be inside the urban boundary and is a 4-lane facility.

As a result, we will be using HSM Chapter 12 analysis procedures and spreadsheet,
and Form Number 750-020-21c.

Form No. 750-020-21 a b and c: Present Worth Analysis

Each HSM chapter has a spreadsheet available to calculate crash prediction.

This screen capture shows the segment input sheet from the HSM Chapter 12 spreadsheet.

[cont.]

The Chapter 10, 11 and 12 spreadsheets or Form Numbers 750-020-21a, b, and c
were developed under NCHRP 17-38 while Form No. 750-020-21d spreadsheet
was developed under NCHRP 17-58.

FDOT has used the crash prediction capabilities of these spreadsheets
and added a crash cost calculation capability using Florida associated crash costs
obtained from historical data.

Form No. 750-020-21c: Present Worth Analysis Urban and Suburban Arterials (2 to 5 Lanes)

These spreadsheets calculate crash predictions for segments and intersections;
to start the calculation navigate to the corresponding tabs at the bottom of the spreadsheet.

Once in the desired tab - intersection or segment - the information input should begin.

The yellow and blue cells are for input with the blue being pull down menus.

The upper part of the form requires input for the safety performance function, or SPF, information
and the following part is for the crash modification factor or CMF inputs.

Refer to the MUTS Chapter 5 for a detailed explanation on the data collection for these values.

One of the CMF input is whether roadway lighting is present or not present.

For lighting justification analysis, we always start with this being "not present."

This is the no-build or without lighting analysis for crash prediction.

Form No. 750-020-21 a b & c: Crash Cost Methodology

Before going any further, let's look at the *Introduction* tab and information available to the practitioner.

First, navigate to the introductions tab by clicking towards the bottom of the screen.

Once in this tab, the user will see information regarding how the crash cost spreadsheet works.

All the input variables are explained as well as the crash cost computation methodology used in these excel spreadsheets.

Note that the Introduction tab is consistent with the cell coloring expected in the input tabs: yellow cells represent manual input while blue cells represent drop down menus.

For example, the Minor or Major Growth Rate is a required input.

For the segments tab, only the major growth rate is required.

For the intersections tab, both major and minor growth rates are required.

The Introduction tab also provides recommended FDOT values as applicable.

Form No. 750-020-21: Crash Cost Spreadsheet

Moving to the crash cost spreadsheet,
this tab contains the input variables described on the Information tab.

This spreadsheet holds all variables except AADT.

The current AADT should be entered in the Segment or Intersection tab,
and an annual traffic growth rate is entered in this tab.

The analyst should also add the Rate of Return, Project Opening Year, and Analysis Period.

The spreadsheet will show the increasing AADTs
and recalculates the predicted crash frequency for each year.

Another important variable is whether crash data was used in the analysis.

Using existing crash data will enhance the predictive capabilities.

Crash Data Application

Crash data is shown here as "observed number" and the analysis applies the Empirical Bayes method, also called EB method, to take the predicted number of crashes using the SPF to an expected number of crashes using EB.

The first graph shows one way of conceptualizing the EB method.

The circle on the curve shows the predicted average number of crashes based on the SPF.

The triangle is the observed number of crashes at the site, and the diamond represents the expected average number of crashes per year calculated by using the EB method.

The observed crash frequency and predicted average crash frequency are combined using a weighted average equation and a weighting factor “w”.

The second graph shows the observed number of crashes to be lower than the predicted number of crashes from the SPF and the expected number using EB is lower than the predicted number.

From these two examples, we conclude that the expected number of crashes obtained using EB is always between the predicted number and the observed number of crashes.

Note that the expected number of crashes using EB is not the average or median due to the weighting factor used.

Let’s take a look at when we can make use of the existing crash data.

Should Existing Crashes Be Applied?

The use of existing crash data is not appropriate for all improvement conditions.

Generally minor improvements involving a change in CMF are OK for the application of crash data.

However, the use of existing crash data is not applicable to the improved condition for major improvements, requiring the change in SPFs, such as a roadway widening from 2 lanes to 4 lanes divided.

Another major improvement that precludes us from using crash data is median modification such as from a 4-lane undivided roadway to a 4-lane divided roadway.

In roadway lighting justification analysis for an existing facility,
with and without lighting is a CMF in the predictive equations and crash data can be applied.

However, if the roadway lighting justification analysis is being done
as part of a 2-lane widening project for a future 4 lane condition,
the 2-lane facility's existing crash data should not be applied.

How is EB Applied in the Spreadsheet?

The EB analysis is initiated when the average "observed" crashes per year
are entered in the spreadsheet's urban site tab as shown on Column 5.

The crash data needs to be broken down to be single- or multiple-vehicle as shown on Column 1.

If you are using 5 years of crash data, enter the average value,
similar to what has been done in this example.

The spreadsheet will then calculate the expected average crash frequency shown in Column 8.

Existing or Proposed Analysis?

Once you have the crash data recorded, navigate to the Crash Cost tabs.

The EB method is applied in the spreadsheet using the analyze button.

When selected, you will get a pop-up asking if you are doing an existing analysis or proposed analysis.

Think about the existing analysis as the no-build or without lighting alternative.

The proposed then would be the build or with lighting alternative.

If you select the existing analysis, there is no further action required,
and the spreadsheet will proceed with the crash cost calculation using the expected crash frequency.

How are Crash Costs Computed?

Progressing further down the spreadsheet there are four basic headings: year, AADT, Annual Number of Crashes, and Annual Cost.

The year will start with the current year which matches the year for the AADT entered in the Segment or Intersection tab for the SPF calculation.

Remember AADT is not coded in the crash cost tab but in the Segment or Intersection tab.

The first crash cost analysis year will be the Project Opening Year and the analysis will be conducted for the number of years entered in the Analysis Period cell under the crash cost tab.

The AADT is grown annually by applying the recorded Growth Rate under the crash cost tab.

The spreadsheet will then prepare the expected annual crash frequency for each year in the analysis period.

These crashes are distributed by crash severity following the KABCO scale.

The KABCO scale includes 5 categories: fatality, incapacitating, non-incapacitating, and possible injury crashes, and property damage only, or PDO crashes.

The spreadsheet contains default distributions for these crash severities varying by facility type.

The number of expected crashes is distributed using these percentages.

Finally, using these crash default distributions and KABCO crash costs, the spreadsheet will provide an annualized cost by severity and present value.

Let’s take closer look at the Annual Cost and how these values are calculated.

What Does a Crash Cost?

Using the Annual Number of Crashes from the Crash Cost tab, the number of crashes per year by severity level is then converted to a monetary value using FDM Table 122.6.2 – FDOT KABCO Crash Costs.

The table shown in the screen is used to covert the crashes to a dollar amount.

Note that this table reflects crash costs with crash data from 2013 to 2017, and FDOT updates these values on an annual basis as new data becomes available.

We recommend referring to the current version of FDM Chapter 122 for the latest available crash costs.

Life Cycle Crash Cost Prediction

The annual number of crashes for each crash severity
is multiplied by the corresponding KABCO cost per crash to get the annual cost.

The annual cost by severity is then added to get the total annual crash cost.

The spreadsheet then determines the present value for the crash cost using a 4% discount rate.

Each year's present value for the analysis period is summed to get the total present value.

This completes the no-build or without lighting analysis
and its associated life cycle crash cost prediction.

Conduct Build or With Lighting Analysis

The next step is to conduct the build or with lighting analysis.

For this analysis, the no-build or without lighting spreadsheet will be used.

First, you will have to do a save as for a new copy as the build or with lighting analysis spreadsheet.

Using the build analysis spreadsheet,
we will make two modifications to calculate the build life cycle crash cost.

First, go to the appropriate segment or intersection tab,
and change the lighting CMF from "Not Present" to "Present".

You will see numbers below will change and this results in a new N-predicted.

Existing or Proposed Analysis?

The next step is to update the crash cost spreadsheet.

The basic inputs will be the same so the new N-expected needs to be applied
and the "analyze" button starts this process.

Again, you will get a pop-up and this time you need to click the proposed button.

There will be a second pop-up requesting the existing or no build alternative's N-predicted
and N-expected to conduct the ratio method and compute the new build condition N-expected.

This is for the proposed conditions EB analysis using the ratio method
and provides the proposed conditions expected crash frequency for the crash cost calculation.

Once entered, the spreadsheet will update to calculate the new Total Present Value
for the build or with lighting condition.

It is important to note that since the lighting CMF is less than 1,
the net present value will always be less than the no-build or without lighting condition.

SR 40: Project Example

Let’s go back to the State Road 40 example we have been discussing today.

SR 40: Benefit-Cost Analysis

This segment requires we conduct two segment analyses:
the first one for Tymber Creek Road to Booth Road and the second one for Booth Road to west of I-95; and two intersection analyses: one for Tymber Creek Road and one for Booth Road.

The combined results shown on the screen are for the build alternative.

The total present worth crash cost for the no-build or without lighting is $ 29,360,492,
and when lighting is added the build total present worth crash cost is $ 26,359,514.

The crash cost savings due to adding lighting is $3,000,978 for the 20-year life cycle.

For the benefit-cost and net present value analysis,
this needs to be taken to an annualized crash cost savings.

The equation shown here for a 20-year analysis and 4% discount rate
yields a value of 13.59 to divide into the 20-year crash cost savings
taking it to an annualized crash cost of $220,822.51.

This is the annualized benefit.

The cost of the constructing, operating, and maintaining the lighting is the other factor.

First the construction cost needs to be annualized over the life cycle.

The FDOT Benefit-Cost spreadsheet can be used for this calculation.

This tool can be downloaded through a link available on the resources page to this training.

The "other" has been changed to lighting and the service life has been changed to 15 years
to be consistent with FDOT guidance.

The estimated construction cost is entered into the spreadsheet
and an annual operations and maintenance cost of $2,000
is added giving a total annual cost of $34,667.85.

The benefit-cost ratio, or "B over C", and the net present value, or NPV,
are calculated using these equations.

The results of this analysis show a benefit-cost ratio of 6.37 and a net present value of $186,154.66.

Arterial roadway lighting is justified when the benefit cost ratio is greater than 1
and there is a positive net present value.

Given the results we are seeing,
it can be concluded there is a positive benefit to lighting this section of State Road 40.

MUTS Chapter 14 Forms Overview

Let’s pause the State Road 40 discussion to walkthrough the NCHRP 17-58 spreadsheet.

As you may recall, this spreadsheet is for 6 to 8 lane two-way facilities and one-way streets.

This is based upon recently completed research to be included in the HSM 2nd Edition.

NCHRP 17-58 Spreadsheet

Similar to the previously discussed analysis spreadsheets, FDOT has modified this spreadsheet
to conduct crash cost estimates for a without and with lighting condition.

Let’s start the walkthrough of the spreadsheet with the "FDOT Modifications" tab.

The tab's contents explain that, unlike the previous analysis,
NCHRP 17-58 does not have a lighting CMF for roadway segments.

However, the NCHRP 17-58 final report provided sufficient details to adjust the SPF
to obtain reliable estimates of the average crash frequency when lighting is or is not present.

This information is provided within this tab and will not be discussed here.

NCHRP 17-58: Overview

The tabs in the NCHRP 17-58 spreadsheet are intersections,
two-way segments for 6, 7 and 8 lane roadways,
and one-way segments for 2, 3 and 4 lane one-way streets.

The analyses from these three tabs are summarized in the Totals Tab.

FDOT has added a Crash Cost Totals and Factors tabs to this spreadsheet.

The Factors tab contains the adjustment factors for without and with roadway lighting in segments.

There are Florida specific crash severity distributions used for the crash cost analysis.

NCHRP 17-58: Applying Crash Data

The data to be entered into the segments and intersections tabs
is explained in detail in MUTS Chapter 5 and will not be addressed in this training.

The crash data is entered into the Totals tab at the top of the tab.

The first step is to identify whether you will be using "site-specific" or "project-level" crash data.

It is recommended "site-specific" crash data be used for the segment or intersection being analyzed.

Project specific data is intended to be used for multiple segments and intersections.

Once the crash data is entered, the spreadsheet will conduct the N-expected analysis.

NCHRP 17-58: Crash Costs

The crash cost totals tab requires some data input.

Once entered and the "analyze crash costs" button is pressed,
the total crash costs without and with lighting for each segment and intersection being analyzed
will be provided.

The input values are opening year, analysis period and rate of return.

As noted in the previous spreadsheets, the rate of return is 4% for FDOT projects.

The growth rates for each segment and intersection approach should also be entered.

Note that the intersection analysis requires the major road segment type to be entered.

The total crash cost is the present worth value for the analysis period designated in the inputs.

The input cells are highlighted in blue.

What happens when the HSM is not applicable?

There may be conditions when the use of the previously explained HSM analysis
may not be applicable.

So, what should we do when the HSM is not applicable?

Let’s take a look.

A good example for when HSM is not applicable is when we are analyzing a ten-lane arterial roadway which does not have an SPF.

Another example is when the AADT exceeds the SPF upper limit.

For example, the two-lane urban roadway SPF has an upper limit of 32,600 AADT,
and the four-lane divided urban roadway SPF has an upper limit of 66,000 AADT.*[cont.]*

MUTS Section 14.3.2 provides methods to conduct a net present value computation.

Unlighted: Crash Frequency

The first step is to compute the unlighted crash frequency by using the equation shown.

ADT is average daily traffic.

The % ADT is the percent of average daily traffic at night determined by examining traffic data.

NRU is a nighttime crash rate value for unlighted conditions.

NRU is expressed as nighttime crashes per million vehicle miles for mainline sections.

This value must be obtained by researching crash records.

Here is an example of the values and input to be used.

The input values are 35,000 for ADT, 0.30 for % ADT at night and 10 for NRU.

These values yield an N unlighted,
or an annual crash frequency expected under unlighted conditions, of 38.325.

We will carry over this number to the next step for calculations.

Unlighted: Crash Costs

The next step is to quantify the monetary cost of the unlighted conditions.

The unlighted crash frequency from the previous step, 38.325 crashes, is applied to crash costs.

This can be done in one of two ways.

One method is to use FDM Table 122.6.4 - HSM crash distribution for Florida.

Florida based crash distributions for HSM analysis

FDM Table 122.6.4 provides a crash distribution using Florida specific crash data.

This distribution should be considered when applying crash frequency by facility type to obtain the number of crashes by severity.

These crash distributions are reflecting crash data through 2017, as additional data is processed, the table will be updated in the FDM.

Confirm the crash distributions and KABCO crash costs being applied are the most recent available.

We recommend referring to the current version of FDM Chapter 122 for the latest available cash distributions for Florida.

Applying the crash distributions to our project example, we have a 4-lane divided roadway in an urban/suburban setting, so we will use these crash distributions to complete the cost analysis.

Unlighted: Crash Costs

First, we populate the crash distribution for our project example. The unlighted crash frequency of 38.325 from the previous step should be applied to the proper facility type crash distribution to obtain the number of crashes by severity.

Then these crash numbers can be applied to the FDOT KABCO Crash Costs from FDM Table 122.6.2.

FDOT KABCO Crash Costs

FDM Table 122.6.2 – FDOT KABCO Crash Costs reflects crash costs with crash data from 2013 to 2017, and FDOT updates these values on an annual basis as new data becomes available.

We recommend referring to the current version of FDM Chapter 122 for the latest available crash costs.

Let’s apply these crash costs back to our example to complete the cost analysis.

Unlighted: Crash Costs

Once we have the KABCO crash costs, we multiply the crash prediction by severity by the crash costs to obtain the total crash costs as shown.

The final step is the addition of all crash severities to obtain to the $6.87 million.

FDOT Average Crash Costs

The second method is to multiply the unlighted crash frequency of 38.325 by a value from FDM Table 122.6.1 – FDOT Average Crash Costs by Facility Type to obtain the total unlighted crash cost.

Note that this table is based on crash data from 2013 to 2017, and FDOT updates these values on an annual basis as new data becomes available.

We recommend referring to the current version of FDM Chapter 122 for the latest available crash costs.

Lighted: Crash Frequency

The following step is similar to first one we discussed when HSM is not applicable and instead we will now apply a CMF for lighted conditions.

We recommend obtaining the CMF from the online FHWA CMF Clearinghouse. The link to the Clearinghouse is available on the Resources page. When selecting a CMF, it is recommended to use 4- and 5-star CMFs due to their reliability when compared to CMFs with a lower star rating.

Note it is also important to choose a CMF which is applicable to the crash severity and area type as the ones shown on the screen. We will be using this CMF for our example.

Lighted: Crash Costs

Step 4 is similar to Step 2 with a few modifications. If you previously applied the crash distributions, this analysis for varying CMFs can be easily done. For Fatal through PDO crashes use 0.74 as the CMF to get the total crashes by crash type.

Then the FDM Table 122.6.2 crash costs can be applied. Once we have the KABCO crash costs, we multiply the crash prediction by severity by the crash costs to obtain the total crash costs as shown here. The final step is the addition of all crash severities to obtain to the $5.093 million.

B/C and NPV Summary

The four-step analysis we just finished is for one year and computes the benefits for one year. In this case, the difference between the unlighted and lighted crash costs or the annual crash cost benefit is $1,785,076.
If you do multiple years of crash analysis, the best way is to determine each years' crash cost and then present worth starting at the opening year.
To do a life cycle analysis, you would repeat this analysis with different ADTs for each year of the life cycle.
Another way to do this is to do an opening and 15-year lighting life cycle analysis where the only variable to change is ADT.
You can compute with and without lighting crash costs for the two years and then get an average of the two for the annualized crash cost benefit.

The final step is to calculate the benefit-cost ratio and net present value.
This is similar to the State Road 40 analysis we conducted using HSM.
The construction cost to install the lighting or IC is $2,500,000 and this is taken to an annualized cost over a 15-year life cycle to be $224,750.
The present value of annual maintenance cost or PVMC is $5,000 and the present value of annual electric costs or PVEC is $4,000.
The total annual cost is $233,750.
To obtain the benefit cost, we divide the cost difference by the total annual cost which yields a B/C ratio of 7.64.
For the net present value, we subtract the annual cost from the cost difference yielding a NPV of $1,551,326.

Next, add them up and then annualize using the previously explained Ati equation.
The construction and operations plus maintenance costs are also annualized using the same method as previously explained.

Summary of Justification Process

In closing, the roadway lighting justification procedure is done in two steps.

Step 1 is the initial screening using the FHWA Lighting Handbook's form, modified for FDOT's use, called FDOT's Lighting Geometric and Operational Factors.

Step 2 is the computation of the benefit cost and net present value using HSM procedures.

End Of Lesson

This concludes the Manual on Uniform Traffic Studies computer based training, Chapter 14 - Roadway Lighting Justification 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.

On the next slide, please read the directions carefully before continuing to the quiz.
Thank you for your time and attention.

[LMS]

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

A passing grade of 70% is required to obtain the Certificate of Completion for the training.
If a grade below 70% is obtained, the trainees are required to re-take the full training until a passing grade of 70% or higher is obtained.
If you do not pass the quiz, please return to the Course Content tab and re-take this training.

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

On the next slide, please read the directions carefully before continuing to the quiz.
Thank you for your time and attention.