Hands-on Exercises: IHSDM Crash Prediction Module (CPM)

Overview

The Crash Prediction Module estimates the frequency and severity of crashes that would be expected on a highway considering its geometric design and traffic characteristics.

In Exercise 1, you will use the Crash Prediction Module to estimate the frequency and severity of crashes on IHSDM Pike - an existing rural 2-lane highway.

In Exercise 2, you will create and evaluate a freeway segment using the newly added methodology developed under NCHRP Project 17-45, and reflected in draft Highway Safety Manual (HSM) Chapter 18.

In Exercise 3, you will create a Site Set for a multilane rural highway and use the Crash Prediction Module to evaluate the sites (highway segments and intersections).

Exercises:

1. Evaluate IHSDM Pike (A Rural Two-Lane Highway)

2. Evaluate a 6-Lane Urban Freeway Segment with Site-Specific Observed Crash Data (HSM Draft Chapter 18, Sample Problem 5)

3. Evaluate a Site Set (A Rural Multilane Highway)
Running IHSDM from a USB Drive

For this workshop, the IHSDM 2012 Release is pre-installed on a USB drive. To run IHSDM:

1. Connect the USB drive to your computer.
2. In most cases you will be prompted for a set of actions including “Open folder to view files using Windows Explorer.” This option will open a Windows Explorer that shows the content of the USB drive. If you did not get a prompt, open a Windows Explorer and locate the USB drive.
3. Explore the folder named “IHSDM2012.”
4. To start IHSDM, locate “ihsdm.exe” and invoke it by either double clicking or right clicking and choosing “Open.”

5. When the IHSDM is run for the first time, a “Welcome to IHSDM” window pops up that shows your user name and allows you to add some personal information to your account. **Click OK to close the “Welcome to IHSDM” window.**
6. After dismissing the “Welcome to IHSDM” window, the IHSDM interface will pop up.

7. Close the “Welcome” window by clicking on the **OK** button. This will open the “Workflow Wizard.”
Exercise 1: Evaluate IHSDM Pike (A Rural Two-Lane Highway)

Overview of IHSDM Pike:

- Length = 14281.693 ft (2.7 miles)
- Project limits: Station 0+000 to Station 14+281.693
- Functional classification = Arterial
- Terrain = Rolling
- Design speed = 50 mph
- Cross-section:
  - 11 ft wide travel lanes
  - No shoulders
- Horizontal alignment:
  - generally curvilinear, including several compound curves and one reverse curve
- Vertical alignment:
  - some sections have steep (over 5%) vertical grades
- Average Daily Traffic (ADT):
  - In 2001: 5000 vpd
  - In 2010: 7000 vpd
- Intersection:
  - At Station 12+861.286: skewed 4-leg signalized (IHSDM Pike / Route 1)
You will now use the IHSDM Workflow Wizard to create a Project and import data for IHSDM Pike…

Create an IHSDM Project:

1. The Workflow Wizard should be open. If not, select “File> Workflow Wizard” from the main IHSDM menu.

2. To create a new Project:
   a. On the “Select a Project Option” screen, select “Create New Project”, then click “Next”.
   b. On the “Enter new project attributes” screen, fill in or select:
      o New Project Title = “IHSDM Pike”
      o New Project Comment = “IHSDM Pike Evaluation”
      o Unit System = U.S. Customary
c. Click on “Next”

3. To Import Highway Data:
   a. On the “Select highway data option” screen, select “Import New Highway”, then click on the “Next” button
b. On the “Choose a highway data import file” screen, click on the “ihsdm.network.example.xml” file, which contains a sample dataset. Click on “Next” to import the example file.

c. On the “Select a highway” screen, select ‘ihsdm pike’ as “Highway to be evaluated.” Click on “Next.”
4. To Setup a New Evaluation:
   a. On the “Enter new evaluation attributes” screen, enter “CPM1” as the Evaluation Title and click on “Next” to continue.
b. On the “Summary” window, check to ensure that the previous steps were completed properly (i.e., Project = ‘IHSDM Pike’; Highway = ‘ihsdm pike’; Evaluation = ‘CPM1’)

c. Click “Finish” to exit the Workflow Wizard and start the Evaluation Wizard. A “CPM1” node should appear in the navigation tree. The Evaluation Wizard will now guide you through using the Crash Prediction Module to evaluate IHSDM Pike…
NOTE:

The Evaluation Wizard can also be started by clicking on the Highway you wish to Evaluate (e.g., IHSDM Pike) and then selecting “New Evaluation” from the Highway Operations button panel (lower left on main IHSDM interface).
Evaluate IHSDM Pike by using the Evaluation Wizard:

1. Fill in or select:
   - Title: CPM1
   - Evaluation Bounds:
     Minimum Station = 0.000
     Maximum Station = 14+281.693
   - Evaluation type: Crash Prediction

Click on “Next”.

NOTE: To view the highways under the “IHSDM Pike” Project, click on the + sign to the left of the “IHSDM Pike” node to expand the tree (if not already expanded). You should see highway nodes for ‘ihsdm pike’ and ‘route1’ and an intersection node for ‘route1/ihsdm pike.’
Run the Crash Prediction Module (CPM) Evaluation

1. “Set crash prediction attributes”:
   - Policy for Superelevation: AASHTO 2011 Policy (U.S. Customary)
   - Configurations:
     - Calibration: HSM configuration
     - Crash Distribution: HSM configuration
     - Model/CMF: HSM configuration
   - Evaluation Period:
     - First year of Analysis: 2012
     - Last Year of Analysis: 2017
   - Crash History: select “None” for Empirical-Bayes Analysis, since crash data will not be used in this exercise

2. IHSDM checked the highway data provided vs. the data that could be used for the crash prediction evaluation. The Data Issues Summary screen informs the user the highway(s) and intersection(s) that may have further data needs. In this case, the user is alerted that IHSDM Pike has 5 missing or incomplete data elements. Select “Next” to continue.
3. The “data issues” for IHSDM Pike screen shows data elements that are required or used by the evaluation process, except for certain elements that may affect the sectioning of the highway, for example Horizontal and Vertical Elements. Here, five data elements are preceded by an orange question mark, indicating that these optional data elements have not been provided. (Note: A red “X” is used to indicate missing required data.)

Since IHSDM Pike does not have any of the elements listed (i.e., no shoulder, no two-way left turn lane, no lighting, no automated speed enforcement, and no centerline rumble strip), **confirm that no changes are needed to the data at this time by selecting “Next.”**
4. Since Ihsdm Pike has one intersection with route 1, there are data elements required for the intersecting highway. The next screen shows the required data elements and their status for the intersecting highway (route 1).

The required or used data on route 1 are all shown with a green check mark, indicating that all data are available.

Click “Next”.

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**Figure Description:**
- **Crash Prediction Data:**
  - Two-way Left Turn Lane
  - Shoulder Section
  - Annual Average Daily Traffic
  - Design Speed
  - Driveway Density
  - Roadside Hazard Rating
  - Lighting
  - Automated Speed Enforcement
  - Centerline Rumble Strip

**Undivided, Two-Lane, Rural, Arterial:**
- Highway ID: Ihsdm Pike
- Highway Co.: existing roadway design
- Import File: D:\MNTAUAT\data\HSDM 2012 Release 8650\data
- E Max (%): 5% Default Normal, -2.0

**Horizontal Alignment Bounds**
- Min Sta. (ft.): 0.000 Max Sta. (ft.): 14+281.693

**Coordinates**
- Sta. (ft.): 6.000 X (ft.): 40,000.00 Y (ft.): 49,000.80

**Heading**
- Sta. (ft.): 0.000 Angle (deg): 98.000

**Elevation**
- Sta. (ft.): 0.000 Elevation (ft.): 1,000.00
5. On the “Evaluation settings summary” screen, check the summary to ensure that the previous steps were completed properly. **Make sure the box is checked for “Show Report on Run Completion”**. Click “Run” to run the Evaluation.
6. The status screen shows the progress of the evaluation. The Evaluation Report should open in an html browser automatically. **Minimize the report for later access.**
View/Interpret CPM Output

1. Generate CPM graphic output outside of the Evaluation Report:

   a. Close the “Crash Prediction Status” window. Click the “Show Graphs” button on the main interface button panel, and then select “Crash Prediction Graph.” This opens the graph in the Graph Editor. Click on the “maximize” icon in the upper right corner of the window for a better view.
Q 1.1: By visual inspection, which horizontal design element (red graph) has the highest crash rate (crashes/mi/year)? (Answer: Horizontal curve from approximately 4+500 to 4+600)

b. Close the graph by clicking on the ‘X’ in the upper right corner.

2. View/Interpret the CPM Evaluation Report:

   a. Maximize the Evaluation Report, or, if closed, click the “Show Report” button on the status window, and select Default Format to open the Evaluation Report.

   b. Scroll through the Evaluation Report (or click on the link in the Table of Contents) to find “Expected Highway Crash Rates and Frequencies (Section 1)”
Q 1.2: For the entire IHSDM Pike, from 2012 to 2017:

i. What is the expected Total Crashes for the highway? \( \text{(Answer: 94.20)} \)

ii. What percentage of the Total Crashes is expected to be Fatal and Injury Crashes? \( \text{(Answer: 33\%)} \)

iii. How many Fatal and Injury Crashes are expected? \( \text{(Answer: 30.98)} \)
c. Scroll through the Evaluation Report (or click on the link in the Table of Contents) to find the “Expected Crash Frequencies and Rates by Highway Segment (Section 1)” table

- **Q 1.3:** For the (curve) segment beginning at station 4+507.470 and ending at station 4+564.731:
  
  i. What is the Expected Number of Crashes for the Evaluation Period (2012 to 2017)? *(Answer: 0.99)*
  
  ii. What is the Expected Crash Rate (in crashes/mi/yr)? *(Answer: 15.3)*
  
  iii. What is the Expected Crash Rate (in crashes/million-veh-mi)? *(Answer: 5.98)*
Q 1.4: For the intersection of IHSDM Pike and Route 1 (station 12+861.286)
   i. What is the expected crashes/million entering vehicle? (Answer: 1.54)
   ii. What is the expected number of crashes/year for the intersection? (Answer: 6.45)

Close the Evaluation Report when you are done.
Exercise 2: Evaluate a 6-Lane Urban Freeway Segment with Site-Specific Observed Crash Data

From Draft HSM Chapter 18, Sample Problem 5:

The Project

A project of interest consists of two sites located on a six-lane urban freeway:

- “Segment 1”: a tangent segment
- “Segment 2”: a segment with a horizontal curve

The Question

What is the expected crash frequency of the project (i.e., Segment 1 and Segment 2 combined) for a particular year, incorporating both the predicted crash frequencies and the observed crash frequencies using the site-specific EB Method?

The Facts

The study year is 2011. The conditions present during this year are as follows:

- 2 freeway segments:
  - Segment 1 (tangent) – Station 6640 to 10600 (0.75 mi)
  - Segment 2 (with a curve) – Station 10600 to 14560 (0.75 mi)
- Data common to both segments:
  - Crash period is 2009 and 2010
  - AADT = 120,000 vpd; use the same AADT volumes for 2009 to 2011
  - 10 percent of AADT volume occurs during high-volume hours
  - 12-ft lane width
  - 6-ft inside shoulder width
  - 40-ft median width
  - No median or roadside barrier
  - 30-ft clear zone width
  - No Type B weaving sections
Four ramps in the vicinity of the segments (Note: the “Segment” shown in the Figure includes both Segments 1 and 2):

<table>
<thead>
<tr>
<th>Ramp (a,b)</th>
<th>Distance from Ramp to Beginning of Segment 1 (mi) $X_{a,b}$</th>
<th>Distance from End of Segment 2 to Ramp (mi) $X_{a,b}$</th>
<th>Ramp Volume, AADT$_{a,b}$ (veh/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b, ent</td>
<td>0.5</td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td>e, ext</td>
<td></td>
<td>0.1</td>
<td>7,150</td>
</tr>
<tr>
<td>e, ent</td>
<td></td>
<td>0.1</td>
<td>6,750</td>
</tr>
<tr>
<td>b, ext</td>
<td>0.5</td>
<td></td>
<td>7,675</td>
</tr>
</tbody>
</table>

- 30 observed fatal-and-injury crashes
  - Segment 1: 10 multiple-vehicle, 4 single-vehicle
  - Segment 2: 8 multiple-vehicle, 8 single-vehicle
- 50 observed property-damage-only crashes
  - Segment 1: 14 multiple-vehicle, 12 single-vehicle
  - Segment 2: 10 multiple-vehicle, 14 single-vehicle

Additional Segment 1 Data:
- 0.75-mi length (Station 6640 to 10600)
- 10-ft outside shoulder width
- No rumble strips on inside or outside shoulders
Additional Segment 2 Data:

- 0.75-mi length (Station 10600 to 14560)
- One horizontal curve
  - 2,100-ft equivalent radius
  - 0.25-mi length, entirely in the segment
  - Curve exists on both roadbeds
- 7-ft outside shoulder width
- 0.25 mi of rumble strips on outside shoulders in both travel directions
- 0.25 mi of rumble strips on inside shoulders in both travel directions
Use the IHSDM Crash Prediction Module (CPM) to Evaluate the 6-Lane Urban Freeway Segment with Site-Specific Observed Crash Data

An archived IHSDM Project has been created for this exercise. Begin by Un-Archiving the Project, which contains a Highway for the Sample Problem:

Un-archive the “HSM Ch 18 Sample Problems” Project:
1. In the main IHSDM interface, click on your Username in the navigation tree.
2. Select “Un-Archive Project” from the User Operations button panel (lower left)

3. Browse to find the Tutorial folder in the IHSDM software home directory and click on the “ihsdm.project.HSM Ch 18 Sample Problems.zip” file.

4. Click on Open. The HSM Ch 18 Sample Problems Project should now be available in your navigation tree.
Run a CPM Evaluation on the Urban 6F–SP5 Highway

1. Click on the **Urban 6F–SP5** highway node. This Highway contains the data for HSM Chapter 18, Sample Problem 5.

2. Select **New Evaluation** from the Highway Operations button panel to start the Evaluation Wizard.
3. Add a title in the Title field, e.g., “Sample Problem 5”

4. Set the Evaluation Bounds:
   - Minimum Station: 6640
   - Maximum Station: 14560

5. Click on Next
6. Set the Evaluation Period
   • First Year of Analysis: 2011
   • Last Year of Analysis: 2011

7. Set Empirical-Bayes Analysis to **Site-Specific**. The “Highway with Crash History,” and “Potential Range of Crash History Data” fields will become active/editable.

   • Set the “Highway with Crash History” to the **Urban 6F – SP5** highway
   • “Potential Range of Crash History Data”:
     • Set the “Starting Year” to 2009
     • Set the “Ending Year” to 2010
8. Click Next
9. The crash history data is displayed (80 crashes). Click on Next to accept the data.
10. Specify the period of crash history data to be used in the evaluation:

- Ensure that 2009 and 2010 are listed under “Years Selected for Evaluation” on the right side of the panel.

- If 2009 and/or 2010 is listed under “Years Excluded from Evaluation,” move them to Years Selected for Evaluation by clicking on the Year to highlight it; then clicking the arrow pointing to the right.

- Click on Next

11. Click Next again on the Highway/Intersection Data Issues Summary screen

12. Click Next on the screen displaying data elements that can be edited

13. Click Next on the “Warnings” screen (if any appears)

View/Interpret CPM Output (Evaluation Report):

1. Maximize the Evaluation Report, or, if closed, click the “Show Report” button on the status window, and select Default Format to open the Report.
2. Scroll through the Evaluation Report (or click on link in the Table of Contents) to find “Expected Freeway Crash Rates and Frequencies (Section 1)”

**Q 2.1:** For the 6-lane urban freeway segment…

- What is the Expected Total Crashes for the highway? *(Answer: 41.01)*
- How many Fatal and Injury Crashes are expected? *(Answer: 13.55)*
- How many Property-Damage–Only Crashes are expected? *(Answer: 27.46)*
Table 4. Expected Crash Rates and Frequencies (Section 1)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year of Analysis</td>
<td>2011</td>
</tr>
<tr>
<td>Last Year of Analysis</td>
<td>2011</td>
</tr>
<tr>
<td>Evaluated Length (mi)</td>
<td>1.5000</td>
</tr>
<tr>
<td>Average Future Road AADT (vpd)</td>
<td>120,000</td>
</tr>
<tr>
<td>Expected Crashes</td>
<td></td>
</tr>
<tr>
<td>Total Crashes</td>
<td>41.01</td>
</tr>
<tr>
<td>Fatal and Injury Crashes</td>
<td>13.55</td>
</tr>
<tr>
<td>Property-Damage-Only Crashes</td>
<td>27.46</td>
</tr>
<tr>
<td>Percent of Total Expected Crashes</td>
<td></td>
</tr>
<tr>
<td>Percent Fatal and Injury Crashes (%)</td>
<td>33</td>
</tr>
<tr>
<td>Percent Property-Damage-Only Crashes (%)</td>
<td>67</td>
</tr>
<tr>
<td>Expected Crash Rate</td>
<td></td>
</tr>
<tr>
<td>Crash Rate (crashes/mi/yr)</td>
<td>27.3414</td>
</tr>
<tr>
<td>Fatal and Injury Crash Rate (crashes/mi/yr)</td>
<td>9.0323</td>
</tr>
<tr>
<td>Property-Damage-Only Crash Rate (crashes/mi/yr)</td>
<td>18.3091</td>
</tr>
</tbody>
</table>

Close the Evaluation Report when you are done.

Close the “Crash Prediction Status” window, if you have not already done so.
Exercise 3: Evaluate a Site Set (A Rural Multilane Highway)

I. Create a new Project titled “Siteset – Rural Multilane”
   1. Highlight your User node in the navigation tree
   2. Select New Project from the User Operations button panel
   3. Enter “Siteset – Rural Multilane” as the title

II. Create a Siteset and Enter Data
   1. Highlight the “Siteset-Rural Multilane” project node in the Navigation Tree
   2. Select “New Site Set” from the Project Operations button panel
   3. Enter “Rural Multilane” as the title
4. Click **Next**, and then click **Finish** on the “Summary” screen.
5. The Site Set Editor automatically opens after the creation of a new site set.

6. Click on “+” icon to the left of the “Rural Multi-Lane Site Data” node in the Navigation Tree to expand the list. The types of roadway segments and intersections evaluated are listed underneath.

7. Select the first sub-node “Four-Lane Undivided Segment (RML_4U), then click on the “Add/Edit Site Data” button on the right side of the panel.
8. The selected RML-4U site data opens in an editor window. At the moment, it’s empty since we just created a new site set. There are three tabs in the editor, hosting three categories of data:

i. Site Data

ii. Required Segment Traffic Data

iii. Crash Data (optional, used for EB process)

9. Click on the Add button on this interface to add a new row in the Site Data table. You may enter data by selecting each cell in the row, or by highlighting a row, and clicking the Edit button.
10. Highlight the newly added row, and then click on the Edit button to bring up a dialog window that allows clearer view of the data items. Enter the following:

- Site No.: this is system generated, non-editable
- Highway: R4U
- Site Description: 0-1000
- Length (mi): 0.1894
- Left Side Lane Width (ft): 10.50
- Right Side Lane Width (ft): 10.25
- Left Side Paved Shoulder (ft): 4.0
- Right Side Paved Shoulder (ft): 4.0
- Left Side Gravel Shoulder (ft): 2.0
- Right Side Gravel Shoulder (ft): 2.0
- Left Side Turf Shoulder (ft): 1.0
- Right Side Turf Shoulder (ft): 1.0
- Left Side Slope (v:h): 1:4
- Right Side Slope (v:h): 1:4
- Lighting: yes
- Automated Speed Enforcement: yes
11. Click OK
12. Click on the “Required Segment Traffic Data” tab
13. Click on the Add button to add a row, then highlight the row and click on the Edit button to open the editing dialog. Enter the following data:

- Site No.: 1
- Year: 2007
- AADT (vpd): 10000

Note: Multiple years of AADT data may be entered for one site, with each year of AADT identified in one row.

14. Click OK to dismiss the dialog.
15. Click on the Crash Data tab to see the crash data table. Similar to the AADT table, multiple years of crash history data may be entered for one site, with each year of crashes identified in one row. For this exercise, no crash data are entered for site 1.
16. Click **OK** at the bottom of the screen to save the data and dismiss this window. Notice that on the right side of the Editor, there is one site listed in the summary table. The check mark indicates that the data entry is valid (complete).

![Site Data Table](image)

17. Select **File -> Update** from the Editor’s menu bar to save the editing. Notice that now a green check mark icon shows at the left of the “Four-Lane Undivided Segment (RML-4U)” node, indicating that data are present for this segment category.

![Data Set Attributes](image)

18. Select **File->Cancel**, or click on the “x” at the upper right corner of the Site Set Editor to close it.

### III. Import a Site Set

1. On the main interface, highlight the “Siteset-Rural Multilane” project node, and then click on the “Import Highway/Intersection/Site Set” button on the Project Operations button panel.

2. Select “**Multilane Rural Siteset.xml**” from the available highway files.
3. Click Next. Then click Finish on the next screen. Notice that in the Navigation Tree, a new site set node now appears as a sub-node of the project.

4. Highlight the “Multilane Rural Siteset (imported)” site set node, and select the Edit Site Set button (or double click the site set node) to open the Site Set Editor.

5. Click on the “+” icon to the left of the “Rural Multi-Lane Site Data” node to expand the list.

6. Select any of the site data items that have a green check mark, and click on the Add/Edit Site Data button to view the imported data.

7. After inspecting the data, click OK to dismiss the editing window. (If a “SiteSet Multilane Rural Siteset data has been modified” dialog pops-up, click on the “Discard” button.)

8. Select File-> Cancel to dismiss the Site Set Editor.
IV. Evaluate a site set with Crash Prediction.

1. Highlight the **“Multilane Rural Siteset (imported)”** node in the Navigation Tree, and then click on the New Evaluation button on the Site Set Operations button panel.

2. On the “Set crash prediction attributes” screen, enter the following data (accepting the default values for the other items):
   - Title: CPM 1
   - First Year: 2012
   - Last Year: 2017
3. Click on **Next**.
4. Click on **Run** on the Summary screen.

V. **View/Interpret CPM Output (Evaluation Report):**

1. Maximize the Evaluation Report, or, if closed, click the “Show Report” button on the status window, and select Default Format to open the Report.
2. Scroll through the Evaluation Report (or click on links in the Table of Contents) to find **“Expected Crash Frequencies and Rates by Site”** for 4-lane undivided (4U) segments (Table 2); 4-lane divided (4D) segments (Table 4); and 3-leg stop-controlled (3ST) intersections (Table 6).

   - **Q 3.1:** For the multilane rural highway…
     - What is the Expected No. of Crashes for 4U site No. 1? *(Answer: 0.04)*
     - What is the Expected No. of Crashes for 4D site No. 2? *(Answer: 0.08)*
     - What is the Expected No. of Crashes for the one 3ST Intersection? *(Answer: 1.61)*

**Close the Evaluation Report when you are done.**