IHSDM Economic Analyses Tool (EA Tool) Tutorial

This Tutorial demonstrates how the IHSDM Economic Analyses Tool (EA Tool) can be used to conduct economic analyses. The EA Tool uses existing CPM Evaluation results from an archived project to estimate crash costs and to conduct a Benefit-to-Cost (B/C) analysis.

Overview

In this Tutorial, an economic analysis is conducted on a 3.8 mile section of freeway (“Example Freeway”), which includes two interchanges (“Interchange 2250” and “Interchange 17750”). Each interchange contains ramps, C-D roads, and ramp terminals. The freeway begins as a 6-lane rural facility and transitions to an 8-lane urban facility. A plan view of the freeway – as represented in the IHSDM Highway Viewer - is shown in the figure below.

The IHSDM Project which contains the freeway section (“Example Freeway-Economic Analysis”) includes Crash Prediction Module (CPM) Evaluations for some components. The results of these Evaluations (i.e., predicted crashes) will be used in the economic analysis.

The Example Freeway-Economic Analysis Project includes the existing “Example Freeway” and its components (the “Base Case” for the economic analysis) and two alternative cases (“Alt1” and “Alt2”):

- “Alt1” consists of widening all shoulders on the freeway to 10 ft. Shoulders on the existing Example Freeway (Base Case) vary from 4 ft to 10 ft.
- “Alt2” consists of changing all freeway segment lane widths to 12 ft. Lane widths on the existing Example Freeway vary from 10.6 ft to 13 ft.
Work Problem

Exercises:

This Tutorial exercise includes the following steps in using the IHSDM EA Tool to conduct an economic analysis:

- **11.1: Un-Archive an existing archived Project**
- **11.2: Create a new Economic Analysis (EA) Project**
- **11.3: Define Cases for the economic analysis**
  - Define the Base Case
  - Define the Alternative Cases
- **11.4: Conduct an Economic Analysis**
- **11.5: Review the results in an Economic Analysis Report**
11.1: Un-Archive an Existing Project (Example Freeway-Economic Analysis)
Start from the IHSDM User Node and select the Un-Archive Project operation.

Browse to the Tutorial sub-folder of the IHSDM home folder. Then, select “ihsdm.project.Example Freeway-Economic Analysis.zip” and Open.

The “Example Freeway-Economic Analysis” project will appear in the IHSDM Tree.
The following figure highlights highways and interchanges that are associated with the Base Case, Case Alt1, and Case Alt2, respectively. Note that these all reside in the same “Example Freeway – Economic Analysis” Project.
11.2: Create a new Economic Analysis (EA) Project
Choose the “Economic Analyses” node from the IHSDM Tree and select the New EA Project operation,

This opens an Add a new EA Project Wizard. Enter “EA Project-Example Freeway” as the Title and select Next:
Select **Finish** in the next window:

An Economic Analysis Project node (EA Project-Example Freeway) appears underneath the “Economic Analyses” main node, and the **Economic Analysis (EA) Project Editor** opens:
11.3: Define Cases for the Economic Analysis
This section steps through the process of defining a Base Case and Alternative Cases.

A Crash Cost Configuration file (from the IHSDM Administration Tool) must be selected for the EA Project (see figure, below). This file applies to all of the Cases.

Accept the default configuration, which contains the following:

<table>
<thead>
<tr>
<th>Configuration Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash Unit Cost Zero Year</td>
</tr>
<tr>
<td>Crash Cost Index</td>
</tr>
<tr>
<td>Discount Rate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>KABCO Unit Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>K Cost ($/Crash)</td>
</tr>
<tr>
<td>A Cost ($/Crash)</td>
</tr>
<tr>
<td>B Cost ($/Crash)</td>
</tr>
<tr>
<td>C Cost ($/Crash)</td>
</tr>
<tr>
<td>O Cost ($/Crash)</td>
</tr>
</tbody>
</table>

The default KABCO crash unit costs (in 2016 dollars) are those recommended as national KABCO comprehensive crash unit costs in FHWA Report on “Crash Costs for Highway Safety Analysis” (FHWA-SA-17-071; January 2018).

Note that the user can modify any of the above values via the IHSDM Administration Tool (AdminTool).

**Base Case**
The figure below shows the highways and interchanges related to the Base Case. In the exercise that follows, Evaluations for the Example Freeway and three components of Interchange 2250 will be selected as part of the Base Case definition.
Define the “Base Case”

In the EA Project Editor, select the Add button to the right of the Cases table, which opens an Edit the Case window. Enter “Base Case” as the Title and check the “Is Base Case” box. The Base Case for the Economic Analysis is that to which other alternative cases (two, in this exercise) will be compared.

Do not click on the OK button yet…
Associate CPM Evaluations with the Base Case

In the exercise below you will associate Evaluations from 4 facilities with the Base Case:

- Evaluation of a freeway (“Example Freeway”) located in the Example Freeway-Economic Analysis Project
- Evaluation of a ramp (“C-D A Entrance 1”) located in “Interchange 2250” (which is part of the Example Freeway-Economic Analysis Project)
- Evaluation of a C-D road (“C-D Road A”) located in “Interchange 2250”
- Evaluation of a ramp terminal (“Crossroad A Terminal D4”) located in “Interchange 2250”

<table>
<thead>
<tr>
<th>Project/Interchange</th>
<th>Facility</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example Freeway-Economic</td>
<td>Example Freeway</td>
<td>Evaluation 1</td>
</tr>
<tr>
<td>Interchange 2250</td>
<td>C-D A Entrance 1</td>
<td>Interchange 2250: Evaluation 1: C-D A Entrance 1</td>
</tr>
<tr>
<td>Interchange 2250</td>
<td>C-D Road A</td>
<td>Interchange 2250: Evaluation 1: C-D Road A</td>
</tr>
<tr>
<td>Interchange 2250</td>
<td>Crossroad A Terminal D4</td>
<td>Interchange 2250: Evaluation 1: Crossroad A Terminal D4</td>
</tr>
</tbody>
</table>
Begin to associate Evaluations with the Base Case by selecting the **Add** button on the **Edit the Case** window (to the right of the **Evaluations** table). A dialog pops up for associating previously run CPM Evaluations with the Base Case. This dialog includes pull-down menus to select an Evaluation by identifying (in order):

- The (CPM) Project or Interchange containing the facility that was evaluated.
- The Facility that was evaluated.
- The Evaluation itself.

Continue by selecting “Example Freeway-Economic Analysis” as the Project, “Example Freeway” as the Selected Facility, and “Evaluation 1” as the Selected Evaluation. Then click on the **Calculate Crash Cost** button to have the program estimate the “Present Value of Crash Cost” for this evaluation ($15,044,283, for the evaluation period of 2017-19). [Note: The user also has the option of manually entering this value.]
Click the **OK** button.

The first Base Case evaluation is thus added to the list:
Following the instructions below, add the other 3 evaluations to the Base Case; this time from the Interchange named “Example Freeway-Economic Analysis: Interchange 2250”:

<table>
<thead>
<tr>
<th>Project/Interchange</th>
<th>Facility</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interchange 2250</td>
<td>C-D A Entrance 1</td>
<td>Interchange 2250: Evaluation 1: C-D A Entrance 1</td>
</tr>
<tr>
<td>Interchange 2250</td>
<td>C-D Road A</td>
<td>Interchange 2250: Evaluation 1: C-D Road A</td>
</tr>
<tr>
<td>Interchange 2250</td>
<td>Crossroad A Terminal D4</td>
<td>Interchange 2250: Evaluation 1: Crossroad A Terminal D4</td>
</tr>
</tbody>
</table>

Click the Add button to begin.

In the Edit the evaluation data window… After selecting each Evaluation, click on the Calculate Crash Cost button to populate the Present Value of Crash Cost field. Then, click on the OK button.

The Present Value of Crash Cost for the Base Case (i.e., the sum of values for all 4 associated Evaluations) is $16,089,111.
Enter “Present Value of Other Costs”

In the **Edit the Case** window, enter $2,400,000 as the “Present Value of Other Costs” for the entire Base Case. (Note that this value includes initial construction costs, maintenance costs, etc., and must be determined outside of IHSDM.) The Base Case is now set in the EA Project Editor with present values for both “Crash Cost” and “Other Cost.”

Select **OK** to return to the main EA Project Editor window.
**Alternative Cases**

The figure below shows the highways and interchanges related to Case Alt1 and Case Alt2.

**Case Alt1:** In the exercise that follows, Evaluations for the “Example Freeway –Alt1” and three components of “Interchange 2250 –Alt1” will be selected as part of the Case Alt1 definition.

**Case Alt2:** In the exercise that follows, Evaluations for the “Example Freeway –Alt2” and three components of “Interchange 2250 –Alt2” will be selected as part of the Case Alt2 definition.
Define Alternative Case “Alt1”
Begin by selecting the Add button on the EA Project Editor (to the right of the Cases table). This opens an Edit the Case window. Enter “Alt1” as the Title and leave the “Is Base Case” box unchecked. Do not click the OK button yet…

Associate CPM Evaluations with Alternative Case “Alt1”
In the exercise below you will associate Evaluations from 4 facilities with the Case Alt1:

- Evaluation of a freeway (“Example Freeway-Alt1”) located in the Example Freeway-Economic Analysis Project
- Evaluation of a ramp (“C-D A Entrance 1 -Alt1”) located in “Interchange 2250 –Alt1” (which is part of the Example Freeway-Economic Analysis Project)
- Evaluation of a C-D road (“C-D Road A –Alt1”) located in “Interchange 2250 –Alt1”
- Evaluation of a ramp terminal (“Crossroad A Terminal D4 –Alt1”) located in “Interchange 2250 –Alt1”

<table>
<thead>
<tr>
<th>Project/Interchange</th>
<th>Facility</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example Freeway-Economic Analysis</td>
<td>Example Freeway-Alt1</td>
<td>Evaluation 1</td>
</tr>
<tr>
<td>Interchange 2250–Alt1</td>
<td>C-D A Entrance 1 -Alt1</td>
<td>Interchange 2250 -Alt1: Evaluation 1: C-D A Entrance 1 –Alt1</td>
</tr>
<tr>
<td>Interchange 2250–Alt1</td>
<td>C-D Road A -Alt1</td>
<td>Interchange 2250 -Alt1: Evaluation 1: C-D Road A –Alt1</td>
</tr>
<tr>
<td>Interchange 2250–Alt1</td>
<td>Crossroad A Terminal D4 -Alt1</td>
<td>Interchange 2250 -Alt1: Evaluation 1: Crossroad A Terminal D4 –Alt1</td>
</tr>
</tbody>
</table>

Begin to associate Evaluations with Case “Alt1” by selecting the Add button on the Edit the Case window (to the right of the Evaluations table). A dialog pops up for associating previously run CPM Evaluations with Alternative Case “Alt1”.

Continue by selecting “Example Freeway-Economic Analysis” as the Project, “Example Freeway –Alt1” as the Facility, and “Evaluation 1” as the Evaluation. Then click on the Calculate Crash Cost button to have the program estimate the “Present Value of Crash Cost” for this evaluation ($12,941,371, for the evaluation period of 2017-19).

Click the OK button.

The first Case Alt1 evaluation is thus added to the list.

Following the instructions below, add the other 3 evaluations to Case Alt1; this time from the Interchange named “Example Freeway-Economic Analysis: Interchange 2250 – Alt1”:
In the **Edit the evaluation data** window… After selecting each Evaluation, click on the **Calculate Crash Cost** button to populate the Present Value of Crash Cost field. Then, click on the **OK** button.

The Present Value of Crash Cost for Case Alt1 (i.e., the sum of values for all 4 associated Evaluations) is $13,986,200.

**Enter “Present Value of Other Costs”**

In the **Edit the Case** window, enter $3,400,000 as the “Present Value of Other Costs” for the entire Case “Alt1.” Case “Alt1” is now set in the EA Project Editor with present values for both “Crash Cost” and “Other Cost.”

Select **OK** to return to the main EA Project Editor window.

**Define Alternative Case Alt2**

Begin by selecting the **Add** button on the EA Project Editor (to the right of the **Cases** table). This opens an **Edit the Case** window. Enter “Alt2” as the Title and leave the “**Is Base Case**” box unchecked. Do **not** click the **OK** button yet…
Associate CPM Evaluations with Alternative Case “Alt2”

Following the same procedure as for the Base Case and Alt1, in the exercise below you will associate Evaluations from 4 facilities with Case Alt2:

- Evaluation of a freeway (“Example Freeway-Alt2”) located in the **Example Freeway-Economic Analysis** Project
- Evaluation of a ramp (“C-D A Entrance 1 –Alt2”) located in “Interchange 2250 –Alt2” (which is part of the **Example Freeway-Economic Analysis** Project)
- Evaluation of a C-D road (“C-D Road A –Alt2”) located in “Interchange 2250 –Alt2”
- Evaluation of a ramp terminal (“Crossroad A Terminal D4 –Alt2”) located in “Interchange 2250 –Alt2”

<table>
<thead>
<tr>
<th>Project/Interchange</th>
<th>Facility</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example Freeway-Economic Analysis</td>
<td>Example Freeway-Alt2</td>
<td>Evaluation 1</td>
</tr>
<tr>
<td>Interchange 2250–Alt2</td>
<td>C-D A Entrance 1 -Alt2</td>
<td>Interchange 2250 -Alt2: Evaluation 1: C-D A Entrance 1 –Alt2</td>
</tr>
<tr>
<td>Interchange 2250–Alt2</td>
<td>C-D Road A -Alt2</td>
<td>Interchange 2250 -Alt2: Evaluation 1: C-D Road A –Alt2</td>
</tr>
<tr>
<td>Interchange 2250–Alt2</td>
<td>Crossroad A Terminal D4 -Alt2</td>
<td>Interchange 2250 -Alt2: Evaluation 1: Crossroad A Terminal D4 –Alt2</td>
</tr>
</tbody>
</table>

Begin to associate Evaluations with Case “Alt2” by selecting the **Add** button on the **Edit the Case** window (to the right of the **Evaluations** table). A dialog pops up for associating **previously run** CPM Evaluations with Alternative Case “Alt2”.

Continue by selecting “Example Freeway-Economic Analysis” as the Project, “Example Freeway –Alt2” as the Facility, and “Evaluation 1” as the Evaluation. Then click on the **Calculate Crash Cost** button to have the program estimate the “Present Value of Crash Cost” for this evaluation ($14,649,793, for the evaluation period of 2017-19).

Click the **OK** button. The first Case Alt2 evaluation is thus added to the list.

Following the instructions below, add the other 3 evaluations to Case Alt2; this time from the Interchange named “Example Freeway-Economic Analysis: Interchange 2250 –Alt2.”
In the **Edit the evaluation data** window… After selecting each Evaluation, click on the **Calculate Crash Cost** button to populate the Present Value of Crash Cost field. Then, click on the **OK** button.

The Present Value of Crash Cost for Case Alt2 (i.e., the sum of values for all 4 associated Evaluations) is $15,694,621.

**Enter “Present Value of Other Costs”**

In the **Edit the Case** window, enter $2,600,000 as the “Present Value of Other Costs” for the entire Case ”Alt2.” Case “Alt2” is now set in the EA Project Editor with present values for both “Crash Cost” and “Other Cost.”

Select **OK** to return to the main EA Project Editor window.
The Present Value of Crash Costs and the Present Value of Other Costs are now shown for all three Cases.

**Update the EA Project and Close the EA Project Editor**
From the EA Project Editor menu choose **File / Update** and then **File/Cancel** to update the data and close the editor.
11.4: Conduct an Economic Analysis
Select the “EA Project-Example Freeway” node (under the main Economic Analysis node) in the IHSDM navigation tree, and choose the New EA Analysis operation. In the Run Economic Analysis … window, enter “EA Analysis-Non-EB” as the Title and click on Next.

On the next window, select Run with the “Show Report on Run Completion” box checked.

The EA Analysis will run and the Economic Analysis Report will open.

Lesson 11
11.5: Review the Economic Analysis Report
The Economic Analysis Report contains the following sections:

- Configuration Summary
- Analysis Output Summary
- Crash Cost Data

Configuration Summary
As shown in the figure below, the Configuration Summary lists values from the selected Economic Analysis Configuration Data file. In this exercise, the default Configuration file was selected.

These values were used in the Economic Analysis to convert the predicted crashes to a present value of crash costs. For each Case (Base Case and Alternative Cases Alt1 and Alt2), the selected CPM Evaluations contained predicted crashes broken down by KABCO severity levels, for the years 2017, 2018, and 2019.

The KABCO crash unit costs are in 2016 dollars (as indicated by the “Crash Unit Cost Zero Year”). To determine the crash unit costs for the analysis years of 2017-2019, the “zero year” crash unit costs were increased by 2% per year (as indicated by the Crash Cost Index of 0.02).

Crash costs for each year were determined by multiplying the number of crashes of a given severity level (e.g., “K” crashes) by the unit cost for that severity level. “Present Values” for crash costs were calculated by “discounting” the future year values to the present (2017). The default discount rate of 0.03 (3%) was used for the discounting.
The Analysis Output Summary shows the Present Value of Crash Costs and Present Value of Other Cost for all Cases, including the Base Case. In addition, it shows the Net Present Value of Benefits (B) and Net Present Value of Costs (C), the Present Value of Net Benefits (B-C), and the Benefit Cost Ratio (B/C) for each Alternative Case.

The Net Present Value of Benefits (B) for each Alternative Case is equal to the (Present Value of Base Case Crash Cost) – (Present Value of Alternative Case Crash Cost).

The Net Present Value of Costs (C) for each Alternative Case is equal to the (Present Value of Alternative Case Other Cost) – (Present Value of Base Case Other Cost).

The results show that Alt1 has a higher Present Value of Net Benefits (B-C), and Benefit Cost Ratio (B/C), as compared to Alt2.
Crash Cost Data
The Crash Cost Data section of the Economic Analysis Report provides two tables for each Case. The first is the Evaluation Data table, which lists the Present Value of Crash Cost for each Evaluation associated with the Case. The figure below shows the Alt1 Evaluation Data.

Alt1 Data

Case Title: Alt1
In Base Case: false
Present Value of Crash Cost: 13,986,199.65
Present Value of Other Cost: 3,490,000.00

<table>
<thead>
<tr>
<th>Project or Interchange</th>
<th>Selected Facility</th>
<th>Selected Evaluation</th>
<th>Present Value of Crash Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example Freeway-Economic Analysis</td>
<td>Example Freeway -Alt1</td>
<td>Evaluation 1</td>
<td>12,941,371.44</td>
</tr>
<tr>
<td>Example Freeway-Economic Analysis : Interchange 2250 -Alt1</td>
<td>C-D A Entrance 1 -Alt1</td>
<td>Interchange 2250 -Alt1 : Evaluation 1 : C-D A Entrance 1 -Alt1</td>
<td>400,320.97</td>
</tr>
<tr>
<td>Example Freeway-Economic Analysis : Interchange 2250 -Alt1</td>
<td>C-D Road A -Alt1</td>
<td>Interchange 2250 -Alt1 : Evaluation 1 : C-D Road A -Alt1</td>
<td>237,983.72</td>
</tr>
<tr>
<td>Example Freeway-Economic Analysis : Interchange 2250 -Alt1</td>
<td>Crossroad A Terminal D4 -Alt1</td>
<td>Interchange 2250 -Alt1 : Evaluation 1 : Crossroad A Terminal D4 -Alt1</td>
<td>406,523.53</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>13,986,199.65</td>
</tr>
</tbody>
</table>

The Evaluation Crashes table shows the breakdown of crashes by KABCO severity level for each Evaluation associated with the Case. The figure below shows the Alt1 Evaluation Crashes.

<table>
<thead>
<tr>
<th>Project or Interchange</th>
<th>Selected Facility</th>
<th>Selected Evaluation</th>
<th>Fatal (K) Crashes (crashes)</th>
<th>Incapacitating Injury (A) Crashes (crashes)</th>
<th>Non-Incapacitating Injury (B) Crashes (crashes)</th>
<th>Possible Injury (C) Crashes (crashes)</th>
<th>No Injury (O) Crashes (crashes)</th>
<th>Total Crashes (crashes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example Freeway-Economic Analysis</td>
<td>Example Freeway -Alt1</td>
<td>Evaluation 1</td>
<td>0.6297</td>
<td>1.5401</td>
<td>9.4714</td>
<td>17.6464</td>
<td>49.9142</td>
<td>79.2001</td>
</tr>
<tr>
<td>Example Freeway-Economic Analysis : Interchange 2250 -Alt1</td>
<td>C-D A Entrance 1 -Alt1</td>
<td>Interchange 2250 -Alt1 : Evaluation 1 : C-D A Entrance 1 -Alt1</td>
<td>0.0194</td>
<td>0.0587</td>
<td>0.4039</td>
<td>0.3781</td>
<td>0.9766</td>
<td>1.8366</td>
</tr>
<tr>
<td>Example Freeway-Economic Analysis : Interchange 2250 -Alt1</td>
<td>C-D Road A -Alt1</td>
<td>Interchange 2250 -Alt1 : Evaluation 1 : C-D Road A -Alt1</td>
<td>0.0113</td>
<td>0.0343</td>
<td>0.2363</td>
<td>0.2212</td>
<td>0.8876</td>
<td>1.3907</td>
</tr>
<tr>
<td>Example Freeway-Economic Analysis : Interchange 2250 -Alt1</td>
<td>Crossroad A Terminal D4 -Alt1</td>
<td>Interchange 2250 -Alt1 : Evaluation 1 : Crossroad A Terminal D4 -Alt1</td>
<td>0.0039</td>
<td>0.0964</td>
<td>0.4690</td>
<td>1.4018</td>
<td>2.2330</td>
<td>4.2040</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>0.6643</td>
<td>1.7295</td>
<td>10.5806</td>
<td>19.6457</td>
<td>54.0114</td>
<td>86.6314</td>
</tr>
</tbody>
</table>

So, for Case Alt1, a total of 86.6 crashes are predicted to occur from 2017-19, resulting in a present value crash cost (2017 dollars) of $13,986,200.
For Alt2, 94.9 total crashes are predicted to occur from 2017-19, resulting in a present value crash cost (2017 dollars) of $15,694,621.

For the Base Case, 95.1 total crashes are predicted to occur from 2017-19, resulting in a present value cost (2017 dollars) of $16,089,111.

**Conclusion:**
The results of the Economic Analysis suggest that while both Case Alt1 and Case Alt2 are economically “acceptable” when compared to the Base Case (i.e., their B/C ratios are greater than 1, and their Present Value of Net Benefits are positive), Case Alt1 is clearly superior, given its higher Present Value of Net Benefits ($1,102,911 vs. $194,490).

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