Pennsylvania’s Use of IHSDM for a Safety Analysis of Freeway Interchange Design Alternatives on I-70 (P16-1759)

Project Purpose
- The Pennsylvania Department of Transportation (PennDOT) submitted a Conceptual Plan of Access (CPoA) request to the FHWA Pennsylvania Division Office for a section of I-70 in western Pennsylvania, which included two closely spaced interchanges with some I-70 mainline improvements (Alternative 2A) and the other which removed one of the interchanges and included a new connector road and local roadway network improvements (Alternative 3).
- While both the alternatives appeared to be acceptable based on engineering and operations review, the FHWA Interstate System Access Informational Guide contains eight policy requirements that must be addressed for Interstate access modifications. Policy Point three requires "that the proposed change in access does not have a significant adverse impact on the safety and operation of the Interstate facility."
- The Highway Safety Manual (HSM) and safety analysis tools, such as FHWA’s Interactive Highway Safety Design Model (IHSDM), offer a data driven approach to support and strengthen Policy Point three analysis.
- To assist with the evaluation of the operational and safety effects of the proposed project alternatives, the FHWA Pennsylvania Division Office coordinated with the FHWA Geometric Design Laboratory (GDL) through the FHWA Office of Safety Research and Development to utilize the IHSDM software tool.

IHSDM Crash Prediction Module
The IHSDM Crash Prediction Module (CPM) was used on this project to apply HSM Part C Predictive Methods for Freeway Segments (Chap. 18), Freeway Ramps/Interchanges (Chap. 19), and Rural 2-Lane Highways (Chap. 10). IHSDM CPM capabilities include:
- Evaluation of freeway segments, including segments with speed change lanes.
- Evaluation of freeway ramps/interchanges, including:
  - Ramps
  - Collector-Distributor (C-D) Roads
  - Application of the Empirical-Bayes (E-B) process to factor historical crash data into the evaluation.

Existing Design
- 4-lane rural freeway (I-70)
- Typical conditions include a narrow median with barrier, narrow shoulders, and tight configurations on some entrance and exit ramps
- 2 closely spaced interchanges (Exit 53 – “Yukon” interchange; and Exit 54 – “Madison” interchange), roughly 4,000 feet apart; AASHTO recommends 3 miles spacing in rural areas

Data Preparation and Data Input into IHSDM
- The FHWA-GDL compiled the necessary data - including AADT’s, crash data, and alternative geometrics - to evaluate the alternative designs for the period of 2018-2038.
- The IHSDM CPM data requirements are based on the crash prediction methods for rural two-lane highways, freeway segments and ramps/interchanges described in HSM Chapters 10, 18 and 19. Geometric data available for I-70 Freeway and Ramps, as well as for SR 3014 and the Alt. 3 Connector Rd. Geometric data for other highways affected by these changes were estimated by using an on-road map of the existing HS.
- Two IHSDM projects were created – one for Alt. 2A and one for Alt. 3. (The IHSDM data structure for Project 2A is shown below.)
- In addition to the I-70 mainline, a total of 8 ramps and 4 ramp terminals were evaluated for Alt. 2A, and 4 ramps and 2 ramp terminals for Alt. 3. Since closing an interchange would have an effect on the traffic distribution of the local highways beyond the interchanges, expected crashes were also estimated for a number of local roads and intersections.

Evaluation of Alternatives Using IHSDM
- The IHSDM CPM was first used to evaluate each entity (freeway segments, ramps, ramp terminals, crossroads, and intersections) for both alternatives without considering crash history data. Alt. 2A was superior to Alt. 3 in terms of expected safety performance. Expected crashes for Alt. 2A were approximately 10% lower than for Alt. 3 (670 vs. 747 crashes for 2018-38). Results for Alt. 2A are indicated by white text, and results for Alt. 3 are indicated by grey text.
- A crash break-down based on severities (Fatal and Injury (FI) vs. Property Damage Only (PDO)) analysis also shows that Alt. 2A is superior to Alt. 3 in terms of expected safety performance. Table 4.5 shows that Alt. 2A has about 15% fewer FI crashes than Alt. 3.
- Due to signficant changes to the interchanges in Alts. 2A and 3 versus the existing design, the Empirical-Bayes (E-B) process to consider crash history data could only be applied to SR 3037 (including the SR 3037 / SR 3030 intersection) and SR 3010 (including the SR 3010 / SR 3030 intersection). Although crash data were also provided by PennDOT for SR 3010, it was not used since the interchange was significantly changed compared to the existing condition.
- Results with crash data also show that Alt. 2A is expected to have about 10% fewer total crashes compared with Alt. 3 (583 vs. 648 crashes). Of note is that the crash data for SR 3037 and SR 2009-13 showed crash experiences much lower than that predicted by the models.

Acknowledgment
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Table 1: Design Alternatives

<table>
<thead>
<tr>
<th>Facility</th>
<th>2018-2038 Expected Crashes</th>
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<tbody>
<tr>
<td>Alt. 2A</td>
<td>583 648</td>
</tr>
<tr>
<td>Alt. 3</td>
<td>670 747</td>
</tr>
<tr>
<td>Without Crash Data</td>
<td>401 453</td>
</tr>
<tr>
<td>With Crash Data</td>
<td>502 577</td>
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Table 2: Alternative Design Characteristics

<table>
<thead>
<tr>
<th>Facility</th>
<th>Design Characteristic</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Alternative 2A</td>
</tr>
<tr>
<td>L-70 Mainline</td>
<td>Sight alignment change</td>
</tr>
<tr>
<td>“Yukon” Interchange (Exit 53)</td>
<td>Remove</td>
</tr>
<tr>
<td>“Madison” Interchange (Exit 54)</td>
<td>Reconfigure</td>
</tr>
<tr>
<td>SR 3014</td>
<td>Shift slightly to the north</td>
</tr>
<tr>
<td>Road to connect SR 3014 and SR 3037 to Huntingdon St</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 3: Results and Conclusions

- Alt. 2A is expected to have fewer crashes than Alt. 3 over the period of 2018-38, with and without considering crash history data.
- The models are not calibrated to the state of Pennsylvania, so the results should only be used to compare crashes in relative terms.
- IHSDM is an invaluable tool for applying all HSM Part C methods. For this alternative design, IHSDM was used to new closely not only the 170 mainline and interchange components, but also parts of the local road network (rural 2-step highway): interchange and intersections beyond the proposed alternatives.
- The safety analysis results were provided to the FHWA Pennsylvania Division staff to support their response to Penn DOT’s POA request and the identification of a preferred alternative.