Incorporating Data-Driven Safety Analysis in Traffic Impact Analysis

2020 ITE Western & Mountain District Meeting
July 1, 2020
What is Data-Driven Safety Analysis?

• The application of the latest evidence-based tools and approaches to safety analysis

• Provides reliable estimates of an existing or proposed roadway’s expected safety performance

• Helps agencies quantify the safety impacts of transportation decisions, similar to the way agencies quantify:
  – traffic growth
  – environmental impacts
  – pavement life
  – construction costs
  – traffic operations
Future **safety performance** is considered in **ALL** transportation investment decisions.
Foundational DDSA Methods: 
the AASHTO Highway Safety Manual, first edition

2010 Release:
• Rural Two-Lane Roads
• Multilane Rural Highways
• Urban/Suburban Arterials

2014 Supplement:
• Freeway Segments
• Ramps
• Ramp Terminals

New Research for HSM 2nd Ed:
• E.g. 6-lane urban arterials, All Way Stop intersections, Roundabouts, SPUIs

Source: AASHTO
The Vision for the HSM

A Document Akin To the HCM...

1. Definitive; represents quantitative ‘state-of-the-art’ information

2. Widely accepted within professional practice of transportation engineering

3. Science-based; updated regularly to reflect research

Source: Transportation Research Board
The HSM has resulted in the development of:

- Spreadsheets
- Software Products
- Guidance Documents
- Crash Modification Factors Clearinghouse

Source: AASHTO, AASHTOWare, Roadway Safety Foundation
DDSA throughout the Project Development Process


Planning

Alternatives Analysis

Design

Construction, Operations & Maintenance

Source: FHWA
DDSA How-To Guides

A series of instructional guides illustrating how Data-Driven Safety Analysis can be incorporated and applied in common transportation tasks and processes, with the goal of helping agencies assess future safety performance and make more-informed decisions.

Incorporating DDSA in:

- Traffic Impact Analyses ([link](https://safety.fhwa.dot.gov/rsdp/resources.aspx))
- Intersection Control Evaluation
- Road Diets (Reconfiguration)
- Site-specific Curve Improvements
- Systemic Curve Improvements
- Lane/Shoulder Allocation

[https://safety.fhwa.dot.gov/rsdp/resources.aspx](https://safety.fhwa.dot.gov/rsdp/resources.aspx)
Traffic Impact Analyses

- Engineering Studies that estimate the impacts of a proposed traffic generator on the transportation system

- Traditionally focused on capacity and operational aspects of increased traffic volume
  - Assumed improvements to address operational impacts would also provide safety benefits
The almighty peak periods...

Oftentimes, operational analysis focuses on an hour, or even fraction of an hour...

What is operationally better for peak-period operations is not necessarily what is best for safety under the full range of conditions...
Incorporating DDSA in Traffic Impact Analyses

Proposed Development
- Identify the Study Area
- Develop the Site Plan
- Develop Ingress/Egress Conceptual Plan
- On-Site/Off-Site Land Use

Existing Conditions
- Document Physical Characteristics
- Collect Traffic Volumes and Non-motorized Data
- Identify and Obtain Safety Data
- Evaluate Pedestrian and Bicycle Accommodations
- Summarize Data and Identify Safety Issues
- Perform Capacity/Queueing Analyses for Existing Conditions

Projected Growth
- Background Traffic Forecasting
- On-Site and Off-Site Development Traffic Forecasting
- Build and No-Build Conditions Total Traffic

Traffic Analysis
- Develop Preliminary Alternatives
- Evaluate Site Access
- Perform Capacity/Queueing Analysis
- Traffic Control/Geometric Consideration
- Perform Safety Analysis of Each Preliminary Alternative
- Compare Alternatives and Make Recommendations
Benefits of incorporating DDSA into TIAs

- Identify existing safety issues
- Identify future safety issues in advance
- Reduced delay caused by crashes
- Improved pedestrian accommodation
- Improved ingress/egress
Example: Proposed new development

- Pharmacy with a drive-thru

<table>
<thead>
<tr>
<th>Proposed Development</th>
<th>Gross Trips</th>
<th>Pass-By Capture</th>
<th>Net New Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacy with Drive-Through</td>
<td>46 (24 in/22 out)</td>
<td>49.0%</td>
<td>23 (12 in/11 out)</td>
</tr>
<tr>
<td></td>
<td>123 (62 in/61 out)</td>
<td></td>
<td>63 (32 in/31 out)</td>
</tr>
</tbody>
</table>

AM peak hour; PM peak hour

Tool: ITE Trip Generation report, 9th Edition
Trip Distribution and Volume Forecasting

Figure 7: Trip and Pass by Assignment

LEGEND
- Study Roadway
- Study Intersection
- 20
- PM Net New Trips
- (80)
- PM Pass-By Trips

Proposed Pharmacy

Existing Development

Table 2: Peak Period Pedestrian Counts

<table>
<thead>
<tr>
<th>Intersection Leg</th>
<th>AM Peak Period</th>
<th>PM Peak Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>South</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>East</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>West</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>
Summarize and Visualize Crash Data

Crash Types (2015-2017)

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear End</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sideswipe</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Right-Turn (Angle)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Left-Turn (Angle)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Credit: Toxcel

Imaging provided by Google Maps 2019
### Operational Analysis: Existing & Future No-Build

**Table 3: Intersection Capacity Analysis (Existing Conditions)**

<table>
<thead>
<tr>
<th>Year 2018 Delay (LOS)</th>
<th>Existing Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Hour</td>
<td>EB</td>
</tr>
<tr>
<td>AM Peak Hour – Average Control Delay in Seconds/ Vehicle (LOS)</td>
<td>48.5 (D)</td>
</tr>
<tr>
<td>PM Peak Hour – Average Control Delay in Seconds/ Vehicle (LOS)</td>
<td>35.6 (D)</td>
</tr>
</tbody>
</table>

**Table 4: Intersection Capacity Analysis (Future Background)**

<table>
<thead>
<tr>
<th>Year 2020 Delay (LOS)</th>
<th>No-Build Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Hour</td>
<td>EB</td>
</tr>
<tr>
<td>AM Peak Hour – Average Control Delay in Seconds/ Vehicle (LOS)</td>
<td>47.3 (D)</td>
</tr>
<tr>
<td>PM Peak Hour – Average Control Delay in Seconds/ Vehicle (LOS)</td>
<td>35.5 (D)</td>
</tr>
</tbody>
</table>

Develop Preliminary Alternatives

Alternative 1:
- Install retroreflective backplates
- Install ped facilities (curb ramps, crosswalk, ped signals) on north and south legs
- Optimize signal timings

Alternative 2:
- Install retroreflective backplates
- Install ped facilities (curb ramps, crosswalk, ped signals) on north and south legs
- Optimize signal timings
- Install SB Right-Turn Lane
- Change EB/WB lanes from shared left/thru lane + right lane to left lane + shared thru/right lane
- Change EB/WB left turn signal phase from permitted to protected-permitted
# Operational Analysis: Alternatives 1 & 2

## Table 5: Alternative 1 and 2 Intersection Capacity Analysis (2020 Total Conditions)

<table>
<thead>
<tr>
<th>Year 2020 Delay (LOS)</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EB</td>
<td>WB</td>
</tr>
<tr>
<td><strong>Peak Hour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM Peak Hour – Average Control Delay in Seconds/Vehicle (LOS)</td>
<td>45.1 (D)</td>
<td>48.6 (D)</td>
</tr>
<tr>
<td>PM Peak Hour – Average Control Delay in Seconds/Vehicle (LOS)</td>
<td>56.0 (E)</td>
<td>50.2 (D)</td>
</tr>
</tbody>
</table>

Predictive Safety Analysis

- HSM Part C (predictive method)
  - Spreadsheet developed under NCHRP 17-38
  - FHWA Interactive Highway Safety Design Model
- HSM Part D (Crash Modification Factors)
  - FHWA CMF Clearinghouse

FREE Tools available at:
http://www.highwaysafetymanual.org/Pages/Tools.aspx
## IHSDM Results

<table>
<thead>
<tr>
<th>Alternative</th>
<th>2020 through 2040 Total Crash Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future No Build (with background growth and NO site traffic)</td>
<td>112.3 (84.58 – PDO; 27.72 – Fi)</td>
</tr>
<tr>
<td>Future Build (with site-related traffic)</td>
<td>129.91 (98.21 – PDO; 31.70 – Fi)</td>
</tr>
<tr>
<td>Future Build (with site-related traffic and Alternative 1 improvements)</td>
<td>129.91 (98.21 – PDO; 31.70 – Fi)</td>
</tr>
<tr>
<td>Future Build (with site-related traffic and Alternative 2 improvements)</td>
<td>119.66 (91.31 – PDO; 28.35 – Fi)</td>
</tr>
</tbody>
</table>

*Future Build (with site-related traffic) and Future Build (with site-related traffic and Alternative 1 improvements) are expected to have the same total crash frequency because neither option includes geometric changes. The crash frequency for Alternative 1 will change after the application of CMFs, which is shown below.*

**IHSDM**

Interactive Highway Safety Design Model

*Tool: FHWA IHSDM, [www.ihsdm.org](http://www.ihsdm.org)*
Application of additional CMFs

Table 7: Proposed Intersection Modifications and CMFs

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>CMF Description</th>
<th>CMF ID &amp; CMF Value</th>
<th>Clearinghouse Quality Level</th>
<th>Crash Applicability Description</th>
<th>Included In the Analysis?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of crosswalk</td>
<td>“Install High-Visibility Crosswalk”</td>
<td>CMF ID: 4123 0.60</td>
<td>2 stars</td>
<td>Vehicle/Pedestrian Crashes</td>
<td>No</td>
</tr>
<tr>
<td>Install pedestrian countdown timer</td>
<td>“Install Pedestrian Countdown Timer”</td>
<td>CMF ID: 8790 0.912</td>
<td>3 stars</td>
<td>All crashes at the intersection</td>
<td>Yes</td>
</tr>
<tr>
<td>Add retroreflective backplates</td>
<td>“3-inch yellow retroreflective sheeting to signal backplates”</td>
<td>CMF ID: 1410 0.85</td>
<td>4 stars</td>
<td>All crashes at the intersection</td>
<td>Yes</td>
</tr>
<tr>
<td>Optimize Signals</td>
<td>CMF does not exist</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: FHWA CMF Clearinghouse

Table 8: Composite CMF and Applicable Crashes

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>Crash Modification Factor</th>
<th>Applicable Crash Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install pedestrian countdown timer + install retroreflective backplates</td>
<td>0.78¹</td>
<td>100% of crashes</td>
</tr>
</tbody>
</table>

Crash Reduction from ped countdown timers + retro backplates = 22%

# Crash Reduction Results

## Table 9: Crash Reduction Results with Predictive Method and CMF Application

<table>
<thead>
<tr>
<th>Alternative</th>
<th>20-Year IHSDM Crash Frequency (From Table 7)</th>
<th>Composite Crash Modification Factor</th>
<th>Applicable Crashes (%)</th>
<th>Total Crash Frequency with CMF (20 Years)</th>
<th>Total Crash Reduction (Count, 20 Years)</th>
<th>Total Crash Reduction (Percentage, 20 Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Future Build (with site-related traffic)</td>
<td>129.91 (98.21 – PDO; 31.70 – Fl)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0%</td>
</tr>
<tr>
<td>Future Build (with site-related traffic and Alternative 1 improvements)</td>
<td>129.91 (98.21 – PDO; 31.70 – Fl)</td>
<td>0.78</td>
<td>100%</td>
<td>101.3 (76.6 – PDO; 24.7 – Fl)</td>
<td>28.6 (21.6 – PDO; 7.0 – Fl)</td>
<td>22.0%</td>
</tr>
<tr>
<td>Future Build (with site-related traffic and Alternative 2 improvements)</td>
<td>119.66 (91.31 – PDO; 28.35 – Fl)</td>
<td>0.78</td>
<td>100%</td>
<td>93.3 (71.2 – PDO; 22.1 – Fl)</td>
<td>36.6 (27.0 – PDO; 9.6 – Fl)</td>
<td>28.2%</td>
</tr>
</tbody>
</table>
Benefit-Cost Analysis

Table 10: Comprehensive Crash-Level Costs

<table>
<thead>
<tr>
<th>Severity</th>
<th>Comprehensive Crash-Level Cost (2016 dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>$11,295,400</td>
</tr>
<tr>
<td>A</td>
<td>$655,000</td>
</tr>
<tr>
<td>B</td>
<td>$198,500</td>
</tr>
<tr>
<td>C</td>
<td>$125,600</td>
</tr>
<tr>
<td>O</td>
<td>$11,900</td>
</tr>
</tbody>
</table>

Source: FHWA Crash Costs for Highway Safety Analysis

Table 11: Benefit-Cost Analysis Comparing Alternative 1 and Alternative 2 to the Future No-Build alternative

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Total Crash Reduction Difference</th>
<th>Present Value of Crash Cost Savings (20 Years)</th>
<th>Total Estimated Costs</th>
<th>Benefit-Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>24.7 (18.6 – PDO; 6.1 – Fl)</td>
<td>$1,754,704</td>
<td>$115,000</td>
<td>15.3</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>31.2 (22.9 – PDO; 8.3 – Fl)</td>
<td>$2,370,463</td>
<td>$150,000</td>
<td>15.8</td>
</tr>
</tbody>
</table>
*FHWA cites specific tools as examples of ways to implement safety analysis approaches, not as an endorsement of these tools over others.