

# FHWA Interchange Configuration Safety Comparison Tool

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VHB

# Meet VHB

1,800+ passionate professionals  
including engineers, scientists, planners, and designers

Founded in 1979

30+ locations on the east coast

## Core services

Transportation planning and engineering

Land development

Planning and design

Environmental

Applied technologies

## Markets

Transportation agencies

Real estate

County and local governments

Institutions

Federal government

Energy



# Meeting With You Today



**Scott Himes, PHD, PE**

Highway Safety Engineer

# Agenda

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Background Motivation

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FHWA Division Survey

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Data Collection

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Implementation Tool and User Guide

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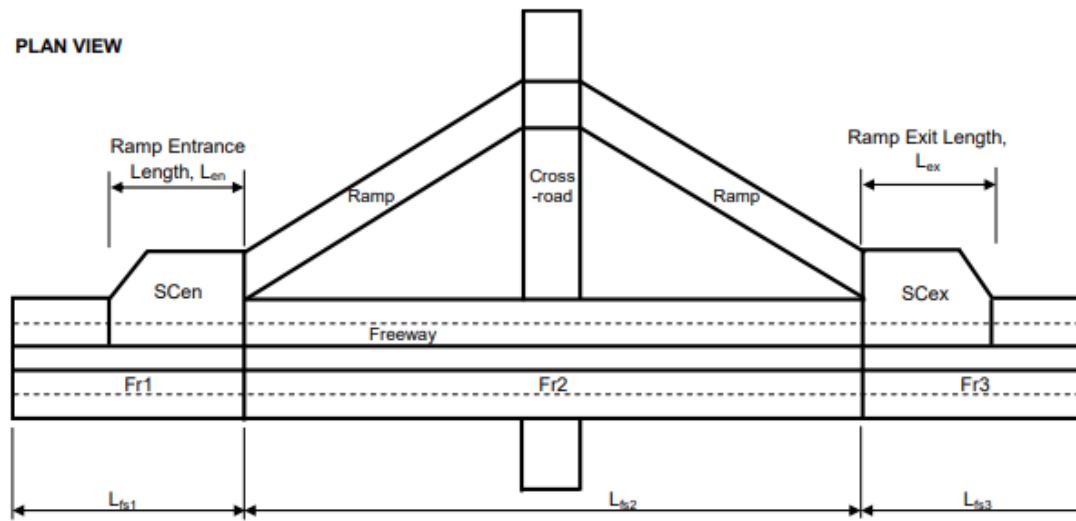
Key Findings

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Questions

# Background Motivation

- Proposed changes in access to the Interstate System require documentation
  - Occur early in project development process
  - HSM/ISATe requires detailed data
- ISATe aggregates component-level details



# Background Motivation

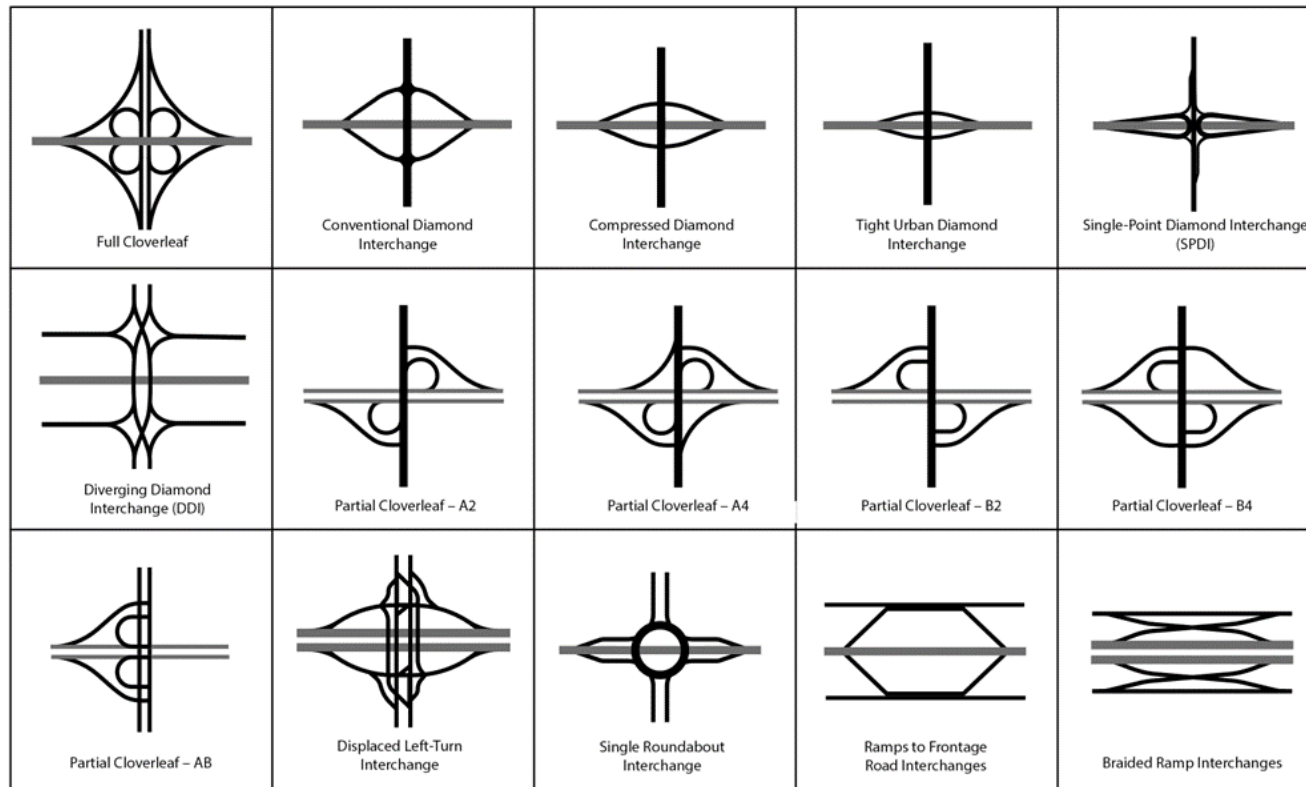
- FHWA sought to develop planning level models
  - Crash frequency
  - Crash severity
  - Proposed or existing interchange
- Focused on interchanges most commonly considered in IJR's
- Included development of a spreadsheet implementation tool

# FHWA Division Survey

- Surveyed FHWA Divisions
  - Number of annual IJR's received
  - Number of new or reconfigured service interchanges

# FHWA Division Survey

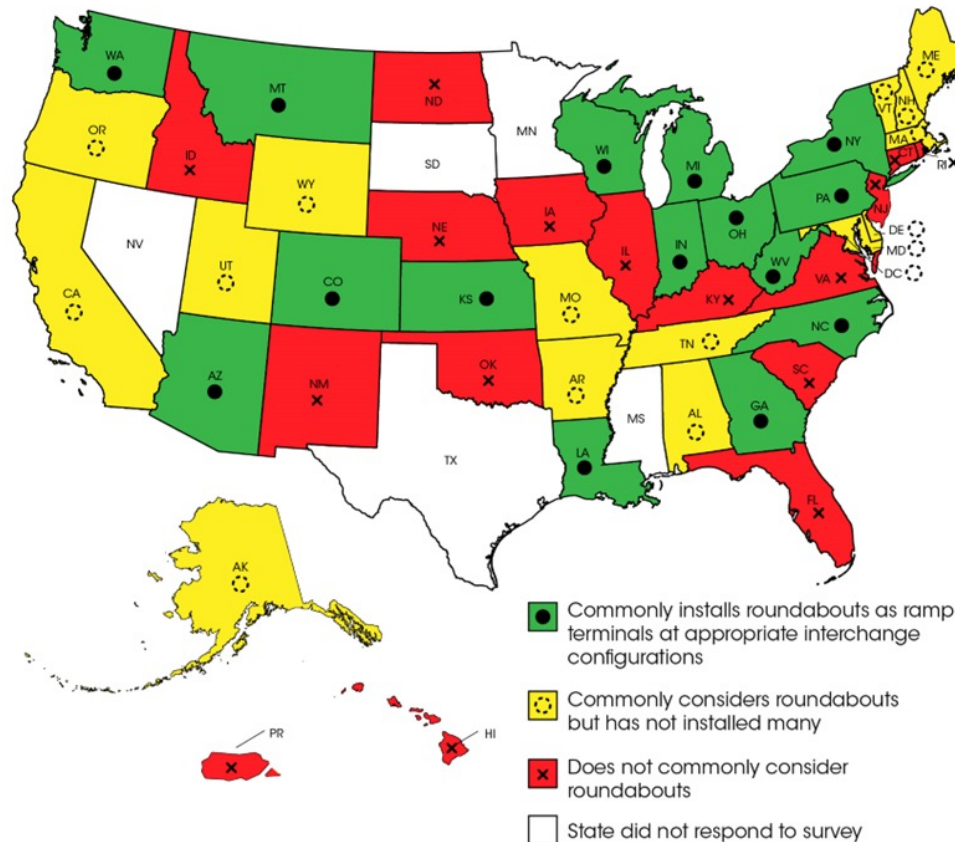
- Surveyed FHWA Divisions
  - How commonly each configuration is considered or selected





# FHWA Division Survey

- Surveyed FHWA Divisions
  - How commonly roundabout terminals are considered or installed

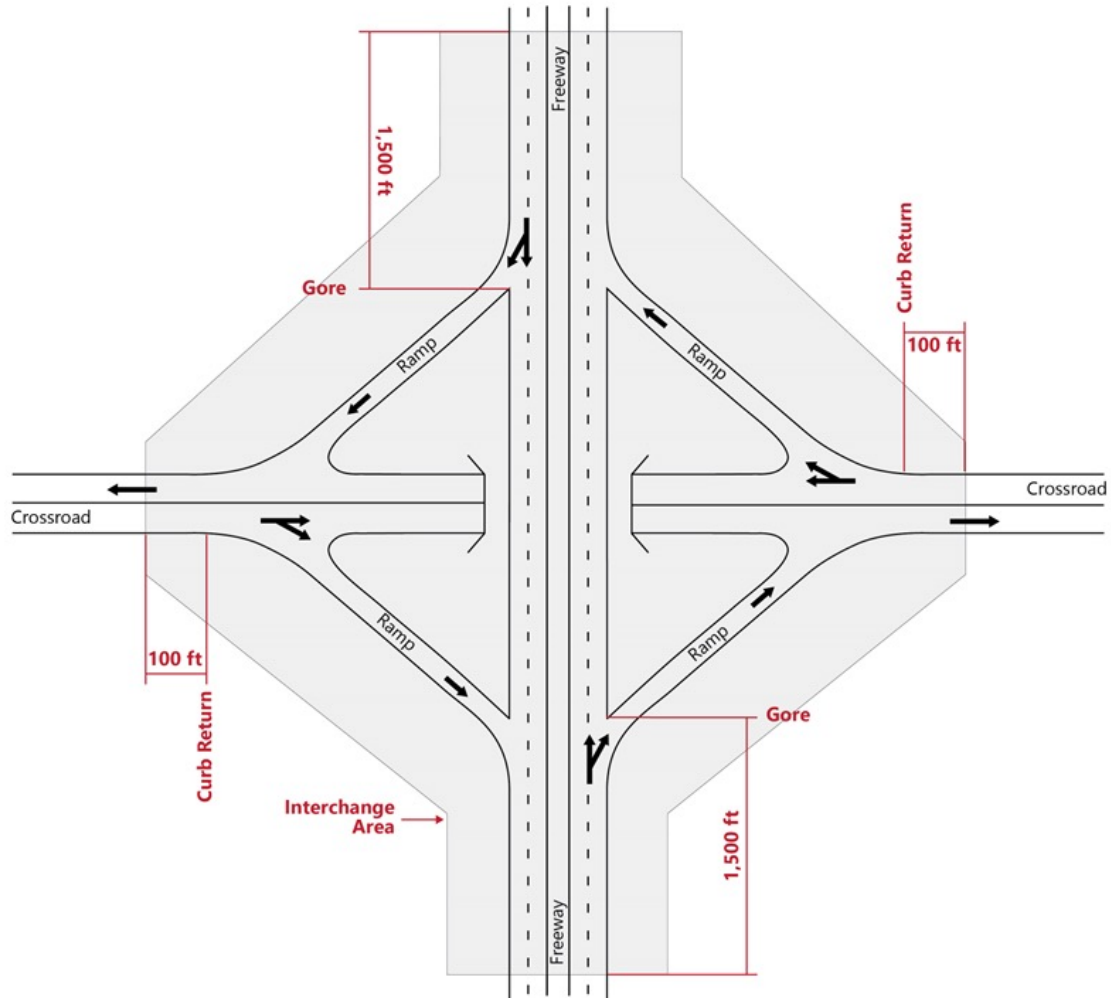


# FHWA Division Survey Results

| Interchange Configuration | Considered Only | 0–2 Per Year | 3–5 Per Year | 6–8 Per Year | 9+ Per Year | Total Score | Total Score Constructed Only |
|---------------------------|-----------------|--------------|--------------|--------------|-------------|-------------|------------------------------|
| <b>Score weight</b>       | <b>0.25</b>     | <b>1</b>     | <b>4</b>     | <b>7</b>     | <b>9</b>    | —           | —                            |
| Diamond                   | 9               | 24           | 9            | 1            | 0           | 69.25       | 67                           |
| DDI                       | 13              | 25           | 4            | 0            | 0           | 44.25       | 41                           |
| Compact Diamond           | 16              | 22           | 1            | 1            | 0           | 37          | 33                           |
| Tight Diamond             | 14              | 25           | 1            | 0            | 0           | 32.5        | 29                           |
| Parclo Type A             | 21              | 20           | 0            | 0            | 0           | 25.25       | 20                           |
| SPDI                      | 23              | 19           | 0            | 0            | 0           | 24.75       | 19                           |
| Single Roundabout         | 32              | 6            | 1            | 1            | 0           | 25          | 17                           |
| Parclo Type B             | 26              | 15           | 0            | 0            | 0           | 21.5        | 15                           |
| Parclo Type AB            | 29              | 13           | 0            | 0            | 0           | 20.25       | 13                           |
| Frontage Road             | 31              | 9            | 0            | 0            | 0           | 16.75       | 9                            |
| Braided ramp              | 33              | 7            | 0            | 0            | 0           | 15.25       | 7                            |
| Cloverleaf                | 37              | 6            | 0            | 0            | 0           | 15.25       | 6                            |
| DLT                       | 40              | 0            | 0            | 0            | 0           | 10          | 0                            |
| <b>Total</b>              | <b>324</b>      | <b>191</b>   | <b>16</b>    | <b>3</b>     | <b>0</b>    | <b>357</b>  | <b>276</b>                   |

# Data Collection

## Interchange Area Definition



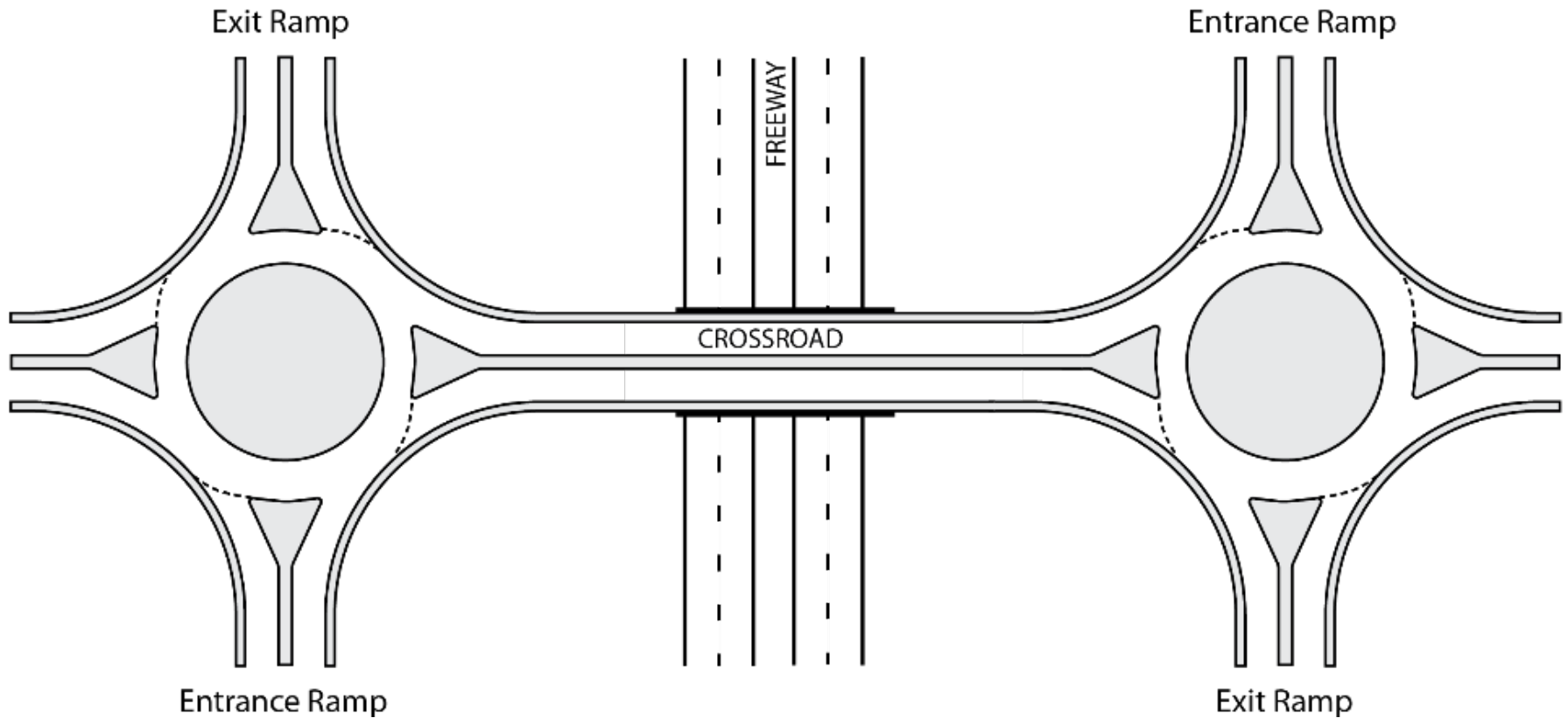
# Data Collection

## Interchange Sample Size

| Interchange Configuration | Arizona   | Missouri  | North Carolina | Ohio      | Utah      | Total      |
|---------------------------|-----------|-----------|----------------|-----------|-----------|------------|
| Diamond                   | 11        | 11        | 9              | 13        | 19        | 63         |
| Compact Diamond           | 4         | 0         | 3              | 5         | 3         | 15         |
| Tight Diamond             | 7         | 7         | 2              | 4         | 3         | 23         |
| DDI                       | 0         | 12        | 3              | 2         | 7         | 24         |
| SPDI                      | 13        | 9         | 7              | 3         | 16        | 48         |
| Parclo Type A2            | 0         | 3         | 5              | 2         | 0         | 10         |
| Parclo Type A4            | 0         | 1         | 7              | 7         | 1         | 16         |
| Parclo Type B2            | 2         | 1         | 4              | 3         | 1         | 11         |
| Parclo Type B4            | 0         | 0         | 6              | 2         | 0         | 8          |
| Parclo Type AB2           | 4         | 9         | 11             | 9         | 2         | 35         |
| Parclo Type AB4           | 2         | 0         | 2              | 5         | 1         | 10         |
| <b>Total</b>              | <b>43</b> | <b>53</b> | <b>59</b>      | <b>55</b> | <b>53</b> | <b>263</b> |

# Data Collection

Roundabout Diamond Included in Conventional Diamond Sample Size



# Data Collection

## Crash Data Locating



# Data Collection

## Interchange Configuration Summary Data

| Int. Config. | Freeway AADT Range | Crossroad AADT Range | Entrance Ramp AADT | Exit Ramp AADT | KABC Crashes | PDO Crashes |
|--------------|--------------------|----------------------|--------------------|----------------|--------------|-------------|
| Diamond      | 5,000–210,000      | 350–40,500           | 100–33,400         | 125–24,500     | 2,139        | 7,157       |
| CD           | 23,100–236,000     | 11,000–52,900        | 6,800–25,500       | 4,250–22,500   | 1,246        | 4,278       |
| TDI          | 17,000–207,300     | 3,200–55,000         | 4,000–36,500       | 4,500–36,700   | 4,552        | 13,659      |
| DDI          | 29,000–191,000     | 2,000–47,000         | 2,000–38,500       | 2,000–45,000   | 4,037        | 10,883      |
| SPDI         | 21,000–261,000     | 3,700–64,000         | 3,100–70,000       | 3,200–75,000   | 11,964       | 38,102      |
| Parclo A2    | 6,400–115,300      | 1,500–30,615         | 650–9,400          | 1,300–21,800   | 673          | 1,283       |
| Parclo A4    | 46,181–135,000     | 12,000–68,000        | 10,200–34,400      | 9,300–39,600   | 1,032        | 3,663       |
| Parclo B2    | 7,298–123,000      | 150–32,000           | 35–14,800          | 35–12,400      | 744          | 1,789       |
| Parclo B4    | 23,900–144,000     | 1,200–67,500         | 4,900–32,200       | 4,300–31,000   | 555          | 1,855       |
| Parclo AB2   | 5,500–300,000      | 200–51,500           | 200–29,200         | 200–24,600     | 3,144        | 9,841       |
| Parclo AB4   | 22,000–132,300     | 9,000–57,000         | 5,600–27,600       | 5,500–27,200   | 423          | 1,253       |

# Data Collection

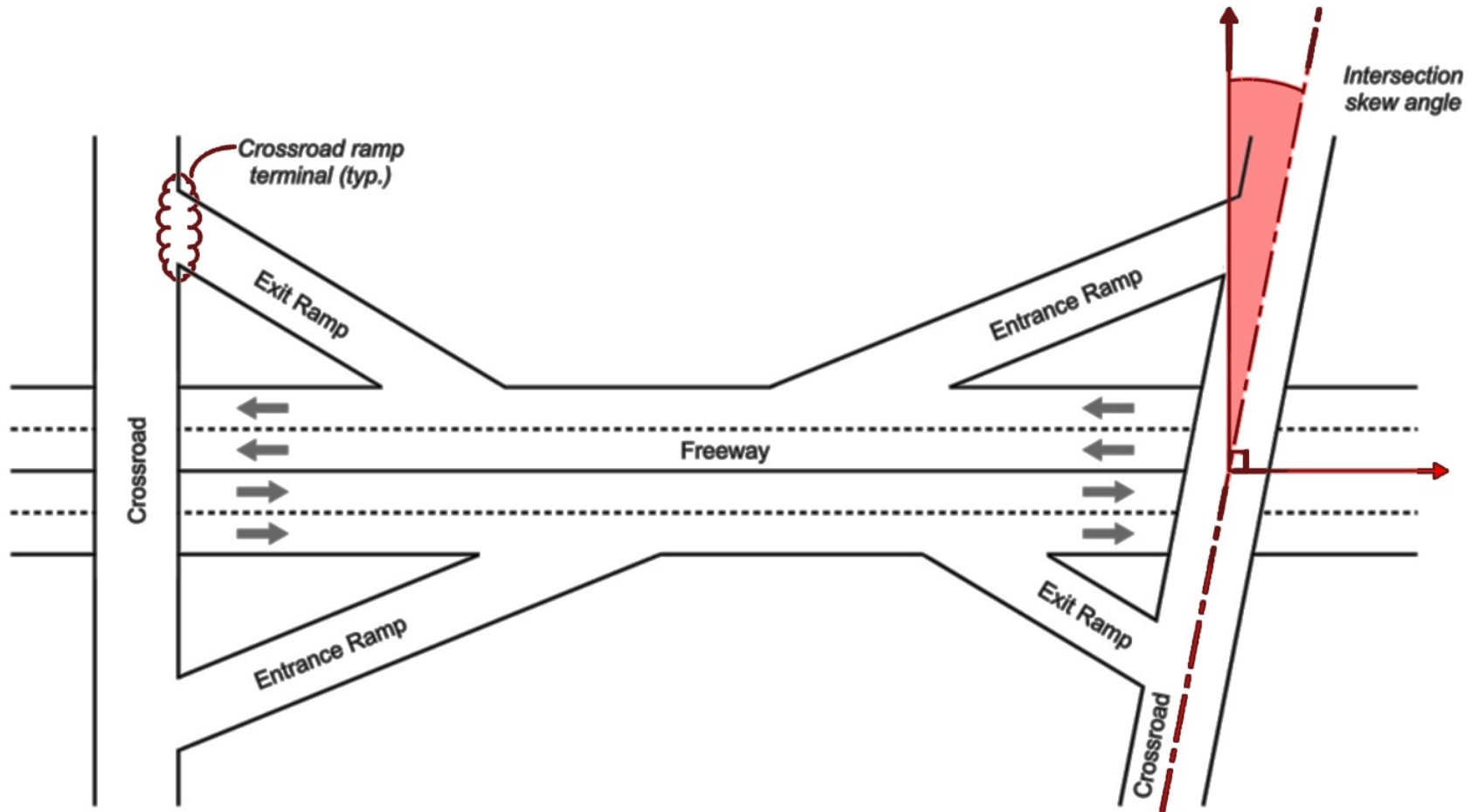
## Key Data Elements

- Area type
- Component AADTs
- Posted speed limits
- Distance to adjacent signal or roundabout on cross-street



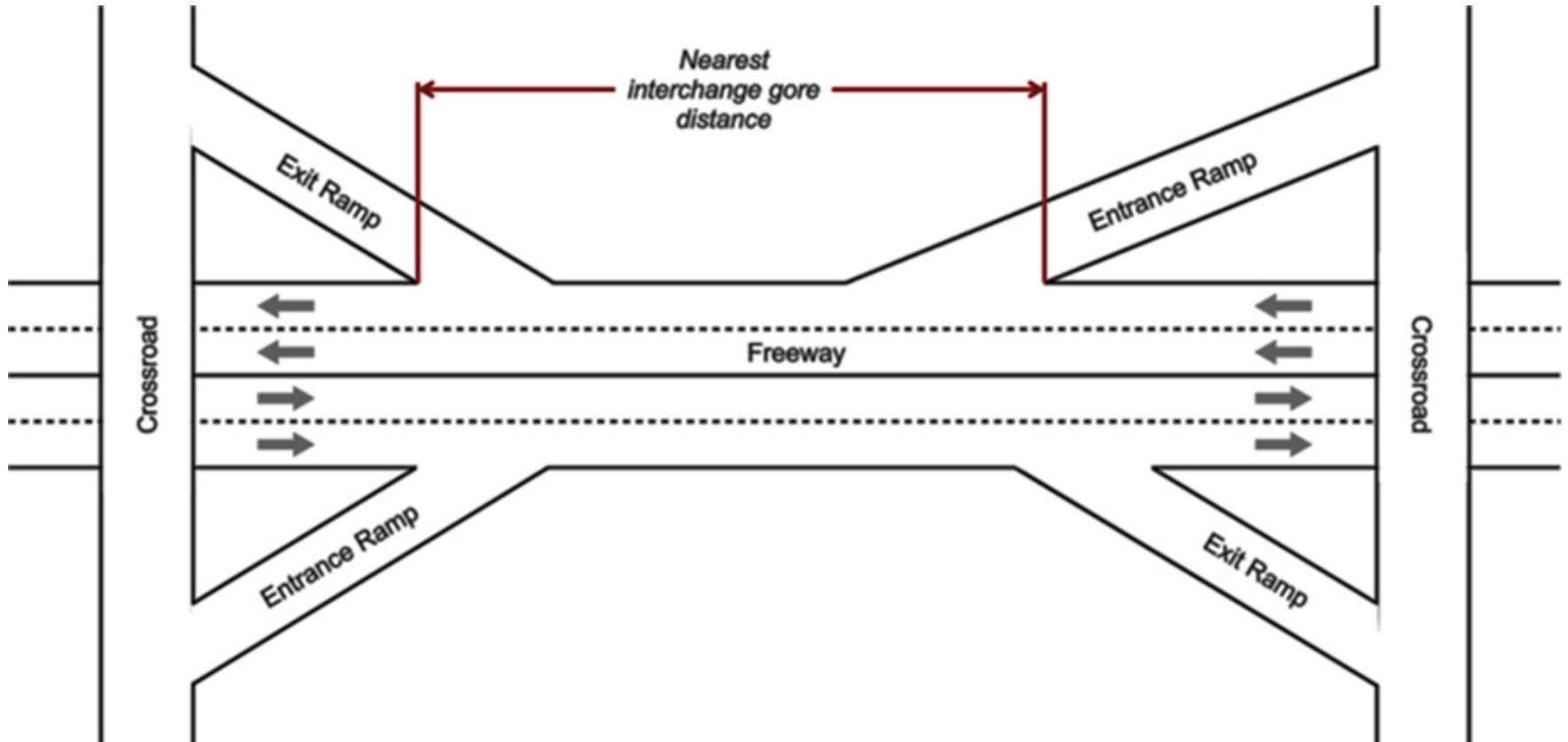
# Data Collection

## Key Data Elements



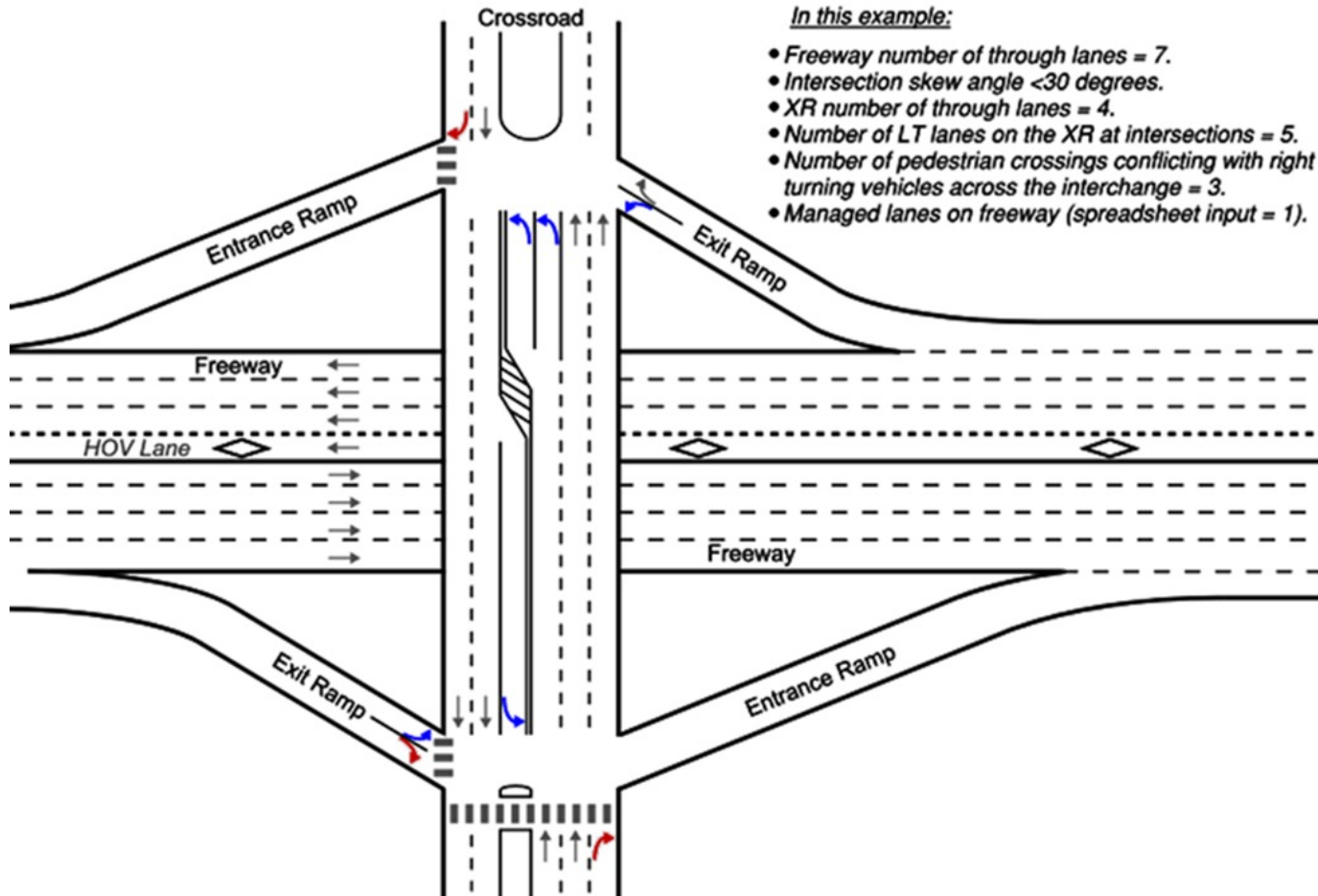
# Data Collection

## Key Data Elements

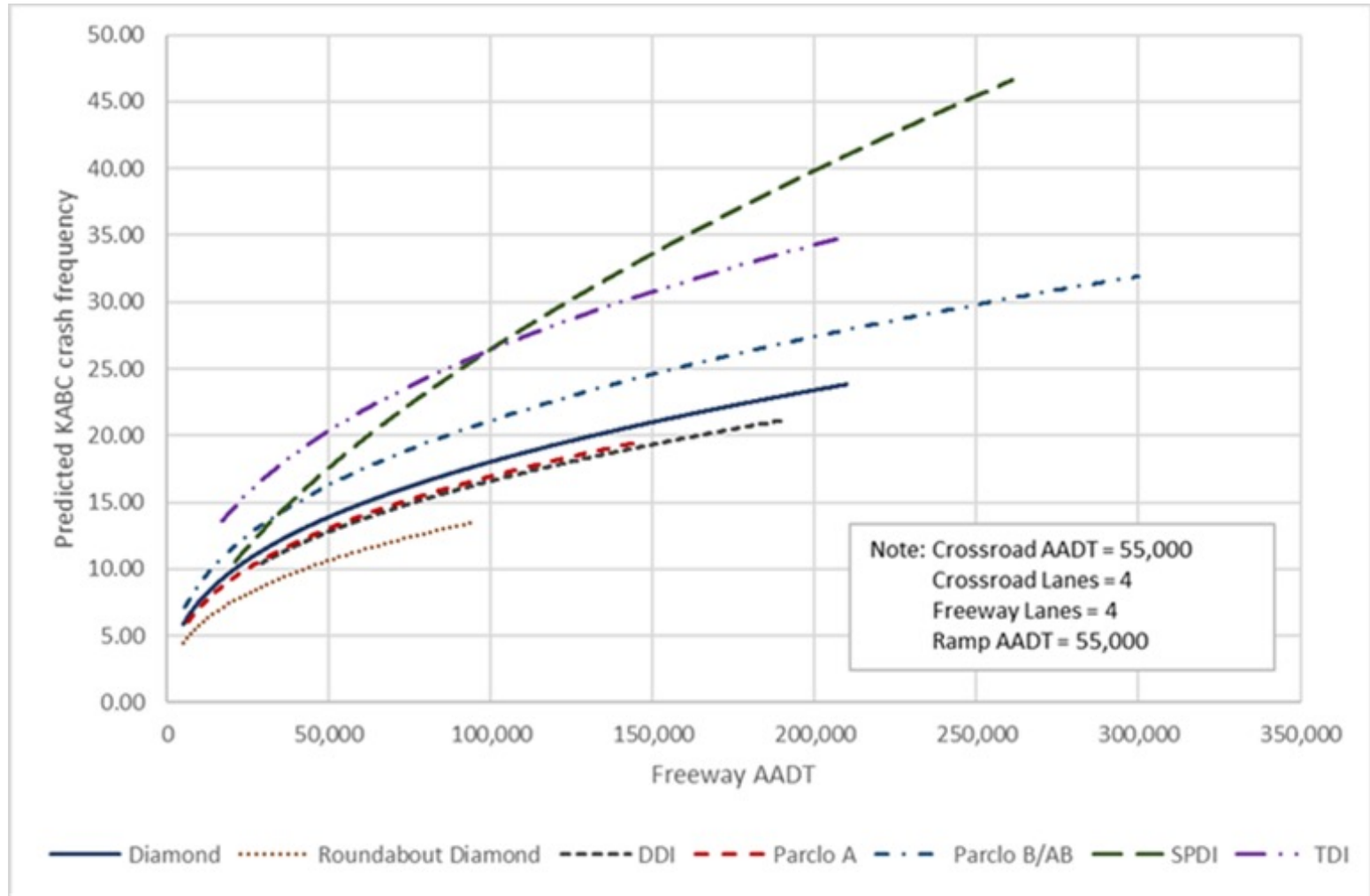


# Data Collection

## Key Data Elements



# Results KABC



# Implementation Tool and User Guide

| User Input  |                        |                       |        |              |          |        |        |
|---|------------------------|-----------------------|--------|--------------|----------|--------|--------|
| Input Characteristic  | Diamond/<br>Compressed | Roundabout<br>Diamond | DDI    | Parclo B, AB | Parclo A | SPDI   | TDI    |
| Urban area type (1 = yes, 0 = no)                                 | 0                      | 0                     | 0      | 0            | 0        | 0      | 0      |
| Intersection skew angle >30 degrees (1 = yes, 0 = no)             | 0                      | 0                     | 0      | 0            | 0        | 0      | 0      |
| Nearest interchange gore distance within 0.5 mi (1 = yes, 0 = no) | 0                      | 0                     | 0      | 0            | 0        | 0      | 0      |
| Managed lanes on freeway (1 = yes, 0 = no)                        | 0                      | 0                     | 0      | 0            | 0        | 0      | 0      |
| Freeway AADT (value in vehicles/day)                              | 60,000                 | 60,000                | 60,000 | 60,000       | 60,000   | 60,000 | 60,000 |
| Freeway no. of through lanes (bidirectional total) (no.)          | 4                      | 4                     | 4      | 4            | 4        | 4      | 4      |
| XR AADT (value in vehicles/day)                                   | 5,000                  | 5,000                 | 5,000  | 5,000        | 5,000    | 5,000  | 5,000  |
| XR no. of through lanes (bidirectional total) (no.)               | 4                      | 4                     | 4      | 4            | 4        | 4      | 4      |
| Total ramp AADT (value in vehicles/day)                           | 20,000                 | 20,000                | 20,000 | 20,000       | 20,000   | 20,000 | 20,000 |
| COV of ramp volumes (see below) (decimal #; calculation)          | 0                      | 0                     | 0      | 0            | 0        | 0      | 0      |
| Number of LT lanes on the XR at intersections (no.)               | 0                      | 0                     | 0      | 0            | 0        | 0      | 0      |

NOTE: Changes to the table above will be reflected on the KABC worksheet.

This is the base condition. Analysts must fill out the entire column even if this interchange type is not under consideration.

| Coefficient of Variation (COV) of Ramp Calculation Tool |     |                |      |
|---|-----|----------------|------|
| Ramp 1 AADT =   | 500 |                |      |
| Ramp 2 AADT =   | 500 | Std. Deviation | 0.00 |
| Ramp 3 AADT =   | 500 | Mean           | 500  |
| Ramp 4 AADT =   | 500 | COV            | 0.00 |
| Ramp 5 AADT =   |     |                |      |
| Ramp 6 AADT =   |     |                |      |

NOTE: range of acceptable COV values is 0 to 1.15. Use this value for COV inputs in table

NOTE: leave input cells blank for any ramps not included in analysis.

# Implementation Tool and User Guide

**SDF Design and Operational Input Table for Interchange Configurations (Note: Data for Column B must be entered and data for Columns C through G can be entered for comparative analysis)**

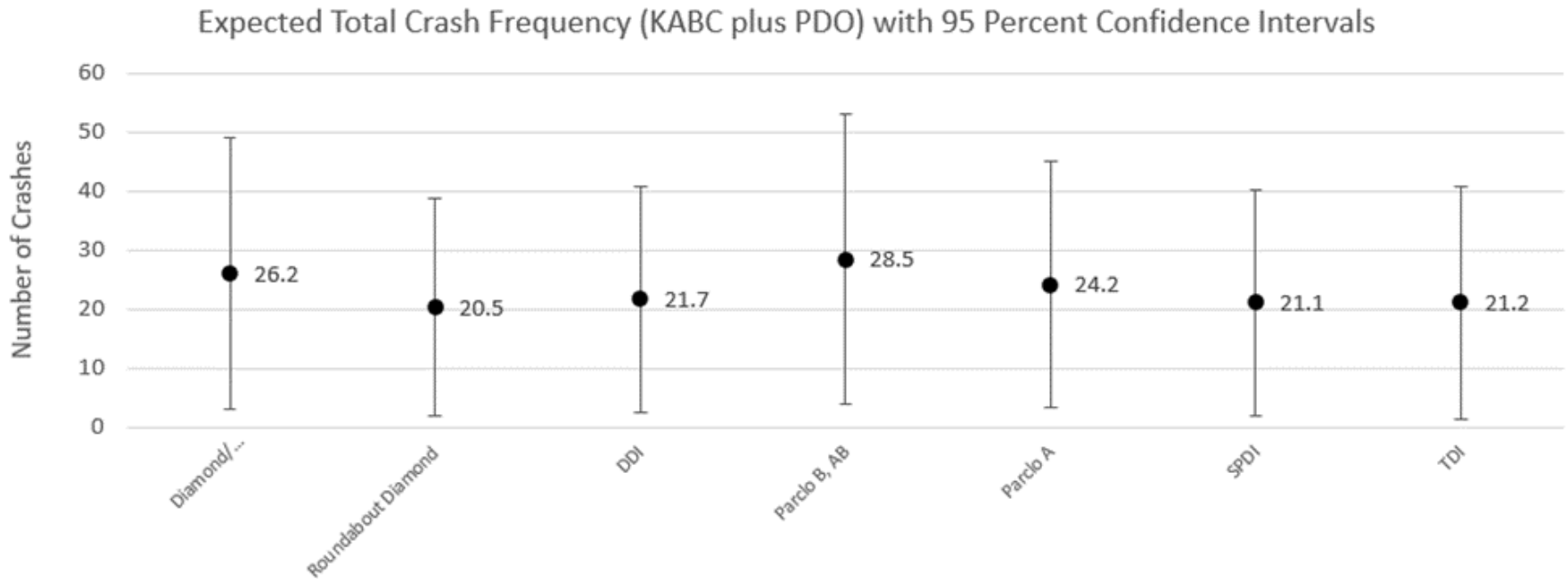
| Input Characteristic  | Diamond/<br>Compressed | Roundabout<br>Diamond | DDI | Parclo<br>(All Types) | SPDI | TDI |
|---|------------------------|-----------------------|-----|-----------------------|------|-----|
| Freeway AADT ≥ 200,000 vpd<br>(1 = yes, 0 = no; Value in vpd)   | 0                      | 0                     | 0   | 0                     | 0    | 0   |
| XR AADT ≥ 30,000 vpd<br>(1 = yes, 0 = no; Value in vpd)   | 0                      | 0                     | 0   | 0                     | 0    | 0   |
| Freeway posted speed limit<br>(Value in mph)  | 55                     | 55                    | 55  | 55                    | 55   | 55  |
| XR posted speed limit<br>(Value in mph)   | 45                     | 45                    | 45  | 45                    | 45   | 45  |
| Nearest XR adjacent intersection (signal or roundabout)<br>within 0.10 mi of ramp terminal<br>(1 = yes, 0 = no)       | 0                      | 0                     | 0   | 0                     | 0    | 0   |
| Nearest interchange gore distance within 0.25 mi<br>(1 = yes, 0 = no)   | 0                      | 0                     | 0   | 0                     | 0    | 0   |
| Number of pedestrian crossings conflicting with right-<br>turning vehicles across interchange<br>(Ranges from 0 to 7) | 0                      | 0                     | 0   | 0                     | 0    | 0   |
| Freeway has eight or more lanes (bidirectional total)<br>(1 = yes, 0 = no)  | 0                      | 0                     | 0   | 0                     | 0    | 0   |
| XR has four or more lanes (bidirectional total)<br>(1 = yes, 0 = no)  | 1                      | 1                     | 1   | 1                     | 1    | 1   |
| Type A or B parclo interchange (includes A2/A4/B2/B4)<br>(1 = yes, 0 = no)  |                        |                       |     | 1                     |      |     |
| Type AB parclo interchange (includes AB2/AB4)<br>(1 = yes, 0 = no)  |                        |                       |     | 0                     |      |     |

# Implementation Tool and User Guide

| Model Output (Do Not Edit)  |                        |                       |       |              |          |       |       |
|---|------------------------|-----------------------|-------|--------------|----------|-------|-------|
| Predicted Crash Frequency   | Diamond/<br>Compressed | Roundabout<br>Diamond | DDI   | Parclo B, AB | Parclo A | SPDI  | TDI   |
| 95 percent CI LB ( <i>crashes/year</i> )                                | 0.00                   | 0.00                  | 0.00  | 0.00         | 0.00     | 0.00  | 0.00  |
| Expected PDO crash frequency ( <i>crashes/year</i> )                    | 19.74                  | 15.52                 | 15.74 | 20.95        | 17.11    | 16.38 | 17.17 |
| 95 percent CI UB ( <i>crashes/year</i> )                                | 41.28                  | 32.83                 | 33.27 | 43.71        | 36.02    | 34.55 | 36.14 |
| 95 percent CI LB ( <i>crashes/year</i> )                                | 0.00                   | 0.00                  | 0.00  | 0.00         | 0.00     | 0.00  | 0.00  |
| Expected KABC crash frequency (from KABC sheet) ( <i>crashes/year</i> ) | 6.47                   | 4.95                  | 5.96  | 7.58         | 7.12     | 4.77  | 3.98  |
| 95 percent CI UB ( <i>crashes/year</i> )                                | 14.46                  | 11.42                 | 13.43 | 16.67        | 15.75    | 11.05 | 9.47  |
| 95 percent CI LB ( <i>crashes/year</i> )                                | 3.23                   | 1.99                  | 2.63  | 4.02         | 3.44     | 1.91  | 1.41  |
| Expected total crash frequency (KABC + PDO) ( <i>crashes/year</i> )     | 26.21                  | 20.47                 | 21.69 | 28.53        | 24.23    | 21.14 | 21.15 |
| 95 percent CI UB ( <i>crashes/year</i> )                                | 49.18                  | 38.95                 | 40.75 | 53.04        | 45.02    | 40.37 | 40.90 |

| Predicted Crash Frequency by Severity                    | Diamond/<br>Compressed | Roundabout<br>Diamond | DDI  | Parclo B, AB | Parclo A | SPDI | TDI  |
|--|------------------------|-----------------------|------|--------------|----------|------|------|
| Expected KABC crash frequency ( <i>crashes/year</i> )    | 6.47                   | 4.95                  | 5.96 | 7.58         | 7.12     | 4.77 | 3.98 |
| KA crash frequency (SDF Model 2) ( <i>crashes/year</i> ) | 0.34                   | 0.82                  | 0.15 | 0.62         | 0.20     | 0.52 | 0.15 |
| B crash frequency (SDF Model 2) ( <i>crashes/year</i> )  | 1.08                   | 0.13                  | 0.48 | 0.21         | 0.78     | 0.17 | 0.46 |
| C crash frequency (SDF Model 2) ( <i>crashes/year</i> )  | 5.05                   | 4.00                  | 5.32 | 6.75         | 6.14     | 4.07 | 3.38 |

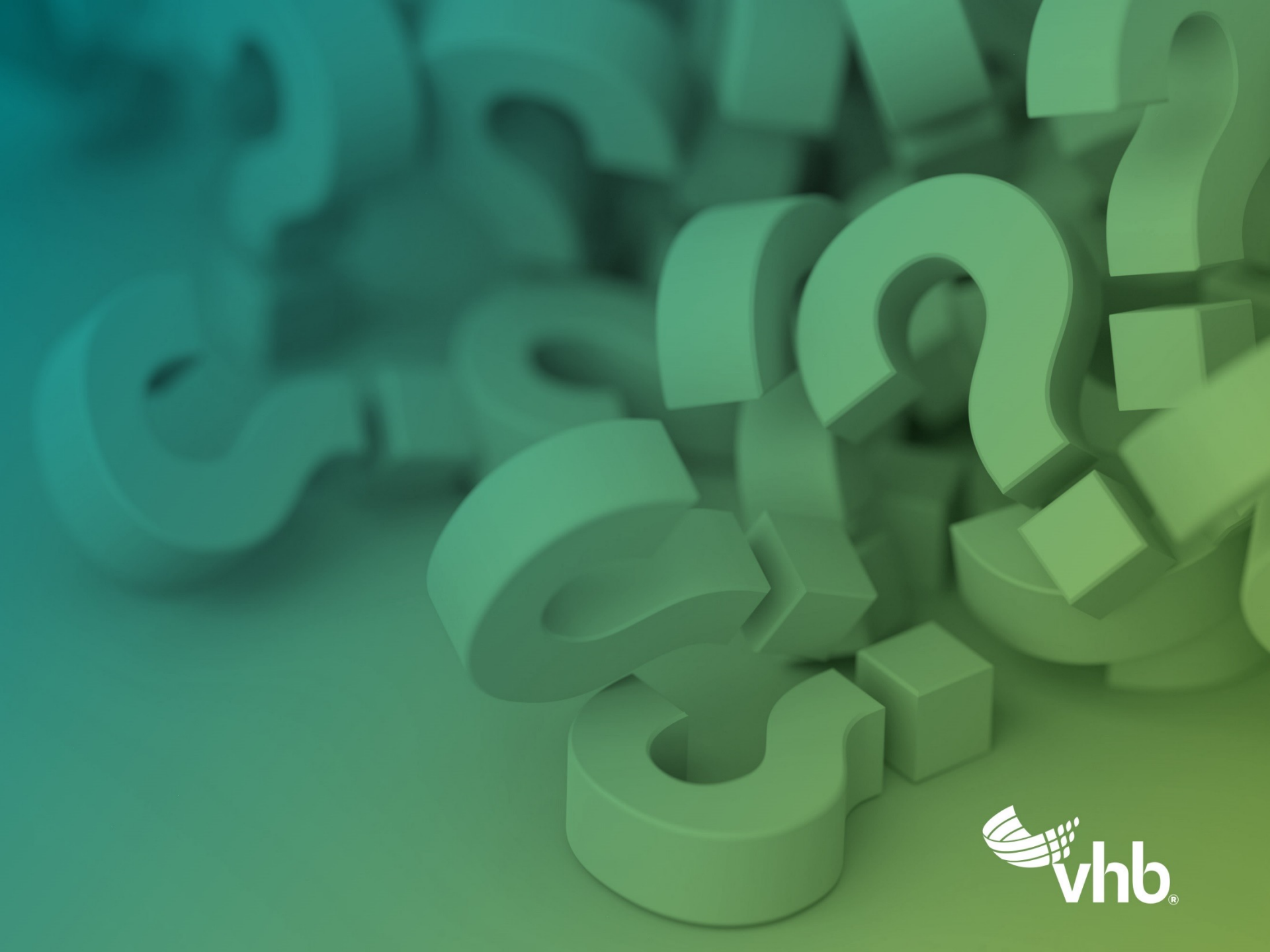
# Implementation Tool and User Guide





# Key Findings

- Interaction between freeway AADT per lane and ramp AADT for crash frequency
- Includes crossroad AADT per lane
- Relationships among configurations similar for PDO crashes as KABC crashes
- Confidence interval provides an indication of variability among comparisons



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