Freeway and Interchange Crash Prediction – ECAT

ODOT HSM Freeway and Interchange Training
2018

Course Objectives and Outcomes

Objectives:
- To inform participants about the latest methods of freeway and interchange safety analysis
- To demonstrate how to apply these tools to the design and alternatives analysis process

Participants should be able to:
- Apply evaluation tool (ECAT) to typical designs
- Evaluate the safety performance associated with a design
- Understand the relationship of key geometric elements of freeways and interchanges to safety performance
Session 1
Introduction & Background on Freeways and Interchanges

Freeway and Interchange Crash Prediction
Challenges for ODOT

Interchange and freeway corridor projects are the most complex and expensive of all roadway projects

Basic interchange forms vary in cost, footprint and operations ..... as well as their safety performance
We should understand the expected safety performance of a $250 million investment

Would you expect these three alternatives to experience the same number of crashes over a 30 year project life?

If not, would it be helpful to understand the potential differences when selecting a preferred alternative?

Interchange and Corridor Planning and Design Issues

- Configuration (service and system)
- Design geometry (e.g., design speed of ramps)
- Interchange spacing
- Weaving vs. CD roads vs. ramp braids
- Design Level of Service (number of lanes and amount of traffic for which design should accommodate)
- Impact of Design Waiver/Exceptions
HSM Chapter on Freeways and Interchanges

- AASHTO funded research on freeways and interchanges to fill the 1st edition gap
- NCHRP Project 17-45 – ‘ISATe’ – Interchange Safety Analysis Tool Enhanced
- Provides Methods and Models for predicting Average Annual Crash Frequency for Freeways and Ramps
  - ISATe Tool released for use in 2012
  - Published as HSM 2014 Supplement
- ECAT Tool has been updated to add Freeway Analysis (2016/2017)

Crash Prediction for Freeway Segments and Interchanges

- Statistical modeling process similar to other chapters in HSM was used
  - SPF, CMF, C
  - Data from California, Maine and Washington state
- ‘Google earth’ used to obtain horizontal and cross sectional data on hundreds of miles of freeways and interchanges
HSM Freeway Analysis Provides High Value in Planning and Design

- Predict crashes before and after reconstruction of a corridor
- Evaluate effect of adding new interchange
- Evaluate effect of increasing capacity of an existing corridor through widening
- Evaluate effect of increasing or decreasing weaving distance
- Compare performance of CD vs. mainline weaving vs ramp braid solutions
- Predict and compare the safety performance of interchange configuration alternatives
- Evaluate and refine preliminary geometry
- Evaluate and document design exceptions

Freeway Crash Prediction Components

- **Freeway Segments**
- **Ramps**
- **Ramp Terminal Intersections with Crossroad**
Key Concept: General form of the HSM predictive methods

Predicted Crash Frequency →

\[ SPF \times (CMF_1 \times CMF_2 \times \ldots) \times C \]

'Safety Performance Function'

'Crash Modification Factors'

'Local Calibration Factor'

Key Concept: Safety Performance Function

- Depending on Site Type
  (Freeway Segment, Ramp Segment or Ramp Terminal) may consider:
  - Rural vs. Urban
  - Number of Lanes
  - Single Vehicle
  - Multiple Vehicle
  - Fatal and Injury
  - Property Damage Only
Key Concept: Crash Modification Factors (CMF)

- Used to calculate change in crash frequency for a specific change in geometry
  - Adapts SPF to non-base conditions
  - One CMF per design element (e.g. lane width)
  - 13 CMFs for freeways (Table 18-13, pp. 18-35)
  - 9 CMFs for ramp segments (Table 19-22, pp. 19-45)
  - 11 CMFs for crossroad ramp terminals (Table 19-23, pp. 19-46)

Key Concept: Segmentation

- Divide facility into homogenous segments
- Most time-intensive part of analysis
- Most important part of analysis

The more homogenous a section, the more accurate your results!
Key Concept: Calibration

- Model derived from multiple state databases
- Reporting thresholds vary state-by-state
- Uses of an calibrated vs. uncalibrated model
  - Calibrated - preferred
    - ODOT has calibration factors for use in Ohio analysis for many conditions – included in ECAT
  - Uncalibrated - still a good analysis tool
    - Compare multiple alternatives against one another
    - K/A reporting is fairly consistent state-by-state
    - Compare predicted crash pattern against observed crash pattern
    - Meaningful for work outside Ohio or where calibration factors don’t exist (for conditions not covered by HSM models there will be no calibration factors - ASK ODOT !!!)

Data Requirements: Freeway Segments

- Geometric Data
  - Basic Roadway Data – Length, number of lanes, area type
  - Alignment – horizontal curve
  - Cross Section – lane width, inside/outside shoulder widths, rumble strips, median barrier
  - Roadside data – clear zone, roadside barrier
  - Ramp Access – presence, side, length of speed-change area

- Traffic Data
  - AADT - Segment, entrance ramp, exit ramp
  - Proportion of AADT during high-volume hours
### Data Requirements: Ramp Segments

**Geometric Data**
- Basic Roadway Data – Length, number of lanes, Average Speed on Freeway, type of traffic control at ramp terminal, area type
- Alignment – horizontal curve
- Cross Section – lane width, left/right shoulder widths, lane add/drop in segment
- Roadside data – barrier
- Ramp Access – length of speed-change area, length of weaving section

**Traffic Data**
- AADT - segment

### Data Requirements: Ramp Terminal Intersections

**Geometric Data**
- Basic Intersection Data – area type, terminal configuration, presence of non-ramp public street
- Alignment – skew, distance to nearest public street intersection on outside crossroad leg, distance to adjacent ramp terminal
- Traffic Control – presence of protected left/right turn control on crossroad
- Cross Section – crossroad median width, number of lanes crossroad and ramp, right-turn channelization on crossroad, left-turn and right-turn lanes/bays on crossroad
- Access data – number of drives, public street approaches
- Ramp Access – presence, side, length of speed-change area

**Traffic Data**
- AADT – ramp, crossroad
Freeway Analysis Limitations

Site types not addressed
- Facilities with HOV lanes
- Ramp metering
- Frontage roads
- Speed change lanes at crossroads

Geometric elements not addressed
- Vertical geometry
- > 10-lane freeway segments
- > 2-lane ramp segments
- Differing barrier types (i.e. cable vs. guardrail vs. jersey barrier)
- Single point diamond intersection configuration
- Roundabout ramp terminal intersections
- Diverging Diamond

Special Conditions

Freeways with Barrier Separated Managed Lanes
- Managed Lanes (Express, HOT, HOV) are considered part of median
- Analysis is performed for General Purpose lanes with managed lane entry/exit points treated as entrance or exit ramps

Toll Facilities
- Can be analyzed provided the section is sufficiently distance from toll facility so that the facility does not influence vehicle operations
- Areas in immediate vicinity of a toll plaza, where widened to accommodate vehicles through a toll plaza, or areas that experience toll-related traffic queues or speed changes cannot be analyzed via HSM
Freeway Analysis Considerations

- **Both Directions of Freeway Analyzed**
  - May require averaging of values - see comments/notes in tools
  - Situations with significantly different cross section or differing number of lanes by direction requires special analysis approach – ASK ODOT !!!

ECAT Limits

- One file can accommodate up to 75 elements of freeway segments, ramp segments, and/or crossroad ramp terminals
- An elements is an individual homogenous freeway segment, homogenous ramp segment, or ramp terminal intersection
Workflow

- **Step 1: Identify analysis limits**
- **Step 2: Define study period**
  - Consecutive years for which an estimate of the expected average crash frequency is desired
- **Step 3: Acquire data**
- **Step 4: Segment project into individual sites**
  - Freeway segment
  - Ramp or CD segment
  - Crossroad ramp terminal
- **Step 5: Enter data for each element (segments and intersections)**
- **Step 6: Run analysis**

Questions and Discussion
UP NEXT
Session 2: Overview of ECAT Tool
Session 2
Fundamentals of HSM
Predictive Methods for
Freeways and Application
Using ECAT

Freeway Predictive Analysis

Evaluation Scope
- Individual site
  - Freeway segment
  - Ramp or C-D road segment
  - Crossroad ramp terminal
- Freeway facility
  - Adjacent sites forming freeway and interchange
Economic Crash Analysis Tool

- ODOT spreadsheet to complete HSM calculations.
- ECAT has the ability to:
  - calculate predicted crash frequencies,
  - complete empirical bayes calculations,
  - predict crash frequencies for proposed conditions,
  - conduct alternatives analyses, and
  - complete benefit-cost analysis.

http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/HSIP/Pages/ECAT.aspx

ECAT – Where to Find It?

http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/HSIP/Pages/ECAT.aspx
The ECAT Tool

**Excel Spreadsheet**

**Input**
- By individual site element
  - Freeway segment
  - Ramp or CD road segment
  - Crossroad ramp terminal intersection

**Segmentation is key!**

**Output**
- Crashes for entire facility
- Crashes by component
- Distribution of crashes

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Using the Spreadsheet Tool

**HSM Toolbox:**
- Follow the steps in the “Analysis Processing” box.
- Can open toolbox at any time by clicking toolbox icon.
Using ECAT – Follow the Steps

Basic ECAT Analysis Steps:
- Create a project file
- Enter general project information and define elements (segments and intersections)
- Load crash data from CAM tool (black box)
- Assign crashes to project elements by location ID (red box)
- Generate analysis tabs for the segments and intersections (blue box)
- Enter site data for existing and proposed (if applicable) conditions
- Generate the summary report and benefit cost (yellow box)

ECAT Input Freeway Segments Tab
### ECAT Input Freeway Segments

<table>
<thead>
<tr>
<th>Freeway Segment Details</th>
<th></th>
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<tbody>
<tr>
<td>Freeway Segment Number</td>
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<tr>
<td>Freeway Segment Description</td>
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<td>Design Day</td>
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<td>Traffic Volume</td>
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<td>Length of Exit Ramp</td>
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### ECAT Input Ramp Segments

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ECAT Input Ramp Terminal Intersections

Reviewing Results

Crashes for Entire Facility
Reviewing Results

Crashes by Segment

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<tr>
<th>Project Element ID</th>
<th>Common Name</th>
<th>Crash Severity Level</th>
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<th>B</th>
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Reviewing Results

Crashes by Type

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<thead>
<tr>
<th>Crash Type</th>
<th>Predicted Crash Frequency</th>
<th>Expected Crash Frequency</th>
<th>PSI</th>
<th>Proposed Expected Crash Frequency</th>
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<tr>
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<td>0.270</td>
<td>10.05</td>
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<tr>
<td>Pedestrian</td>
<td>8.000</td>
<td>8.000</td>
<td>10.05</td>
<td>8.000</td>
</tr>
</tbody>
</table>
Data Requirements: Freeway Segments

- Geometric Data
  - Basic Roadway Data – Length, number of lanes, area type
  - Alignment – horizontal curve
  - Cross Section – lane width, inside/outside shoulder widths, rumble strips, median barrier
  - Roadside data – clear zone, roadside barrier
  - Ramp Access – presence, side, length of speed-change area

- Traffic Data
  - AADT - Segment, entrance ramp, exit ramp
  - Proportion of AADT during high-volume hours
Freeway Segment Safety Performance Function

Characteristics
- \( N_{spf} = a \times (AADT)^b \times L \)
- Coefficients \( a \) and \( b \) by...
  - Area type
  - Number of lanes
  - Crash type
  - Severity

Crash Modification Factors

Freeway Segment CMFs
- 13 available
- Most are functions of geometric variables
- Developed to work with SPF
  - Match base conditions
  - Calibrated to work in combination (without over-estimating safety influence)
Freeway Segment Crash Modification Factors

- Horizontal curve
- Lane width
- Shoulder width
  - Inside
  - Outside
- Median width
- Barrier
  - Median
  - Roadside
- High volume (congestion)
- Lane change (ramp related)
- Shoulder rumble strips
- Outside clearance
- Ramp entrance
- Ramp exit

Geometric Inputs and CMFs

- Each geometric element has one or more CMFs associated with it
- What do you expect the effect of the following elements would be on crashes (safety performance)?
  - Horizontal Curve
  - Lane Width
  - Weaving Length
  - Location of ramp (right-hand vs. left-hand)
- CMF > 1.00 means increased predicted crash frequency
- CMF < 1.00 means decreased predicted crash frequency
- Table 18-33, pp. 18-35
Median Barrier

- Barrier Data
  - Continuous
    - Offset from traveled way
  - Pieces
    - Length and offset

Median Width

- Cable Median Barrier Width = 1 Foot
Median Barrier Example

Four pieces
1. Length ($L_{ib,1}$) = 0.05 mi, Offset ($W_{off,in,1}$) = 14 ft
2. Length ($L_{ib,2}$) = 0.03 mi, Offset ($W_{off,in,2}$) = 5 ft
3. Length ($L_{ib,3}$) = 0.02 mi, Offset ($W_{off,in,3}$) = 5 ft
4. Length ($L_{ib,4}$) = 0.06 mi, Offset ($W_{off,in,4}$) = 14 ft

Add pieces with the same offset
**Median Barrier Example**

- Add length of pieces with the same offset
- Four pieces becomes two pieces
  1. Length \(L_{ib,1+4}\) = 1.10 mi, Offset \(W_{off,in,1+4}\) = 14 ft
  2. Length \(L_{ib,2+3}\) = 0.05 mi, Offset \(W_{off,in,2+3}\) = 5 ft

**High Volume**

- Volume Variation During Average Day
- Proportion of AADT during hours where the volume exceeds 1,000 veh/h/ln
- Proportion > 0.0 if:
  - Hourly volumes continuously high,
  - A few very high peak hours
- Use nearest traffic station data
High Volume

- **Base Condition**
  - Proportion = 0.0

- **Limits**
  - 0.0 to 1.0

- **Notes**
  - Default values available in ISATe

Lane Change

Weaving Section Types

**Type B**
- a. Major Weave with Lane Balance at Exit Gore
- b. Major Weave with Merge at Entry Gore
- c. Major Weave with Merge at Entry Gore and Lane Balance at Exit Gore

**Other Types**
- a. Major Weave Without Lane Balance or Merging
- b. Two-Sided Weave
Lane Change

**Ramp Location and AADT**
- Need for upstream entrance and downstream exits
  (Not upstream exits and downstream entrances)

Ramp Location within Segment

**Ramp Location**
- Ramp in segment has $x = 0.0$
- Still need AADT
Interchange Ramps

- Data Requirements
- Safety Performance Function
- Crash Modification Factors
- Examples

Data Requirements:

Ramp Segments

- Geometric Data
  - Basic Roadway Data – Length, number of lanes, Average Speed on Freeway, type of traffic control at ramp terminal, area type
  - Alignment – horizontal curve
  - Cross Section – lane width, left/right shoulder widths, lane add/drop in segment
  - Roadside data – barrier
  - Ramp Access – length of speed-change area, length of weaving section

- Traffic Data
  - AADT - segment
Interchange Ramps

- Segment-Based Evaluation
- Method works for all configurations

Diamond (Diagonal)  Parclo Loop (Non-Free-Flow)  Free-Flow Loop  Buttonhook

Outer Connection  Direct Connection  Semi-Direct Connection  Collector-Distributor

Interchange Ramps Safety Performance Function

- Characteristics
  - \( N_{spf} = a \times (AADT)b \times L \)
  - Coefficients \( a \) and \( b \) by...
    - Exit, entrance, C-D road
    - Area type
    - Number of lanes
    - Crash type
    - Severity

2/16/2018
Interchange Ramps Crash Modification Factors

- Ramp Segment CMFs
  - 9 Available
  - Most are functions of geometric variables
  - Developed to work with SPF
  - Match base conditions
  - Calibrated to work in combination (without over-estimated safety influence)
  - Table 19-22, pp. 19-45

Interchange Ramps Crash Modification Factors

- Ramp or C-D Road
  - Horizontal curve
  - Lane width
  - Shoulder width
    - Right/Left
  - Barrier
    - Right/Left
  - Ramp speed-change lane
  - Lane add or drop

- C-D Road
  - Weaving section

![Diagram of weaving section](image)
**Horizontal Curves (Ramps)**

- **Curve Location**
  - Curve Speed Prediction
  - Used to estimate curve entry speed
  - Based on curves and tangents encountered
  - Milepost 0.0 location

---

**Horizontal Curves (Ramps)**

- **Curve Location**
  - Milepost = distance along ramp to start of curve
  - Establish one milepost 0.0 for all segments on ramp
  - Establish one milepost 0.0 for all ramps with a common ramp entrance or exit location
**Horizontal Curves (Ramps)**

- **Curve Location – Special Case**
  - Two “milepost 0.0” for some segments
  - Goal is to estimate average curve entry speed on these segments
    - For these segments, use milepost 0.0 of the higher volume ramp

**Crossroad Ramp Terminal Intersections**

- Intersection Configurations
- Data Requirements
- Safety Performance Functions
- Crash Modification Factors
- Examples
Ramp Terminal Intersection Configurations

Seven configurations

**D3ex: Diagonal Exit**  
**D3en: Diagonal Entrance**  
**D4: Diagonal 4-Leg**

Data Requirements: Ramp Terminal Intersections

- **Geometric Data**
  - Basic Intersection Data – area type, terminal configuration, presence of non-ramp public street
  - Alignment – skew, distance to nearest public street intersection on outside crossroad leg, distance to adjacent ramp terminal
  - Traffic Control – presence of protected left/right turn control on crossroad
  - Cross Section – crossroad median width, number of lanes crossroad and ramp, right-turn channelization on crossroad, left-turn and right-turn lanes/bays on crossroad
  - Access data – number of drives, public street approaches
  - Ramp Access – presence, side, length of speed-change area

- **Traffic Data**
  - AADT – ramp, crossroad
Ramp Terminal Intersection Configurations Cont.

A4: 4-Quad Parclo A
B4: 4-Quad Parclo B

A2: 2-Quad Parclo A
B2: 2-Quad Parclo B

Ramp Terminal Intersection Safety Performance Functions

Characteristics
- \( N_{spf} = a \times (AADT_{xrd})^b \times (AADT_{ex} + AADT_{en})^d \)
- \( AADT_{xrd} \) = crossroad traffic
- \( AADT_{ex} \) = entrance ramp traffic
- \( AADT_{en} \) = exit ramp traffic
- Coefficients \( a \) and \( b \) by...
  - Configuration
  - Type of control (signal, stop)
  - Area type
  - Number of crossroad lanes
  - Severity
Ramp Terminal Intersection Safety Performance Function

- **D4 Configuration**
  - One-way stop
  - Signal

![Diagram of D4 Configuration]

Crash Modification Factors

- **Crossroad Ramp Terminal CMFs**
  - 11 Available
  - Most are functions of geometric design or traffic control variables
  - Developed to work with SPF
  - Table 19-23, pp. 19-46
Ramp Terminal Intersection Crash Modification Factors

- Signal or Stop
  - Exit ramp capacity
  - Crossroad turn lane
    - Left turn
    - Right turn
  - Access point frequency
  - Segment length
  - Median width

- Signal
  - Protected-only left-turn phase
  - Channelized right-turn
    - Crossroad
    - Exit ramp
  - Non-ramp leg

- Stop
  - Skew Angle

HSM Freeway Analysis Project Example
I-270/US 33 Improvements: Dublin, OH

- Interchange is unique
  - Operates as a service interchange to the east as it approaches the Frantz Road/Post Road intersection
  - Operates as system interchange to the west
Project Application – I-270/US 33 Interchange

**Goals**
- Improve Safety
- Address Traffic Congestion
- Resolve Obsolete Geometric Designs
- Fiscal responsibility - Develop phased plan to meet funding constraints

**Three alternatives further studied and developed**
- Alternative 4
- Alternative 7
- Alternative 8

I-270/US 33 Improvements: Alternative 4
I-270/US 33 Improvements: Alternative 7

I-270/US 33 Improvements: Alternative 8
Crash Analysis, 2015-2035 Crash Predictions

- HSM tool for the I-270/US 33 Interchange
  - The model was uncalibrated as used
  - The results used for comparisons are relative
  - Focused on KAB type crashes from 2015-2035
    - Most important crash types
    - Reliability of data is greater
  - Safety was one of many criteria used to determine the preferred alternative

Results

- Total KAB predicted crashes 2015-2035
  - Existing: 308 crashes
  - Alt. 4: 323 crashes
  - Alt. 7: 360 crashes
  - Alt. 8: 320 crashes

- Societal costs 2015-2035
  - Existing: $97M
  - Alt. 4: $90M
  - Alt. 7: $102M
  - Alt. 8: $88M
Interpretation

- Trade-off of reconfiguring interchanges with high speed ramp designs
- Increases VMT

<table>
<thead>
<tr>
<th>Alternative</th>
<th>2015 VMT</th>
<th>2035 VMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>646,908</td>
<td>849,555</td>
</tr>
<tr>
<td>Alt 4</td>
<td>910,494</td>
<td>1,198,120</td>
</tr>
<tr>
<td>Alt 7</td>
<td>907,212</td>
<td>1,194,732</td>
</tr>
<tr>
<td>Alt 8</td>
<td>906,375</td>
<td>1,193,947</td>
</tr>
</tbody>
</table>

- ‘Higher quality’ design
- Safety performance is better even though VMT is 30% greater than existing

Alternative 8 – Preferred Alternative (Phase 2)

PHASE 2 CONSTRUCTION (in 10-15 years)

REMOVE LOOP RAMP
Loop Ramp Crash Prediction

- ISATe used to predict ramp KAB type crashes from 2015 to 2025
  - Option 1 – Maintain existing ramp with a 230’ radius
  - Option 2 – Reconstruct ramp with a 200’ radius
  - Option 3 – Reconstruct ramp with a 185’ radius

<table>
<thead>
<tr>
<th></th>
<th>Crash type: K</th>
<th>Crash Type: A</th>
<th>Crash Type: B</th>
<th>2015-2025 Total KAB Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1</td>
<td>0.4</td>
<td>1.1</td>
<td>7.1</td>
<td>9</td>
</tr>
<tr>
<td>Option 2</td>
<td>0.4</td>
<td>1.2</td>
<td>7.7</td>
<td>10</td>
</tr>
<tr>
<td>Option 3</td>
<td>0.4</td>
<td>1.3</td>
<td>8.2</td>
<td>10</td>
</tr>
</tbody>
</table>

Loop Ramp Crash Prediction

- Per the HSM, comparing the predicted crashes is the appropriate approach for the analysis
- Using an uncalibrated model is an accepted analysis method
- From HSM work in Ohio, the KAB crashes are very close to model predictions
Summary

- Model predicts that the KAB crashes for the options are anywhere from 9-10 crashes on the ramp proper over a 10 year period
- Little difference between the options as far as crash performance
- Because weaving movements are removed, the main issue will be the speed entering the ramp curve
- Speed will have a significant influence on safety performance regardless of option

Summary

- Existing ramp radius will be maintained for the project
- Treatments will be implemented to slow traffic on the approach
- These countermeasures (or lack thereof) would be expected to have a more appreciable influence on expected crash performance than the ramp radius
Questions and Discussion

UP NEXT
Session 3: ECAT Demonstration
Session 3
ECAT Demonstrations

Example 1: Urban Mainline and
Weaving Section (2en, 2ex)
Example 2: Urban Mainline and
Weaving Section (2en, 1ex)

Session 3 Overview

- Terminology
- Getting started with ECAT
- Overview of the Input Freeway Segments tab
- Example analyses
- Discussion of results
Session 3 Terminology

- Terminology
  - Begin/End Milepost
  - Increasing Milepost
  - Decreasing Milepost
  - Project Limits
  - S-C ("speed-change") Lane

Setting Up ECAT

- Enable macros
- Main tab
Workflow

- **Step 1: Identify analysis limits**
- **Step 2: Define study period**
  - Consecutive years for which an estimate of the expected average crash frequency is desired
- **Step 3: Acquire data**
- **Step 4: Segment project into individual sites**
  - Freeway segment
  - Ramp or CD segment
  - Crossroad ramp terminal
- **Step 5: Enter data for each element (segments and intersections)**
- **Step 6: Run analysis**

Freeway Segmentation

- A new segment begins where there is a change in:
  - Number of Through lanes
  - Lane Width
  - Outside Shoulder Width
  - Inside Shoulder Width
  - Median Width
  - Ramp Presence (specifically the speed-change area)
  - Clear Zone Width
Example Freeway Segmentation

- Homogenous geometry
  - No more than 1 entrance and 1 exit in each segment (in each direction)
  - If comparing multiple alternatives, make sure that the start and end points of each alternative are identical. Segment limits between these points may vary.

Segmentation and Through Lanes

- A new segment should be started at the gore point of a ramp if a lane is added or dropped at the ramp or CD road

- The number of through lanes for a segment for a ramp add or drop area defined as follows:
  - For the freeway segment use the total number of through lanes in both directions
  - Do not include auxiliary lanes in a weaving section unless the weaving section exceeds 0.85 miles (4,500 ft)
  - Do not include a ‘parallel’ acceleration lane associated with a ramp that merges with or diverges from the freeway unless it exceeds 0.30 miles (1,600 feet)
Freeway Through Lanes at Ramps

For a speed change lane use the number of through lanes in the portion of the freeway adjacent to the speed change lane plus freeway lanes in the opposing travel direction.

A segment with a lane-add or lane-drop taper should be entered with the same number of through lanes as the freeway just downstream of the lane-add or lane-drop.

Otherwise, begin segment at the gore point if the lane is added or dropped at a ramp or C-D road.
### Ramp Spacing and Taper Lengths

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance Ramp</td>
<td>Length of o-lane at segment $L_{entr}$ (m)</td>
</tr>
<tr>
<td>Exit Ramp</td>
<td>Distance from and tapered to downstream exit ramp gore $L_{exit}$ (m)</td>
</tr>
<tr>
<td>Side</td>
<td>Length of edge lane at segment $L_{edge}$ (m)</td>
</tr>
</tbody>
</table>

#### Ramp in segment
- Define type (lane add or speed change lane)
- Define length of entrance from gore tip to 2' separation
- Define side (left or right)

#### Ramp outside of segment
- Entrance: Define distance from begin milepost of the current segment to 2' wide gore point of previous upstream entrance ramp
- Exit: Define distance from end milepost of the current segment to 2' wide gore point of next downstream exit ramp

### Geometric Input Tolerances

#### Detailed in HSM
- **Cut a new segment if:**
  - Number of lanes changes
  - Lane width changes by 0.5 feet or more
  - Shoulder width changes by 1 foot or more
  - Ramp is present
  - Clear zone width changes by 5 feet or more
  - Median width starts changing, stops changing, first exceeds 90 feet, first drops below 90 feet
Handout Exercise #1:
Urban Freeway Segment (2en, 2ex)

Exercise #1 Summary Results

Summary of Anticipated Safety Performance of the Project (average crashes/year)

<table>
<thead>
<tr>
<th>Project Element ID</th>
<th>Common Name</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment 1A</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Segment 1B</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Segment 2A</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Segment 2B</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Segment 3A</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Segment 3B</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Segment 4A</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Segment 4B</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

ODOT Safety Training
Handout Exercise #2: Urban Freeway Segment (2en, 1ex)

- Same freeway
- Removed increasing milepost exit ramp
- Shortened weaving section between decreasing milepost ramps
- Note same overall analysis boundaries
- What will be the predicted change in safety performance?

Exercise #2 Summary Results

Summary of Anticipated Safety Performance of the Project (average crashes/year)

<table>
<thead>
<tr>
<th>Project Element ID</th>
<th>Common Name</th>
<th>Crash Severity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>KA</td>
</tr>
<tr>
<td>Segment 1.0.B</td>
<td></td>
<td>0.986</td>
</tr>
<tr>
<td>Segment 2.0.B</td>
<td></td>
<td>1.151</td>
</tr>
<tr>
<td>Segment 1.0.B</td>
<td></td>
<td>0.966</td>
</tr>
<tr>
<td>Segment 2.0.B</td>
<td></td>
<td>0.584</td>
</tr>
<tr>
<td>Segment 1.0.B</td>
<td></td>
<td>0.457</td>
</tr>
<tr>
<td>Segment 2.0.B</td>
<td></td>
<td>0.511</td>
</tr>
</tbody>
</table>

Existing Conditions Project Element Predicted Crash Summary (Without Animal Crashes)
## Comparison & Discussion

### Exercise 1

<table>
<thead>
<tr>
<th>Predicted Existing Conditions</th>
<th>KA</th>
<th>B</th>
<th>C</th>
<th>O</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N predicted</td>
<td>2.5724</td>
<td>8.8392</td>
<td>10.0112</td>
<td>52.7512</td>
<td>74.1740</td>
</tr>
</tbody>
</table>

### Exercise 2

<table>
<thead>
<tr>
<th>Predicted Existing Conditions</th>
<th>KA</th>
<th>B</th>
<th>C</th>
<th>O</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N predicted</td>
<td>2.6461</td>
<td>9.1596</td>
<td>10.3763</td>
<td>55.0901</td>
<td>77.2721</td>
</tr>
</tbody>
</table>

## Questions and Discussion
UP NEXT

Session 3 cont.: More ECAT Demonstrations
Session 3 cont.
More ECAT Demonstrations

Example 3: Ramp Segment
Example 4: Ramp Terminal Configuration
Comparison

Ramp Configurations

- Segment-based evaluation
  - Works for all ramp configurations up to 2 lanes
  - Similar to freeway segment analysis
  - Can also analyze C-D roads
**Mileposting**
- Used to model the speed of a vehicle along the ramp
- Establishes ramp horizontal curve CMF
- Milepost = distance along ramp to start of curve
- Establish one milepost 0.0 for all segments on ramp
- Establish one milepost 0.0 for all ramps with a common entrance or exit location

**Mileposting: Special Case**
- Some ramps have two possible milepost 0.0 locations
- Goal is to estimate average curve entry speed on these segments
  - Use milepost 0.0 of the higher volume ramp
Geometric Input Tolerances

- Cut a new segment if:
  - Number of lanes changes
  - Lane width changes by 0.5 feet or more
  - Shoulder width changes by 1 foot or more
  - Merging/diverging ramp is present

Exercise #3: Freeway Ramp Segments

![Typical Sections Diagram]
**Exercise #3 Summary Results**

**Summary of Anticipated Safety Performance of the Project (average crashes/year)**

<table>
<thead>
<tr>
<th></th>
<th>0.0</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
<th>1.1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>KS</td>
<td>0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>3.6</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>4.0</td>
</tr>
<tr>
<td>C</td>
<td>0.5</td>
<td>0.7</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>3.6</td>
</tr>
<tr>
<td>O</td>
<td>0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Total</td>
<td>0.5</td>
<td>0.7</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>3.6</td>
</tr>
</tbody>
</table>

**Existing Conditions Project Element Predicted Crash Summary (Without Animal Crashes)**

<table>
<thead>
<tr>
<th>Project Element ID</th>
<th>Common Name</th>
<th>Crash Severity Level</th>
<th>Total</th>
</tr>
</thead>
</table>
| Ramp 1             |             | A                    | 1.519
| Ramp 2             |             | A                    | 1.519

**Ramp Terminal Analysis**

- Most rigid part of ECAT analysis
- Method addresses seven different configurations from drop-down menu
Handout Exercise #4: Ramp Terminal Configuration Comparison

Exercise #4 Characteristics

A4 Configuration
- Signal control
- ¼ mile to next intersection
- 800 feet between terminals
- Crossroad
  - 12’ median width
  - 4 lanes both approaches
  - 2 lane exit ramp approach
- Right turns yield
- No right turn bays

D4 Configuration
- Signal control
- ¼ mile to next intersection
- 800 feet between terminals
- Left turns protected
- Channelized
- 12 foot lanes
- Right turns yield
- Channelized
- Crossroad
  - 12’ median width
  - 4 lanes both approaches
  - 2 lane exit ramp approach
  - Exit ramp approach channelized
  - No outside approach right turn bay
  - 1 driveway on outside crossroad
Comparison & Discussion
• A4 Ramp Terminal

<table>
<thead>
<tr>
<th>KA</th>
<th>B</th>
<th>C</th>
<th>O</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N_{predicted - Existing Conditions}</td>
<td>0.0658</td>
<td>0.4738</td>
<td>0.7763</td>
<td>2.7179</td>
</tr>
</tbody>
</table>

Comparison & Discussion
• D4 Ramp Terminal

<table>
<thead>
<tr>
<th>KA</th>
<th>B</th>
<th>C</th>
<th>O</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N_{predicted - Existing Conditions}</td>
<td>0.0710</td>
<td>0.2930</td>
<td>0.4528</td>
<td>3.9634</td>
</tr>
</tbody>
</table>
Questions and Discussion

UP NEXT
Session 4: Full Interchange Example
Session 4
Full Interchange Example

Example 5: Full Interchange

Putting It All Together

- ECAT can analyze combinations of ramps, ramp terminals, and freeway segments
- Use in the planning phase when comparing various alternatives
  - What happens when you switch interchange configurations (diamond to a parclo?)
  - What happens when you change the spacing between proposed interchanges?
  - What about adding/removing access to a location entirely?
- An uncalibrated model is still useful for alternative comparison!
Analyzing Output

- **Output Summary tab**
  - Breaks down crash types and severity for entire facility by facility component (freeway, ramps, and crossroad terminals)

- **Other output tabs**
  - Shows segment-by-segment CMF development and crash number and type development for freeway segments, ramp segments, and ramp terminals
  - CMF of 1.00 is the base condition
    - CMF > 1.00 means increased predicted crash frequency
    - CMF < 1.00 means decreased predicted crash frequency
  - Can use these tabs to isolate factors that directly impact the safety of a specific segment
  - Also a good place to QC: look for unusually high/low CMFs and ask yourself: “does this make sense?”

Best Practices

- **Analysis is only as good as your inputs**
  - Record any and all assumptions on a separate spreadsheet as a QC tool

- **Homogenous segmentation is key to a good analysis**
  - Allows you to properly identify factors leading to safety issues
  - Produce a segmentation diagram during the analysis process
    - Can be quickly derived from a single-line drawing in the planning phase
    - Allows for easy visual comparison between spreadsheet and actual geometric information
    - Can act as an exhibit in design reports
  - Refer to the manual and previous slides for a list of advice about cutting segments
  - Sometimes you cannot cut a perfect segment – again, record any and all assumptions
Example Assumptions Sheet

<table>
<thead>
<tr>
<th>Assumption No.</th>
<th>Location (Sheet and Row/Column Number)</th>
<th>Assumption</th>
<th>Reason for assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GENERAL</td>
<td>The project uses split median PCLs instead of a single centerline. Distances were based off of one of the PCLs instead of splitting the median.</td>
<td>There is only minor deviation between the PCLs. Stationing.</td>
</tr>
<tr>
<td>2</td>
<td>Mainline G29</td>
<td>Median is transitioning in segment 1. Assumed an average 25&quot; median width.</td>
<td>Median transition is minor and does not require a new segment.</td>
</tr>
<tr>
<td>3</td>
<td>G30</td>
<td>Outside shoulder rumble strips are present in all lane segments.</td>
<td>Modern projects typically include rumble strips in pavement details. Pavement details not available. Field data not within budget.</td>
</tr>
<tr>
<td>4</td>
<td>Mainline G36</td>
<td>Assumed a 2'-0&quot; barrier with dimensions.</td>
<td>No typical section detailing barrier dimensions.</td>
</tr>
<tr>
<td>5</td>
<td>Mainline G29</td>
<td>Median is transitioning in segment 1. Assumed an average 15&quot; median width.</td>
<td>Median transition is minor and does not require a new segment.</td>
</tr>
</tbody>
</table>

Segmentation Diagram Best Practices

- Indicate type of segment (ramp, ramp taper in a freeway segment, freeway segment, ramp terminal) by color
- Number each segment to correspond to ECAT worksheet
- Indicate traffic volumes by segment
- Indicate direction of increasing/decreasing milepost and direction of traffic flow

- Different engineers may have different workflows to segment a facility
  - Segment entire facility prior to starting analysis
  - Segment facility as analysis is conducted
  - Benefits/drawbacks to each?
Workshop Exercise

- Segment and analyze the interchange given the data shown in your worksheet packet
- As you work, think about how best to leave a record of your assumptions and method of analysis for future QA/QC

Pre-Reconstruction Condition Segmentation
Pre-Reconstruction Condition Output

Summary of Anticipated Safety Performance of the Project (average crashes/year)

<table>
<thead>
<tr>
<th></th>
<th>KA</th>
<th>B</th>
<th>C</th>
<th>O</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Npredicted - Existing Conditions</td>
<td>1.1664</td>
<td>4.3819</td>
<td>4.6693</td>
<td>32.7776</td>
<td>42.9952</td>
</tr>
</tbody>
</table>

Post-Reconstruction Condition Segmentation
Post-Reconstruction Predictions

- What do you expect the post-reconstruction prediction will be?
  - Total crashes
  - Crashes by severity
  - Freeway vs. ramp crashes

Post-Reconstruction Condition Output

<table>
<thead>
<tr>
<th></th>
<th>KA</th>
<th>B</th>
<th>C</th>
<th>O</th>
<th>Total</th>
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<tbody>
<tr>
<td>Npredicted - Existing Conditions</td>
<td>1.1664</td>
<td>4.3819</td>
<td>4.6693</td>
<td>32.7776</td>
<td>42.9952</td>
</tr>
<tr>
<td>Npredicted - Proposed Conditions</td>
<td>1.1102</td>
<td>4.2922</td>
<td>4.7580</td>
<td>23.0896</td>
<td>33.2500</td>
</tr>
</tbody>
</table>
Pre-construction versus Post-construction total crashes by segment type

Output Comparison

- Reduction in mainline crashes predicted in post-construction
- Similar ramp crashes predicted in both scenarios
- More multi-vehicle crashes predicted in pre-reconstruction
- Single vehicle crashes remain almost the same
- Reduction in minor injury and PDO crashes in post-construction
Predicted Crash Comparisons: Freeway Segment 2

Pre-Construction vs. Post-Construction

2/16/2018
Predicted Crash Comparisons: Ramp 4

Pre-Construction

Post-Construction

One Lane Ramp

2nd exit removed

Two Lane Ramp

Ramp 4 Crash Comparison: Pre-Construction vs. Post-Construction

Pre-Construction

Post-Construction

C/PDO

K/A/B

2/16/2018
Discussion

- Why would we see a decrease in predicted crashes?

Final Questions and Discussion
ISATe Example

Exercises

Exercise 1: Mainline Freeway Segment 1
(Session 3)

Exercise 2: Mainline Freeway Segment 2
(Session 3)

Exercise 3: Ramp Segment
(Session 3)

Exercise 4: Ramp Terminal Configuration
(Session 3)

Exercise 5: Full Interchange
(Session 4)
Session 3

Exercise 1: Mainline Freeway Segment 1

SEGMENT 1
L = 5000'
AADT = 127,000
RAMP AADT = 8100

SEGMENT 2
L = 2000'
AADT = 140,000
RAMP AADT = 1780

SEGMENT 3
L = 3000'
AADT = 136,210
RAMP AADT = 2010
Session 3
Exercise 2: Mainline Freeway Segment 2

SEGMENT 1
L = 5000'
AADT = 127,000

RAMP AADT = 8100

SEGMENT 2
L = 1200'
AADT = 140,000

RAMP AADT = 1780

SEGMENT 3
L = 3800'
AADT = 142,010

INCREASING MILEPOST
Session 3
Exercise 3: Ramp Segment

- L = 55’
- R = 300’
  - L = 133’
  - L = 228’
- R = 800’
- L = 439’
- L = 480’

MILEPOST 0

- AADT = 8100
- 188’ OF BARRIER

R = 150’
L = 706’
AADT = 2500

NO CONTROL
TYPICAL SECTIONS

PR & LOOP RAMP

PR & DIAMOND RAMP
Session 3
Exercise 4: Ramp Terminal Configuration

**A4 Configuration**
- Signal control
- ¼ mile to next intersection
- 800 feet between terminals
- Crossroad
  - 12’ median width
  - 4 lanes both approaches
  - 2 lane exit ramp approach
- Right turns yield
- No right turn bays

**D4 Configuration**
- Signal control
- ¼ mile to next intersection
- 800 feet between terminals
- Left turns protected
  - Channelized
  - 12 foot lanes
- Right turns yield
  - Channelized
- Crossroad
  - 12’ median width
  - 4 lanes both approaches
  - 2 lane exit ramp approach
- Exit ramp approach channelized
- No outside approach right turn bay
- 1 driveway on outside crossroad
A4 Configuration

D4 Configuration
# Session 4

*Exercise 5: Full Interchange*

## PRE RECONSTRUCTION CONFIGURATION ASSUMPTIONS

<table>
<thead>
<tr>
<th>Design Element</th>
<th>Dimensions/ Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainline number of basic lanes</td>
<td>4</td>
</tr>
<tr>
<td>Mainline lane width</td>
<td>12’</td>
</tr>
<tr>
<td>Mainline outside shoulder width</td>
<td>10’</td>
</tr>
<tr>
<td>Mainline inside shoulder width</td>
<td>4’</td>
</tr>
<tr>
<td>Mainline median width</td>
<td>72’</td>
</tr>
<tr>
<td>Clear zone</td>
<td>30’</td>
</tr>
<tr>
<td>Mainline median barrier width</td>
<td>2’ or 56’ (segment 3)</td>
</tr>
<tr>
<td>Nearest distance from edge of travelled way to median barrier face</td>
<td>8’</td>
</tr>
<tr>
<td>Outside barrier offset from edge of shoulder</td>
<td>2’</td>
</tr>
<tr>
<td>Rumble strips</td>
<td>Not present</td>
</tr>
<tr>
<td>Ramp right shoulder width</td>
<td>9’</td>
</tr>
<tr>
<td>Ramp left shoulder width</td>
<td>4’</td>
</tr>
<tr>
<td>Diamond ramp lane width</td>
<td>16’</td>
</tr>
<tr>
<td>Loop ramp lane width</td>
<td>17.5’</td>
</tr>
<tr>
<td>Clear zone</td>
<td>30’</td>
</tr>
<tr>
<td>Mainline median cable barrier width</td>
<td>Varies, 40’-52’ (40’, 48’, 52’)</td>
</tr>
<tr>
<td>Nearest distance from edge of travelled way to outside shoulder barrier face</td>
<td>12’</td>
</tr>
<tr>
<td>Outside barrier offset from edge of shoulder</td>
<td>2’</td>
</tr>
<tr>
<td>Rumble strips</td>
<td>Not present</td>
</tr>
<tr>
<td>Ramp right shoulder width</td>
<td>6’</td>
</tr>
<tr>
<td>Ramp left shoulder width</td>
<td>4’</td>
</tr>
<tr>
<td>Diamond ramp lane width</td>
<td>16’</td>
</tr>
<tr>
<td>2-lane ramp lane width</td>
<td>12’</td>
</tr>
<tr>
<td>2-lane ramp right shoulder width</td>
<td>8’</td>
</tr>
<tr>
<td>2-lane ramp left shoulder width</td>
<td>6’</td>
</tr>
<tr>
<td>Loop ramp lane width</td>
<td>16’</td>
</tr>
<tr>
<td>Average freeway traffic speed</td>
<td>60 MPH</td>
</tr>
</tbody>
</table>

## POST RECONSTRUCTION CONFIGURATION ASSUMPTIONS

<table>
<thead>
<tr>
<th>Design Element</th>
<th>Dimensions/ Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainline number of basic lanes</td>
<td>6 west end and core, 8 east end</td>
</tr>
<tr>
<td>Mainline lane width</td>
<td>12’</td>
</tr>
<tr>
<td>Mainline outside shoulder width</td>
<td>10’</td>
</tr>
<tr>
<td>Mainline inside shoulder width</td>
<td>10’</td>
</tr>
<tr>
<td>Mainline median width</td>
<td>Varies, 40’-52’ (40’, 48’, 52’)</td>
</tr>
<tr>
<td>Clear zone</td>
<td>30’</td>
</tr>
<tr>
<td>Mainline median cable barrier width</td>
<td>1’</td>
</tr>
<tr>
<td>Nearest distance from edge of travelled way to median barrier face</td>
<td>15’</td>
</tr>
<tr>
<td>Nearest distance from edge of travelled way to outside shoulder barrier face</td>
<td>12’</td>
</tr>
<tr>
<td>Outside barrier offset from edge of shoulder</td>
<td>2’</td>
</tr>
<tr>
<td>Rumble strips</td>
<td>Not present</td>
</tr>
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<td>Ramp right shoulder width</td>
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<td>16’</td>
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<tr>
<td>Average freeway traffic speed</td>
<td>60 MPH</td>
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</tbody>
</table>
**Proposed System**

Segment 1  Sta 15+00 to Sta 27+00
Segment 2  Sta 27+00 to Sta 39+00
Segment 3  Sta 39+00 to Sta 54+00

<table>
<thead>
<tr>
<th>RAMP NUMBER</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>325</td>
</tr>
<tr>
<td>2</td>
<td>3200</td>
</tr>
<tr>
<td>3</td>
<td>1950</td>
</tr>
<tr>
<td>4</td>
<td>6300</td>
</tr>
<tr>
<td>6</td>
<td>3250</td>
</tr>
<tr>
<td>7</td>
<td>2650</td>
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</tbody>
</table>

**MAINLINE** 42200 AADT