AASHTO Highway Safety Manual Freeway and Interchange Crash Prediction Methodology – ISATe
I-74 Peoria Case Study

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Presentation Overview

- Background on safety prediction for freeways and interchanges
- ISATe description, data needs and applications
- Demonstration of ISATe output
- Case Study – I-74 Peoria
Freeway Corridor and Interchange Projects

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

Marquette Interchange, Milwaukee, WI
We ought to understand the expected safety performance of a $250 million investment.

Would you expect these three alternatives to experience the same number and severity of crashes over a 30 year project life? If not, would it be helpful to understand the potential differences when selecting a preferred design alternative?
Common interchange and corridor planning and design issues

- Configuration
- 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)
- Cross section (median, shoulders)
- Design exceptions
The AASHTO Highway Safety Manual (HSM)

- Provides technical background on the basic ‘science’ of crashes
- Safety management methods and approaches
- Establishes an understanding the effects of treatments on crashes
- Offers methodologies for predicting crashes on highways of all type (the vision of the HSM)
Draft HSM Chapter on Freeways and Interchanges

- NCHRP Project 17-45 – ‘ISATe’ – Interchange Safety Analysis Tool Enhanced
  - Texas Transportation Institute (Jim Bonneson, PI)
  - CH2M HILL subcontractor
- Research completed late 2011
  - Specifically funded to support HSM development
  - Research accepted by panel in mid 2012
  - TRB Highway Safety Performance CMTE has recommended adoption into the AASHTO HSM
  - AASHTO reviews and balloting in process
What does ISATe do?

*Based on characteristics of a freeway and its interchanges.*

- Freeway and interchange design characteristics
  - Mainline segments
  - Exit and entrance ramps
  - Crossroad ramp terminals
- Traffic Volumes (AADT)
  - Any single year (e.g., design year, current year)
  - Project life

*ISATe predicts frequencies and characteristics of crashes*

- Crashes by Severity (KABCO)
  - K – at least fatality
  - A – at least one incapacitating injury
  - B – at least one evident but non-capacitating injury
  - C – at least one possible injury
  - O – no injury; property damage only
- Crashes by Type
  - MV (rear-end, sideswipe, angle, head on)
  - SV (Run-off-road, fixed object)
General form of the HSM predictive method

Predicted Crash Frequency =>

SPF \times (CMF1 \times CMF2 \times \ldots) \times C

'Safety Performance Function'

'Crash Modification Factors (or Functions)'

'Local Calibration Factor'
ISATe Crash Prediction Components

- Freeway Segments
- Ramps
- Ramp Terminal Intersections with Crossroad
Freeway Segment Safety Performance Functions – ‘SPF’

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

![Graph showing the relationship between AADT and fatal-injury crash frequency for rural and urban freeways.](image)
Crash modification factors included in the freeway segment models – design elements

- Lane Width
- Shoulder Width (Left, Right)
- Median Width
- Horizontal Curve Radius
- Median Barrier – presence and type
- Outside (Right) Barrier – presence and type
- Outside Clearance
Crash modification factors included in the freeway segment models – Operational elements

- Length of weaving section
- Lane changing (presence of ramps)
- Hours of ‘congestion’ (> 1000 vphpl)
- Presence of lighting
- Presence of shoulder rumble strip
- Signing and pavement markings
High Volume

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

- Crash modification factor for effect of congestion
ISATe models both service and system interchange ramp configurations

Ramp Configurations

- Segment-Based Evaluation
  - Method works for all configurations

Diamond (Diagonal)
Parclo Loop (Non-Free-Flow)
Free-Flow Loop
Buttonhook
Outer Connection
Direct Connection (used at directional interchanges)
Semi-Direct Connection (used at directional interchanges)
Collector-Distributor
Safety Performance Functions (SPF) for Ramps

- 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

![Graphs showing SPF for entrance and exit ramps with different lane configurations and AADT levels.](image)
Exit and entrance ramp design elements included in the ramp models

- Number of lanes
- Ramp width
- Shoulder widths
- Horizontal alignment (continuous)
- Presence and location of barrier (left; right)
- Lengths of acceleration and deceleration lanes
- Proximity of other ramps
Entrance and exit ramp operational elements included in the ramp models

- Type of ramp (exit or entrance)
  - Diverge configuration (lane balanced vs. lane drop)
  - Add configuration (merge vs. lane add)
- Location of ramp (left vs. right)
- Length of weaving (CD roads)
- Presence of lighting on ramps
ISATe models crossroad ramp terminal intersections

Terminal Configurations

- Configuration-Based Evaluation
  - Method addresses seven configurations

Diagonal, Exit
- Type: D3ex

Diagonal, Entrance
- Type: D3en

Diagonal, 4-Leg
- Type: D4
Terminal Configurations

• Crossroad Ramp Terminal Configurations

4-quad Parclo A

4-quad Parclo B

2-quad Parclo A

2-quad Parclo B
Safety Performance Functions (SPF) for ramp terminal intersections

**Safety Performance Function**

- **Characteristics**
  - \( N_{spf} = a \times (AADT_{xrd})^b \times (AADT_{ex} + AADT_{en})^d \)
  - \( AADT_{xrd} = \) crossroad traffic
  - \( AADT_{en} = \) entrance ramp traffic
  - \( AADT_{ex} = \) exit ramp traffic
  - Coefficients \( a, b, d \) by...
    - Configuration
    - Type of control (signal, stop)
    - Area type
    - Number of crossroad lanes
    - Severity
Crossroad ramp terminal intersection elements included in the intersection models

- Area type (rural, urban)
- Number of approach legs
- Number of lanes on crossroad
- Turning movement traffic volumes
- Presence and number of turning lanes
- Geometry (diamond, parclo with skew)
- Type of traffic control (stop, traffic signal)
C – Calibration Factor

Predicted Crash Frequency =>

\[ \text{SPF} \times (\text{CMF1} \times \text{CMF2} \times \ldots) \times C \]

‘Safety Performance Function’

‘Crash Modification Factors (or Functions)’

‘Local Calibration Factor’
Calibration factor – ‘C’

- ISATe developed from HSIS data from Maine, Washington and California
- Commonalities among states enabling transference of models
  - Licensing practices and traffic laws
  - Geometric design practices and policies (AASHTO)
  - Vehicle capabilities
- State databases vary by quality and completeness
- Reporting thresholds for PDOs vary by state
- Other characteristics influence overall safety profile of a state
  - Demographics (older drivers and younger drivers)
  - Climate
  - Terrain
  - Legislation and enforcement policies
Reviewed results:

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

Let's take a closer look...
I-74 Pre-Construction

- 1950’s vintage design characteristics
- 4-lane freeway (2 each direction)
- Congestion during peak periods
- Limited/no shoulders
- Multiple weaving sections along mainline
- Left-hand exits and entrances
I-74 Pre-construction
I-74 Reconstruction

- 2002 - 2006
- Over ten years in planning and design
- $500 M effort
- Complete reconstruction of mainline
- Constructed one new interchange at Sterling Avenue;
- Built two tunnels in Downtown Peoria;
- Removed and repaved more than eight miles of I-74;
- Improved 11 interchanges;
- Reconstructed 32 bridges;
- Built 88 retaining walls;
- Installed 162 traffic signals
I-74 Peoria Reconstruction
Pre-construction Configuration (portion of project)
I-74 Peoria, Illinois
Post-reconstruction configuration

Segments 1 to 11 =>
I-74 PEORIA RECONSTRUCTION
MULTI-VEHICLE CRASHES
2006-2009

534 TOTAL

297

237

PRE-CONSTRUCTION (PREDICTED)

POST-RECONSTRUCTION (PREDICTED)

179

117

296 TOTAL

207

55

262 TOTAL

OBSERVED CRASH DATA (POST-RECONSTRUCTION)
I-74 PEORIA RECONSTRUCTION
SINGLE-VEHICLE CRASHES
2006-2009

355 TOTAL

PRE-CONSTRUCTION (PREDICTED)

POST-CONSTRUCTION (PREDICTED)

243 TOTAL

OBSERVED CRASH DATA (POST-RECONSTRUCTION)

67 TOTAL
I-74 Peoria ISATEe evaluation

853 TOTAL

505 TOTAL

349 TOTAL

PRE-CONSTRUCTION (PREDICTED)

POST-RECONSTRUCTION

OBSERVED CRASH DATA (POST-RECONSTRUCTION)
I-74 predicted multivehicle crashes by location post reconstruction (2006 – 2009)
I-74 actual (observed) multivehicle crash frequency post reconstruction (2006 – 2009)
Summary

- Uncalibrated for Illinois
- ISATe predicted a significant improvement in corridor safety
  - Reduction of 41% of Total Crashes
  - Reduction of 44% of Severe Crashes
  - Actual pre-construction crash data not available but corridor was selected for improvement in part because of its poor safety history; and it is widely acclaimed as a much better, safer facility
- ISATe overpredicted crashes for I-74
  - Single vehicle crashes in particular (barrier related)
  - Severe crashes in particular
Use of ISATe

- Relative comparisons are valid absent calibration factors
- Caution against use of absolute frequencies without calibration
  - High variance for less severe and PDO crashes
  - Fatal and serious injury crashes should be more consistent
  - Caution even with these given inherent differences among states
- **States will need to conduct calibration to use ISATe**
  - Many states are developing their own HSM-like models rather than calibrating
  - We expect that few if any states will try to replicate ISATe; and rather will calibrate
  - IDOT is calibrating ISATe
ISATe status and implementation efforts

- Research has been approved by panel and is now in public domain
  - Will be a web-only document; not yet posted
  - Developed as new chapter for the Highway Safety Manual
- TRB Highway Safety Performance Committee has recommended its adoption within the HSM; AASHTO balloting is in process; acceptance is expected
- Training courses are being developed for a number of states interested in its use
- Expect its use to be encouraged by FHWA as part of their IJR/IMR process once out
Questions and Discussion

- If you would like to learn more about ISATe or the AASHTO Highway Safety Manual please contact me:

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