Ramp Reversal Projects
Guide to Successful Project Implementation
Presentation Outline

1) Background
2) Key topics
3) State-of-the-practice
4) District surveys
5) Case studies
6) Project evaluation
7) Guidelines
MODULE 1
BACKGROUND
Research Project 0-5105

- RMC 4 – Traffic Operations
- Project title
  - Development of Guidelines for Ramp Reversal Projects
- Funding
  - $135,262
- Joint Texas Transportation Institute (TTI) and University of Texas at Arlington (UTA) project
TxDOT Project Team

- Lauren Garduno (ODA) – Program Coordinator
- Roy Parikh (FTW) – Project Director
- Project Advisors
  - Brian Barth (DAL)
  - Albert Durant (FTW)
  - Doug Eichorst (ODA)
  - Cynthia Landez (DES)
  - Wade Odell (RTI)
The Research Team

- Scott Cooner (TTI) – Research Supervisor
- Steve Venglar (TTI) – Co-Research Supervisor
- Dr. Jim Williams (UTA)
- Other members:
  - Ed Pultorak (TTI)
  - Yatin Rathod (TTI)
  - Stephen Mattingly (UTA)
  - Phong Vo (UTA)
MODULE 2
KEY TOPICS
#1: When to Consider Reversals

- When & where should the use of ramp reversals be considered?

<table>
<thead>
<tr>
<th>Type</th>
<th>Left Lane</th>
<th>Right Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGLE ON &gt; OFF</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
</tr>
<tr>
<td>SINGLE OFF &gt; ON</td>
<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
</tr>
<tr>
<td>PAIR</td>
<td><img src="image5" alt="Diagram" /></td>
<td><img src="image6" alt="Diagram" /></td>
</tr>
</tbody>
</table>
#2: Diamond vs. X-ramp Pattern

When & where should an X-ramp pattern be used as opposed to diamond ramp design?
## Pros and Cons of Converting from Diamond to X-Ramps

<table>
<thead>
<tr>
<th>PROS</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Increased development along frontage road</td>
<td>– <strong>Costly</strong> means of improving signal operation</td>
</tr>
<tr>
<td>+ <strong>Reduced through demand</strong> on frontage road approach to intersection</td>
<td>– Construction activities will <strong>disrupt business</strong> along frontage road</td>
</tr>
<tr>
<td>+ <strong>Move the weaving area</strong> between an entrance ramp and exit ramp from the main lanes to the frontage road, where speeds and volumes are lower</td>
<td>– Invites <strong>sling-shot maneuvers</strong> allowing motorists to bypass cross-street signals; this poses safety and capacity problems on frontage road</td>
</tr>
<tr>
<td>+ <strong>Increased storage area</strong> for cross-street intersection queuing</td>
<td>– Addresses the queue storage problem but <strong>queueing delay will not be remedied</strong></td>
</tr>
<tr>
<td>+ Better opportunity to use frontage road as alternate route as part of <strong>incident management</strong> if auxiliary lanes are provided</td>
<td>– Likely increase in <strong>short trips</strong> on the freeway</td>
</tr>
<tr>
<td></td>
<td>– Construction of auxiliary lanes may require <strong>major reconstruction</strong> at cross-streets</td>
</tr>
</tbody>
</table>
#3: Project Evaluation

- How should ramp reversal projects be evaluated?
  - Operational impacts
  - Safety impacts
  - Basic economic impacts
MODULE 3
STATE-OF-THE-PRACTICE
Ramp Reversal Studies

- Not much literature
- Report 210-12F
- Texas issue
  - Frontage Roads
- 1980s case study
  - IH 610 in Houston
  - B/C ratio of 3.8 to 1
X-ramp Studies

- Tipton & Pinnel – 1967
  - TTI Report 335-1F
- Borchardt – 1986
  - TTI Report 2903-4F
- Klaver – 1995
  - TTI Report 2903-4F
- Kockelman – 2000
  - CTR 1873-1
Braided Ramp Studies

Bonilla & Urbanik (376-2F) – 1986

- Grade-separation when:
  - Weaving or access problems not solved by ramp elimination or relocation

- Warrants
- Guidelines

Photo Courtesy of TTI
## Freeway Weaving

### Highway Capacity Manual

<table>
<thead>
<tr>
<th>LOS</th>
<th>Freeway Weaving Segment</th>
<th>Multilane and Collector-Distributor Weaving Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤ 10.0</td>
<td>≤ 12.0</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 10.0 – 20.0</td>
<td>&gt; 12.0 – 24.0</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 20.0 – 28.0</td>
<td>&gt; 24.0 – 32.0</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 28.0 – 35.0</td>
<td>&gt; 32.0 – 36.0</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 35.0 – 43.0</td>
<td>&gt; 36.0 – 40.0</td>
</tr>
<tr>
<td>F</td>
<td>&gt; 43.0</td>
<td>&gt; 40.0</td>
</tr>
</tbody>
</table>
Frontage Road Weaving

- Fitzpatrick – 1996
  - Procedures for analyzing frontage road weaving
  - Spacing requirements for ramp junctions
  - LOS analysis
- Adopted in TxDOT Roadway Design Manual
Recommended “Desirable” Modifications to the Current Guidelines of the TxDOT Operations and Procedures Manual
(Figure 7, Texas Transportation Institute Report No. 2927-2)
TTI Project 7-2927 - Minimum

Preferred Access Control at Entrance Ramp
Junction with Frontage Road

Intersection of Travelways

Intersection of Roadway Surfacing

Entrance Ramp

Frontage Road

100’

50’

150’ MIN. ACCESS DENIED

Absolute Minimum Guidelines for the TxDOT Operations and Procedures Manual
(Figure 8, Texas Transportation Institute Report No. 2927-2)
MODULE 4
DISTRICT SURVEYS
Survey Questions

- Project type
- Date of implementation
- Roadway type
- Project cost
- Project rationale
- Evaluation studies
Survey Responses

- 18 of 25 Districts responded
Project Type

Type of Ramp Modification

- 18, 50%
- 13, 36%
- 2, 6%
- 3, 8%

- Single ramp reversal (on to off)
- Single ramp reversal (off to on)
- Ramp reversal pair (on/off to off/on)
- X-ramp corridor
Date of Implementation

Project Implementation Status

- 14, 38%
- 11, 31%
- 11, 31%

Legend:
- Existing
- Ongoing
- Planned
Roadway Type

23, 64%

2, 6%

8, 22%

3, 8%

Interstate
US Highway
State Highway
FM, Loop or Other
Project Rationale

- Safety issues 68%
- High traffic volumes 60%
- Inadequate ramp spacing 43%
- Main lane weaving 43%
- Political/developer request 41%
- Land access 30%
- Frontage road weaving 11%
Project Rationale - Others

- Two-way to one-way frontage road conversion (6)
- Exit ramp queue spillback (5)
- Better utilize frontage road capacity (2)
- Eliminate two consecutive entrance ramps
- Construction of an additional overpass
- Alleviate frontage road congestion at the arterial street
MODULE 5

CASE STUDIES
Identify and Select Study Sites

- Candidate sites
  - Survey, internet searches & previous evaluations
  - 12 ramp reversal case studies
  - 3 X-ramp corridor case studies

Graphic Courtesy of Texas Transportation Institute
Operational Evaluation

- Impacts
  - System delay
  - Volume fluctuations
    - Freeway main lanes
    - Frontage road
    - Downstream intersection
  - Queuing
  - Ramp spacing

Graphic Courtesy of Jacobs Civil (Dallas)
Safety Evaluation

- Crash rate before vs. after
  - Main lane
  - Frontage road
  - Total
- Anecdotal

Photo Courtesy of Grover Schretter, TxDOT Fort Worth District
Basic Economic Evaluation

- Sales tax receipts
  - Corridor vs. citywide
- Property values
  - Corridor
- Business development

Photo Courtesy of Cedar Hill Economic Development Corporation
WB SH 114 in Grapevine

- Reversed Bus. 114 entrance with Spur 103 (Main St.) exit
- Construction cost = $2,025,193
- Driving force = improved access
- Property owners paid for engineering design

Photo Courtesy of Flickr.com (public)
Aerial Photos

1999

- WB Spur 103 exit ramp
- WB Business 114 entrance ramp

2003

- WB Business 114 entrance ramp
- WB Spur 103 exit ramp
Evaluation Results

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td>+</td>
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</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td>≪ ≫</td>
</tr>
</tbody>
</table>

**Lesson learned:** exit ramp warning sign placement is critical.
Reversed the Matlock entrance with the FM 157 (Cooper St.) exit
Construction cost = $7,049,023
Driving force = improved access to Parks Mall
Joint funding
Roadway Layout

- Parks Mall
- IH 20
- Matlock Road
- Cooper/FM 157
2

Improved Frontage Road

1 2 3 4

2-lane Cooper exit

Overhead sign bridge

Photo by Texas Transportation Institute
## Evaluation Results

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</tr>
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</table>

**Lesson learned:** speed enforcement needed on frontage road.
3 EB IH 30 in Dallas

- Significant slowdown on IH35E
- Short weaving section
- Horizontal curve – truck rollovers
- Construction cost = $600,000

Photo Courtesy of NCTCOG
3 Roadway Layout
Before Volumes

(PM Peak Hour)

FROM NB IH35E
FROM EB IH 30
FROM SB IH35E (2577)
FROM NB IH35E (2226)
LAMAR EXIT (150)
GRIFFIN EXIT (152)
HARWOOD (1161)
TO IH45 (2380)
TO EB IH 30

(2012)
(2577)
(1649)
(1984)
(3633)
(593)
(956)
(363)
(956)
(3792)
(301)
(369)
(321)
(301)
(369)
(321)
(301)

(2012)
FROM EB IH 30
FROM SB IH35E (2577)
FROM NB IH35E (2226)
LAMAR EXIT (150)
GRIFFIN EXIT (152)
HARWOOD (1161)
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(2012)
(2577)
(1649)
(1984)
(3633)
(593)
(956)
(363)
(956)
(3792)
(301)
(369)
(321)
(301)
(369)
(321)
(301)
After Volumes

(PM Peak Hour)

(2529) FROM EB IH 30 (3818) TO EB IH 30
(2554) (1672) (383) (1265) (5388)

(2529) FROM SB IH35E (2554) (3818) (2529)
(2554) (1672) (383) (1265) (5388)

FROM NB IH35E (2244)
LAMA R EXIT (139)
GRiffin EXIT (258)

TO EB IH 30 (4482)
HARWOOD (413)
TO IH45 (2759)

(-748)
(+185)
(+309)
Evaluation Results

- Delay reduction of $700,000/yr.
- 31% decrease in injury crash rate
- Truck rollovers have ceased
- B/C ratio = 9:1
### Evaluation Results

<table>
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<tr>
<td>![Image]</td>
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<td>![Image]</td>
<td>+</td>
</tr>
<tr>
<td>![Image]</td>
<td>Ø</td>
</tr>
</tbody>
</table>

**Lesson learned**: even reversal of single ramp can produce significant benefits.
Emergency exit ramp built across the existing Harwood entrance ramp
Closed with a traffic gate during non-incident conditions
Construction cost = $600,000
Driving force = incident management
Property owners paid for engineering design
4 Roadway Layout
### Evaluation Results

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<tr>
<td><img src="image3.png" alt="Image 3" /></td>
<td>Ø</td>
</tr>
</tbody>
</table>

**Lesson learned**: operational flexibility provides benefits.
SB US 67 in Cedar Hill

- Reversed the SB Pleasant Run entrance with the FM 1382 exit
- Construction cost = $1,041,783
- Driving force = improved safety
- Joint funding
### Evaluation Results

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<tr>
<td><img src="image3.png" alt="Image" /></td>
<td>+</td>
</tr>
</tbody>
</table>

**Lesson learned:** ramp reversals can produce significant economic impacts.
SB IH35 in Austin

- Bottleneck project on lower level of IH 35 – southbound
  - Eliminate 2 entrances
  - Reverse two ramps
  - Add auxiliary lane
- Construction cost = $2,376,137
- Driving force = improved safety
6 Roadway Layout
IH 35 Lower Level

Photo Courtesy of texasfreeway.com
# Main Lane Speed Study

<table>
<thead>
<tr>
<th>Direction</th>
<th>Peak</th>
<th>Section</th>
<th>Speed Before (mph)</th>
<th>Speed After (mph)</th>
<th>Significant Difference?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbound</td>
<td>AM</td>
<td>51st – Airport</td>
<td>23.6</td>
<td>32.8</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Airport – 38 ½</td>
<td>53.3</td>
<td>52.9</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38 ½ – 32nd</td>
<td>55.0</td>
<td>56.3</td>
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<tr>
<td></td>
<td></td>
<td>32nd – 26th</td>
<td>56.2</td>
<td>55.8</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26th – Manor</td>
<td>55.8</td>
<td>57.9</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manor – MLK</td>
<td>56.8</td>
<td>58.4</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>PM</td>
<td>51st – Airport</td>
<td>12.6</td>
<td>19.4</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Airport – 38 ½</td>
<td>7.5</td>
<td>11.8</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38 ½ – 32nd</td>
<td>7.3</td>
<td>10.8</td>
<td>Yes</td>
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<tr>
<td></td>
<td></td>
<td>32nd – 26th</td>
<td>5.9</td>
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<td></td>
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<td>26th – Manor</td>
<td>7.8</td>
<td>10.6</td>
<td>No</td>
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<tr>
<td></td>
<td></td>
<td>Manor – MLK</td>
<td>8.0</td>
<td>11.6</td>
<td>Yes</td>
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</table>
## Frontage Road Speed Study

<table>
<thead>
<tr>
<th>Direction</th>
<th>Peak</th>
<th>Section</th>
<th>Speed Before (mph)</th>
<th>Speed After (mph)</th>
<th>Significant Difference?</th>
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<tbody>
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<td><strong>Southbound</strong></td>
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<tr>
<td>AM</td>
<td>51st – Hancock</td>
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<td>41.3</td>
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<tr>
<td></td>
<td>Hancock – 38 ½</td>
<td>8.1</td>
<td>10.9</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>38 ½ – 32nd</td>
<td>17.1</td>
<td>20.5</td>
<td>Yes</td>
<td></td>
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<tr>
<td></td>
<td>32nd – Manor</td>
<td>27.8</td>
<td>20.6</td>
<td>Yes*</td>
<td></td>
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<tr>
<td></td>
<td>Manor – MLK</td>
<td>21.3</td>
<td>23.9</td>
<td>No</td>
<td></td>
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<tr>
<td></td>
<td>MLK – 15th</td>
<td>19.5</td>
<td>36.5</td>
<td>Yes</td>
<td></td>
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<tr>
<td>PM</td>
<td>51st – Hancock</td>
<td>38.4</td>
<td>38.9</td>
<td>No</td>
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<tr>
<td></td>
<td>Hancock – 38 ½</td>
<td>5.3</td>
<td>8.3</td>
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<tr>
<td></td>
<td>38 ½ – 32nd</td>
<td>18.9</td>
<td>15.9</td>
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<tr>
<td></td>
<td>32nd – Manor</td>
<td>29.9</td>
<td>23.9</td>
<td>Yes*</td>
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<td>Manor – MLK</td>
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<td>MLK – 15th</td>
<td>25.5</td>
<td>28.4</td>
<td>No</td>
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</table>
## Safety Evaluation

<table>
<thead>
<tr>
<th>Direction</th>
<th>Condition</th>
<th>Total Crashes</th>
<th>Non-Injury</th>
<th>Minor Injury*</th>
<th>Major Injury or Fatality</th>
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</thead>
<tbody>
<tr>
<td>Southbound</td>
<td>Before (4/30/00 – 5/1/01)</td>
<td>96</td>
<td>24</td>
<td>69</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>After (10/2/01 – 9/30/02)</td>
<td>62 (-35%)</td>
<td>27 (+13%)</td>
<td>34 (-51%)</td>
<td>1 (-67%)</td>
</tr>
</tbody>
</table>

* Includes accidents classified as “possible injury”
### Evaluation Results

<table>
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<tr>
<td><img src="image1.png" alt="Image 1" /></td>
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<tr>
<td><img src="image2.png" alt="Image 2" /></td>
<td>+</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image 3" /></td>
<td>Ø</td>
</tr>
</tbody>
</table>

**Lesson learned:** proper implementation produces safety benefits.
NB IH 35 in Austin

- Bottleneck project on lower level of IH 35 – northbound
  - Eliminate 2 entrances
  - Reverse single ramp
  - Add acceleration lane

- Construction cost = $2,376,137
- Driving force = improved safety
7 Roadway Layout
### Main lane Speed Study

<table>
<thead>
<tr>
<th>Direction</th>
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<th>Speed Before</th>
<th>Speed After</th>
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<tbody>
<tr>
<td>Northbound</td>
<td>AM</td>
<td>11th – MLK</td>
<td>53.3</td>
<td>56.1</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MLK – 26th</td>
<td>57.0</td>
<td>58.0</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26th – 38 ½</td>
<td>60.1</td>
<td>61.4</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38 ½ - Airport</td>
<td>59.1</td>
<td>60.4</td>
<td>No</td>
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<tr>
<td></td>
<td></td>
<td>Airport – 51st</td>
<td>54.7</td>
<td>50.4</td>
<td>No</td>
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<tr>
<td></td>
<td>PM</td>
<td>11th – MLK</td>
<td>23.8</td>
<td>24.2</td>
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<td>No</td>
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<tr>
<td></td>
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<td>38 ½ - Airport</td>
<td>37.1</td>
<td>48.3</td>
<td>No</td>
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<td></td>
<td></td>
<td>Airport – 51st</td>
<td>34.3</td>
<td>38.0</td>
<td>No</td>
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## Frontage Road Speed Study

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<tbody>
<tr>
<td>Northbound AM</td>
<td>MLK – Manor</td>
<td>26.0</td>
<td>10.5</td>
<td>Yes*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manor – 32&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>19.6</td>
<td>15.7</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32&lt;sup&gt;nd&lt;/sup&gt; - 38 ½</td>
<td>32.1</td>
<td>35.8</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>38 ½ – Hancock</td>
<td>16.6</td>
<td>21.1</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Northbound PM</td>
<td>MLK – Manor</td>
<td>26.2</td>
<td>12.1</td>
<td>Yes*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manor – 32&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>19.2</td>
<td>27.5</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32&lt;sup&gt;nd&lt;/sup&gt; – 38 ½</td>
<td>30.5</td>
<td>27.0</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>38 ½ - Hancock</td>
<td>13.3</td>
<td>12.6</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MLK – 15&lt;sup&gt;th&lt;/sup&gt;</td>
<td>25.5</td>
<td>28.4</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

- Significant delay impacts are noticed in the after data collection due to the installation of a traffic signal at the Manor interchange along IH 35; these delays are not necessarily related just to the geometric reconfiguration of the lower level.
# Safety Evaluation

<table>
<thead>
<tr>
<th>Direction</th>
<th>Condition</th>
<th>Total Crashes</th>
<th>Non-Injury</th>
<th>Minor Injury*</th>
<th>Major Injury or Fatality</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>Before (4/30/00 – 5/1/01)</td>
<td>64</td>
<td>13</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>NB</td>
<td>After (10/2/01 – 9/30/02)</td>
<td>37 (-42%)</td>
<td>9 (-31%)</td>
<td>28 (-44%)</td>
<td>0 (-100%)</td>
</tr>
</tbody>
</table>

* Includes accidents classified as “possible injury”
Lesson learned: speed and throughput should be considered together in evaluating performance.
Reversed the FM 2410 entrance with the W.S. Young exit ramp

Construction cost = $1,169,149

Driving force = commercial development & accommodate increased traffic volumes

City of Killeen contributed $250,000
Aerial Photograph

Mall

Entrance

Exit
Lesson learned: side of freeway with reversals operates better.
SB IH 35E in Denton

- Reversed the southbound State School entrance with the Loop 288 exit ramp
- Construction cost = $1,242,529
- Driving force = improve access to the gateway roadway to a large master planned development
- City of Denton paid for engineering design services
Aerial Photograph

Golden Triangle Mall

New Exit

New Entrance
Lesson learned: Close coordination can lead to a project that is positive for all stakeholders.
Reversed the State School entrance with the Loop 288 exit ramp

Construction cost = $1,427,790

Driving force = commercial development & relieve congestion at Loop 288 intersection

City of Denton paid for engineering design services
## Evaluation Results

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image 122x78 to 193x726" /></td>
<td>+</td>
</tr>
<tr>
<td><img src="image2.png" alt="Image 150x46 to 183x90" /></td>
<td>+</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image 528x60 to 562x208" /></td>
<td>+</td>
</tr>
<tr>
<td><img src="image4.png" alt="Image 520x363 to 574x434" /></td>
<td>+</td>
</tr>
</tbody>
</table>
Lesson learned: consideration of frontage road capacity is important – particularly if the cross section is only 2 lanes.
Reversed the northbound Fox Avenue entrance with the FM 1171 exit ramp
Added auxiliary lane on frontage road
Construction cost = $1,012,826
Driving force = improve safety – eliminate frequent queue spillback problem
Aerial Photograph

FM 1171/Main St.
IH 35E
Fox Ave.
Lesson learned: safety and response time of emergency vehicles & access to emergency medical facilities are important to consider.
EB US 190 in Harker Heights

- Reversed the FM 3470 entrance with the FM 2410 exit ramp
- Construction cost = $986,747
- Driving force = improve access to a new Wal-Mart Supercenter
- Joint funding effort

Photo from Flickr.com (public)
Aerial Photograph
Lesson learned: Agreements to share funding can help accelerate project implementation.
US 83 in Abilene

- X-ramp corridor project
- Main lanes widened from 4 to 6 lanes
- Frontage road capacity unchanged – 2 lanes
- Construction cost = $20,000,000
- Driving force = improve traffic flow and access to businesses
Aerial Photograph
Negative Publicity

- Local newspaper headlines:
  - Freeway mess
  - Freeway ramps confuse drivers
  - Engineers work to fix signal timing
  - Tough exits
- Anecdotally
  - Main lane volumes & congestion decreased
  - Frontage road volumes & congestion increased
Lesson learned: X-ramp corridor projects cause substantial shifts in volumes on the frontage road and this needs to be planned for.
US 83 in Pharr

- X-ramp corridor project
- Main lanes widened from 4 to 6 lanes
- Conway Avenue to Sugar Road
- Construction cost = $36,600,000
- Driving force = rapid growth and projected decrease in traffic operations
Aerial Photograph
## Operational Benefits

<table>
<thead>
<tr>
<th>Corridor Component</th>
<th>Net Present Cost Due to Delay, $Millions(^1)</th>
<th>Net Benefits $Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing Geometrics</td>
<td>Proposed Improvements</td>
</tr>
<tr>
<td>Freeway main lanes</td>
<td>38.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Cross-street interchanges</td>
<td>142.3</td>
<td>25.9</td>
</tr>
<tr>
<td>Frontage roads</td>
<td>0.2</td>
<td>4.1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$181.3</td>
<td>$31.3</td>
</tr>
</tbody>
</table>

\(^1\) The net present cost of delay during the peak hours (AM + PM) over 20 years, assuming a discount rate of 4%, 250 working days per year, and a value of time of 10.78 per veh.-hr.
### Lesson learned:

X-ramp corridor projects can produce significant operational benefits compared to diamond or hybrid configurations.
SH 258 in Corpus Christi

- SH 258 is South Padre Island Dr.
- X-ramp corridor project
- Main lanes will be widened from 4 to 6 lanes in phases
- Project limits: SH 286 Crosstown Expressway to Airline Drive
- Driving force = safety issues and to improve traffic operations

Graphic from Corpus Christi Caller-Times
Effective promotion:

- Newsletters
- Press releases
- Presentations
- Outreach to local businesses
- Local media coverage
## Evaluation Results

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="evaluation_image" alt="Evaluation Image" /></td>
<td>+</td>
</tr>
<tr>
<td><img src="evaluation_image" alt="Evaluation Image" /></td>
<td>+</td>
</tr>
<tr>
<td><img src="evaluation_image" alt="Evaluation Image" /></td>
<td>Ø</td>
</tr>
</tbody>
</table>

**Lesson learned:** Thorough evaluation & well-planned public education can lead to project implementation even in complex corridors.
MODULE 6
PROJECT EVALUATION
Project Evaluation Process

- Evaluation criteria
- Data collection activities
- Traffic analysis tools for project evaluation
- Evaluation framework
- Decision flowchart
  - Cost-effectiveness procedure for ramp reversals
  - Warrants for grade separated ramps
Evaluation Criteria

- Traffic volumes
- Ramp spacing
- Weaving
- Capacity/LOS
- Interchange type
- Cross-street operation
- Auxiliary lanes
- Access
- Queuing
Data Collection Activities

- Traffic volumes
- Travel times
- Queue lengths
- Physical inventory

Photo Courtesy of Texas Transportation Institute
Traffic Analysis Tools

- Model selection
  - FHWA Toolbox
- Microscopic models
  - CORSIM
  - VISSIM
Project Evaluation Framework

- Define purpose and need
- Collect data
- Select analysis tool(s)
- Perform analysis
- Assess viability
Decision Flowchart – Part I

Reversal, X-ramp or Braided Ramp?

Freeway data
- Total volume
- Weaving volumes
- # of lanes
- Vehicle mix

Frontage road data
- Volume
- Weaving
- # of lanes
- Type of operation
- Speed
- Property access
- Location to access

Main lane data
- Volume
- Vehicle mix
- Ramp spacing
Decision Flowchart – Part II

- Are there operational concerns with exit ramp separation from the cross-street? Does it meet guidelines?
- Are there weaving problems on the frontage road or main lanes? Does ramp terming spacing meet guidelines?
- Are there safety or property access concerns that need to be addressed?
Decision Flowchart – Part III

Would the reversal of a single ramp provide operational or safety benefits?

Perform alternatives analysis

Would the reversal of a multiple ramp pairs provide operational or safety benefits?

Use cost-effectiveness evaluation procedure
Evaluation Procedures

- Ramp reversal
  - TTI research project 210-12F
- Cost-effectiveness
- Flowchart
Evaluation Procedures

Grade-separated (i.e., braided) ramps
- TTI research project 376
- Warrants based on volume and crash rate thresholds
- 1,600 vph
MODULE 7
GUIDELINES FOR SUCCESSFUL IMPLEMENTATION OF RAMP REVERSAL AND X-RAMP PROJECTS
Guidelines Development

- Guidelines should be:
  - Clear
  - Concise
  - Practical
Guidelines Synergy

- Ramp modifications
- Access management
Access Management Themes

Texas Access Management Themes . . .

- Improve Safety and Mobility
- Provide Reasonable Access to Developments
- Promote Local Government Partnerships

Graphic from Report No. 0-4141-P3, Texas Transportation Institute
Guidelines Framework

- 5 categories (based on 5Es of SR2S)
  - Educational
  - Encouragement
  - Engineering
  - Enforcement
  - Evaluation
Guideline 1: Educational

Use the local media, department resources and other innovative techniques to promote projects:

- prior to construction
- during construction
- after completion
- following evaluation
Prior to Construction

Arlington

City aims to reduce traffic
The $7 million project hopes to reduce congestion in the I-20 and South Cooper Street corridor.
City Celebrates Progress of $7 Million Ramp Reversal Project at Interstate 20
Officials Say Cooperative Project is Six Months Ahead of Schedule

by Cheryel Carpenter
October 12, 2001
Following Evaluation

Fort Worth Star-Telegram
Accidents up on improved IH 20 frontage road

TTI Analysis
Crash rate actually significantly reduced

Crash Frequency

<table>
<thead>
<tr>
<th># of Crashes</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Crash Rate

<table>
<thead>
<tr>
<th>Rate per 100 MV</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

112
Guideline 2: Educational

- Develop fact sheets, brochures, newsletters or other media to educate the public and stakeholders of the proposed project.
Online Fact Sheet

Expressway

SH 6 (Earl Rudder Freeway) Ramp / Frontage Road Improvements - From Greens Prairie Road to FM 159

Brazos County

The Bryan District is currently developing a project to improve traffic flow within the SH 6 corridor. The improvements will include adjustment or addition of access ramps, conversion of the frontage roads to one-way operation and construction of additional turn-around interchanges. Public meetings were held to assist in determining the preferred improvements.

No new right-of-way acquisition is required for this project.

Construction is anticipated to begin in 2008.

Additional information about this project can be obtained by contacting:

Mr. Karl Nelson, P.E.
Bryan Area Engineer

Phone: 979-779-8233
Fax 979-779-1375
Email: knelson@dct.state.tx.us

Bryan Area Office
2102 Tabor Road - In Bryan

Back to Brazos County project list

Return to Bryan District county list

Graphic from TxDOT website - www.dot.state.tx.us
Good job of highlighting project goals
Guideline 3 - Educational

- Develop educational and promotional messages consistent with the three access management themes.
  - Improve safety and mobility
  - Provide reasonable access to developments
  - Promote local government partnerships
Guideline 4 - Encouragement

- Encourage funding contributions from local government entities and private developers to offset project implementation costs.
US 190 in Harker Heights

$350,000

$242,000

$350,000

- TxDOT
- Harker Heights
- Wal-Mart
Guideline 5 - Encouragement

- Encourage local government entities and business owners to consider access revisions of frontage road driveways as part of the ramp modification project.
Driveway Closure/Consolidation

Photo Courtesy of Texas Transportation Institute
Guideline 6 - Engineering

- Provide adequate storage to prevent vehicles from stacking onto the main lanes.

Photo Courtesy of Innovative Transportation Solutions, Inc. - Dallas
Exit Ramp Spillback

- Queue spillback from exit ramps is a common occurrence in urban areas, particularly at locations where inadequate storage is available.

Photo Courtesy of NCTCOG
Avoid Unsafe Situation

11-vehicle accident
- Time: About 8 a.m. today
- Vehicles involved: 11
- What happened: A westbound truck sideswipes and weaves by cars before pinning one car to a left guardrail; fire erupts
- Casualties: One killed and 12 injured

Graphic from Honolulu Star-Bulletin Article
### Table 3-16: Desirable Space Between Exit Ramps and Driveways, Side Streets, or Cross Streets

<table>
<thead>
<tr>
<th>Total Volume (Frtg Rd + Ramp) (vph)</th>
<th>Driveway or Side Street Volume (vph)</th>
<th>Spacing (ft [m])</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number of Weaving Lanes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>&lt;2500</td>
<td>&lt;250</td>
<td>460 [140]</td>
</tr>
<tr>
<td>-</td>
<td>&gt;250</td>
<td>520 [160]</td>
</tr>
<tr>
<td>-</td>
<td>&gt;750</td>
<td>790 [240]</td>
</tr>
<tr>
<td>-</td>
<td>&gt;1000</td>
<td>1000 [300]</td>
</tr>
<tr>
<td>&gt;2500</td>
<td>&lt;250</td>
<td>920 [280]</td>
</tr>
<tr>
<td>-</td>
<td>&gt;250</td>
<td>950 [290]</td>
</tr>
<tr>
<td>-</td>
<td>&gt;750</td>
<td>1000 [300]</td>
</tr>
<tr>
<td>-</td>
<td>&gt;1000</td>
<td>1000 [300]</td>
</tr>
</tbody>
</table>
Guideline 7 - Engineering

- Provide adequate distance between successive ramps to facilitate safety and mobility.

Graphic from AASHTO Green Book
Minimum weaving length without auxiliary lane 2000 ft (600 m)
Minimum weaving length with auxiliary lane 1500 ft (450 m)

Desirable control points A-A

ENTRANCE RAMP FOLLOWED BY EXIT RAMP

CASE 1

Minimum distance 1000 ft (300 m)

ENTRANCE RAMP FOLLOWED BY ENTRANCE RAMP

CASE 3

This situation will be encountered only on infrequent occasions and special design treatment will be required. It will usually require an added freeway lane.

EXIT RAMP FOLLOWED BY EXIT RAMP

CASE 2

EXIT RAMP FOLLOWED BY ENTRANCE RAMP

CASE 4

The distance between an exit ramp followed by an entrance ramp will be governed by the geometrics of the connections to the adjacent roadway or connecting roadway.

ARRANGEMENTS FOR SUCCESSIVE RAMPS

The distances shown above are generally used but reference should be made to the AASHTO publication "A Policy on Geometric Design of Highways and Streets" and the Highway Capacity Manual for more specific information since operational aspects are influenced by traffic volumes and may require longer distances.
Case 1: EN-EX

- Minimum weaving length without auxiliary lane: **2,000 ft**
- Minimum weaving length with auxiliary lane: **1,500 ft**
Case 2: EX-EX

Minimum distance of 1,000 ft
Case 3: EN-EN

This situation will be encountered only on infrequent occasions and special design treatment will be required. It will usually require an added freeway lane.
Case 4: EX-EN

The distance between an exit ramp followed by an entrance ramp will be governed by the geometrics of the connections to the adjacent roadway or connecting roadway.

800 ft
Guideline 8 - Engineering

Consider the use of braided ramps when economic, geometric and traffic flow conditions are favorable.

Grade-separated ramps should be considered when the volume of the entrance and exit ramp pair exceeds 1,600 vphpl.
Aerial View of Braided Ramps
Guideline 9 - Engineering

Provide auxiliary lanes to mitigate merging impacts and provide operational continuity at strategic locations.
Guideline 10 - Engineering

- Provide adequate capacity on the frontage road to service anticipated traffic demands.

Photo Courtesy of Texas Transportation Institute
Frontage Road Operational Evaluation

- Level-of-service procedures
- Not required in Interstate Access Justification report, but should be
- Avoid problems and public backlash
- Particularly important if the frontage road is **two lanes**
Guideline 11 - Engineering

Adjust signalized intersection operations to account for traffic pattern changes caused by the ramp modifications.

Photo Courtesy of Texas Transportation Institute
Guideline 12 - Engineering

- Develop construction staging and traffic control plans to minimize the negative impacts of the ramp modification project.

Photo Courtesy of Texas Transportation Institute
Guideline 13 - Engineering

Consider changes to frontage road driveway access to promote safe and efficient operations with the revised ramp locations.

Photo Courtesy of Texas Transportation Institute
Access Control @ Exit Ramps

Graphic from TxDOT Roadway Design Manual, October 2005 (Figure 3-13)

1. For exit ramp to driveway, side street, or cross street spacings, see Table 3-16.

2. When the 250 ft [75 m] separation distance cannot be obtained, consideration should be given to channelization methods that would restrict access to driveways within the 250 ft [75 m] separation distance.

Note: This sheet is not intended to show channelization, striping, or pavement marking details. Refer to the Texas MUTCD.
Access Control @ Entrances

Graphic from TxDOT Roadway Design Manual, October 2005 (Figure 3-14)

When the 100 ft [30 m] separation distance cannot be obtained, consideration should be given to channelization methods that would restrict access to driveways within the 100 ft [30 m] separation distance.

NOTE: THIS SHEET IS NOT INTENDED TO SHOW CHANNELIZATION, STRIPING, OR PAVEMENT MARKING DETAILS. REFER TO THE TEXAS MUTCD.
Guideline 14 - Engineering

- Account for the impacts of revised ramp configuration on access to hospitals and other emergency medical facilities.
Guideline 15 - Engineering

- Make necessary revisions to guide and wayfinding signing so that motorists can react properly to the ramp modification project.
Guideline 16 - Engineering

Ramp reversals should be considered when frontage roads are being converted from two-way to one-way operation.

Photo Courtesy of Texas Department of Transportation
Guideline 17 - Enforcement

- Coordinate with law enforcement officials for speed enforcement on frontage roads following ramp modifications.

Photo Courtesy Flickr.com (public)
Guideline 18 - Enforcement

- Utilize speed trailers or other speed mitigation techniques to supplement enforcement efforts.

![Speed Limit Signs](image)
Guideline 19 - Evaluation

- Utilize traffic simulation models to evaluate and justify complex projects.
Guideline 20 - Evaluation

For interstate projects, follow the requirements contained in Section 4 Additional Access to the Interstate System of the Roadway Design Manual.
Guideline 21 - Evaluation

If evaluation studies are performed prior to project implementation, consider the operational impacts (capacity and level-of-service) on both the freeway main lanes and frontage road facilities.
WRAP-UP

How to implement a successful ramp reversal, braided ramp or X-ramp corridor project
When to Consider Reversed and X-ramp Implementation

6 scenarios:
- Locations where a significant level of existing or planned development is located along the frontage road.
- New construction of a freeway corridor in an urban or suburban setting.
- An existing freeway corridor is undergoing complete reconstruction.
- A lack of adequate spacing between the exit ramp and cross street exists that routinely causes exiting queues to back up onto the freeway main lanes.
- During conversion of frontage roads from two-way to one-way operations.
- When an evaluation study shows that ramp modifications will significantly improve the overall operational performance and produce a benefit-cost ratio greater than 1.0.
Parting Message

Overall, case studies show that the operational, safety and basic economic impacts of ramp modification projects are primarily positive in nature. Further implementation of this type of project is strongly recommended using the guidance developed in the 5105 research.
Questions?

0-5105 Project Summary Report is Online at: