Potential Rural Expressway Intersection Safety Treatments

Research Conducted in Coordination with NCHRP 15-30,
"Median Intersection Design for Rural High-Speed Divided Highways"

Presented by:

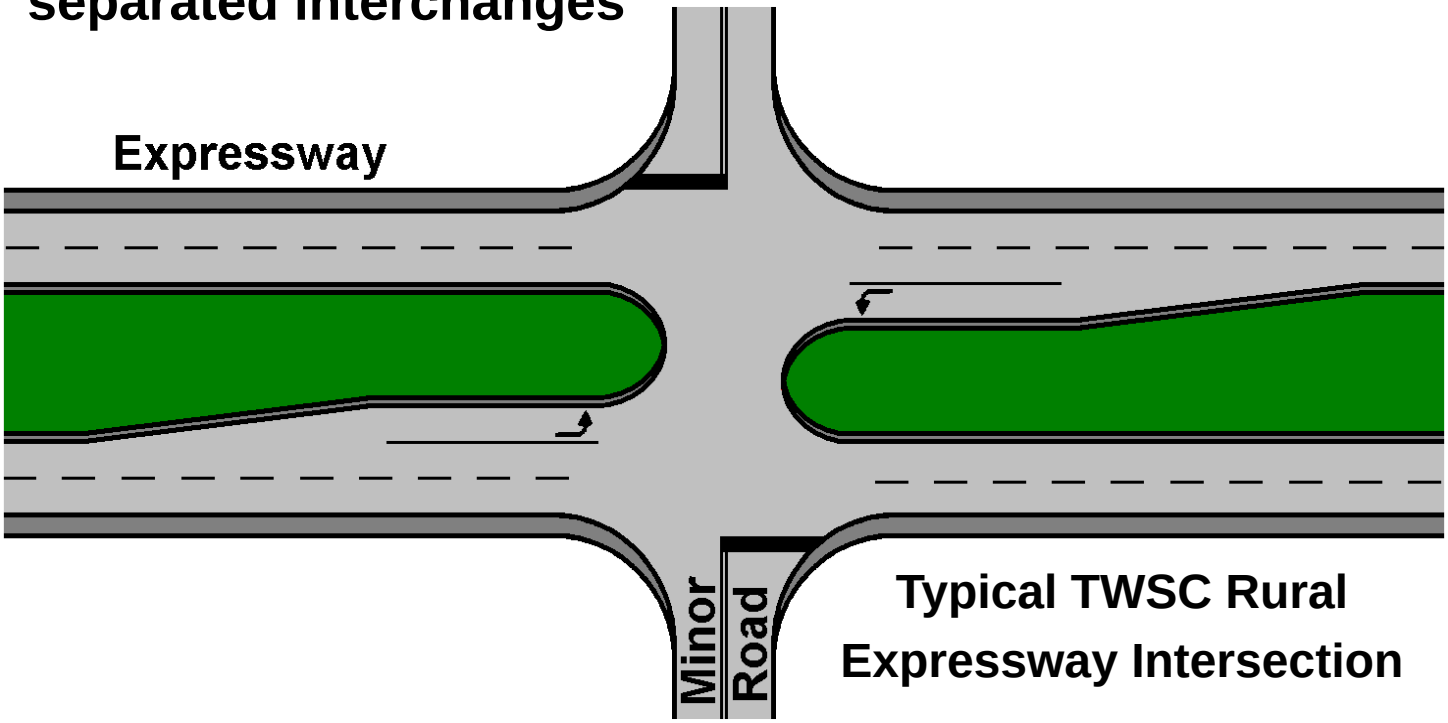
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INTRODUCTION

- **What is a Rural Expressway?**
  - **A high speed (≥ 50 mph), multi-lane, divided highway with partial access control.**
  - **Typically divided by a wide, depressed, turf median**
  - **Presents a combination of at-grade intersections & grade separated interchanges**



Typical TWSC Rural Expressway Intersection

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NEBRASKA



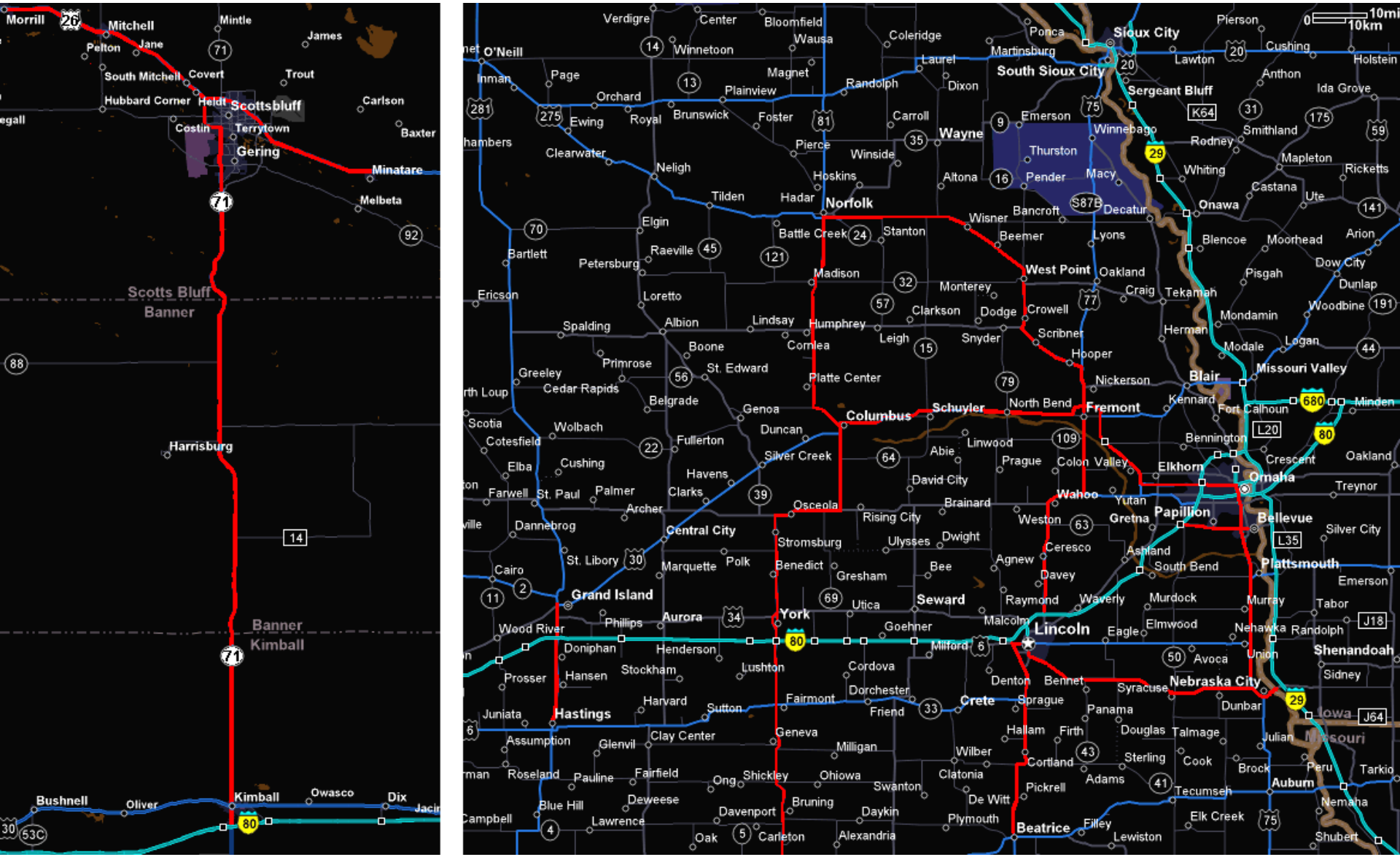
MISSOURI

Converting 2-Lane Highways to Expressways

- Popular Highway Safety Improvement In Many States
  - Why?
    - Provide Freeway Capacity @ Lesser Expense
    - Make Passing Easier/Safer
    - Reduce Likelihood of Head-On & Opposite Direction Sideswipe Collisions



- Expressways Fastest Growing Component in US Highway System
  - Expressway Mileage Increased ≈ 2600 miles (1996 – 2002)
- Expansion Expected to Continue
  - 26/28 DOT's Plan to Expand Expressway System Over Next 10 Years



Nebraska Expressway System

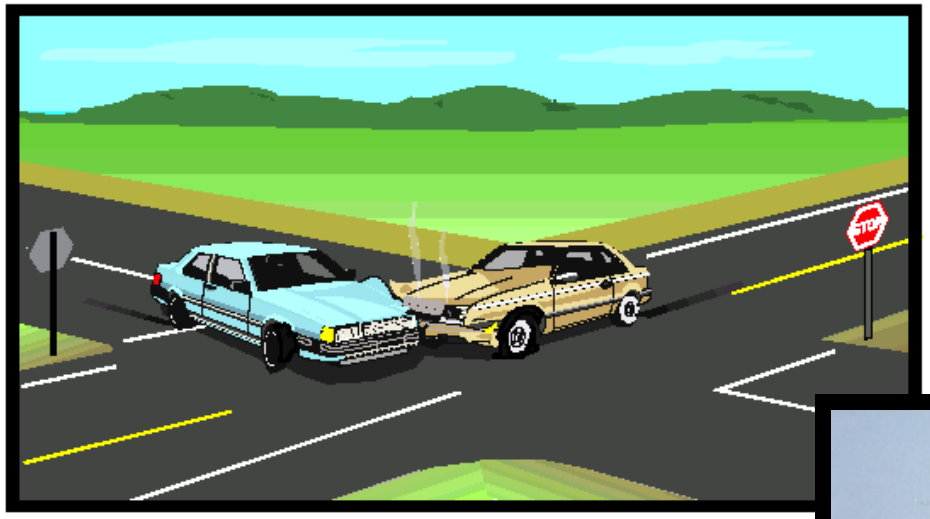
(≈ 600 Miles Functionally Classified as Expressway)

Nebraska Highway Crash Experience (2-Lane vs. 4-Lane Expressway)

CRASH TYPE	CRASH RATES (crashes/million vehicle miles) 324 MI OF RURAL 2-LANE HWYS PLANNED FOR EXPRWY CONVERSION	111 MI OF RURAL 4-LANE DIVIDED EXPRWYS (ADT < 8000 vpd)	PERCENT DIFF.
All Crashes	**0.942**	**0.991**	**+ 5.2**
Fatal	0.022	0.015	-31.8
Injury	0.324	0.309	-4.6
Property Damage Only	0.596	0.668	+ 12.1
Intersection-Related Crashes	**0.231**	**0.236**	**+ 2.2**
Single Vehicle Crashes	**0.556**	**0.661**	**+ 18.9**
Run-Off-Road	0.213	0.247	+ 16.0
Animal	0.309	0.381	+ 23.3
Multiple Vehicle Crashes	**0.386**	**0.330**	**-14.5**
Sideswipe (Opposite)	0.067	0.005	-92.5
Head-On	0.012	0.004	-66.7
Rear-End	0.131	0.093	-29.0
Sideswipe (Same)	0.064	0.051	-20.3
Left-Turn	0.026	0.025	-3.8
Right-Angle	**0.087**	**0.149**	**+ 71.3**

Source: Nebraska Department of Roads Highway Safety Division, *Accident Experience of Rural Highways: Two-Lane Versus Four-Lane Expressways*, February 2000.

PROBLEM STATEMENT



- Right-Angle Intersection Collisions on Rural Expressways Are Reducing the Safety Benefits That Should Be Achieved When Converting Rural 2-Lane Highways To Expressways



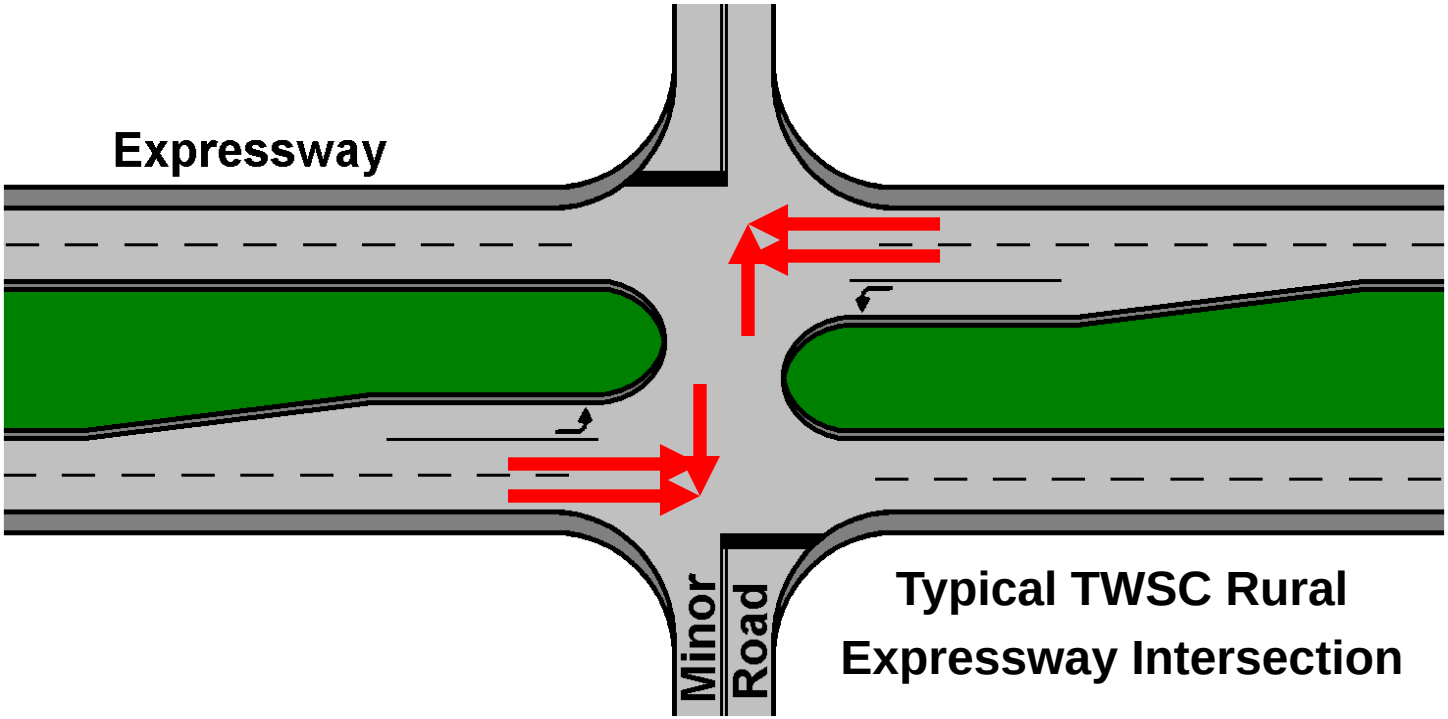
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PROBLEM STATEMENT

- **Problem Not Specific To Nebraska**
  - Minnesota, Utah, & Iowa Data Have Shown Similar Trends
  - Greater Than 50% of Expressway Intersection Crashes are Right-Angle Collisions
- **2004 Mn/DOT Study Discovered . . .**
  1) Rural expressway intersections have a greater proportion of right-angle collisions than intersections on 2-lane highways.
  2) 87% of right-angle crashes were due to inability of minor road drivers to select safe gaps.
  3) 78% of right-angle crashes were “far-side” collisions.
  4) Intersection recognition by drivers on minor approaches was not a contributing factor.

PROBLEM STATEMENT SUMMARY

- Primary Rural Expressway Intersection Safety Problem is Right-Angle, Far-Side Collisions
- Underlying Cause = Poor Gap Selection Choices By Left-Turning & Crossing Minor Road Drivers



Typical TWSC Rural Expressway Intersection

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PROJECT OBJECTIVES

- **Active Project NCHRP 15-30**
  - **Recommending improvements to the AASHTO Green Book & MUTCD regarding intersection design on rural expressways.**

    http://www4.trb.org/trb/crp.nsf/NCHRP+projects

    (Click on Area 15)

- **TASKS**

  1) **Review Current Green Book & MUTCD Design Guidance (Identify Areas Where Guidance is Lacking)**
  2) **Literature Review (Identify Safe Design Treatments)**
  3) **Survey of State DOTs (Case Studies of Innovative Intersection Design Treatments)**
  4) **Develop Recommended Text for the Green Book & MUTCD**

Potential Rural Expressway Intersection Safety Treatments

- DOT's Have Experimented with a Wide Range of Intersection Safety Treatments at Problematic Rural Expressway Intersections to Improve Safety Performance While Avoiding Costly Grade Separation.

- These Treatments Can Be Divided Into 3 Broad Categories
  1) Conflict Point (Access) Management
  2) Gap Selection Aids
  3) Intersection Recognition Devices

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CONFLICT POINT MANAGEMENT

- Conflict points represent the locations where vehicle paths cross as they move from one leg to another.
- Conflict point management treatments remove, reduce, or control the number and type of conflicts that can occur at an intersection.
- Intersection conflict point analysis suggests that the more conflict points an intersection design has, the more dangerous it will be.
  - Assumes crash risk is equal at each conflict point
- However, the crash risk associated with each point actually varies depending on the complexity and volumes of the movements involved.

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CONFLICT POINT MANAGEMENT

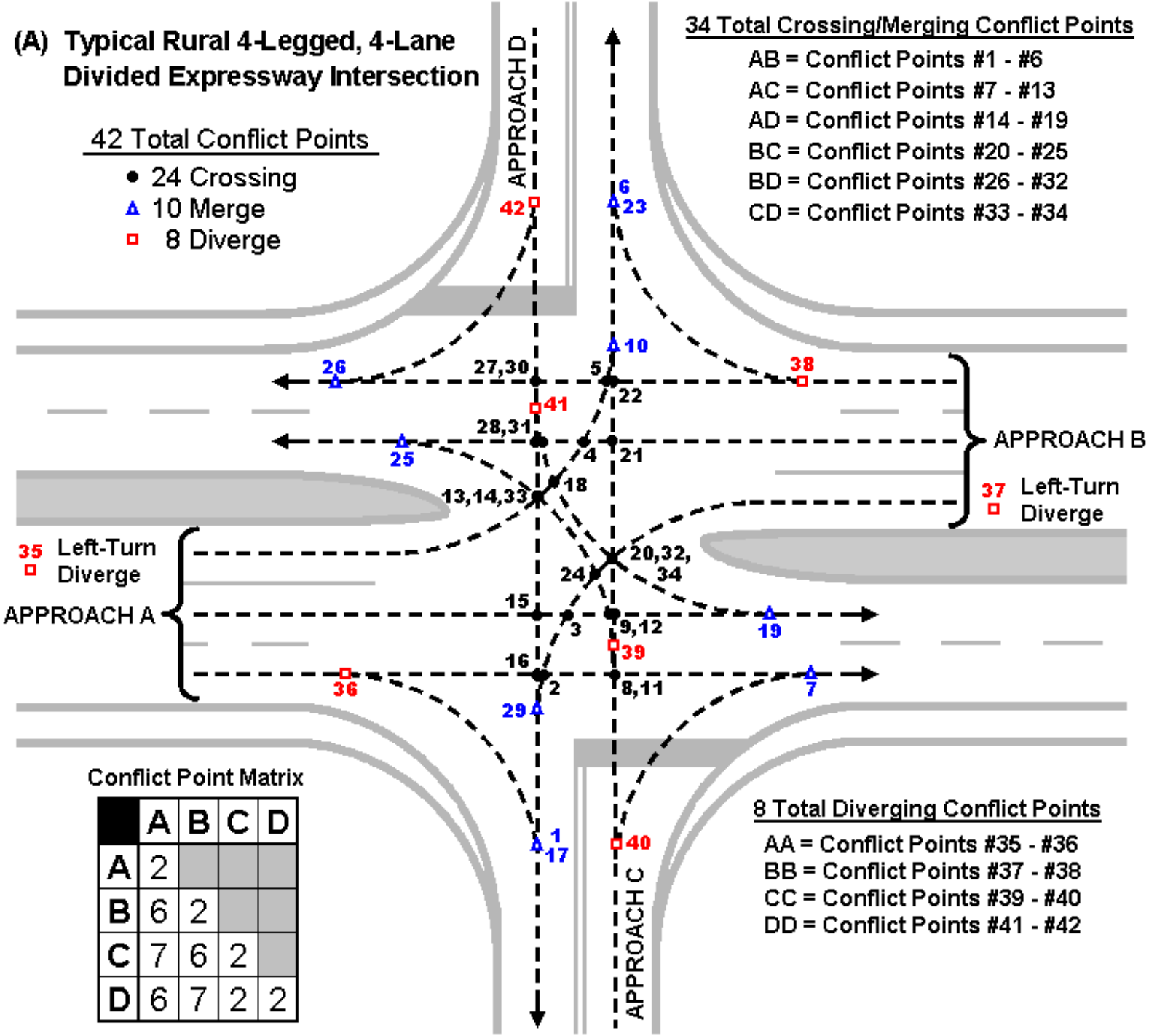
- **Conflict Point Management Treatments Include:**
  1) Conversion to Grade Separation/Interchange
  2) Use of Frontage Roads to Remove Low Volume Intersections
  3) Conversion of 4-Legged Intersections to 3-Legged
  4) Use of Indirect Movements
     - J-Turn Intersection Design
     - Loops
     - Jug-Handles
  5) Providing Left/Right-Turn Lanes or Longer Lanes
  6) Providing Right-Turn Ramps
  7) Reducing Median Opening Length
  8) Signalization

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CONVERSION TO T-INTERSECTIONS

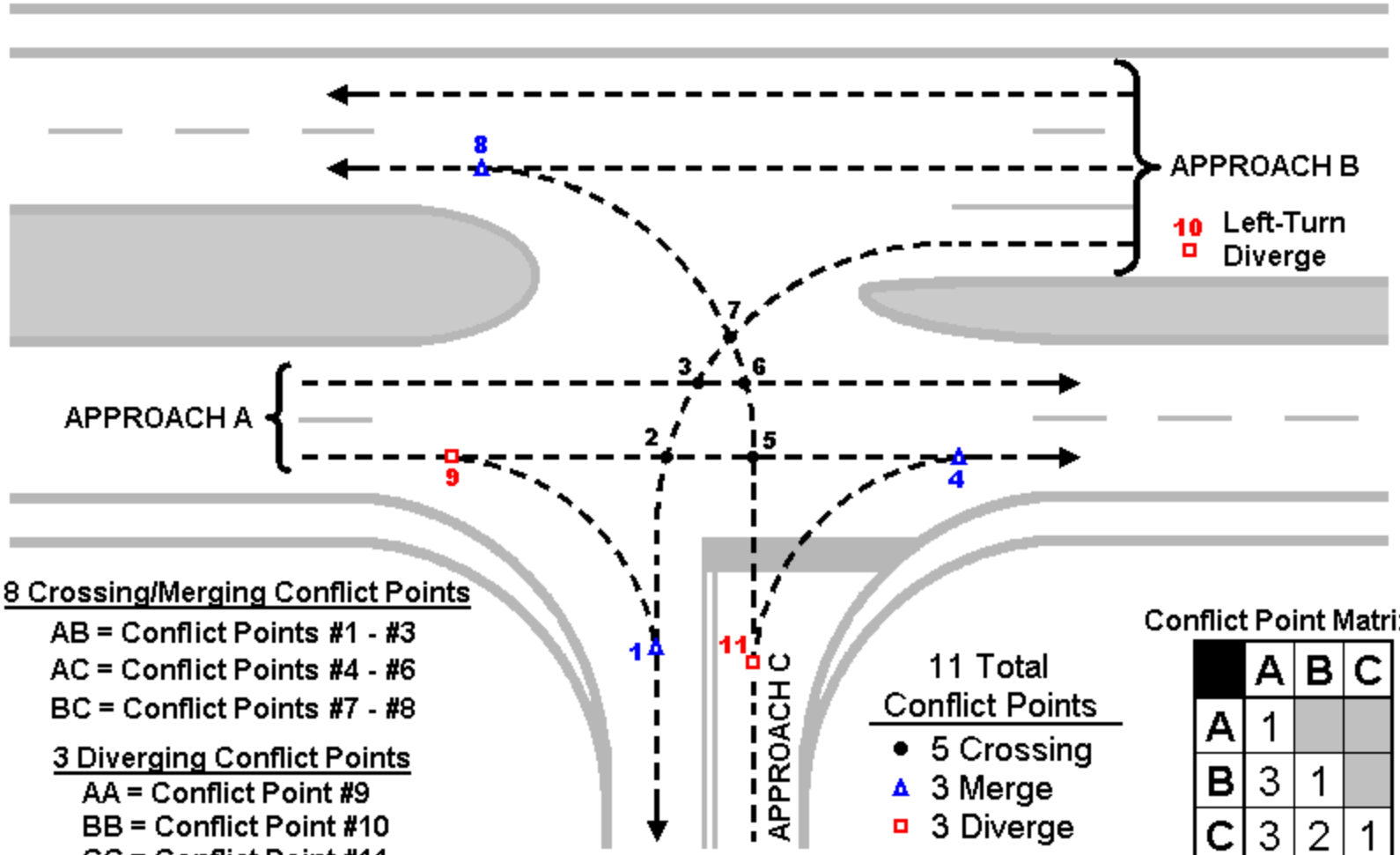
- Crash models developed in NCHRP 375 (1995) revealed that crash frequency and rates at 3-legged expressway intersections are substantially lower than at 4-legged.
- This has long been acknowledged since 3-legged intersections have fewer conflict points
  - 4-Legged Expressway Intersection = 42
  - 3-Legged Expressway Intersection = 11 (75% less)
- Therefore, converting four-legged expressway intersections to three-legs should improve rural expressway intersection safety
  - Alabama DOT has experienced positive results

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	A	B	C	D
A	2			
B	6	2		
C	7	6	2	
D	6	7	2	2

(B) Typical Rural 3-Legged, 4-Lane Divided Expressway Intersection



8 Crossing/Merging Conflict Points

AB = Conflict Points #1 - #3
AC = Conflict Points #4 - #6
BC = Conflict Points #7 - #8

3 Diverging Conflict Points

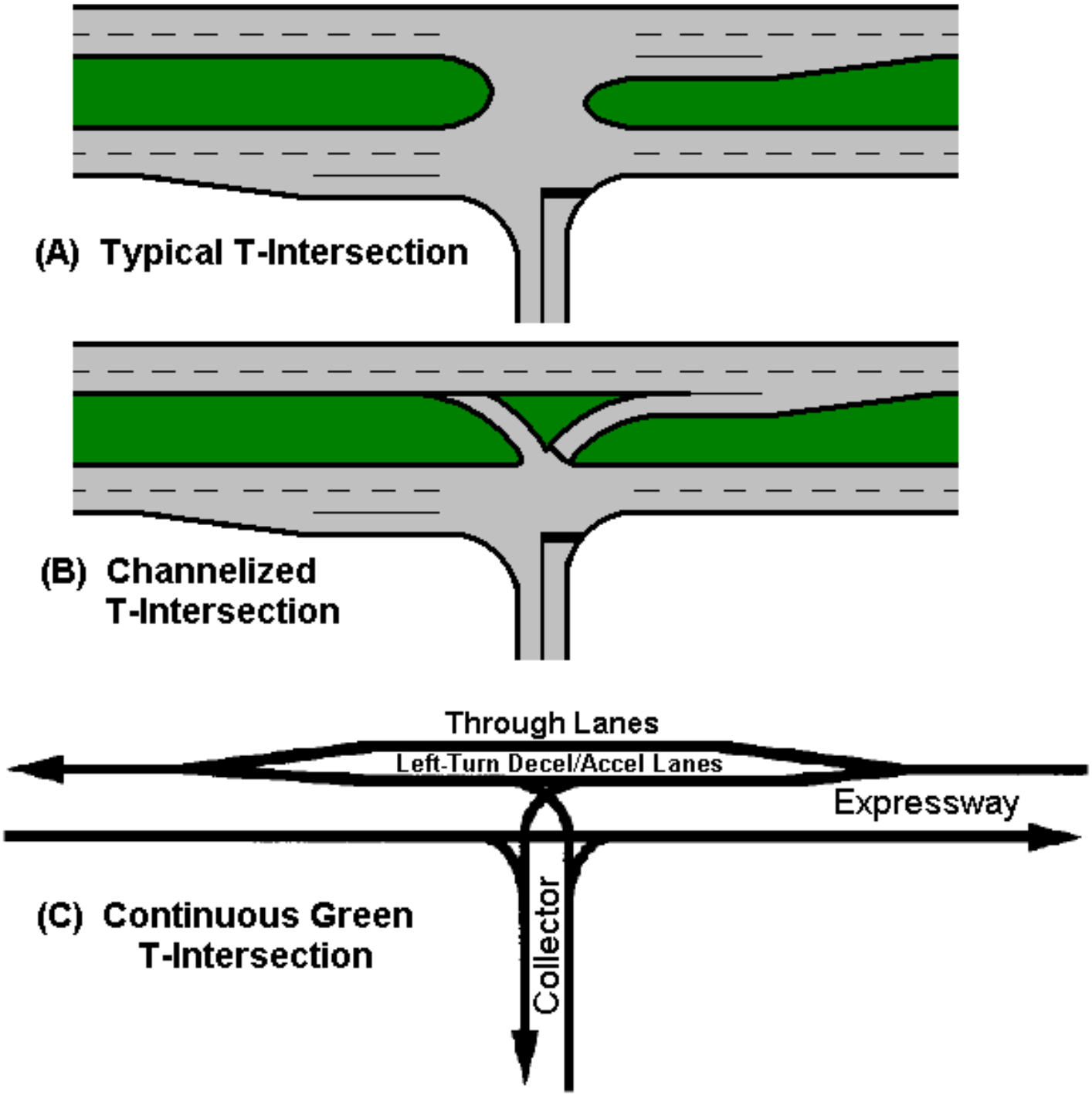
AA = Conflict Point #9
BB = Conflict Point #10
CC = Conflict Point #11

11 Total Conflict Points

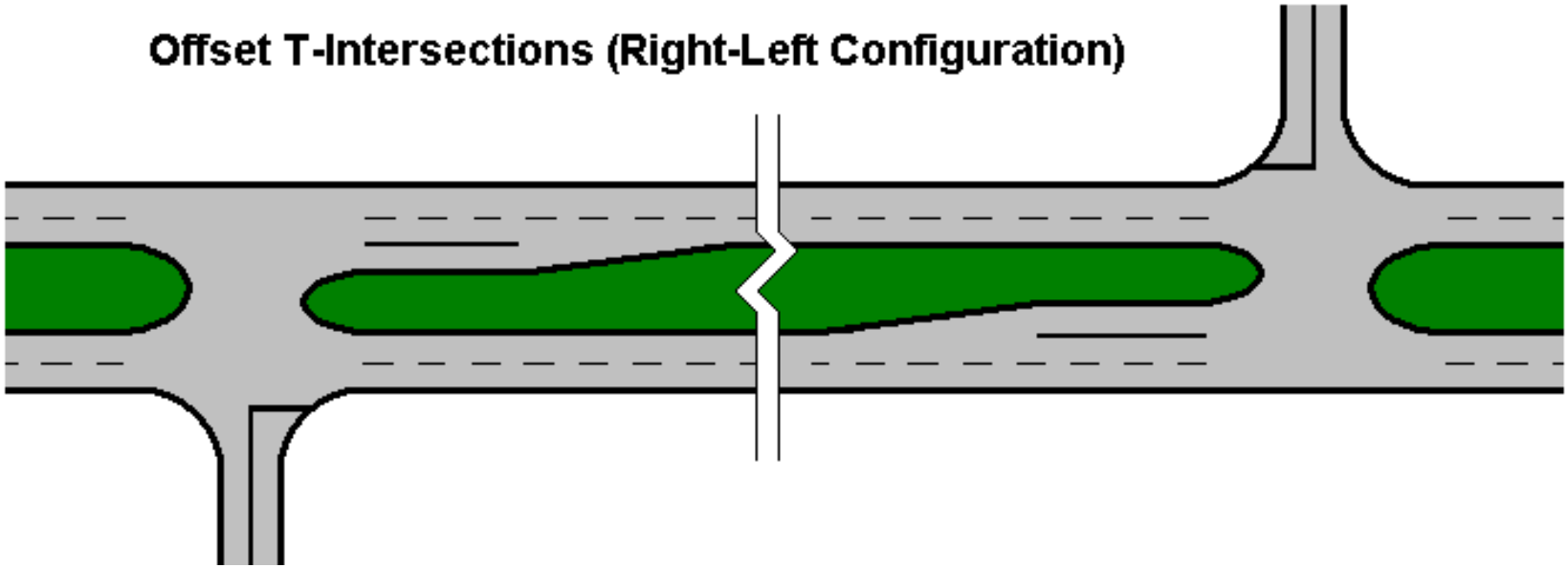
- 5 Crossing
- 3 Merge
- 3 Diverge

Conflict Point Matrix

	A	B	C
A	1		
B	3	1	
C	3	2	1


(A) Typical T-Intersection
(B) Channelized T-Intersection
Through Lanes
Left-Turn Decel/Accel Lanes
Expressway
Collector
(C) Continuous Green T-Intersection

Offset T-Intersection

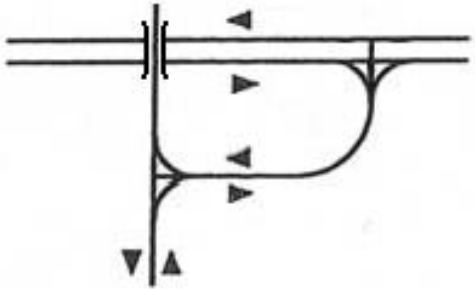


- Right-Left Configuration Preferred over Left-Right
- Proper Spacing?
  - 500 Feet to ½ Mile (Minimum Intersection Spacing Used)
- Identifying Opportunities to Create Offset T Intersections should be part of initial expressway corridor development process.

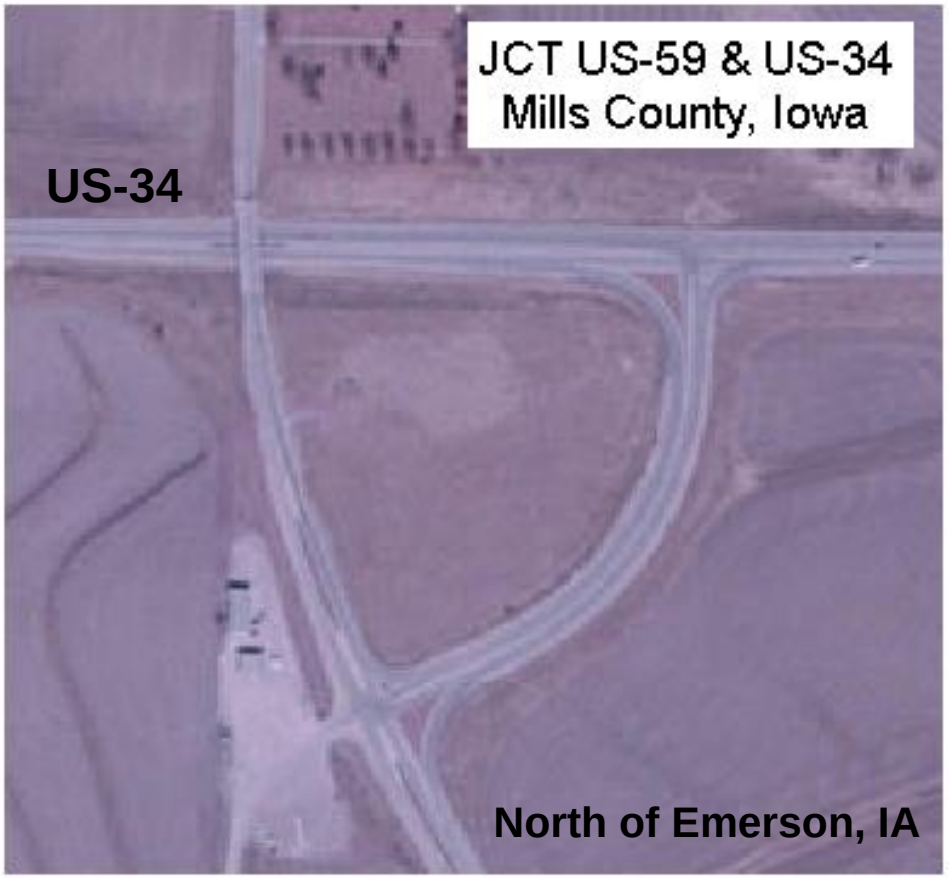
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One-Quadrant Interchange

One-Quadrant Interchange Design



Green Book Exhibit 10-1c



J-TURN INTERSECTION

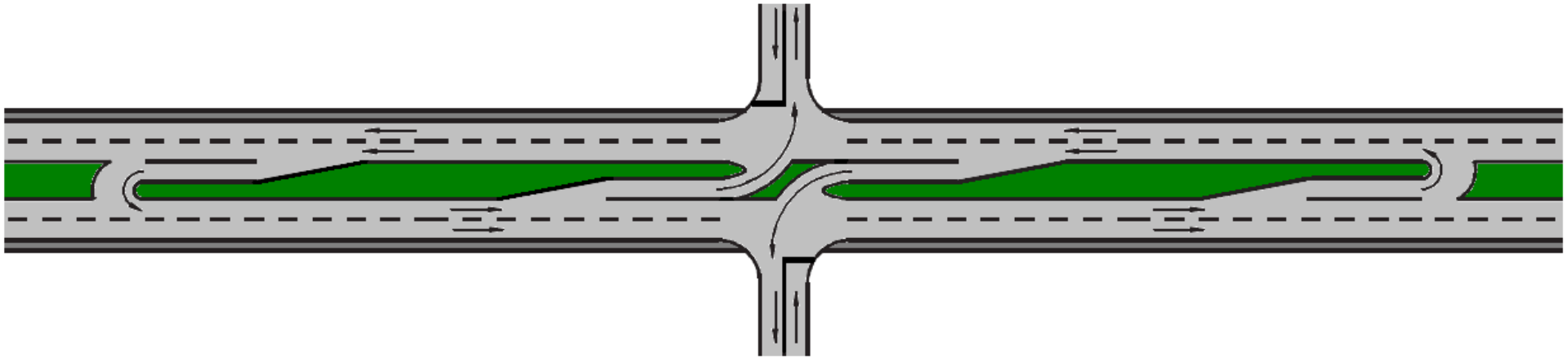
- **"The ability to accommodate high volumes of traffic safely and efficiently through intersections depends largely on the arrangements provided for handling intersecting traffic."**

  – AASHTO Green Book, p. 743

- **The greatest crash risk movements (i.e., those accounting for the greatest share of crashes) at rural expressway intersections are typically the minor road left-turn and crossing maneuvers.**

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J-TURN INTERSECTION

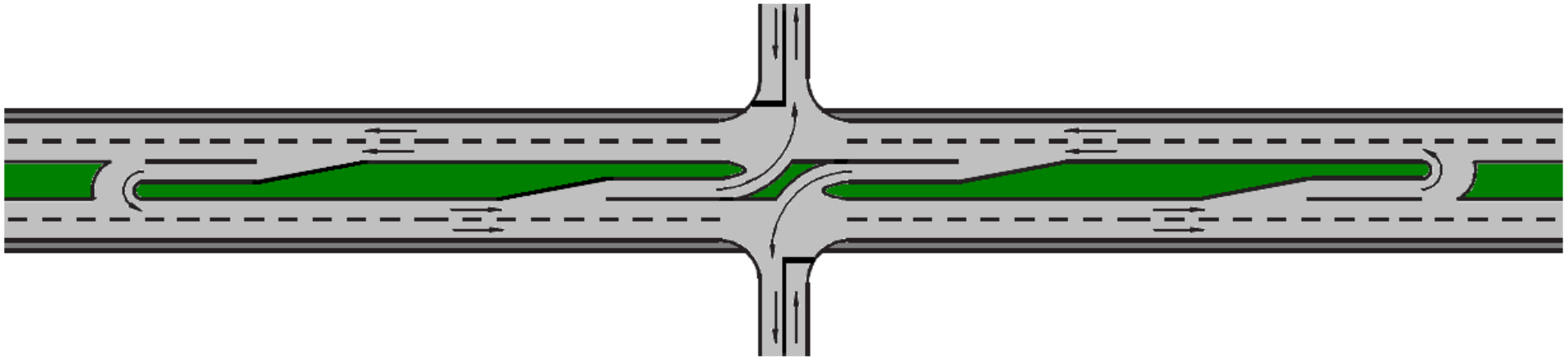


- J-Turn Intersection is a directional median opening combined with 2 median U-turns that allows left-turning traffic off the expressway, but forces left-turning and crossing minor road traffic to turn right, merge left, make a U-turn, and return to the intersection.
- “There is no indication that U-turns at unsignalized median openings constitute a safety concern.” – NCHRP 524 (2004)
- 24 Total Conflict Points

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J-TURN INTERSECTION

- "J-Turn" Coined by Maryland DOT in 2000 when they constructed one at JCT US-301 & MD-313
  - Maryland's experience has shown that J-Turn Intersections can offer superior safety performance.
- U-Turn Spacing (Maryland Design = 1500 feet)
- Disadvantage – Wide Median Width Required to Accommodate U-Turns



J-TURN INTERSECTION

- **“For U-turn openings designed specifically for the purpose of eliminating the left-turn movement at a major intersection, they should be designed with a median left-turn lane.” – AASHTO GB, p. 710**
- **Minimum Median Widths to Accommodate U-Turns by Different Design Vehicles:**

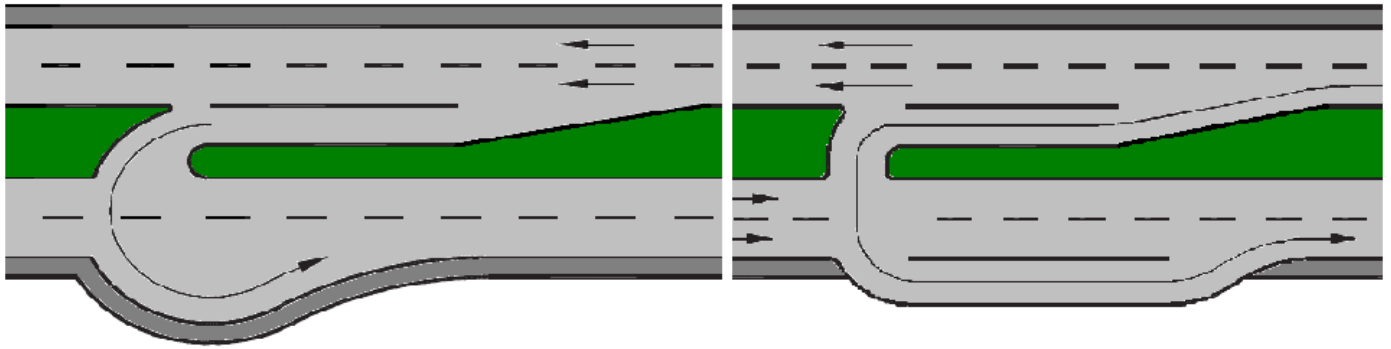
	Minimum Median Width (ft): U-Turn From Left-Turn Deceleration Lane			
Design Vehicle	To Left-Turn Median Acceleration Lane	To Expressway Inner Lane	To Expressway Outer Lane	To Expressway Shoulder
19 ft. P	54	42	30	20
30 ft. SU 40 ft. BUS	87	75	63	53
55 ft. WB-50 65 ft. WB-60	95	83	71	61

* For all calculations, 12 foot wide lanes assumed

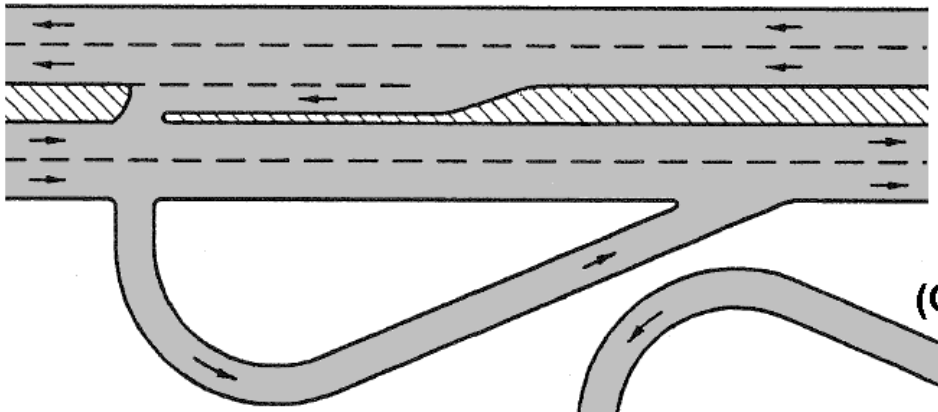
J-TURN INTERSECTION

Special U-Turn Treatments With Narrow Medians

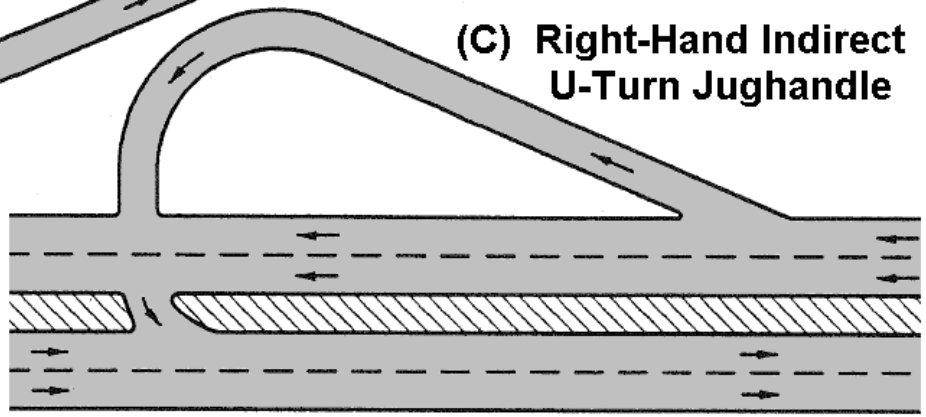
(A) Examples of Median Openings with Left-Turn Lanes & Loons



(B) Left-Hand Indirect U-Turn Jughandle



(C) Right-Hand Indirect U-Turn Jughandle



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CONCLUSIONS

- Far-side, right-angle collisions at TWSC rural expressway intersections are reducing the safety benefits that should be achieved when converting rural two-lane highways to expressways.
- The treatments described in this presentation
  - —Converting 4-legged Intersections to 3-legs
  - —J-Turn Intersections

  seem to have the greatest potential to improve rural expressway intersection safety while avoiding costly grade separation.
- Use of these strategies should be considered at intersections with safety concerns as well as during expressway corridor planning.

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FUTURE WORK

- **Further research is necessary to. . .**
  1) **Determine the actual crash reduction potential of these treatments**
  2) **Determine volume warrants for these treatments or under what conditions these treatments are most appropriate.**

ACKNOWLEDGMENTS

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QUESTIONS?

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