



**NORTH CAROLINA**

Department of Transportation

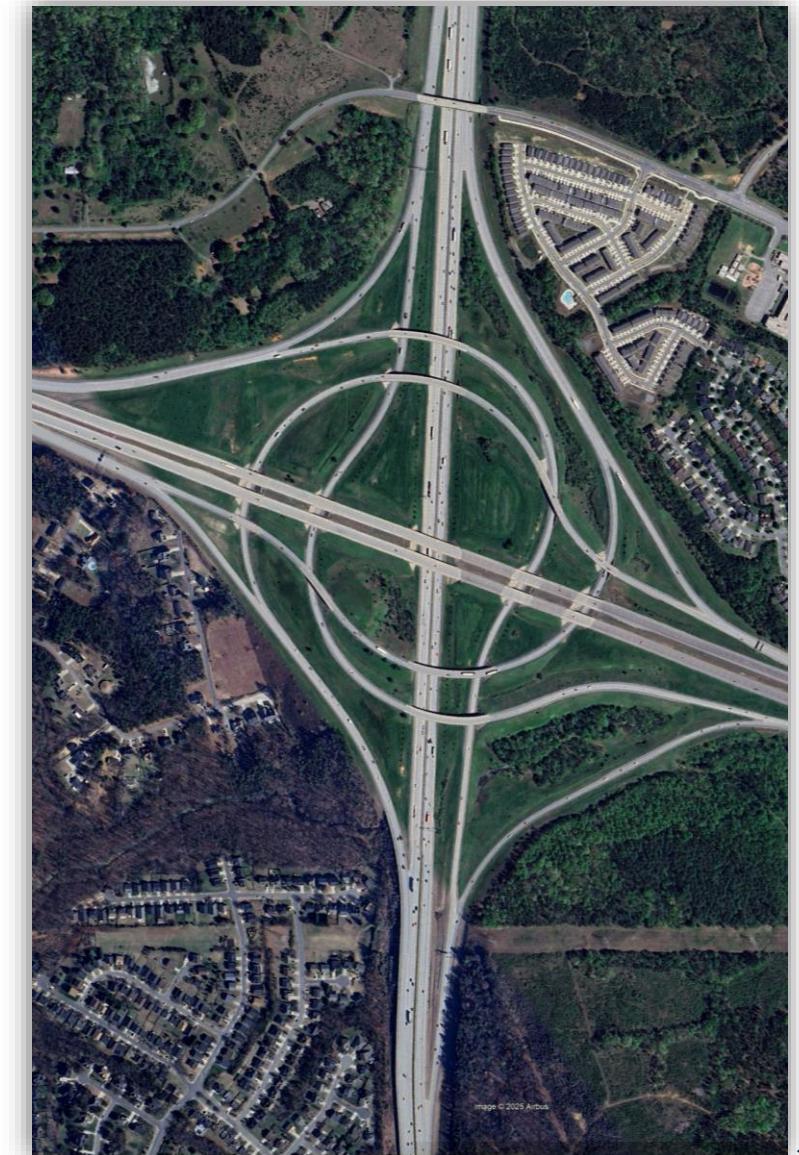
# Interchange Design Lunch and Learn

Research, Standards, and Innovation Team  
Roadway Design Unit

December 17, 2025

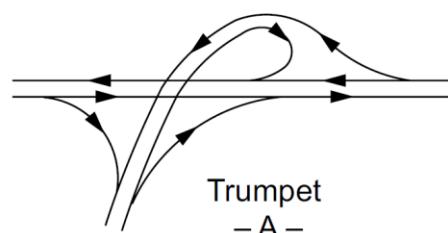
Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina

## What is an Interchange?

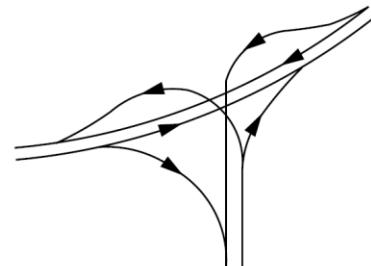


## Types of Interchanges and How to Choose

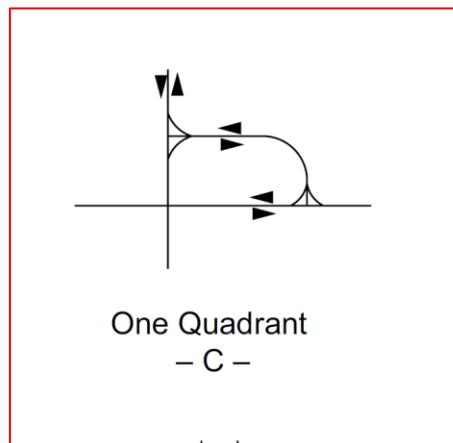
1. Traffic Forecast and Capacity Analysis
2. Available Right of Way and Existing Topography
3. Constructability and Maintenance of Traffic
4. Cost



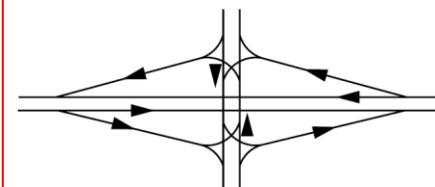
Trumpet  
- A -



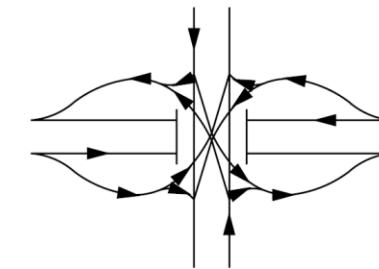
Three-Leg Directional  
- B -



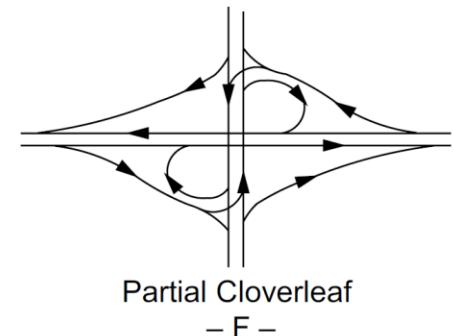
One Quadrant  
- C -



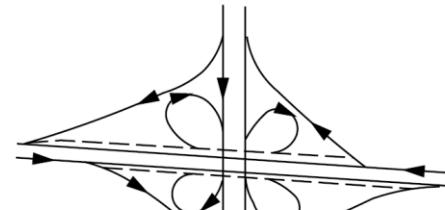
Diamond  
- D -



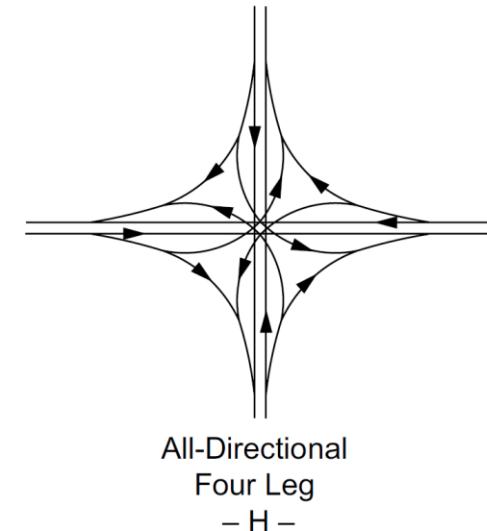
Single-Point  
Diamond Interchange  
- E -



Partial Cloverleaf  
- F -



Full Cloverleaf  
- G -



All-Directional  
Four Leg  
- H -

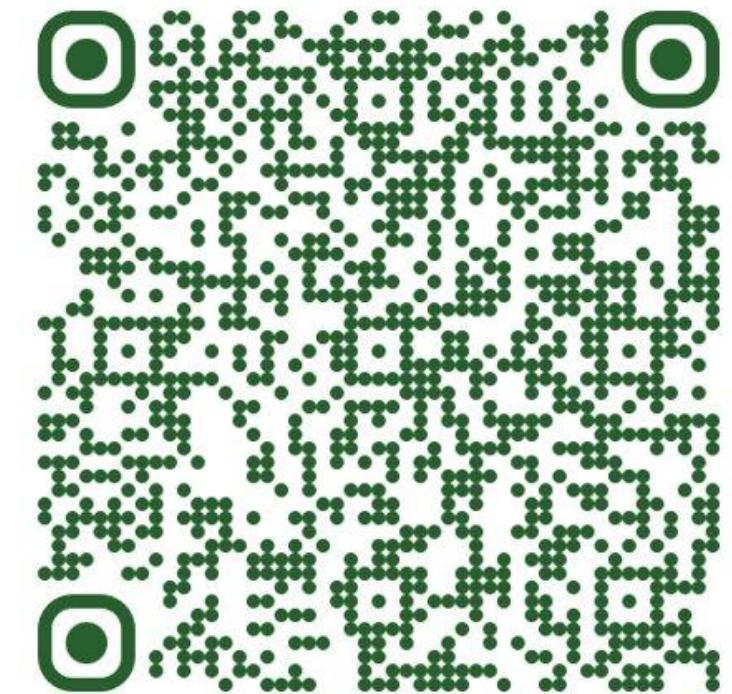
## Additional Guidance

### Selecting Optimum Intersection or Interchange Alternatives

Guidance for the staff and consultants of the  
Congestion Management Section  
Mobility and Safety Division  
North Carolina Department of Transportation

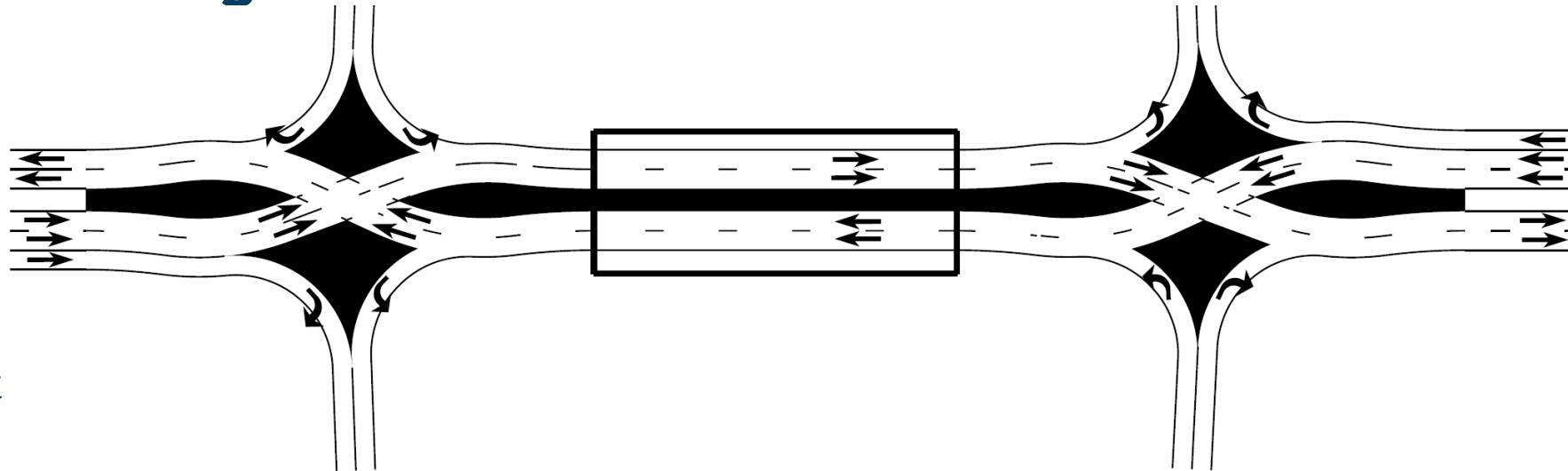
By Joseph E. Hummer, PhD, PE  
State Traffic Management Engineer

Updated January 2024



## Innovative Designs

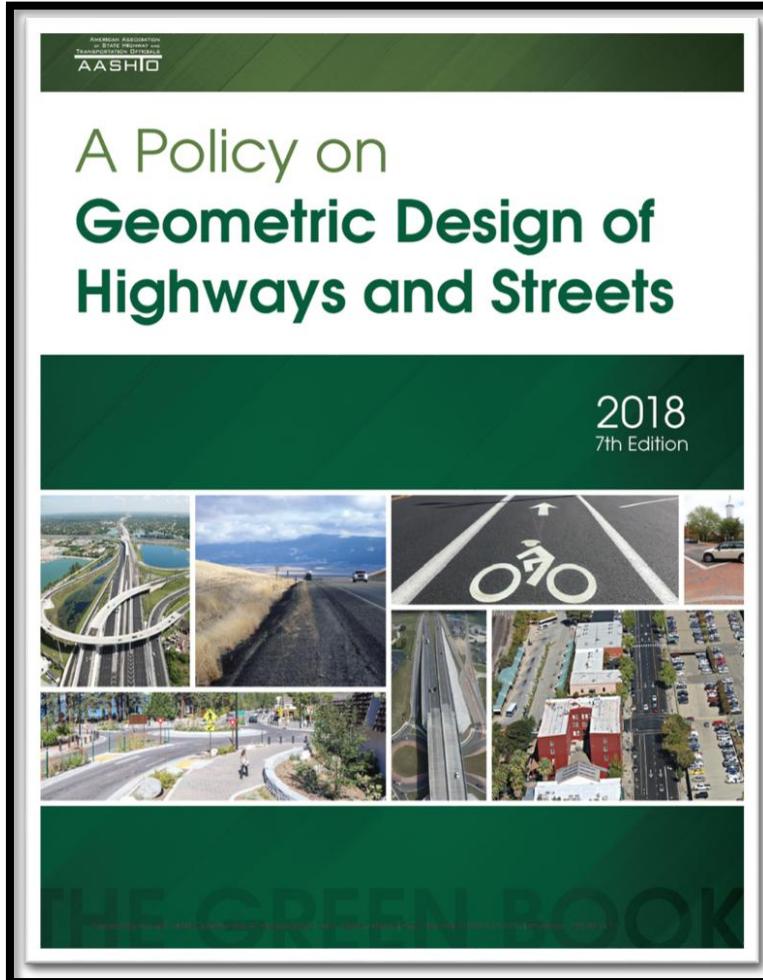
Diverging  
Diamond



Roundabout



## Design Resources



The image shows the front cover of the 'NORTH CAROLINA DEPARTMENT OF TRANSPORTATION ROADWAY DESIGN MANUAL'. The cover is white with black text. At the top, it says 'NORTH CAROLINA DEPARTMENT OF TRANSPORTATION' and 'ROADWAY DESIGN MANUAL'. Below that, it says 'Implementation Date: November 1, 2021' and 'Revised November 2025'. To the right is the North Carolina Department of Transportation logo, which features a red and blue map of the state with the text 'STATE OF NORTH CAROLINA' and 'DEPARTMENT OF TRANSPORTATION'. The cover has three large photographs: an aerial view of a bridge over water, a night view of a city skyline, and a view of a winding road through a forest.

 **Contact Form**  
For questions, feedback, and to sign up for notifications to the *Roadway Design Manual*.

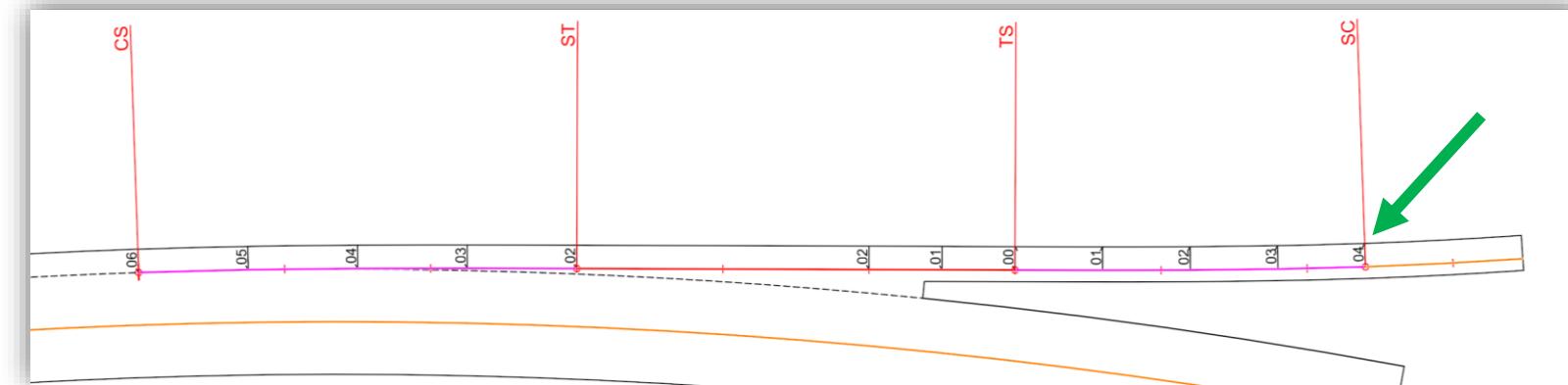
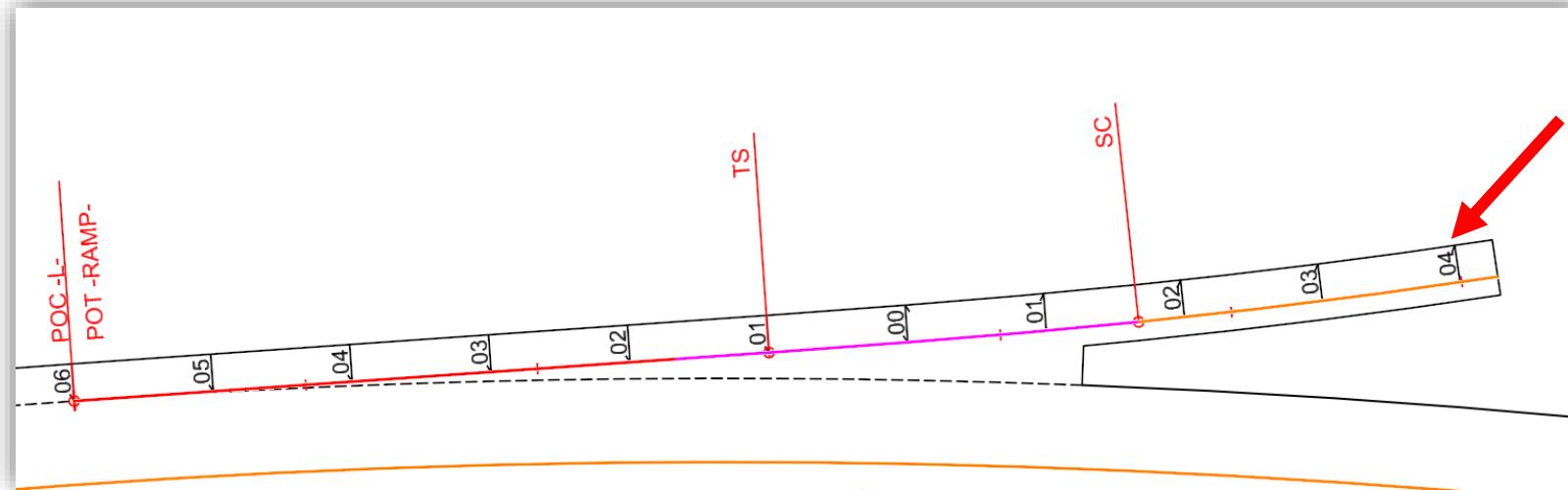
# Common Design Challenges

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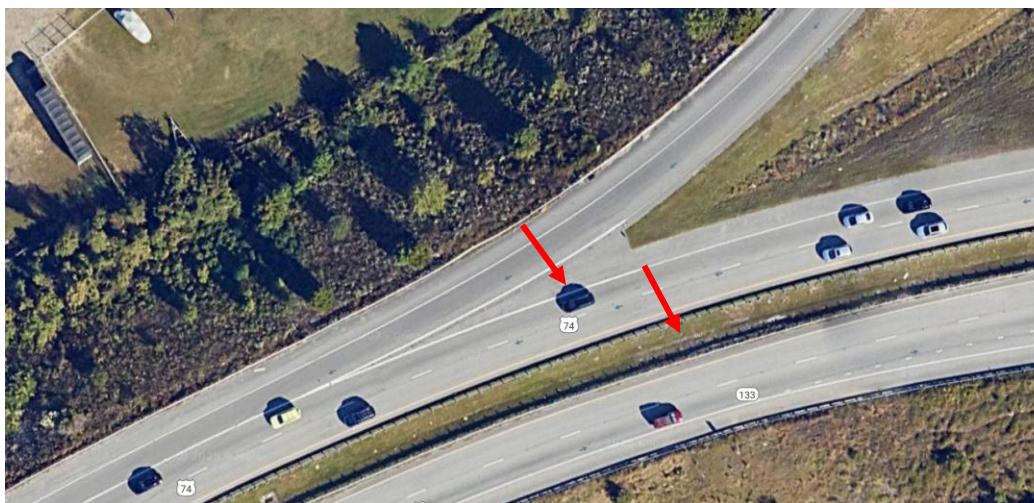
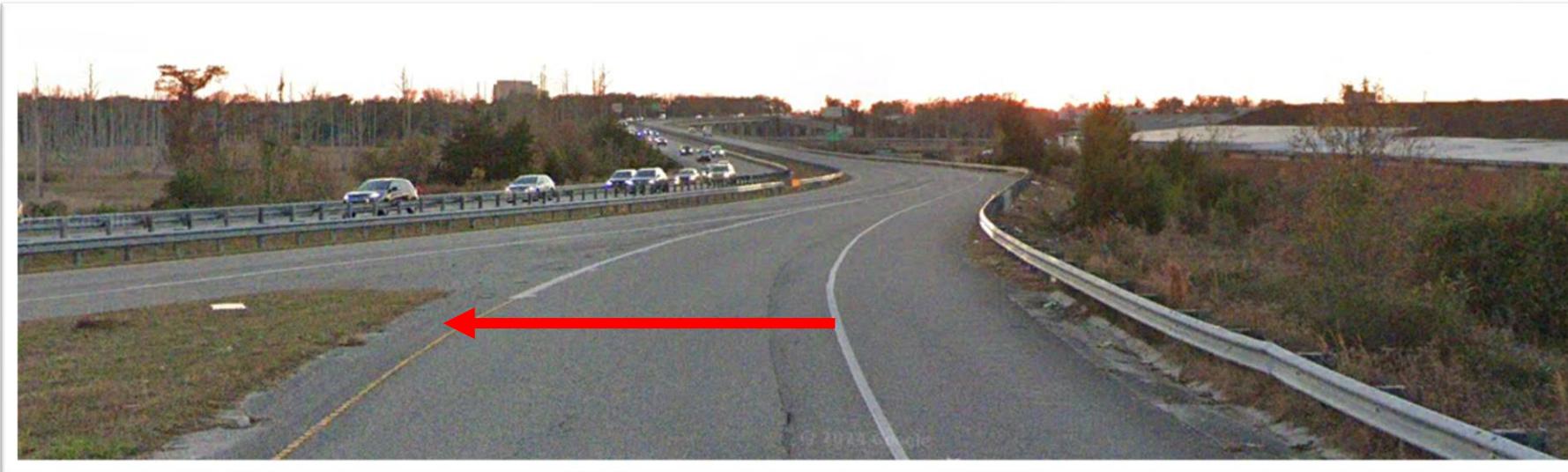
## Common Design Challenges

- High-side Superelevation Ties
- Low-speed Loop Connections
- Complex Weave Locations

## High-side Superelevation Ties

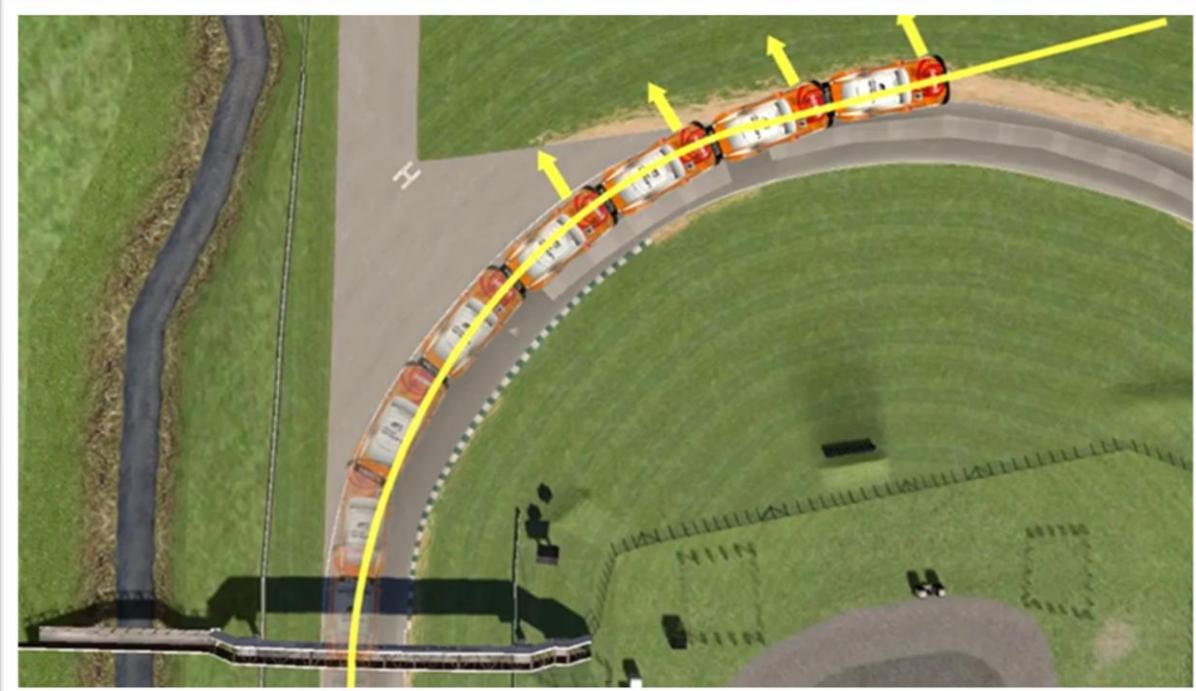
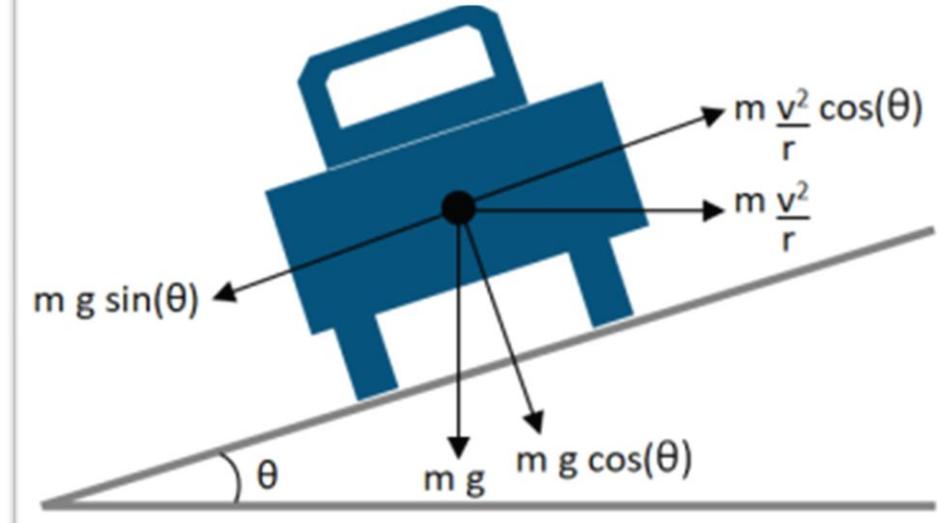


## High-side Superelevation Ties



## High-side Superelevation Ties

Horizontal alignment and superelevation distribution are not independent design elements. If superelevation cannot be properly distributed, changes to the horizontal alignment are needed.



## Low-speed Loop Connections

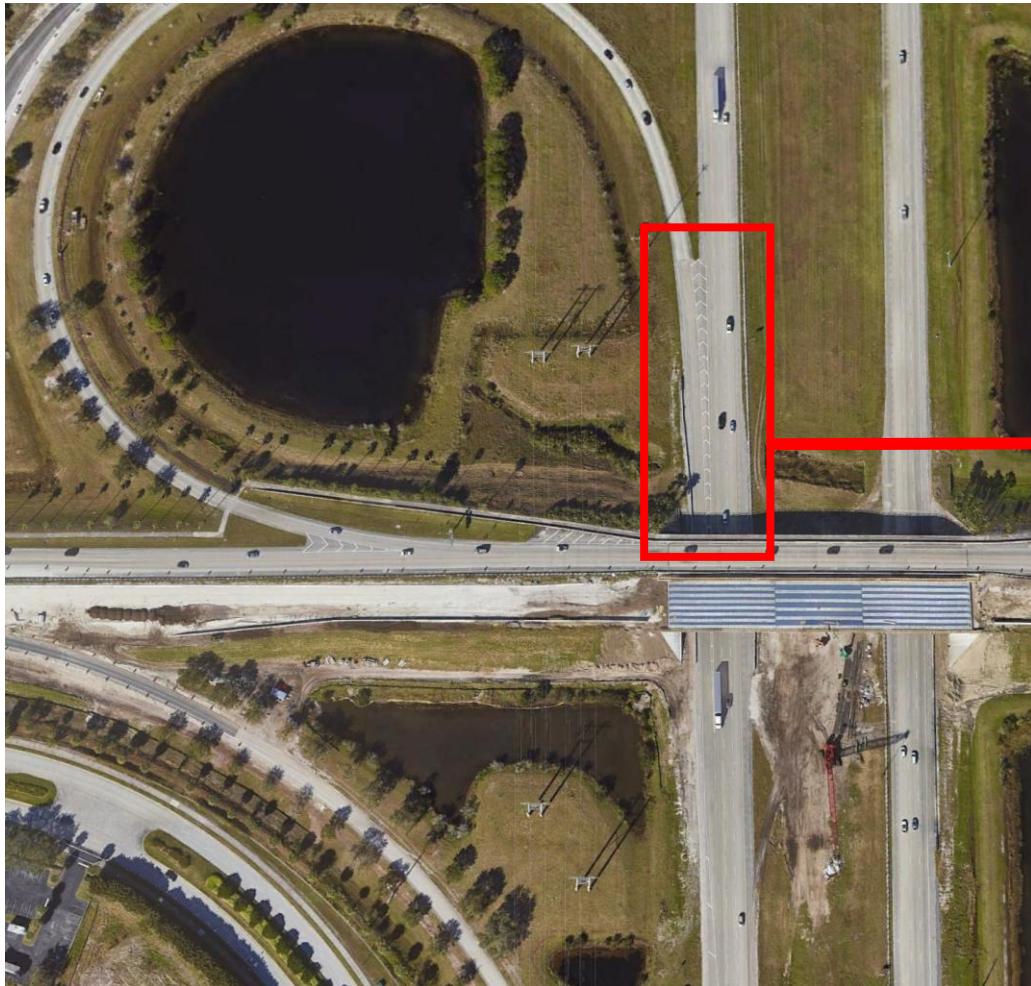


Table 10-4. Minimum Acceleration Lane Lengths for Entrance Terminals with Flat Grades of Less Than 3 Percent

U.S. Customary										
Acceleration Lane Length, $L_a$ (ft) for Design Speed of Controlling Feature on Ramp, $V'$ (mph)										
Highway		Stop Condition	15	20	25	30	35	40	45	50
Average Running Speed (i.e., Initial Speed) at Controlling Feature on Ramp, $V'_a$ (mph)										
Design Speed, $V$ (mph)	Merge Speed, $V_a$ (mph)	0	14	18	22	26	30	36	40	44
30	23	180	140	—	—	—	—	—	—	—
35	27	280	220	160	—	—	—	—	—	—
40	31	360	300	270	210	120	—	—	—	—
45	35	560	490	440	380	280	160	—	—	—
50	39	720	660	610	550	450	350	130	—	—
55	43	960	900	810	780	670	550	320	150	—
60	47	1200	1140	1100	1020	910	800	550	420	180
65	50	1410	1350	1310	1220	1120	1000	770	600	370
70	53	1620	1560	1520	1420	1350	1230	1000	820	580
75	55	1790	1730	1630	1580	1510	1420	1160	1040	780
80	57	2000	1900	1800	1750	1680	1600	1340	1240	980



## Alternatives to Low-speed Loop Connections



## Low-speed Loop Connections

Provide a minimum length of 300 feet for spirals used on loops transitioning on or off a high-speed facility for new construction and where reconstruction allows, to help mitigate for the speed differential.

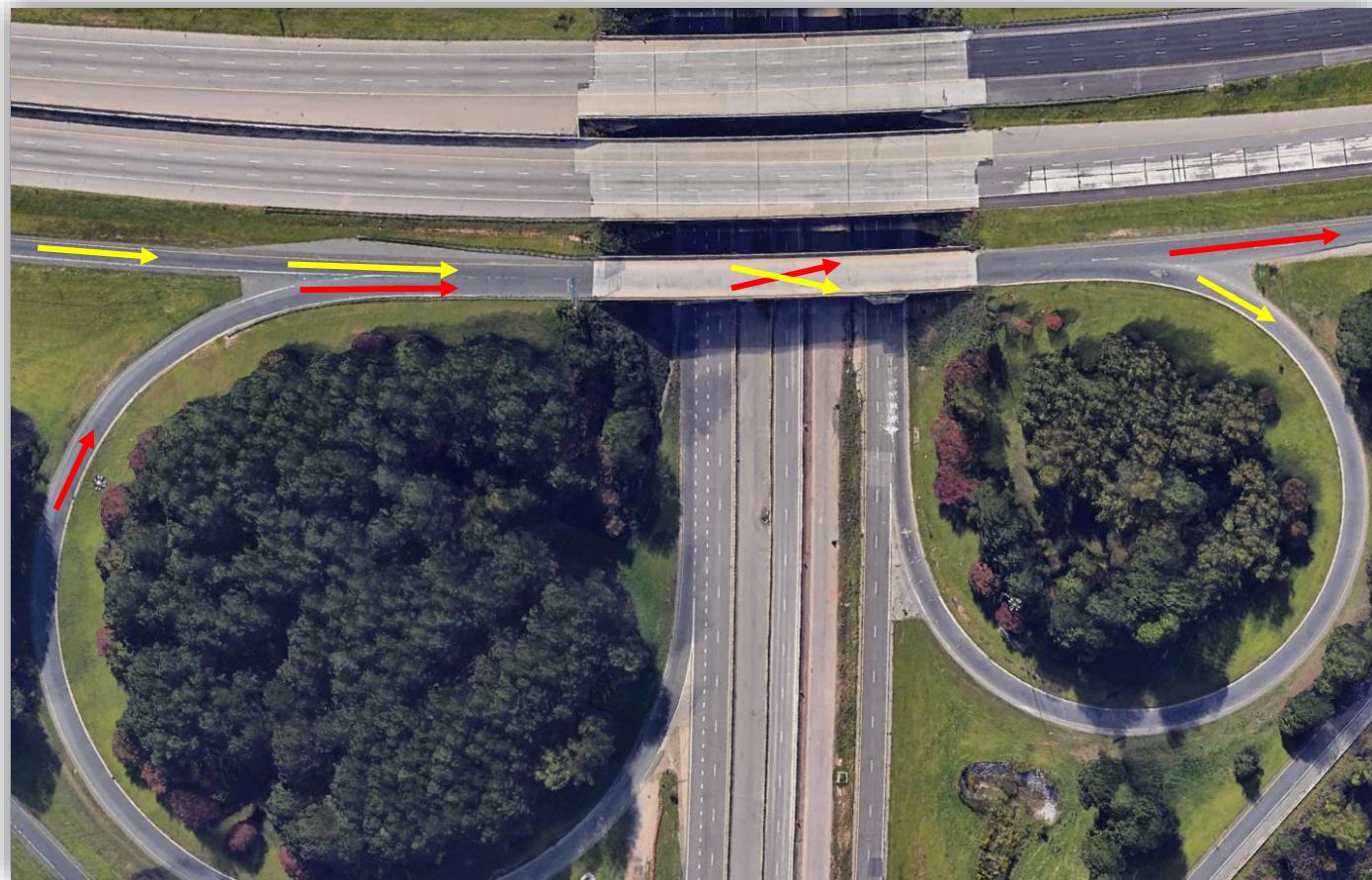


Aviation Parkway and I-440, NC

## Complex Weave Locations



### Simple Weave



I-440 and I40 west of Raleigh, NC

## Complex Weave Locations

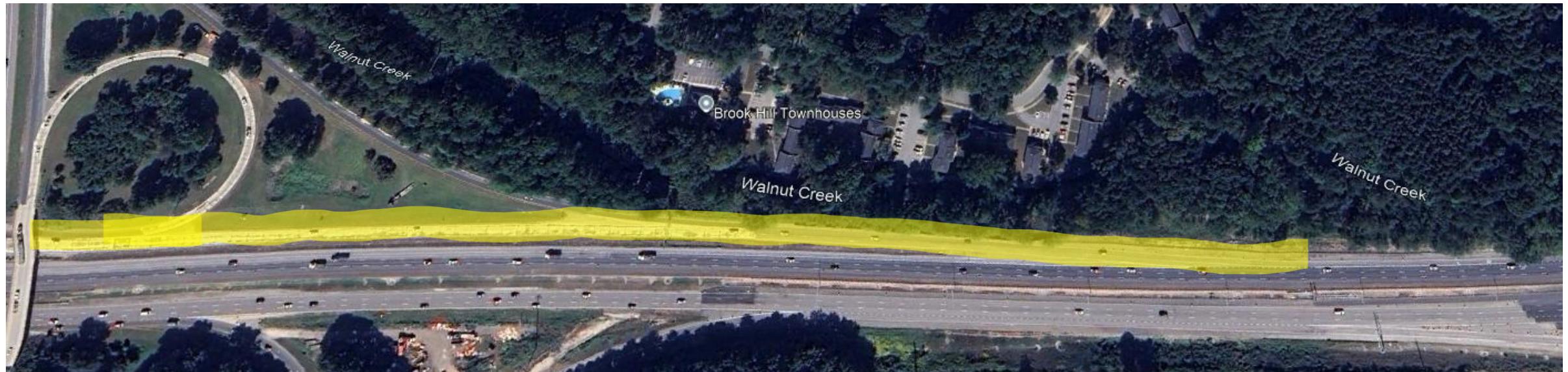
Braided Ramp



I-65 North of Louisville, KY

## Complex Weave Locations

Collector-Distributor  
US-1 and I-40



West Side of Interchange

## Complex Weave Locations



Interstate 540 over US 1 South of Raleigh

East Side of Interchange



# Interchange Improvement Example

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## 2004 – I-4 and US-192 Orlando, FL



## 2007 (Current) – I-4 and US-192 Orlando, FL







# Additional Design Considerations

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## Additional Design Considerations

- Lane Balance
- Ramp Intersection Skew
- Free Flow Ramps
- Merge vs Yield Geometry
- Wrong Way Driver Mitigation
- False Cut
- Interchange and ramp spacing
- Vertical Clearance
- Signage

## Lane Balance

### 10.9.5.9 Coordination of Lane Balance and Basic Number of Lanes

1. At entrances, the number of lanes beyond the merging of two traffic streams should not be less than the sum of all traffic lanes on the merging roadways minus one, but may be equal to the sum of all traffic lanes on the merging roadways (see Figure 10-52).

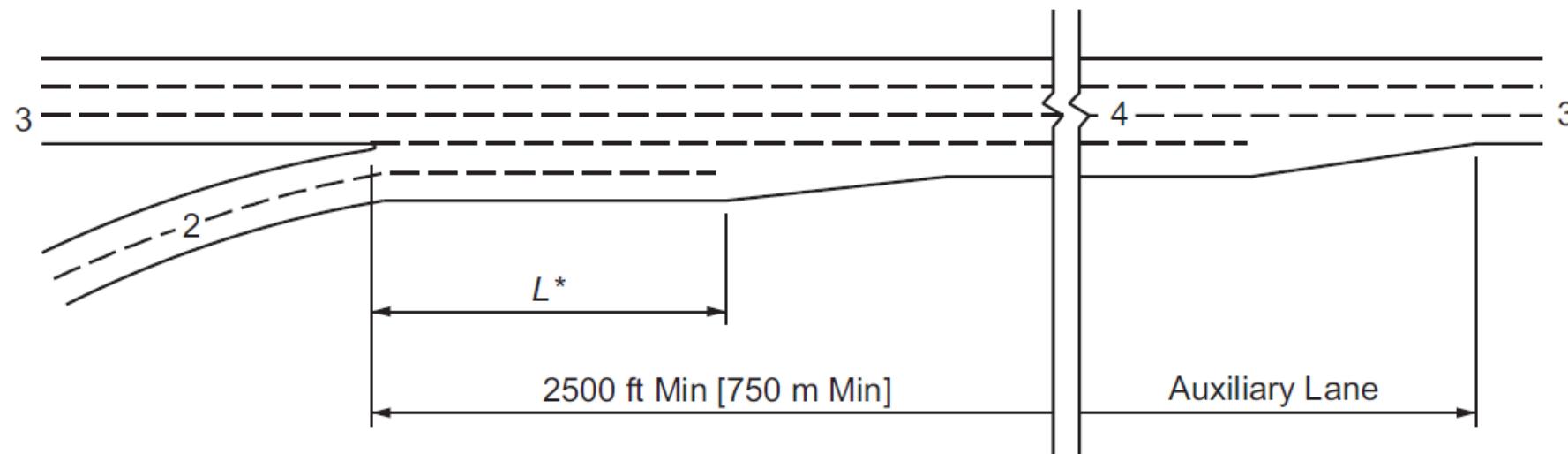


## Lane Balance

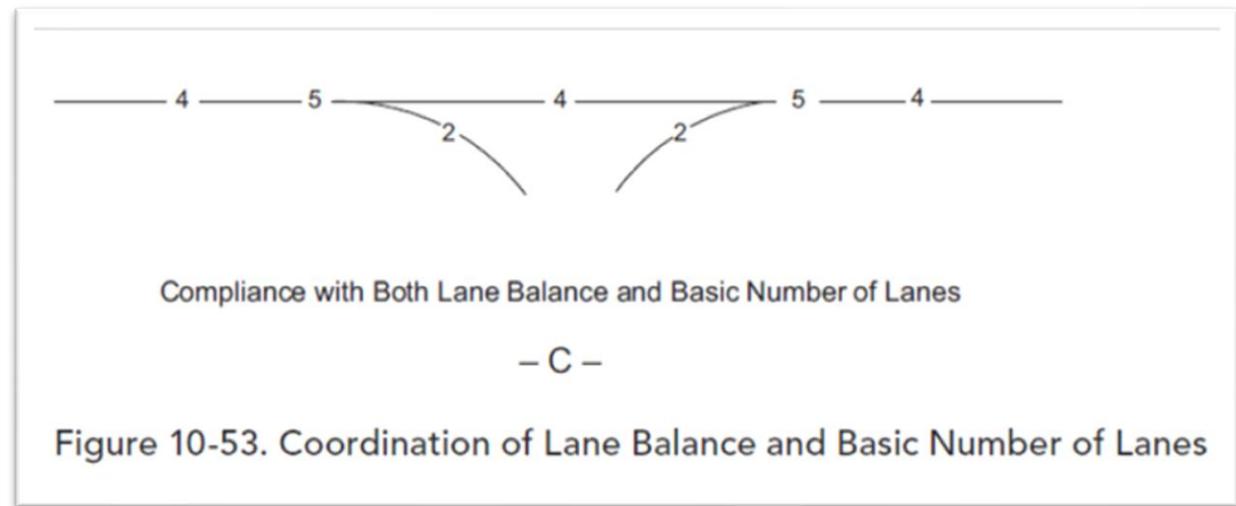
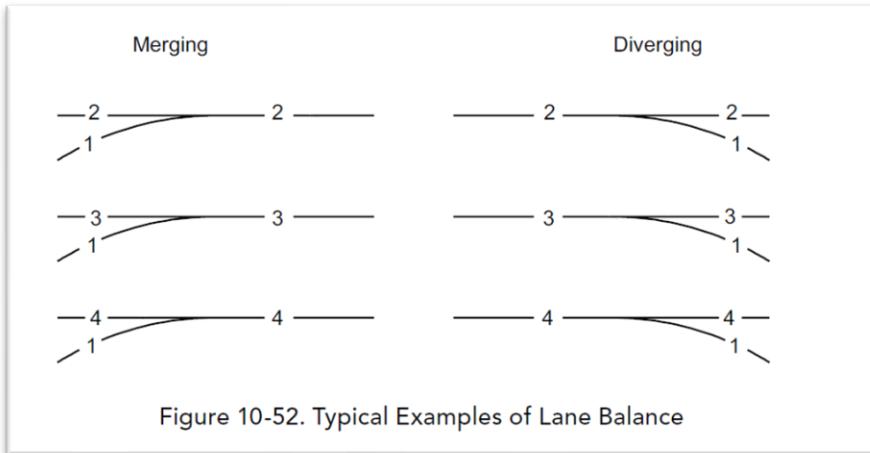
### 10.9.5.9 Coordination of Lane Balance and Basic Number of Lanes

1. At entrances, the number of lanes beyond the merging of two traffic streams should not be less than the sum of all traffic lanes on the merging roadways minus one, but may be equal to the sum of all traffic lanes on the merging roadways (see Figure 10-52).

#### AUXILIARY LANE EXTENDED FOR EFFECTIVE DISTANCE BEYOND ENTRANCE



## Lane Balance

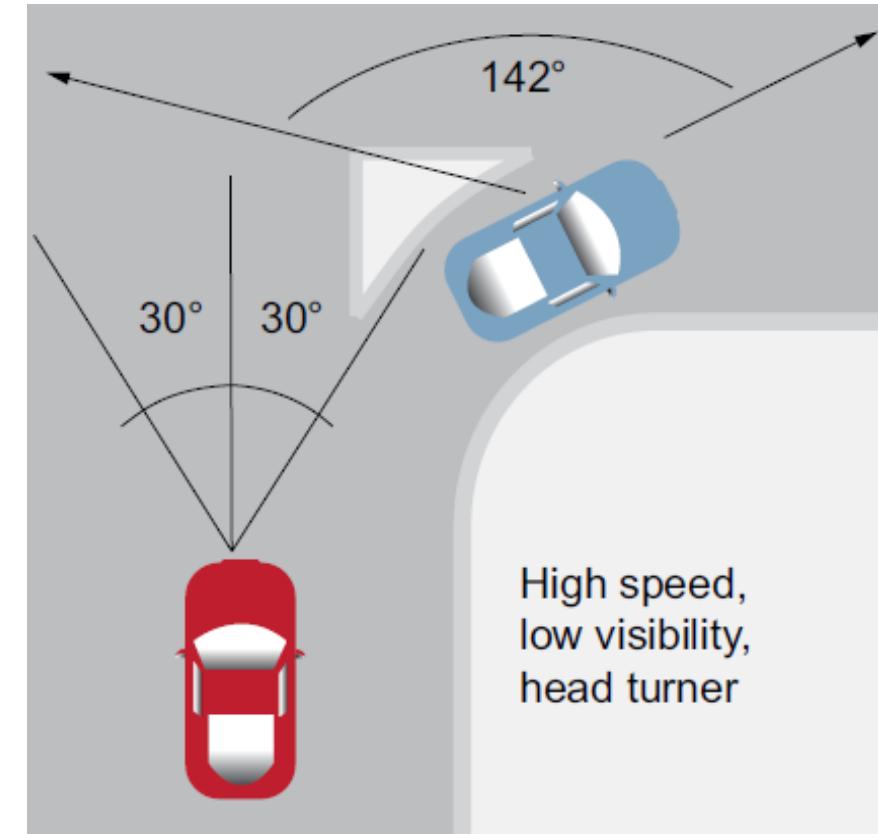
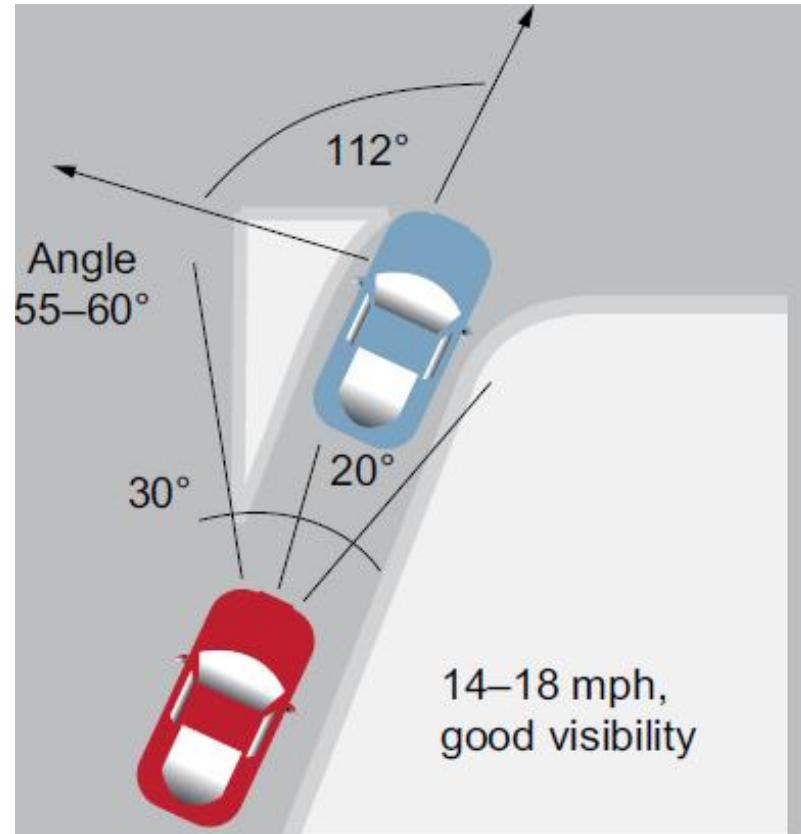


### 10.9.5.9 Coordination of Lane Balance and Basic Number of Lanes

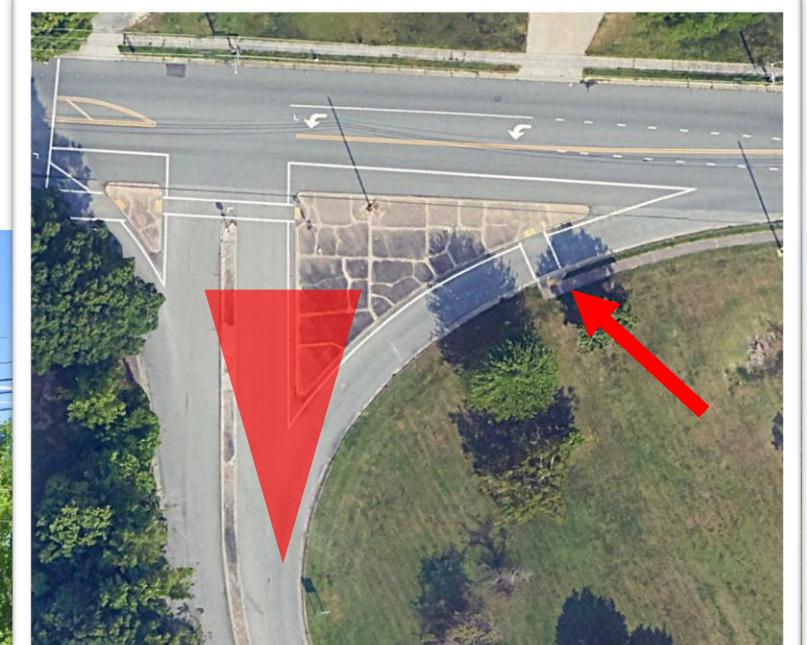
2. At exits, the number of approach lanes on the highway should be equal to the number of lanes on the highway beyond the exit, plus the number of lanes on the exit, minus one.

**Lane Balance Not Met**  
Between Poole Road and I-87  
NB

## Stop/Yield Controlled Ramp Termini Skew



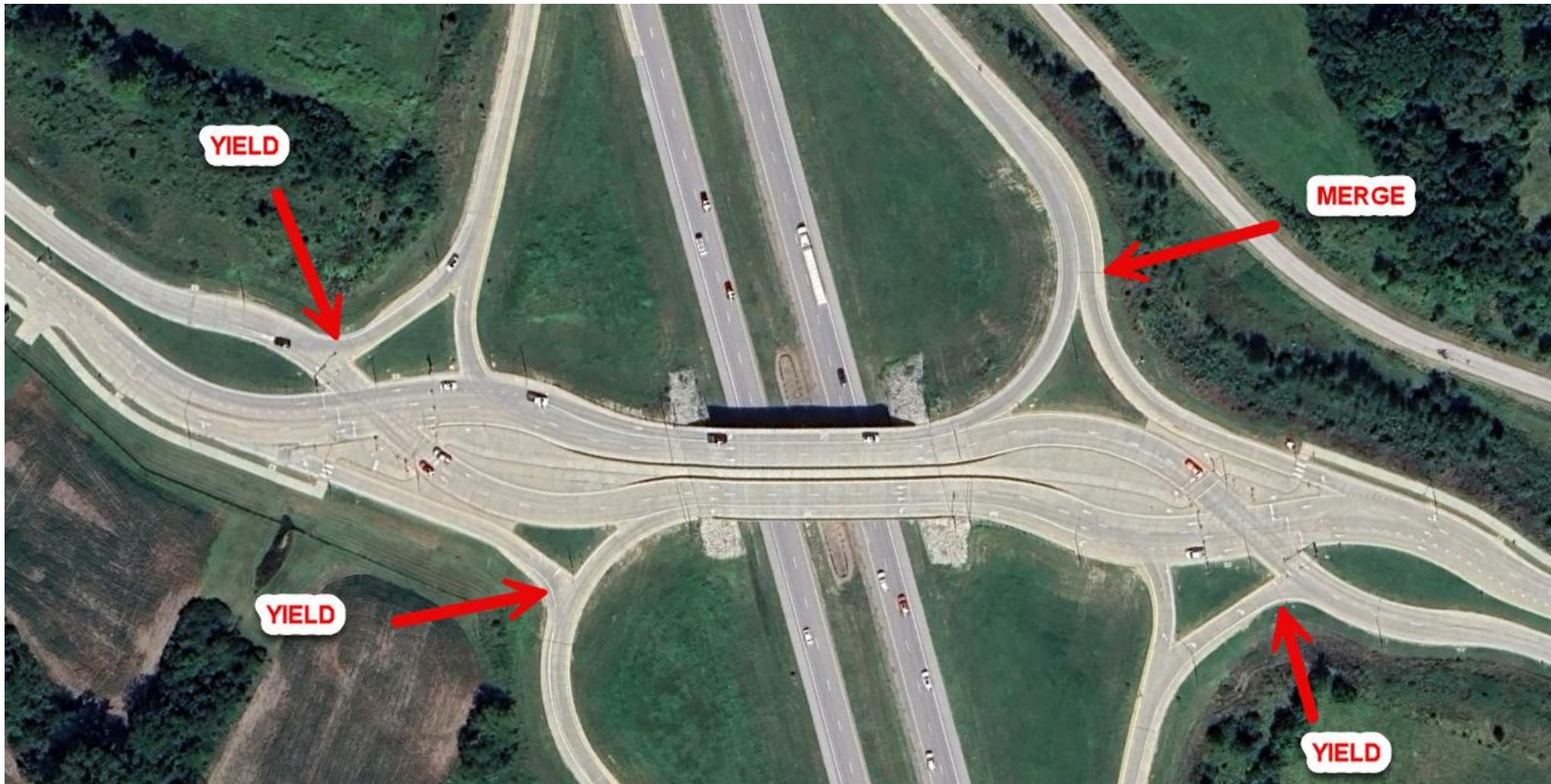
## Stop/Yield Controlled Ramp Termini Skew



## Free Flow Ramps



## Merge vs Yield Geometry



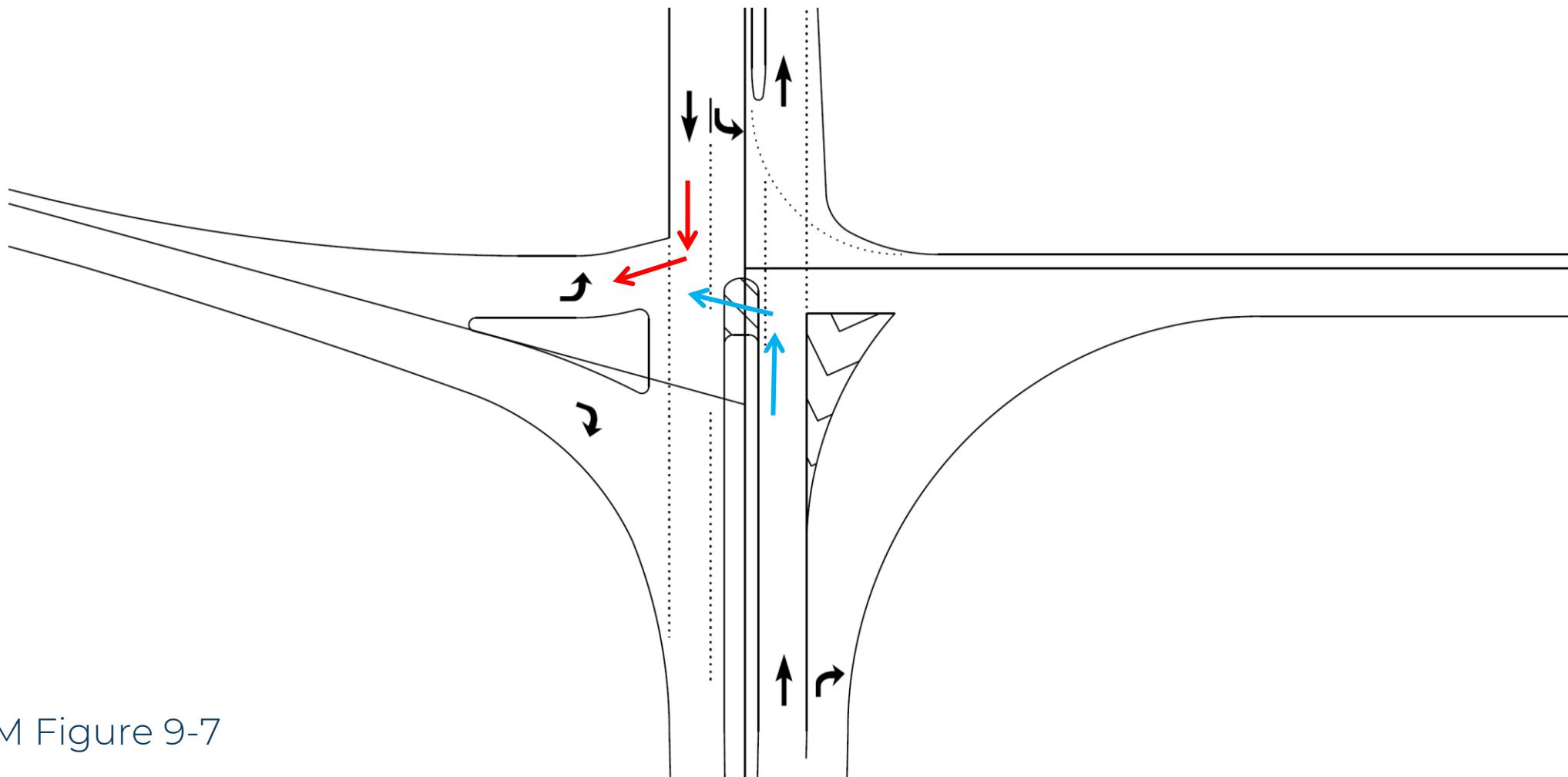
## Merge vs Yield Geometry



## Wrong-Way Driver Considerations



## Wrong-Way Driver Considerations



RDM Figure 9-7

## Wrong-Way Driver Considerations



# False Cut

## GENERAL NOTES:

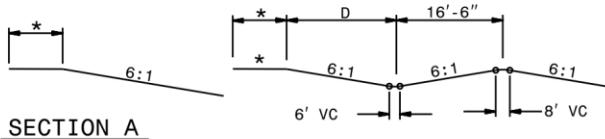
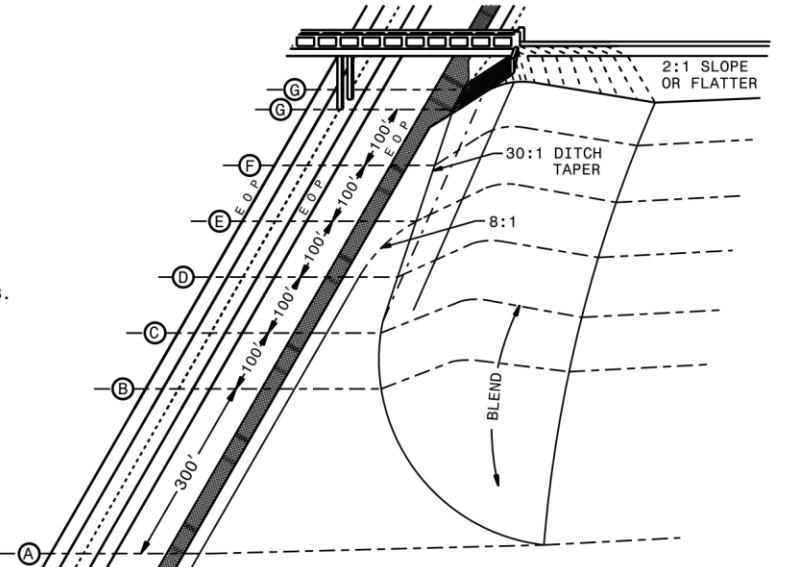
USE THIS GRADING GUIDE AT GRADE SEPARATIONS WITH FALSE CUT APPROACH.

IF STRUCTURE HAS OUTSIDE PIERS, ELIMINATE THE 6' VERTICAL CURVE.

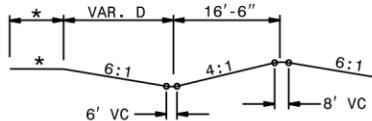
D - TYPICAL DITCH WIDTH

\* - SEE ROADWAY TYPICAL SECTIONS FOR NORMAL SHOULDER WIDTHS, SHOULDER SLOPES, AND DITCH WIDTHS.

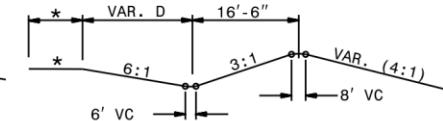
\*\* - SEE ROADWAY PLANS AND/OR STRUCTURE PLANS FOR VARIABLE OFFSET.



SECTION A

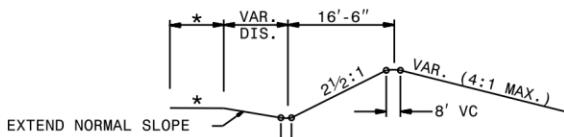


SECTION B

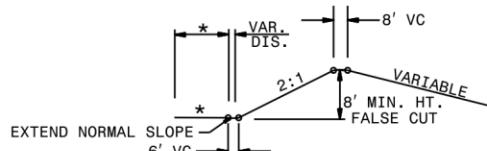


SECTION C

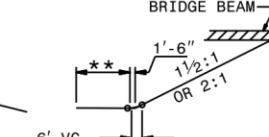
SECTION D



SECTION E



SECTION F



SECTION G

1-24] STATE OF  
NORTH CAROLINA  
DEPT. OF TRANSPORTATION  
DIVISION OF HIGHWAYS  
RALEIGH, N.C.

ROADWAY STANDARD DRAWING FOR  
GRADING FOR FALSE CUT  
AT GRADE SEPARATIONS

SHEET 1 OF 1  
225.07

## False Cut



NCDOT is currently evaluating our underpass guidance. If you have questions or comments, please contact us.

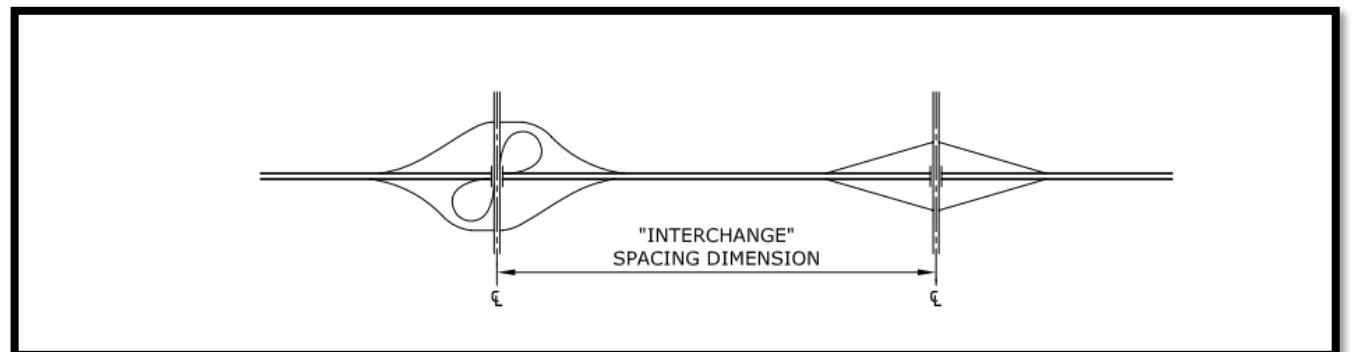
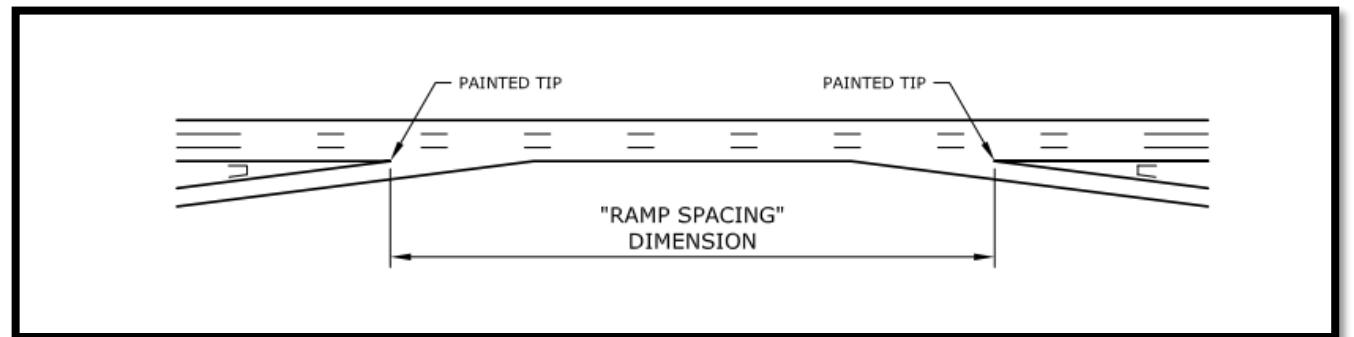


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# Interchange and Ramp Spacing

	All Roadways	Interstate Highways
Relevant AASHTO Policy	<i>A Policy on Geometric Design of Highways and Streets (4)</i>	<i>A Policy on Design Standards Interstate System (14)</i>
Minimum Recommended Urban Interchange Spacing	1 mile	1 mile
Minimum Recommended Rural Interchange Spacing	2 miles	3 miles

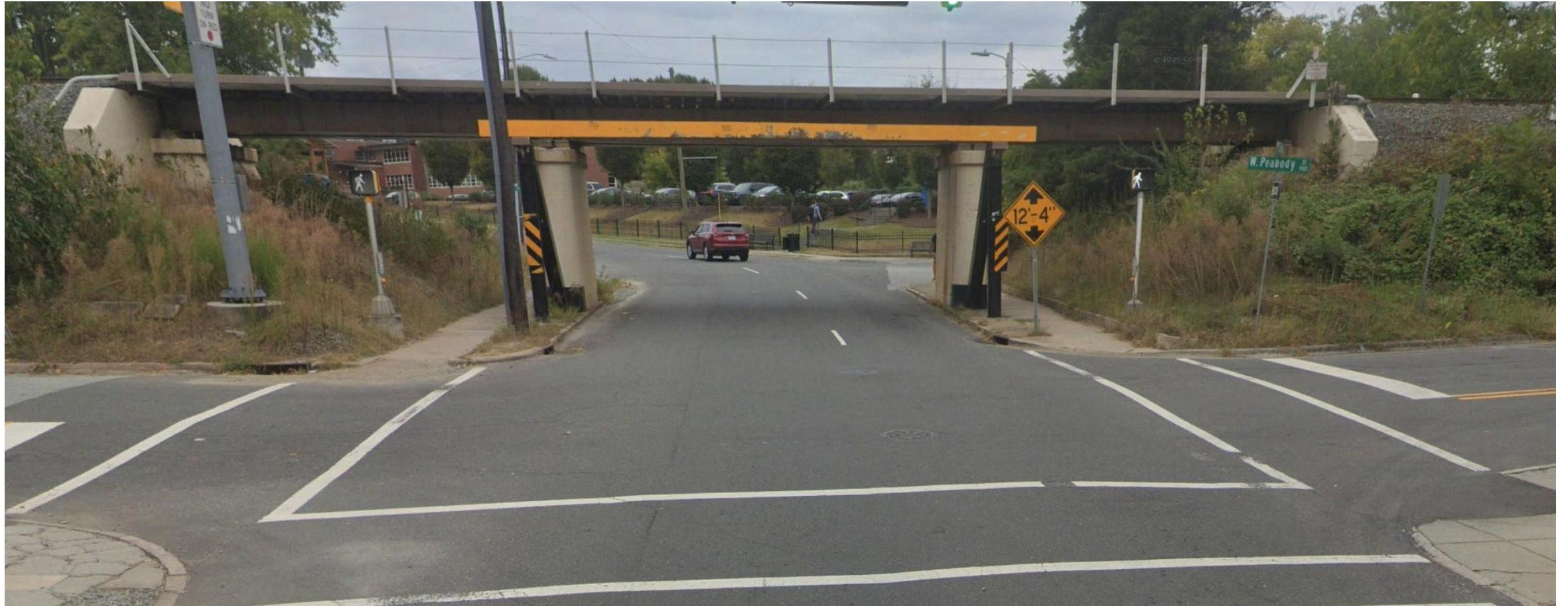


## Signing

- Don't overload drivers!
- Advance signage for exits
- Location is critical to allowing drivers to make decisions



## Vertical Clearance



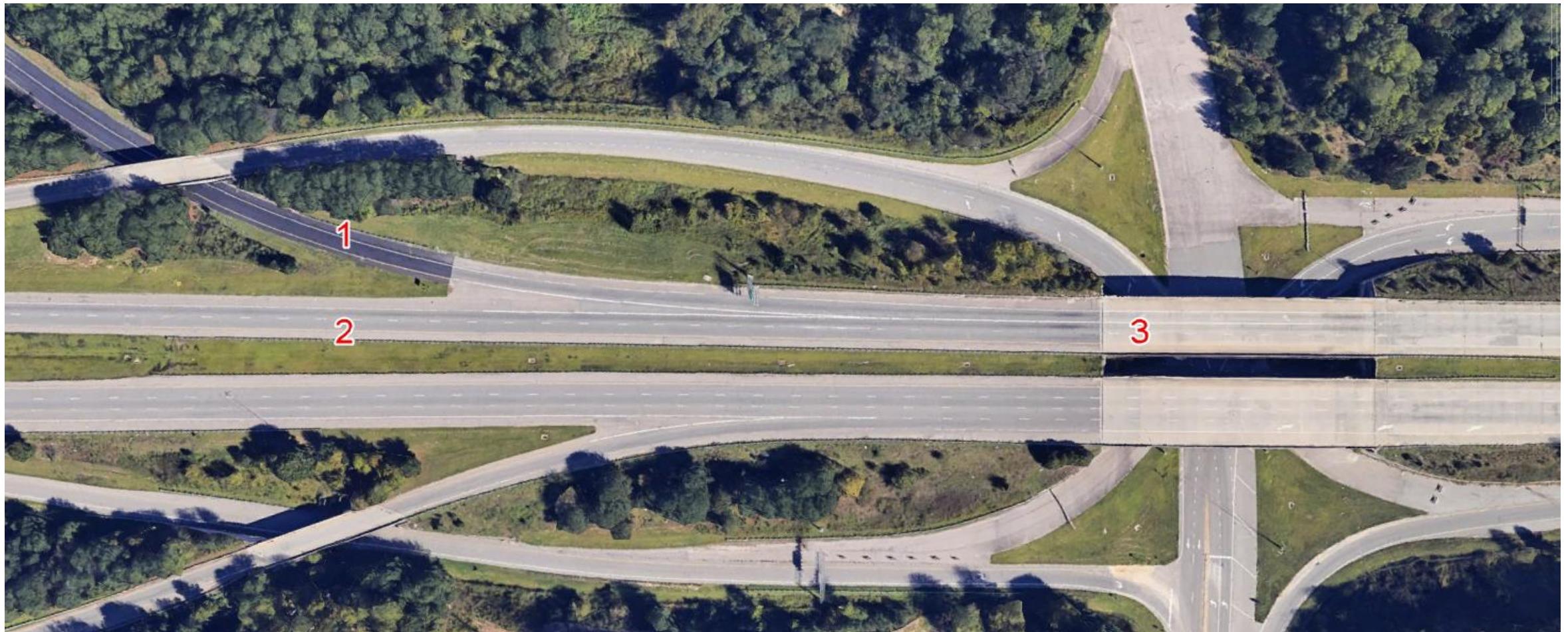
# Interchange Design Best Practices

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## Best Practices

- Route Continuity
- Side slopes near gores
- Parallel vs taper ramp entrances and exits
- Lane drops
- Y-line control of access at interchanges
- Y-line desirable to go over mainline
- Adjacent intersection considerations

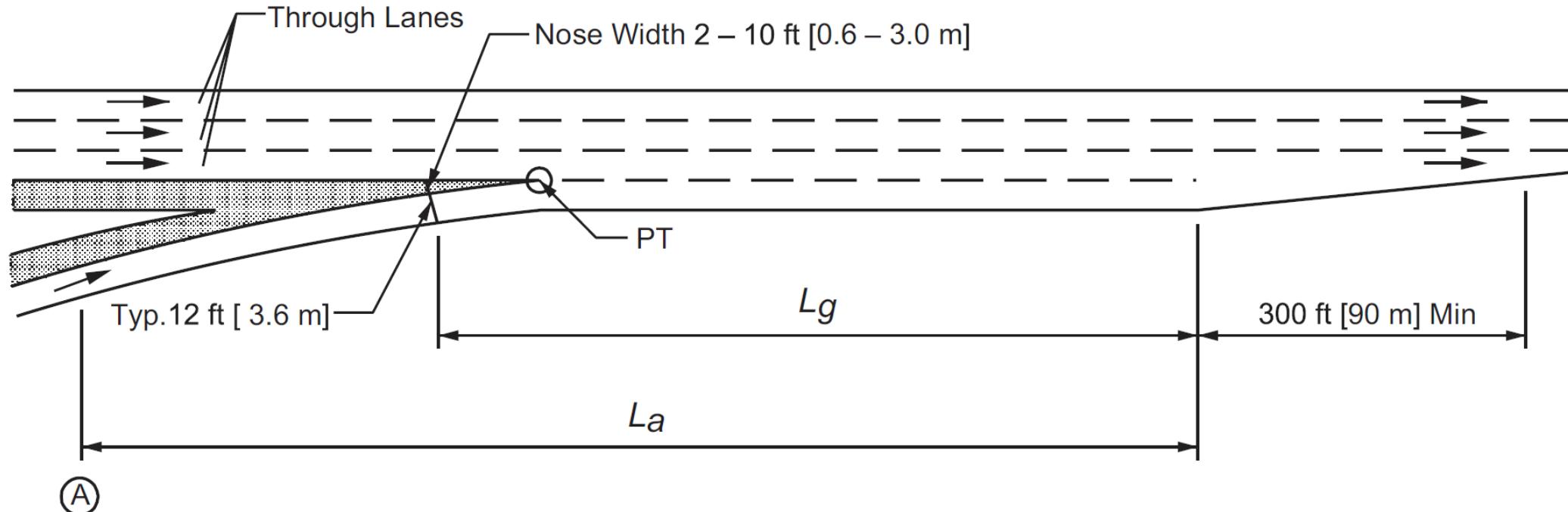
## Route Continuity



## Side Slopes Near Gores



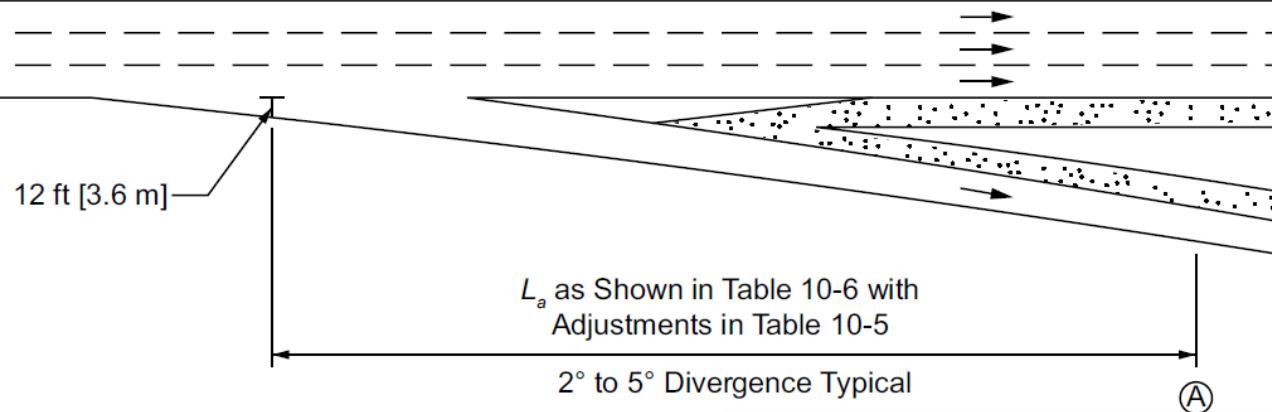
## Parallel vs Taper Ramp Entrances



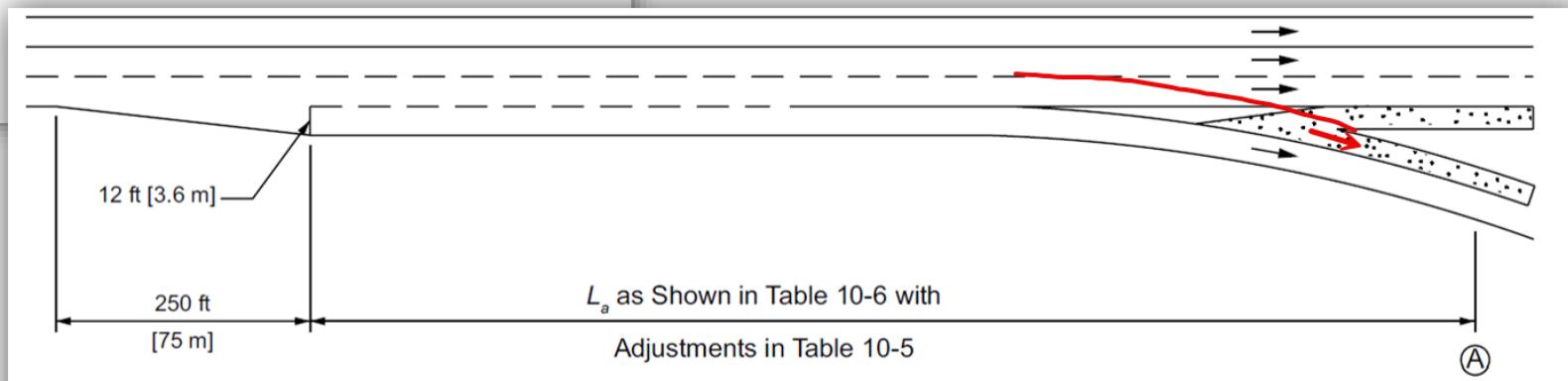
Parallel Design

– B –

## Parallel vs Taper Ramp Exits



Tapered Design – Tangent  
- A -



Parallel Design  
- C -

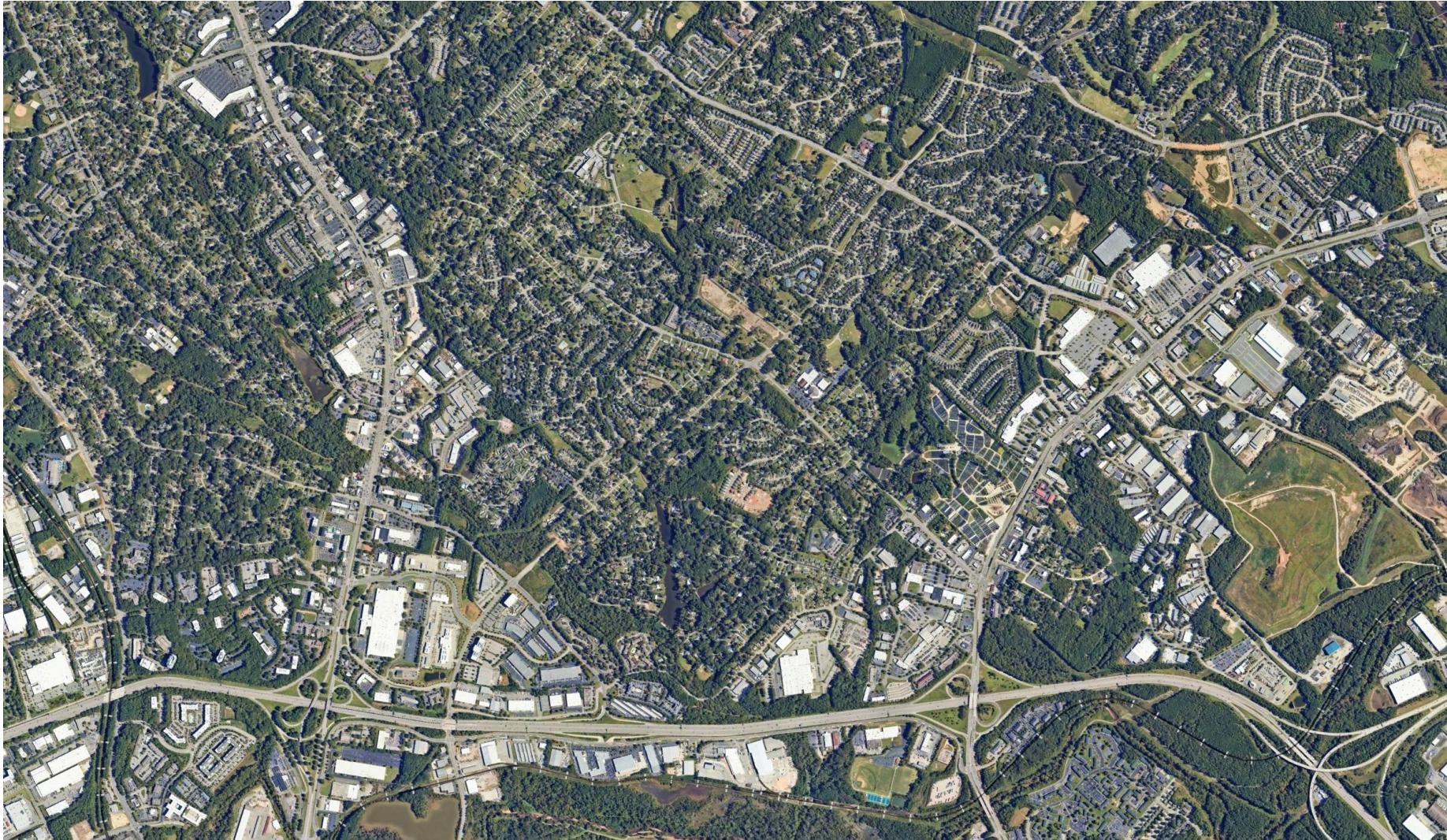
## Lane Drops



## -Y- Line Desirable to go over -L-



## -Y- Line Control of Access at Interchanges



## Adjacent Intersection Considerations



## Questions?

Interchange Design Practices continue to evolve as new data is gathered, and designs are implemented around the world.

Please share with us in the industry any success stories, challenges, experiences and opportunities for innovation and improvement on our highway system.

# Contact Us

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**Michael Lindgren, PE**

[mdlindgren@ncdot.gov](mailto:mdlindgren@ncdot.gov)

919-707-6207

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# Thank you!

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