

2014 Design Training Expo



Source of Images: Isebrands, Google Earth, Isebrands

Modern Roundabouts: A Safe & Robust Intersection Alternative

Lake Buena Vista, FL ■ June 11, 2014



U.S. Department
of Transportation
**Federal Highway
Administration**

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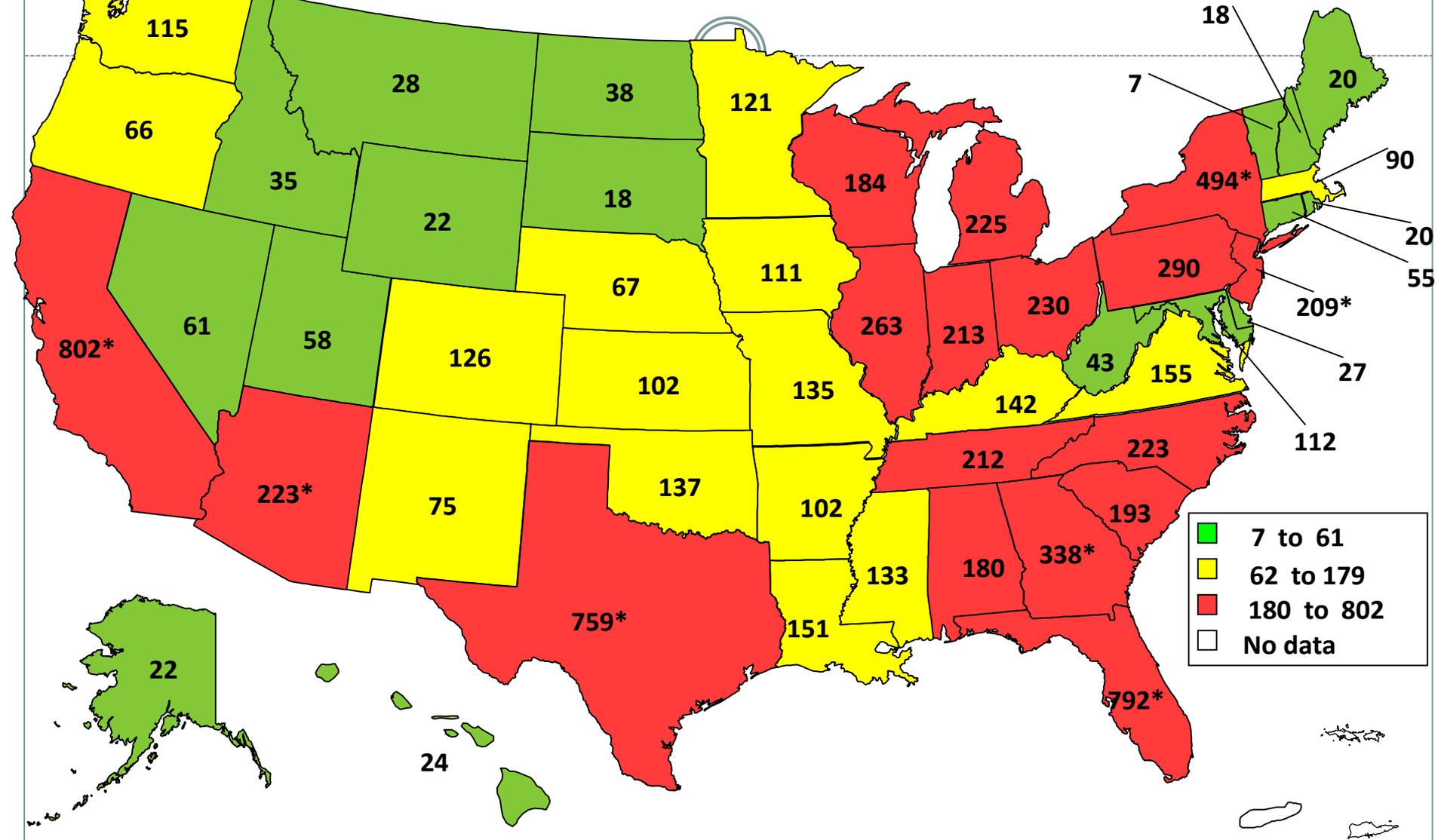
Topics for Discussion



- » Intersection Safety Facts
- » Roundabout Guidance and Policy
- » Roundabout Safety Facts
- » Design and Operational Guidance
- » Examples
- » Summary
- » Questions/Discussion



2011 Intersection Fatalities



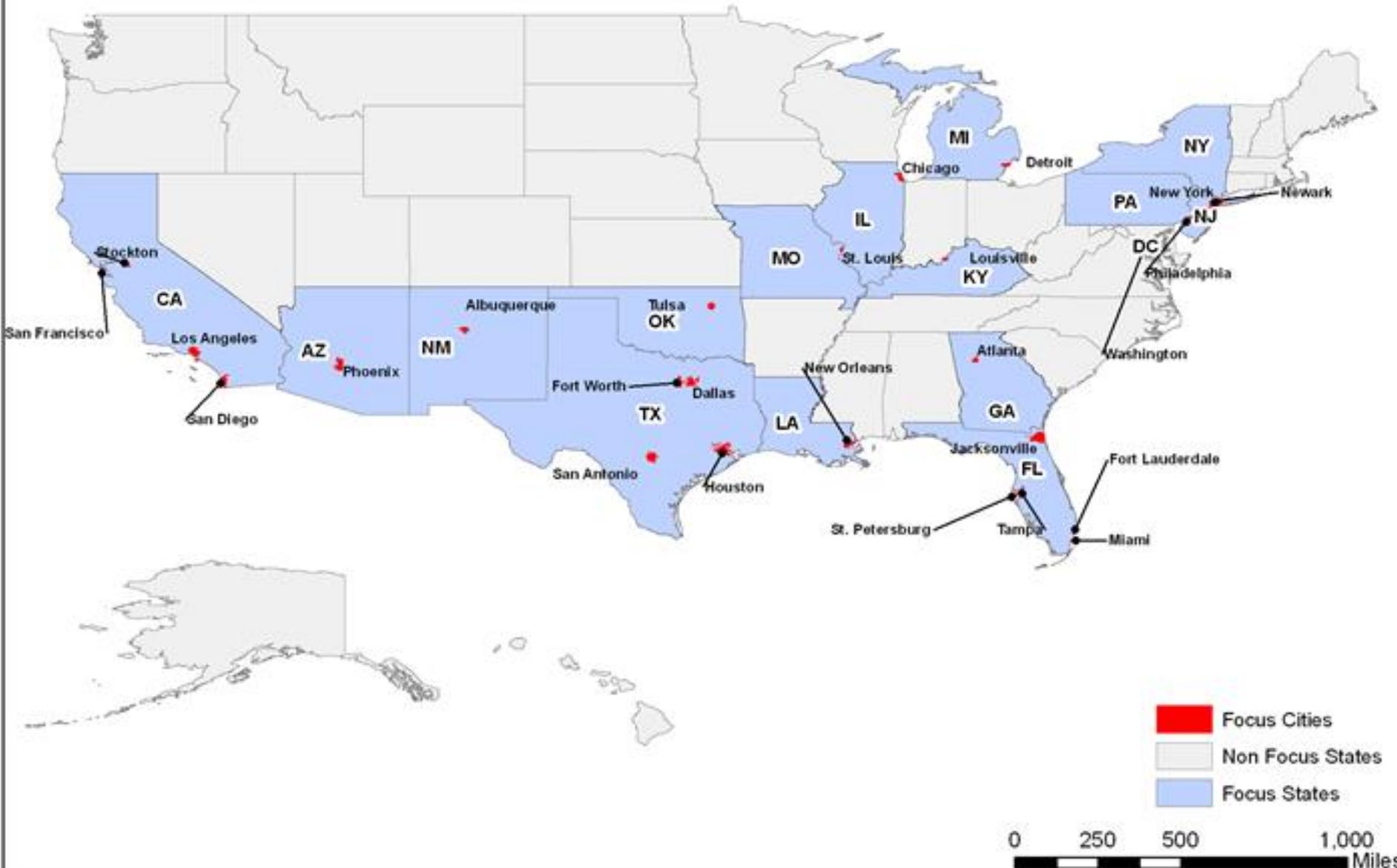
FHWA Focused Approach to Safety

State Safety Focus Areas

-  Roadway Departures
-  Pedestrians
-  Intersections



FHWA Pedestrian Safety Focus States and Cities



Intersection Safety Facts



- » About half of all severe crashes occur at intersections
- » Angle crashes account for over 40% of fatal crashes at intersections
- » Left turn crashes account for over 20% of fatal crashes at intersections
- » Ped/Bike crashes account for 25% of fatal crashes at signalized intersections



Source Isebrands, FHWA

Key Areas for Improving Intersection Safety

- » Increase awareness of intersections
- » Increase visibility of intersections and traffic control devices
- » Improve the design of intersections to reduce conflicts
- » Improve driver navigation to reduce confusion
- » Improve the operations of intersections
- » Improve sight distance at intersections
- » Improve driver compliance with traffic control devices

FHWA Proven Safety Countermeasures



Roundabouts



Corridor Access Management



Backplates with Retroreflective Borders



Longitudinal Rumble Strips and Stripes on Two-Lane Roads



Enhanced Delineation and Friction for Horizontal Curves



Safety Edge_{SM}



Medians and Pedestrian Crossing Islands in Urban and Suburban Areas



Pedestrian Hybrid Beacon



Road Diet



Roundabouts

FHWA Roundabout Guidance



Roundabouts are the preferred safety alternative for a wide range of intersections. Although they may not be appropriate in all circumstances, they should be considered as an alternative for all proposed new intersections on Federally-funded highway projects, particularly those with major road volumes less than 90 percent of the total entering volume. Roundabouts should also be considered for all existing intersections that have been identified as needing major safety or operational improvements. This would include freeway interchange ramp terminals and rural intersections. (2008 Memo, FHWA Office of Safety)

Why Support Roundabout Implementation?



» Safety

- » Reduction in speeds for ALL vehicles (15-25 mph)
- » Less severe crashes (significantly reduces occurrence of angle crashes caused by running a stop sign or a red light)

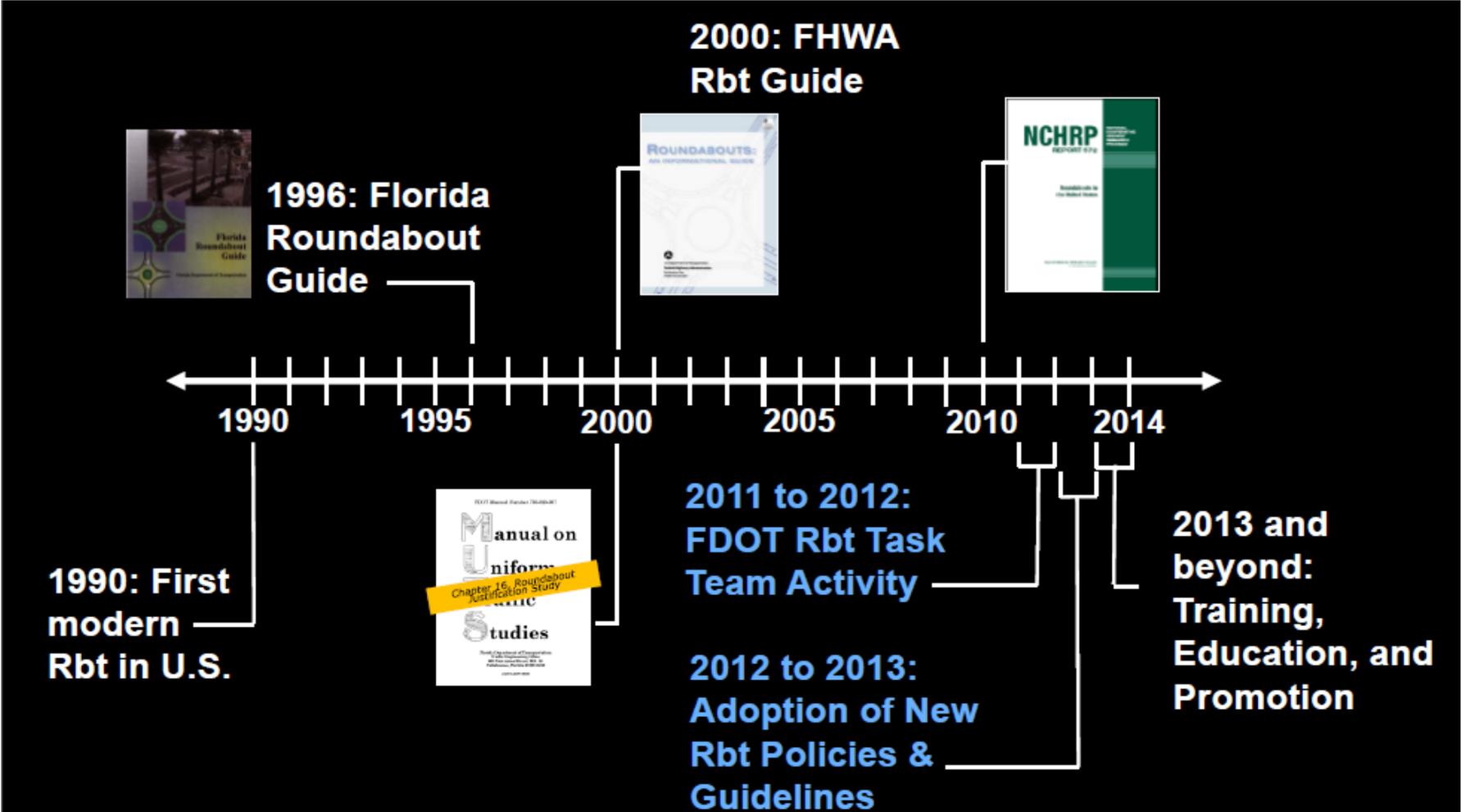
» Operations

- » Reduction in delays (Less time at the intersection 24hrs/day)
- » Suitable for traffic volumes over 60,000 vehicles/day

» Environment

- » Potential reduction in emissions (starts and stops, idling)
- » Less pavement, more green space on approaches
 - » Opportunities for landscaping in the center island
 - » Wide nodes and narrow roads (keep corridors narrow and no left turn lanes)

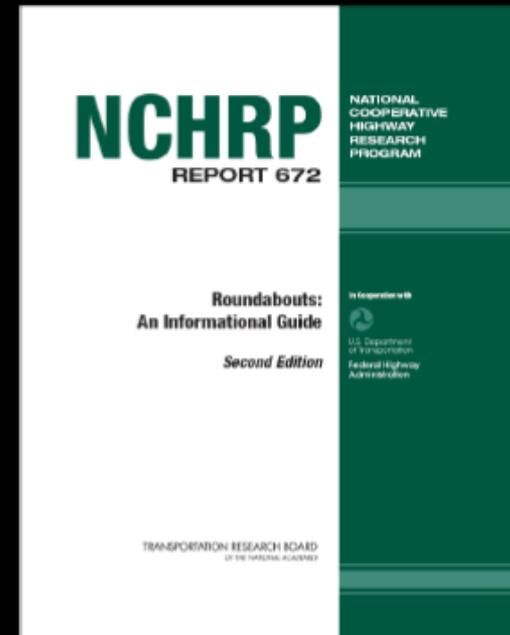
Florida Roundabout Timeline



FDOT Roundabout Design Guidance



- › Adopted by FDOT as the current roundabout design guidance document
- › Vetted by FDOT Roundabout Task Team
- › Supplemented in Florida by:
 - *FDOT Plans Preparation Manual*
 - *FDOT Intersection Design Guide*
 - *Florida Greenbook*
 - *Project Development & Environmental Manual*



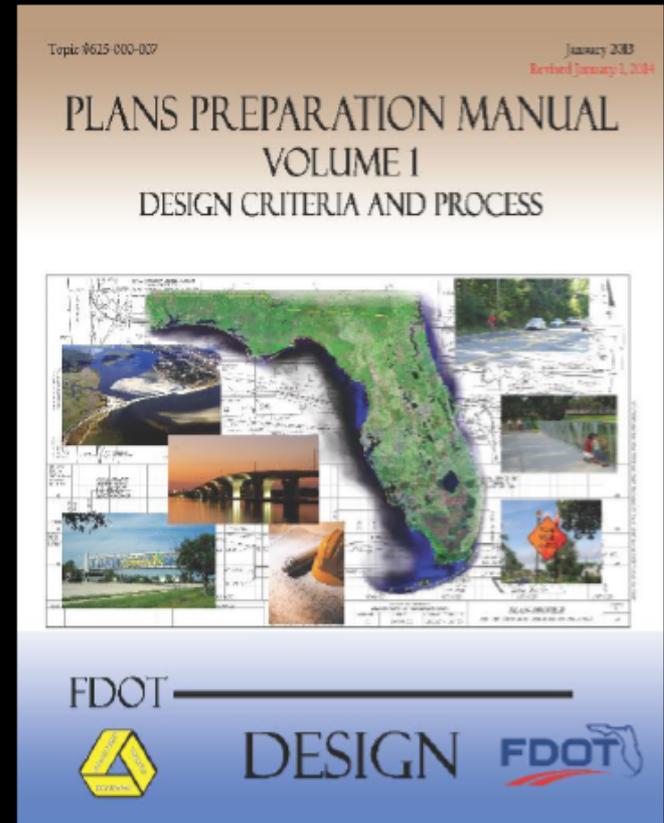
FDOT Roundabout Policy



- › Plans Preparation Manual, Volume 1, Chapter 2

Section 2.13 - Intersections

*“Roundabouts **shall** be evaluated on new construction, reconstruction and safety improvement projects, as well as anytime there are proposed changes in intersection control that will be more restrictive than the existing conditions.”*



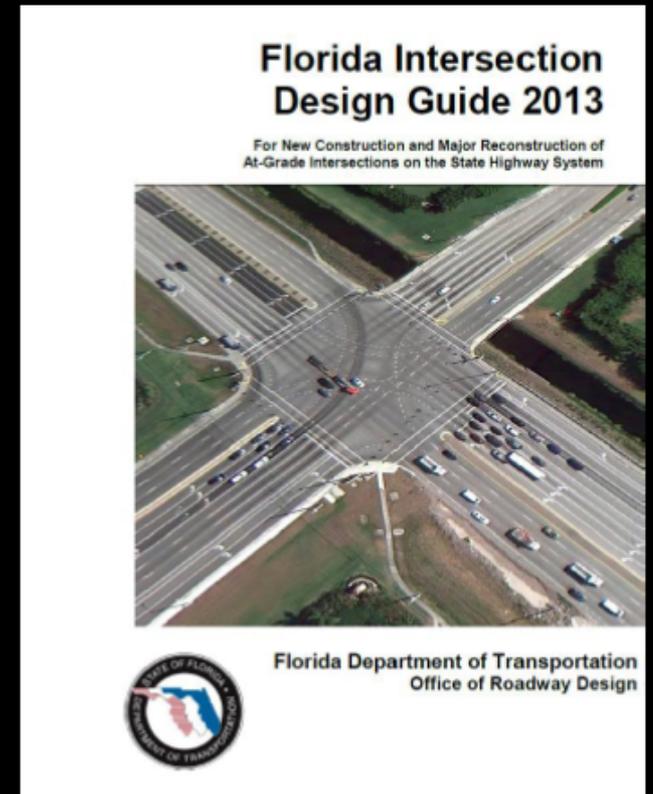
FDOT Roundabout Policy



- › Florida Intersection Design Guide (2013 Edition)

Section 2.2.3 – Traffic Control Modes

“Due to substantial safety characteristics, and potentially significant operational and capacity advantages, the modern Roundabout is a preferred traffic control mode for any new road or reconstruction project. Roundabouts should be considered as an alternative to all the other traffic control modes...”

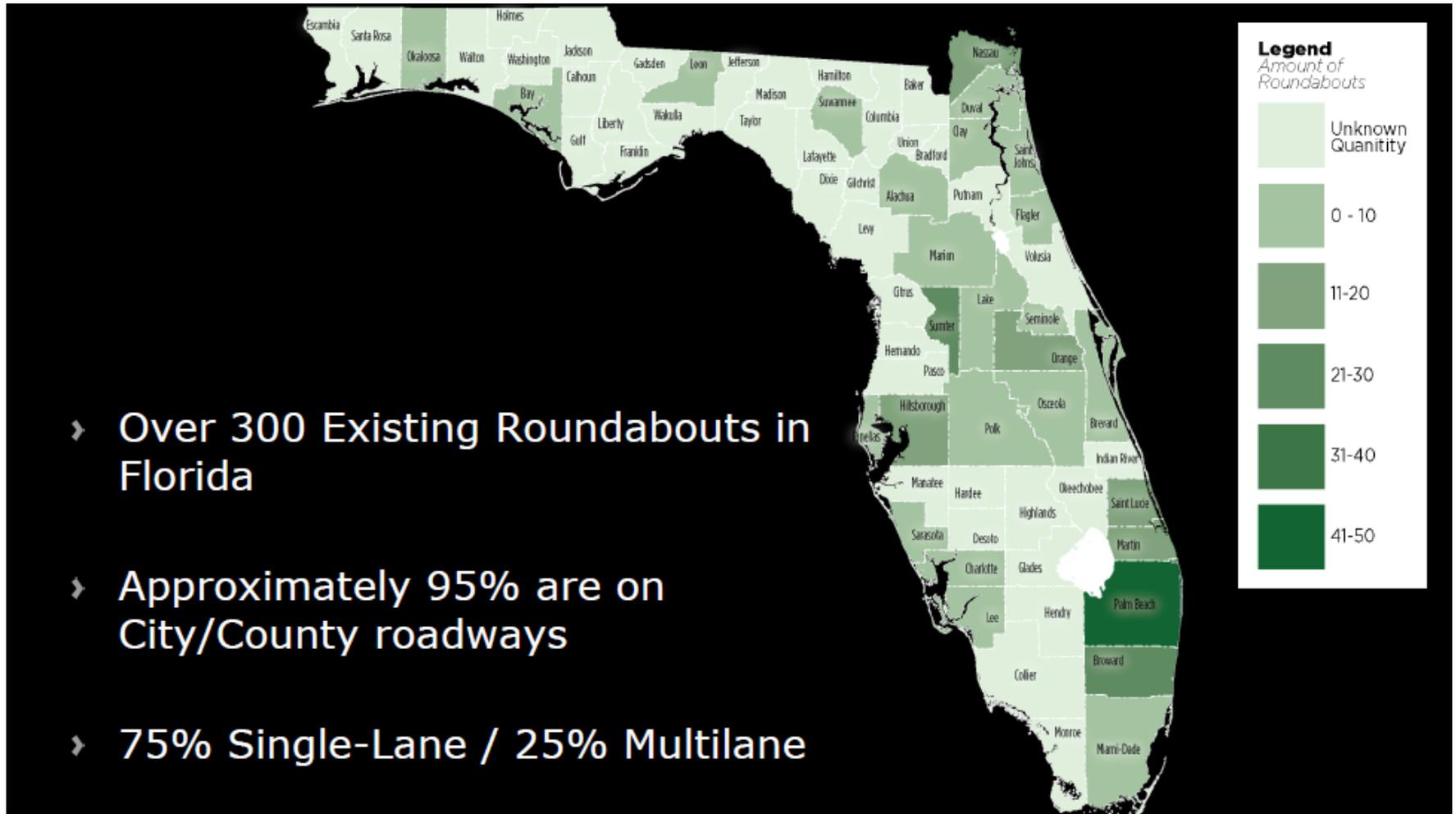


FDOT Roundabout Policy



- › Roundabout Screening now conducted for:
 - *Any New Construction*
 - *Reconstruction*
 - *Isolated Intersection Improvements*
 - Operational Improvements
 - Safety Improvements
 - *New Interchanges or Interchange Modifications*
 - *PD&E Studies*
 - *Complete Streets Projects*
 - *Etc.*

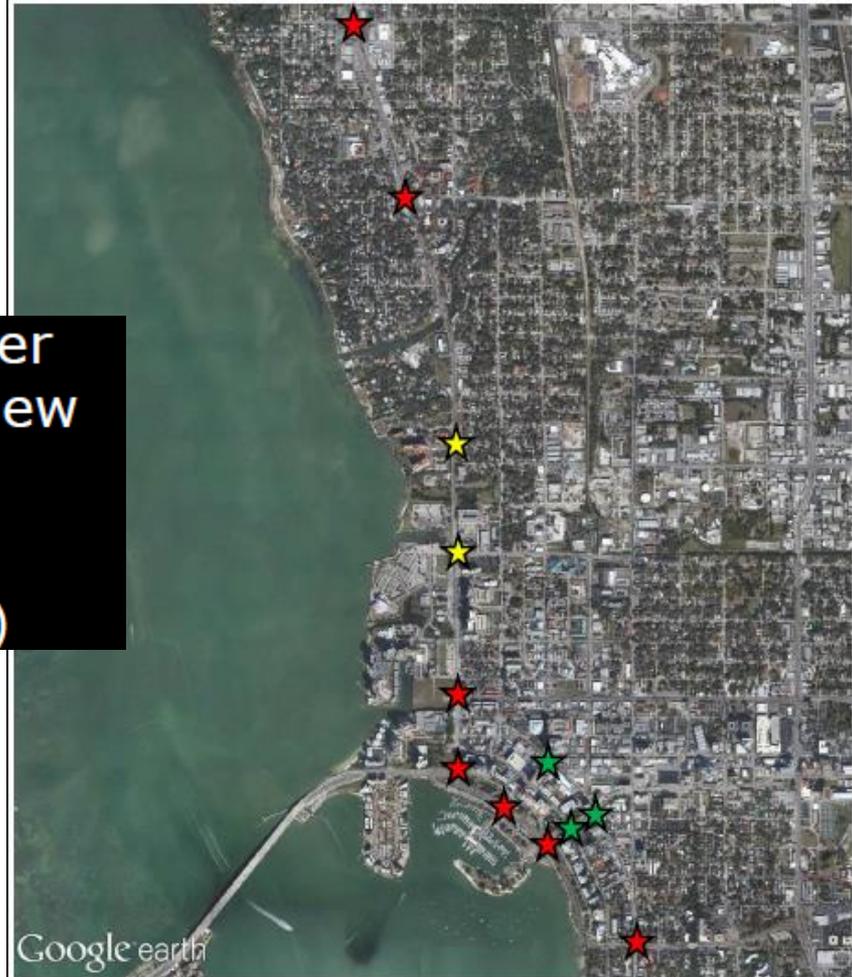
Current FL Roundabout Implementation



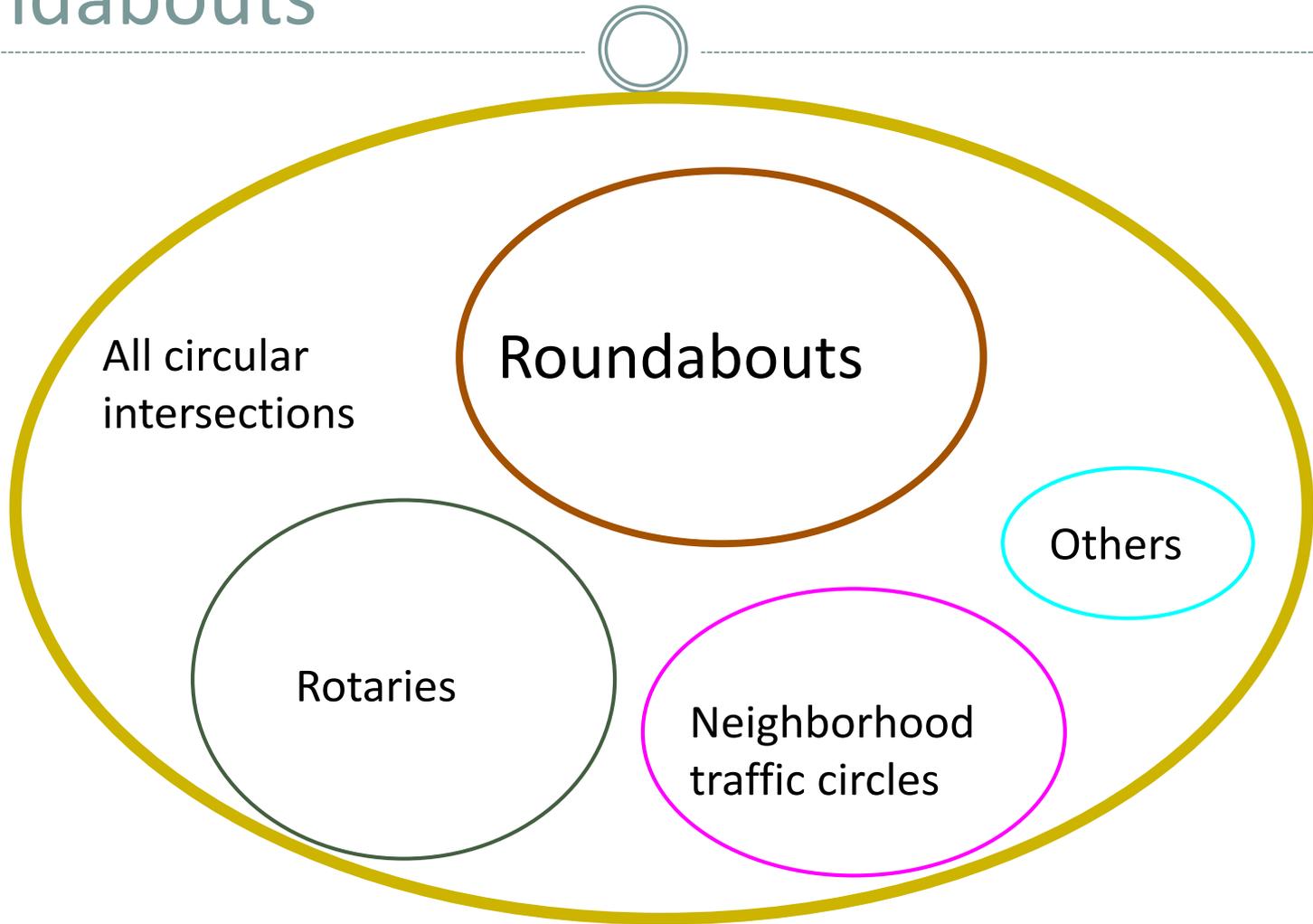
US 41 in Sarasota



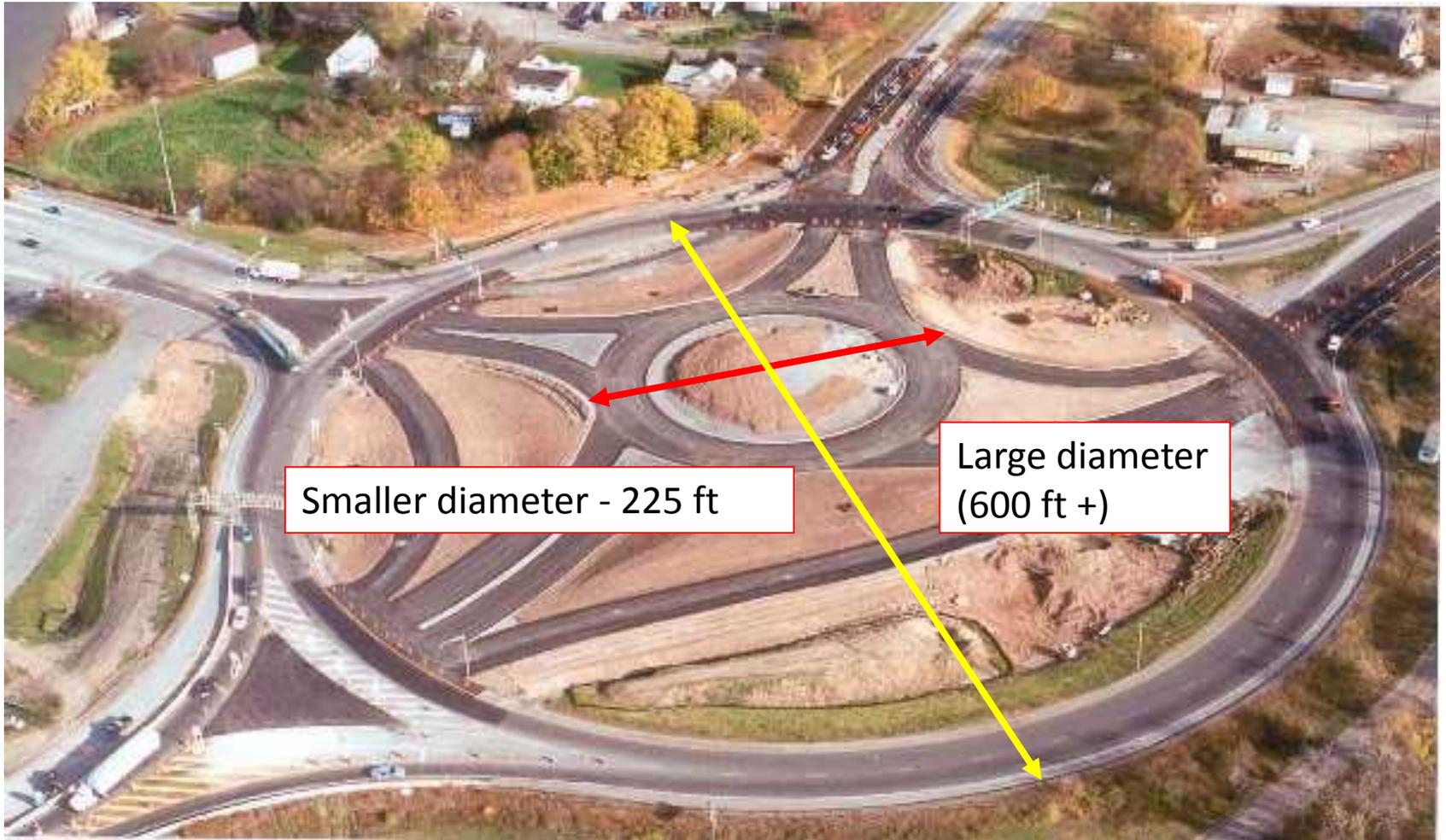
- ★ Proposed - Under Evaluation/Review
- ★ In Design
- ★ Constructed (City roadways)



Not All Circular Intersections Are Roundabouts



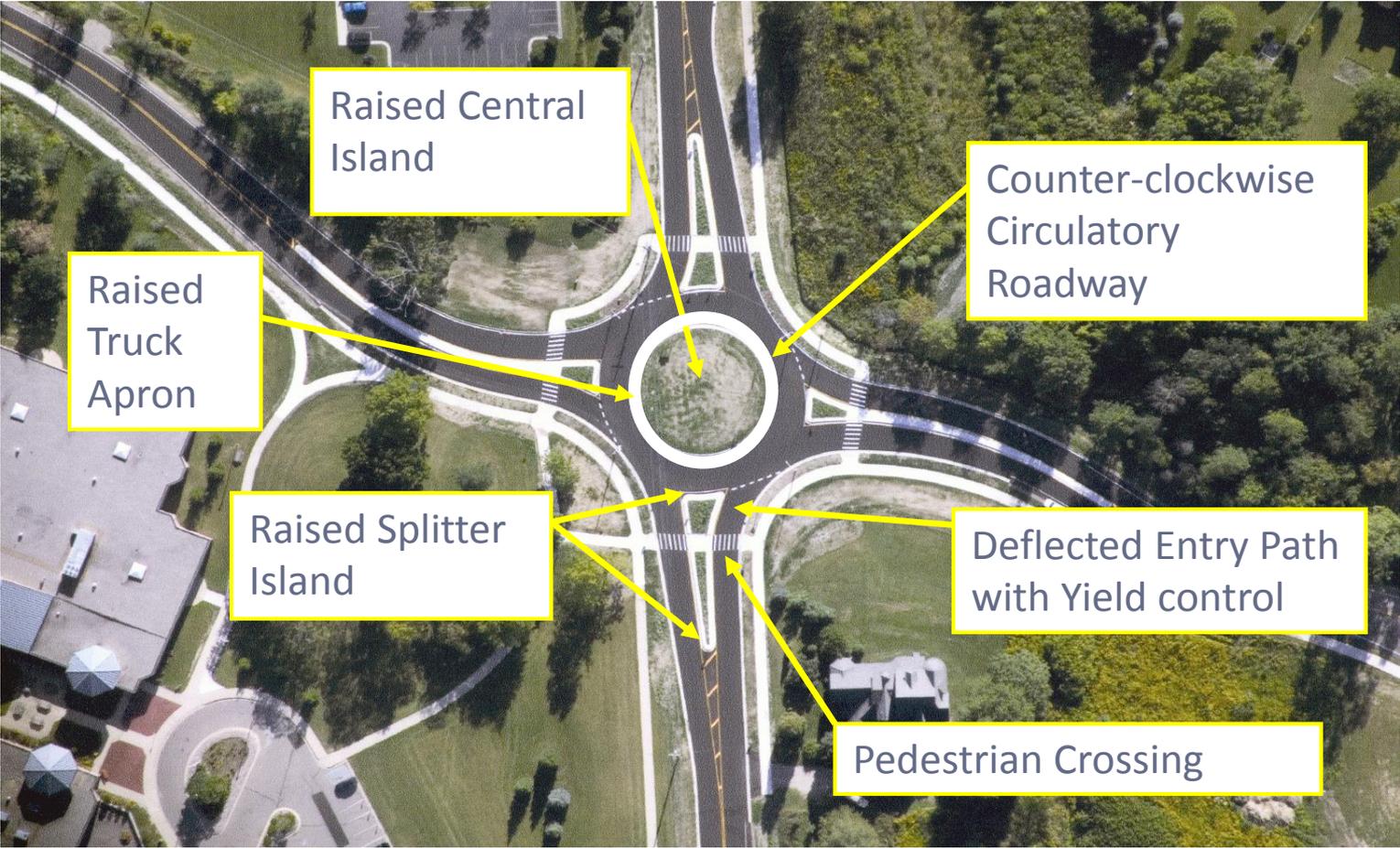
Traffic Circle to Roundabout Retrofit



Traffic Circle to Roundabout Retrofit

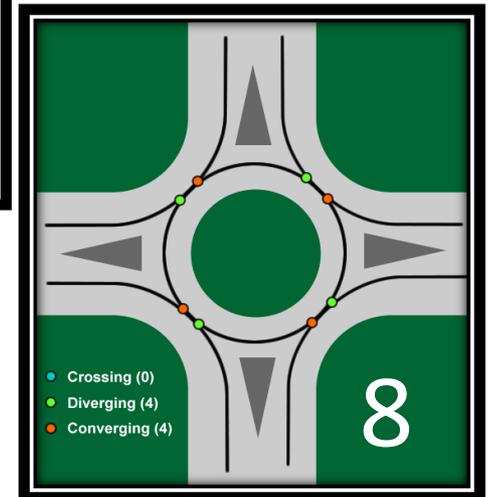
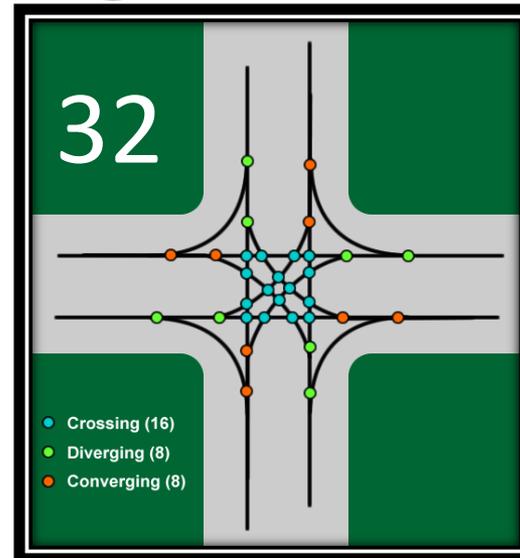


Physical Features of a Modern Roundabout



Roundabout Safety Experience

- » Fatal and injury crashes reduced significantly
- » The number of conflict points is $\frac{1}{4}$ of traditional intersection
- » Changes in the types of crashes
- » Slow speeds for all vehicles



Roundabout Safety Experience



- » 35% Reduction in All Crashes
- » 76% Reduction in Injury/Fatal Crashes
- » 89% Reduction in Injury/Fatal Crashes in Rural Environments



AASHTO Highway Safety Manual



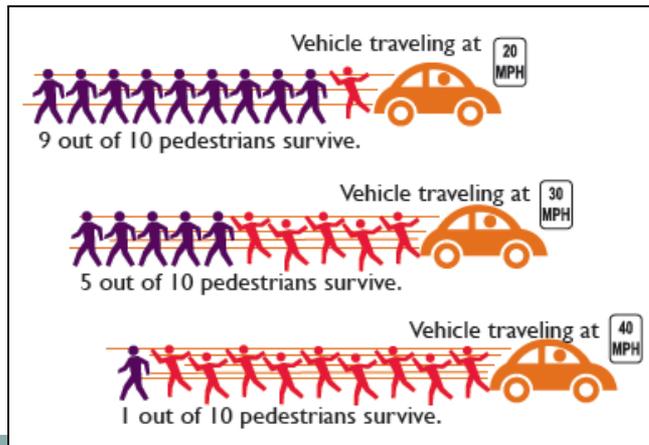
Table 14-4. Potential Crash Effects of Converting a Stop-Controlled Intersections into a Modern Roundabout (29)

Setting (Intersection type)	Traffic Volume	Crash type (Severity)	CMF	Std. Error
All settings (One or two lanes)		All types (All severities)	0.56	0.05
		All types (Injury)	0.18	0.04
Rural (One lane)		All types (All severities)	0.29	0.04
		All types (Injury)	0.13	0.04

Pedestrians Roundabout Experience



- » Low speeds (15-25mph)
- » Fewer conflict points (16 to 8 ped-veh)
- » Shorter crossing distances
- » Cross only one direction of travel at a time



Designing Roundabouts



Roundabout Categories & Typical Footprint



- » Mini-roundabouts
 - » 45 to 90 ft diameter
 - » Mountable center island

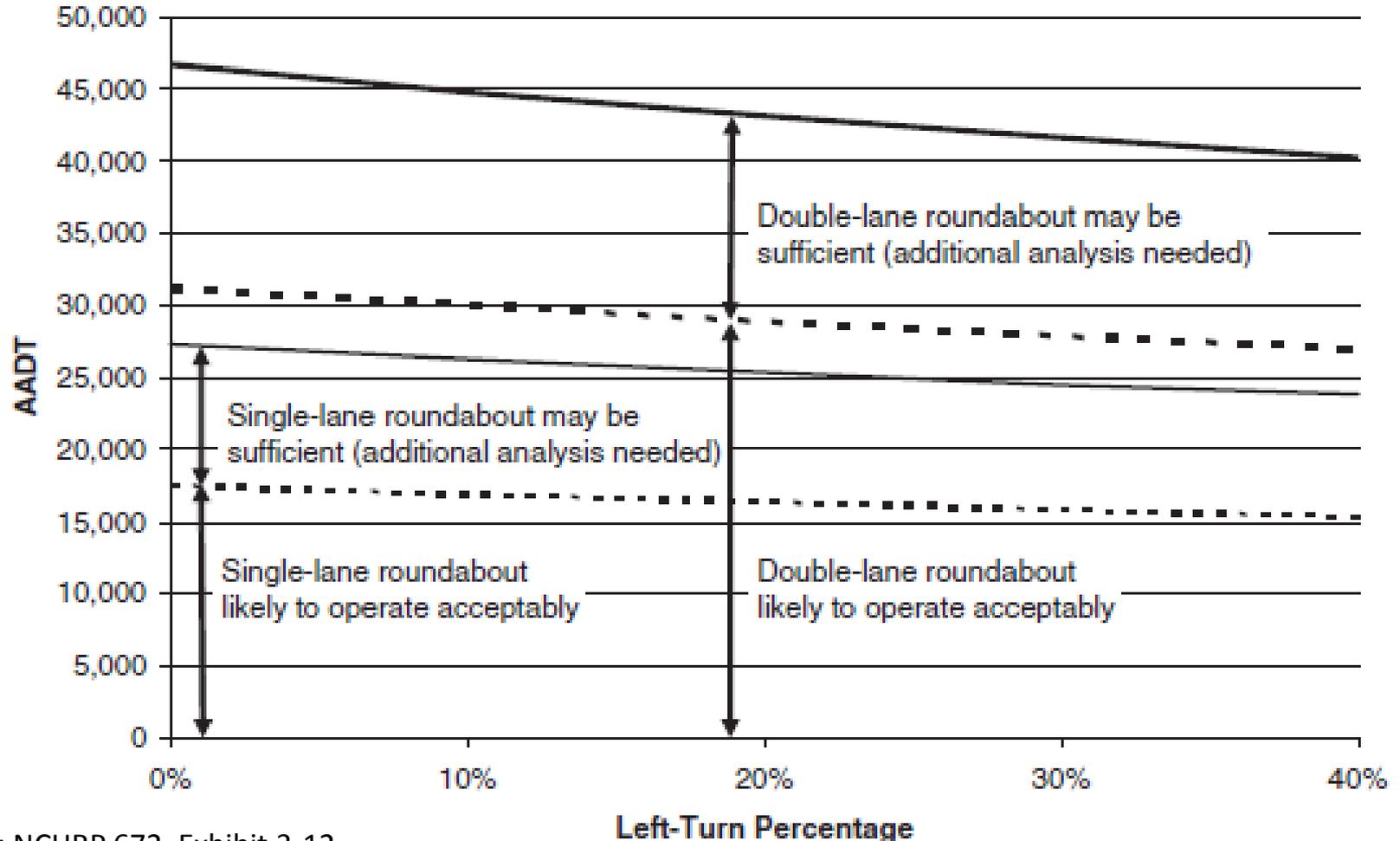


- » Single-Lane Roundabouts
 - » 90 to 180 ft diameter
 - » Low to high approach speeds



- » Multilane Roundabout
 - » 150 to 300 ft diameter
 - » Hybrid designs common

Planning Level Capacity - AADT



Source: NCHRP 672, Exhibit 3-12

Planning Level Capacity - VPH



Volume Range (sum of entering and conflicting volumes)	Number of Lanes Required
0 to 1,000 veh/h	<ul style="list-style-type: none"> Single-lane entry likely to be sufficient
1,000 to 1,300 veh/h	<ul style="list-style-type: none"> Two-lane entry may be needed Single-lane may be sufficient based upon more detailed analysis.
1,300 to 1,800 veh/h	<ul style="list-style-type: none"> Two-lane entry likely to be sufficient
Above 1,800 veh/h	<ul style="list-style-type: none"> More than two entering lanes may be required A more detailed capacity evaluation should be conducted to verify lane numbers and arrangements.

Source: New York State Department of Transportation

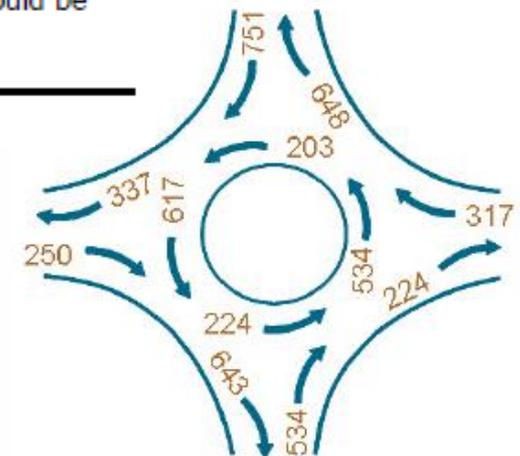
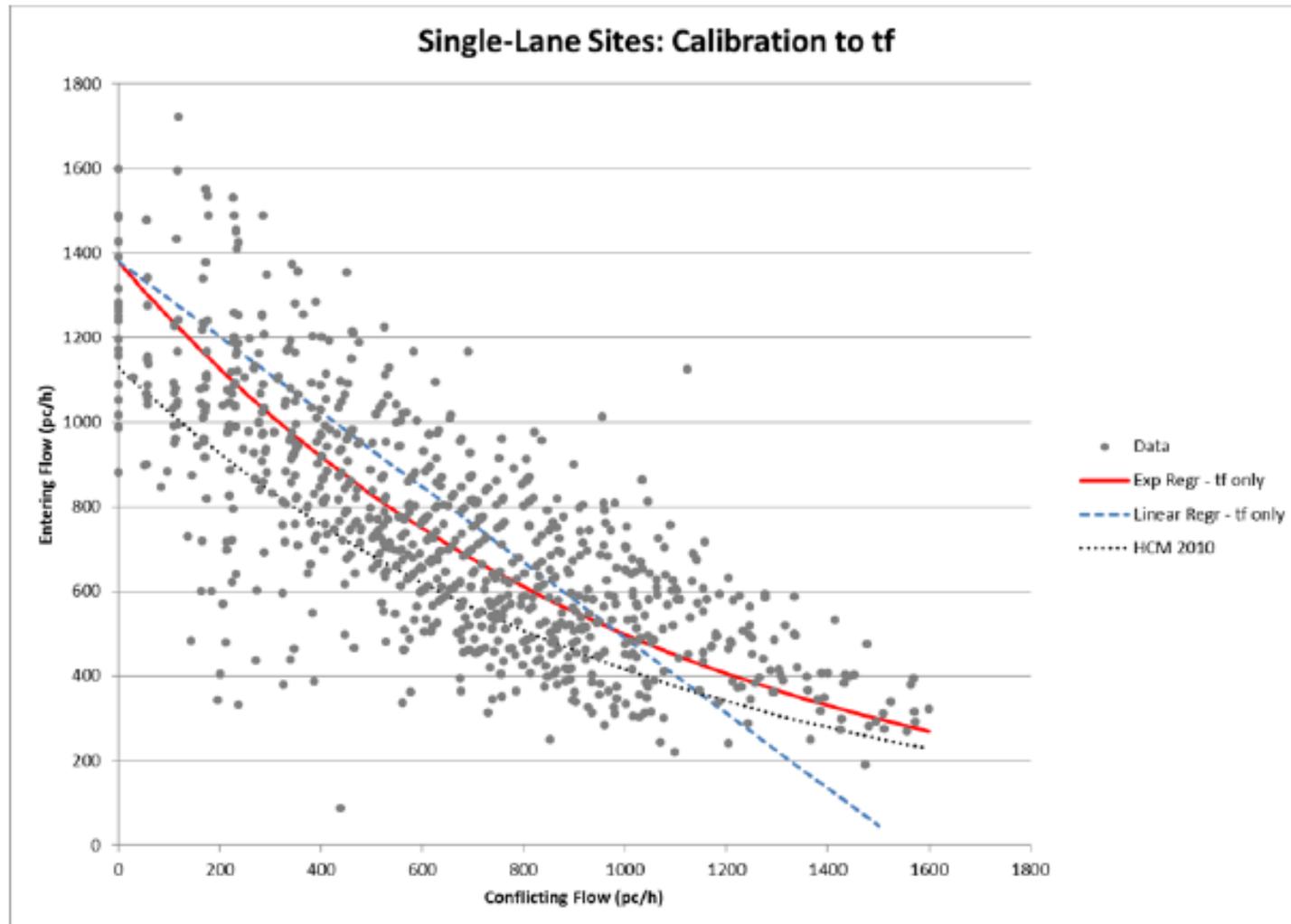
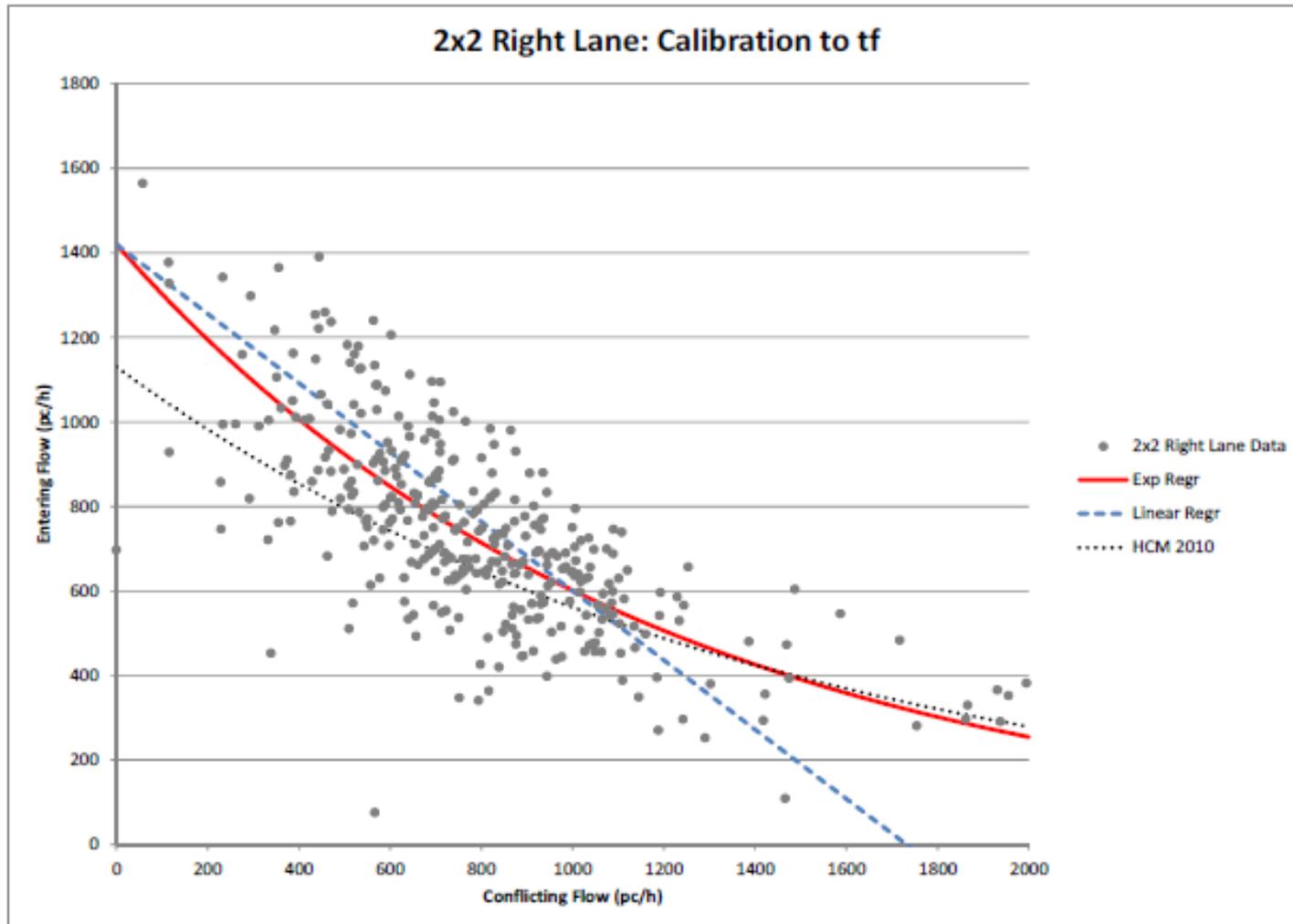


Table Source: NCHRP 672

FHWA DRAFT Calibrated Capacity Model - SLR



FHWA DRAFT Calibrated Capacity Model – MLR (Rt)



Georgia DOT Capacity Analysis Tool



GDOT
Roundabout Analysis Tool
v 1.2
Updated: 9/8/10

Welcome to GDOT's Roundabout Analysis Tool. This tool is designed for the user to determine the functionality of a proposed roundabout. The analysis is based on NCHRP Report 572 and the FHWA's Roundabout Design Guide (2000) standards. Please read the notes in the [instructions](#) tab before using the spreadsheet.

Analyst:

Agency/Company:

Date:

Project Name or P#:

Year, Peak Period:

County/District:

Intersection:

Insert Project Information Here in the BLUE SPACE. This information is linked to the Single Lane and Multi Lane Worksheets.

Proposed Design Configuration Chart

Directions for this Section only: (see instructions tab for other sections)

- Select the type of roundabout you are analyzing.
- Key in the number of approaches and the street names at the proposed intersections.
- Complete the Approach Characteristics Chart:
 - Select the Street Name from the pull-down menu for each approach leg
 - Select the Lane Type for each entry approach lane
**The first box is the inner lane, the second box is the outer lane*
 - Select Yes or No if a right turn bypass will be added to each approach leg

Roundabout Characteristics

Roundabout Type:	<input type="text" value="Multi-Lane"/>	Chart Key:	<input type="text" value="Street Name"/>
# of Approaches:	<input type="text" value=""/>	Single Lane	<input type="text" value="All"/>
Name of Streets:	<input type="text" value=""/>	Multi-lane	<input type="text" value="Bypass?"/>
			<input type="text" value="Street Name"/>
			<input type="text" value="Inner Ln"/>
			<input type="text" value="Outer Ln"/>
			<input type="text" value="Bypass?"/>

Approach Leg Characteristics:

	North Leg (1)	NE Leg (2)	East Leg (3)	SE Leg (4)
Street Name:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Entry Lane Config:	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>
Bypass to Adj Leg?	<input type="text" value="Yes"/>	<input type="text" value="Yes"/>	<input type="text" value="Yes"/>	<input type="text" value="Yes"/>
	South Leg (5)	SW Leg (6)	West Leg (7)	NW Leg (8)
Street Name:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Entry Lane Config:	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>	<input type="text" value="Left only"/> <input type="text" value="Thru"/> <input type="text" value="All"/>
Bypass to Adj Leg?	<input type="text" value="Yes"/>	<input type="text" value="Yes"/>	<input type="text" value="Yes"/>	<input type="text" value="Yes"/>

Preliminary Roundabout Rendering**

Roundabout Considerations Worksheet

Roundabouts may not operate well if there is too much traffic entering the intersection or if the percentage of traffic on the major road is too high. Candidate intersections shall be analyzed to determine whether a roundabout will perform acceptably. Shown below are thresholds to determine if a roundabout capacity analysis is required:

# of circulatory lan. ADTs (current/ build year)	% traffic on Major Road
Single Lane less than 25,000	less than 90%
Multi-Lane less than 45,000	less than 90%

Other things to consider when evaluating roundabouts as an alternative are Right of Way, sight distance, environmental impacts, and access to adjacent properties.

Volume Information (for Analysis Time Period)

1 Enter the Major/Minor Street ADT Volumes in the Chart below:

	Volume	Split
Major Street	<input type="text" value=""/>	<input type="text" value="0%"/>
Minor Street	<input type="text" value=""/>	<input type="text" value="0%"/>
Total volumes:	<input type="text" value="0"/>	

Proximity to Other Intersections

2 How close is the nearest signal (miles or feet)

3 Is the proposed intersection located within a coordinated signal network?

Go up to next section...

START HERE
Instructions
Single Lane
Multi-Lane

Ready
59%

Size, Position, Alignment



(a) Centered on Existing Intersection



(b) Center Shifted to the South



(c) Center Shifted to the East

Fastest Path Speeds



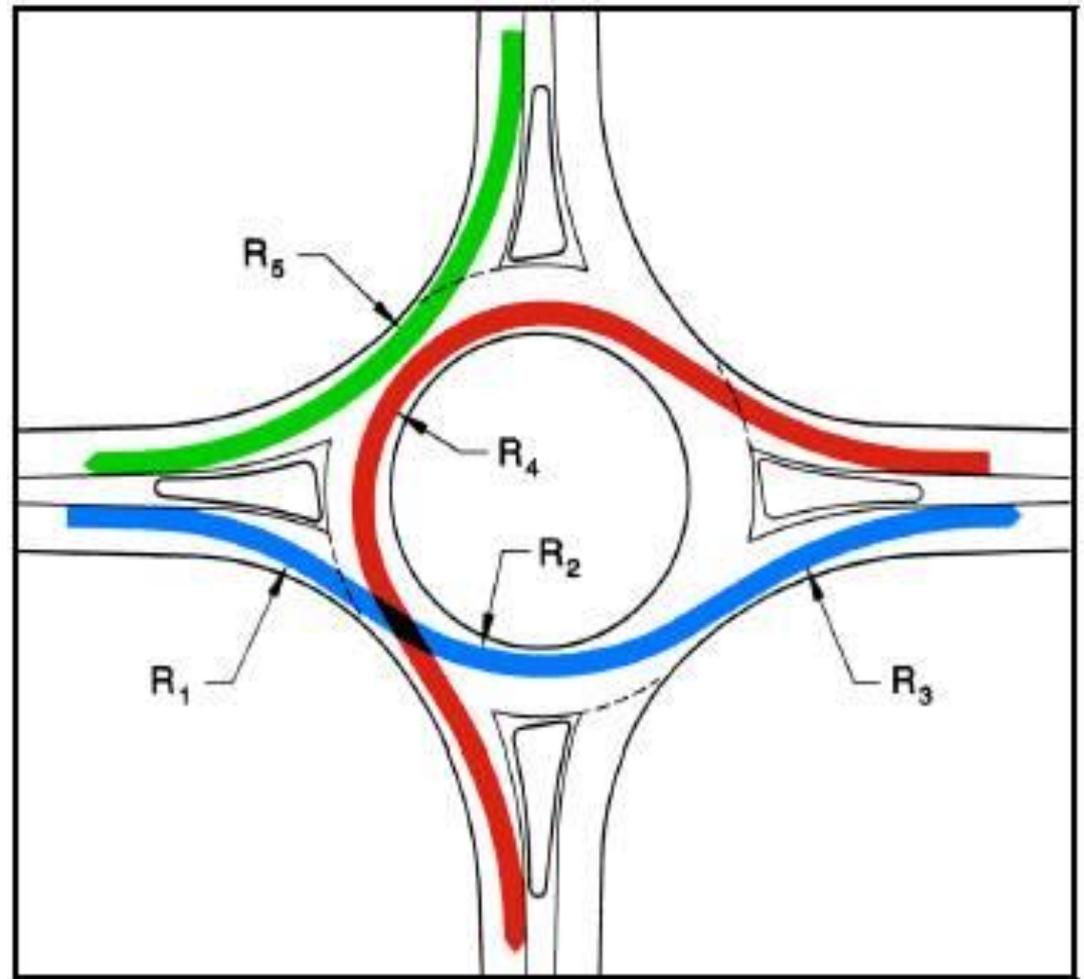
R1: entry path radius ·
Deflection

R2: circulating radius

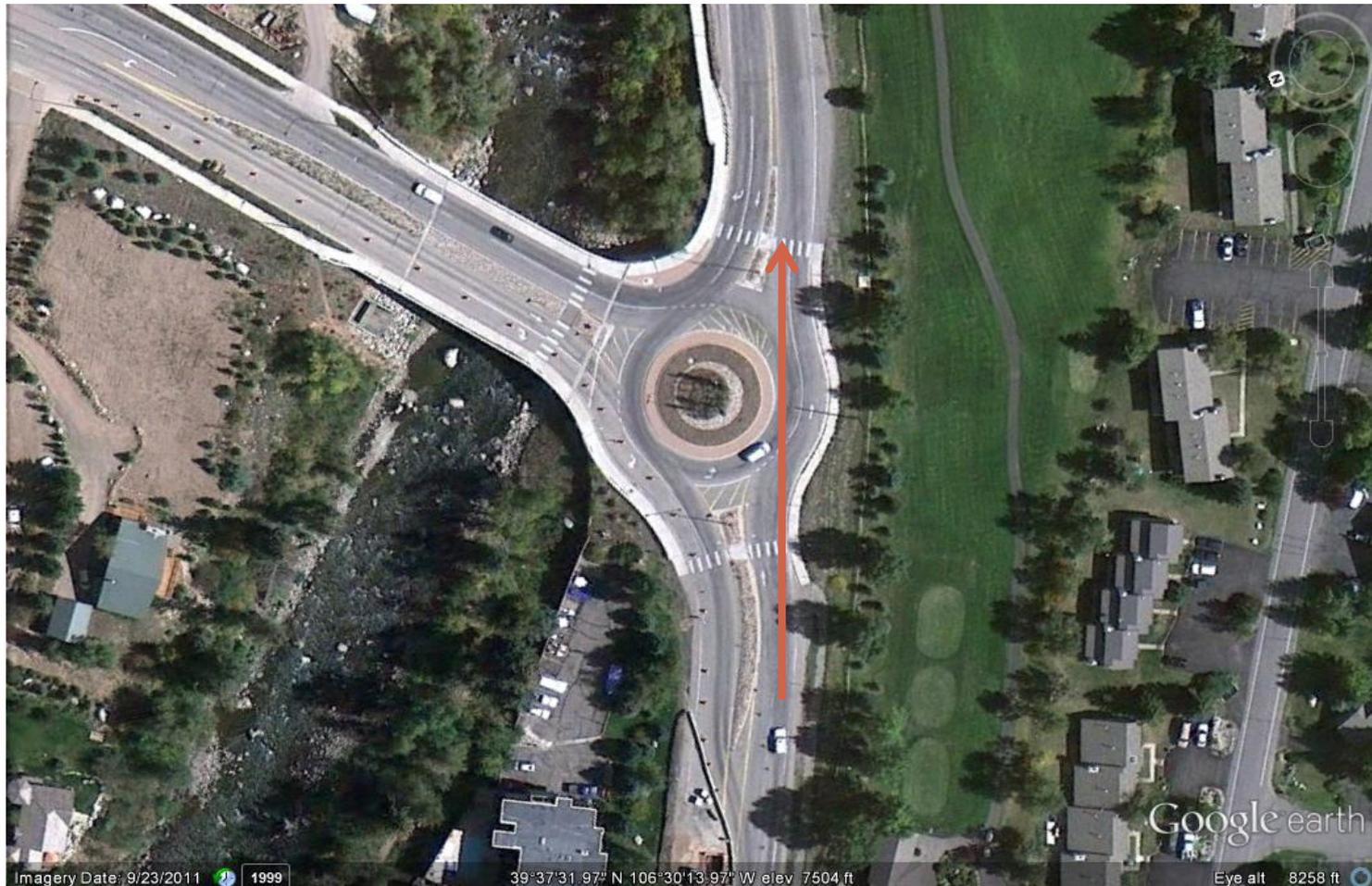
R3: exit path radius

R4: left turn radius

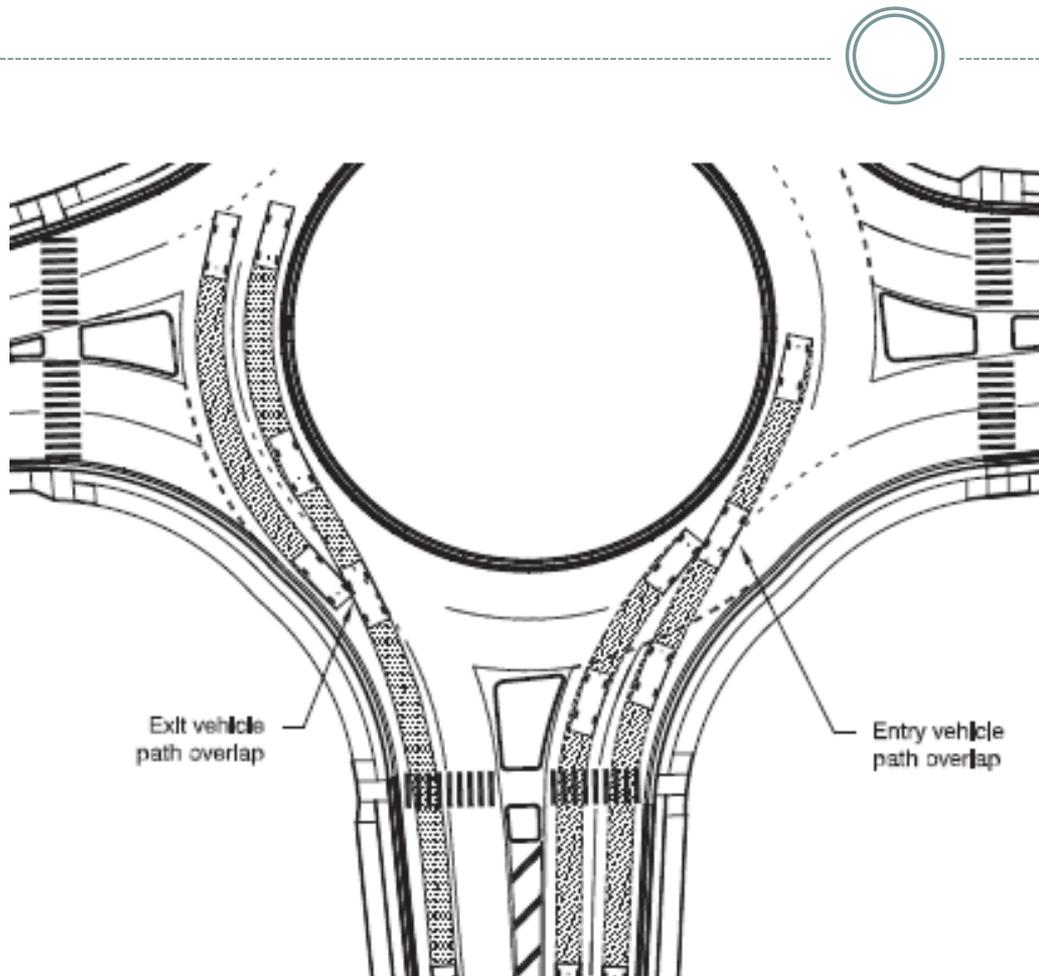
R5: right turn radius



Lack of Speed Control/Vehicle Path Overlap



Multi-lane Designs – Vehicle Path Overlap



- » Common error for first time designers
- » Techniques available to correct
- » Design and markings must complement each other

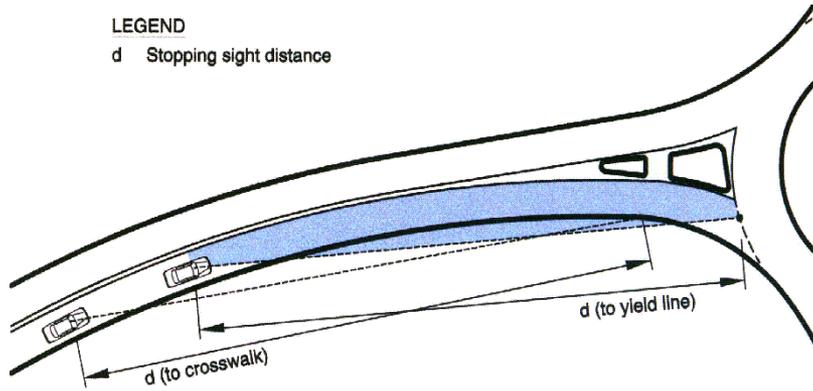
Source: NCHRP 672

Sight Distance



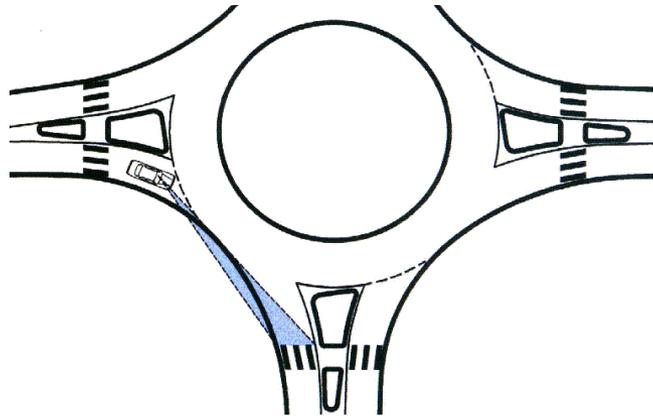
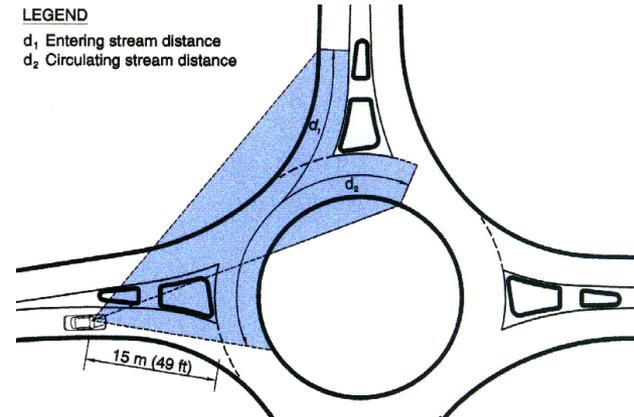
LEGEND

d Stopping sight distance



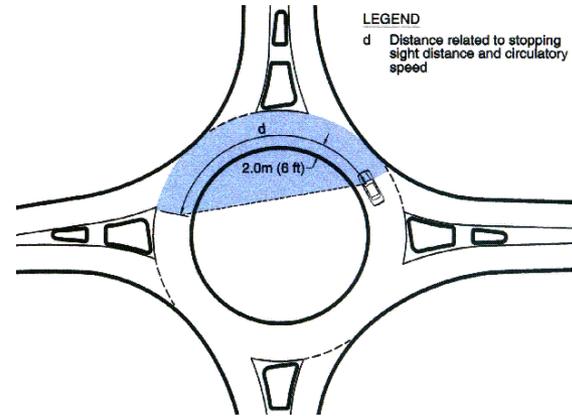
LEGEND

d_1 Entering stream distance
 d_2 Circulating stream distance



LEGEND

d Distance related to stopping sight distance and circulatory speed

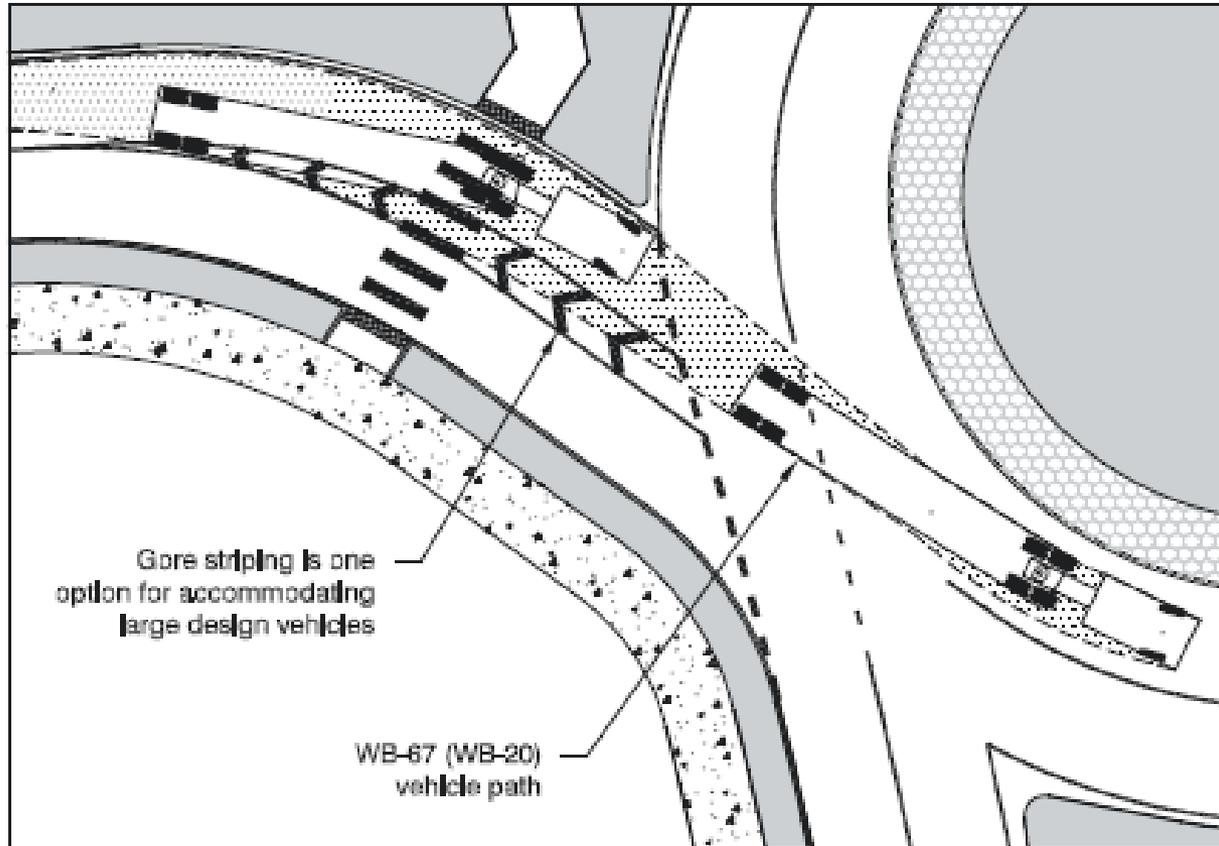




Large Vehicles

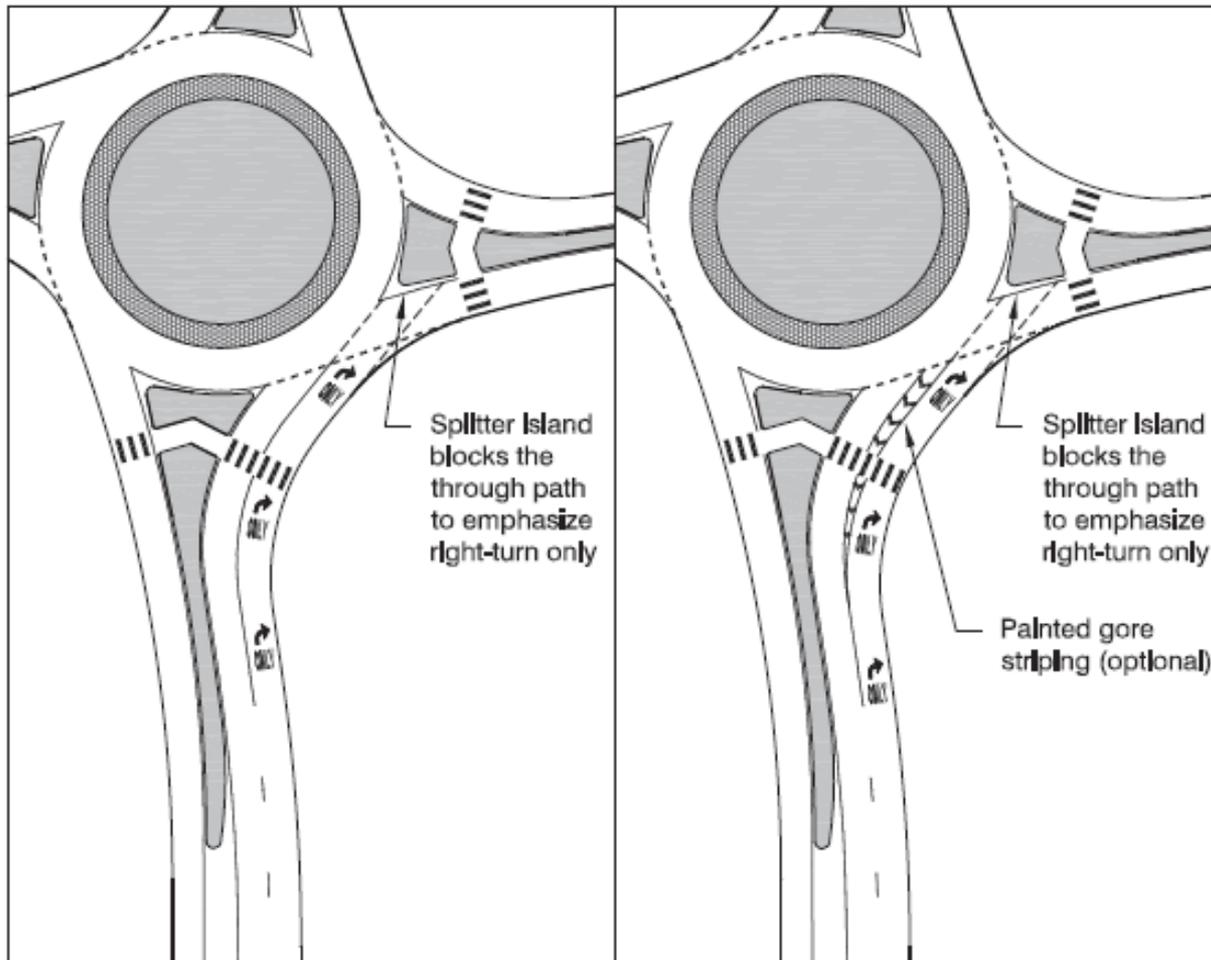


Gore Striping



Source: New York State Department of Transportation (11)

Exclusive Right Turn Lanes



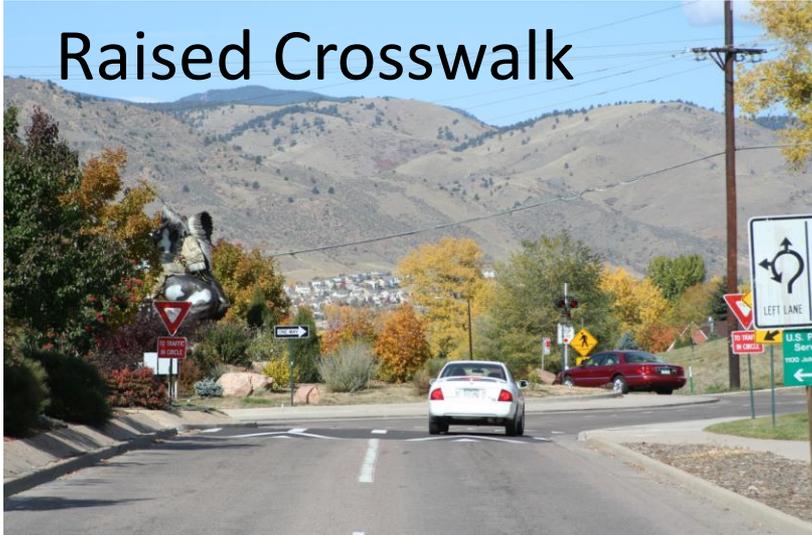
Bikes at Modern Roundabouts



Accessibility at Modern Roundabouts



Raised Crosswalk



Pedestrian Hybrid Beacon



Rectangular Rapid Flash Beacon



A Design Lessons Learned Case Study



Photo Courtesy: Hillary Isebrands

A Design Lessons Learned Case Study



Before



A Design Lessons Learned Case Study



After



Photo Courtesy: Hillary Isebrands

A Safety Case Study- The Problem



Photo Courtesy: Kansas DOT

A Safety Case Study – The Evidence

ACCIDENT SUMMARY

No. Of Accidents: 35
 Fatal: 3
 Personal Injury: 17
 Property Damage: 15

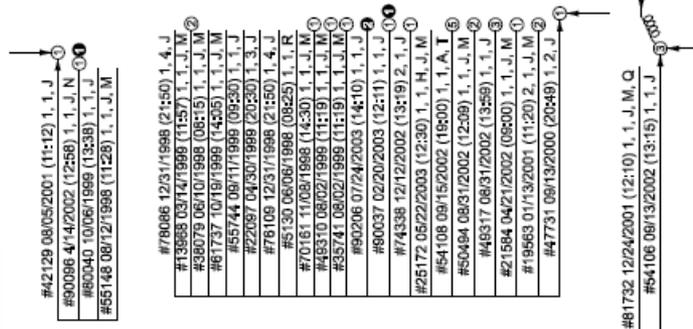
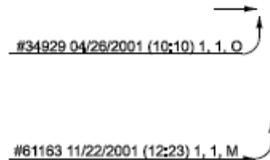
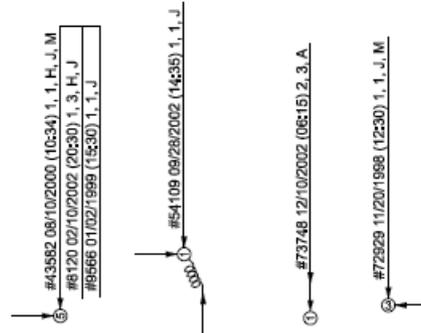
Injury Record: 40
 Fatalities: 4
 Personal Injuries: 36

STUDY PERIOD
 01/1998 - 08/2003



DRIVER ACTION

A. Illegal or Unsafe Speed	O. Improper Lane Change
B. Impeding Traffic	P. Vehicle Malfunction
C. Following Too Close	Q. DM Not See
D. Improper Overtaking	R. Vision Obstructed
E. Improper Turn	S. Deer Related
F. Improper Start, Stop, Park	T. D.U.I. (drugs)
G. Traf. Control Viol'n, Lights	V. Hit & Run
H. Traf. Control Viol'n, Signs	
J. Fall to Yield R/W	
K. Drove Left of Center	
L. No or Improper Signal	
M. Careless- Inattention	
N. Avoid Vehicle, Object, Ped.	(*) Median Related



ACCIDENT RATE

$$\frac{(\# \text{ Acc.})(10^7)}{(365)(\text{Yrs.})(\text{ADT})} = \frac{35 \times 10^7}{365(5.7)(4886)} = 34.38$$

Critical Rate: $\frac{34.38}{4.17} = 8.37$ ACC/TMEV

LEGEND

Fatality	●	Uninvolved	—
Personal Injury	○	Vehicle	—
Property Damage	◐	Pedestrian	—
Fixed Object	□		—

Case # Date (Time) Road Cond. Light Cond. Action

COLLISION DIAGRAM

KANSAS DEPT. OF TRANSPORTATION
 BUREAU OF TRAFFIC ENGINEERING

COUNTY: Marion DATE: 03/18/2008
 COMPLETED BY: Connie Eakes

CONTRIBUTING FACTORS

ROAD SURFACE COND.	LIGHT COND.
1. Dry	1. Daylight
2. Wet	2. Dawn/Dusk
3. Water Const.	3. Dark, LTG.
4. Snow/Ice	4. Dark, NO LTG.
5. Slippery	5. Unknown
6. Unknown	

A Safety Case Study – The Solution



Source: Kansas DOT

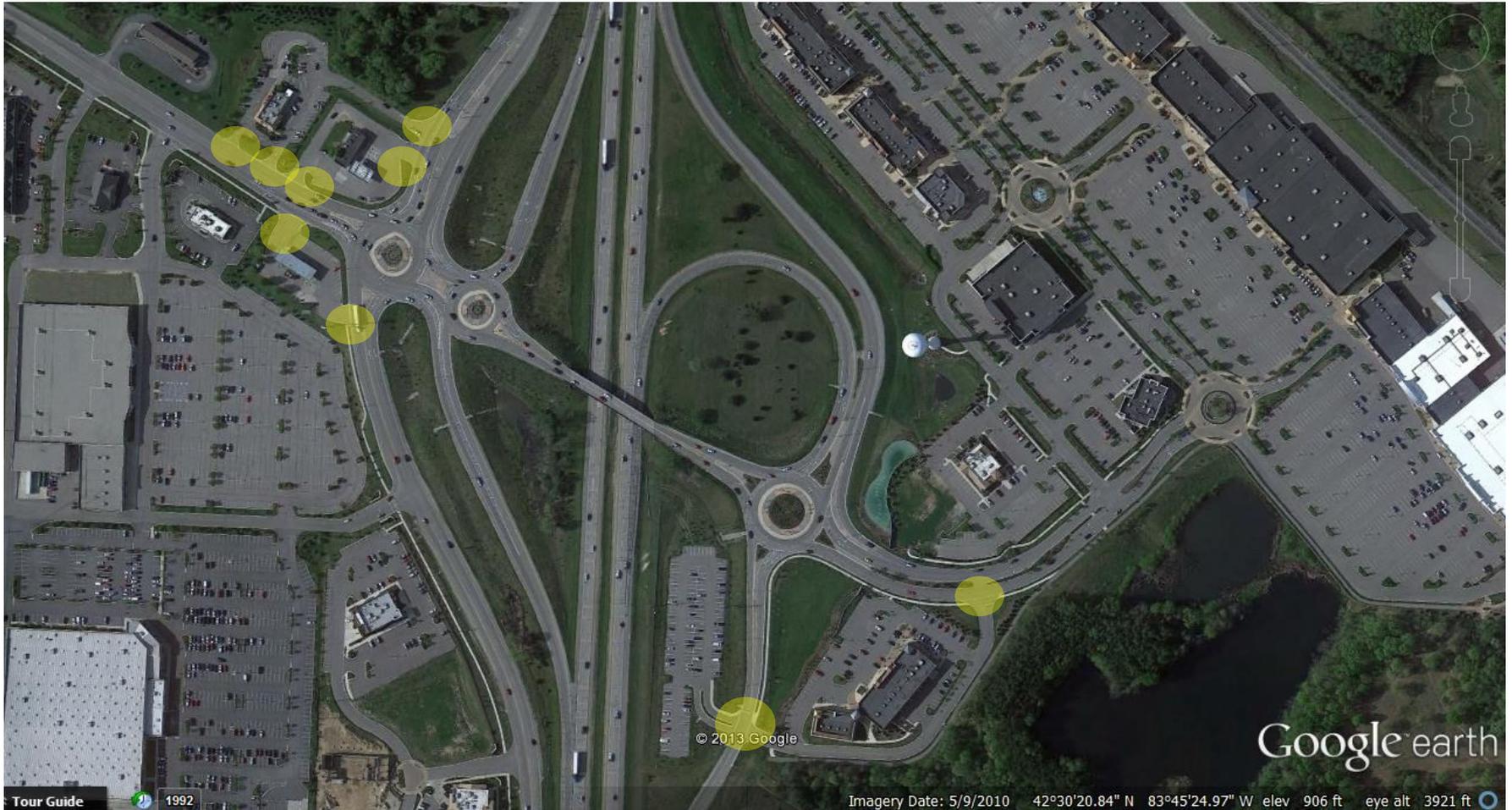


Source: Isebrands



Source: Isebrands

US 23 and Lee Rd, Livingston County, MI



WisDOT – High Speed 4 Lane Divided Highway



Dodgeville, WI
Source: Google Earth

© 2014 Google

Google earth

Imagery Date: 10/8/2013 42°58'17.11" N 90°06'54.13" W elev: 1156 ft eye alt: 2607 ft

WashDOT SR 539 – 4 lane Divided Hwy



I-70 and Pecos St – Denver, CO

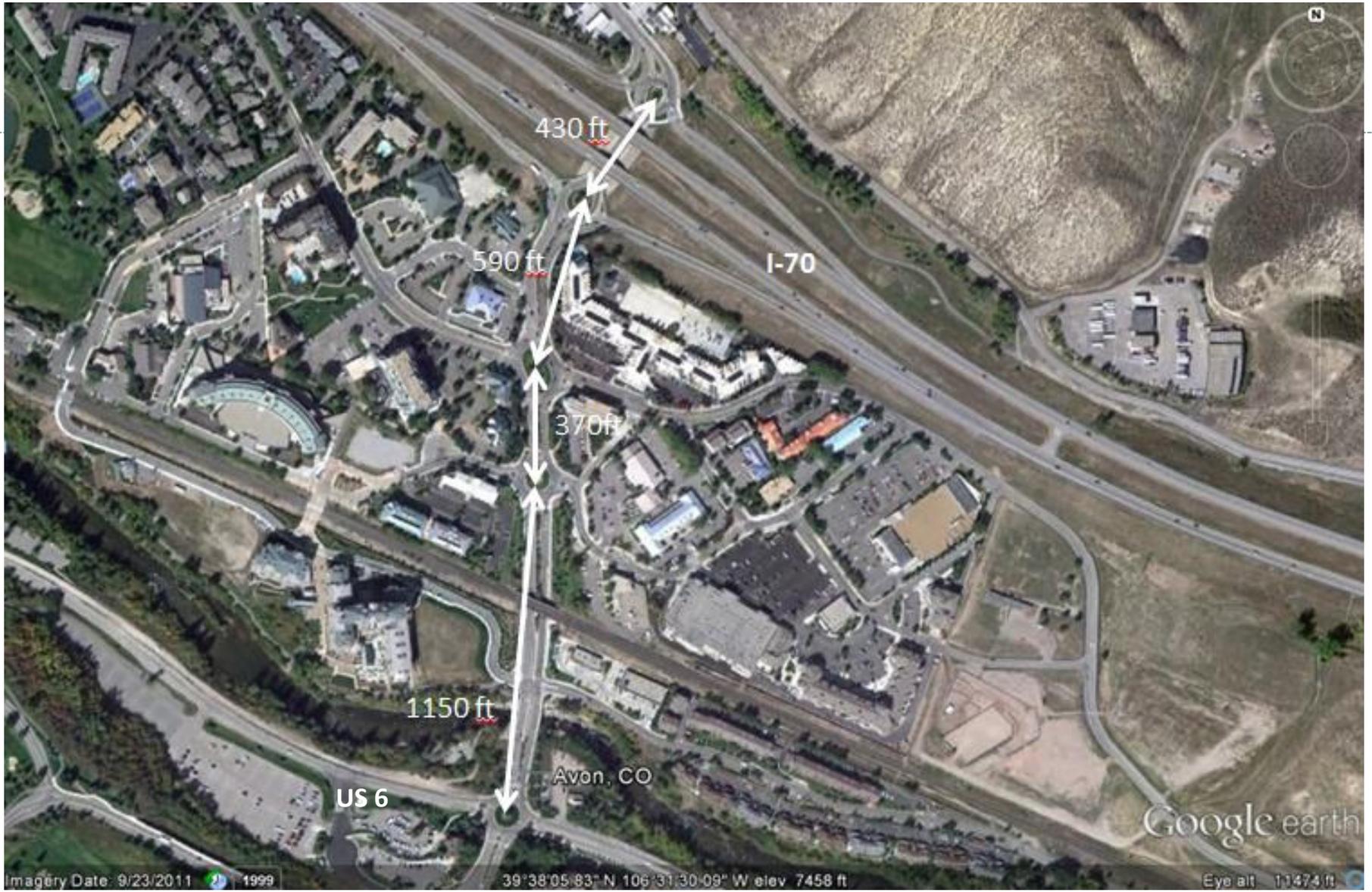


Before



After





Imagery Date: 9/23/2011 1999

39°38'05.83" N 106°31'30.09" W elev 7458 ft

Eye alt 11474 ft



Source of Images: Google Earth

44°00'50.50" N 88°34'43.44" W e

Design Review Checklist (1 of 2)

- » Is the diameter appropriate for context? What are the Fastest Path Speeds?
 - » Design Speeds for R1, R2, R3, R4, R5
 - » Relationship between radiuses (max 12mph difference)
- » Is alignment appropriate?
- » Is there enough deflection?
- » What is the design vehicle?
 - » How often does design vehicle use intersection?
- » Multi-lane roundabout
 - » Potential for vehicle path overlap?
 - » How robust are traffic projections?
 - » Should it really be constructed as a SLR?





Design Review Checklist (2 of 2)

- » Are the splitter island lengths appropriate?
 - » High speed approaches
 - » Driveways/Access
- » Pedestrian and bicycle features
 - » Landscaping buffer for way finding
 - » Width of crosswalk/refuge area sufficient
 - » Bike ramp
- » Is there a truck apron? (check height, width)
- » Is there curb and gutter on the outside?
- » Is the lighting design appropriate?
- » Does the signing and marking complement the design?
- » Were any analysis for design tools used?



Peer Reviews

- » Why are they important?
 - » Roundabouts are still fairly “new”
 - » Roundabout design not in academic curriculum
 - » Not every agency has a roundabout expert on board (and that is okay)
 - » An unbiased opinion almost always adds value
 - » You can learn a lot from a peer review – it makes you a better designer
- » On-call contract or pre-qualified designer until in-house expertise are developed (Iowa DOT, Kansas DOT, GDOT)

Education – Videos and Websites

- » Brief decision makers about roundabouts before you have a project on the table
- » Provide decision makers and public with Q&A briefing sheet including FAQ



The screenshot shows the homepage of the 'Roundabout Outreach and Education Toolbox' from the U.S. Department of Transportation Federal Highway Administration. The page features a search bar, a 'Browse by Attribute' section with dropdown menus for Outreach Strategy, Outreach Product Type, Roundabout Complexity, Roundabout Setting, Implementation Stage, Geographic Region, Target Audience, and State, and a 'View All' button. A 'Help Grow the Toolbox' section is also visible, encouraging users to submit case studies or products.



<http://www.youtube.com/watch?v=OvoFjirrgYA>



Current Publications and Research



- » NCHRP 672 – Roundabouts: An Informational Report, Second Edition
- » NCHRP 674 - Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities
- » NCHRP 03-100: Evaluating the Performance of Corridors with Roundabouts (In Publication)
- » FHWA - Mini Roundabout Safety and Operational Study (On-going)
- » FHWA - Accelerating Roundabout Implementation in the United States: Evaluations to Address Key Issues (On-going)
- » NCHRP 03-110: Life Cycle Cost Analysis of Intersections (New)

Summary



» Safe

- » Most vehicles average 15 to 25 mph thru intersection
- » Fewer conflict points
- » Reduce probability of right angle, injury type crashes
- » Reduces fatal and injury crashes on average by 80%

» Efficient

- » All movements (LT, TH, RT) have equal priority
- » 24 hours a day (little stopping during off peak)

» Smart

- » Game changing design in terms of safety and operations
- » Provides flexibility where none may have existed before

2014 Design Training Expo



Source of Images: Isebrands, Google Earth, Isebrands

Thank You ■ Questions and Discussion

Hillary N. Isebrands, PE, PhD

FHWA Resource Center, Safety & Design Technical Service Team ■ Lakewood, CO

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U.S. Department of Transportation
Federal Highway Administration