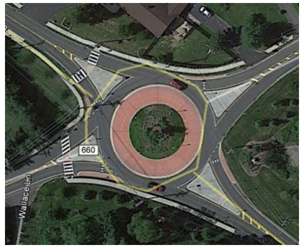
The Fundamentals of Modern Roundabouts

November 7, 2019



Presented by: Hillary Isebrands, PE, PhD
FHWA Resource Center
National Safety & Design Team

Federal Highway Administration
RESOURCE CENTER

NJTPA
NORTH JERSEY TRANSPORTATION PLANNING AUTHORITY

U.S. Department of Transportation
Federal Highway Administration

Topics for Discussion

- » Circular Intersections
- » The Safety Difference
- » The Design of a Roundabout
- » Proactive Education
- » Roundabouts in Practice

Image Source Isebrands Hwy 8 and 47 in Rhinelander, WI

Circular Intersections

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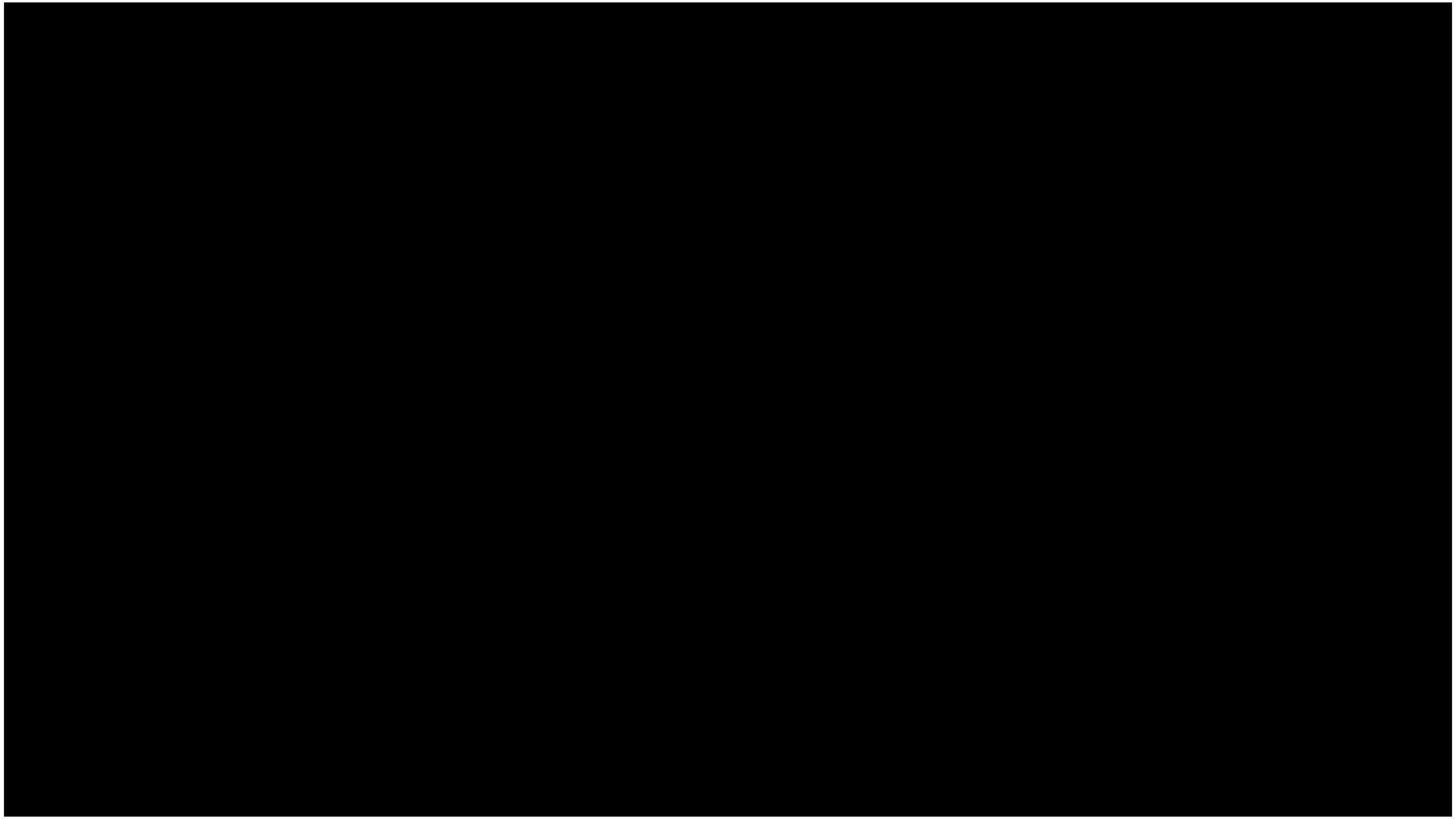
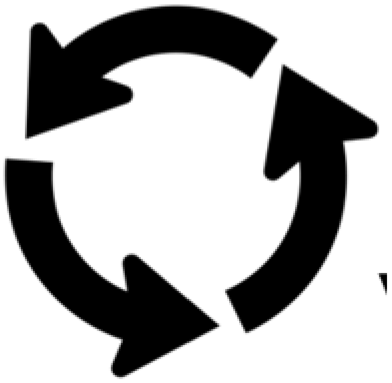
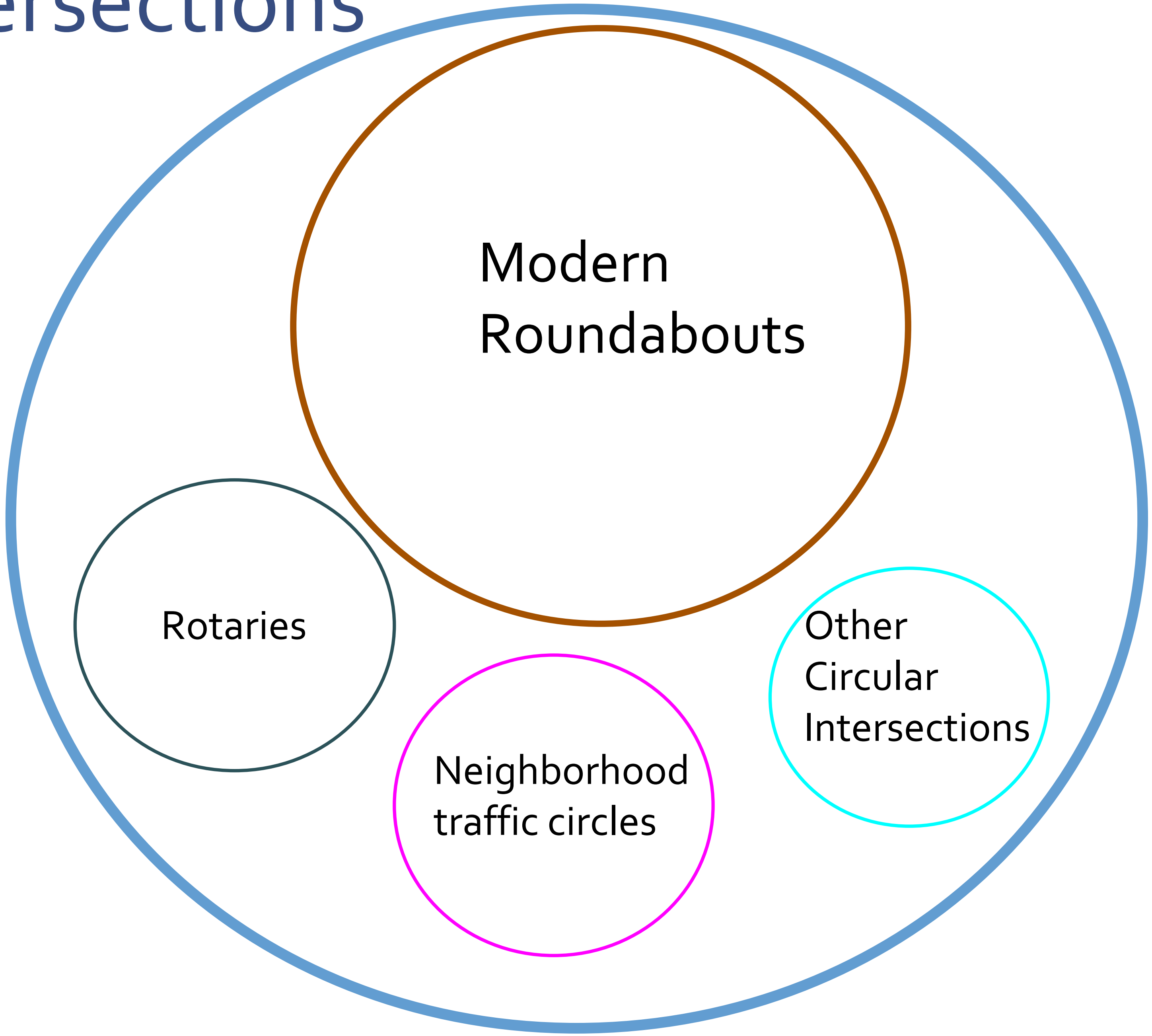
FHWA Roundabout Video



https://www.youtube.com/watch?v=9LQ9zoZN6So

Not all Circular Intersections are Created Equal





Physical Features of a Modern Roundabout

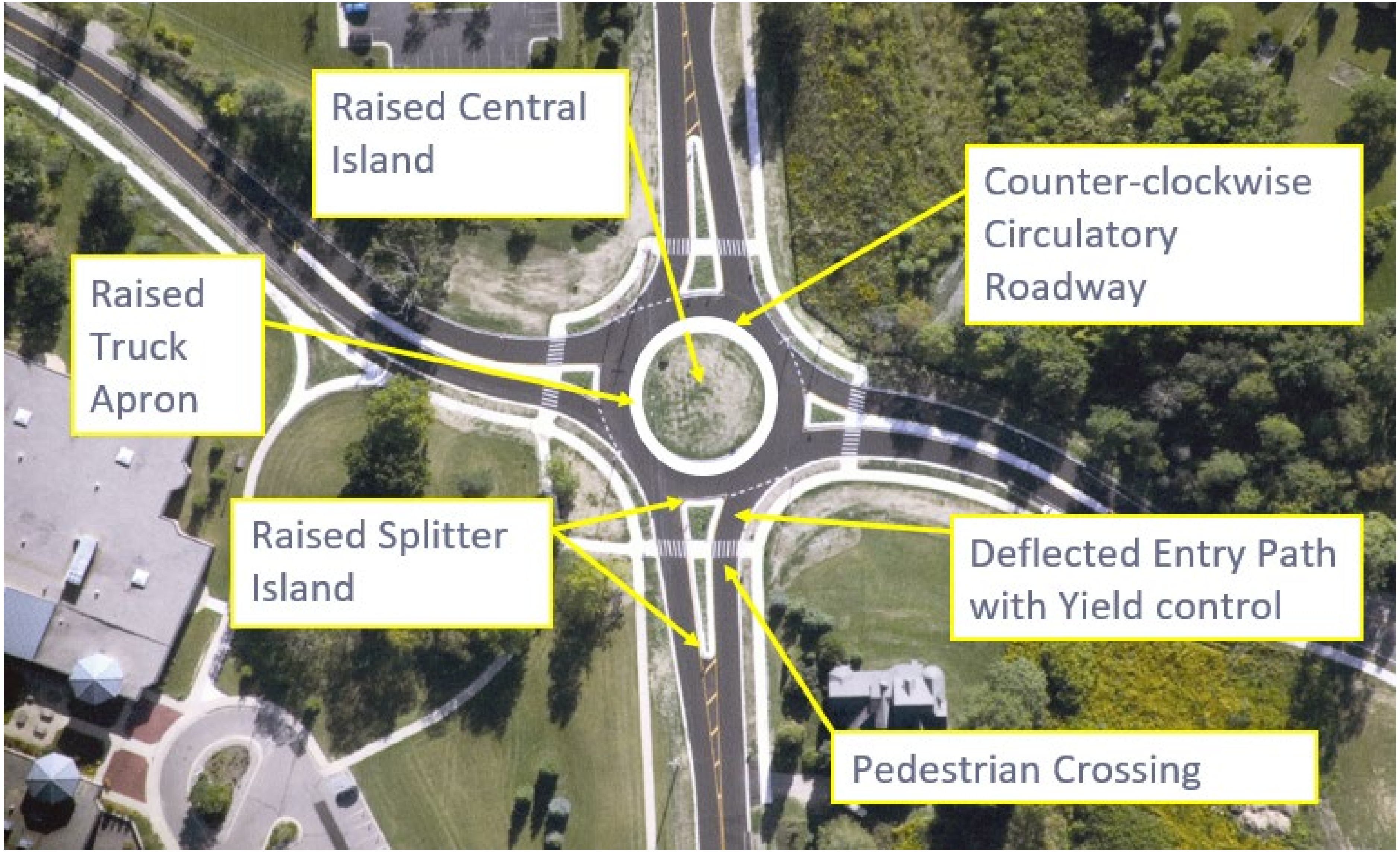


Photo Source: FHWA

Circular Retrofit

Photo Source: NYSDOT

Circular Retrofit

Image Source: GoogleEarth

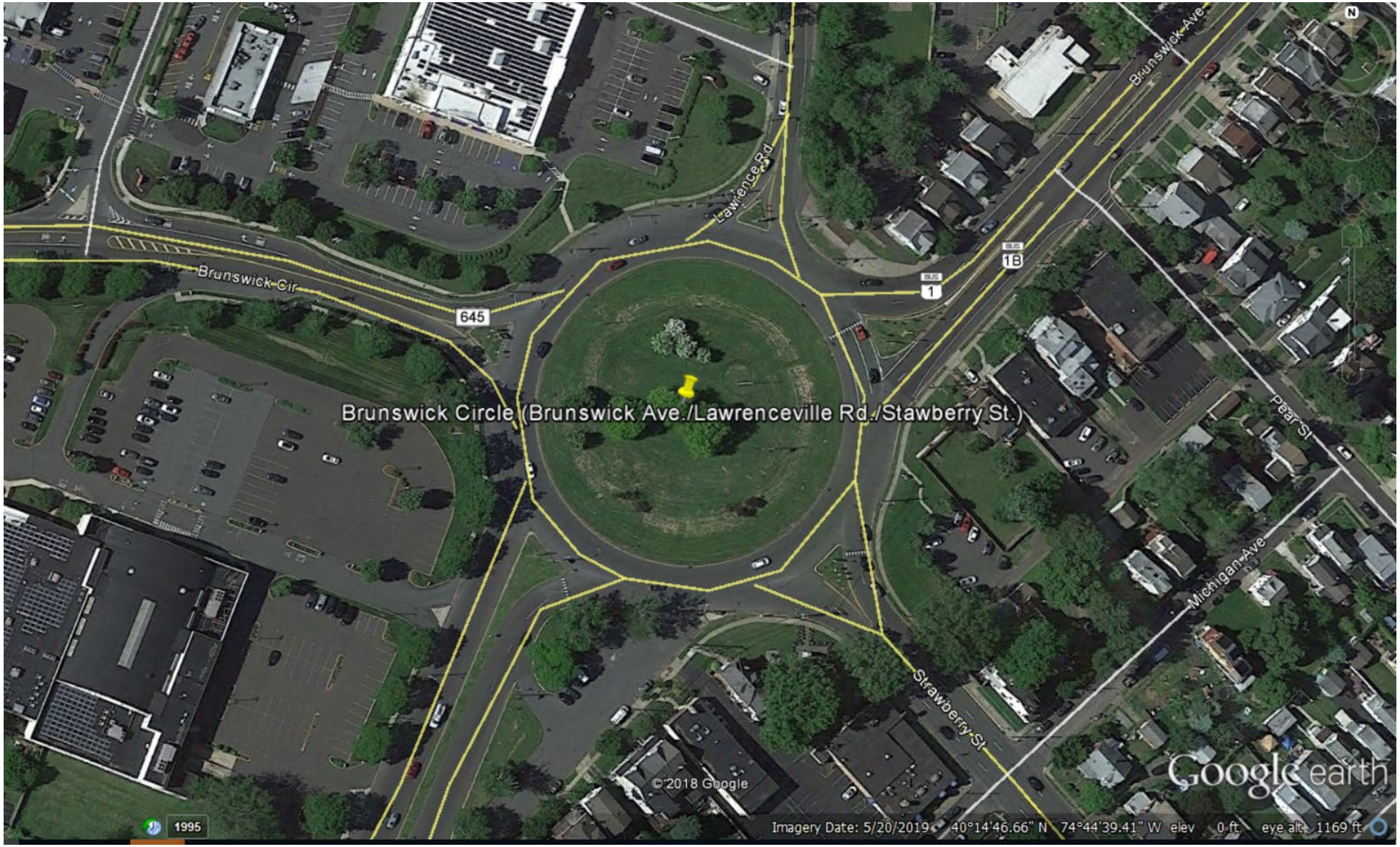


Image Source: GoogleEarth

Neighborhood Traffic Calming Circles

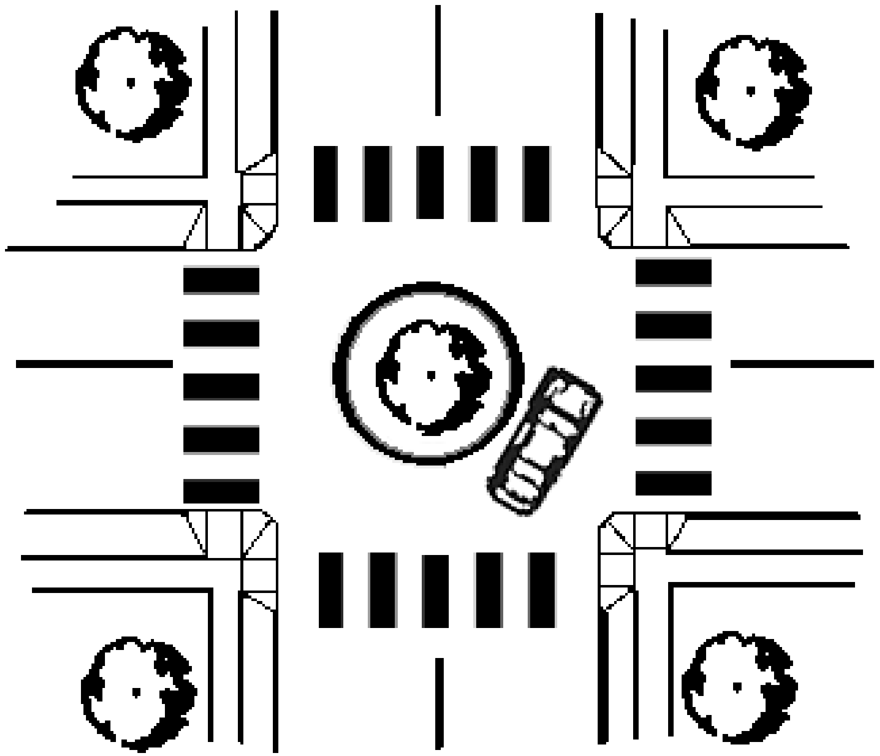
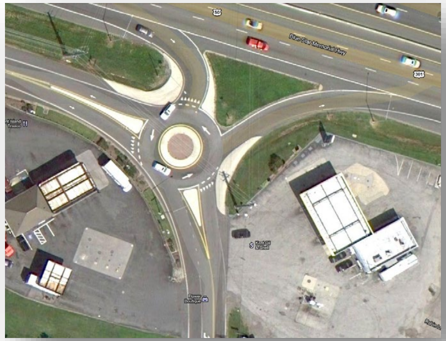


Image Source: FHWA

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

Image Source: GoogleEarth and Isebrands

The Safety Difference

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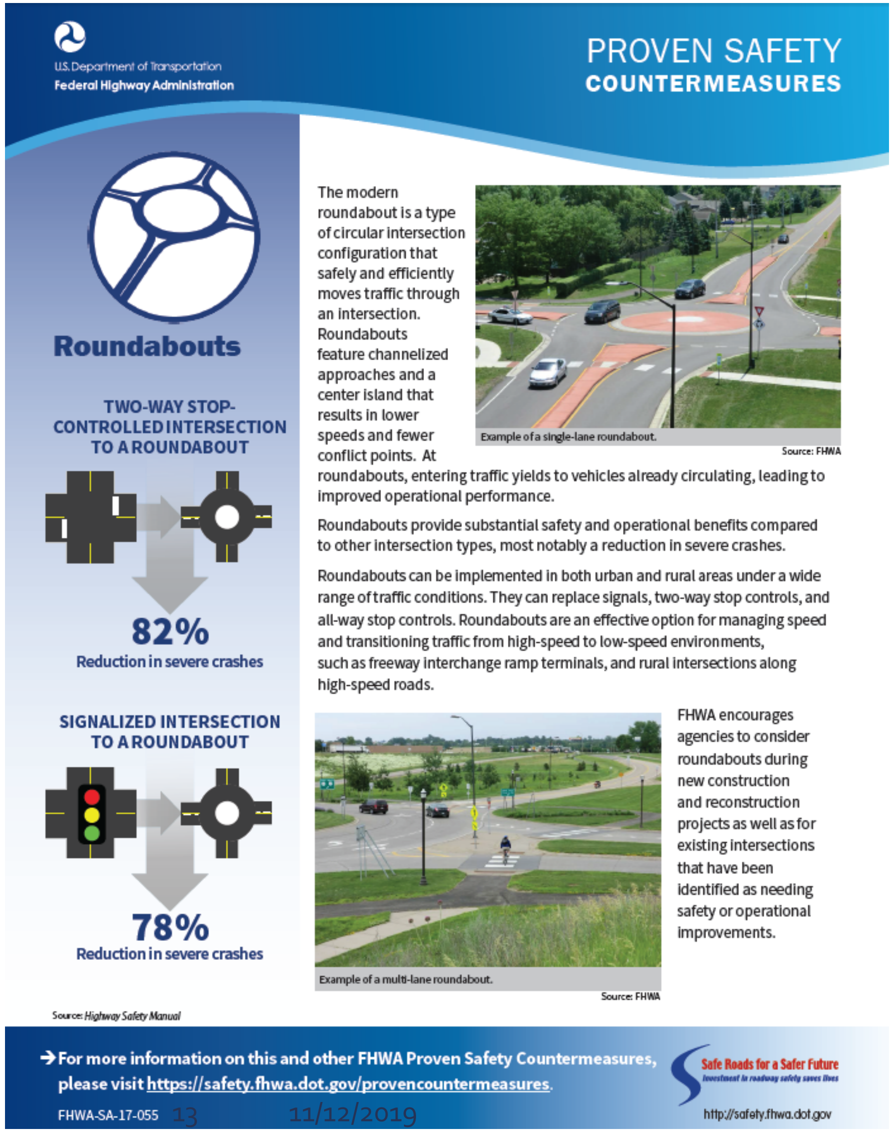
Federal Highway Administration

A Proven Safety Countermeasure



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PROVEN SAFETY COUNTERMEASURES

Roundabouts

TWO-WAY STOP-CONTROLLED INTERSECTION TO A ROUNDABOUT

82%
Reduction in severe crashes

SIGNALIZED INTERSECTION TO A ROUNDABOUT

78%
Reduction in severe crashes

Source: *Highway Safety Manual*

The modern roundabout is a type of circular intersection configuration that safely and efficiently moves traffic through an intersection. Roundabouts feature channelized approaches and a center island that results in lower speeds and fewer conflict points. At roundabouts, entering traffic yields to vehicles already circulating, leading to improved operational performance.

Example of a single-lane roundabout.
Source: FHWA

Roundabouts provide substantial safety and operational benefits compared to other intersection types, most notably a reduction in severe crashes.

Roundabouts can be implemented in both urban and rural areas under a wide range of traffic conditions. They can replace signals, two-way stop controls, and all-way stop controls. Roundabouts are an effective option for managing speed and transitioning traffic from high-speed to low-speed environments, such as freeway interchange ramp terminals, and rural intersections along high-speed roads.

Example of a multi-lane roundabout.
Source: FHWA

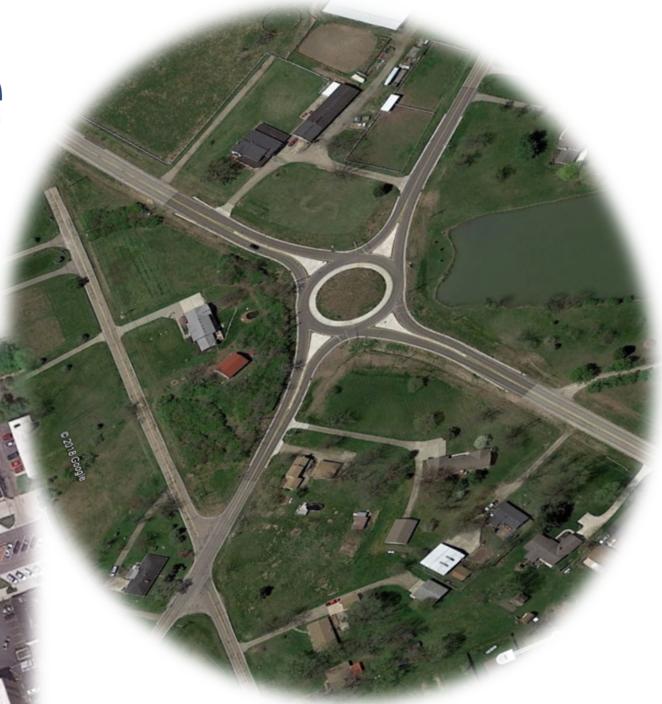
FHWA encourages agencies to consider roundabouts during new construction and reconstruction projects as well as for existing intersections that have been identified as needing safety or operational improvements.

→ For more information on this and other FHWA Proven Safety Countermeasures, please visit https://safety.fhwa.dot.gov/provencountermeasures.

Safe Roads for a Safer Future
Investment in roadway safety saves lives

FHWA-SA-17-055 13 11/12/2019

http://safety.fhwa.dot.gov



Source: GoogleEarth

Roundabout Facts

1. **Well designed roundabouts SAVE LIVES!**
2. Speed control and speed consistency are critical to safety (15-25 mph)
3. Single lane roundabouts only have 8 veh-veh conflict points
4. Pedestrian have shorter crossing distances
5. Pedestrians cross only one direction of travel at a time

Aerial photo: Isebrands

Lives Saved!

Connecticut Strategic Highway Safety Plan

Improving Safety for All Road Users
Roundabouts

In Connecticut, approximately one out of every five motor vehicle-related fatalities occurs at a conventional intersection.[1] At an intersection, all roadway users cross paths as they travel through or turn from one road to another, so it is not surprising that a major part of addressing road safety involves intersections.

One of the most effective safety countermeasures to reduce intersection crashes and fatalities is the roundabout. A roundabout is a one-way, circular intersection in which traffic flows counterclockwise around a center island. Roundabouts differ from rotaries and traffic circles, because they operate at lower speeds making them safer and simpler to use.

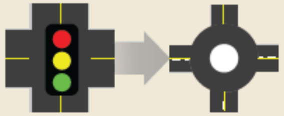
WHY ARE ROUNDABOUTS SO BENEFICIAL?

Some of the ways roundabouts benefit communities include:

- Roundabouts virtually eliminate broadside ("T-bone") and head-on collisions, which tend to be the most serious crashes.
- The design of the roundabout calms traffic, making it easier for motorists to make driving decisions such as avoiding potential crashes and finding gaps to enter the roundabout.
- Raised "splitter" islands allow pedestrians to cross one direction of traffic at a time. These islands, combined with lower speeds, offer pedestrians more crossing opportunities and improve safety.
- With traffic signals, drivers may try to speed up to "beat the light." This is not an issue with roundabouts, which reduces the potential for high-speed crashes.
- Since there are no stop signs or traffic signals to halt traffic, roundabouts promote a continuous flow for vehicles and, in turn, reduces delay and congestion.
- Fewer stops and reduced idling time leads to less pollution, noise, and fuel use.
- Without the hardware, maintenance, and electrical costs associated with traffic signals, roundabouts can save thousands of dollars per year per location.

Converting to a roundabout results in less crashes.

SIGNALIZED INTERSECTION TO A ROUNDABOUT



Reductions up to:

78% SEVERE CRASHES

48% OVERALL CRASHES

Source: AASHTO *Highway Safety Manual.*

CONNECTICUT DOT CONVERTED 5 INTERSECTIONS TO ROUNDABOUTS

Reductions:

81% SEVERE CRASHES

49% OVERALL CRASHES

As of 2017, 150 crashes and 100 injuries have been prevented.

a City to Experience — CITY OF CARMEL, INDIANA — SPRING 2017

SAFER STREETS
Designing for Safety

Carmel's streets have become safer overall with the addition of boulevard designs and more than 100 roundabouts replacing traditional traffic light or stop sign intersections. The result is a 65 percent decrease in accidents with injury for all 487 miles of road in the city. This number is even more significant when you realize that our population has grown 187 percent since 1996, which was used as the base year before Carmel's first roundabout opened. The chart below shows how Carmel's accident rate per population has continued to drop from 1996 until today.

Year	Population	Accidents with Injury	% of Population with Injury Accidents	Decrease vs. 1996
1996	31,808	216	0.68%	00%
2001	41,251	232	0.56%	-18%
2006	67,339	249	0.37%	-46%
2011	81,668	212	0.26%	-62%
2016	91,374	215	0.24%	-65%

Sources: City population estimates; Engineering report on road miles; Police Department accident statistics

See the complete report online at **Carmel.IN.gov**

Read more about roundabouts on pages 4 - 5 inside.

Telling the Safety Story

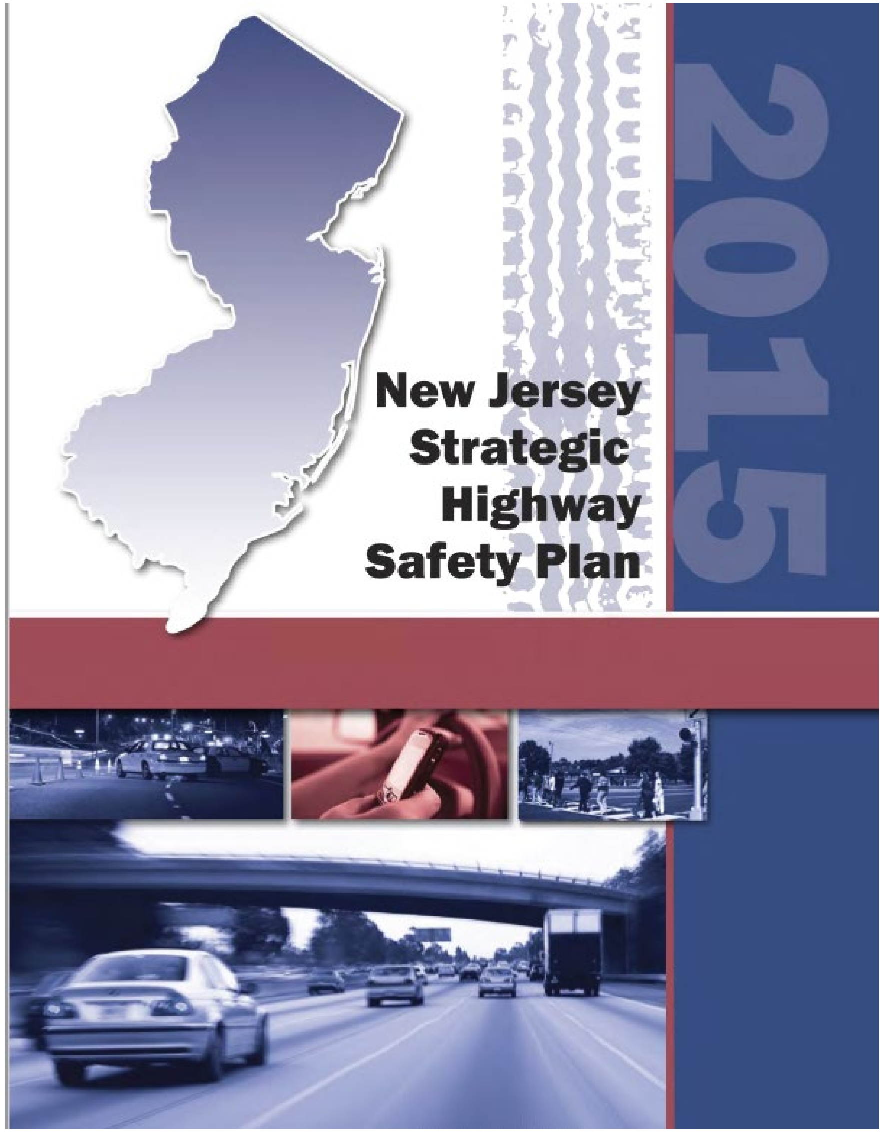
https://www.youtube.com/watch?v=cHvo86TQ2LI

- One intersection death every 46 hours in New Jersey
- One pedestrian death every 2 days in New Jersey

Road to Zero

- Double Down on what Works
- Implement Proven Safety Countermeasures
- Get ahead of the Crash - Systemic Safety Analysis
- Provide a Safe System

TZD Toward Zero Deaths®
National Strategy on Highway Safety



The Design of the Roundabout

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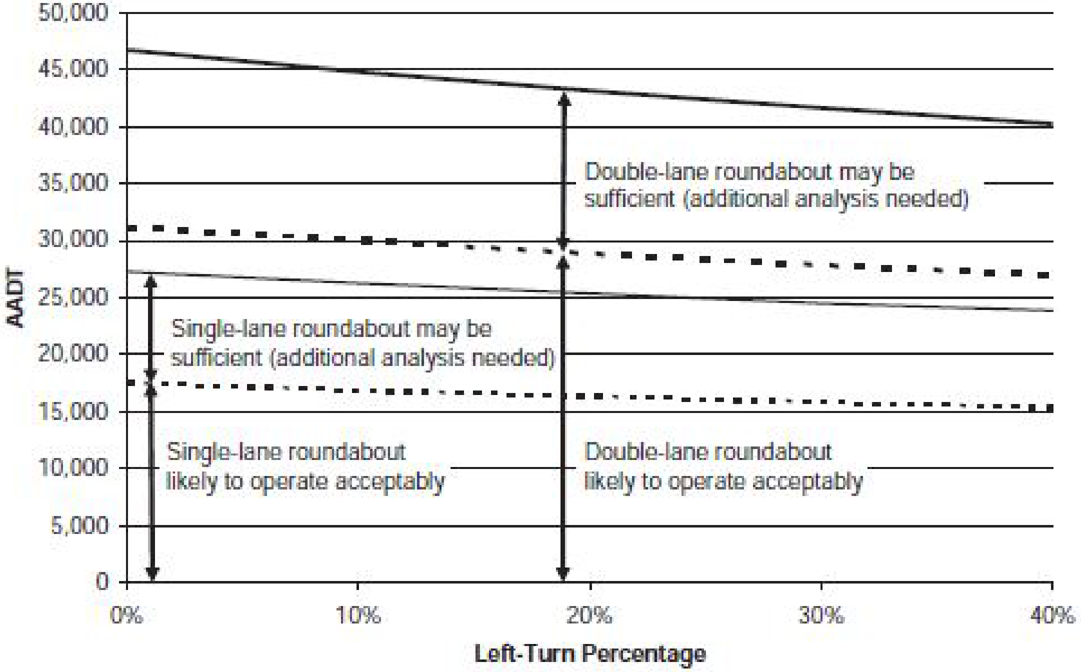
Roundabouts and Road Users

- From Pedestrians
  - To Bikes
    - To Cars
      - To Transit
        - To Trucks
          - To Farming equipment

Image Source: Isebrands, Iowa DOT

Traffic Volumes



Volume Range (sum of entering and conflicting volumes)	Number of Lanes Required
0 to 1,000 veh/h	▪ Single-lane entry likely to be sufficient
1,000 to 1,300 veh/h	▪ Two-lane entry may be needed ▪ Single-lane may be sufficient based upon more detailed analysis.
1,300 to 1,800 veh/h	▪ Two-lane entry likely to be sufficient
Above 1,800 veh/h	▪ 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

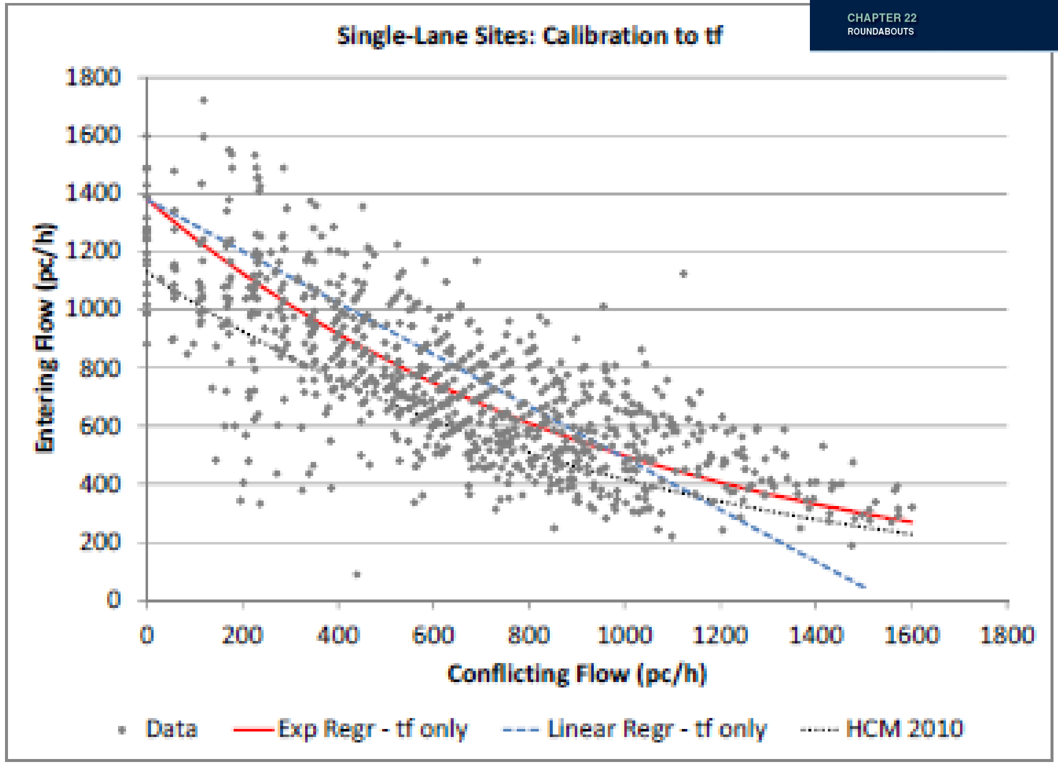
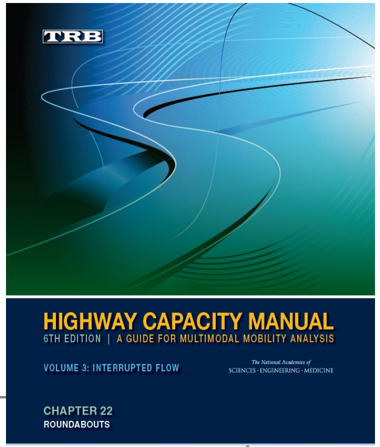


Figure 2. Scatter Plot. Regression models for single-lane roundabout sites with calibration to follow-up time.



Design Fundamentals

NCHRP
REPORT 672

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Roundabouts: An Informational Guide

Second Edition

In Cooperation with
U.S. Department of Transportation
Federal Highway Administration

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Facilities Development Manual — *Wisconsin Department of Transportation*
Chapter 11 Design
Section 26 Roundabouts

FDM 11-26-1 General — *June 24, 2016*

1.1 General

This section and its sub-sections are comprised of roundabout design and operations guidelines developed through research and experience. Much of the prescribed guidance has been proven through application, evaluation and refinement - a truly continuous improvement process.

The Department has updated previous versions of this guide to account for changes in national roundabout guidelines made possible through research, namely NCHRP 572 - Roundabouts in the United States, 2006 and NCHRP 672, Roundabouts: An Informational Guide, Second Edition. The NCHRP guidelines and research are heavily relied upon in this chapter. Where appropriate and justified by local experience, exceptions for use by the Wisconsin Department of Transportation are noted. Where both references are cited but differences exist, the Facilities Development Manual guidance shall govern.

The modern roundabout is a subset of many types of circular intersections. The term modern roundabout and roundabout are used interchangeably throughout this document. The roundabout is a one-way circular intersection where circulating traffic is given priority over entering traffic and where entry speeds are low relative to older unconventional circular intersections. The term "modern roundabout" is used in the United States to differentiate roundabouts from the older and often large diameter nonconforming traffic circles, rotaries or very small traffic calming circles used on residential streets.

Traffic circles fell out of favor in this country by the mid 1950's because they encountered safety and operational problems as traffic volumes increased beyond their operational thresholds. However, substantial progress has been achieved in the subsequent design of circular intersections, and the modern roundabout should not be confused with the traffic circles of the past.

Roundabouts may be considered for a wide range of intersection types including but not limited to freeway interchange ramp terminals, state route intersections, and state route/local route intersections. Roundabouts generally process high volume left turns more efficiently than all-way stop control or traffic signals, and will process a wide range of side road volumes. Roundabouts can improve safety by reducing vehicle speeds and eliminating crossing conflicts that are present at conventional intersection. The required intersection sight distance is greatly reduced from what is required for a signalized intersection due to the reduced intersection speeds.

The modern roundabout is defined by three basic principles:

1. Yield-at-Entry - Vehicles approaching the roundabout must wait for a gap in the circulating flow, or yield, before entering the circle.
2. Deflection - Traffic entering the roundabout is directed or channeled to the right with a curved entry path into the circulating roadway.
3. Geometric Curvature - The radius of the circular road and the angles of entry are designed to slow the speed of vehicles.

The following is a list of locations where a roundabout may be feasible:

1. Intersections with a high-crash rate or a higher severity of crashes
2. High-speed rural intersections
3. Freeway ramp terminals
4. Transitions in functional class or desired speed change (including rural to urban transitions)
5. Existing intersections that are failing
6. Aesthetics is an objective
7. Intersections of dissimilar functional class (arterial-arterial, arterial-collector, arterial-local, collector-collector, collector-access)
8. Four-leg intersections with entering volumes less than 5,000 vph or approximately 50,000 ADT

Roundabout Critical Design Parameters	403-2 REFERENCE SECTION 403.7

Roundabout Critical Design Parameters
Project - County Route Section
PID

Design Parameters	Leg 1	Leg 2	Leg 3	Leg 4	Leg 5
Inscribed Circle Diameter, FT					
Entry Width, FT					
Entry Angle PHI ϕ, DEG					
Exit Width, FT					
Circulatory Roadway Width Upstream of Entry, FT					

Fastest Path Speed	Leg 1	Leg 2	Leg 3	Leg 4	Leg 5
R_1, Radius/Speed, FT/MPH					
R_2, Radius/Speed, FT/MPH					
R_3, Radius/Speed, FT/MPH					
R_4, Radius/Speed, FT/MPH					
R_5, Radius/Speed, FT/MPH					
R_5, Bypass Radius/Speed, FT/MPH					

Minimum Sight Parameters	Leg 1	Leg 2	Leg 3	Leg 4	Leg 5
Approach Design Speed, MPH					
Approach Stopping Sight Distance, FT/MPH					
Circulatory Stopping Sight Distance, FT/MPH					
Exit (Crosswalk) Stopping Sight Distance, FT/MPH					
Intersection Sight Distance, FT/MPH					

General	
Design Vehicle(s)	
Truck Apron Width, FT	

Designer:

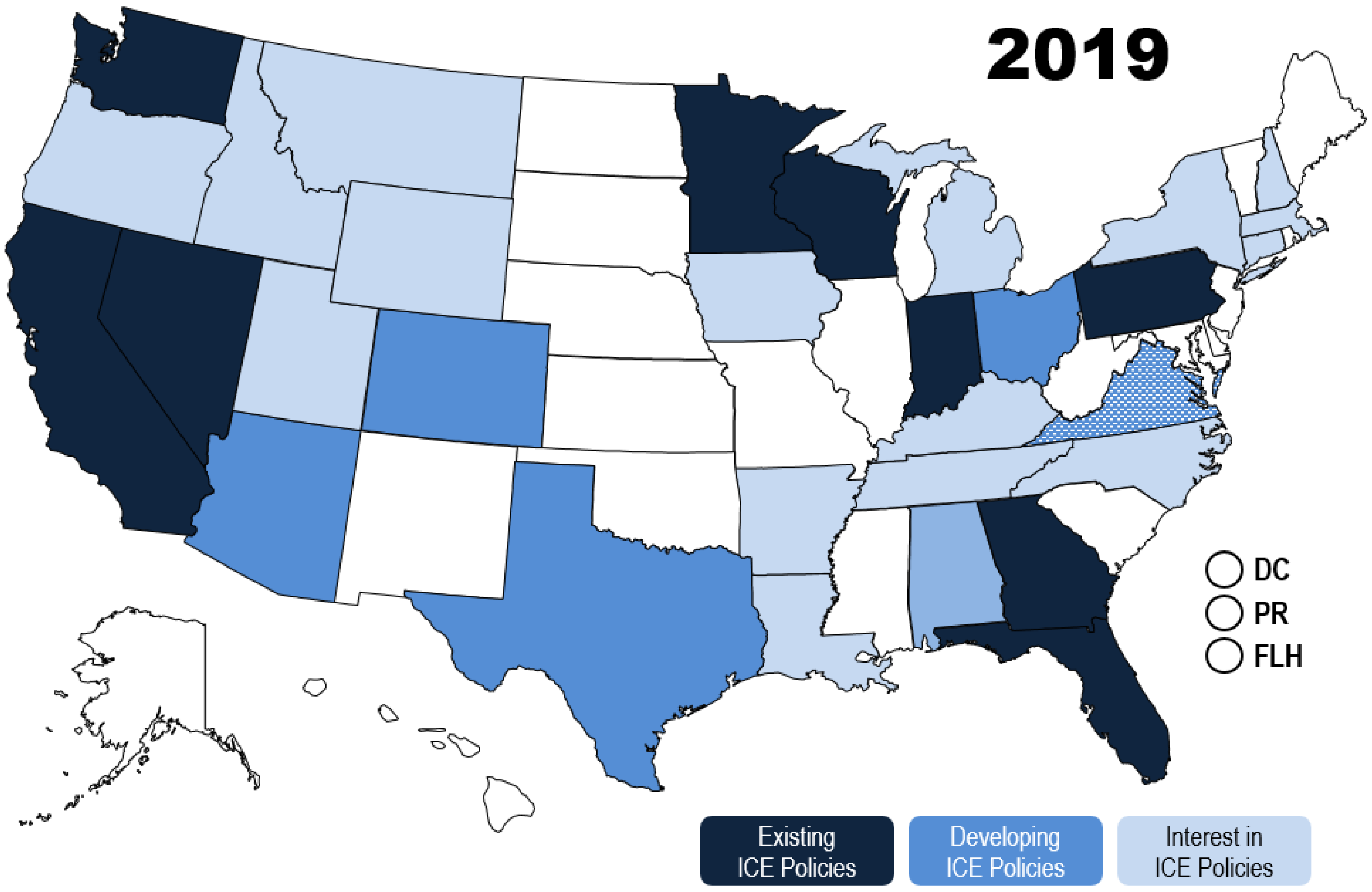
Signature:

Date:

Sources: NCHRP, Wisconsin DOT, Ohio DOT

Intersection Control Evaluation (ICE) Policy Development

ICE is a data driven, performance-based framework and approach established to identify the optimal investment and solution for highway access issues and needs considering all users.



Source: FHWA

Intersection Performance Measures

Safety

» Conflicts
» Speeds
» Exposure
» Crashes

Operations

» Delay (sec/veh)
» Queue length (ft)
» Travel Time
» Reliability
» Degree of saturation (v/c)
» Level of Service

Environment

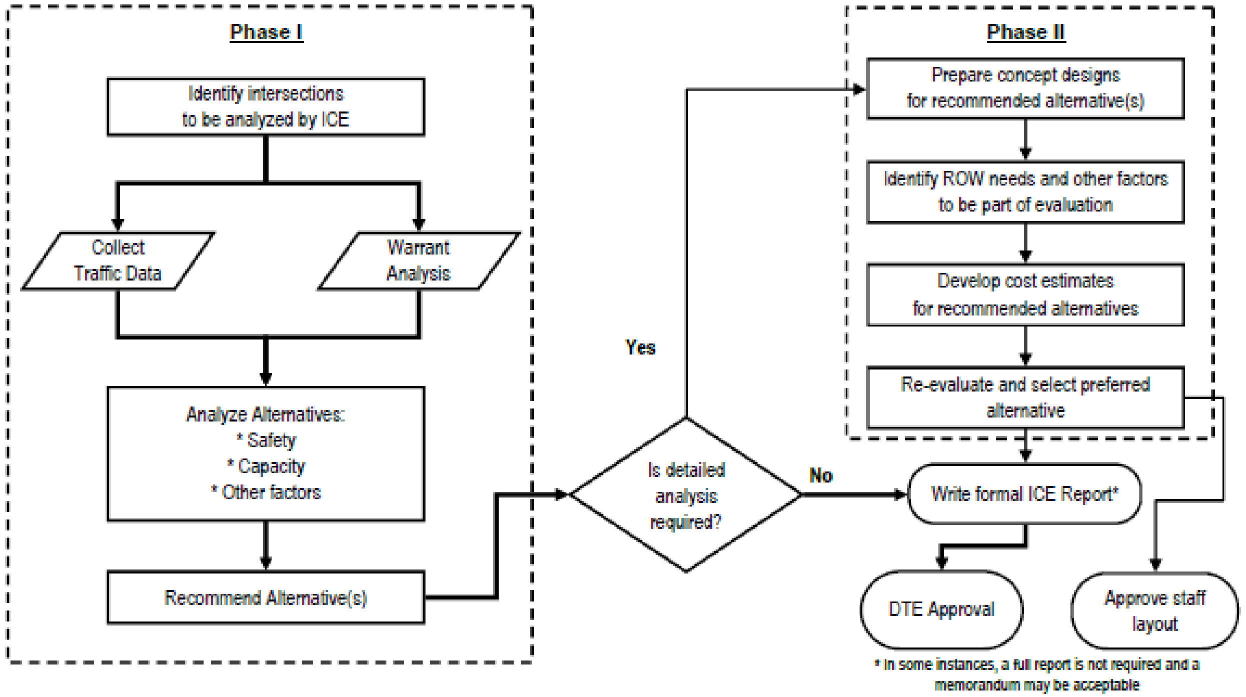
» Footprint
» Emissions

Pedestrians

» Conflicts
» Accessibility
» Speed
» Yielding Rates
» Sight Distance
» Delay
» Connectivity

ICE Policy Examples

Figure 1: The ICE Process



ICE Performance Summary Matrix for NB I-5 / LaNovia & Valle Road Interchange

Performance Measure	Alt 2: Signalize Existing I/S	Alt 3: Relign & Signalize	Alternative 4 Roundabout
1. Existing AM/PM Average Delay (seconds per vehicle)*	29.6/29.1	28.6/28.7	7.9/9.6
2. Existing AM/PM Volumes Level of Service (LOS)	C/C	C/C	A/A
3. 2035 AM/PM Average Delay (seconds per vehicle)	44.9/46.8	35.7/35.5	24.2/24.4
4. 2035 AM/PM Volumes Level of Service (LOS)	D/D	D/D	C/C
5. Longest Vehicle Queue (2035 pm)	25 cars	17 cars	18 cars
6. Right-of-Way Requirement	None	3,500 ft^2	40 ft^2
7. Construction Traffic Control	$39,100	$108,400	$69,800
8. Retaining Wall	No	Yes	No
9. Project Cost	$940,000	$2,891,000	$1,682,000
10. Benefit (Delay Savings) / Cost Ratio	**2.61**	**0.7**	**6.18**
11. Environmental Document	Mitigated Negative Declaration	Mitigated Negative Declaration	Mitigated Negative Declaration
12. Collision Cost Savings (Life of Project)	**$2,026,000**	**$1,170,000**	**$9,537,000**
13. Safety Performance B/C Ratio	**2.16**	**0.4**	**5.68**

*** The existing average delay (s/veh) based on 2012 traffic volumes is 23.4 (AM) & 59.0 (PM)**

Sources: MnDOT, CalTrans

Relationship between the Facilities Development Process and the ICE Process

Phase Elements \ Phase Names		Project Initiation	Project Definition		Project Delivery			Project Proposal Execution		
Life Cycle (Construction ID)		00	10		11	12	15	20		40
Milestone		Project Initiation Complete	Prelim. Scope Complete	Final Scope Certification Approved	Resourcing Complete / Start Final Delivery	Design Study Report Approved	PS&E Submitted	Project LET	Project Award	
Deliverables (Deliverables listed may have been started in a previous phase but must be completed prior to advancing to the next phase) — Project Management Plan	Scope	• Conceptual Scope	• Prelim. Scope	• Final Scope	• Implement Scope					
	Schedule	• Conceptual Milestone Schedule • APLP Target Goals & Schedule • Program Let Schedule	• Final Milestone Schedule • Final Work Breakdown • Final APLP Schedule • Final Let Schedule Date • Non-let Schedule Dates		• Monitor and Manage Schedules					
	Budget	• Conceptual Const.Estimate	• Design Delivery Budget • Const. Estimate • Non-Let Estimate		• Refine Const. Estimate • Refine Non-Let Estimate					
	Phase Deliverables	• Design ID(s) loaded • Construction ID(s) loaded • Design ID(s) Authorized • Highway Improvement Type • Structures Identified • Signed SMFA (design connect.hwy.)	**Phase I: ICE** • Purpose and Need • Resource Assignments • Safety Certification • Improvement Strategy • Risk Assessment	**Phase II: ICE** • Signed Pavement Design Report • Draft Env. Document • Utility Impacts • R/W Impacts • Structure Certification • Railroad Proj. Submittal Package • Signed SMFA & SMMA (const.) • Risk Assessment	• Final Delivery Resourcing	• Prelim. Plan • Structure Survey Report • Prelim. Structure Plan • Signed Env. Document • Signed DSR • Recordable Plat • Risk Assessment	• PS&E package • Permits • Risk Assessment	• Plan Revisions • Bid Advertisement • Addenda (if required)	• Bid Review	• Design ID Closed • Design Files Archived
Phase Activities		see FDM Chapter 3 - attachment 1.2								
Change Management		Establishes original baseline for applying Change Management process.			Change Management process in effect.					

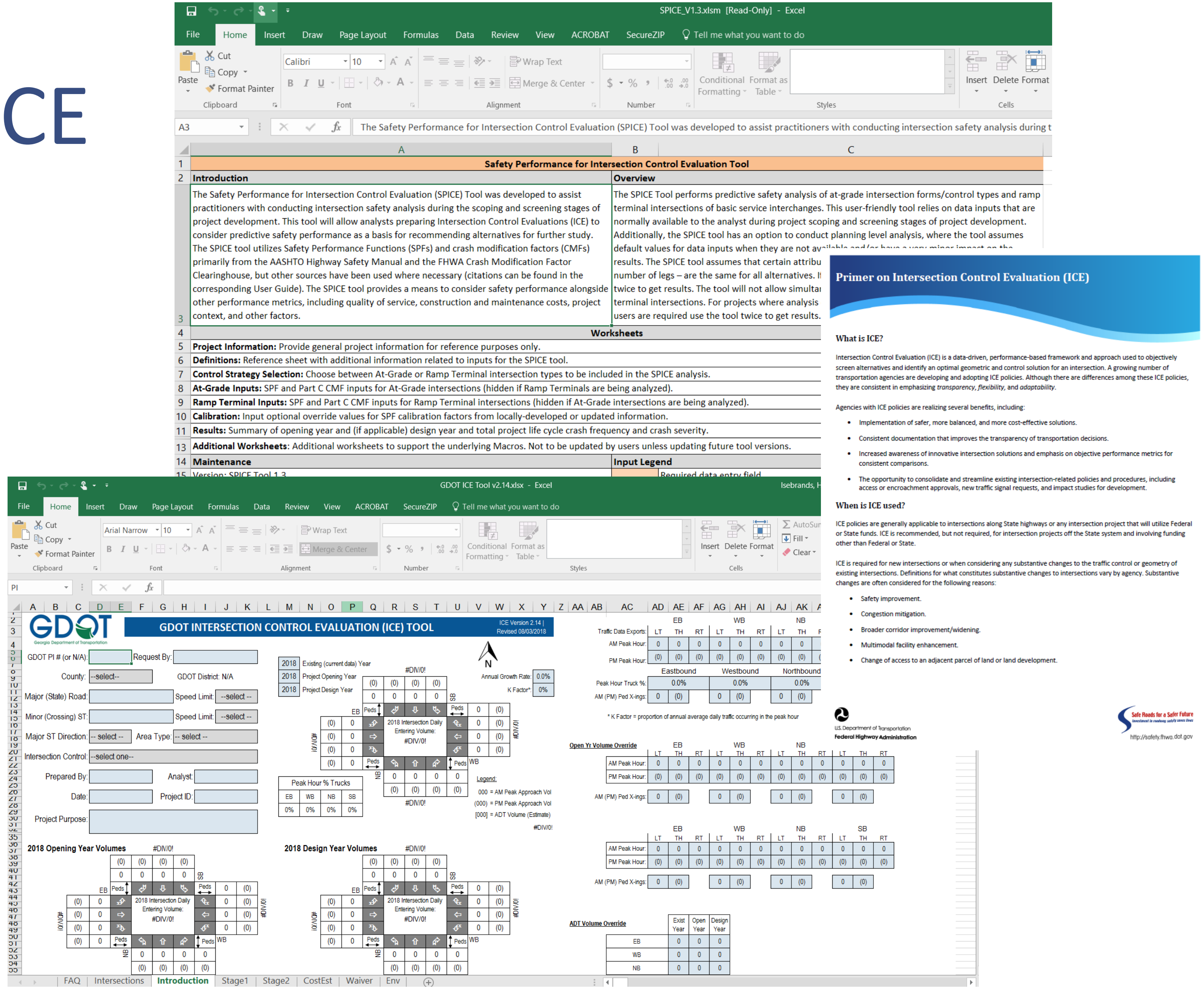
Tools to Support ICE

<u>National Resources</u>

- CAP-X
- SPICE
- LCCET (via NCHRP 03-110)

<u>State Resources</u>

- Kentucky (IDAT)
- Georgia (ICE Tool)
- Virginia (V-JuST)



http://www.dot.ga.gov/PS/DesignManuals/DesignGuides

Design Details

» Truck aprons
» Raised crosswalks
» Splitter island lengths
» Drop bike lanes

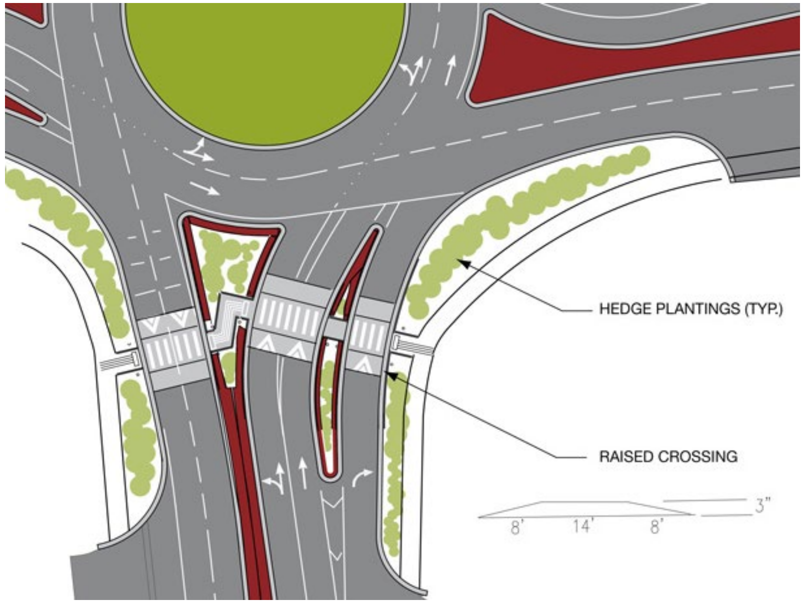


 Image Sources: Isebrands, MTJ Engineering, Google Earth

Get out of your Comfort Zone

» Get Outside
» Draw
» Have Hard Discussions

Photo sources: Isebrands, Morgan Beryl

Proactive Education

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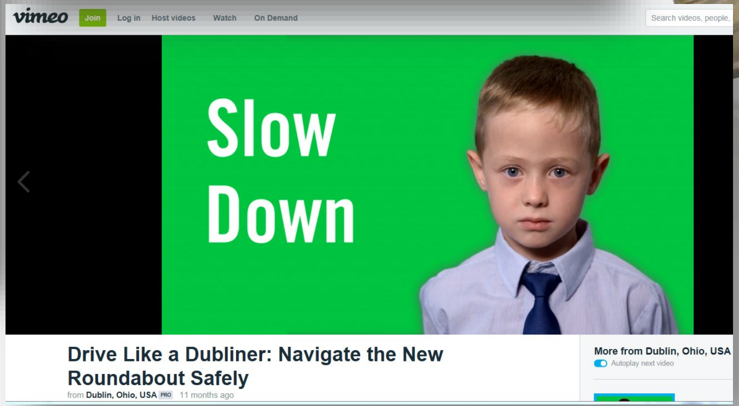
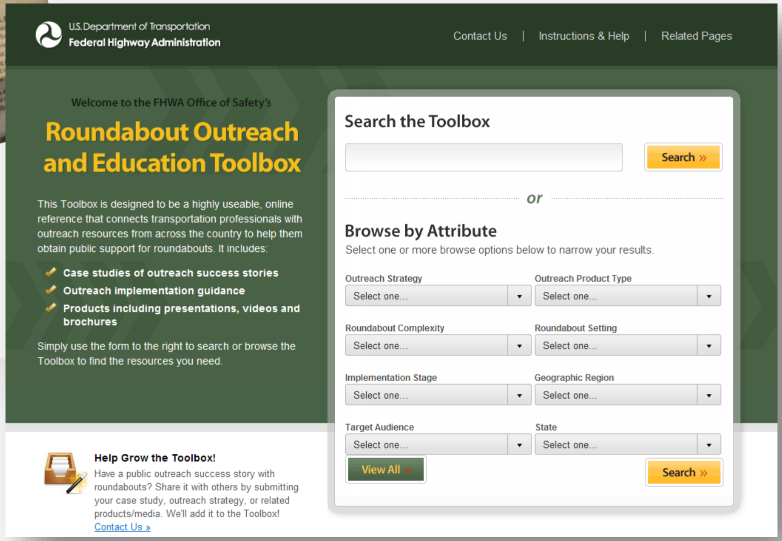
Federal Highway Administration

Roundabout Education

- » Persistence
- » Resilience
- » Facts
- » Creativity





Source: MythBusters; Dublin, OH; Eagle Enterprise: City of Shakopee, MN, Isebrands, FHWA

National Roundabouts Week

Letty Schamp @lettyschamp · 20 Sep 2018

Day 4 of #RoundaboutsWeek: lower speeds = much lower chance of injury. In the 12 yrs since Hilliard opened its first roundabout, @NorwichTwpFD has never had to use these Jaws of Life tools at a roundabout crash. #RoundaboutsSaveLives. Escape the scrape -know the #RoundaboutRules

3 17

2020 International Roundabout Conference

The National Academies of
SCIENCES · ENGINEERING · MEDICINE
TRB
TRANSPORTATION RESEARCH BOARD

TRB 6th International Roundabout Conference

Monterey, California
May 18-20, 2020

Organized by
TRB Standing Committee on Roundabouts (ANB75)

Hosted by
Transportation Agency for Monterey County

Call for Abstracts

Submission Deadline Extended: September 13, 2019

Please submit at the following website:
https://trb.secure-platform.com/a/page/Roundabout2020

If you have any questions, please contact:
Brian J. Walsh, Committee Chair
Washington State DOT, ***walshb@wsdot.wa.gov***

Bernardo Kleiner, TRB Staff: Bkleiner@nas.edu

More information can be found at:
http://www.trb.org/Calendar/Calendar.aspx

The International Roundabout Conference gathers a professional community to share and consider experiences and knowledge with the goal to increase successful roundabout projects. This triennial conference provides a forum for the exchange of ideas on all aspects of roundabouts as we work together to improve the safety and sustainability of our roadway network.

Abstract Topic Guidelines

We are seeking high-quality, informative presentations highlighting case studies, projects, technical papers and/or research on a range of roundabout topics including but not limited to:

- *Innovative Roundabout Solutions (IE – Roundabouts with rail, raised crosswalks, cost reduction techniques)*
- *Non-Motorized User Consideration*
- *Corridors*
- *Mini Roundabouts*
- *Mini/Compact Roundabouts*
- *Multilane Roundabout Considerations*
- *Phasing of Design and/or Construction*
- *Public Outreach and Education*
- *Roundabout Planning*
- *Systemic Roundabouts*

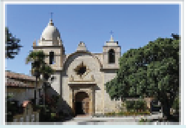
NOTE: Other topics will be considered.

Abstract will be considered for one of the following presentation types:

- *Individual Slide Presentation*
- *Panel Discussion*
- *Poster Display*
- *Hybrid - Slide and Poster Presentation*

About the Venue

Mission San Carlos Borromeo de Carmelo



Monterey is a city on California's rugged central coast. In 1769, the first European land exploration made it one of California's first communities and was host to the first theater, public building, public library, publicly funded school, printing press, and newspaper in the state. Also famous is Monterey Bay Aquarium, with thousands of marine life in interactive exhibits.

The conference will be held at the Monterey Bay Portola Hotel and Spa located in the Central Business area and close to many of the early Spanish settlement areas, including the Presidio.

https://trb.secure-platform.com/a/page/Roundabout2020; https://app.truelook.com/?u=tt1433948002#tl_live

Roundabouts in Practice

Federal Highway Administration
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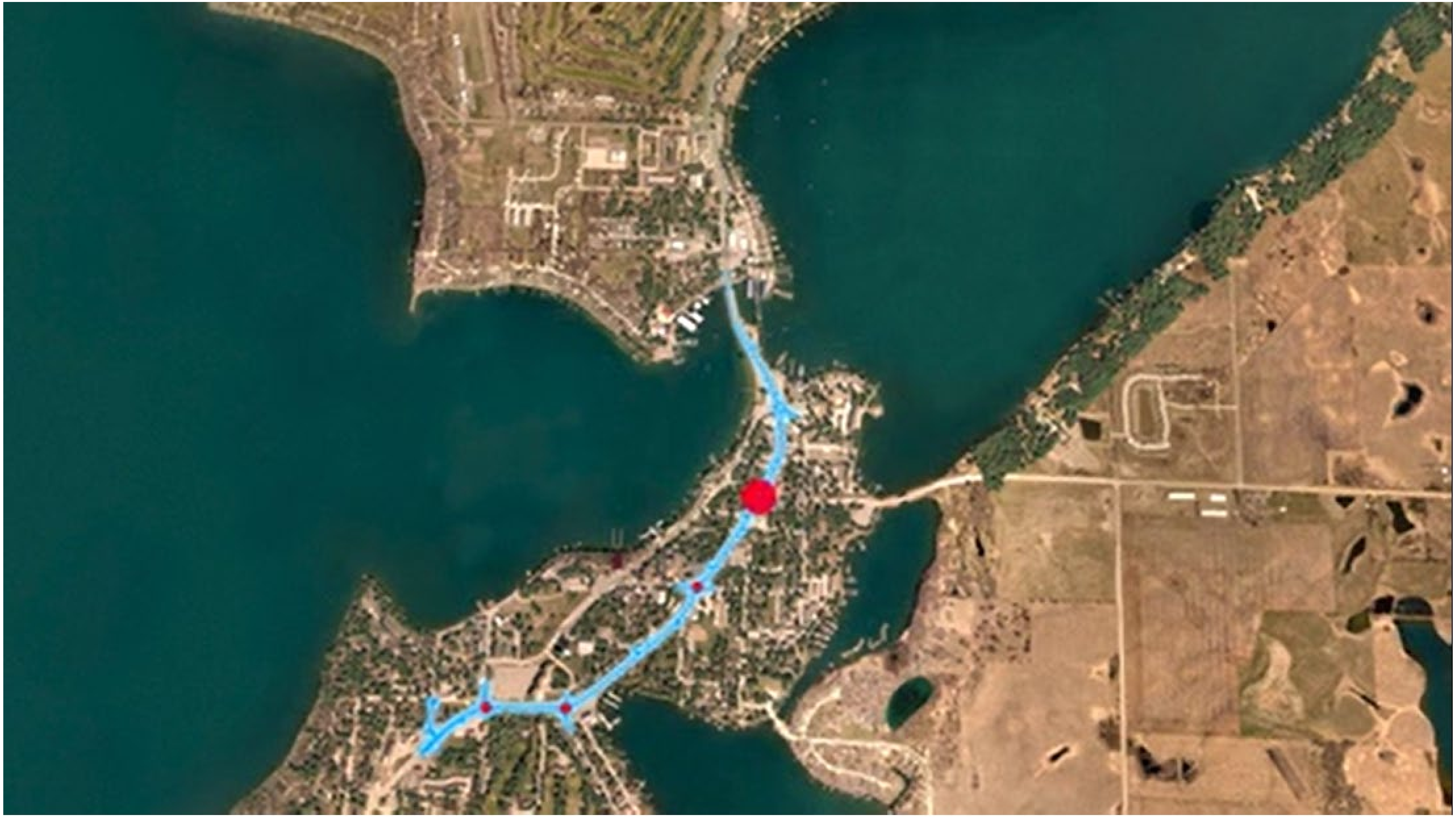
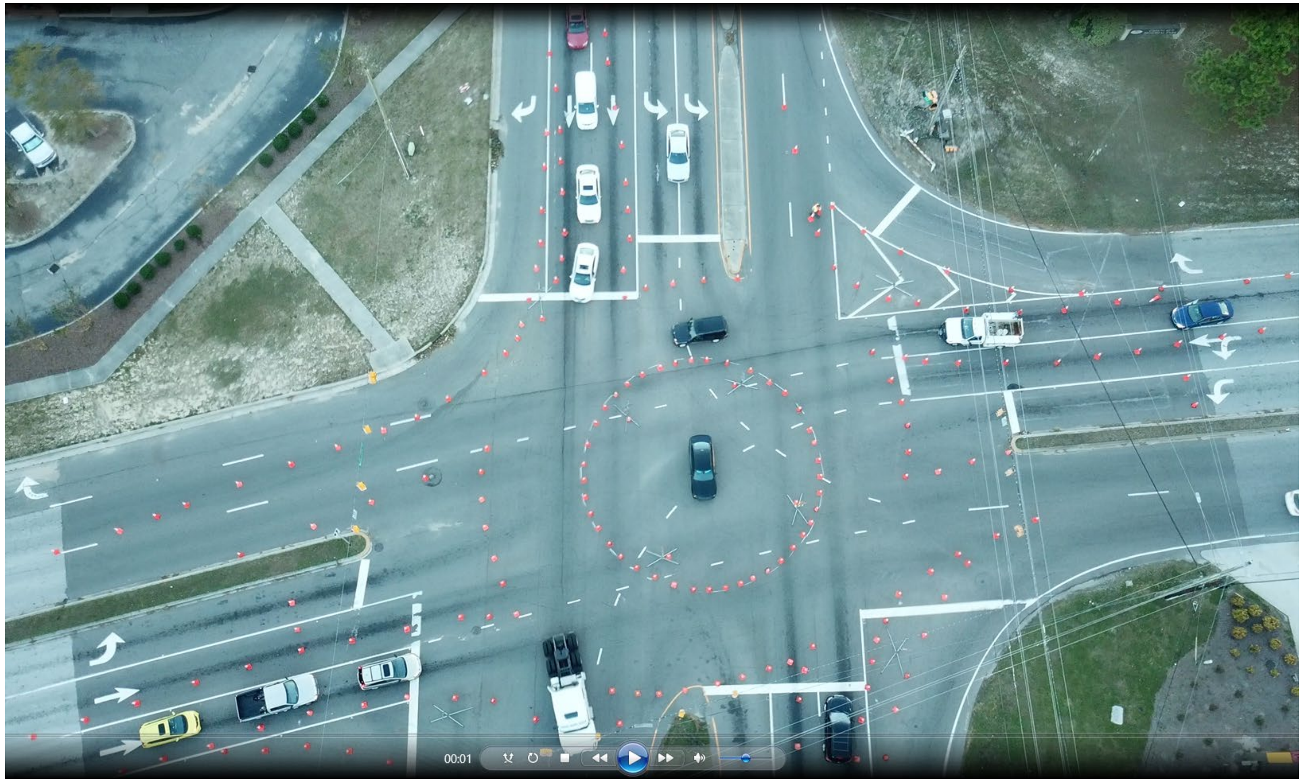
Federal Highway Administration



Source: Imagine Iowa Great Lakes

Wilmington, NC on September 17, 2018



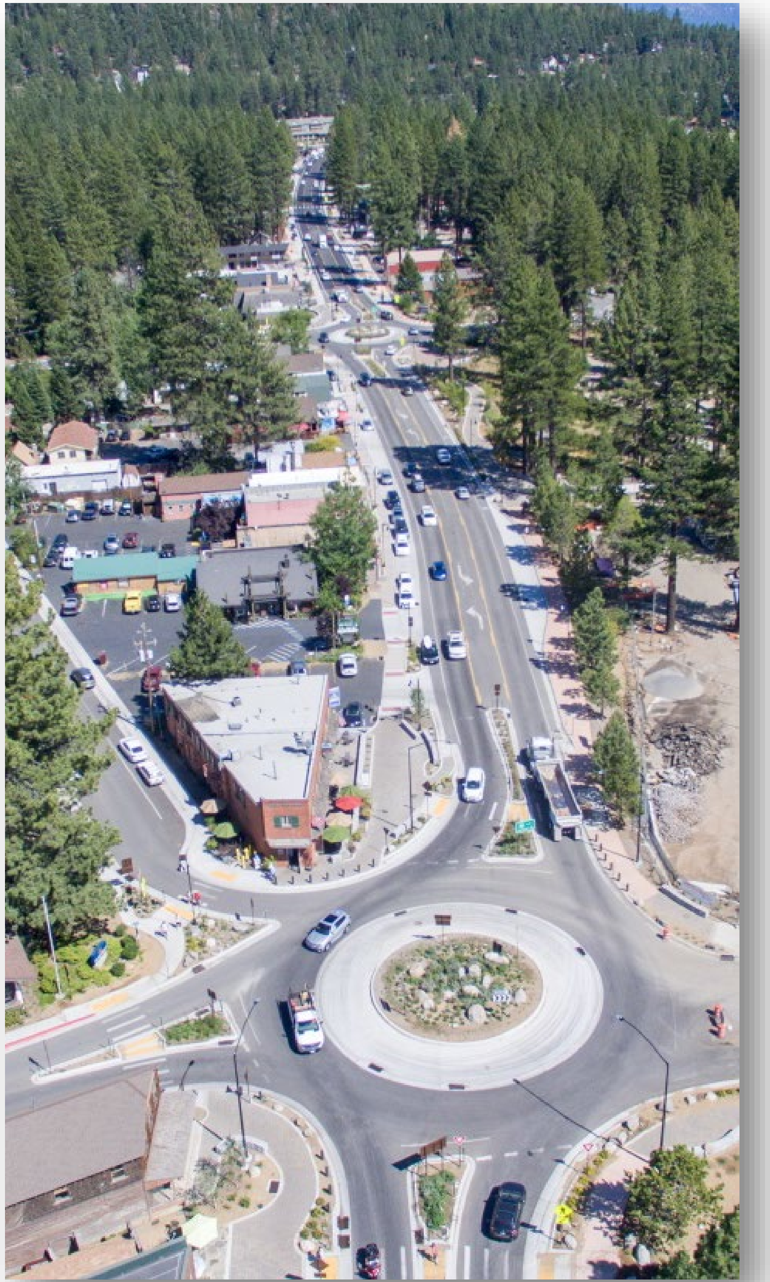
CONSTRUCTION COMPLETION – FALL 2011

PRE-ROUNDABOUT CRASH HISTORY

- 2008-2010 – 20 CRASHES & 6 INJURIES

POST CONSTRUCTION CRASH HISTORY

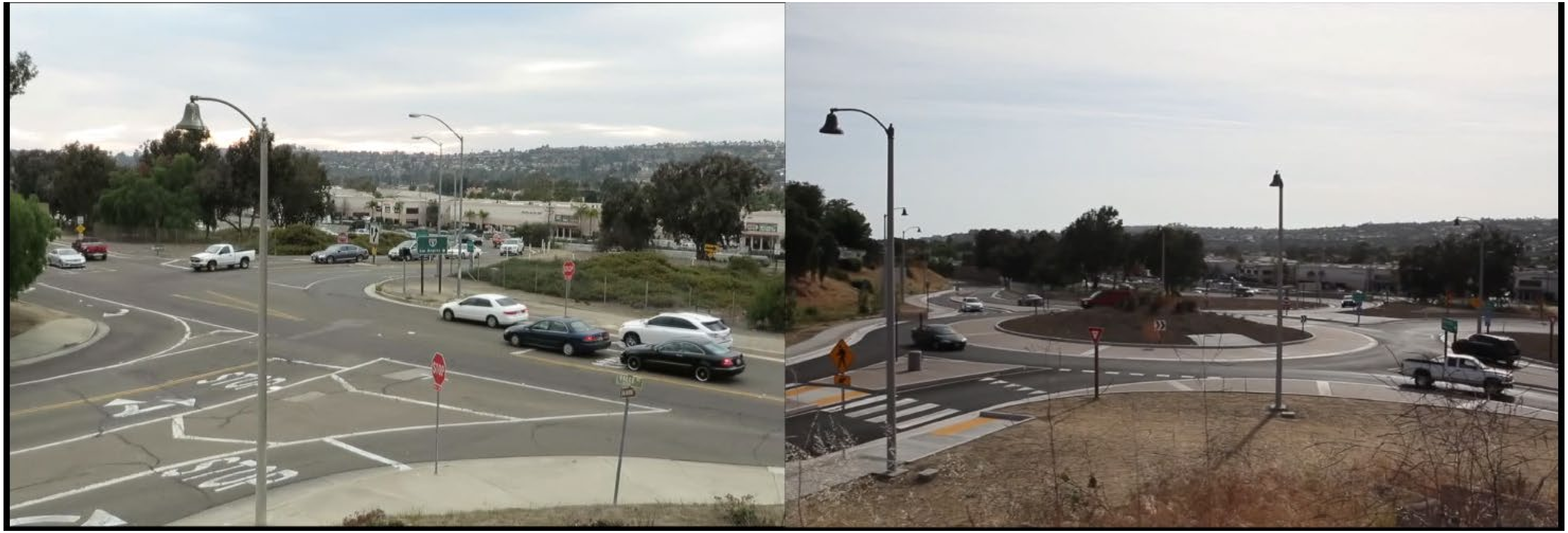
- 2011-2013 – 20 CRASHES & 4 INJURIES



Kings Beach, CA

Image Sources: Placer County and Google Earth

Before & After



Video Source: Michael Baker

Roundabouts…

- » Are circular intersections.
- » Reduce conflict points.
- » Have slow speeds (15-25mph).
- » Improve overall capacity of intersections.
- » Should be considered for all types of projects.
- » Provide design flexibility.
- » Save Lives!

Photo source: Isebrands and Tahoe Transportation District

Thank You,
Have a Safe Day!

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