

Roundabout Workshop

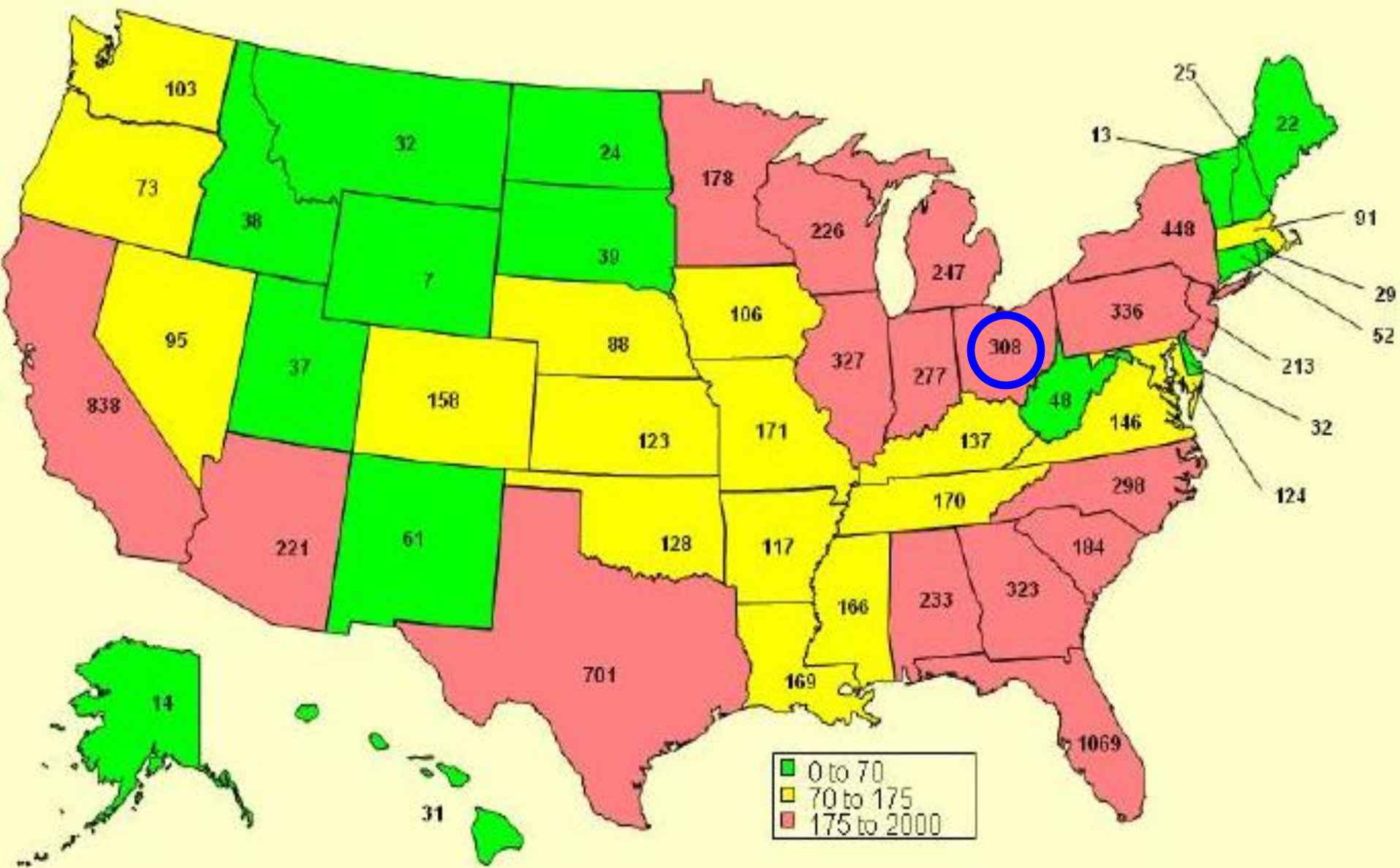
Module 2 - Safety



Intersection Safety

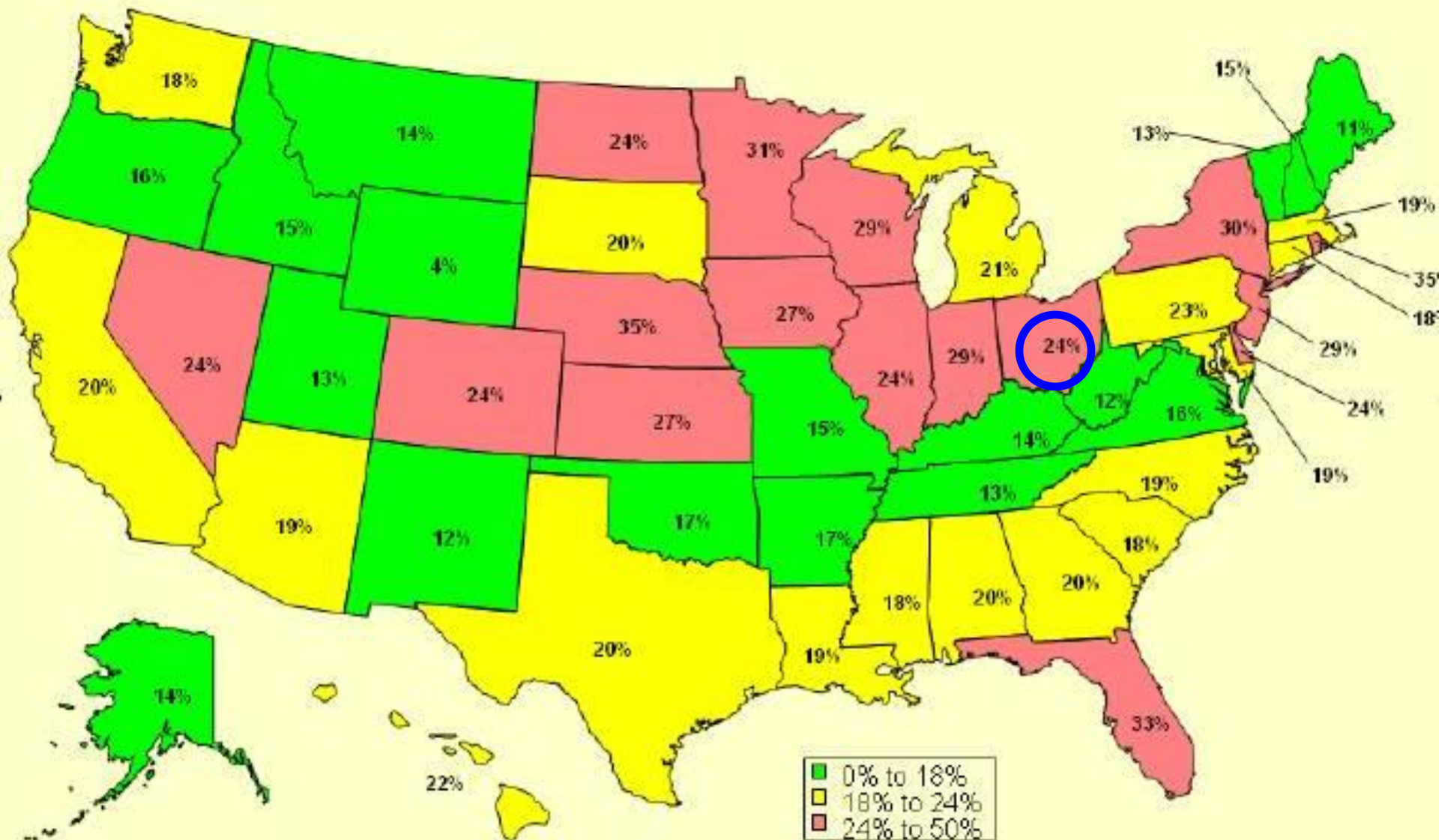
- Approx 3 Million intersections in US
 - 2.7 Million unsignalized
 - 265,000 signalized
 - < 1000 modern roundabouts
- 9,188 Intersection Fatalities/Year (2005)
- 21% of fatal crashes occur at intersections
- More than 45% of all injury crashes occur at intersections

2004 Actual Intersection Fatalities

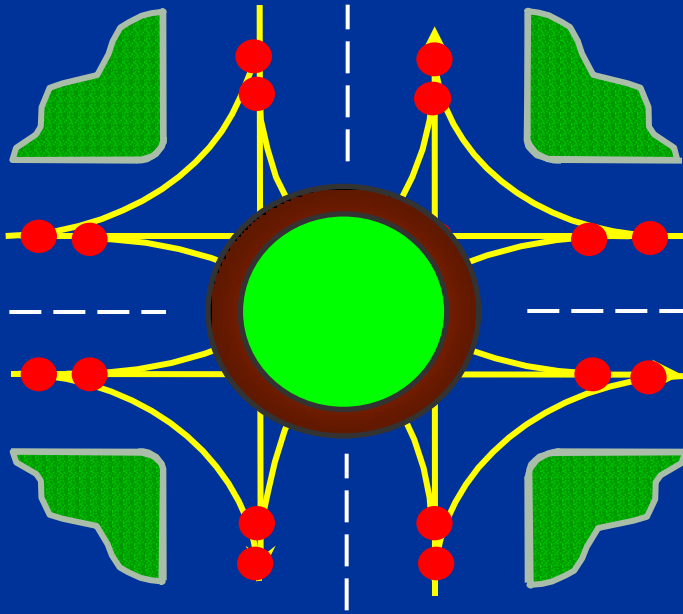


2004 Intersection Fatalities

% of Total Fatalities



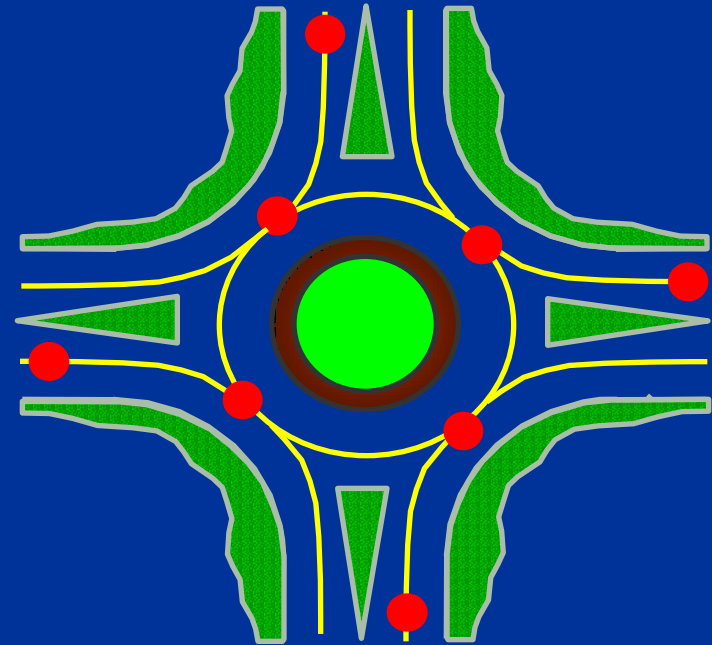
Comparison of Vehicle Conflict Points



32 conflict points

- High-speed
- High-angle
- High-energy

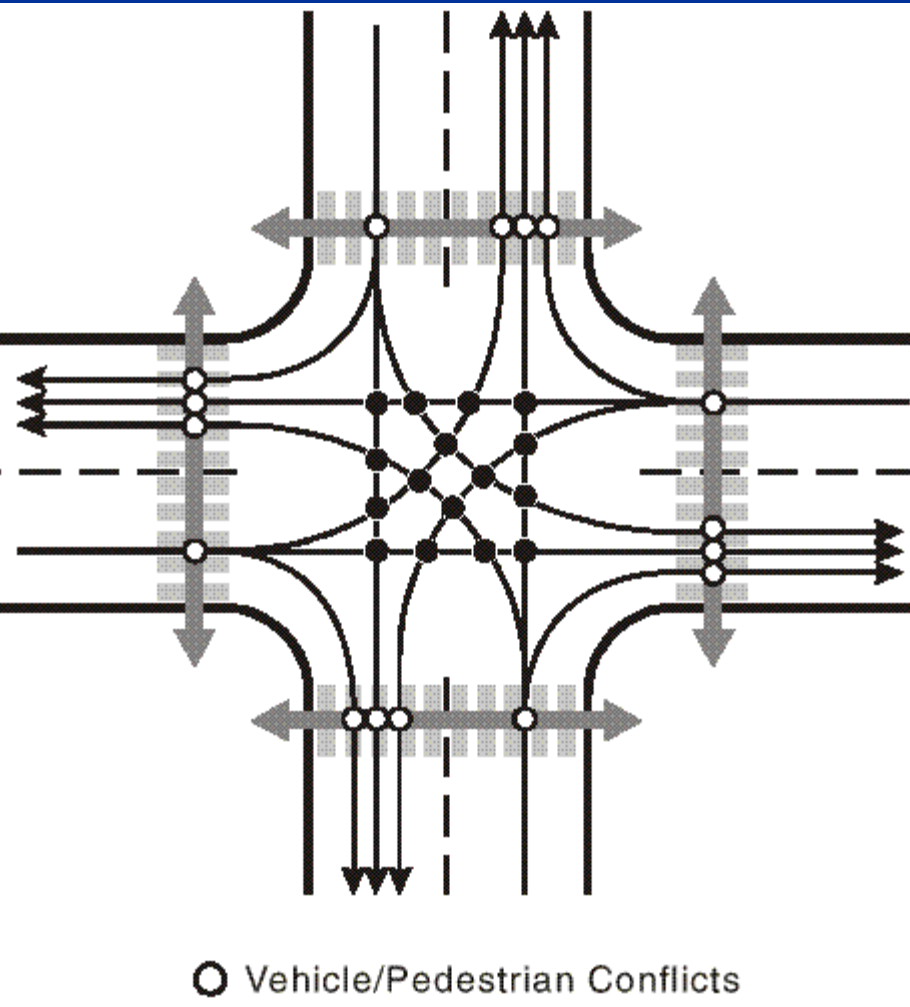
75% fewer
conflicts



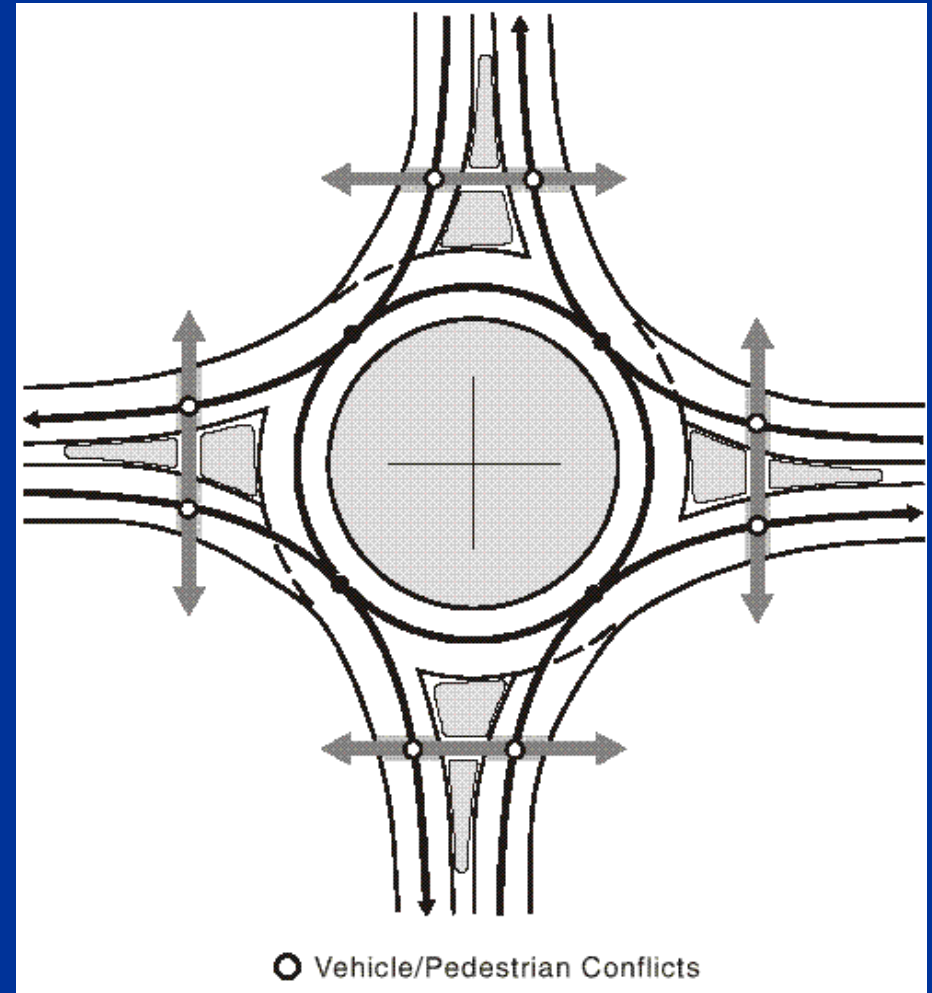
8 conflict points

- Low-speed
- Low-angle
- Low-energy

Comparison of Vehicle / Pedestrian Conflicts

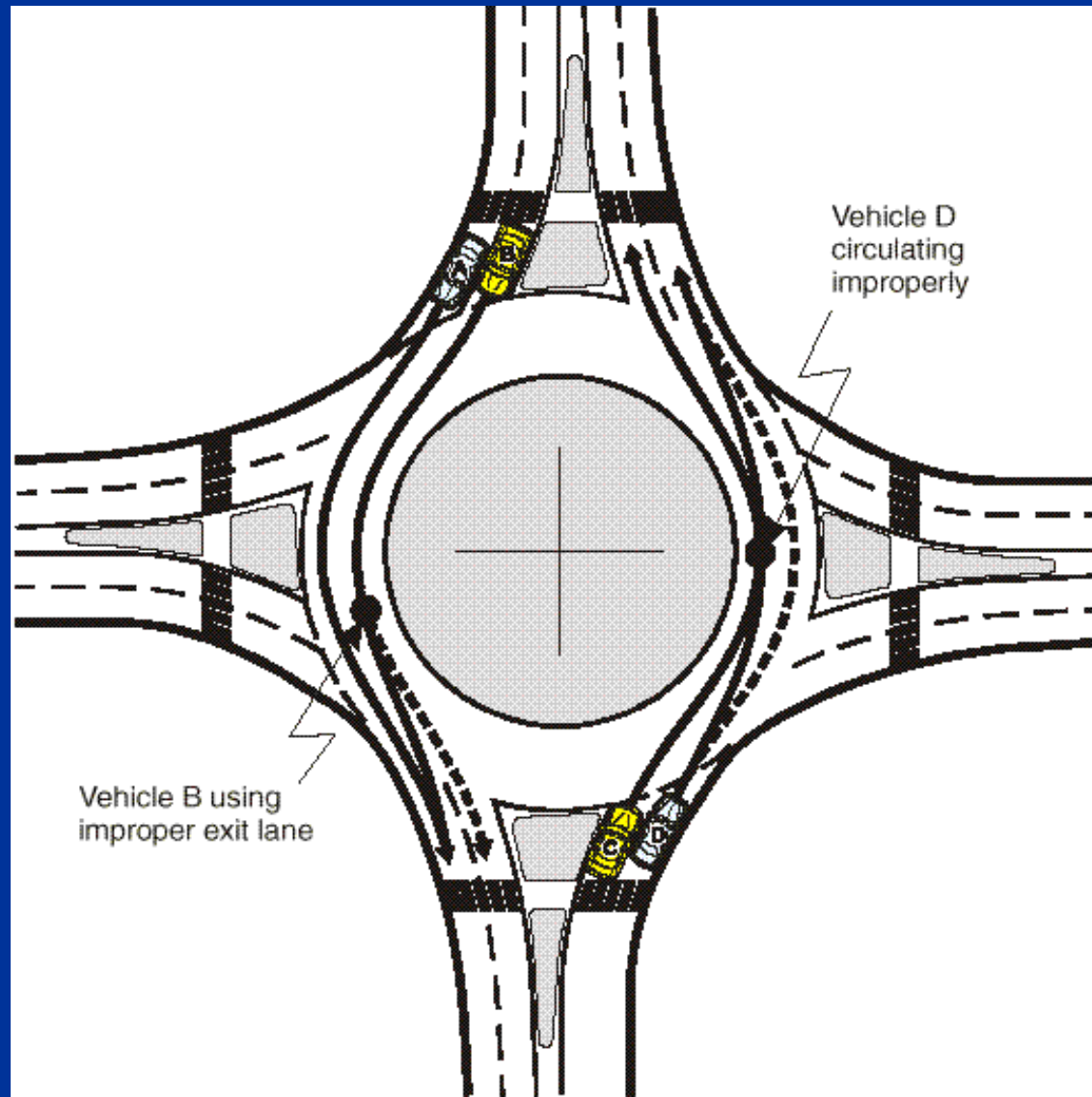


16 Conflicts

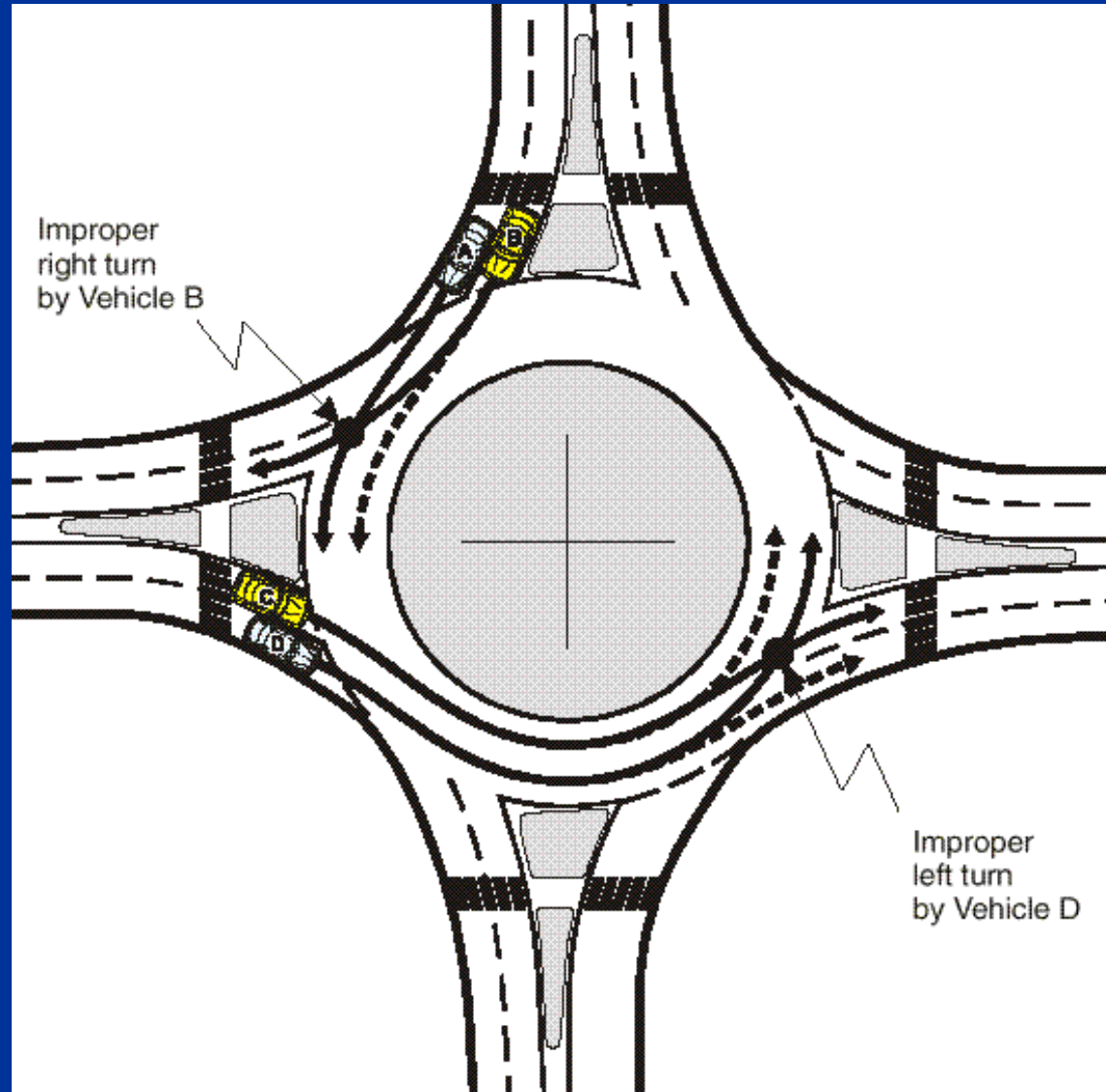


8 Conflicts

Vehicles Improperly Changing Lanes at Multi-Lane Roundabouts Create Conflicts

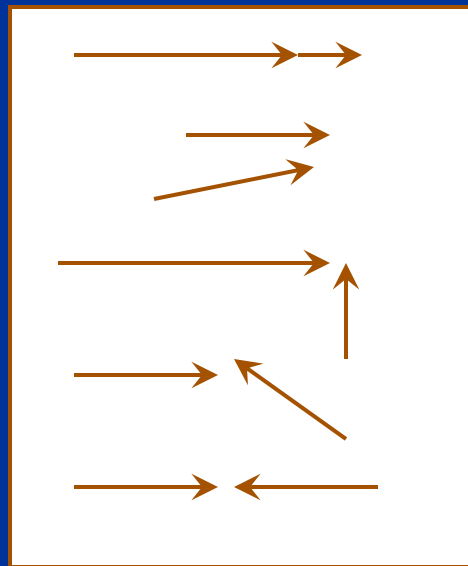


Vehicles Turning from Improper Lanes at Multi-Lane Roundabouts Create Conflicts



Severity of Vehicular Conflicts is REDUCED

- Crash severity is related to the relative velocities of the conflicting streams



Rear-end
Sideswipe
Angle
Angle
Head-on

Least severe

Most severe

Wrong way moves are possible, but difficult....



U.S. Safety Report

(The Insurance Institute for Highway Safety)

Before-after studies at 24 intersections

- 39% overall decrease in crashes
- 76% decrease in injury crashes
- 89% decrease in fatal/incapacitating crashes
- 75% reduction in traffic delays!

www.highwaysafety.org

New York State DOT Study – October 2003

Before/After Characteristics (sample size)	All	PDO	Injury
All Sites (33)	47%	41%	72%
Urban Stop → 1L Rbt (12)	69%	67%	80%
Rural Stop → 1L Rbt (9)	65%	63%	68%
Urban Stop → 2L Rbt (7)	8%	0%	73%
Urban Signal → Rbt (5)	37%	31%	75%

STOP/Signal vs. Roundabout AMFs

Characteristic before conversion	AMF	
	All	Injury
Single-lane urban STOP-controlled	0.39	0.23
Single-lane rural STOP-controlled	0.42	0.18
Multilane-Urban STOP-controlled	0.85	n/a
Urban Signalized	0.68	0.32
All conversions	0.61	0.24

90% Reduction Fatals

39% ↓ Total

76% ↓ Injury

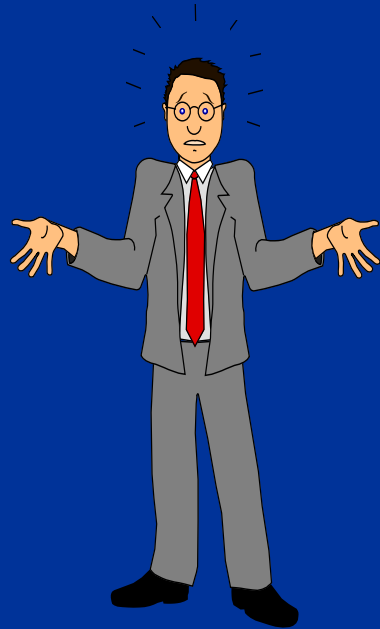
Table 13.2: AMFs for Conversion from STOP-controlled and signalized intersections to Modern Roundabouts

Persaud et al (2000)

The Latest U.S. Safety Report – NCHRP 3-65

- Before-after studies at 55 intersections
- 35% overall decrease in crashes
- 76% decrease in injury crashes
- 81% decrease in fatal/incapacitating crashes for single lane urban roundabouts
- 71% decrease in fatal/incapacitating crashes for single lane rural roundabouts

Estimating Intersection Safety Performance



Is it possible to estimate
the safety performance
of an intersection?

What are the main factors
that influence crash risk?

Crash Frequency Models

Based on research from crash data bases

- Provides basis for screening “high crash” sites (may be calibrated to local conditions)
- Assess quantitative safety benefits of intersection improvements
- Develop crash Modification Factors for intersection improvements

Interactive Highway Safety Design Model (IHSDM)

- ❑ Suite of software analysis tools for designers to consider safety in the design process
- ❑ Evaluates operational and physical characteristics
- ❑ Quantitatively evaluates safety and operational effects
- ❑ Current development focused on two-lane rural highways
- ❑ www.ihsdm.org

SafetyAnalyst

- ❑ Set of software tools to enhance safety decision making process
- ❑ Includes a network screening tool to identify “sites with promise” for safety improvements
- ❑ Quantitatively evaluates if a site has a “higher than expected” crash frequency
- ❑ Under development for system-wide application (more than two-lane rural highways)
- ❑ www.safetyanalyst.org

IHSDM Crash Frequency Models

(for RURAL Intersections <10,000ADT)

a. Three-Leg Stop Controlled Intersection

$$N = e^{(-10.9 + 0.79 \ln (ADT1) + 0.49 \ln (ADT2))}$$

b. Four-Leg Stop Controlled Intersection

$$N = e^{(-9.34 + 0.60 \ln (ADT1) + 0.61 \ln (ADT2))}$$

c. Four-Leg Signalized Intersection

$$N = e^{(-5.73 + 0.60 \ln (ADT1) + 0.20 \ln (ADT2))}$$

Crash Frequency Models – Example

Rural Stop Controlled Intersection

Example Calculation



What is the expected (predicted) number of crashes at a four-leg intersection with STOP control along the minor road (no control of major road) having an ADT of 5000 along the major road and an ADT of 600 on the intersecting side road?

Example: Crash Frequency Model

Rural Stop Control Intersection (<10,000ADT)

b. Four-Leg Stop Controlled Intersection

$$N = e^{(-9.34 + 0.60 \ln (ADT1) + 0.61 \ln (ADT2))}$$

For ADT1 of 5,000 and ADT2 of 600

$$N = e^{(-9.34 + 0.60 \ln (ADT1) + 0.61 \ln (ADT2))}$$

$$= e^{(-9.34 + 0.60 \ln (5000) + 0.61 \ln (600))}$$

$$= 0.72 \text{ crashes per year}$$

SafetyAnalyst Crash Frequency Models

Rural & Urban Intersections (>10,000 ADT)

Safety Performance Factor Equations (*draft*)

$$N = e^a \times AADT^b_{\text{major}} \times AADT^c_{\text{minor}}$$

***From *draft* “Development of SPFs for Safety Analyst Interim Tools”, FHWA Technical Memorandum, December 2004**

SafetyAnalyst (Draft equations)

$$N = e^a \times AADT^b_{\text{major}} \times AADT^c_{\text{minor}}$$

Rural/Urban		a	b	c
Rural 3 App	Stop Minor	-5.35	0.34	0.28
Urban 3 App	Signal	-9.85	0.97	0.18
Rural 4 App	Stop Minor	-8.96	0.65	0.47
Rural 4 App	All-Way Stop	-12.37	1.22	0.27
Rural 4 App	Signal	-6.57	0.66	0.20
Urban 4 App	TWSC	-3.12	0.27	0.16
Urban 4 App	Signal	-3.47	0.42	0.14

Crash Frequency Models – Example

Urban Signal Controlled Intersection

Example Calculation



What is the expected (predicted) number of crashes at a four-leg intersection with Signalized control having an ADT of 25,000 along the major road and an ADT of 5000 on the intersecting side road?

Crash Frequency Model for Urban Signalized Intersection: Example

c. Four-Leg Signalized Intersection

$$\begin{aligned} N &= e^a \times AADT^b_{\text{major}} \times AADT^c_{\text{minor}} \\ &= e^{-3.47} \times AADT^{0.42} \times AADT^{0.14} \end{aligned}$$

For ADT1 of 25,000 and ADT2 of 5,000

$$\begin{aligned} N &= e^{-3.47} \times AADT^{0.42} \times AADT^{0.14} \\ &= e^{-3.47} \times 25,000^{0.42} \times 5,000^{0.14} \\ &= 7.2 \text{ crashes per year} \end{aligned}$$

Roundabout Crash Frequency Model

NCHRP 3-65 Safety Performance Factor
Equations

$$N = a \times (\Sigma AADTs)^b$$

TOTAL CRASHES	Number of Approaches	Number of Approaches
Circulating Lanes	3	4
1	$=0.0011(\Sigma AADT)^{0.749}$	$=0.0023(\Sigma AADT)^{0.749}$
2	$=0.0018(\Sigma AADT)^{0.749}$	$=0.0038(\Sigma AADT)^{0.749}$

Roundabout Crash Frequency Model

NCHRP 3-65 Safety Performance Factor
Equations (*draft*)

$$N = a \times AADT^b$$

Injury/ Fatal CRASHES	Number of Approaches	
Number of Circulating Lanes	5	
1	$=0.0049(\Sigma AADT)^{0.749}$	
2	$=0.0073(\Sigma AADT)^{0.749}$	

Crash Frequency Models

Exercise Problem

An urban 4 approach intersection with 8,500 ADT on the major road and 3,500 ADT on the minor road is currently a 2-way STOP (minor road stops). Six crashes have occurred at this intersection over the past 3 years. Local residents have requested a signal be installed at this intersection.

Crash Frequency Models

Exercise Problem

1. Is the crash experience at this intersection higher than would be expected?
2. What is the estimated safety performance of this intersection if it were signalized?
3. What is the estimated safety performance if the intersection was converted into a roundabout?

Crash Frequency Models

Exercise Problem

Urban 4 approach Intersection – 8,500 ADT
and 3,500 ADT - Currently a 2-way STOP

Estimated # of Crashes

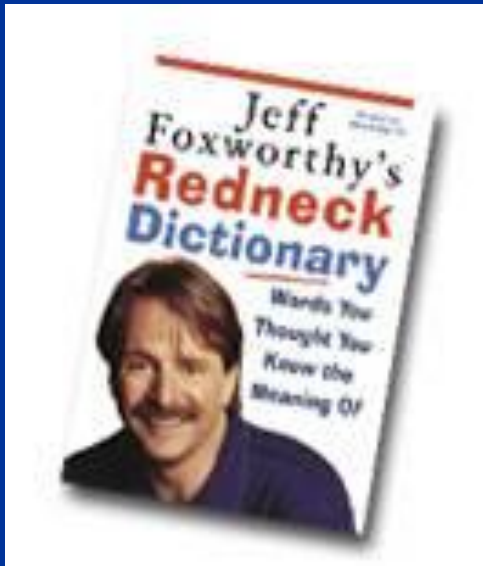
Two-Way Stop	1.9
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Signalized	4.4
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Roundabout	2.6
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QUESTIONS?

“You Might be a Roundabout if”



.....Might be a Roundabout?



.....**Might be a Roundabout?**



.....Might be a Roundabout?



.....**Might be a Roundabout?**



.....Might be a Roundabout?



.....**Might be a Roundabout?**



.....**Might be a Roundabout?**



.....**Might be a Roundabout?**



.....Might be a Roundabout?



QUESTIONS?