

Speakers

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Roundabouts: Art, Engineering, or Both?

Overview

- Part I
 - Introduction to Roundabouts
 - Roundabout Safety
 - Pavement Markings and Signs
 - Maintenance of Traffic During Construction
 - Lighting
 - Q & A

Roundabouts: Art, Engineering, or Both?

Overview

- Part II
 - Capacity Study in Indiana
 - Capacity Calculation Options
 - Use of Simulation for Roundabout Evaluation
 - Roundabout Design
 - Q & A

Roundabouts: Art, Engineering, or Both?

Art, Engineering, or Both?

Merriam-Webster:

- **Art:** "The conscious use of skill and creative imagination especially in the production of aesthetic objects."
- **Engineering:** "The application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people."
- **Where does good roundabout design fit in?**
 - BOTH!

Roundabouts: Art, Engineering, or Both?

History of Roundabouts

- 1800s-1940s** Traffic circles and rotaries used
- 1950s** Circular intersections fall out of favor
- 1966** UK institutes "yield on entry" – birth of the Modern Roundabout
- 1990** First Modern Roundabouts built in US - Nevada
- 1997** First Modern Roundabouts constructed in Indiana

Roundabouts: Art, Engineering, or Both?

Definition – Modern Roundabout

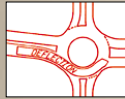
Yield at Entry

- Yield signs
- Yield line
- Circulating traffic has right-of-way



Deflection of entering vehicle path

- Accomplished using “splitter islands”



Entry flare

- Lane width is increased near yield line
- Not mandatory



Roundabouts: Art, Engineering, or Both?



Indianapolis – Monument Circle



Roundabouts: Art, Engineering, or Both?



Kingston, NY Rotary Converted to Roundabout



Roundabouts: Art, Engineering, or Both?



Benefits of a Roundabout

- **Keeps traffic moving (efficient)**
 - Yield instead of stop
- **Aesthetically pleasing**
 - Central island provides opportunity for landscaping
- **Less pollution**
 - Air
 - Noise
- **Safer than conventional intersections**
 - Greater than 90% reduction in fatalities!!
 - Studies performed by Insurance Institute of Highway Safety

Roundabouts: Art, Engineering, or Both?



Roundabout Applications

- High-crash locations
- Congested locations
- Freeway interchanges
- Corridor with multiple intersections
- Where widening is cost-prohibitive
- Access management
- Unusual geometry

Roundabouts: Art, Engineering, or Both?



Where NOT to use a Roundabout

- Wherever queues would back up into the roundabout
- Insufficient sight distance (can't see the roundabout on the approach)
- In the middle of a traffic signal system with good progression
- On a steep ($\geq 5\%$) grade

Roundabouts: Art, Engineering, or Both?



ADA Issues

- Access Board of Americans With Disabilities Act (ADA) has concerns for sight-impaired pedestrians at roundabouts
- What is the concern?
 - Safety – not primarily
 - Accessibility – yes
 - Access Board Research ongoing

Roundabouts: Art, Engineering, or Both?



ADA Issues

- Access Board preliminary recommendations
 - Single lane roundabout: ADA ramps
 - Multi-lane roundabout: ADA ramps & pedestrian signals that stop traffic

Roundabouts: Art, Engineering, or Both?



Roundabout Safety

Roundabout Safety

- According to the IIHS, over 800 people die and over 200,000 are injured in the US each year in crashes involving red light running
- In 2000, the IIHS found roundabouts had 79% fewer accidents with injuries than ordinary intersections.
- Since 2001, IIHS has issued a total of five reports promoting the use of roundabouts



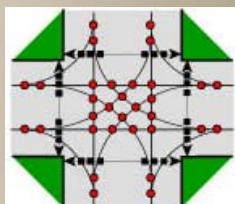
Roundabouts: Art, Engineering, or Both?



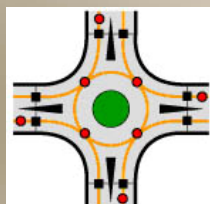
Roundabouts: Art, Engineering, or Both?



Conflict Points



● 32 Vehicle to vehicle conflicts
■ 24 Vehicle to pedestrian conflicts

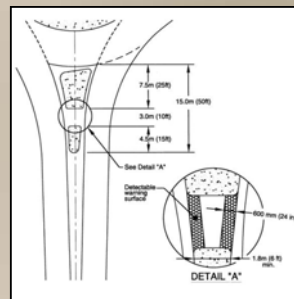


● 8 Vehicle to vehicle
■ 8 Vehicle to pedestrian

Roundabouts: Art, Engineering, or Both?



Pedestrian Crossings



- 25' back from yield line at roundabouts
- Splitter island minimum 6' wide for refuge

Roundabouts: Art, Engineering, or Both?



Speed Reduction

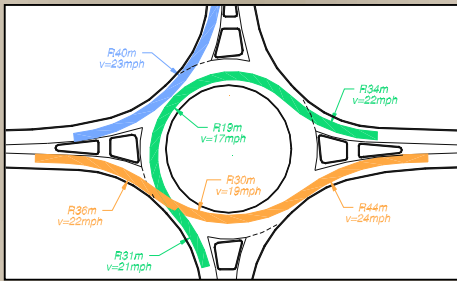


Figure from FHWA Design Guide

Roundabouts: Art, Engineering, or Both?



Pedestrian Fatality in Pedestrian/Vehicle Crash

Vehicle Speed	Odds of Pedestrian Death, Source 1	Odds of Pedestrian Death, Source 2
20 mph	5%	5%
30 mph	45%	37%
40 mph	85%	83%

Source 1: Limpert, Rudolph. Motor Vehicle Accident Reconstruction and Cause Analysis. Fourth Edition. Charlottesville, VA: The Michie Company, 1994, p. 663.
 Source 2: Vehicle Speeds and the Incidence of Fatal Pedestrian Collisions. Australian Federal Office of Road Safety, Report CR 146, October 1994, by McLean AJ, Anderson RW, Farmer MJB, Lee BH, Brooks CG.

Roundabouts: Art, Engineering, or Both?



Carmel Citywide Crash Data

2002-2006

% Accidents with Injury at All Intersections

29%

% Accidents with Injury at Roundabouts

Single Lane 4%
 Multi-Lane 7%



Roundabouts: Art, Engineering, or Both?



Accident Damage Cost Savings

Cost of accident damages is less at roundabouts than traditional signalized intersections

Intersection	Avg. Cost of Damages
96 th Street (signal)	\$13,600
116 th Street (signal)	\$7,300
126 th Street (RBT)	\$2,500
131 st Street (RBT)	\$2,500



(Statistics from Carmel Police Dept. 2006)

Roundabouts: Art, Engineering, or Both?

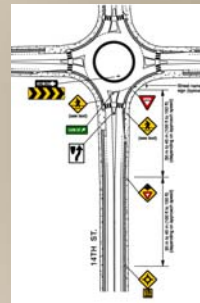


Signing/ Striping

Roundabouts: Art, Engineering, or Both?



FHWA Advanced Signage Guide



Locals often complain about sign clutter

Roundabouts: Art, Engineering, or Both?



Carmel Standard Approach Signage



Roundabout Ahead Sign Assembly

Roundabouts: Art, Engineering, or Both?



Carmel Standard Approach Signage



Multi-Lane Usage Sign

Roundabouts: Art, Engineering, or Both?



Carmel Standard Approach Signage



Pedestrian Crossing Sign

Roundabouts: Art, Engineering, or Both?



Carmel Standard Approach Signage



Yield Sign

Roundabouts: Art, Engineering, or Both?



Carmel Standard Approach Signage



Center Island Sign

Center Island Sign

Roundabouts: Art, Engineering, or Both?



Carmel Standard Approach Signage

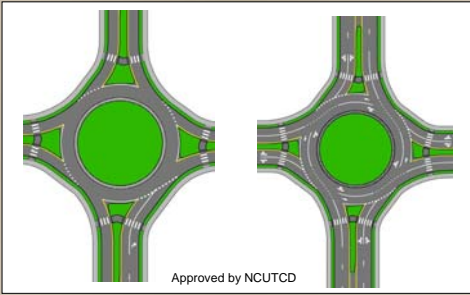


Exiting Street Name Sign

Roundabouts: Art, Engineering, or Both?



Standard Striping



Approved by NCUTCD

Roundabouts: Art, Engineering, or Both?



Standard Carmel Striping

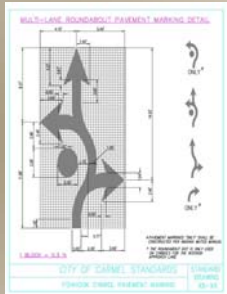


Roundabouts: Art, Engineering, or Both?



Standard Carmel Striping

Specialty Fishhook Lane Indication Arrows



Roundabouts: Art, Engineering, or Both?



Standard Striping



Spiral Pavement Markings

Roundabouts: Art, Engineering, or Both?



Standard Carmel Striping



Spiral Pavement Markings

Roundabouts: Art, Engineering, or Both?



Standard Carmel Striping



Spiral Pavement Markings

Roundabouts: Art, Engineering, or Both?



Standard Carmel Striping



Spiral Pavement Markings

Roundabouts: Art, Engineering, or Both?



Early Education



Roundabouts: Art, Engineering, or Both?



Early Education



Roundabouts: Art, Engineering, or Both?



Roundabout Construction Maintenance-of-Traffic Options

Roundabouts: Art, Engineering, or Both?



Full Closure

- Full intersection closure is quickest and least expensive
 - Must have a detour route available
 - Typical closure time is 45 days

Roundabouts: Art, Engineering, or Both?



45-Day Closure



141st & Towne Road

Roundabouts: Art, Engineering, or Both?



60-Day Closure



136th Street & Illinois Street

Roundabouts: **Art, Engineering, or Both?**



30-Day Closure



Spring Mill Road & Dorset

Roundabouts: **Art, Engineering, or Both?**



Roundabout Construction

- Full intersection closure is quickest and least expensive
 - Must have a detour route available
 - Typical closure time is 45 days
- Partial access can be maintained
 - Extends time of construction
 - Can be accomplished in many variations

Roundabouts: **Art, Engineering, or Both?**



Partial Access



Illinois Street & 131st Street

Roundabouts: **Art, Engineering, or Both?**



Partial Access



Illinois Street & 131st Street

Roundabouts: **Art, Engineering, or Both?**



Partial Access



Old Meridian Street & Guilford Road

Roundabouts: **Art, Engineering, or Both?**



Partial Access



Old Meridian Street & Guilford Road

Roundabouts: Art, Engineering, or Both?



Partial Access



Old Meridian Street & Grand Boulevard

Roundabouts: Art, Engineering, or Both?



Partial Access



Old Meridian Street & Grand Boulevard

Roundabouts: Art, Engineering, or Both?



Developing Effective Standards and Guidelines for Roundabout Lighting

John Beery, PE, PTOE
Noblesville, IN

Roundabouts: Art, Engineering, or Both?



Topics of Discussion

- Roundabout safety
- Available lighting resources
 - IESNA
 - AASTHO
 - State DOT
 - Others
- Developing illumination strategies
 - Location and placement
 - Luminaire selection
 - Spacing
 - Geometrics and signage
- Examples
- Results and conclusions

Roundabouts: Art, Engineering, or Both?



Available Resources

- [HIGHWAY CAPACITY MANUAL 2000](#) – Chapter 17, Part C. Roundabouts, pages 17-45 to 17-48.
- NCHRP Synthesis 264, "Modern Roundabout Practice in the United States", for the National Cooperative Highway Research Program, Transportation Research Board National Research Council: National Academy Press.
- U.S. Department of Transportation, Federal Highway Administration, "Roundabouts: An Informational Guide": [Publication No. FHWA-RD-00-067](#), Copyright June 2000 by National Academy of Sciences.
- "Roadway Lighting" by the Illumination Engineering Society of North America.
- "Roadway Lighting Design Guide" by AASHTO.

Roundabouts: Art, Engineering, or Both?



Why Provide Lighting?

- Reduce nighttime accidents
- Aid police protection and security
- Facilitate traffic flow
- Promote business and use in night hours
- Provide advance warning

Source: "Roadway Lighting" by IESNA

Roundabouts: Art, Engineering, or Both?



Lighting Methodology

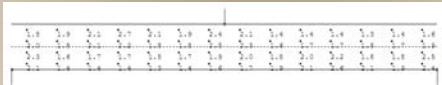
- Present guidance and resources
 - AASHTO
 - IESNA
 - State and local standards
 - Proprietary methods and vendor assistance
- Limitations and applicability

Roundabouts: Art, Engineering, or Both?



Traditional Roadway Lighting Analysis and Methodology

- Linear roadway methodology
 - Select luminaire and mounting height
 - Analyze photometric contours
 - Manually or by computer model
 - Determine spacing and Placement
 - Analyze alternatives



Roundabouts: Art, Engineering, or Both?



AASHTO Guidance

"Roundabouts should be lit to a level that is 1.3 to 2 times the value used on the best lit approach. Uniformity should be 3:1 or better. The illuminance method should be used."^[1]

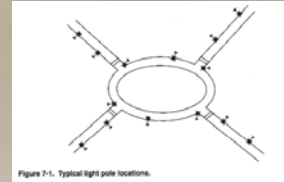


Figure 7-1. Typical light pole locations.

^[1]ROADWAY LIGHTING DESIGN GUIDE, AASHTO, October 2005, page 41.

Roundabouts: Art, Engineering, or Both?



IESNA Guidance

Recommended Illuminance for the Intersection of Continuously Lighted Urban Streets^[1]

Functional Classification	ILLUMINANCE FOR INTERSECTIONS			E_{min}/E_{max}
	Average Maintained Illumination at Pavement by Pedestrian Area Classification			
	High	Medium	Low	
Major/Major	34.0/3.4	26.0/2.6	18.0/1.8	3.0
Major/Collector	29.0/2.9	22.0/2.2	15.0/1.5	3.0
Major/Collector	26.0/2.6	20.0/2.0	13.0/1.3	3.0
Collector/Collector	24.0/2.4	18.0/1.8	12.0/1.2	4.0
Collector/Local	21.0/2.1	16.0/1.6	10.0/1.0	4.0
Local/Local	18.0/1.8	14.0/1.4	8.0/.8	6.0

^[1] American National Standard Practice for Roadway Lighting, ANSIESNA RP-8-00, by the Illumination Engineering Society of North America, June 6, 2000, Table 9, Page 15.

Roundabouts: Art, Engineering, or Both?



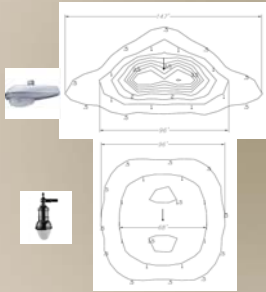
Applying Traditional Strategies to Roundabouts

- Issues:
 - Roundabout is non-linear
 - Motorist unfamiliarity
 - Roundabout offers added flexibility over traditional intersection
 - Luminaire use
 - Pedestrian considerations
 - Other pros and cons

Roundabouts: Art, Engineering, or Both?



Luminaire Selection



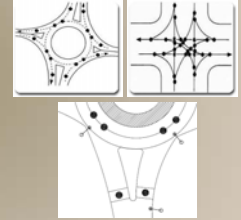
- Know capabilities
- Avoid glare and trespass
 - Don't over illuminate
 - Consider trespass stds
- Select based on functionality
- Consider stock and standard practice

Roundabouts: Art, Engineering, or Both?



Conflict Points and Luminaire Placement

- Initial Locations
 - Crosswalks
 - 45°, 135°, 225°, 315° quadrant points
- Accommodate luminaire capability, and illumination and uniformity requirements
- Consider clear zone
- Evaluate arm lengths



Roundabouts: Art, Engineering, or Both?



Illumination Strategy: Single-Lane Roundabout

Single-Lane Roundabout



- Single-lane roundabout up to 110' in diameter
- Understand capability of luminaires considered
- Place luminaire and poles near conflict points
- Light from exterior of roundabout

Roundabouts: Art, Engineering, or Both?



Single Lane vs. Multiple Lanes

- Considerations
 - Pedestrians
 - Higher Traffic Levels
 - Larger Area to Light
 - Higher Speeds into Entry Lanes

Roundabouts: Art, Engineering, or Both?



Illumination Strategy: Two-Lane Roundabout



- Two lanes from 120' to 180' in diameter
- Know capability of luminaires considered
- Place luminaire and poles near conflict points
- Light from interior of roundabout

Roundabouts: Art, Engineering, or Both?



Summary of Methodology

- Evaluate geometrics
- Light conflict points
- Use familiar luminaires
- Provide consistent lighting to comply with IESNA requirements

Roundabouts: Art, Engineering, or Both?



Results and Conclusions

1. Identify and establish a standard luminaire and mounting height to provide consistent and cost effective illumination. Attempt to accommodate both aesthetics and function.
2. Establish preliminary lighting locations adjacent to the conflict points of the roundabout, including crosswalks.
3. Single lane roundabouts can typically be lit from the exterior of the intersection. Two-lane roundabouts typically require pole placement within the inner circle near the 45°, 135°, 225°, and 315° points for the inner circle conflict points.
4. Two-lane roundabouts may require closer pole spacing or more intense luminaires when lit from the inner circle to improve intensity and to reduce the number of lights.
5. Observe IES guidelines for illumination levels based on the type of intersection.
6. Adjust the type of pole, its location, and the base depending on clear zone requirements

Roundabouts: Art, Engineering, or Both?



Single-Lane Roundabout 136th and Brooks School Road



Questions?


- ADA
- Safety
- Pavement markings & signage
- Maintenance of traffic during construction
- Lighting

Roundabouts: Art, Engineering, or Both?




Roundabouts

Art, Engineering, or Both?





presented at Purdue Road School
March 10, 2009

Assessing Roundabout Capacity and Project Selection




Roundabouts: Art, Engineering, or Both?

Why did the chicken cross the road?


Because the available time headway in opposing traffic met his parameters for gap acceptance.



Roundabouts: Art, Engineering, or Both?

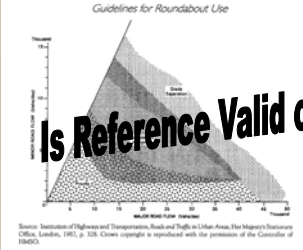
Roundabout Capacity

- Where do I put them?
- What is the capacity of a roundabout?
- Why is the most common question regarding capacity related to ADT?
- What is true capacity of an entry lane?
- Can capacity be quantified?
- What methods can be used to determine operational characteristics?
- What values for capacity are correct?
- Can simulations be accurately utilized?
- On what premise do roundabouts operate?
- Can we recognize "Garbage In/Garbage Out"?



Roundabouts: Art, Engineering, or Both?

Guidelines for Use




Is Reference Valid or Not Valid?

Typical Peak Flow Ranges for Various ADTs

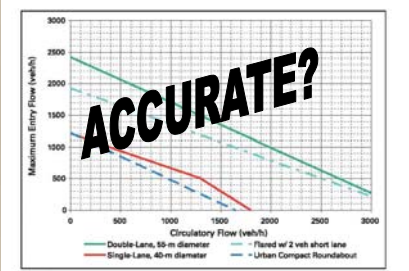

AADT Major Road	Est. Range - Peak Flow for Approach
5,000	193 to 360
10,000	385 to 720
15,000	578 to 1,080
20,000	770 to 1,440
25,000	963 to 1,800
30,000	1,155 to 2,160
40,000	1,540 to 2,880

*For Single Lane, Urban Route



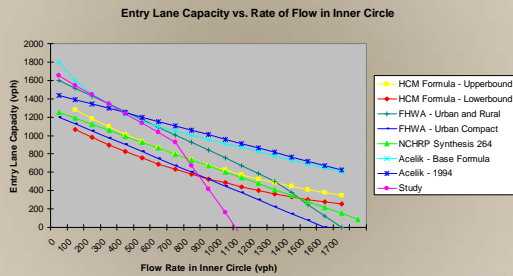
Roundabouts: Art, Engineering, or Both?

FHWA Roundabout Capacity

Roundabouts: Art, Engineering, or Both?

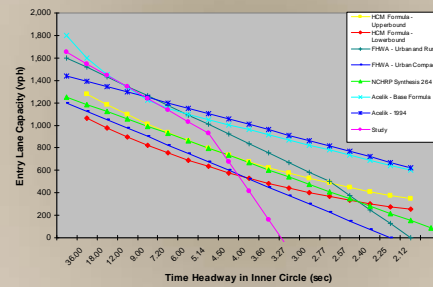
Summary of Capacity Resources



Roundabouts: Art, Engineering, or Both?



Entry Lane Capacity vs. Time Headway in Inner Circle



Roundabouts: Art, Engineering, or Both?



Parameters Affecting Flow and Capacity

- Classification of Facility
- Upstream Free-Flow Speed
- Geometrics
 - Deflection causes reduction in speed
 - Control Delay is inherent from geometrics
 - Geometrics of Inner Circle
- Lane Widths
- Driver Familiarity and Behavior
- Peak Hour Flow and ADT
- Upstream Flow in Inner Circle
- Turning movements within intersection

Roundabouts: Art, Engineering, or Both?



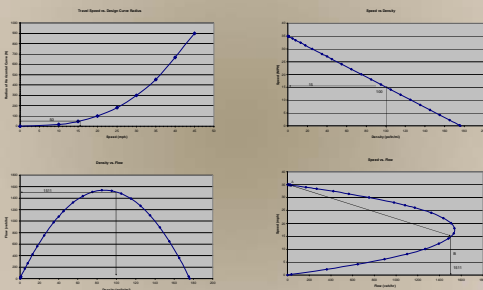
Understanding Capacity

- Understand Differences
 - Conventional Intersection
 - All traffic yields to through movements to the right if no other controls, such as signals are present.
 - Through movements typically take precedent over other movements, unless movement is protected.
 - Roundabouts
 - Entry movements yield to inner circle, regardless of its movement.
 - Therefore, a combinations or all movements in a certain direction can control through our entry movements.

Roundabouts: Art, Engineering, or Both?



Flow Parameters



Roundabouts: Art, Engineering, or Both?



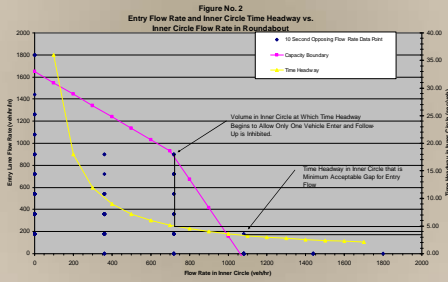
Delay Study

- Completed a series of delay studies in September of 2007 for same existing roundabout approach during peak hour
- Intent of study – To determine the point at which demand meets capacity for an entry lane approach
- Parameters:
 - Data collected in 10 second intervals
 - Counted number of vehicles in queue on entry lane approach
 - Counted vehicles travelling in inner circle upstream of entry lane
 - 10 second vehicle counts were computed to hourly flow rates
 - Time headways for 10 second vehicle counts were analyzed individually
 - Data was extrapolated to evaluate the effects of sustained flow conditions over longer periods of time.

Roundabouts: Art, Engineering, or Both?

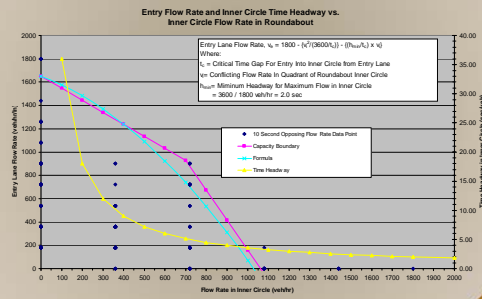


Study Results



Roundabouts: Art, Engineering, or Both?

Study Results



Roundabouts: Art, Engineering, or Both?

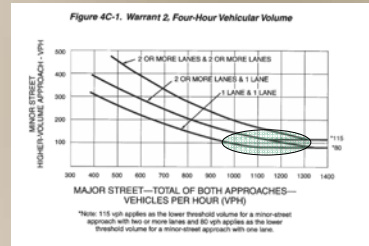
Comparison to MUTCD Signal Warrant #1

Condition B—Interruption of Continuous Traffic		Vehicles per hour on major street (total of both approaches)		Vehicles per hour on higher-volume minor-street approach (one direction only)	
Number of lanes for moving traffic on each approach		100%*	80%*	70%*	56%*
Major Street	Minor Street	100%*	80%*	70%*	56%*
1	1	600	525	420	75 60 53 42
2 or more	1	720	630	504	75 60 53 42
2 or more	2 or more	720	630	504	100 80 70 56
1	2 or more	600	525	420	100 80 70 56

Flow (vph)	Average Headway (sec/veh)
900	4.0
750	4.8

Roundabouts: Art, Engineering, or Both?

Comparison to MUTCD Signal Warrant #2



Flow (vph)	Average Headway (sec/veh)
1,000	3.60
1,100	3.27

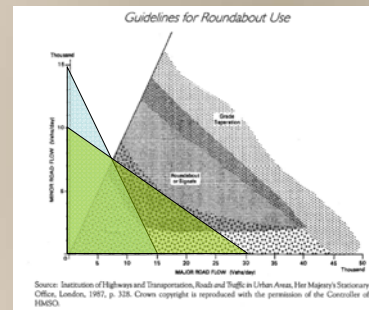
Roundabouts: Art, Engineering, or Both?

ADT Evaluation

AAADT Major Road	Est. Range Peak Hour Flow for Single Approach	Comment
5,000	193 to 360	
10,000	385 to 720	
15,000	578 to 1,080	Maximum Upper Threshold of Single Lane Roundabout with Low Minor Road Flow
20,000	770 to 1,440	
25,000	963 to 1,800	
30,000	1,155 to 2,160	Upper Limit of Two-Lane Roundabout with Significant Minor Road Flow
40,000	1,540 to 2,880	Good luck

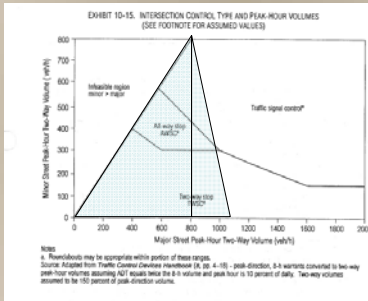
Roundabouts: Art, Engineering, or Both?

Roundabout Usage



Roundabouts: Art, Engineering, or Both?

HCM 2000



Roundabouts: Art, Engineering, or Both?



Conclusions on Capacity

- The flow in the entry lane is directly related to available gaps in flow within the inner circle and the acceptance of those gaps.
- Flow in the inner circle is not a direct function of flow-through ADT.
- Entry lane flow is reduced when the time headway of opposing flow in the inner circle is approximately 5 sec/veh.
- Entry lane flow is shut down at flow rate of approximately 1,100 vph in the inner circle upstream of the subject entry lane.
- Don't believe recommendations from Urban Planners when dealing with the selection of the appropriate traffic control.
- Future consideration of warrants for roundabouts should range from and overlap the warrants for two-way stops, through four-way stops, to at least the minimum warrants for traffic signals (depending on the volume and classification of facility).
- Hierarchy of Flow Parameters that Affect Capacity
 - Movements in Inner Circle
 - Flow Through ADT
 - Geometrics
- Each entry lane approach acts as a TWSC governed by HCM 2000.

Roundabouts: Art, Engineering, or Both?



Computer Applications for Capacity Analysis and Simulation

Roundabouts: Art, Engineering, or Both?



Capacity Analysis Options

- Macroscopic Software Models
 - RODEL and ARCADY (empirical data)
 - aaSIDRA (gap theory + some empirical data)
 - Many others
- Non-software Options
 - FHWA Roundabout Guide Equations (based on empirical data from UK)
 - NCHRP 572 Equations (underfunded + not enough roundabouts at capacity in the US)

Roundabouts: Art, Engineering, or Both?



Simulation Applications

- Simulation is a valuable tool for roundabout evaluation, especially in the following conditions:
 - Close interaction with nearby intersection
 - Unique geometry
 - Complex transportation system
 - Macro analysis shows high v/c ratio
 - Visual presentation for public education

Roundabouts: Art, Engineering, or Both?



Microscopic Simulation Models

- Analyze each individual vehicle
- Can give delay, number of stops, queue lengths, etc.
- Based on gap acceptance theory
- VISSIM, PARAMICS, Etc.

Roundabouts: Art, Engineering, or Both?



VISSIM

- Many transportation applications:
 - Signalized intersections
 - Roundabouts
 - Freeway corridors
 - Transit facilities
 - ITS
 - Etc.

Roundabouts: Art, Engineering, or Both?



VISSIM Advantages for Roundabouts

- Ability to model actual geometry
 - Links and connectors can be configured to any geometry – from simple to complex
- Ability to model traffic interactions between adjacent approaches or intersections
- Seeing is Believing
 - Public Education
- Good estimate of US roundabout capacity

Roundabouts: Art, Engineering, or Both?



VISSIM Advantages for Roundabouts

Simulated Capacity of Roundabouts and Impact of Roundabout Within a Progressed Signalized Road

Joe G. Bared
Federal Highway Administration,
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Virginia Polytechnic Institute and State University,
Falls Church, VA
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Word Count = 2549 (text) + 4000 (figures and tables) = 6549

National Roundabout Conference 2005

Roundabouts: Art, Engineering, or Both?



VISSIM Advantages for Roundabouts

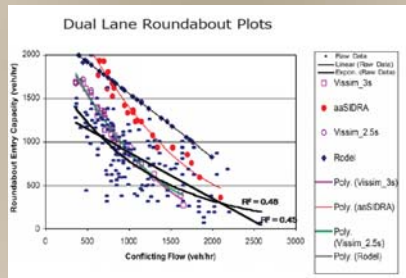
Quoted directly from the paper:

- “(VISSIM) Simulated capacities of single-lane roundabouts are noticeably lower than RODEL and aaSIDRA; however, they are comparable to fitted US field capacity data.”
- “Similarly, capacities of dual-lane roundabouts as simulated by VISSIM are significantly lower than RODEL and aaSIDRA, and are comparable to US field capacity data for a certain fitted regression.”

Roundabouts: Art, Engineering, or Both?



VISSIM Advantages for Roundabouts



Roundabouts: Art, Engineering, or Both?



Simulation Limitations

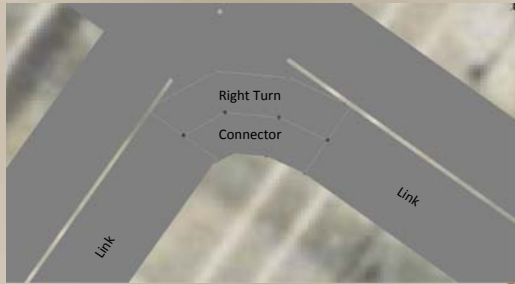
Limitations of Simulation

- Model parameters can be changed by the user that affect results
- Steep learning curve
- Extensive inputs required to build a model

Roundabouts: Art, Engineering, or Both?



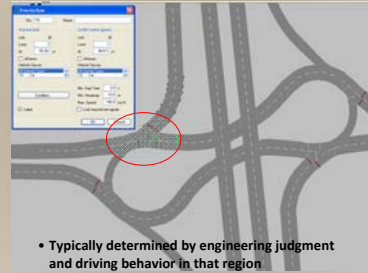
Links and Connectors



Roundabouts: Art, Engineering, or Both?



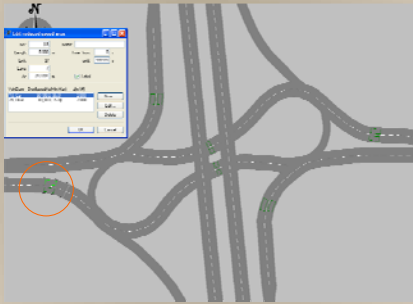
Priority Rule (Yielding Behavior)



Roundabouts: Art, Engineering, or Both?



Reduced Speed Area



Roundabouts: Art, Engineering, or Both?



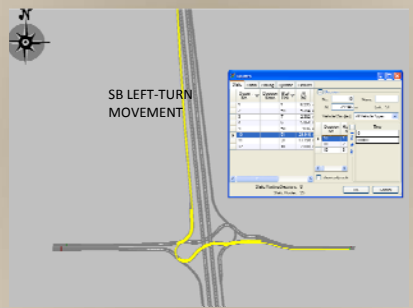
Speed Decisions



Roundabouts: Art, Engineering, or Both?



Route Decisions



Roundabouts: Art, Engineering, or Both?



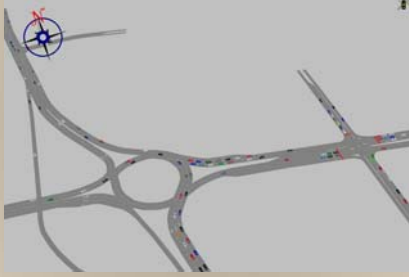
Project Experience: Roundabout vs. Signal



Roundabouts: Art, Engineering, or Both?



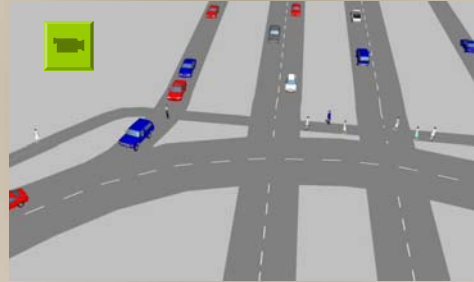
Project Experience: Roundabout/Signal Intersection



Roundabouts: Art, Engineering, or Both?



Project Experience: Vehicle/Pedestrian Interaction



Roundabouts: Art, Engineering, or Both?



Project Experience: Roundabout Interchanges



Roundabouts: Art, Engineering, or Both?



Roundabout Design

Roundabouts: Art, Engineering, or Both?



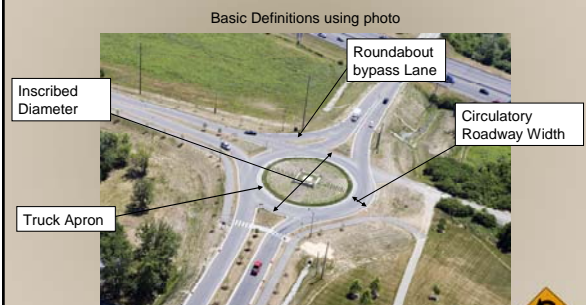
Design Considerations

- Vehicle speeds
 - Entry and exit radii
 - Circulatory roadway diameter
- Design vehicle negotiation of roundabout
- Vehicle path overlap (multi-lane roundabouts)
- Capacity (RODEL, aaSIDRA, or simulation)
- Lighting
- Signs and pavement markings
- Vehicle sight distances
- Pedestrian crossing locations and refuges
- Bicycle facilities

Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout



Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Geometric Basics

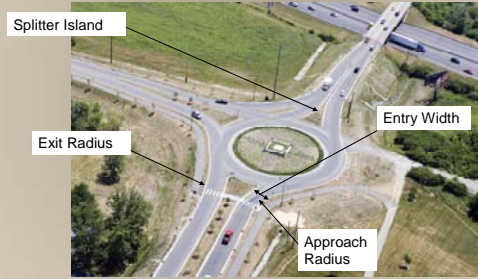
- Inscribed diameter
 - Can range from 100'-150'
 - Typically start with 130' and adjust based on existing conditions
 - Dependent on your design vehicle
- Circulatory roadway width
 - Dependent on your design vehicle
 - Typically start with 15'-16' for a single lane roundabout
- Truck apron width
 - Dependent on your design vehicle tracking
 - Typically start with a minimum of 5'

Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Basic Definitions Using Photo



Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Geometric Basics

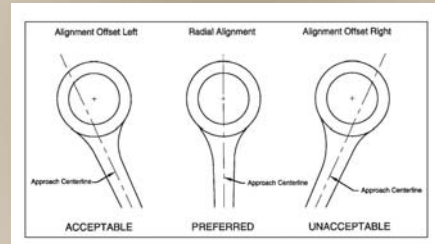
- Entry width
 - 18' practical maximum
- Approach Radius
 - Can range from 80'-120'
 - Typically start with 100'
 - Affects your roundabout capacity and speeds
- Exit Radius
 - Can range from 400'-800'
 - Typically start with 600'
 - Affects your roundabout capacity and speeds

Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

FHWA Recommendations

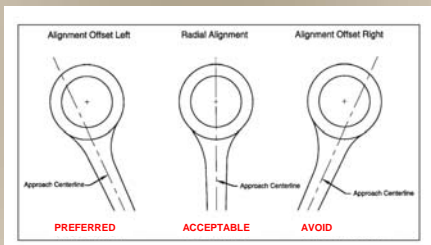


Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Our Recommendations



Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Benefits of Left Offset

- Desired deflection is easier to achieve
- Can utilize a smaller circle without reducing deflection
- Results in slower entry speeds

Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Roundabout Speeds – Circulating vs. Entering

- Conflicting speeds are optimally separated by no more than 6 mph
- 6 mph is rarely achievable
- A maximum speed difference of 12 mph is suggested

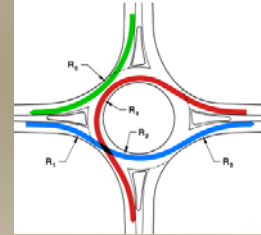
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Roundabout Speeds – Fastest Path

- Definitions of paths per FHWA Guide
- R1-R2-R3 movement is typically fastest path



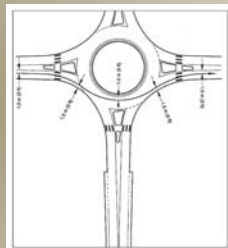
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Roundabout Speeds – Fastest Path

- FHWA Guide provides this illustration to create these paths and graphs to measure the resulting speeds
- HOWEVER, these paths do not necessarily predict your speeds.
- Proper deflection in advance of roundabout will negate the ability to reach R1 speed based on radius/speed tables
- Actual speed should be measured by acceleration calculations based on speeds where entry is the limiting factor



Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Getting Started

- Easy 5-step process with a foundation of designing pavement marking alignments
- Multiple iterations of these five steps will need to be completed to achieve the best geometric design
- Curbs and edges of pavement are derived by the pavement markings in accordance with the FHWA Roundabout Guide.

Disclaimer: There are many approaches to achieve a sound geometric roundabout design. Our approach is just one simple method we have found to work.

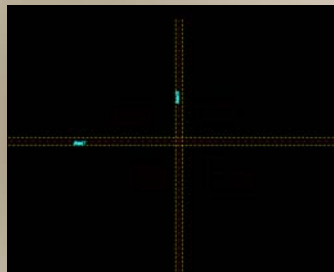
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Situation

- Simple 90-degree intersection
- Both roadways are 2-lane roads



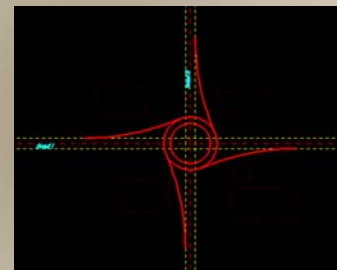
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Step 1

- Draw center circle
- Offset for circulatory roadway width
- Draw exits



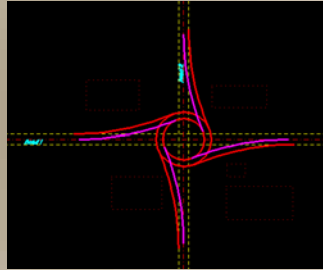
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Step 2

- Fillet centerline to inside of circulatory roadway for exits



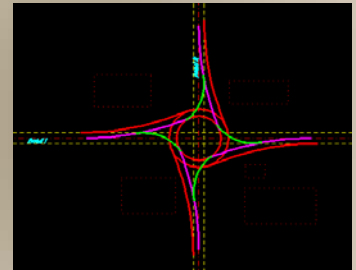
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Step 3

- Fillet inside of exit lane with inside circle to create inside approach lane



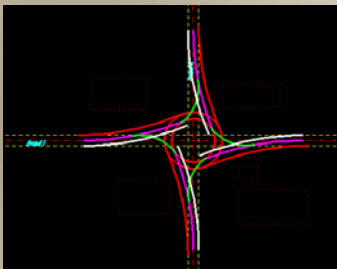
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Step 4

- Offset inside of exit lane to match approaching lane width



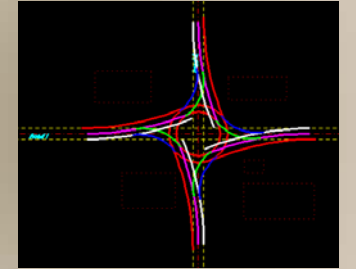
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Step 5

- Fillet with outside edge of circulatory roadway



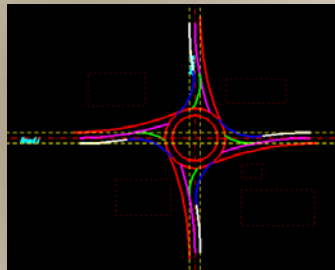
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Step 6

- Trim and review your geometrics



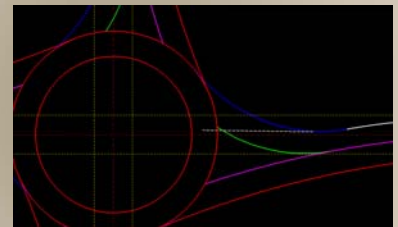
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Deflection Check

- Tangent to outside edge of approach should line up close to point where inside edge of approach intersects circulatory roadway



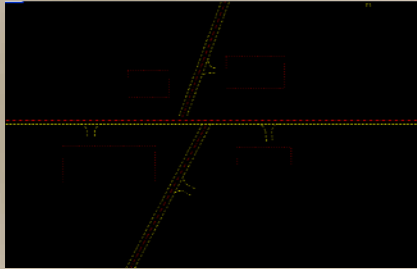
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Situation 2

- Offset intersection
- Higher speed on east-west road

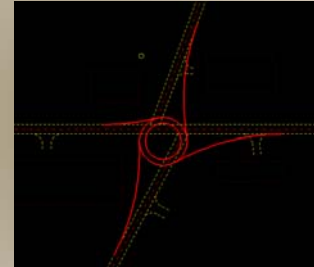


Roundabouts: Art, Engineering, or Both?

Single-Lane Geometric Layout

Step 1

- Draw center circle to maximize deflection on higher speed approach
- Offset for circulatory roadway width
- Draw exits



Roundabouts: Art, Engineering, or Both?

Single-Lane Geometric Layout

Step 2

- Fillet centerline to inside of circulatory roadway for exits



Roundabouts: Art, Engineering, or Both?

Single-Lane Geometric Layout

Step 3

- Fillet inside of exit lane with inside circle to create inside approach lane



Roundabouts: Art, Engineering, or Both?

Single-Lane Geometric Layout

Step 4

- Offset inside of exit lane to match approaching lane width



Roundabouts: Art, Engineering, or Both?

Single-Lane Geometric Layout

Step 5

- Fillet with outside edge of circulatory roadway

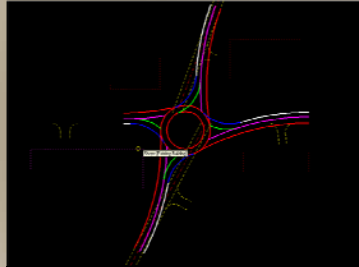


Roundabouts: Art, Engineering, or Both?

Single-Lane Geometric Layout

Step 6

- Trim and review your geometrics



Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Splitter Islands

- Once you are happy with the geometrics of your roundabout, create splitter islands as illustrated Exhibit 6-7 of the FHWA Guide



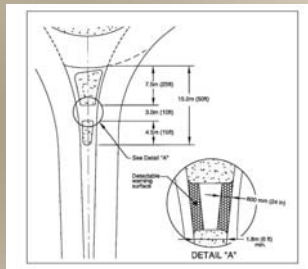
Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Splitter Islands

- Where pedestrian facilities exist, the splitter island should be at least 50'
- Additional modifications to your geometrics may be necessary to develop required splitter island length



Roundabouts: Art, Engineering, or Both?



Single-Lane Geometric Layout

Alterations to Geometric Layout

- Can decrease exit radii to avoid R/W impacts or slow exiting traffic due to crosswalk.
- Be careful not to reduce exit radii too much
- Can offset centerline in Step 4 additionally to create a longer splitter island
- When a median is involved, in Step 4 you can offset the line to match the inside approach edge of the existing median

Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Geometric Basics

- Inscribed diameter
 - Can range from 150'-200'
 - Typically start with 160' and adjust based on existing conditions
 - Dependent on your design vehicle
- Circulatory roadway width
 - Dependent on your design vehicle
 - Typically start with 30'-31' for a 2 lane roundabout
- Truck apron width
 - Dependent on your design vehicle tracking
 - Typically start with a minimum of 5'

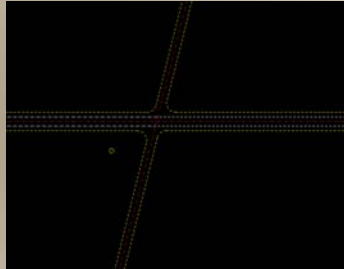
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Situation

- Skewed intersection
- East-west roadway is a 4-lane facility
- North-south roadway is a 2-lane facility



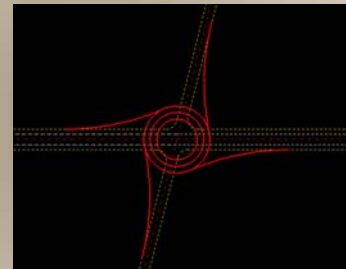
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Step 1

- Draw center circle
- Offset for circulatory roadway width
- Draw exits



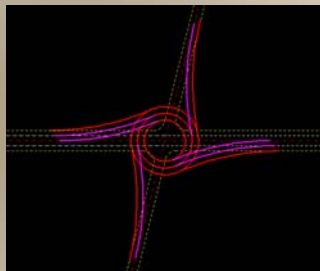
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Step 2

- Fillet inside of exit lanes to inside of circulatory roadway



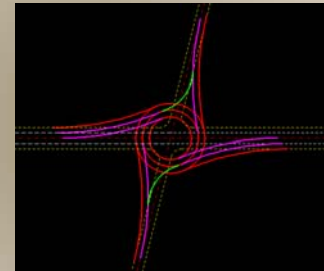
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Step 3

- Fillet inside of exit lane with inside circle to create inside approach lane.
- ONLY DO THIS FOR SINGLE LANE ENTRIES!



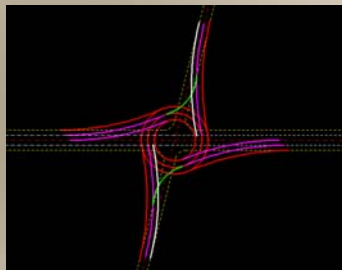
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Step 4

- Offset inside of exit lane to match approaching lane width
- Only do this for the single lane entries!



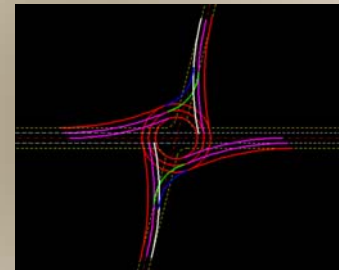
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Step 5

- Fillet with outside edge of circulatory roadway
- Only do this for the single lane entries!

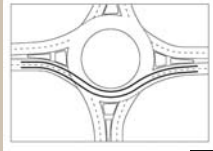


Roundabouts: Art, Engineering, or Both?

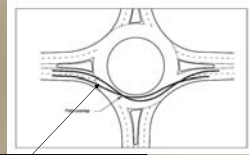


Multi-Lane Geometric Layout

Desired Path of Vehicles



Entry Path Overlap



Speed & Trajectory of vehicle at yield point determines natural path

Striping and proper geometric design is crucial to achieve proper lane use!

Roundabouts: Art, Engineering, or Both?



Unacceptable Vehicle/Path Overlap



Roundabouts: Art, Engineering, or Both?



No Vehicle Path Overlap



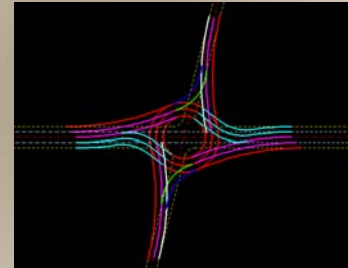
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Step 6

- Create tangents on two-lane approaches to prevent entry path overlap.



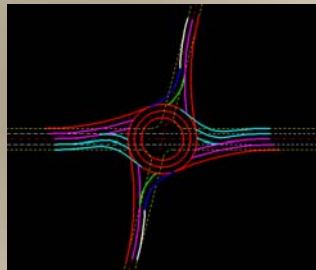
Roundabouts: Art, Engineering, or Both?



Multi-Lane Geometric Layout

Step 7

- Trim and review geometrics



Roundabouts: Art, Engineering, or Both?



Questions?

- Capacity Study in Indiana
- Capacity Calculation Options
- Use of Simulation for Roundabout Evaluation
- Roundabout Design

Roundabouts: Art, Engineering, or Both?

