High Flow Multi-Lane Roundabouts

- Design Optimization
- Project Examples

Mark T. Johnson, P.E.
MTJ Roundabout Engineering

- City of Loveland CO 1994-1998
- Consulting Firm 1998-2001
- Key Contributor to WIDOT Roundabout Design Program 2001 - 2005
- Co-Author of FHWA 2010 Roundabout Guide
- FHWA Authorized P2P Reviewer
Design Optimization

Based on Paper by MTJ for 2017 TRB Annual Meeting

Paper Link Here:
1. **What** is Optimization?
   a) Understanding of *Traffic planning/operational* & *Design components* for safe roundabouts within our transportation system.

2. **Why** is Optimization Important?
   a) Ensure *maximum safety* and ease of use and comfort for all modes
   b) Incorporate *benefits* into our traffic planning/design processes
   c) Ensure *public acceptance* –

3. **How** is Optimization Achieved?
   a) Review “in-service design reviews” of poorly performing roundabouts – *Lessons Learned*
   b) Examples illustrating Design optimization process
   c) Best Practices for Signing and Markings
1. Why is Optimization Important?
   a) Ensure maximum safety and ease of use and comfort for all modes
   b) What is a safe roundabout?
   c) How may PDO’s are considered too many?

186 PDO crashes in first year of operation

Roundabout most accident-prone in Michigan

~180 collisions / year opened in August 2015.

~100 PDO collisions “THIS ROUNDABOUT MUST BE FIXED”

~100 PDO collisions / year opened in August 2014.

“They’re going to use us for experiments”
Roundabout Design For Safety and Operations

Average < 5 crashes/yr 10 years of data, ~2,500 vph

Average < 7 crashes/yr 8 yrs of data, ~2,800 vph

Average < 20 crashes/yr 1.5 yrs of data, ~3,000 vph
Flared- Two Lane Entries:
< 5 per year (over 2 year period).

Three-Lane Entry
Total Ave crashes per year for all crashes at roundabout ~ 15 crashes per year (over 5 year period).
2. Why is Optimization Important

High Volume multi-lanners:

- Significant benefits with high flow multi-lane implementations
  - (Safety, Less Roadway widths, Complete Streets, less costs Infrastructure)
- Complexity: More Traffic = More lanes = More Conflict Points
- Design Aims Compete more sharply
  - Trucks, pedestrians/bikes,
  - Achieving Safety Criteria is more challenging (speed control vs entry angle)
1. **Why** design Optimization?

**Composition of Design Elements**

Often, the poor performance of a roundabout is erroneously attributed to individual design components; “its too big or it too small”

However, poor safety performance is often a function of the arrangement and relationship of multiple design elements: Geometric, Signing and Markings....

**Composition** of design elements.
Rules only applicable in limited situations

2000
Roundabouts: An Informational Guide

2010
NCHRP Report 672

Roundabouts: An Informational Guide
Second Edition

Design Principles Always Applicable
Principles

Roundabout Specific Design Principles

- Safety Speed Control – R1 (UK METHOD)
- Sight Distance (discusses preclusion)
- Entry Angles’ (Phi, view angles)
- Angle between legs (90 best)
- Natural Paths
- Driver Expectancy
- Context
**Design Checks**

- **6.7.4 - View Angles to Left**
  - Preferred maximum 12°

- **6.7.4 - Entry Angles**
  - UK Phi minimum = 20°
  
  \[(\text{Phi} = \frac{\text{measured entry angle}}{2})\]
Roundabout Design Principles

- There are many projects being implemented that are not following these fundamental principles basics (blocking and tackling)
Roundabout Design – Entry and View Angles

Achieving Correct Composition of Competing Objectives

- Severe Neck turning
- Merging Condition
- High Speeds
- Confuses Priority Message
- Circulating Vehicles Out of View
Signing and Pavement Marking Principles
1. Optimize Signing and Pavement markings to provide clear and easily understood information
2. Line types, weight, arrangement important
3. Minimize detection, reading and processing time
4. Maximize comprehension
Must Consider:
- Context,
- System considerations
- Too little information not good.
- Too much equally not good ….
- Must be correct for flows, context, system
- Remove Clutter
- Provide information to drivers when they need it
In-Service Design
Review Example #1
Clear Pattern of Crashes / Driver Confusion Attributed to Design Principles

FHWA P2P Program: Data Courtesy of SCDOT
Roundabout Design - Example #2 - Safety

Existing Confusing Messaging

Before

Clarity in Priority Messaging

After

80% Crash Reduction
Roundabout Design - Example #2 - Safety

Entry Alignment and Natural Path Principles

Existing Confusing Messaging

Before

80% Crash Reduction

AFTER
In-Service Design
Review Example #2
Roundabout Design - Example #3 - Safety

Solid then skip circulating markings
New Signing and Marking

80% Reduction of Wrong Movements from outside Lane

Consistent circulating markings

Roundabout Design - Example #3 - Safety
In-Service Design
Review Example #3
112 Crashes in first year of operation
3,400 vph
34 Crashes After (~80% reduction)
Optimization Example
Optimization
Roundabout Design - Optimization

- Single Lane / Multi-Lane
- Flare and Parallel Entries
- Hybrid / Turbo /Spiral
- Bypass Lanes: Yield and Free
- High Speed Approaches
- Business Access
- Pedestrians and Bicycle accommodations

Summary of Optimization

- Ensure Optimal safety and ease of use and comfort for all modes
- Incorporate operational benefits into our traffic planning/design processes
- Ensure public acceptance – let’s not sink the ship that has taken 25 years to build!
4 High Flow Multi-Lane Project Examples
Project #1

STH 119 / CTH Q (Main Street)
Village of Waunakee, WI

Roundabout Design and Analysis by MTJ Roundabout Engineering
Alternatives Evaluation

4-Lane Widening - Signal

3-Lane section with 2-Lane Flared Entry Roundabout
Alternatives Evaluation

See video at: https://youtu.be/psxlqc89dXE
Access Management with Roundabouts

Reduced Congestion,
fewer impacts, business vitality,
maintain on-street parking thru Downtown area
Access Management with Roundabouts

Reduced Congestion,
fewer impacts, business vitality,
maintain on-street parking thru Downtown area

Photo: MTJ Engineering
Example 2

STH 83 USH 18
Wales, WI - Waukesha County

Design and Analysis by MTJ Roundabout Engineering
Alternatives Evaluation
Alternatives Evaluation

70,000 sq. ft. Mixed Use Commercial Retail Development

- Grocery Store
- C-Store
- Bank

600'

Alternatives Evaluation

70,000 sq. ft. Mixed Use Commercial Retail Development
Alternatives Evaluation

70,000 sq. ft. Mixed Use Commercial Retail Development
Access Management with Roundabouts
Access Management with Roundabouts

Business Access
Access Management with Roundabouts

- 155' ICD
- Short Flared Two-Lane Entry
- Single-Lane Entry
- Aux RT Lanes (two types)
Example #3

Orchard Lake Road
Farmington Hills MI

Design and Analysis by MTJ Roundabout Engineering

Project Team:
Wisconsin DOT
Patrick Engineering
One Source Consulting
Northwestern Connector
Orchard Lake Rd. at 14 Mile Rd
Northwestern Connector
Orchard Lake Rd. at 14 Mile Rd
Northwestern Connector Triangle
VIDEO- Northwestern Connector
Orchard Lake Rd. at 14 Mile Rd
Example #4

- Constrained context
- Closely spaced roundabouts
- Pebble Beach
- Gateway to Greater Monterey Peninsula

Roundabout Design and Analysis by MTJ Roundabout Engineering as part of Omni-Means Lead Prime Firm
Holman Highway 68/ Highway 1 Roundabout Project

http://monterey.org/Services/Planning/Planning-Projects/Holman-Highway-Roundabout-Project

https://www.truelook.com/tl/app/?u=tt1433948002#tl_live

https://youtu.be/zbyvkOBTEZU
Project History (Project Location and Limits)

Holman Highway 68 / Highway 1 Roundabout Project
Total Estimated Cost = $21,170,000 (2009)
~$10M for roundabout corridor

Holman Highway 68 / Highway1 Roundabout Project
2009 Project Report Preferred Alt

Holman Highway 68 / Highway 1 Roundabout Project
Preliminary Roundabout Concept

Holman Highway 68 / Highway 1 Roundabout Project
Smaller Project Footprint
Proposed Phase 1 Project

Total Cost (Phase 1) $7.7mil
Guide Signing
Guide Signing
Guide Signing
Design Optimization - Challenges

Design Optimization

“Built To Deliver”
Design Optimization - Challenges

Identified Issues

1. Westbound Merge
   - Summary sentence?

2. Southbound Exit
   - Summary sentence?

3. Entry-Exit Angle Design
   - Summary sentence?

4. Eastbound Merge to One-Lane Bridge
   - Summary sentence?
Design Optimization - Challenges
Kittleson Concept Design

1 Westbound Issues
- Merging Thru Down-Stream Intersection
- Undefined Intersection
- Vehicular and Bicyclists Safety Concerns

2 Southbound Exit Issues
- Lane Choice/Complexity
- Compressed Decision Making Distance
- Difficult to Sign

"Built To Deliver"
Design Optimization - Challenges
Kittleson Concept Design

Entry-Exit Angle Design Issues
- Poor View Angle to Left
- Priority Confusion Leads to Merge Behavior
- Entry-Circulating Crashes

Eastbound Merge to 1-Lane Bridge Issues
- Very Short Merge Distance
- Lane Utilization

Flat Entry Angle
Truck/Freight Concerns?
Design Optimization - Challenges
Kittleson Concept Design
Design Optimization - Challenges

MTJ Optimization Overlay

Beverly Manor
Holman Highway
Sunridge Road
17 Mile Drive
1 Highway
SB On-Ramp
Holman Highway
Design Optimization - Challenges

MTJ Optimization Overlay

1. Tighter Radius Improvement
   - Slower Speed Benefits
     - Merge Distance Reduction
     - Improved Pedestrian Safety

2. Entry-Exit Angle Improvement
   - Entry/View Angle
   - Separation of Decision Making
   - Improved Signing and Lane Choice
Design Optimization - Challenges

MTJ Optimization Overlay

3 Entry-Exit Angle Design Improvement
- Entry/View Angle
- Separation of Decision Making
- Improved Signing and Lane Choice

4 Merge Distance Improvement
- Longer Merge Distance?
- Improved Lane Utilization

Improved Channelization
Design Optimization - Challenges

MTJ Optimization Design

1. Merge Distance Improvement
   - Defined Intersection Movements
   - Simplified Driver Turning Decisions
   - Safer

Tighter Radius = Slower Speed
125’ Merge Distance Req’d

Bike/Ped Crossing

Improved Bike Lane Delineation

“Built To Deliver”
Design Optimization - Challenges

MTJ Optimization Design

2 Southbound Exit Improvement
- Entry/View Angle
- Separation of Decision Making
- Improved Signing and Lane Choice
Design Optimization - Challenges

MTJ Optimization Design

3 Entry-Exit Angle Design Improvement
- Improved View Angles (12 deg.)
- Sends Correct Priority Message
- Entering Yield to Circulating Traffic
Design Optimization - Challenges

MTJ Optimization Design - Merge Distance Comparison

Merge Distance Improvement

Very Short Merge Distance
Design Optimization - Challenges

MTJ Optimization Design - Merge Distance Comparison

4 Merge Distance Improvement

Longer Merge Distance
Improved Lane Utilization
Holman Highway 68/Highway 1 Roundabout Project

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Thank You / Questions

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