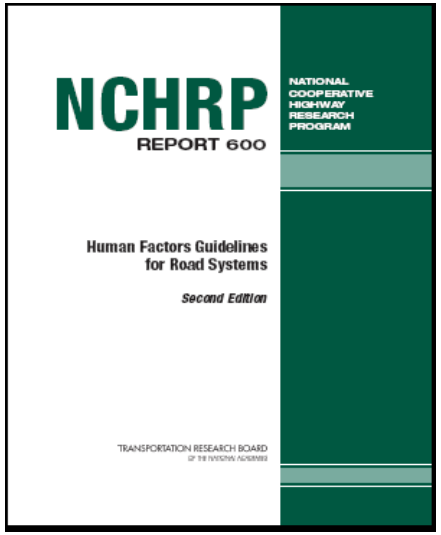
How the Human Factors Guideline is Used by Planners, Designers, & Traffic Engineers



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Adjunct Professor VT, Retired FHWA

February 8, 2017

Todays' Goal:
Describe the HFG and How to Use It

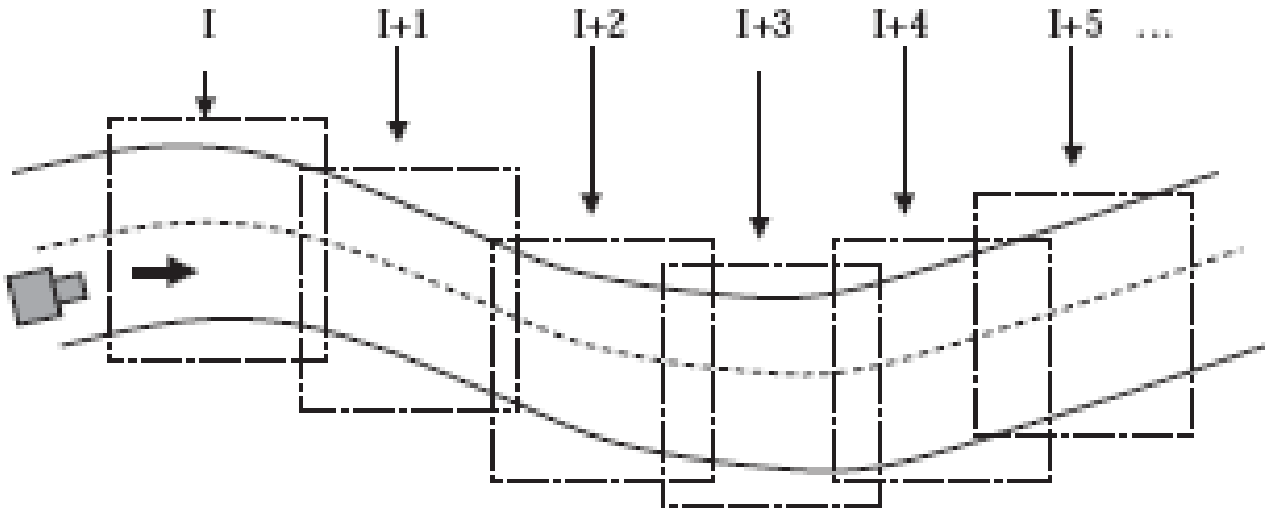
- NCHRP Report 600 "Human Factor Guidelines for Road Systems"
  http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600second.pdf

- Funded by NCHRP contracts & supported by TRB Joint Subcommittee AND10(2)
- Developed by Battelle, Dr. John Campbell and team
- 1st printed, December 2012
- HFG is a living document to be expanded as new, substantive research is available.
- NCHRP update is **underway**

Purpose of HFG

- To supplement AASHTO Design Book and MUTCD by describing human factor needs and limitations
- To aid highway designers, planners & traffic engineers to avoid ‘inadvertently creating’ road-user problems
- To aid development of ‘candidate treatments’ when making HSM crash estimates
- To aid development of the ‘human factor interaction matrix’ (HFIM)

Users' Scan Road in Increments as Virtual Users Should (designers, traffic engineers, & planners)



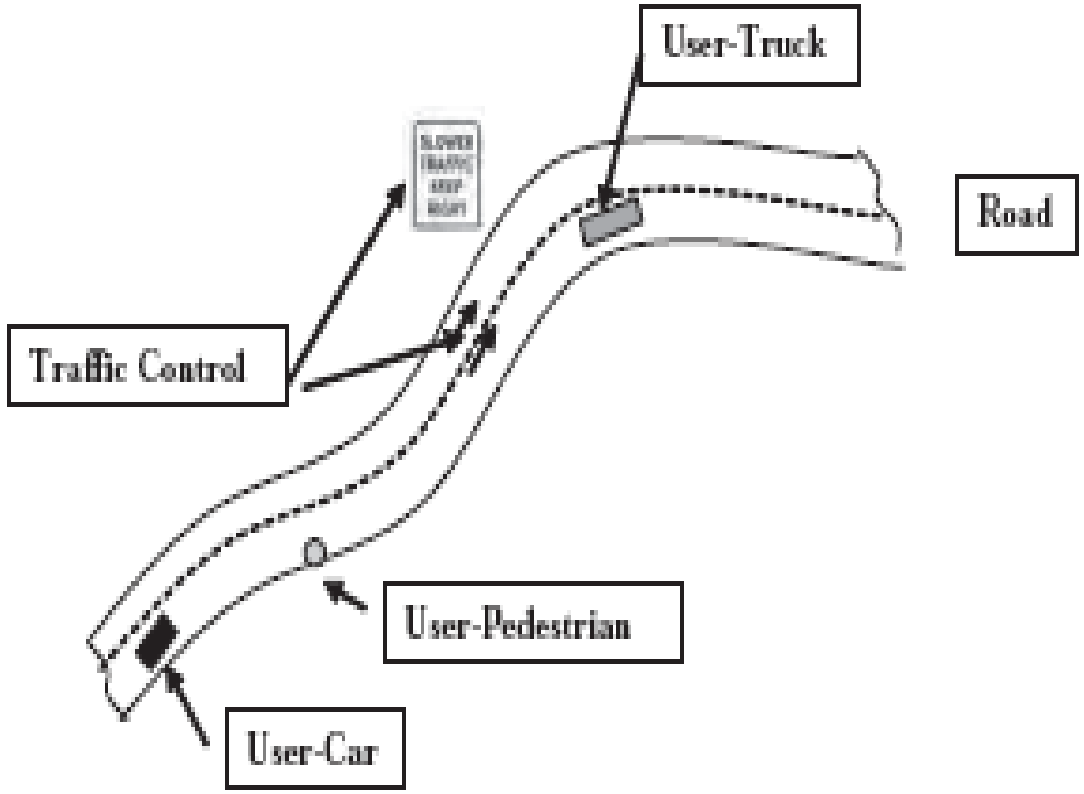
I = User scanning steps (vary in size)

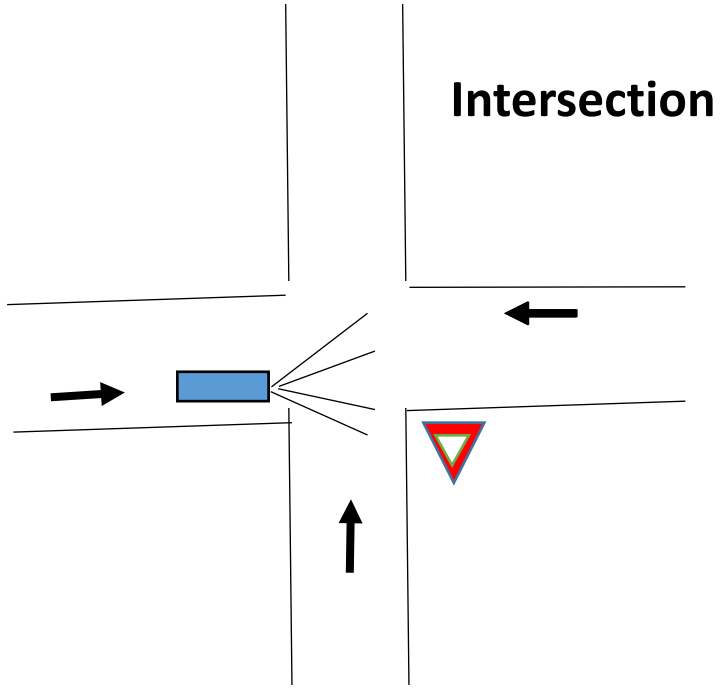
Figure 4-1. Road user scanning steps for finding most meaningful information (MMI).

User Tasks

- Incrementally scan the road or intersection
- Identify changes in the road environment
- Control the vehicle
- Look for conflicts
- Monitor traffic control
- Prepare for downstream changes: road, TCD, traffic, pedestrians, etc.

Users' Look for Information Changes





Information(t) = Information(t -1) + changes during Δt.

Organization of HFG

Part I: Introduction 2 chapters

Part II: Bringing Rd User Capabilities into Hwy Design & Tr. Eng. Practice

2 chapters

Part III: HF Guidelines for **Roadway** Location Elements

13 chapters

Part IV: HF Guidelines for **Traffic Engineering** Elements

4 chapters

Part V: Additional Information

6 chapters

Chapters with Guidelines

Part III: Guidelines For Roadway Location Elements

- Chapter 5 Sight Distance Guidelines (9 topics)
- Chapter 6 Curves (Horizontal Alignment) (6 topics)
- Chapter 7 Grades (Vertical Alignment) (3 topics)
- Chapter 8 Tangent Sections & Roadside (Cross Section) (2 topics)
- Chapter 9 Transition Zones Between Varying Road Designs (1 topic)
- Chapter 10 Non-signalized Intersections (5 topics)
- Chapter 11 Signalized Intersections (4 topics)
- Chapter 12 Interchanges (6 topics)
- Chapter 13 Construction and Work Zones (5 topics)
- Chapter 14 Rail-Highway Grade Crossings (6 topics)
- Chapter 15 Special Considerations for Urban Environments (5 topics)
- Chapter 16 Special Considerations for Rural Environments (4 topics)
- Chapter 17 Speed Perception, Speed Choice, & Speed Control (6 topics)

Chapters with Guidelines cont.

Part IV: Guidelines For Traffic Engineering Elements

- Chapter 18 – Signing (5 topics)
- Chapter 19 – Changeable Message Signs (7 topics)
- Chapter 20 – Markings (5 topics)
- Chapter 21 – Lighting (5 topics)

New Candidates: RAB, Pedestrian, Bicycle Chapter

Summary:

- 22 Chapters
- 90 Guidelines
- 475 References

Guideline Components
(Using 2-page Format)

Left Page

- Introduction
- Design Guideline
- Bar-scale Rating (Expert Judgement Experimental Data)

Right Page

- Discussion
- Design Issues
- Cross References to other guidelines
- Research References

2-Page Format

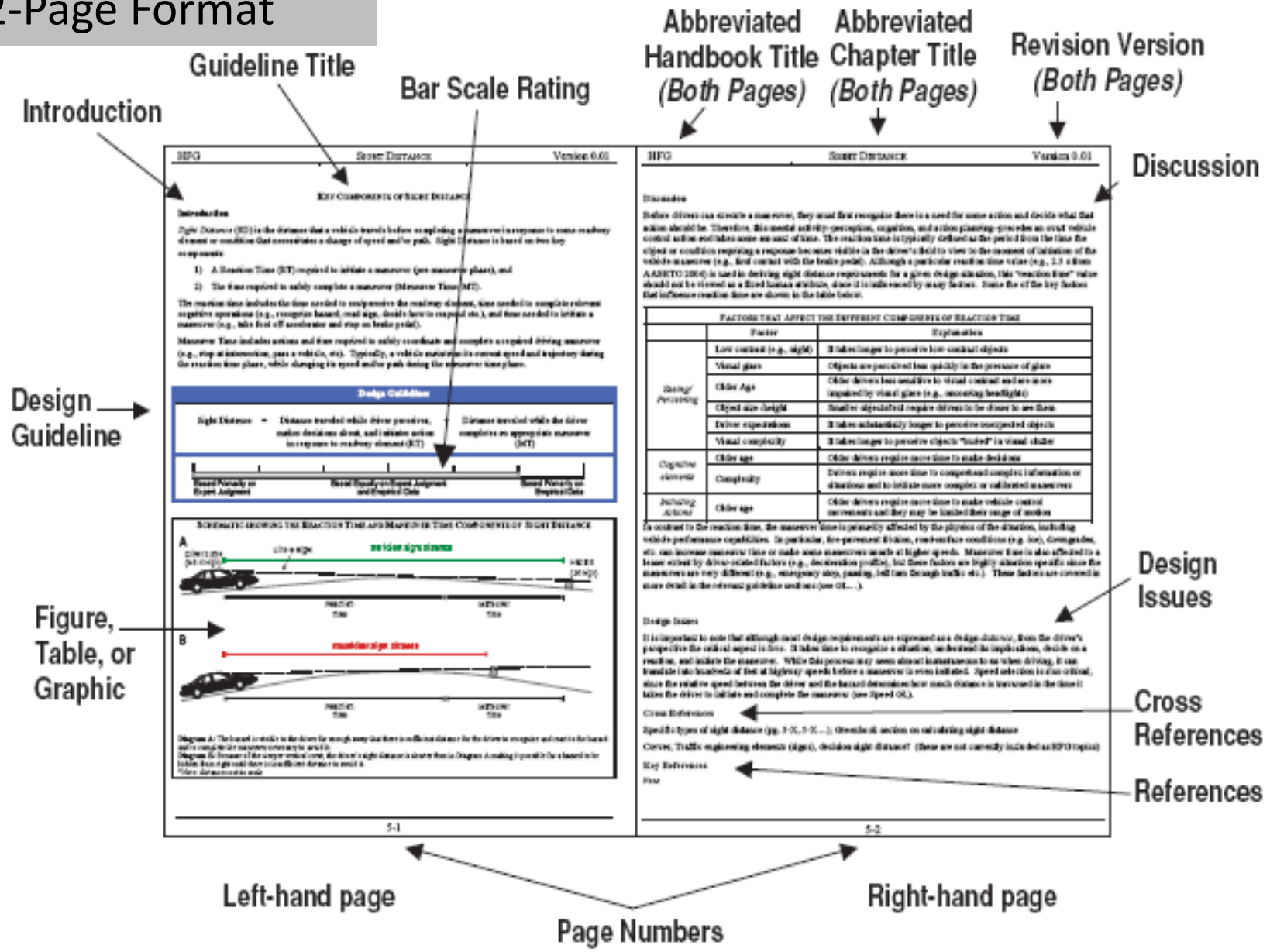
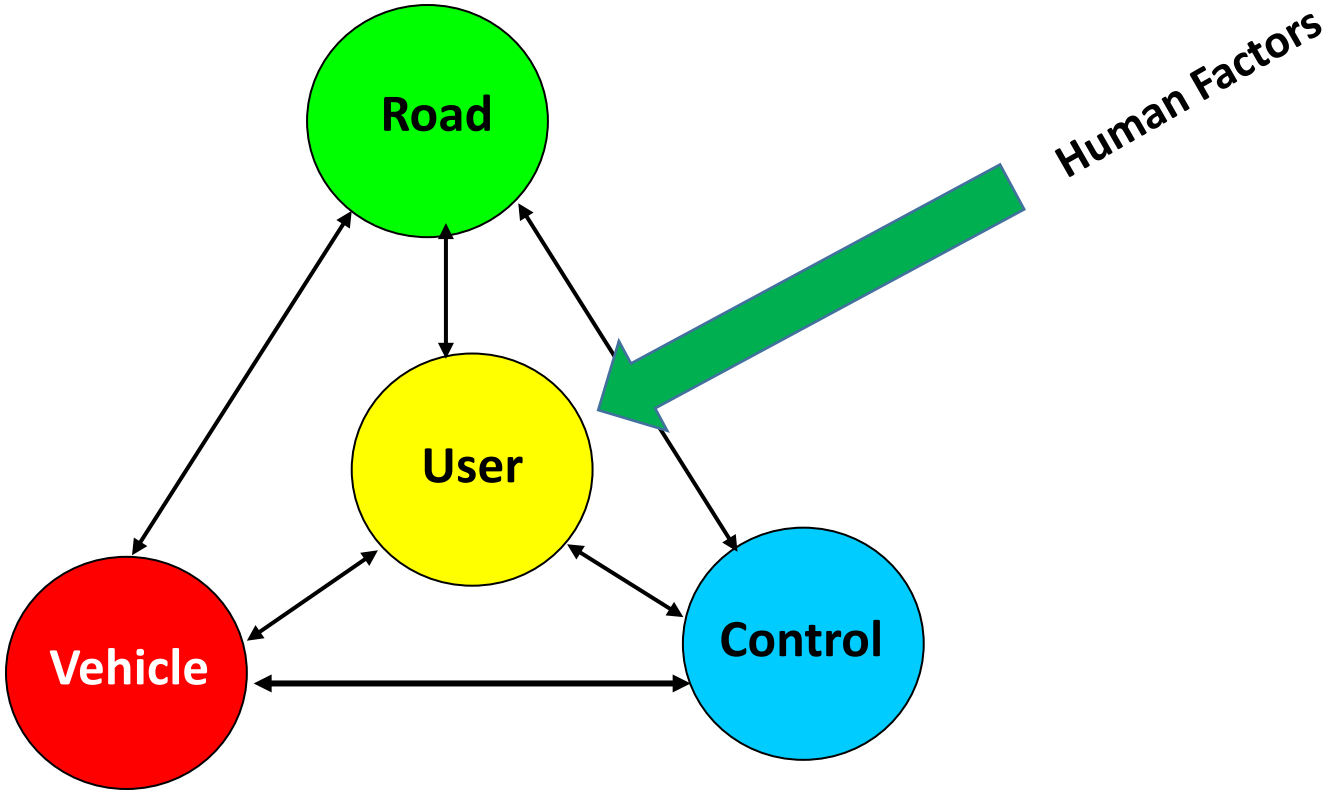


Figure 2-1. Guideline format used in the HFG.

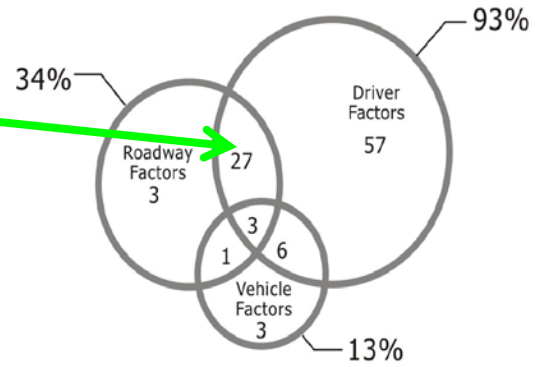
Conceptual System Components



Highway-User Interactions Are Key!

- **System Safety**

Engineers' goal: eliminate road user fatalities



- NHTSA & others emphasize 'driver errors' as 90 % when fixing blame for crashes--that is not reality.
- Our **responsibility** is make roads, signing, & control **clear to users**. 'Self-explaining infrastructure!
- Engineers must be **'virtual road users'** when designing geometrics, signing, marking, & traffic control systems.
- **Goal**: 'Eliminate all fatalities especially the 27 % user-infrastructure ones' from the system.

Understanding the System

(user, infrastructure, vehicle)

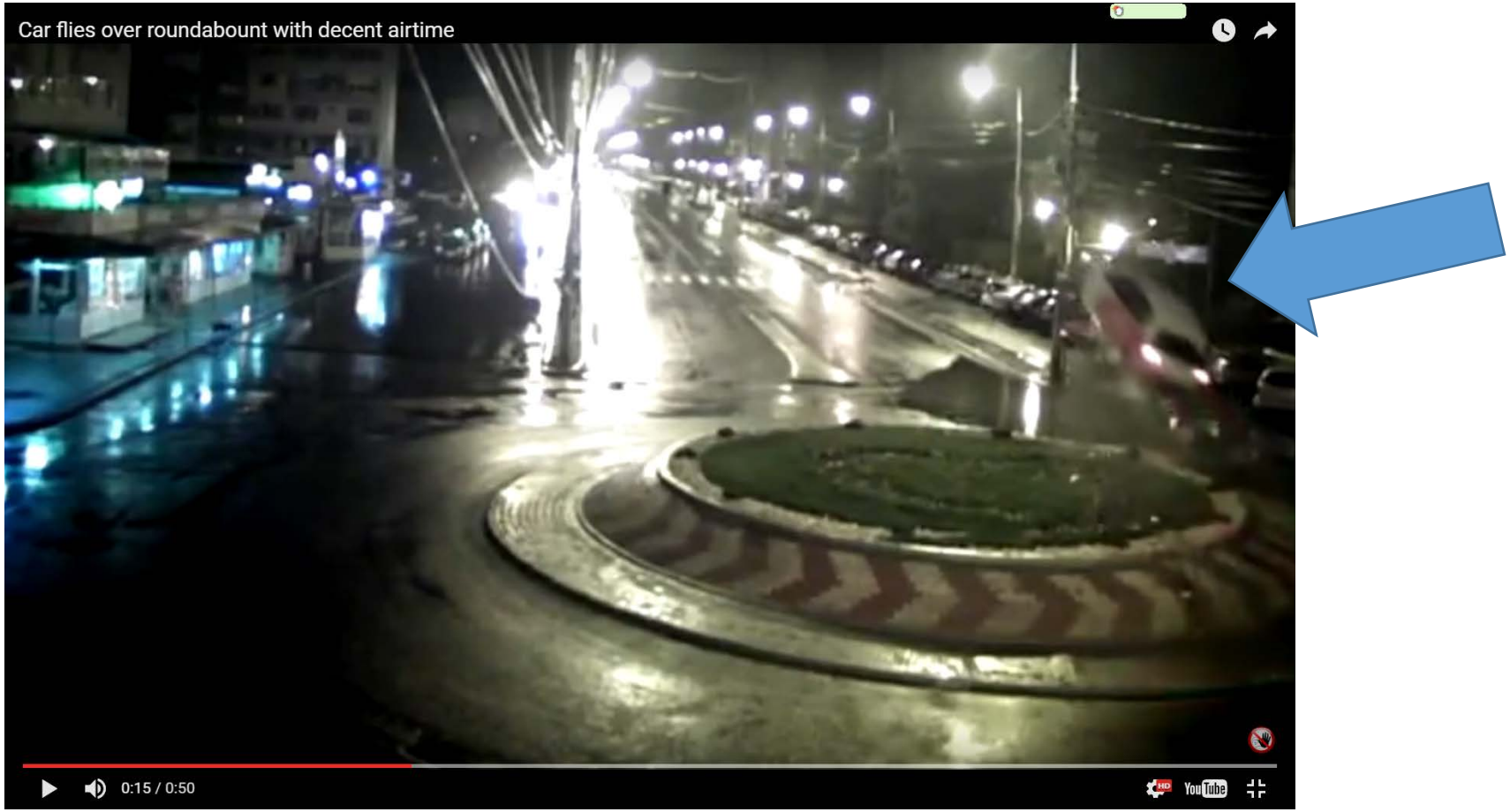
- A system is a set of connected or related things, i.e., user, infrastructure, & vehicle.
- Our understanding of the system is complete if we recognize all the **interrelated & connected** parts **together**!
- **How do we do that?**
- Answer is found in the NHI human factors course oriented to the HFG.
- Answer **is to use the HFIM** or “Human Factors Interaction Matrix.”
- First , consider an example!

Using HFG and HFIM
Example 1: Roundabout – day time

A huge system failure!

Roundabout – night time

http://www.carscoops.com/2016/05/driver-does-dukes-of-hazzard-jump-over.html



HFIM for Romanian Roundabout

Road User	Vehicle	Environment	Road Environment-User Interaction	HFG Help

HFIM for Romanian Roundabout

Road User	Vehicle	Environment	Road Environment-User Interaction	HFG Help
Vehicle drivers	Cars	Near urban area		
Pedestrians	Trucks	Adjacent farm land		
Bikers	Bicycles	Small stores adjacent		
Motor cycle operators	Motor Cycles	Light density		
		No lighting		
		Poor marking		
		Limited signing		
		Inadequate approach signing		
		No pedestrian accommodation		
		Approach geometrics don't reduce speed		

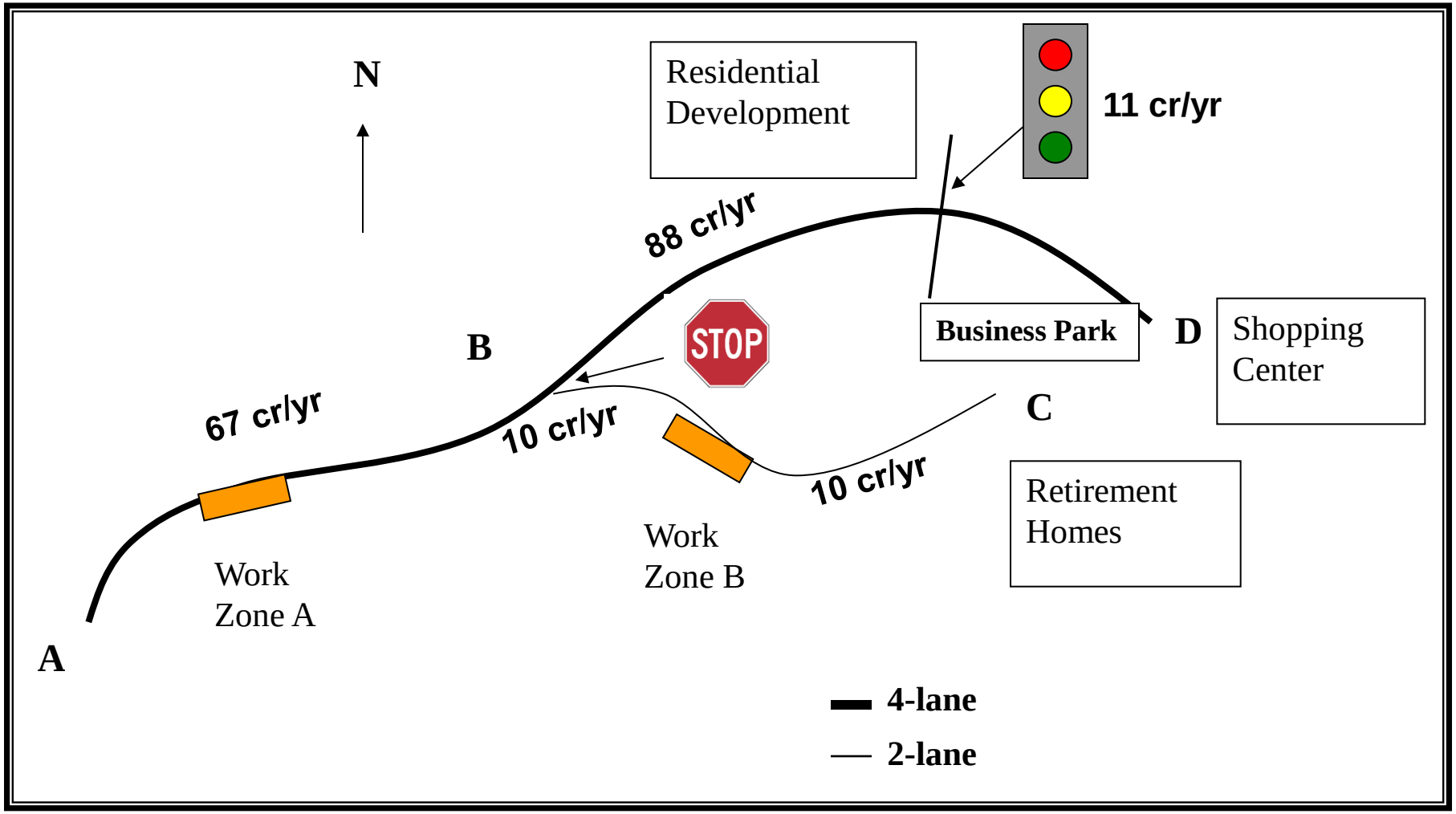
HFIM for Romanian Roundabout

Road User	Vehicle	Environment	Road Environment-User Interaction	HFG Help
Vehicle drivers	Cars	Near urban area	Limited site distance at RAB	
Pedestrians	Trucks	Adjacent farm land	Users can't see pav. markings	
Bikers	Bicycles	Small stores adjacent	Directional signs in center island & too many	
Motor cycle operators	Motor Cycles	Light density	Users have no advance directional signs	
		No lighting	Night visibility bad	
		Poor marking	Splinter islands hard to see; poor contrast	
		Limited signing	Non-specific lane control in RAB	
		Inadequate approach signing	Contrast of RAB with environment inadequate	
		No pedestrian accommodation	Driver information needed	
		Approach geometrics don't reduce speed		

HFIM for Romanian Roundabout

Road User	Vehicle	Environment	Road Environment-User Interaction	HFG Help
Vehicle drivers	Cars	Near urban area	Limited site distance at RAB	5-2, 5-6 sight distance
Pedestrians	Trucks	Adjacent farm land	Users can't see pav. markings	20-2 visibility
Bikers	Bicycles	Small stores adjacent	Directional signs in center island & too many	
Motor cycle operators	Motor Cycles	Light density	Users have no advance directional signs	Chapter 18 all signing
		No lighting	Night visibility bad	21-4, 21-10, 21-12 lighting
		Poor marking	Splinter islands hard to see; poor contrast	**20-10 RAB marking**
		Limited signing	Non-specific lane control in RAB	6-2, 6-4 curve driving
		Inadequate approach signing	Contrast of RAB with environment inadequate	6-10 pav..mk, delineation
		No pedestrian accommodation	Driver information needed	12-8 driver info needs 11-8 ped. needs
		Approach geometrics don't reduce speed		13-10 sign legibility 6-6 speed on curves

Example 2: Joint Use of HFG with HSM Crashes/Yr in Project Area



HF Interaction Matrix for Intersection B

Road User	Vehicle	Environment	Road-Env. Interaction	HFG Help	
High speeds	Cars & trucks	Skew intersection	Judging site distance	Chapter 5, 10-6	-Sight distance -Skew inter.
Gap selection	Slow vehicles	No shoulders	No deceleration lane & shoulder	6-10, 17-2 16-4	-Pav. delineation -Design consist. -Shoulder drops
Intersection conflicts	Fast vehicles	Unlighted	Few safe gaps & dark	10-2, 21-4	-Gap acceptance -Night driving
Poor visibility		Speed Limit 55	Finding information	17-4, 18-6, 20-2	-Sp. perception -Sign conspicuity -Lane markings
		Poor signing & marking	Indecision	Ch 18, 20-8	-Signing -Delineators

Project Summary

Location	Project Summary Treatment	Expected # crashes/ yr before	Expected # crashes/ yr after	Expected Safety Improvement
Inter., Node B	Change skew to 90 degrees *(HFG10-6)*	10.0	9.2	**8%**
Inter., Node B	Install intersection warning signs on D-B and A-B approaches *(HFG 16-8, 18-8)*	10.0	n/a	n/a
Inter., Node B	Install Right turn lane on C-B and A-B approaches *(HFG 11-2)*	10.0	8.6	**14%**
Signal inter. in BD	Change to Protected side street phasing *(HFG 11-2)*	11	9.68	**12%**
Signal inter. in BD	Modify Change plus Clearance interval *(HFG 11-6)*	11	8.58 or 11.66	22% or -6%
Segment AB	Install 4' raised median	66.98	45.4 or 50.0	32-25%
Segment AB	Install continuous shoulder rumble strips *(HFG 16-6)*	66.98	39.3 or 63.8	41-5%
Segment BD	Install 4' raised median	88.44	72.52 or 65.45	18-26%
Segment BD	Reduce access point density to < 10/mile	88.44	71.64 or 61.02	19-31%
Segment BC	Add warning signs *(HFG 16-8, 18-8)*	10.43	10.95 or 7.20	31% or -5%
1.25 mi. curve	Add raised pavement markers	3.42	4.24 or 4.38	not effective
1.00 mi. curve	Add raised pavement markers	2.66	2.95 or 2.31	13% or -11%
1.25 mi. curve	Increase super-elevation	3.42	3.21	**6%**

Example 3: One RAB with 5-others embedded

Magic Roundabout in Swindon, England

HF Issues!

- Should the system be self-explaining – find your own way?
- If not, candidate issues:

1. What is the role of outer and inner splinter islands?
2. How does a user identify a destination path between individual RAB and multiple mini-RAB?
3. How many paths exist?
4. How many conflicts exist & what are the circulating volumes?
5. Should signing and marking be used?
6. If so, how will it be communicated to users? (color coding, symbols, signs)

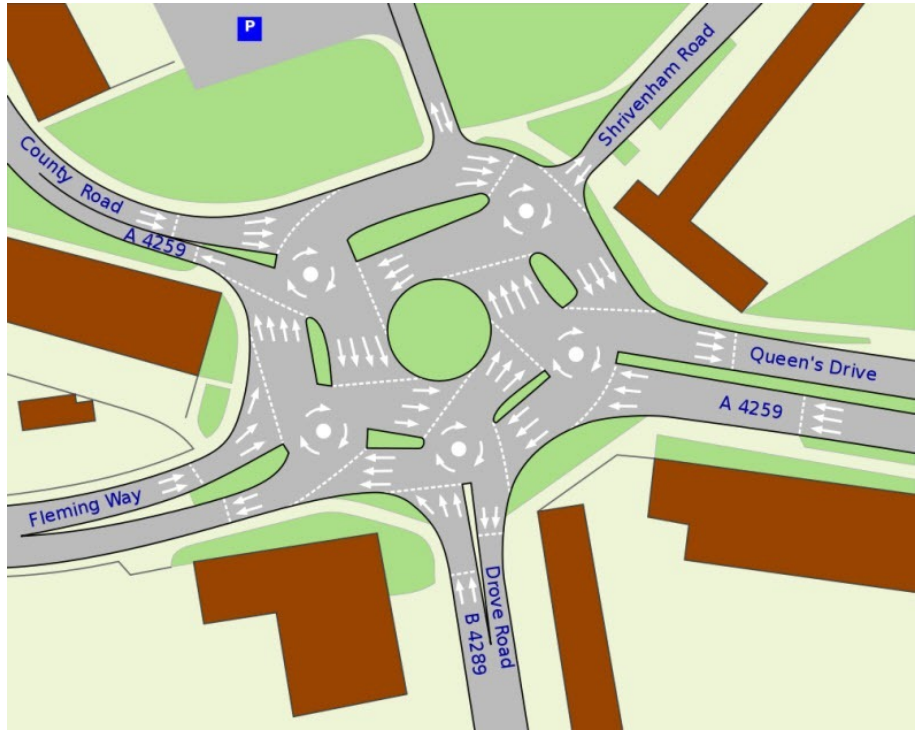
Application of the HFIM

Suggested approach:

A) Find an optimum path(s),
B) Create a HFIM **for each** mini-RAB (5 in this example),
C) Identify the conflict points & find the circulating volumes
D) Create a HFIM for the main RAB (if needed),
E) Interpret all of the RAB,s together as a system problem,
F) …….
G) Last step, identify user-friendly solutions

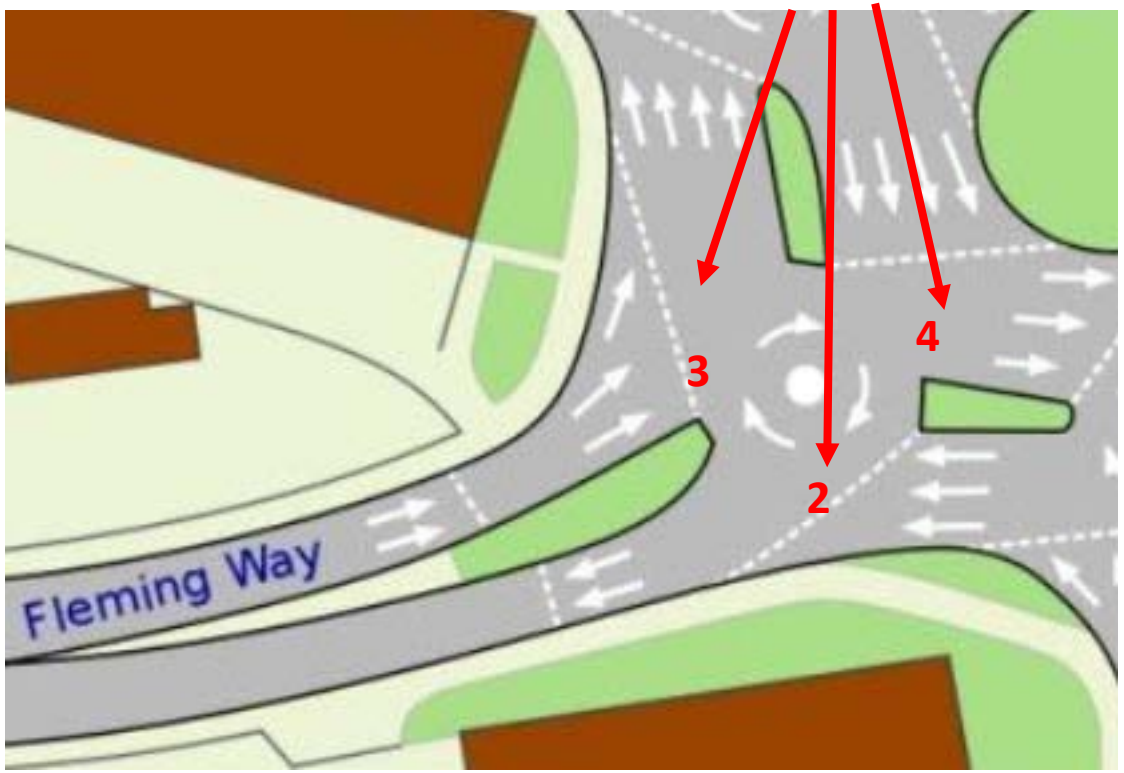
How?: Divide RAB into parts, then Create HFIM for each part

Whole RAB



Part 1

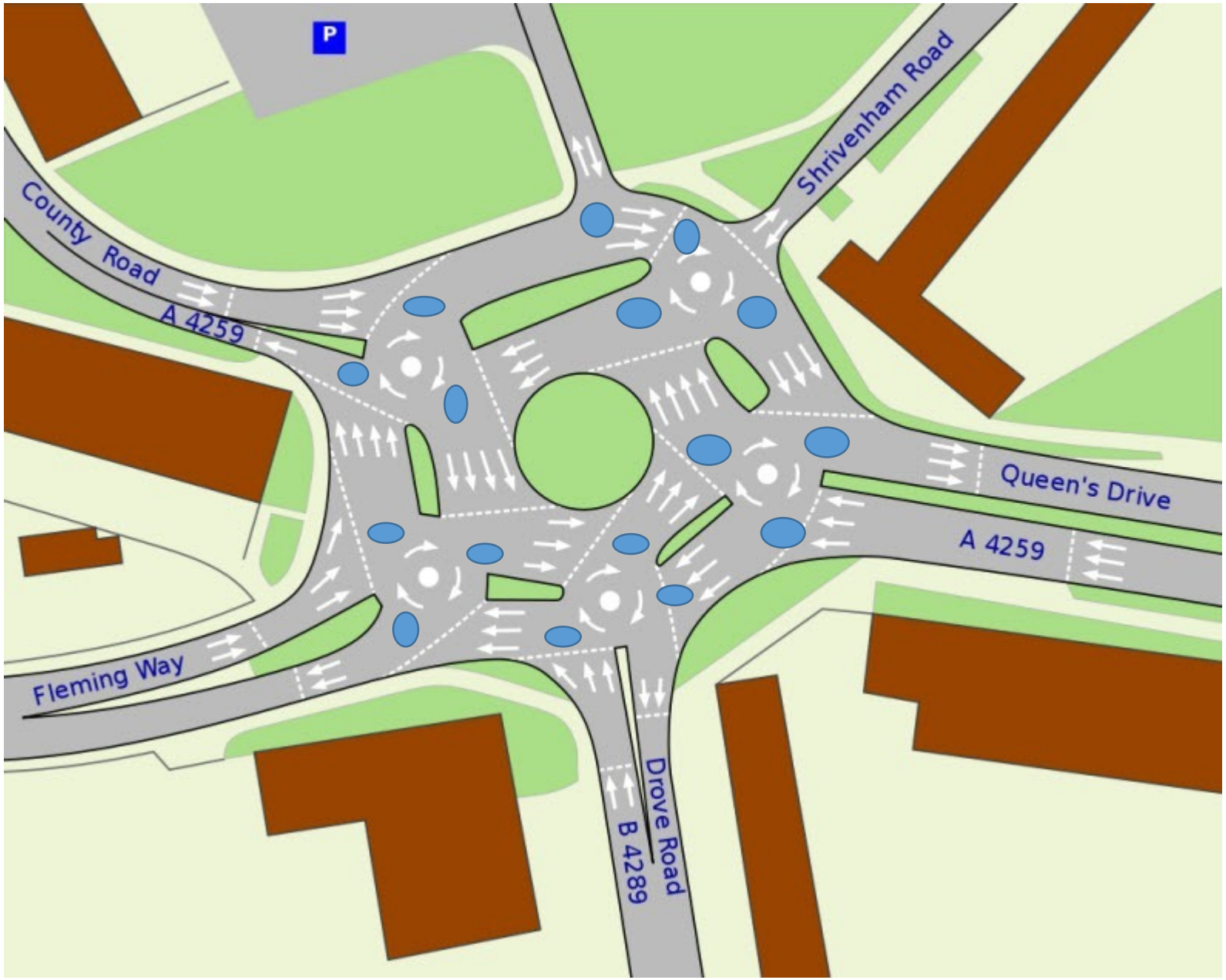
3-Conflict Areas (Sum 9)



Part 1 HFIM

Road User	Vehicle	Environment	Road Environment-User Interaction	HFG Help
Vehicle drivers	Cars	Suburban area	Users can't identify destination	5-2, 5-6 sight distance
Pedestrians	Trucks		Path is uncertain	20-2 visibility
Bikers	Bicycles	Medium density	Directional signs in center island & too many	
Motor cycle operators	Motor Cycles	Lighted	Users have no advance directional signs	Chapter 18 all signing
		No RAB signing	Night visibility poor	21-4, 21-10, 21-12 lighting
		Approach geometrics don't reduce speed	Splinter islands hard to see; poor contrast	**20-10 RAB** **marking**
		No approach signing	Non-specific lane control in RAB	6-2, 6-4 curve driving
		No pedestrian/bike accommodation	Too many decisions needed	6-10 pav. .mk., delineation
		No advisory speed	Possibly 9 conflicts	12-8 driver info needs 11-8 ? Ped.. needs?
		ADT Lane width? Number of lanes? Circulating volume?		13-10 sign legibility 6-6 speed on curves

Conflict Areas for Entire RAB



Conflict Points, 16

Total Conflicts, ± 37

Shriven, 9
Queen, 3
Drove, 7
Fleming, 7
County, 11

Your challenge!

- Identify the human factor issues for individual RABs & the whole system
- Develop one or more HFIM to help understand the HF issues.
- Recommend a functional and safe ‘user-friendly’ system.

Summary: What can you do going forward?

- Promote & show: State and local DOT's
  a) how to **use** HFG & HFIM
  b) how to **jointly use** HFG, HFIM, HSM
- Attend the new NHI course on road user human factors.
  NHI Website Course 380120 -
  "Introducing Human Factors in Roadway Design and Operations"
- NHI Training Course Contact: Thomas Elliott, 703-235-0544

Thoughts to Remember!

- ‘Road users’ safety issues are as important as infrastructure and vehicle issues – we don’t focus on road-users enough!
- How will you integrate the HFIM into your work?
- To what organizations will you describe the HFIM and HFG?
- “Vision Zero” will not succeed if we never identify & eliminate ‘road user’- system problems?
- ‘System safety’ is engineer’s responsibility!

Extra Slides (probably not to be used 35-39)

Examples of HF Oversights

What will users do?

Example 4: Using HFG & HFIM on Arterial

- An intersection has a history of injury & fatal crashes
- Community has complained to DOT many times w/o help

4-lane divided suburban rd.

3.5% down grade ←

Left arrow is location of crashes

Heavy suburban corridor traffic

Speed limit is 45 mph

Heavy left turn traffic

Tr. signal not warranted(MUTCD)

Next: Develop HFIM and Find Guideline Suggestions

Example 4: Human Factor Interaction Matrix (HFIM)

Infrastructure	Vehicle	Road User	Interaction	HFG Help
4-lane divided, 40,000 AADT	Cars	To and from work	Unfamiliar drivers create indecision	Ch. 3 & 4
13'+ median	Light vehicles	Heavy peak users	Left turns gaps hard to assess	10-2,10-4
Left & rt. turn lanes	Few trucks	Few pedestrians	Intersection crashes	HSM & Ped safety research
12' shoulders	Buses	School travelers	LT during school starts and ends	15-6
Bus stops on River Road		Few bicycles	Approach signing needed	18-2, 18-6, 19-2, 19-12, MUTCD
No left turn from Braeburn Parkway			Opposing left turn vehicles restrict gap finding	5-2
Wide intersection, 85' for LT			LT travel across 3-lanes & shoulder	10-2, 10-4
45 mph limit			Curve & speeds hinder gap finding	5-12
NB curve prior to intersection at bottom of -3.5% grade on River Road			Approach speed towards intersection high	17-10, 17-12, 17-14
35' pedestrian Xing on River Rd.			School pedestrian. crossing	20-6, 21-8, 21-12

-User scanning

-Gap acceptance

-Urban environments

-Signing &CMS

-Sight distance guidelines

-Non-signalized intersections

-Speed impact on sight distance
-Appropriate speed limits, counter-measures

- Pavement markings

Candidate Treatments

- Lower speed limit from 45 mph to 35 mph
- Add advanced intersection signing
- Install horizontal signing in advance of intersection
- Improve user sight distance by offsetting opposing LT lanes in median.
- Use advanced flashing beacons or CMS; activated when vehicles waiting to turn left
- Relocate Braeburn Pky. LT to Whitman School with a downsteam J-turn across median for Braeburn Pky.
- Replace intersection with roundabout


THE MAGIC ROUNDABOUT
Ring road
Cirencester
A4289
(M4)
Marlborough
Burford
Oxford
Town
centre
H
A&E
A4312

Human Factors Issues with Roundabouts

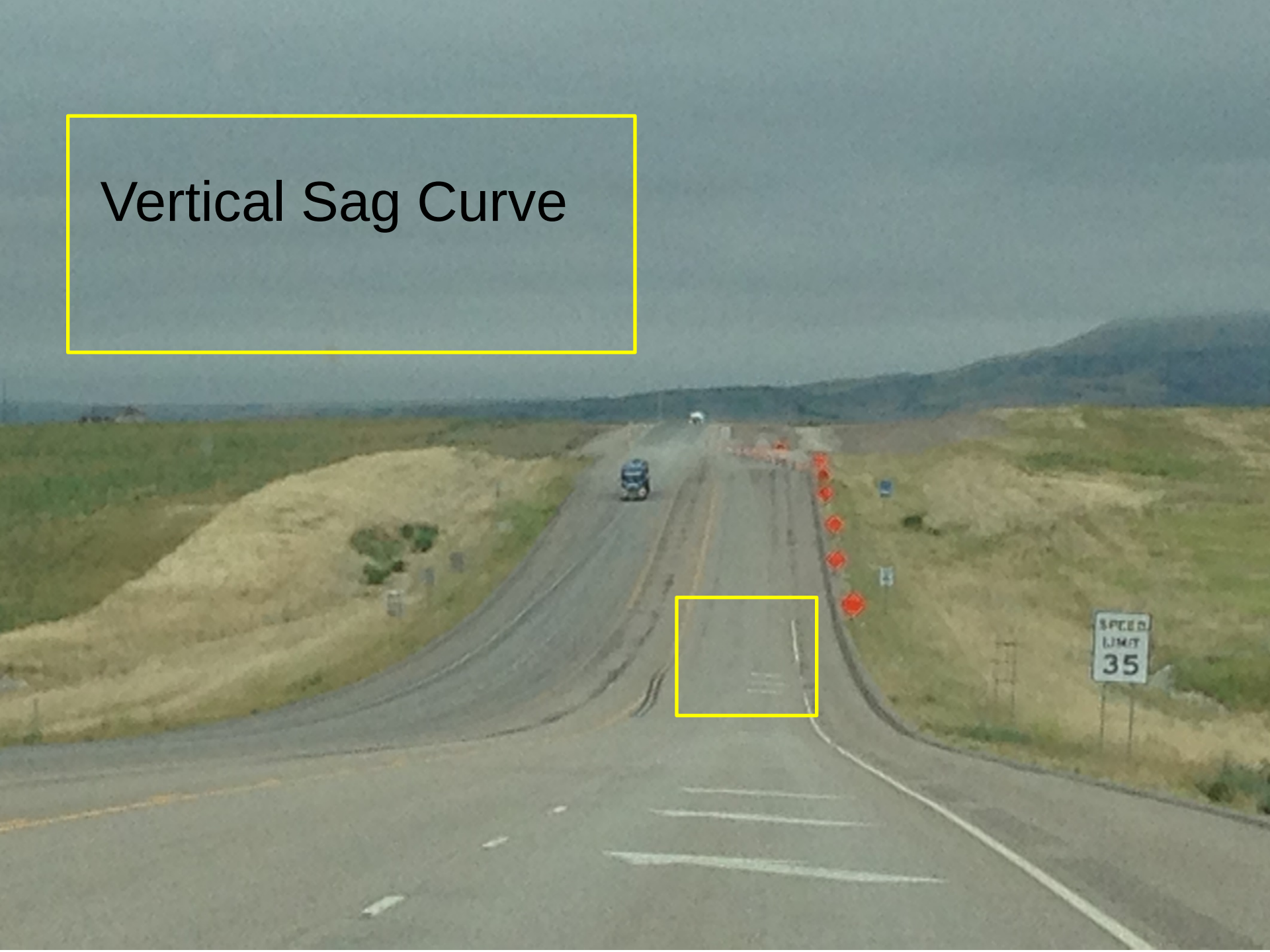
TRB Webinar – February 8, 2017

Brian Walsh, P.E.
Washington State DOT
TRB Roundabout Committee
Co-chair (ANB75)


Baggage Claim
Ground Transportation
Restrooms
Gates B35 to B71, B73
Gates A, C, D, H, Z
Gates B72, B74
B72


0.2mi / 0.3km
LOWER WALLACE FALLS
AND PICNIC SHELTER
0.3mi / 0.5km
MIDDLE WALLACE FALLS
0.6mi / 0.9km
UPPER WALLACE FALLS
1.2mi / 1.9km
TRAILHEAD VIA OLD
RAILROAD GRADE
2.5mi / 4.0km
GREG BALL
TRAIL TO
WALLACE LAKE
PETS MUST BE ON LEASH


LOOSE
GRAVEL


Vertical Sag Curve
SPEED
LIMIT
35

Geometrics – Human Factors

- A Simple Road Example – Roadway Narrows from 24’ to 18’ on a vertical crest curve

Narrows to 16 foot of width

Vertical Crest Curve

Imagine school bus coming up over the crest in dark, What happens?

Terminology

Roundabouts: An Informational Guide

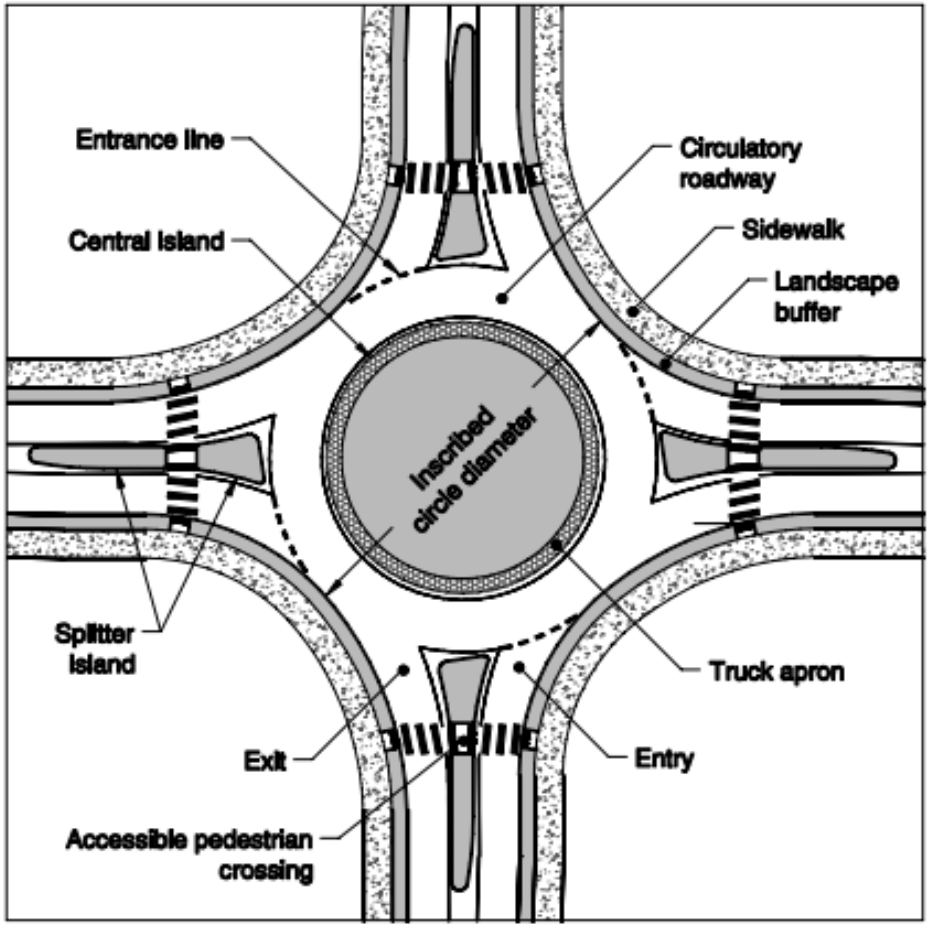


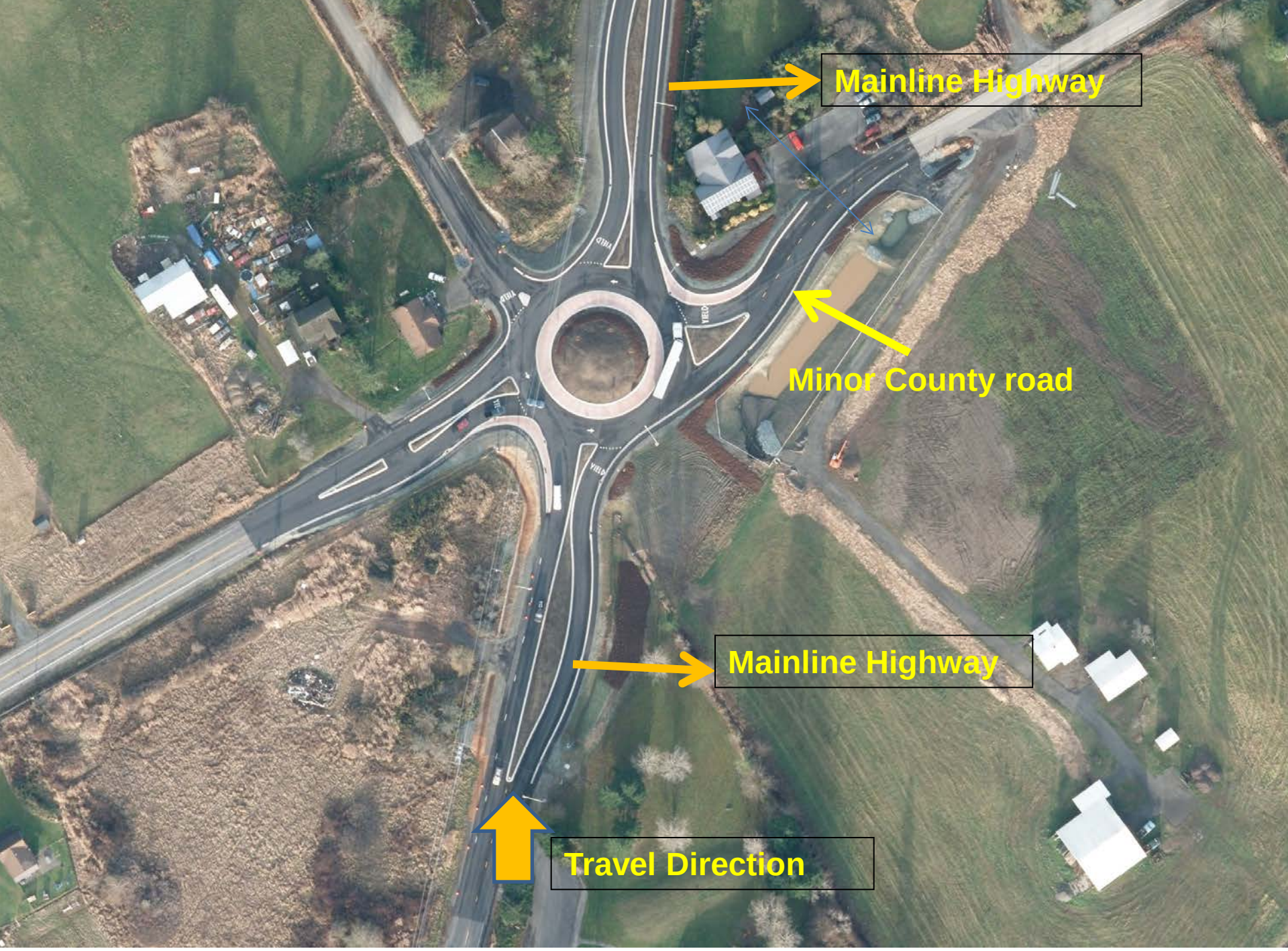
Exhibit 6-2
Basic Geometric Elements of a Roundabout

Human Factors at a Roundabout

- Signing
- Striping
- Context – Approach Speed
- Recognizing gaps
- Pedestrian and Bicycle interactions
- Central Island for deflection/target value for higher speed approaches

Visibility of Central island

- A central island is a defining physical feature of a roundabout and particular in high approach speed environments, a raised central island provides **conspicuity or target value** to give driver ample/sufficient time to slow down and deflect around central island.


Mainline Highway
Minor County road
Mainline Highway
Travel Direction

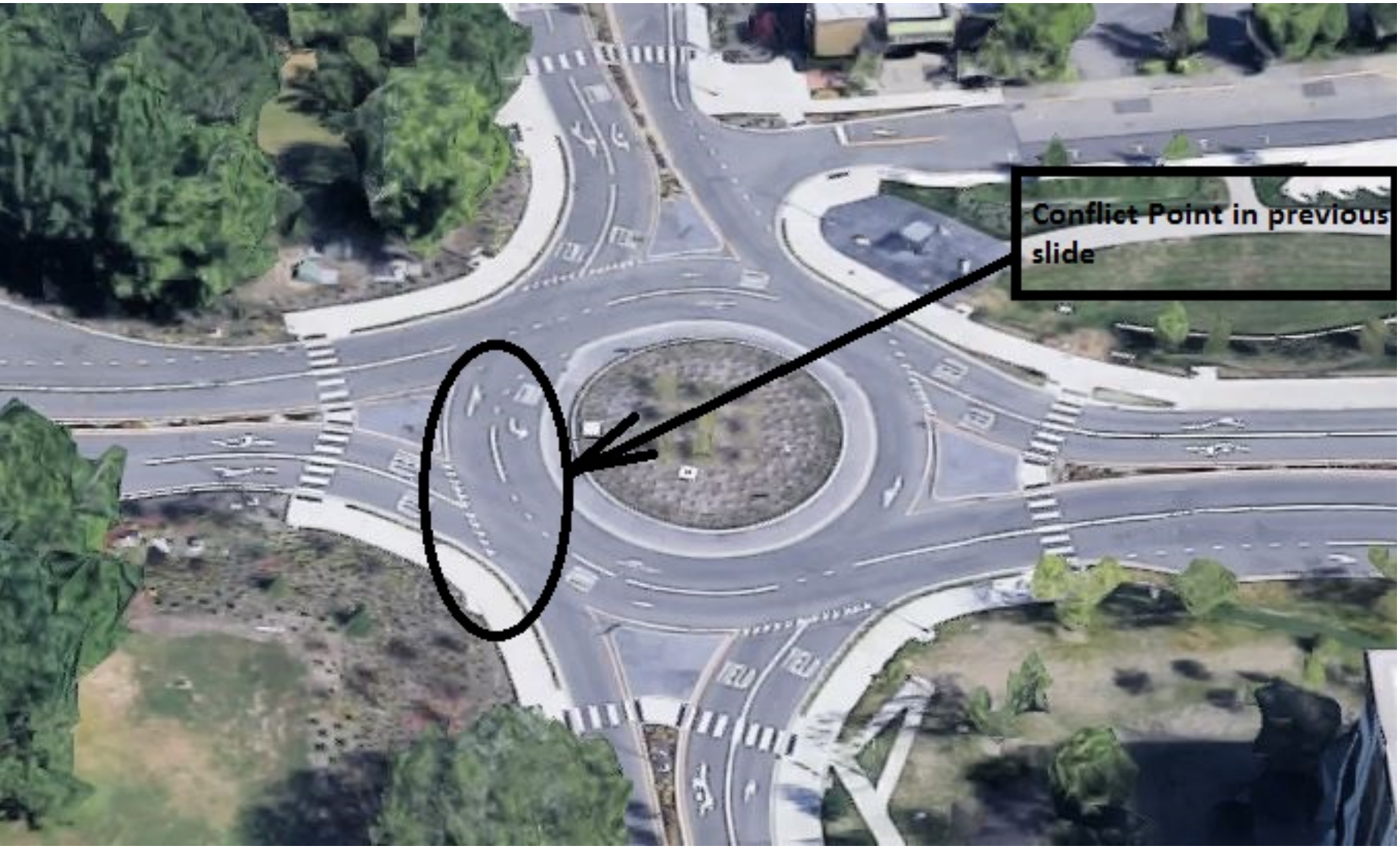

MOUNTAIN
VETERINARY
HOSPITAL
ONE WAY
YIELD

Multi-lane Example

- Usually in an urban, lower speed environment
- Issue isn't seeing the roundabout, but understanding it (striping/signing)
- This understanding is based on two rules:
  - Yielding to ALL circulating traffic
  - Choosing the CORRECT lane for your destination!

Driver Decision to Yield

Troublesome conflict point (s)



Geometric Flow /Lane Path Continuity

Left Turn Spiral

Left Turn Spiral

Spiral to Single Lane Exit

Different Angle of Location

Intersection Sight Distance

Combined Sight Distance Diagram

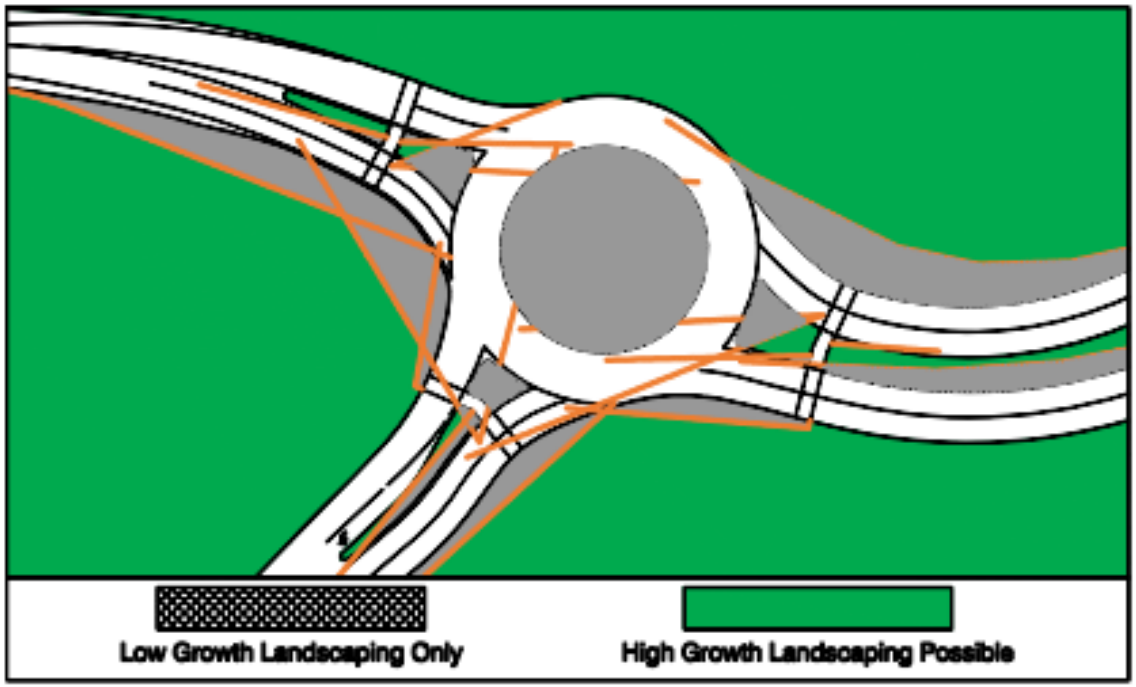


Exhibit 6-60
Example Sight Distance Diagram

Higher Speed Approaches

- Visible yet forgiving….
- Context is “intersection for mainline was a higher speed facility
- Roundabout needs speed reduction curves in advance and a visible central island


Mattawa
1 mi


SPEED
LIMIT
50
GAS
NEXT

Previous Intersection Layout from minor street perspective

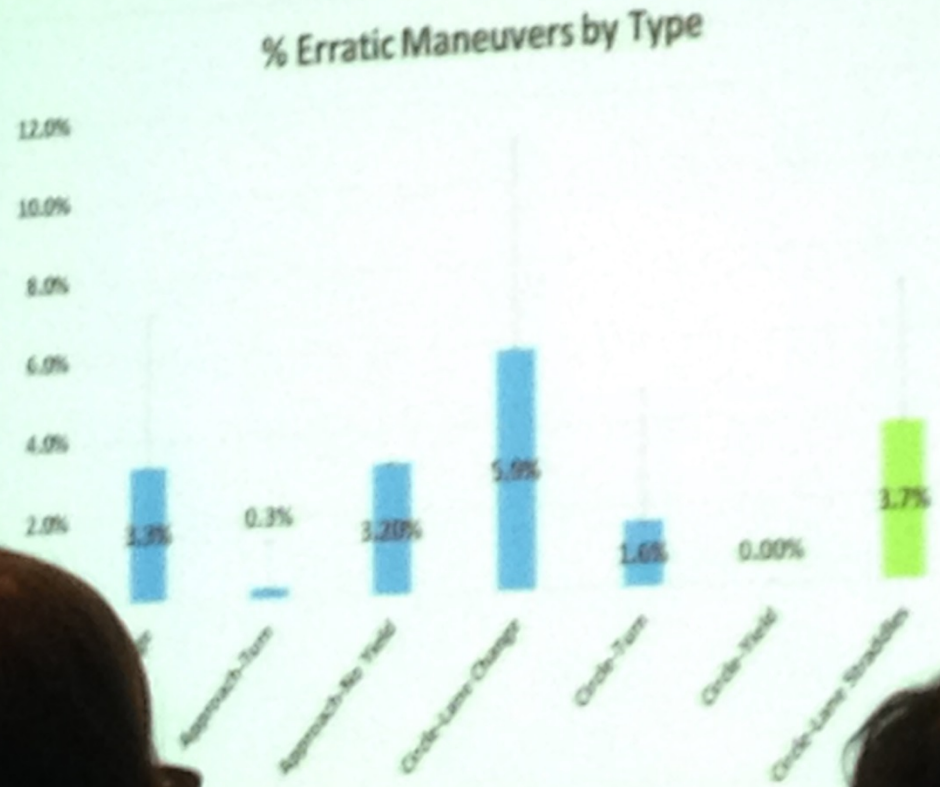

ROUNDABOUT
AHEAD
Yakima
Vantage
COWBOYS

Striping


YIELD
YIELD
LEFT
LANE

Types of Erratic Maneuvers

- Approach: inappropriate lane change
- Circulatory Roadway: inappropriate lane change and lane straddle



Signing

Photo Source – MTJ Engineering

Element of Traffic Analysis in Human Factors

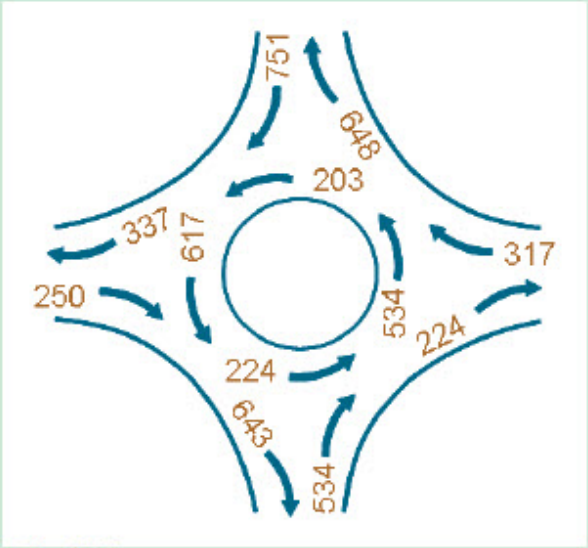
Roundabouts: An Informational Guide

Exhibit 3-15
Example Planning-Level Exercise for Determining Required Numbers of Lanes Using Turning-Movement Data

Example: Estimating Number of Lanes Using Turning-Movement Volumes

Question

How many lanes are required to serve these design-year traffic volumes:



Calculations

Entering volume + Circulating volume = X Compare to Exhibit 3-14

250 + 617 = 867	<1,000	Single Lane OK
534 + 224 = 758	<1,000	Single Lane OK
317 + 534 = 851	<1,000	Single Lane OK

Lane Utilization Analogy

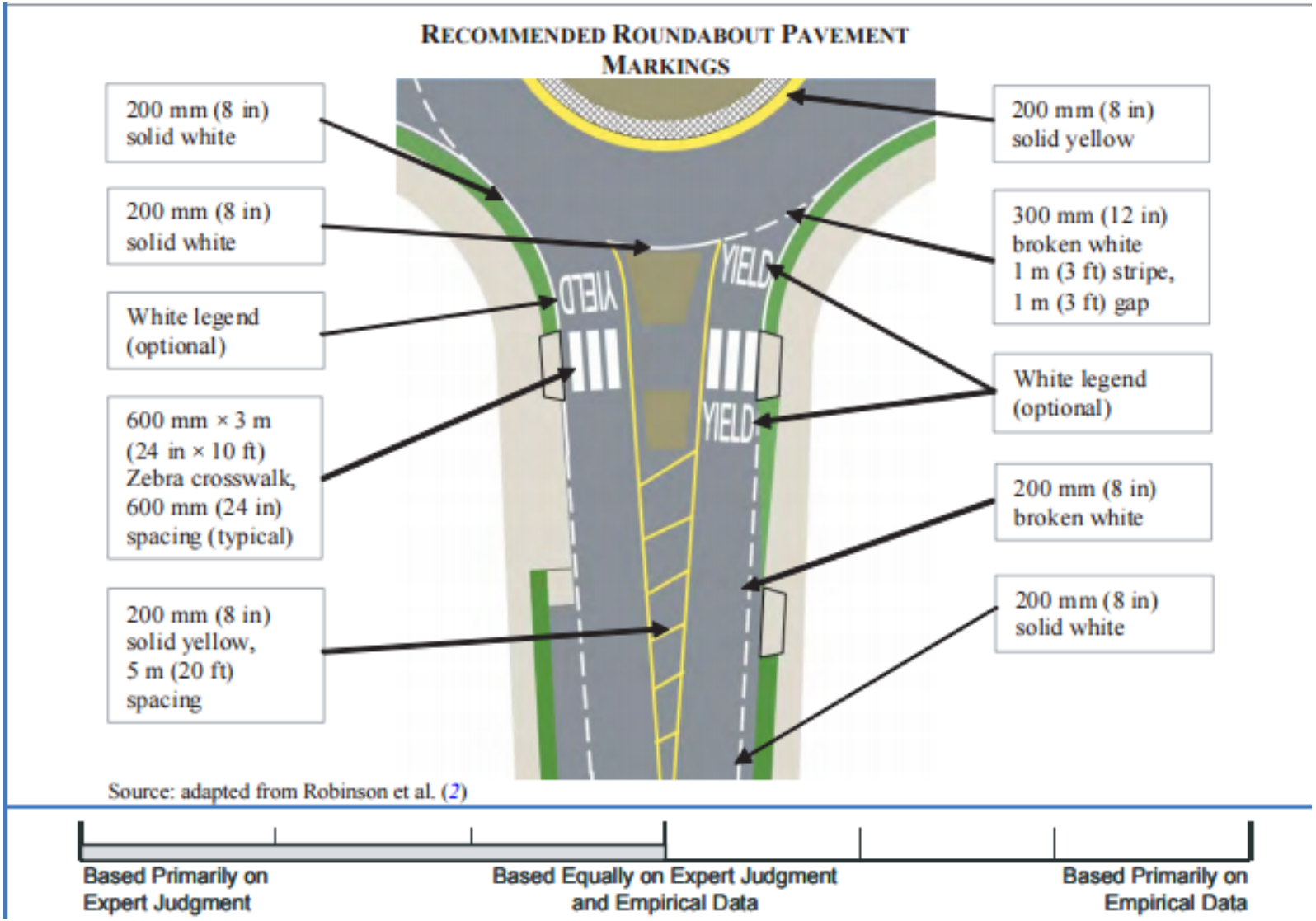
Driver Behavior is always in play …….

A Quick Overview of Existing Human Factors Guide material on the subject of Roundabouts

Current NCHRP 600 Layout for Roundabouts

- Chapter 20 – Markings
  - Markings for Single Lane Roundabout
- Chapter 10 – Non-signalized Intersections
  - Countermeasures for Improving Accessibility for Vision – Impaired Pedestrians at Roundabout

Markings for Roundabouts



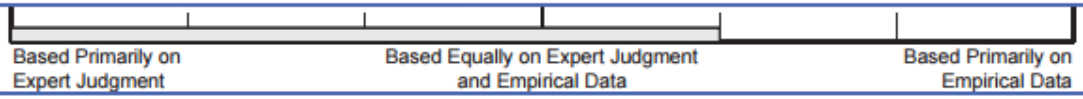
Countermeasures for Improving Accessibility for Vision – Impaired Pedestrians

Design Guidelines

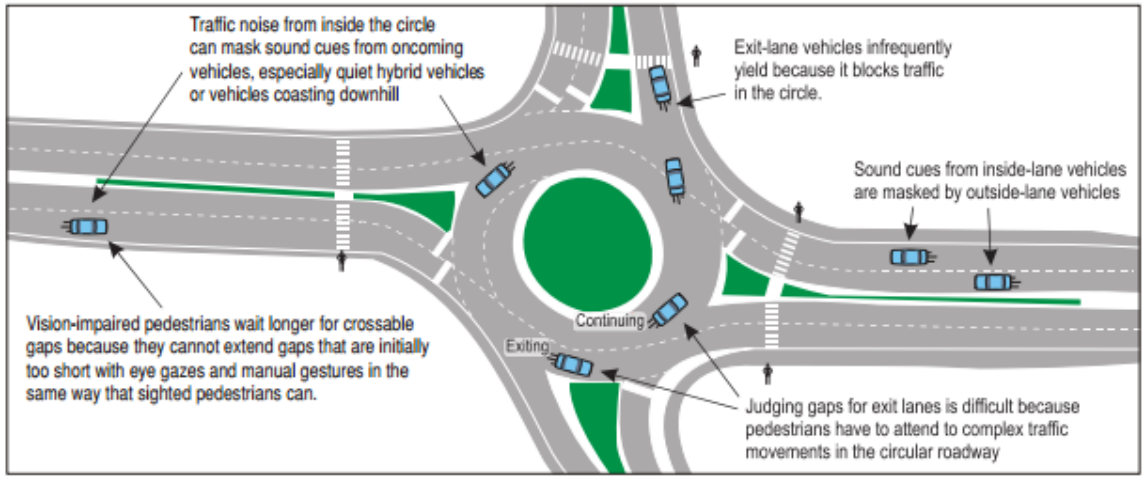
COUNTERMEASURES FOR IMPROVINGACCESSIBILITY FOR VISION-IMPAIRED PEDESTRIANS AT ROUNDABOUTS

Countermeasure	Applicable Situation	Effectiveness
Rumble/sound strips	Two-lane roundabouts	Poor
Rumble/sound strips	One-lane roundabouts	Unknown
Pedestrian-actualized traffic signals at midblock	One or two-lane roundabouts	Good*
Splitter island	One or two-lane roundabouts	Poor
Yield signs	One or two-lane roundabouts	Poor
Advanced vehicle detection technologies	One or two-lane roundabouts	Unknown

*Simulation results only. This countermeasure has not yet been field tested.



The figure below illustrates some of the roundabout elements that cause navigation difficulties for vision-impaired pedestrians.



Other Human Factors worth considering…….


YIELD
YIELD


BRT
APPROACH PLATE
PRESS TO TEST
RECHANNEL
WARN
TORQUE
TORQUE
CABIN CALL
RADIO CALL
N222KA
SPEAKER
COMM 1 2
NAV 1 2
MKR BCN
DME
ADF
OFF
PHONE
FILTER
BOTH
R
V
COMM-1
COMM-2
CABIN
MKR BCN
HI
ON
COMM
1 2
OFF
4/24/200


WATCH
FOR
RATTLESNAKES

Questions and Discussion?

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