

TRANSPORTATION RESEARCH BOARD

Truck Assumptions for Roundabout Design

April 8, 2021



@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.



REGISTERED CONTINUING EDUCATION PROGRAM

#TRBwebinar

Learning Objectives

1. Identify truck driving characteristics for roundabouts
2. Utilize swept path design tools

#TRBwebinar

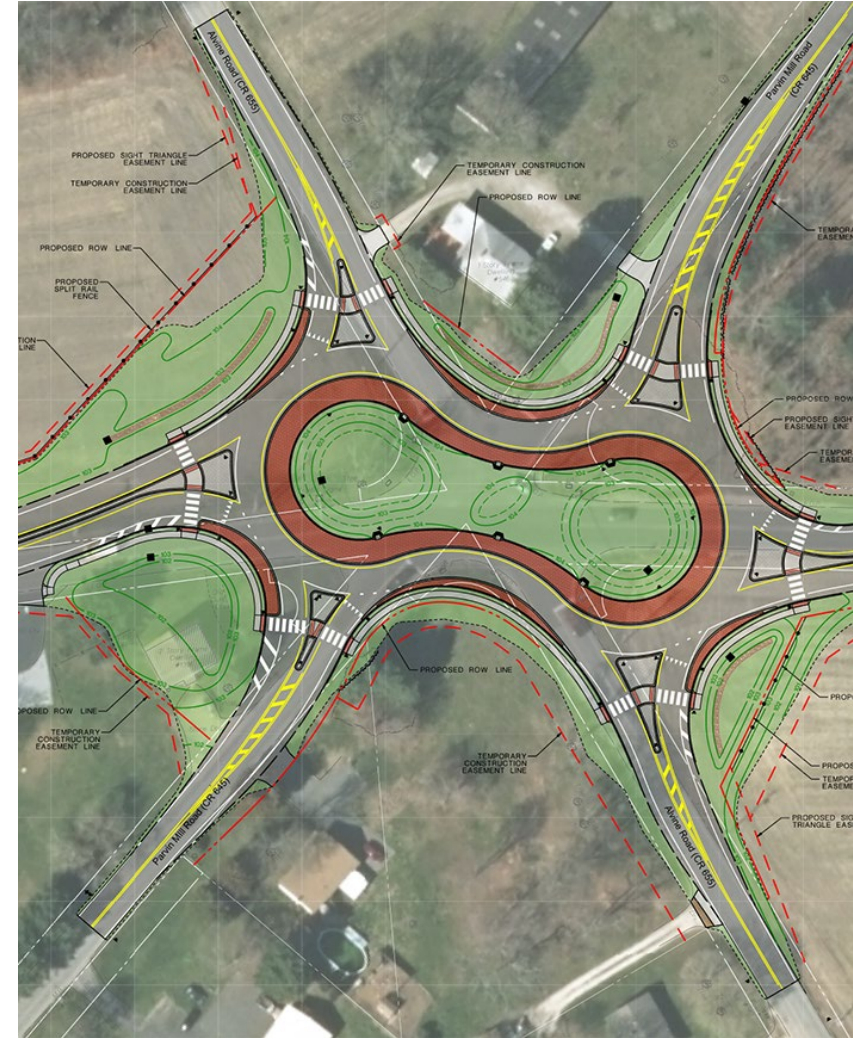


Truck Assumptions for Roundabout Design



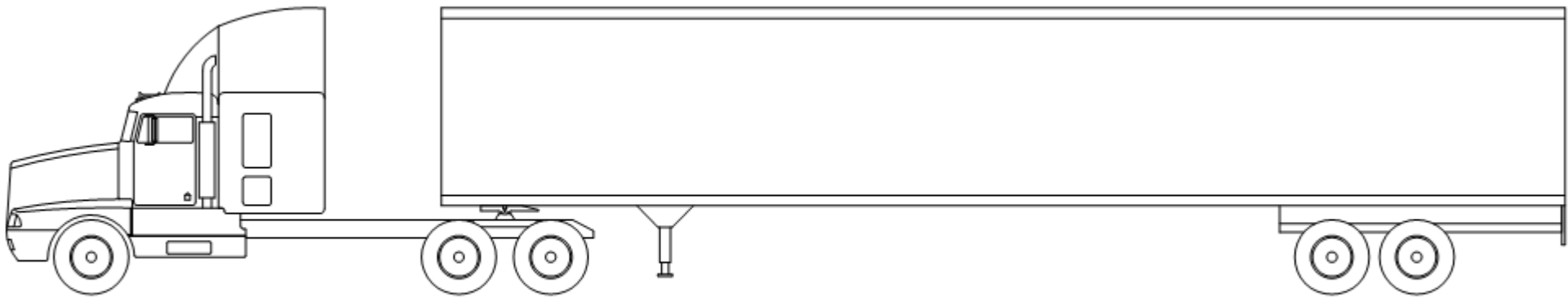
Introductions

- Michael P Mastaglio, PE, PTOE
- Andrew A Thompson, EIT
- Roundabout reviewers in PA
- TRB Roundabout Committee
- Roundabout designers



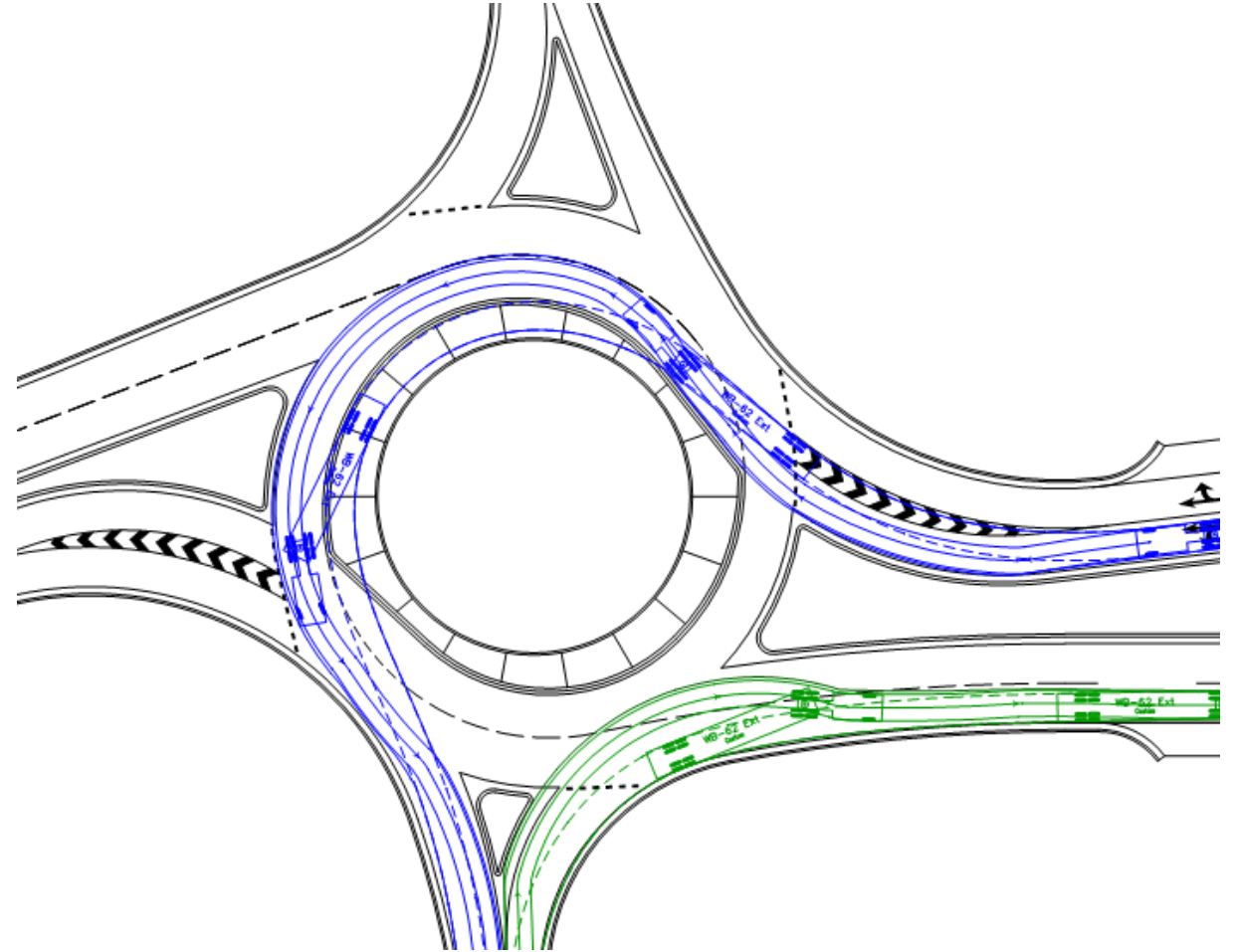
Learning Objectives

- Become intimate with truck dimensions and variability
- Know how to use swept path analysis tools
- Understand how to accommodate trucks at roundabouts



Agenda

1. Why roundabouts and why trucks are important
2. Design vehicles and parameters
3. Single lane roundabouts
4. Multilane roundabouts
5. Design Details
6. Questions and Answers





I. WHY ROUNDABOUTS AND WHY TRUCKS ARE IMPORTANT?

April 2021 – TRB Webinar - Truck Assumptions for Roundabout Design

Background

- Following up on Trucks session from 2017 Green Bay TRB RAB Conference
- Perceived issues with trucks are killing the opportunity to implement roundabouts
- Period of refinement for roundabout design
- Scalability webinar – 2016 Scalability webinars
- 2019 Penn State Traffic Engineering and Safety Conference presentation
- NCHRP 505 - 2003 - Update to AASHTO Green Book 2004
- NCHRP 03-130 (3rd update to RAB Guide) update and ongoing work

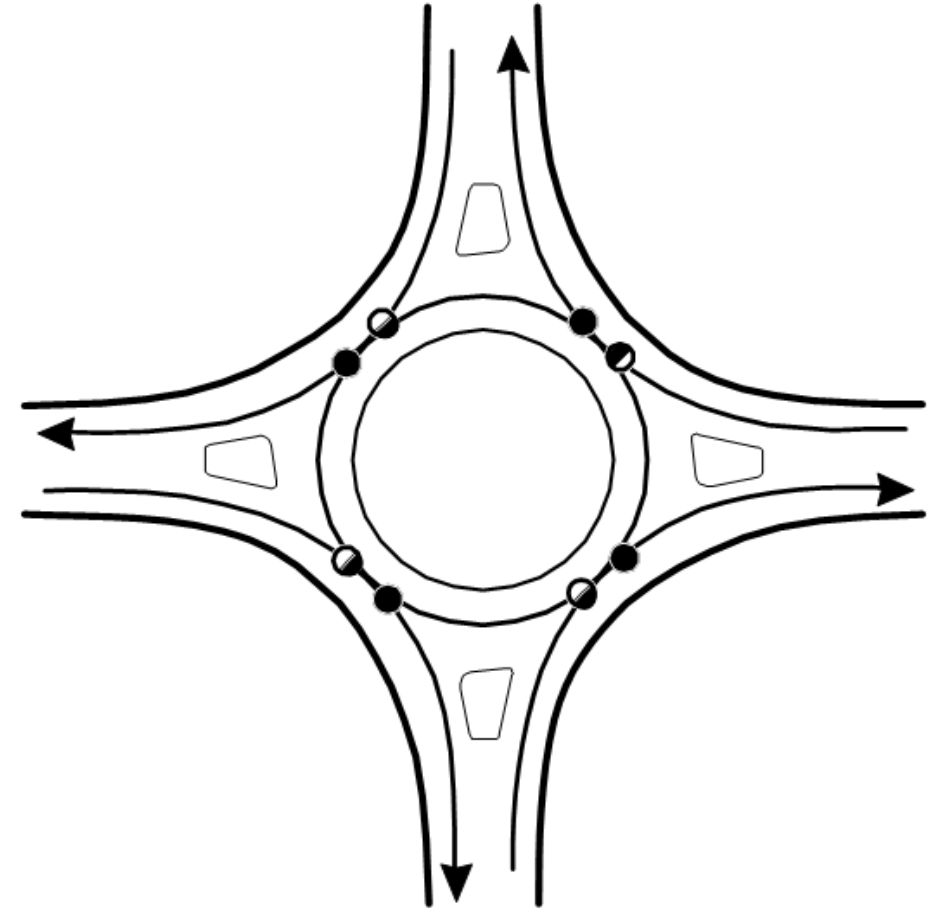
Context – Why a Roundabout

- Primary benefits = safety, operation, and access
- Secondary benefits
 - Gateway
 - Reduces driver distraction
 - Lowers emissions and greenhouse gases
 - Lowers noise pollution



Context – Why are they safe?

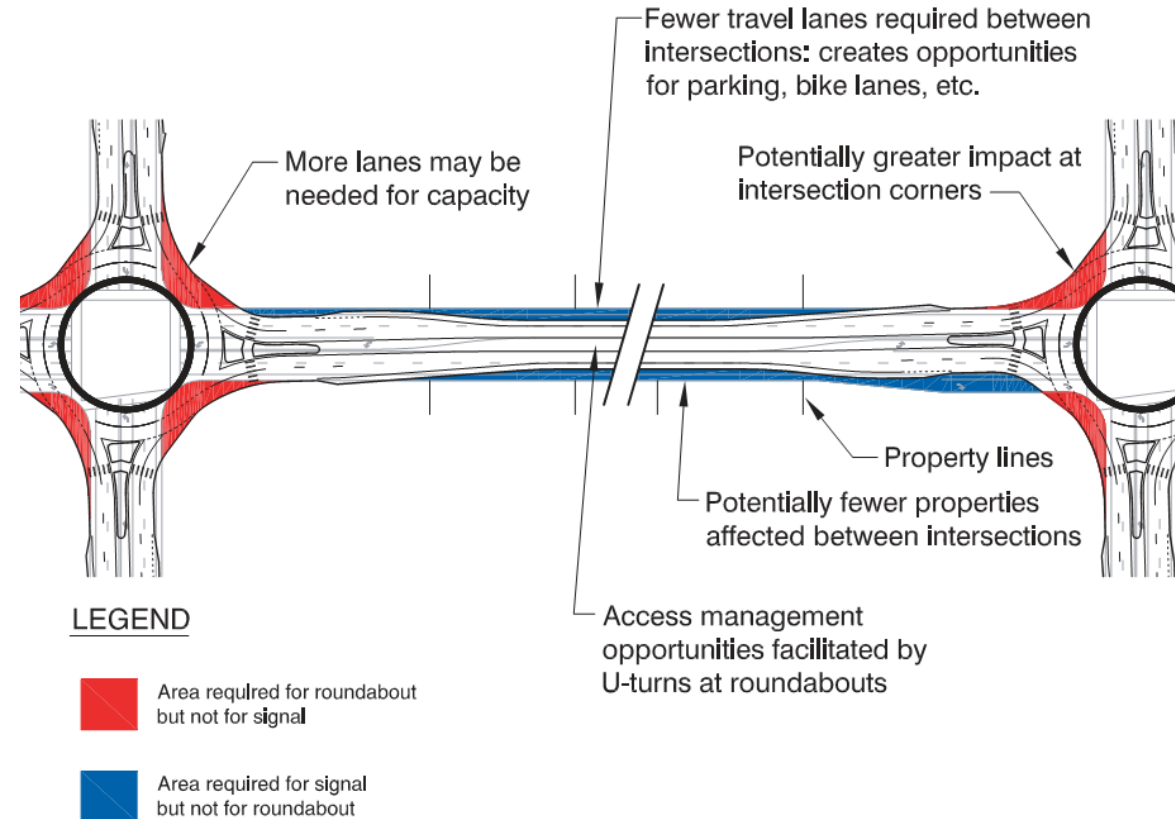
- Elimination of left turn-straight through conflict, slower speeds through deflection,
- Provides for all users, speed harmonization with bikes & special users (horse and buggies, farming equip)



Source: NCHRP Report 672, 2nd Edition

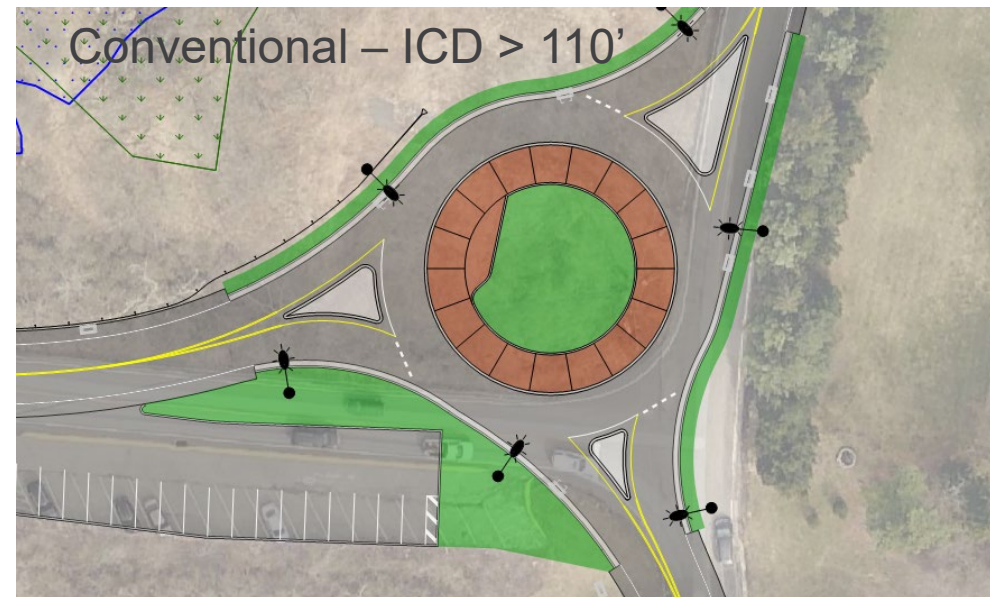
Context – What's the hook?

- Cost
- Node Impacts vs link
- Design process and plan presentation (more conducive to lineal projects)
- Competing elements – Speed control vs large vehicles
- Intersection Control Evaluation (ICE) will start to address



Source: NCHRP Report 672, 2nd Edition

Terminology



Why is it important to accommodate trucks at roundabouts?

Over accommodate



Source: Google Maps

Under accommodate

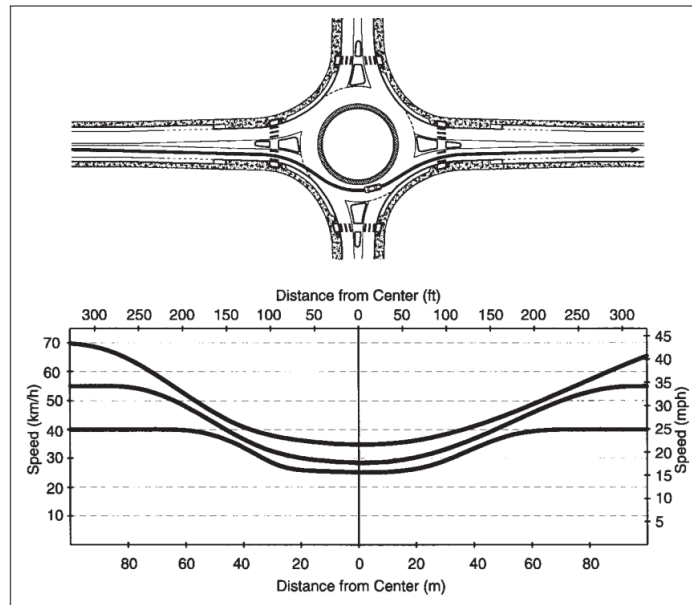


Source: NCHRP Report 672, 2nd Edition

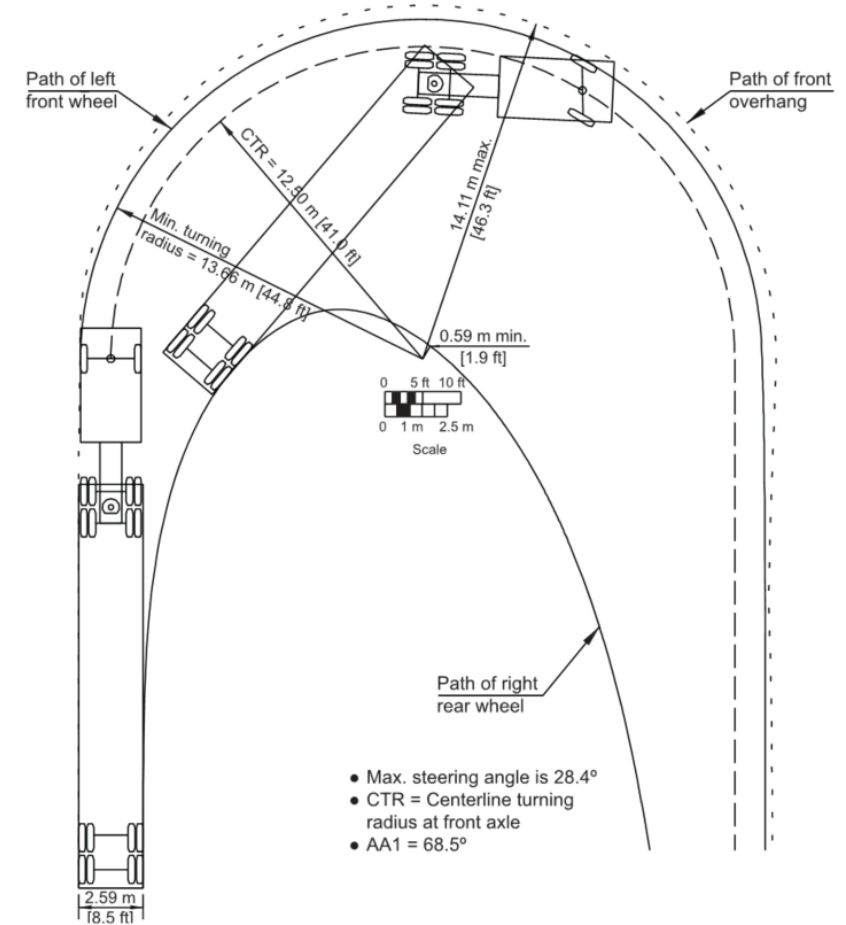
Large Vehicles Compete with Speed Control

Roundabout design balances two main factors:

- Design Vehicles
- Fastest Paths



Source: FHWA Roundabouts: An Informational Guide



Source: AASHTO Green Book 2011

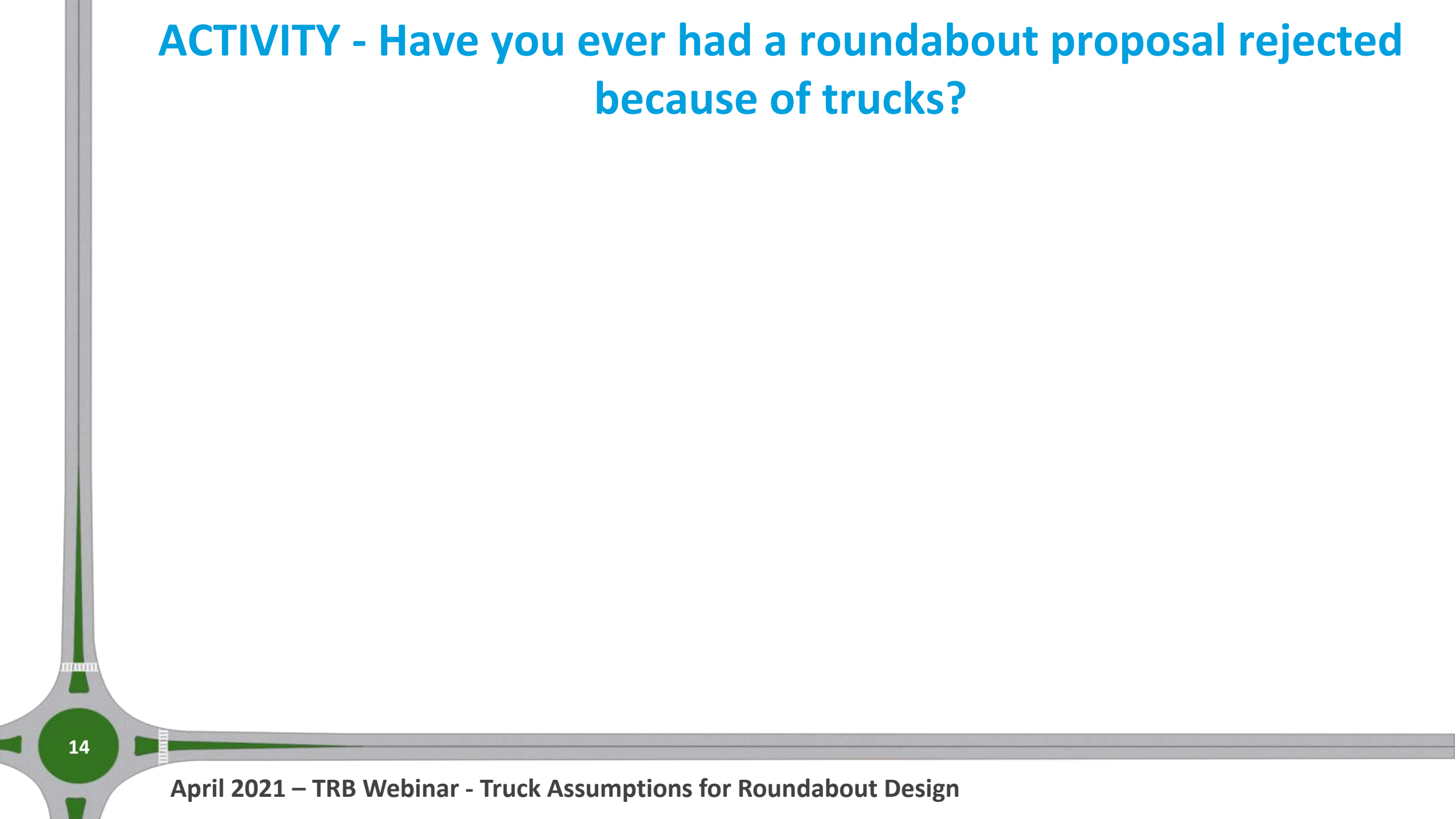
What we've heard

- “I like roundabouts but there’s too much truck traffic”
- “Use a WB-67; it’s the largest in the AASHTO Green Book”
- “The truck percentage is low; Use a WB-50”
- “AutoTurn is ultra conservative”
- “The truck apron is never driven on”
- “There are 53’ trailers; Use a WB-67”
- “Use the largest vehicle that can currently physically make it”

Problem Statement:

Why doesn't the modeled vehicle match what is observed in the field?

ACTIVITY - Have you ever had a roundabout proposal rejected because of trucks?



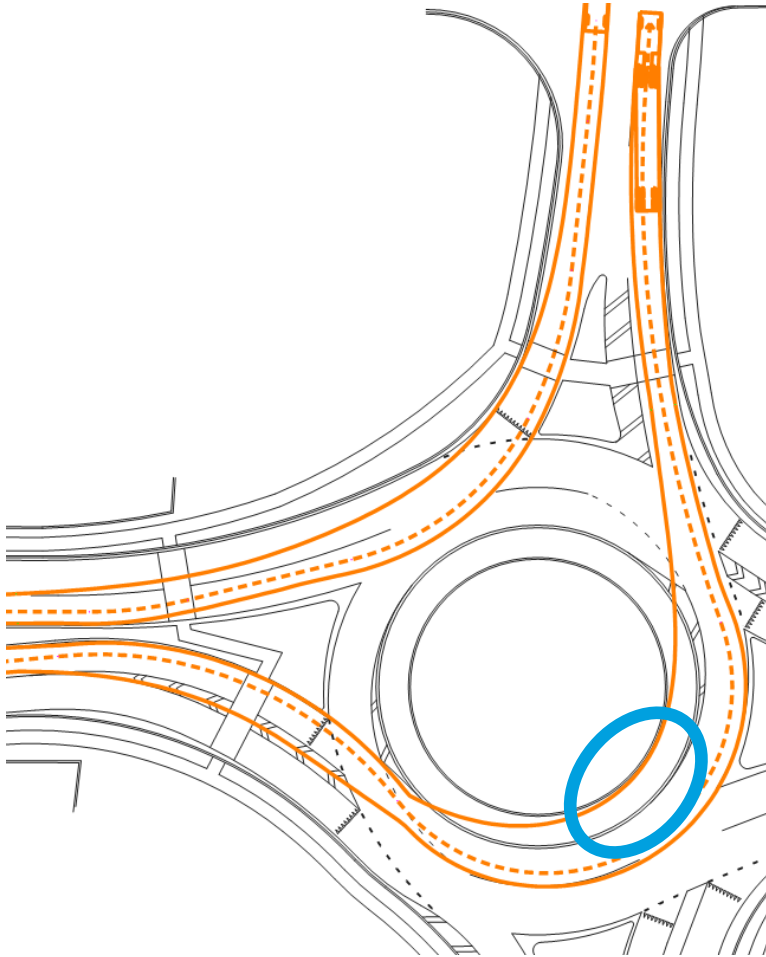


II. DESIGN VEHICLES AND PARAMETERS

Problem Statement

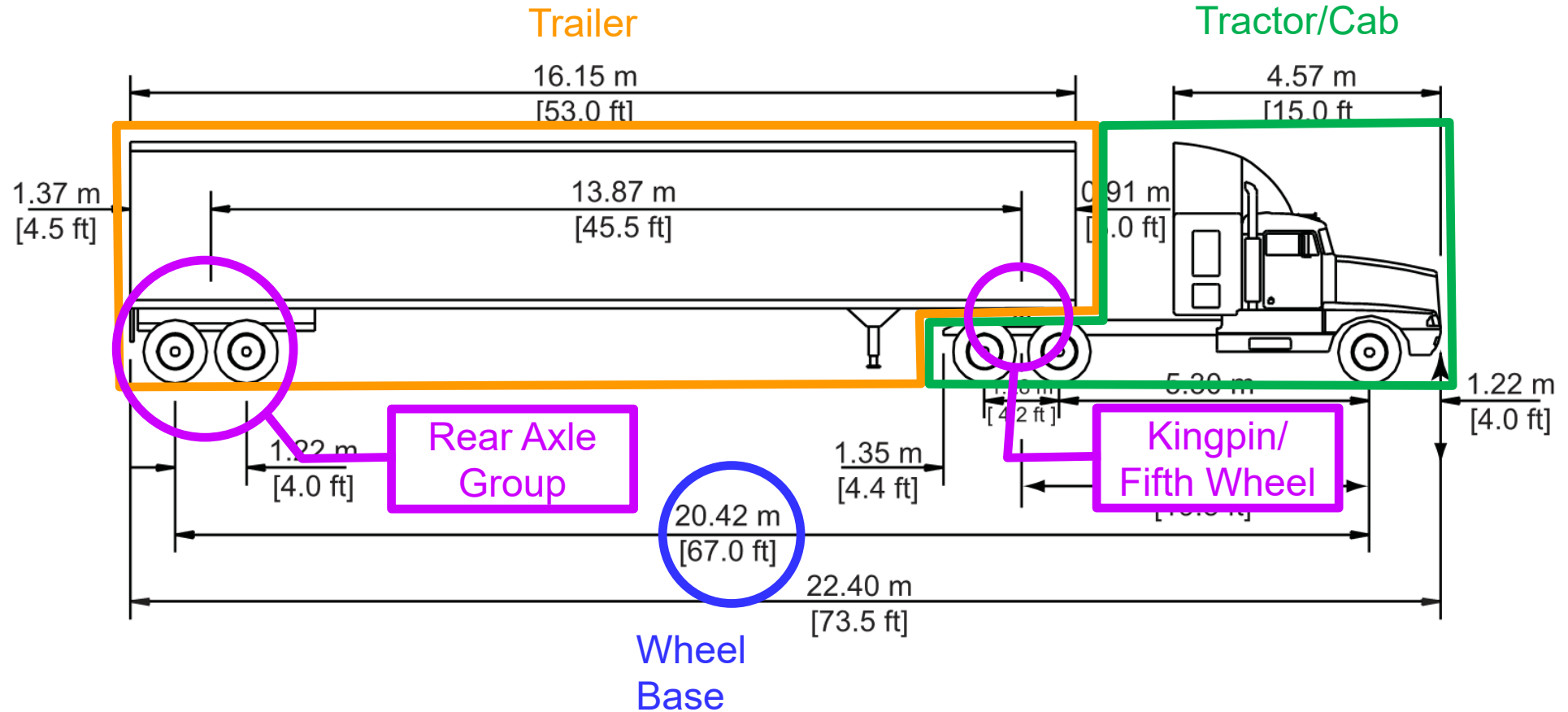
- Where are these WB designations coming from?
- How are we choosing trucks?
- What is the difference between trucks?
- Why aren't trucks we're modeling in the office match what we're seeing in the field?

Model vs Field Observations



ACTIVITY - What comes to mind when you hear WB-67? - WORD CLOUD

Anatomy of a Truck



Many Trucks are configurable!



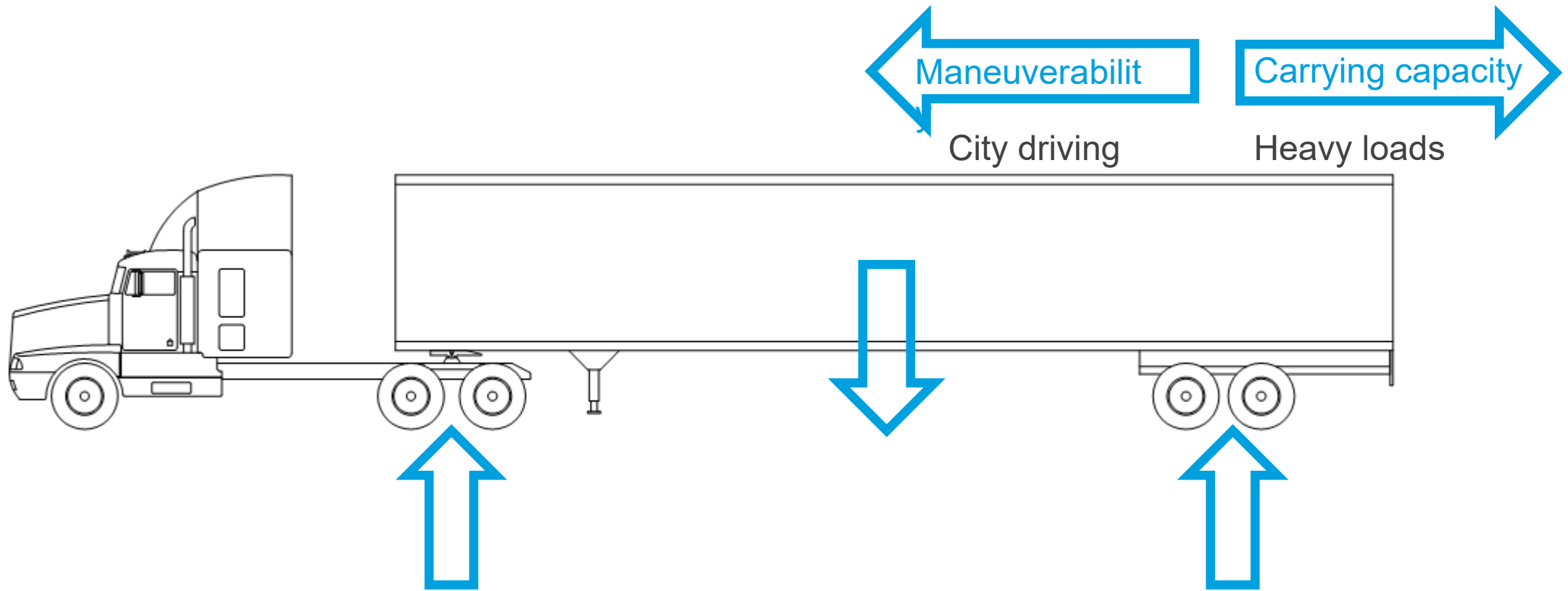
There are exceptions



Wide variety of trucks



Trade-offs



Overhang



Why don't design vehicles match what we see in the field?

AASHTO Green Book 2018

Section 2.8.1 General Characteristics

- *“In the design of any roadway facility, the designer should consider **the largest design vehicle that is likely to use that facility with considerable frequency** or a design vehicle with special characteristics appropriate to a particular location in determining the design of such critical features at intersections and radii of turning roadways.”*
- *“For the purposes of geometric design, **each design vehicle has larger physical dimensions . . . than most vehicles in its class.**”*

How frequent is “considerable frequency”?



Source: Long Beach Airport

ACTIVITY – Have you used a WB-50 in the past 15 years?

AASHTO Green Book 2018

The WB-67 [WB-20] truck should generally be the minimum size design vehicle. . .

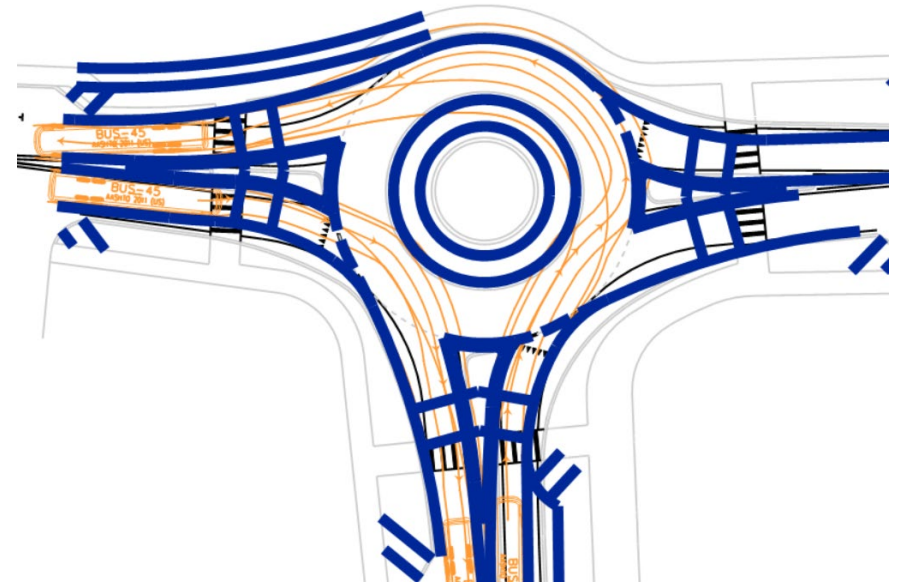
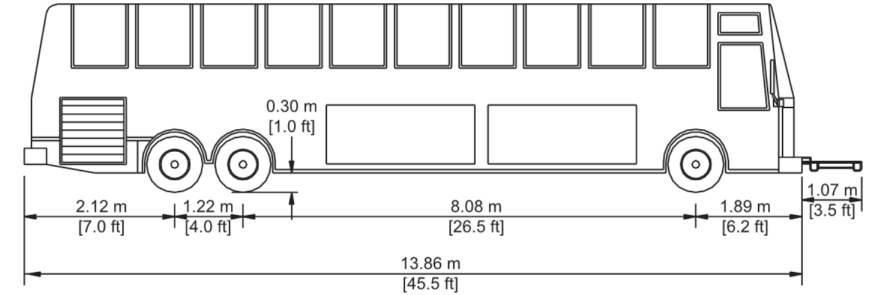
Design Vehicle Type	Pas-senger Car	Single-Unit Truck	Single-Unit Truck (Three Axle)	Intercity Bus (Motor Coach)		City Transit Bus	Conven-tional School Bus (65 pass.)	Large ^a School Bus (84 pass.)	Articu-lated Bus	Inter-mediate Semi-trailer
Symbol	P	SU-30	SU-40	BUS-40	BUS-45	CITY-BUS	S-BUS36	S-BUS40	A-BUS	WB-40
Minimum Design Turning Radius (ft)	23.8	41.8	51.2	41.7	44.0	41.6	38.6	39.1	39.4	39.9
Center-line ^b Turning Radius (CTR) (ft)	21.0	38.0	47.4	37.8	40.2	37.8	34.9	35.4	35.5	36.0
Minimum Inside Radius (ft)	14.4	28.4	36.4	24.3	24.7	24.5	23.8	25.3	21.3	19.3
Design Vehicle Type	Interstate Semi-trailer		"Double Bottom" Combination	Rocky Mtn Double	Triple Semi-trailer/ trailers	Turnpike Double Semi-trail-er/ trailer	Motor Home	Car and Camper Trailer	Car and Boat Trailer	Motor Home and Boat Trailer
Symbol	WB-62*	WB-67**	WB-67D	WB-92D	WB-100T	WB-109D*	MH	P/T	P/B	MH/B
Minimum Design Turning Radius (ft)	44.8	44.8	44.8	82.0	44.8	59.9	39.7	32.9	23.8	49.8
Center-line ^b Turning Radius (CTR) (ft)	41.0	41.0	40.9	78.0	40.9	55.9	36.0	30.0	21.0	46.0
Minimum Inside Radius (ft)	7.4	1.9	19.1	55.6	9.7	13.8	26.0	18.3	8.0	35.0

What is this?

Where'd the WB-50 go?

Design Vehicle ≠ Tractor Trailer

- Not all streets allow tractor trailers
- Not all streets can fit a tractor trailer
- “... the largest design vehicle that is likely to use that facility with considerable frequency” – AASHTO Green Book 2018



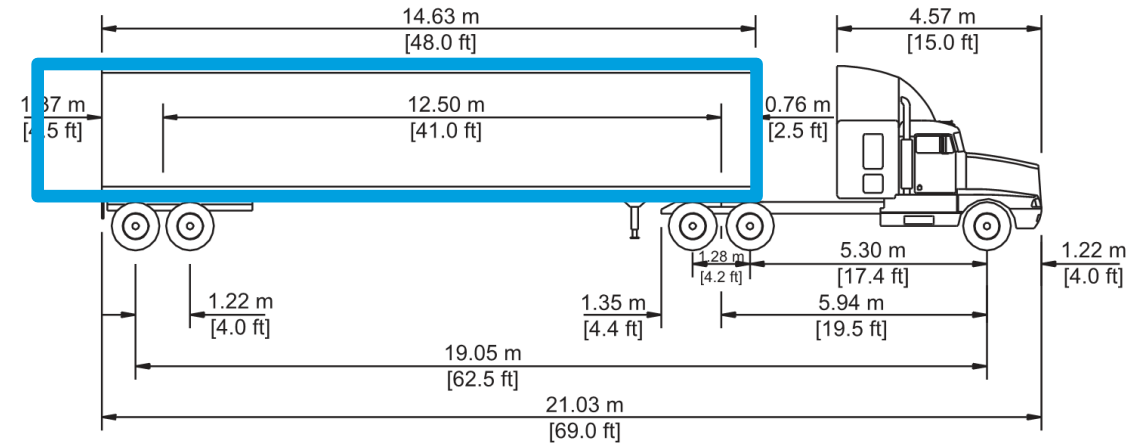
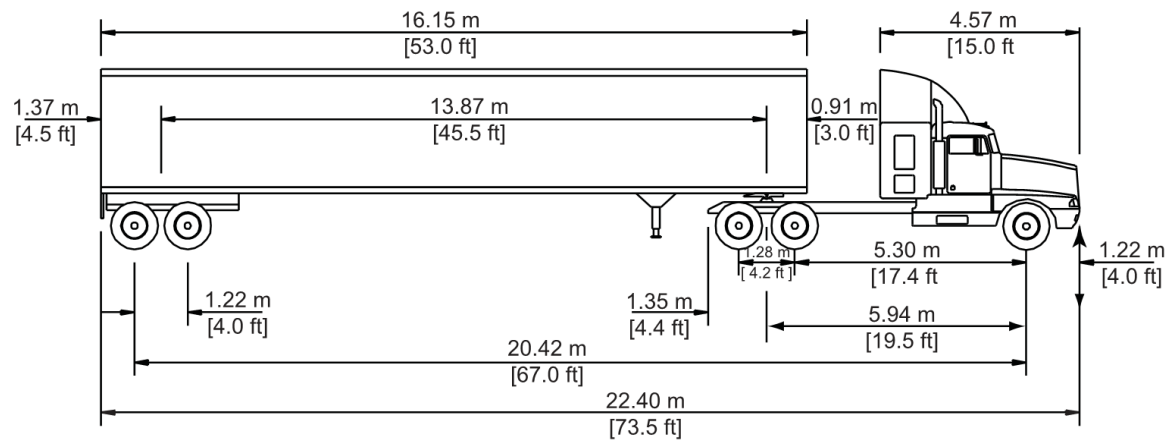
AASHTO Green Book 2018

The WB-67 [WB-20] truck should generally be the minimum size design vehicle. . .

*. . . In many cases, operators of WB-67 [WB-20] and larger vehicles pull the rear axles of the vehicle forward to maintain a kingpin-to-rear-axle distance of **41 ft** [12.5 m], which makes the truck more maneuverable and is **required by law in many jurisdictions**. Where the practice is prevalent, the WB 62 [WB 19] may be used in design for turning maneuvers, but the WB-67 [WB-20] should be used in design situations where the overall length of the vehicle is considered, such as for sight distance at railroad-highway grade crossings.*

AASHTO Green Book supports WB-62 where permitted

WB-67 vs WB-62



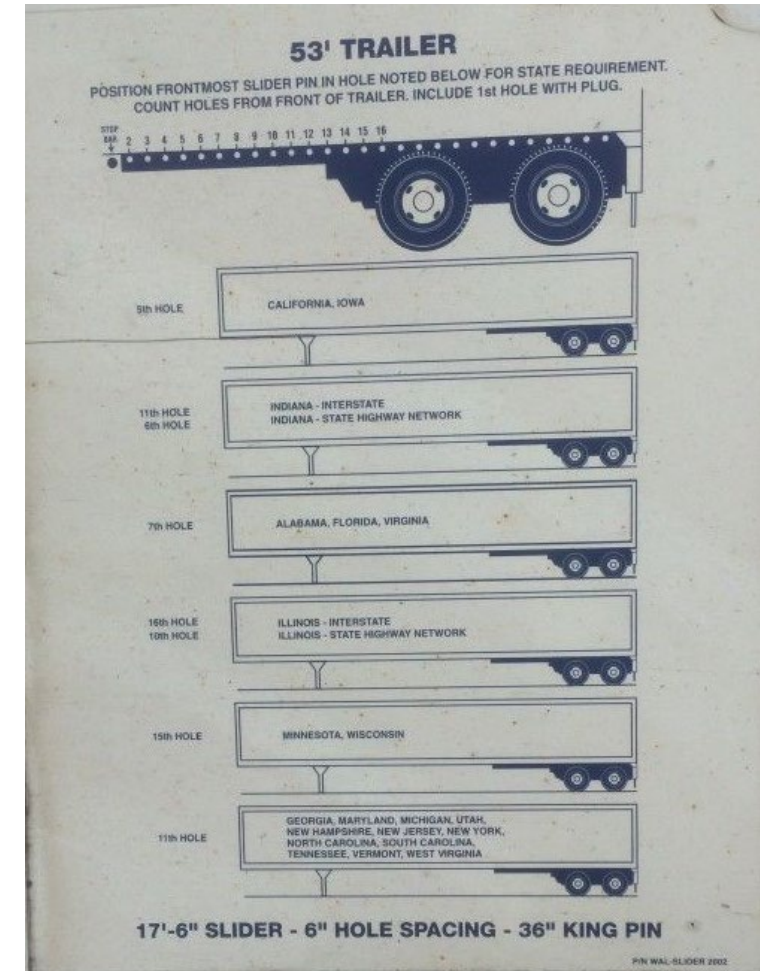
Trailer Length

Pennsylvania Vehicle Code

PA Title 75 Chapter 49 § 4923-b.1 Combinations -

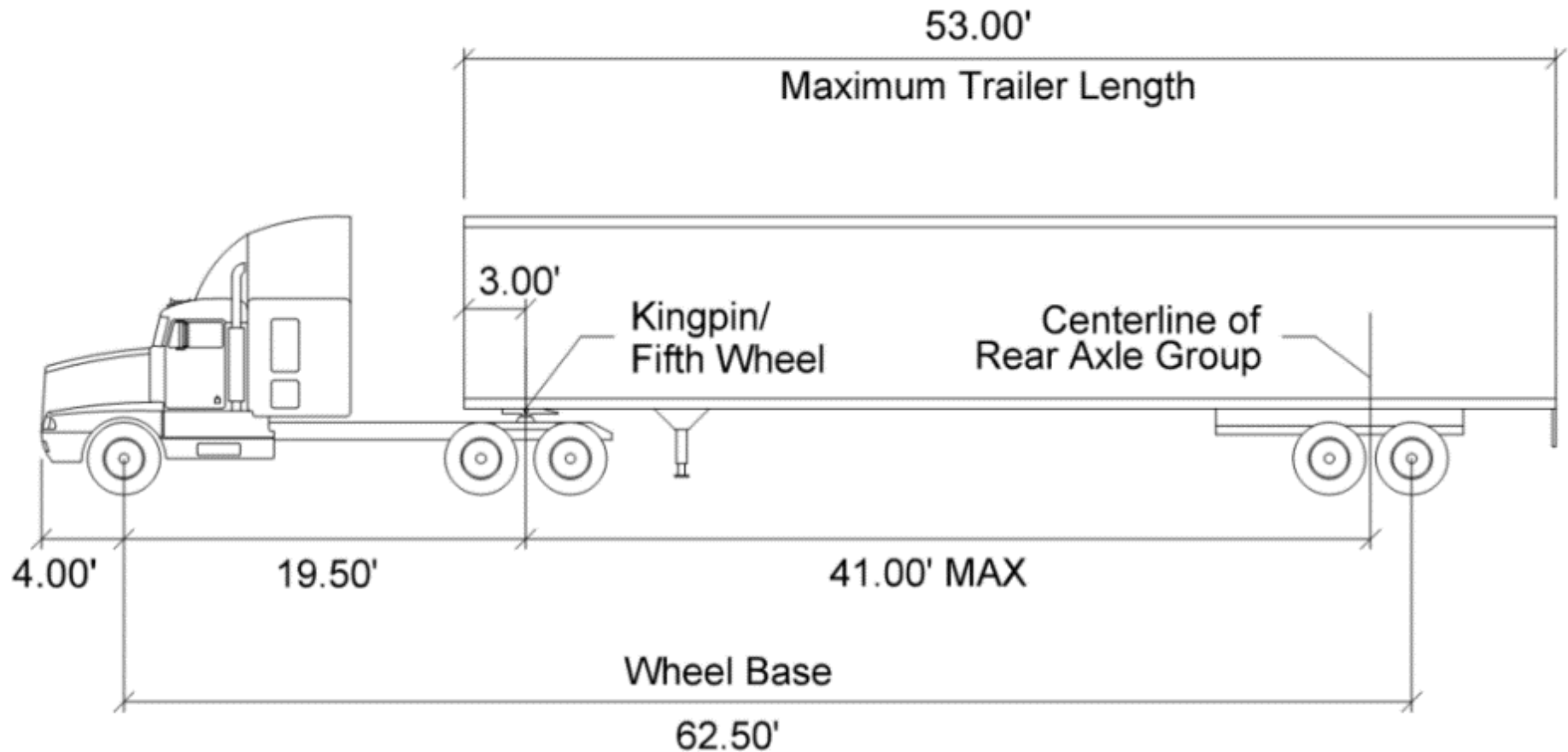
*(1) The length of a single trailer being towed by a truck or truck tractor shall not exceed **53 feet**. Truck or truck tractors towing trailers equipped with a kingpin shall not be operated when the distance between the kingpin and the center line of the rear axle or rear axle group exceeds **41 feet** or, in the case of a trailer used exclusively or primarily to transport vehicles in connection with motor sports competition events, does not exceed 46 feet.*

PA Vehicle Code limits wheel base to WB-62



Source: Truckingtruth

Modified WB-62



Confirming the use of a WB-62




Custom Vehicles

Edit Vehicle Details [X]

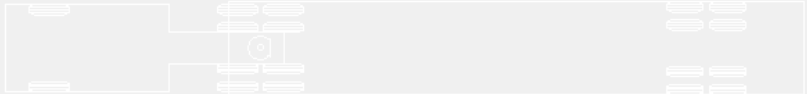
Displayed Data: ☒ Plan/Profile View Data ☐ Roofline View Data

Creation Units: feet [v] Note: Profile for representation purposes only

Profile



Plan



Overall Vehicle Length: 73.50 ft

General Data

Name: WB-62 Ext
Library: Custom [v]
Region: North America [v]
Country: United States [v]
Profile Type: Vehicle [v]
Vehicle Profile: Semitrailer CB [v]
Class: Transport Truck [v]
Lock to Lock Time: 6.0 sec.
Steering Lock Angle: 28.4 deg.

Current Part Data (2/2)

Part Profile: <None> [v]

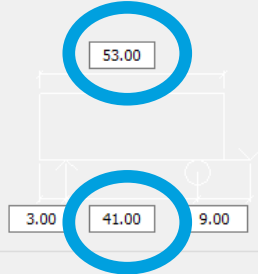
Trailer: Semi [v] Width: 8.50

Steering: Rear Fixed [v]

Articulating Angle: 70.0 deg.
Pitch: 20.0 deg.

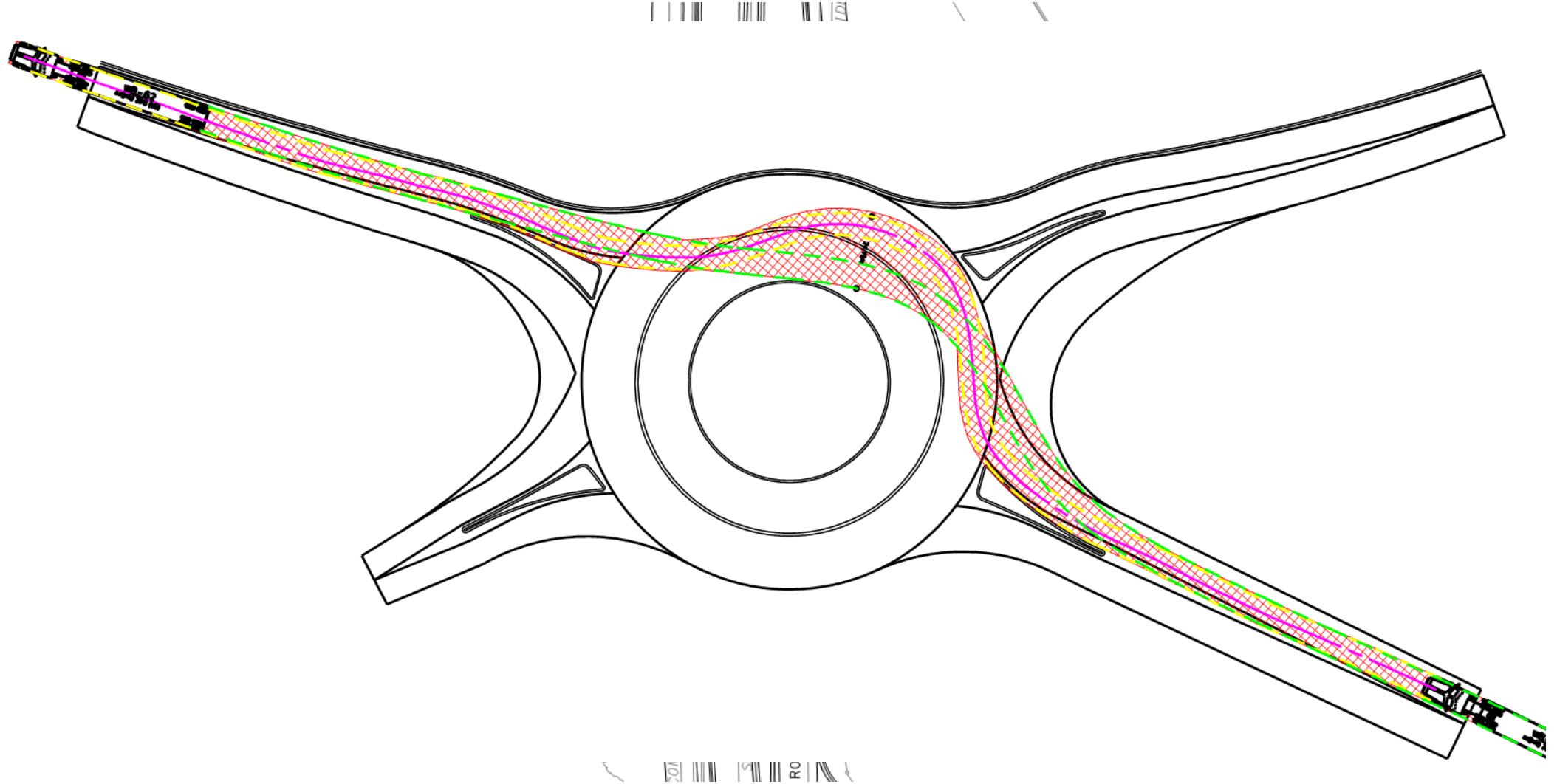
Rear Axle Group

Axes: 2 [v]
Wheels: 4 [v]
Track: 8.50 ft

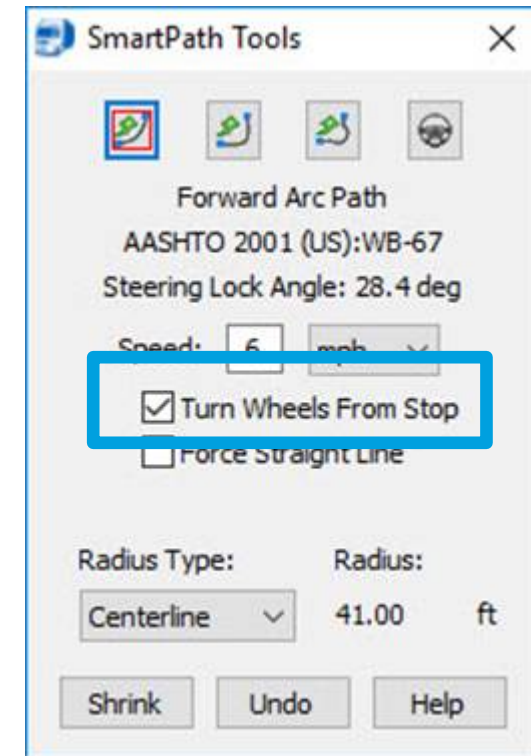
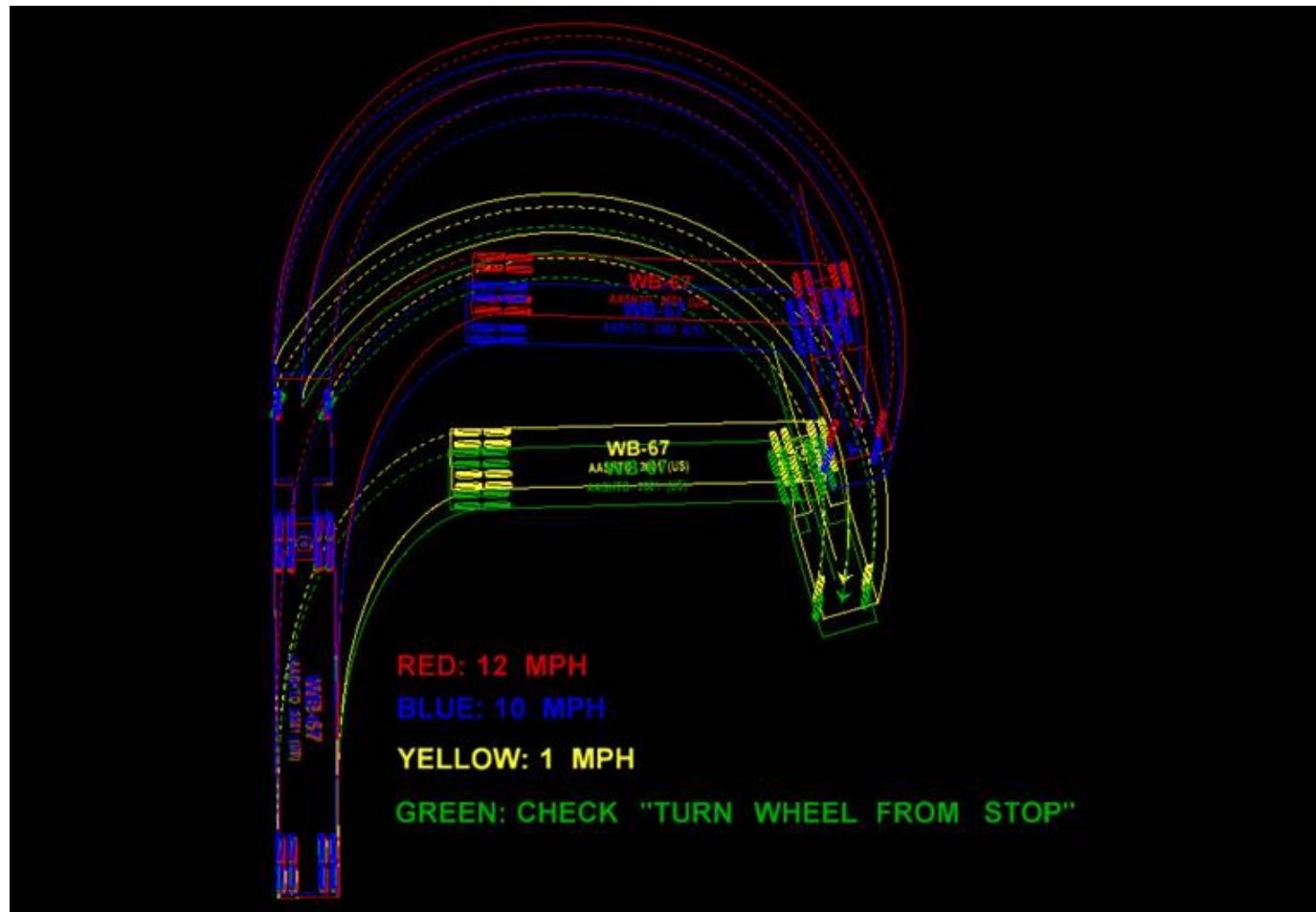


OK Cancel Help

Vehicle paths to avoid



Washington State DOT – AutoTurn at Compacts and Minis





III. TRUCK DRIVERS

Truck Drivers

- Truck drivers are being taught how to use roundabouts
- Drivers maximize maneuverability
- Drivers know the kingpin-to-rear axle regulations and police enforce
- Drivers take over the intersection to make the turn





IV. SINGLE LANE ROUNDABOUTS

Inscribed Circular Diameter

- ICD determined by design vehicle
- Accommodate vs designed for

Roundabout Configuration	Typical Design Vehicle	Common Inscribed Circle Diameter Range*	
Mini-Roundabout	SU-30 (SU-9)	45 to 90 ft	(14 to 27 m)
Single-Lane Roundabout	B-40 (B-12)	90 to 150 ft	(27 to 46 m)
	WB-50 (WB-15)	105 to 150 ft	(32 to 46 m)
	WB-67 (WB-20)	130 to 180 ft	(40 to 55 m)
Multilane Roundabout (2 lanes)	WB-50 (WB-15)	150 to 220 ft	(46 to 67 m)
	WB-67 (WB-20)	165 to 220 ft	(50 to 67 m)
Multilane Roundabout (3 lanes)	WB-50 (WB-15)	200 to 250 ft	(61 to 76 m)
	WB-67 (WB-20)	220 to 300 ft	(67 to 91 m)

* Assumes 90° angles between entries and no more than four legs. List of possible design vehicles is not all-inclusive.

Source: NCHRP 672, 2nd Edition

Design Element	Mini ^[1]	Compact	Single-Lane	Multilane
Number of Lanes	1	1+	1	2+
Inscribed Circle Diameter ^[2]	45' – 80'	65' – 120'	80' – 150'	120' – 165'
Circulating Roadway Width	N/A	N/A	14' – 19'	29'
Entry Widths	N/A	N/A	16' – 18'	25'

Notes:

The "+" symbol used here means that a portion of the circulating roadway may have more than one lane.

[1] Reserved for urban/suburban intersections with a 25 mph or less posted speed.

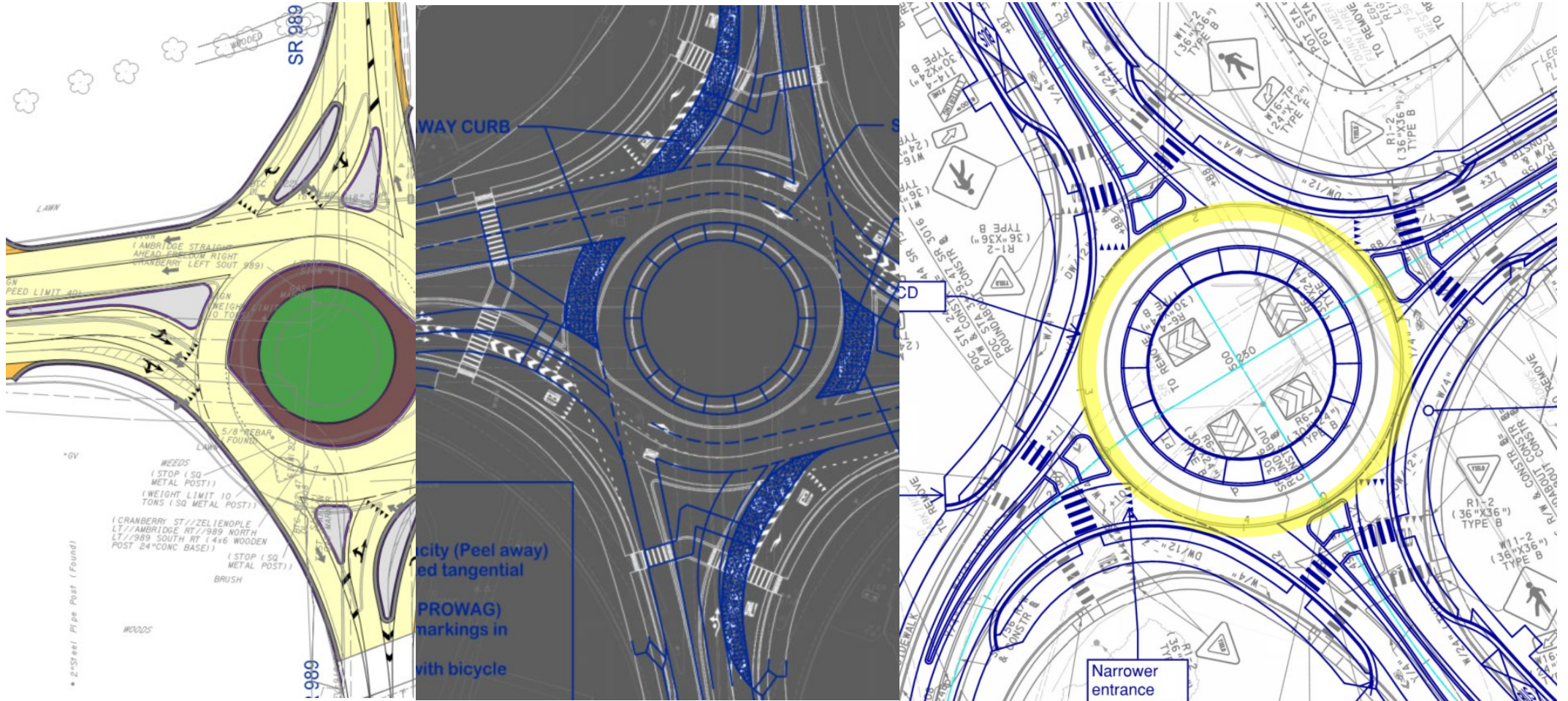
[2] The given diameters assume a circular roundabout; adjust accordingly for other shapes. Some conditions may require ICDs outside ranges shown here.

Source: WSDOT Design Manual M 22-01.17 Chapter 1320

Roundabout Type	Typical Inscribed Circle Diameter ¹	Typical Daily Service Volume ^{2,3} (vpd) 4-leg roundabouts
Single-Lane	120 - 160 ft (35 – 50 m)	less than 25,000
Multilane (2-lane entry)	160 - 215 ft (50 – 65 m)	25,000 to 45,000
Multilane (3 lane entry)	215 - 275 ft (65 – 85 m)	45,000 or more

Source: WisDOT Design Manual FDM 11-26

Smaller Inscribed Circular Diameter



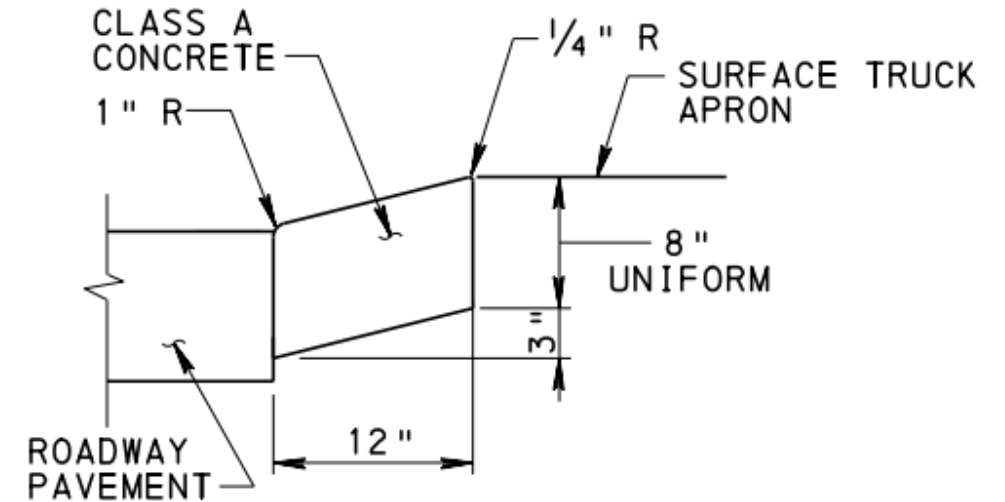
Outside Truck Aprons

- Use as a last resort
- Complicate modelling
- ADA concerns
- DWS placement
- Crosswalk ponding



Truck Aprons

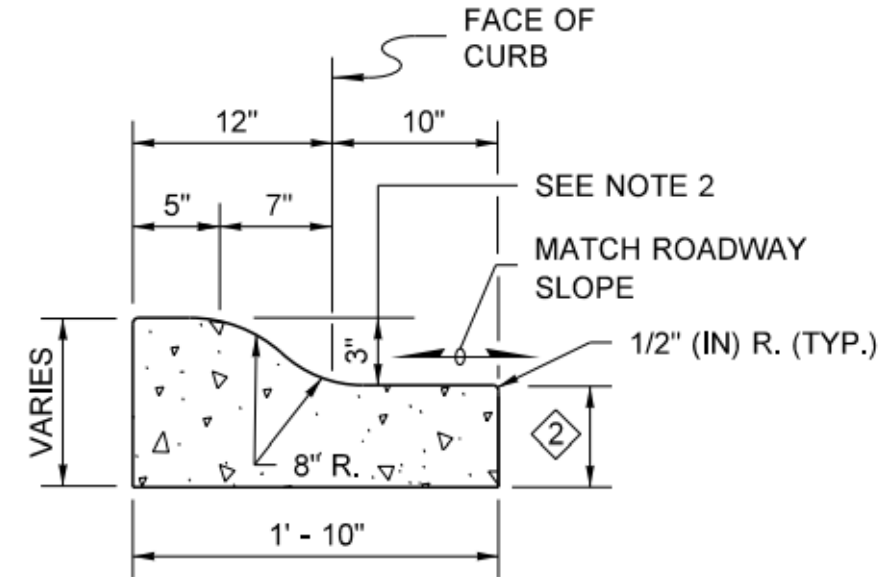
- Cross slope (1%-2%)
- Low boys and OSOW vehicles
- Address Overtipping/load shift concerns
- Discourage use by cars



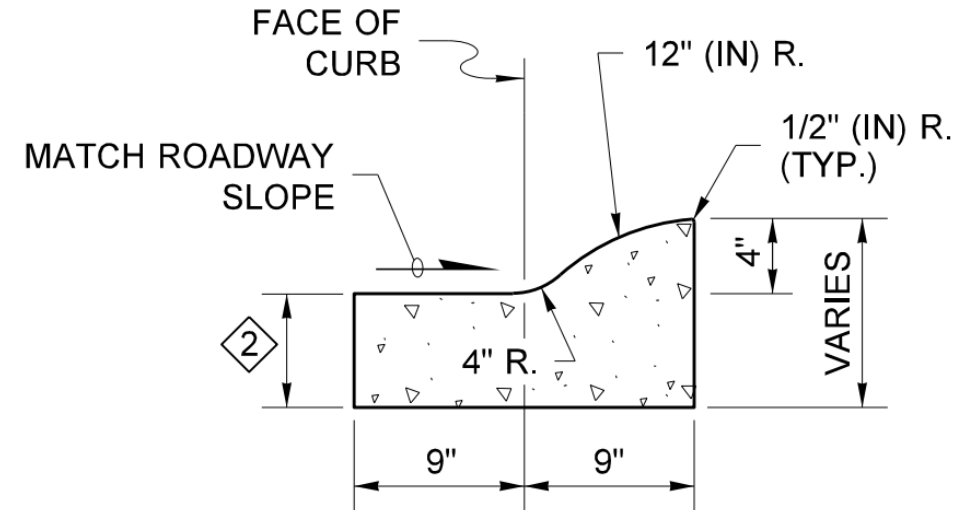
ROUNDAABOUT TRUCK APRON CURB

Source: PennDOT RC-65M

Washington State DOT Mountable Curbs



CURB 1
ROUNDABOUT TRUCK APRON
CEMENT CONCRETE CURB & GUTTER
(ROLLED CURB)



CURB 2
(OUTSIDE, RIGHT SIDE OR SPLITTER ISLAND)
ROUNDABOUT CEMENT CONCRETE
CURB AND GUTTER
(ROLLED CURB)

Source: WSDOT Standard Plan F-10.18.01

Source: WSDOT Standard Plan F-10.18.01

Washtenaw County, MI



Washtenaw County, MI



Washtenaw County, MI



Washtenaw County, MI



City of Bellevue, WA



Dimondale, MI



St James, MN – Compact Roundabouts



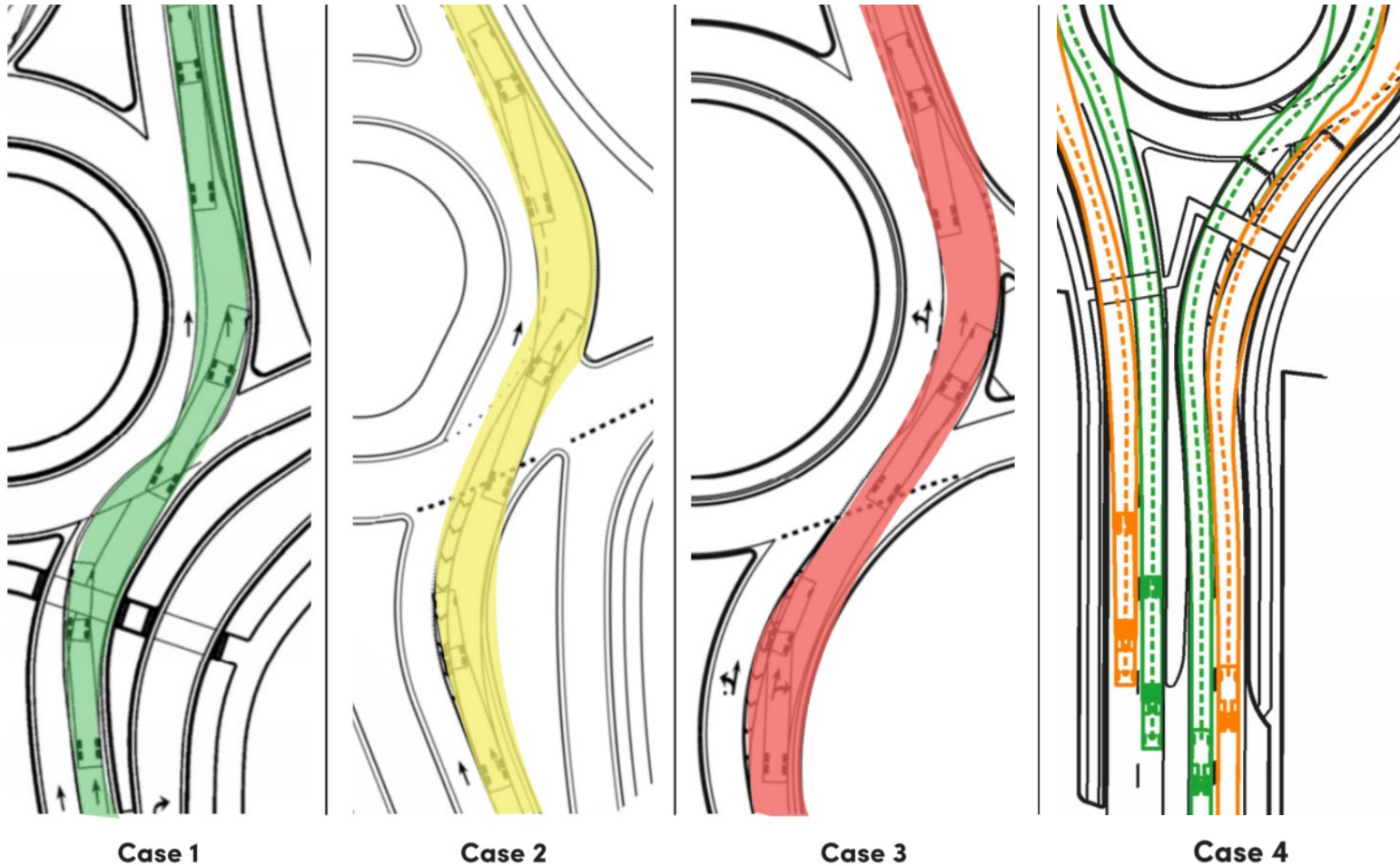
Snoqualmie, WA



A decorative graphic in the bottom-left corner of the slide. It depicts a roundabout with a central green circle containing the white number '54'. Four roadways, shown in grey, enter and exit the roundabout. The roadways are wider at the roundabout and taper to thin lines as they extend towards the corners of the slide. The background of the slide is a light blue gradient.

V. MULTILANE ROUNDABOUTS

Driver Behavior – Truck Case

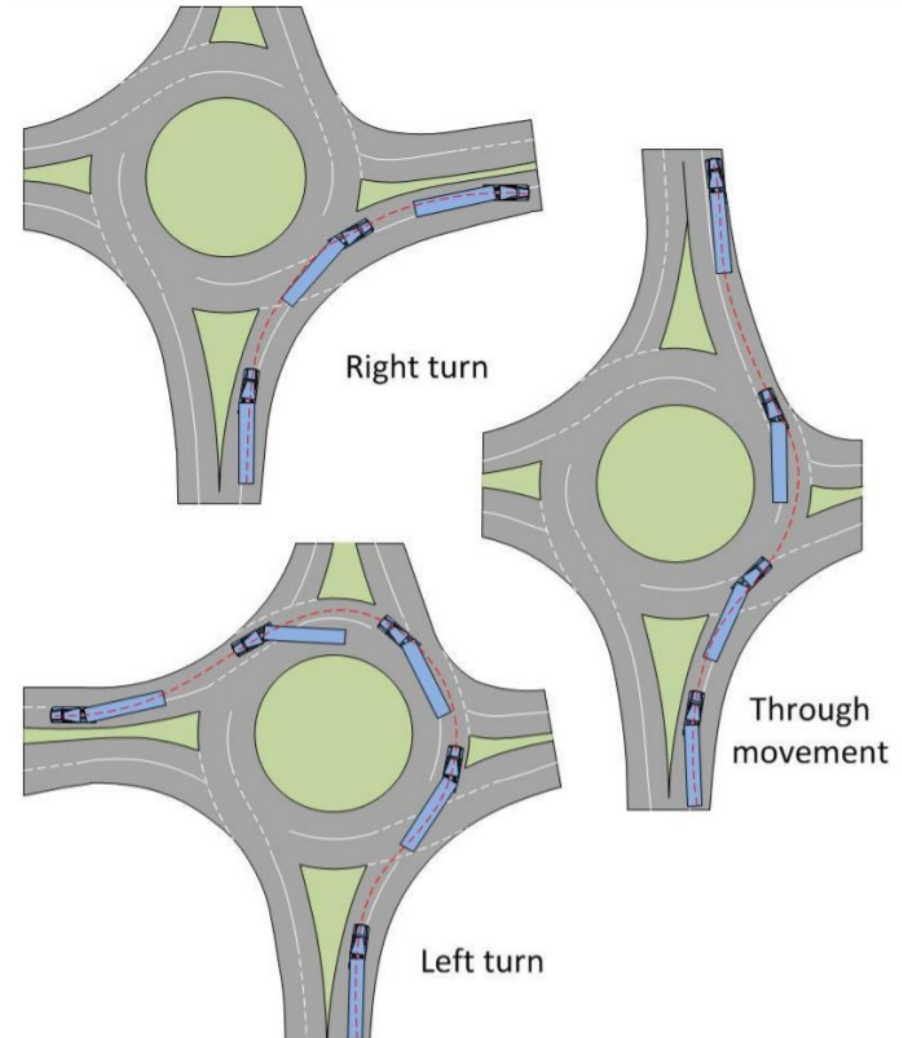


The problem with Case IV



WSDOT Trucks at Multilane Entrances

- Trucks take both lanes upstream of entry
- In effect box out prior to entrance
- Keep vehicles out of blind spot
- Avoid truck apron on multilane roundabouts unless necessary
- Simulate at ~5 mph



Source: WSDOT Design Manual M 22-01.17 Chapter 1320



VI. ACTION ITEMS

Action Items

1. Check your local and state laws regarding largest unpermitted vehicles
2. Whenever you start a project, see if you can track down what types of trucks are driving through your intersection
3. Check your truck routes
4. Do due diligence and look at truck classifications on routes in your state. This information is available from your state DOT
5. Design guides are always being updated, however, understand the design guidance for your locale and incorporate accordingly



VII. RESOURCES

Resources

- If you would like to know more about trucks and the recommended design vehicle
 - NCHRP Report 505 - 2003
 - NCHRP Report 672, 2nd Edition – 2010 (pending 3rd Edition)
 - AASHTO Green Book 2018

Thank you



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Special Thanks: Jeff Bucher, PE Brian Walsh, PE

Today's Panelists

#TRBWebinar



Moderator: Brian Walsh,
Washington State DOT



Michael Mastaglio



Andrew Thompson



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