McTrans

The future of crash prediction methods
What is new in HSM2?

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Disclaimer

This presentation discusses some novel methods expected to be included in the *Highway Safety Manual 2nd Edition*, to be published by AASHTO.

The methodologies presented here and implemented in the Highway Safety Software (HSS2024) reflect the content of published research reports (NCHRP) and are subject to changes before their official publication in the HSM2.

About the Highway Safety Manual

Part A
Introduction and Fundamentals

Part B
Roadway Safety Management

Part C
Predictive Method

Part D
Crash Modification Factors

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Supplement 2014

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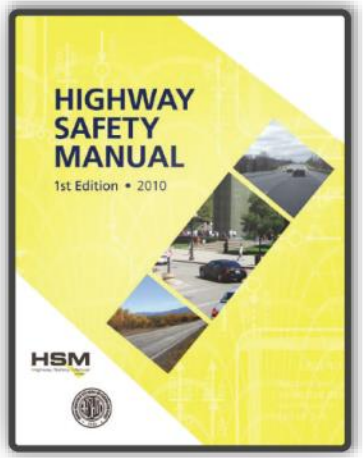
HSM 1st Edition



Development of the Highway Safety Manual 2

Background

- 2010 – 1st Edition (AASHTO)

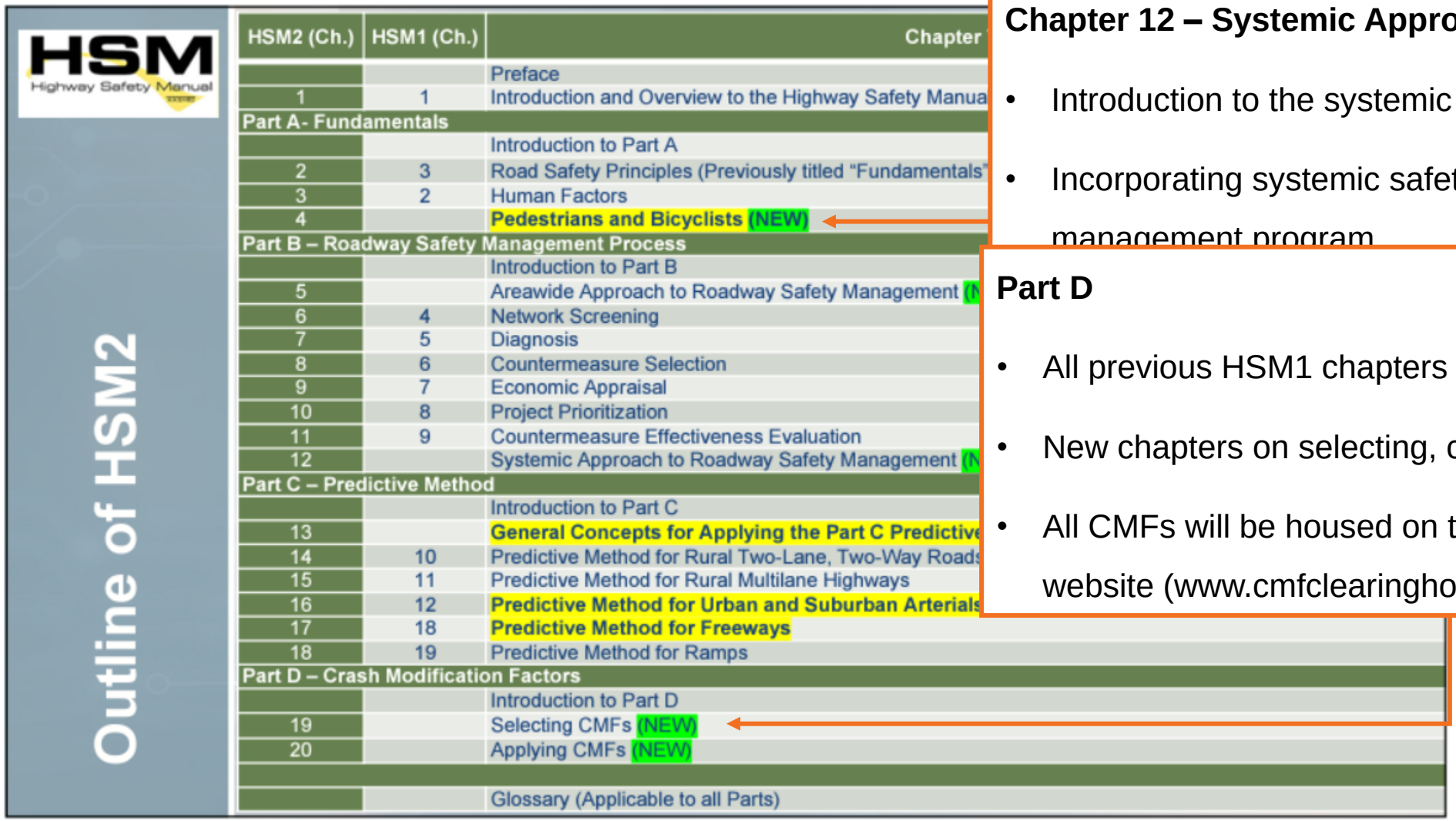
  2014 – Supplement for freeways (AASHTO)

HSM 2nd Edition – Coming Soon

- 2021 – 2024 – National Cooperative Highway Research Program (NCHRP) - Project 17-71 (https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5043)

- 2024 – 2nd Edition to be published by AASHTO

HSM1 vs HSM2 Structure



HSM2 (Ch.)	HSM1 (Ch.)	Chapter
		Preface
1	1	Introduction and Overview to the Highway Safety Manua
Part A- Fundamentals		
		Introduction to Part A
2	3	Road Safety Principles (Previously titled "Fundamentals"
3	2	Human Factors
4		Pedestrians and Bicyclists (NEW)
Part B – Roadway Safety Management Process		
		Introduction to Part B
5		Areawide Approach to Roadway Safety Management (N
6	4	Network Screening
7	5	Diagnosis
8	6	Countermeasure Selection
9	7	Economic Appraisal
10	8	Project Prioritization
11	9	Countermeasure Effectiveness Evaluation
12		Systemic Approach to Roadway Safety Management (N
Part C – Predictive Method		
		Introduction to Part C
13		General Concepts for Applying the Part C Predictive
14	10	Predictive Method for Rural Two-Lane, Two-Way Roads
15	11	Predictive Method for Rural Multilane Highways
16	12	Predictive Method for Urban and Suburban Arterials
17	18	Predictive Method for Freeways
18	19	Predictive Method for Ramps
Part D – Crash Modification Factors		
		Introduction to Part D
19		Selecting CMFs (NEW)
20		Applying CMFs (NEW)
		Glossary (Applicable to all Parts)

Chapter 4 – Bike & Pedestrian Safety

- **Chapter 5 – Areawide Approach**

Chapter 12 – Systemic Approach

- Introduction to the systemic safety methods
- Incorporating systemic safety in your roadway safety management program

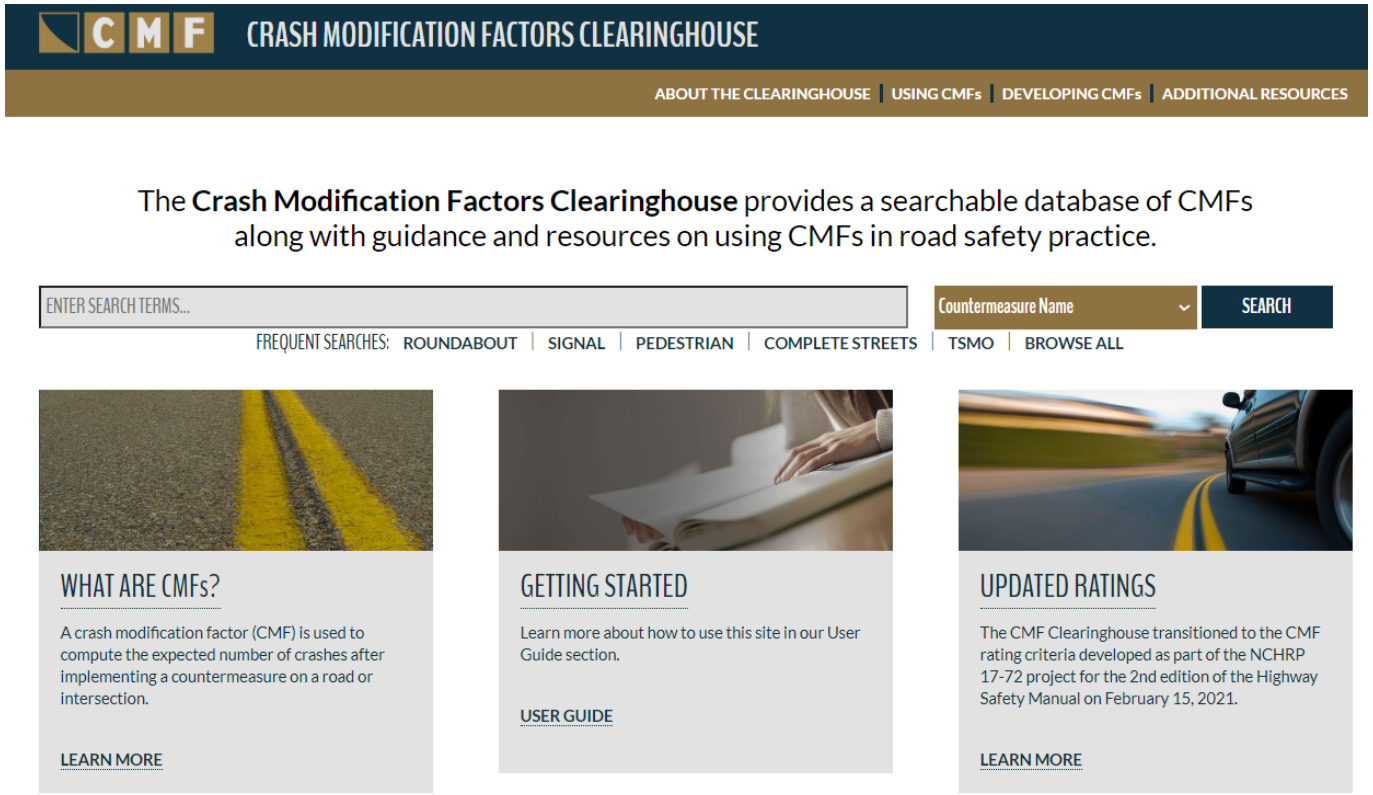
Part D

- All previous HSM1 chapters removed
- New chapters on selecting, creating, and using CMFs
- All CMFs will be housed on the CMF Clearinghouse website (www.cmfclearinghouse.org)

Source: NCHRP Project 17-71A Update (ACS20 Mid-year meeting 2023)

CMF Clearing House

The Crash Modification Factors Clearinghouse houses a web-based database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs



Research - NCHRP Projects

17-50: States Initiative	**17-56:** CMF Pedestrian Crossing	**17-58:** SPF Urban and Suburban Arterials	**17-59:** Intersection Sight Distance	**17-62:** Crash Types and Severities	**17-63:** CMFs
17-68: Intersection CPM	**17-70:** Roundabout CPM	**17-71:** HSM Second Edition	**17-72:** Update CMFs	**17-73:** Pedestrian Safety Analyses	**17-77:** Guide for Systemic Safety Analysis
	17-78: Reliability of CPM's	**17-83**: Training Materials for HSM 2nd Ed.	**17-84:** Pedestrian and Bicycle SPF's	NCHRP Research on Human Factors	

Part C (Predictive Method) Updates

New Pedestrian / Bike CPMs

- Incorporated new methods from NCHRP 17-84 to predict pedestrian and bicycle crashes
- New models more sensitive to site-specific conditions (exposure and infrastructure):
  - Bike lane configurations
  - Shared-use paths
  - Crossing treatments
  - Signal phasing
  - Area population
  - Land use

Urban/Suburban Arterials Segments

HSM 1 – Existing models

- Two-lane undivided (2U)
- Three-lane with TWLTL (3T)
- Four-lane undivided (4U)
- Four-lane divided (4D)
- Five-lane with TWLTL (5T)

HSM 2 – New models

- Six-lane divided (6D)
- Six-lane undivided (6U)
- Seven-lane with TWLTL (7T)
- Eight-lane divided (8D)
- Two-lane One Way (2O)
- Three-lane One Way (3O)
- Four-lane One Way (4O)

New urban arterials: NCHRP 17-58

Implemented in HSS

Urban Segments - CMFs

Intersection Type	Facility Type		
	HSM1 arterials	HSM 2 – 6+lanes arterials	HSM 2 – one-way arterials
# Driveways	✓	✓	✓
Curbside parking	✓	✓	✓
Roadside objects	✓	✓	✓
Median barriers / median width	*	*	
Lighting	✓		
Automated speed enforcement	✓	✓	✓
Posted speed	✓	✓	✓
Right shoulder width		✓	✓
Lane width		✓	✓
Railroad crossings		✓	

** Only applicable for divided roads*

Intersections

HSM 1 – Existing models

- 3-leg stop control (3ST)
- 4-leg stop control (4ST)
- 3-leg signal control (3SG)
- 4-leg signal control (4SG)

HSM 2 – New models

- Roundabouts (R) ✅
- 3-leg turning (3STT)
- Intersections on high-speed arterials (≥ 50 mph)
  - Stop control (3ST-HS, 4ST-HS)
  - Signal (3SG-HS, 4SG-HS)
- All-way stop control ✅
  - 3-leg (3aST) ✅
  - 4-leg (4aST) ✅
- 5-leg signal (5SG)

Roundabouts: NCHRP 17-70

New intersections: NCHRP 17-68

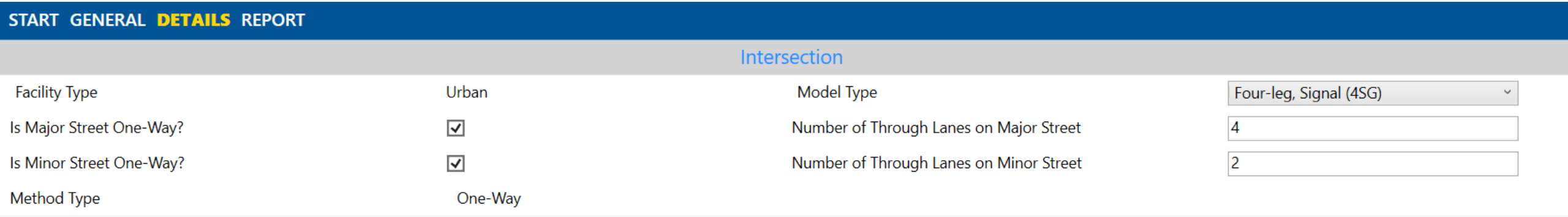
Intersections for new urban segments: NCHRP 17-58

✅ *Implemented in HSS*

Urban Intersections

New crash prediction models for existing urban intersections (signal and stop-control):

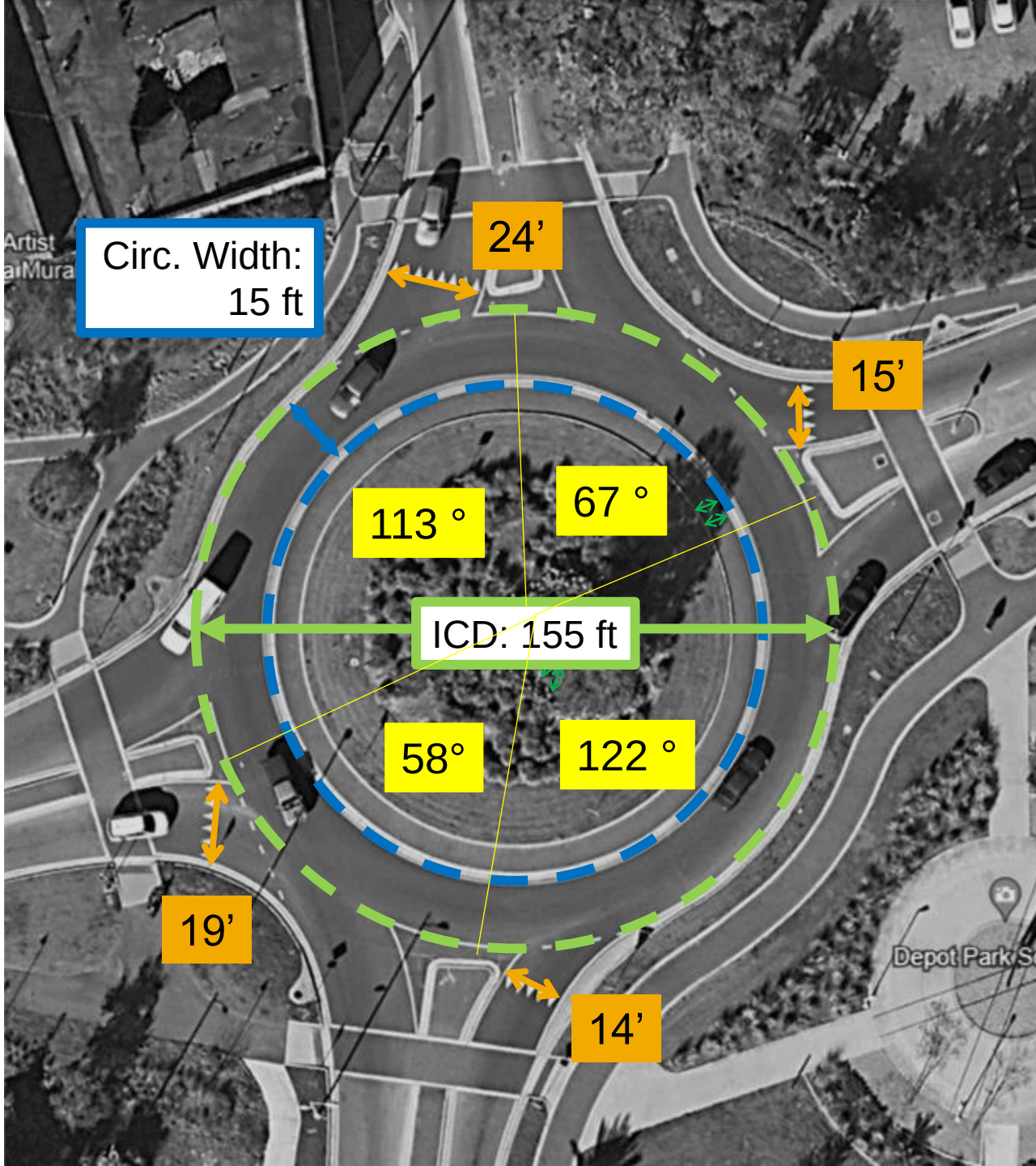
- Two-way street intersecting a two-way street (2x2)
- One-way street intersecting a two-way street (1x2)
- One-way street intersecting a one-way street (1x1)
- 6+lane major roads



Implemented in HSS

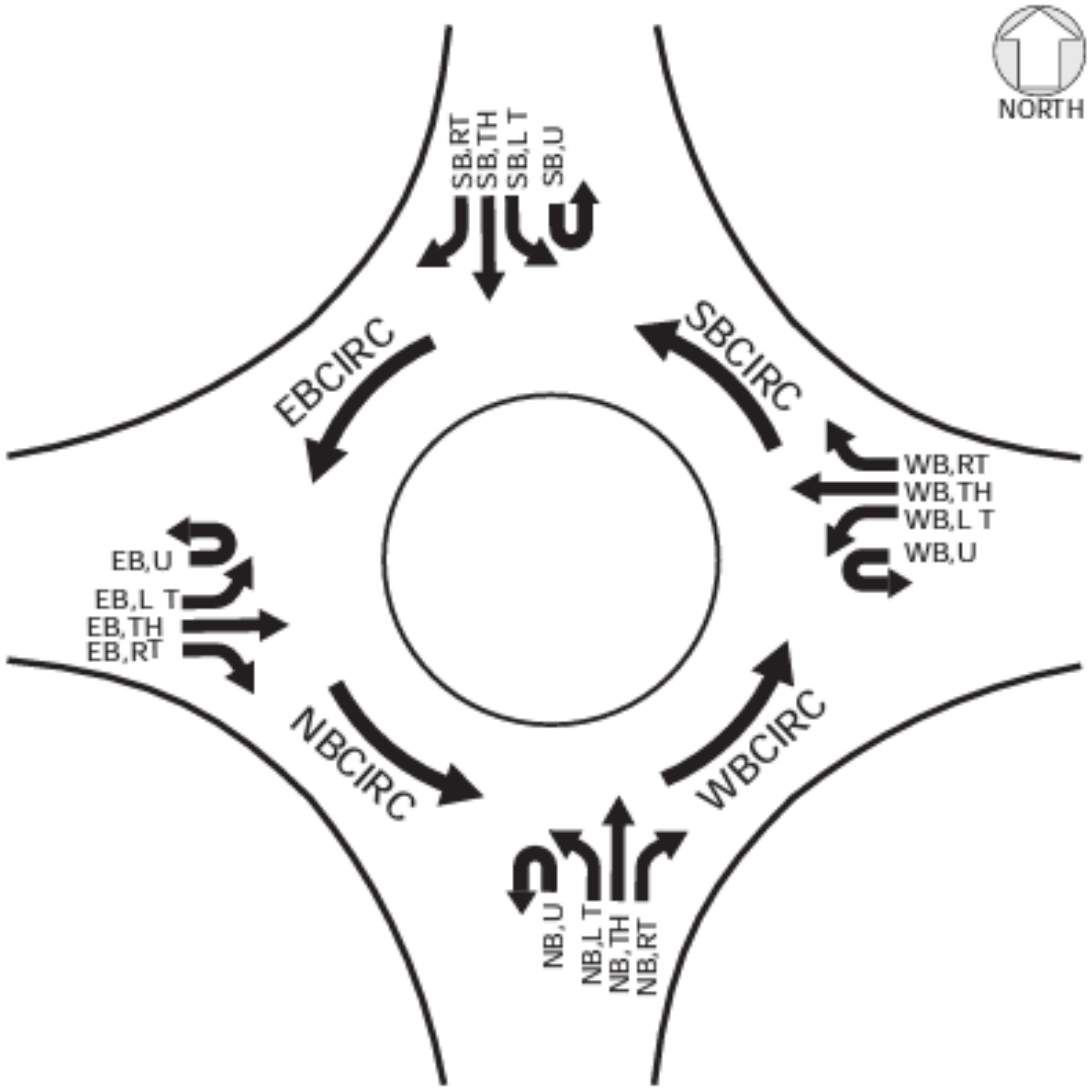
Roundabouts

- Different methods for 1 or 2 circulating lanes
- Geometric inputs:
  - # entering lanes
  - # circulating lanes
  - # exiting lanes
  - Inscribed Circle Diameter (ICD)
  - Circulatory width
  - Entry width
  - Angle to next leg



Roundabouts

- Traffic inputs (per leg):
  - Entering AADT
  - Circulating AADT
  - Exiting AADT
- Other influencing factors:
  - # luminaires (within 250 ft)
  - # access points (within 250 ft)



Source: *Roundabouts: An Informational Guide (FHWA)*

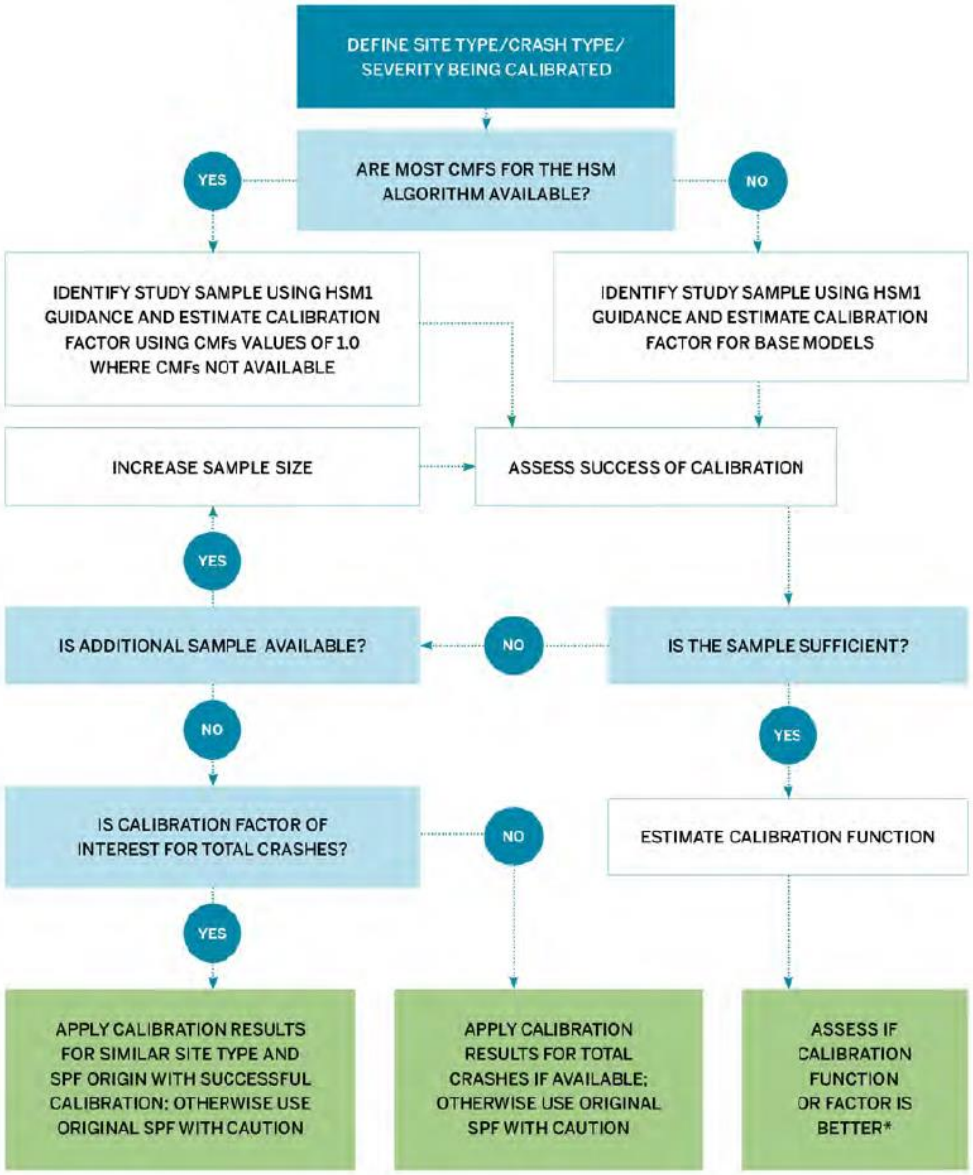
Urban/Suburban Arterials SPFs (Safety Performance Functions)

	HSM 1 – Existing models	HSM 2 – New models
Two-Lane Segments	$N_{SPF} = AADT \times L \times 365 \times 10^{a} \times e^{b}$	$N_{SPF} = L \times e^{b_0} \times AADT^{b_1}$
Multilane Segments	$N_{SPF} = \exp(a + b \times \ln(AADT) + \ln(L))$	$N_{SPF} = \exp(a + b \times \ln(AADT) + \ln(L))$
Urban Segments	$N_{brmv} = \exp(a + b \times \ln(AADT) + \ln(L))$	$N_{brmv} = \exp(a + b \times \ln(AADT) + \ln(L) + c \times DWYDENS)$
Intersections	$N_{SPF} = \exp(\alpha + \beta_1 \times \ln(AADT_{maj}) + \beta_1 \times \ln(AADT_{min}))$	$N_{SPF} = \exp(b_0 + b_1 \times \ln(AADT_{maj}) + b_2 \times \ln(AADT_{min}))$

L: segment length AADT: Annual Avg. Daily Traffic $AADT_{min/max}$: AADT on major/minor street

Single-State Calibration

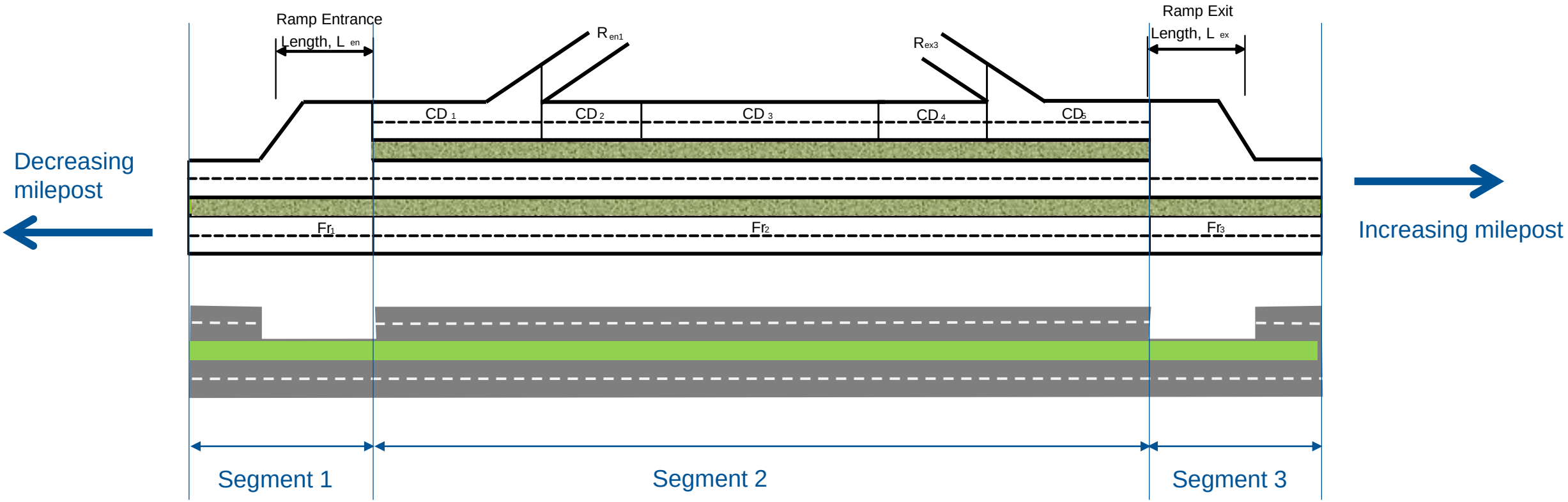
Single-state calibration for many of the Part C models was performed in NCHRP Project 17-72



Suggested revised calibration process

Freeways & Ramps

- Method updated to address **directional** segments rather than two-way segments
- No major changes in existing methods



Freeway segmentation procedure (HSM1)

Ramp Terminals CPMs

HSM 1 – Existing models

- 3-leg terminals with diagonal ramp (D3en/D3ex)
- 4-leg terminals with diagonal ramps (D4)
- 4-leg terminals at four-quadrant Parclo A/B (A4/B4)
- 3-leg terminals at two-quadrant Parclo A/B (A2/B2)

Conventional Diamond Interchange

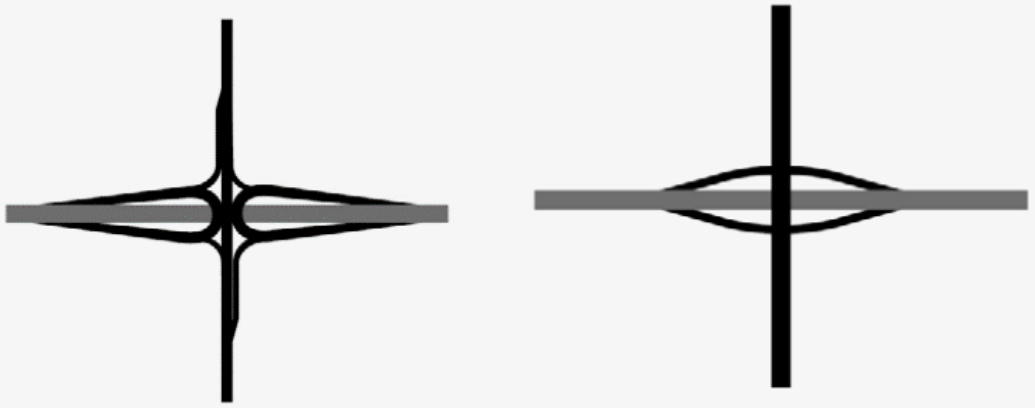
Partial Cloverleaf – A2

Partial Cloverleaf – B4

HSM 2 – New models

All models in HSM1, plus:

- Single-point interchanges (SP)
- Tight diamond interchanges (TD)



Single-Point Diamond Interchange (SPDI)

Tight Urban Diamond Interchange

Highway Safety Software Implementation

HSM2 methods under implementation for next release

HSS™
Highway Safety Software

START GENERAL **DETAILS** REPORT

Intersection

Facility Type	Urban	Model Type	Roundabout (R)

Intersection Input

Total Entering AADT	4000	Number of Legs	4 Leg
Max. Number of Circulating Lanes	1	Inscribed Circle Diameter (ICD), ft	130

Legs Input

	# of Entering Lanes	# of Circulating Lanes	# of Exiting Lanes	Entry Width, ft	Circulating Width, ft	Posted Speed, mi/h
1	1	1	1	24	30	30
2	1	1	1	24	30	30
3	1	1	1	24	30	30
4	1	1	1	24	30	30

	Entering AADT, veh/day	Circulating AADT, veh/day	Exiting AADT, veh/day
1	1000	1000	1000
2	1000	1000	1000
3	1000	1000	1000
4	1000	1000	1000

Leg Details Input

	Outbound Leg associated with a Ramp Terminal	Right-Turn Bypass Lane	# of Access Points	# of Luminaires	Angle - Next Leg
1	☐	☐	0	0	90.0
2	☐	☐	0	0	90.0
3	☐	☐	0	0	90.0
4	☐	☐	0	0	90.0

Crash Modification Factors

CMFICD (Inscribed Circle Diameter, FI)	0.969			
CMFoutbd (Outbound-Only Leg, FI)	1.000			
	Leg 1	Leg 2	Leg 3	Leg 4
CMFbypass (Right-Turn Bypass Lane, FI)	1.000	1.000	1.000	1.000
CMFap (Access Point Frequency, FI)	1.000	1.000	1.000	1.000
CMFap (Access Point Frequency, PDO)	1.000	1.000	1.000	1.000
CMFew (Entry Width, FI)	0.887	0.887	0.887	0.887
CMFew (Entry Width, PDO)	0.856	0.856	0.856	0.856
CMFcl (Circulating Lane, FI)	1.000	1.000	1.000	1.000
CMFcl (Circulating Lane, PDO)	0.856	0.856	0.856	0.856
Weighted CMF (FI)	0.222	0.222	0.222	0.222
Weighted CMF (PDO)	0.214	0.214	0.214	0.214

Predicted Roadway Section Crashes

Crash Severity	Safety Performance Function	Predicted Crash Frequency
Fatal and Injury (FI)	0.107	0.092
Property Damage Only (PDO)	0.605	0.518
Total	0.712	0.610

Economic Analysis (Predicted Crashes)

Crash Severity	Per Crash Societal Crash Cost	Predicted Annual Crashes	Total Societal Crash Cost
Fatal and Injury (FI)	$158,200.00	0.092	$14,559.87
Property Damage Only (PDO)	$7,400.00	0.518	$3,833.04
Total	-	0.610	$18,392.92

Questions / Thank you!

Acknowledgements

We express our sincere acknowledgment to all individuals who have made valuable contributions to this material, including many current and former employees of the McTrans Center, University of Florida Transportation Institute (UFTI), and University of Florida. Their dedicated efforts have greatly contributed to the development and quality of this work.

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