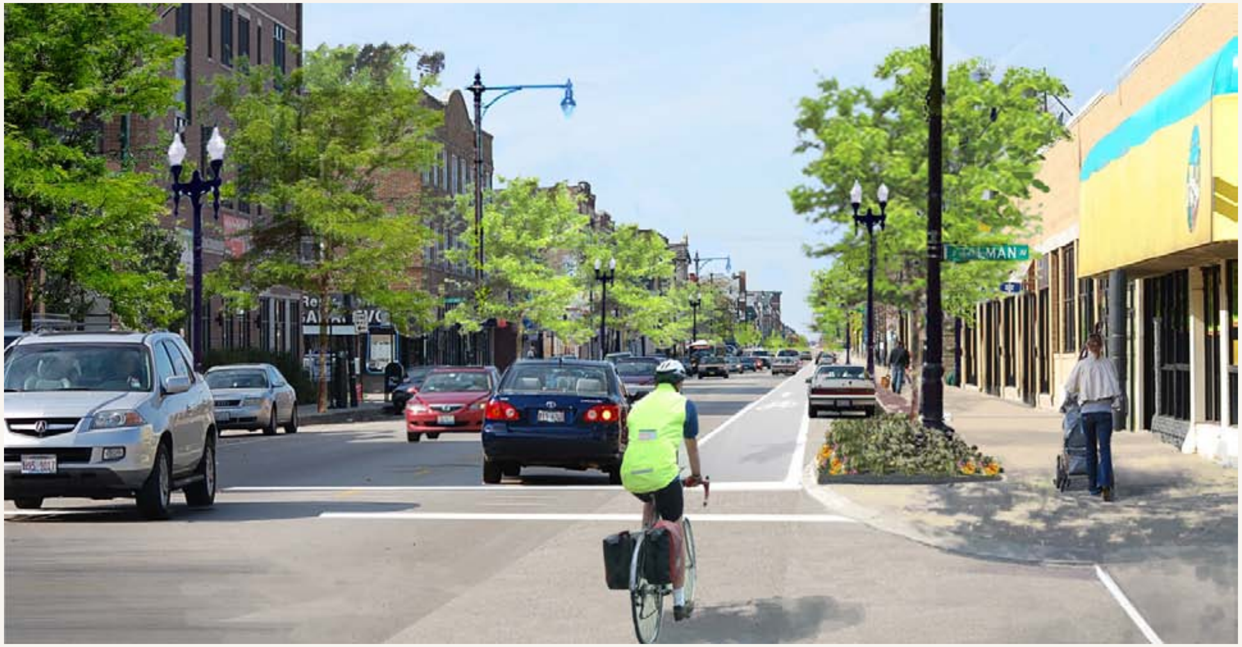
HSM Applications to Suburban/Urban Multilane Streets

Application of Crash Modification Factors to Predicted Crash Frequency for Suburban/Urban Multilane Streets

- Session #6



Predicting Crash Frequency of Suburban/Urban Multilane Streets

Learning Outcomes:

- ►Describe Crash Modification Factors for Multilane Suburban/Urban Streets
- ►Apply Crash Modification Factors (CMF's) to Predicted Crash Frequency for Multilane Suburban/Urban Streets

Predicting Crash Frequency of Suburban/Urban Multilane Streets

Procedure for safety prediction for a roadway segment:

► Combine base models, CMFs, and calibration factor

► $N_{spf\ rs} = N_{brmv} + N_{brsv} + N_{brdwy}$

► $N_{br} = N_{spf\ rs}\ (CMF_{1r} \times CMF_{2r} \times \ldots CMF_{nr})$

► $N_{predicted\ rs} = (N_{br} + N_{pedr} + N_{biker})\ C_r$

Applying CMF's for Conditions other than "Base"

- Next Step is:

$$N_{br} = N_{spf\ rs}(CMF_{1r} \times CMF_{2r} \times .. CMF_{nr})$$

Where:

- ► N_{br} = Predicted number of total roadway segment crashes per year with CMFs applied
- ► $N_{spf\ rs}$ = Predicted number of total roadway segment crashes per year for base conditions
- ► CMF_{1r} CMF_{2r}, .. CMF_{nr} = Crash modification factors for roadway segments

Applying CMF's for Conditions other than "Base"

Table 12-18. Summary of CMFs in Chapter 12 and the Corresponding SPFs

Applicable SPF	CMF	CMF Description
Roadway Segments	CMF_{1r}	On-Street Parking
	CMF_{2r}	Roadside Fixed Objects
	CMF_{3r}	Median Width
	CMF_{4r}	Lighting
	CMF_{5r}	Automated Speed Enforcement

CMF for Curb Parking on Urban Streets

$$CMF_{1r} = 1 + P_{pk} * (f_{pk} - 1.0)$$

Table 12-19. Values of f_{pk} Used in Determining the Crash Modification Factor for On-Street Parking

	Type of Parking and Land Use			
	Parallel Parking		Angle Parking	
Road Type	Residential/Other	Commercial or Industrial/Institutional	Residential/Other	Commercial or Industrial/Institutional
2U	1.465	2.074	3.428	4.853
3T	1.465	2.074	3.428	4.853
4U	1.100	1.709	2.574	3.999
4D	1.100	1.709	2.574	3.999
5T	1.100	1.709	2.574	3.999

Where:

P_{pk} = Proportion of curb length with parking, = $(0.5L_{pk}/L)$

L_{pk} = curb length with on-street parking, both sides (mi) combined

f_{pk} = factor from Exhibit 12-19

CMF for Curb Parking on Urban Streets

Example: For 4-Ln Urban commercial street (4U), *angle* parking *one* side 3.12 miles of 3.6 mile length, commercial area:

$$CMF_{1r} = 1 + P_{pk} (f_{pk} - 1.0)$$

$$CMF_{1r} = 1 + (0.50 (L_{pk}/L) 1) \times (f_{pk} - 1)$$

$$= 1 + (0.50 (3.12/3.6) 1) \times (3.999 - 1)$$

$$= 1 + (0.50(0.867)) \times 2.999$$

$$= 1 + (0.43 \times 2.999)$$

$$\mathbf{= 2.30}$$

CMF for Curb Parking Urban Streets: Example

For 4-Ln Urban commercial street (4U), *parallel* parking *both* sides 3.12 miles of 3.6 mile length, commercial area:

$$CMF_{1r} = 1 + P_{pk}\,(f_{pk} - 1.0)$$

$$CMF_{1r} = 1 + (0.50(3.12/3.6)2) \times (1.709 \;\; -1))$$

$$= 1 + (0.5(0.867)2) \times 0.709$$

$$= 1 + (0.867 \times 0.709)$$

$$= \mathbf{1.614}$$

CMF for Roadside Fixed Objects

$$CMF_{2r} = f_{offset} * D_{fo} * p_{fo} + (1 - p_{fo})$$

Where:

f_{offset} = fixed object offset factor from Exh 12-20

D_{fo} = fixed object density (fixed objects/mi)

p_{fo} = fixed-object collisions as a proportion of total crashes, Exhibit 12-21

- ►Only point objects that are 4inches or more in diameter and do not have a breakaway design are considered.
- ► Point objects that are within 70 feet of each other longitudinally are considered as a single object

CMF for Roadside Fixed Objects

Table 12-20. Fixed-Object Offset Factor

Offset to Fixed Objects (O_{fo}) (ft)	Fixed-Object Offset Factor (f_{offset})
2	0.232
5	0.133
10	0.087
15	0.068
20	0.057
25	0.049
30	0.044

Example: For 4-Ln Urban undivided street (4U) with power poles at 2 ft offset

$f_{offset} = 0.232$

$p_{fo} = 0.037$

- Offset is measured from edge of travel way

Table 12-21. Proportion of Fixed-Object Collisions

Road Type	Proportion of Fixed-Object Collisions (p_{fo})
2U	0.059
3T	0.034
4U	0.037
4D	0.036
5T	0.016

CMF for Roadside Fixed Objects: Example

For one mile of 4-Ln Urban undivided commercial curbed street (4U) with power poles on *one* side on 150 foot spacing 2 feet from edge of travel way:

$$\mathbf{CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})}$$

$$= 0.232\,(5280/150)(1)(0.037) + (1 - 0.037)$$

$$= 0.232 \times 35.2 \times 0.037 + (0.963)$$

$$= 0.302 + 0.963$$

$$= \mathbf{1.265}$$

CMF for Roadside Fixed Objects: Example

For one mile of 4-Ln Urban undivided commercial curbed street (4U) with power poles on *both* sides on 150 foot spacing 2 feet from edge of travel way:

$$\mathbf{CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})}$$

$$= 0.232\ (5280/150)(2)(0.037)) + (1 - 0.037)$$

$$= 0.232 \times 70.4 \times 0.037 + (0.963)$$

$$= \mathbf{1.567}$$

CMF for Roadside Fixed Objects: Exercise

For one mile of 4-Ln Urban undivided commercial curbed street (4U) with trees (12” dia) on *one* side spaced 80 feet apart 5 feet from edge of travel way:

$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})$$

CMF_{2r} = __0.133__ (5280/80)(1)(__0.037__) + (1 – __0.037__)

= 0.133 x 66 x 0.037+ (0.963)

= _______

CMF_{3r} for Median Width – Urban/Suburban Multilane Streets

Table 12-22. CMFs for Median Widths on Divided Roadway Segments without a Median Barrier (CMF_{3r})

Median Width (ft)	CMF
10	1.01
15	1.00
20	0.99
30	0.98
40	0.97
50	0.96
60	0.95
70	0.94
80	0.93
90	0.93
100	0.92

- ►This CMF applies only to divided roadway segments with traversable medians without barrier.
- ►The effect of traffic barriers on safety would be expected to be a function of barrier type and offset, rather than the median width; however, the effects of these factors on safety have not been quantified. Until better information is available, an CMF value of 1.00 is used for medians with traffic barriers.

CMF for Lighting

$$CMF_{4r} = 1 - (p_{nr} \times (1.0 - 0.72\, p_{inr} - 0.83\, p_{pnr}))$$

Where:

p_{inr} = proportion of total nighttime crashes for unlighted roadway segments that involve a nonfatal injury

p_{pnr} = proportion of total nighttime crashes for unlighted roadway segments that involve PDO crashes only

p_{nr} = proportion of total crashes for unlighted roadway segments that occur at night

CMF for Lighting

$$CMF_{4r} = 1- [p_{nr} \times (1.0 – 0.72\ p_{inr} – 0.83\ p_{pnr})\ ]$$

Table 12-23. Nighttime Crash Proportions for Unlighted Roadway Segments

	Proportion of Total Nighttime Crashes by Severity Level		Proportion of Crashes that Occur at Night
Roadway Segment Type	Fatal and Injury p_{inr}	PDO p_{pnr}	p_{nr}
2U	0.424	0.576	0.316
3T	0.429	0.571	0.304
4U	0.517	0.483	0.365
4D	0.364	0.636	0.410
5T	0.432	0.568	0.274

- These are default values for nighttime crash proportions; replace with local information
- If light installation increases the density of roadside fixed objects, adjust CMF_{2r}

CMF for Lighting: Example

For 4-Ln Urban undivided commercial curbed street (4U) with power poles on 150 foot spacing 2 feet from edge of travel way on one-side– Add Lighting

$$CMF_{3r} = 1- [p_{nr} \times (1.0 – 0.72\ p_{inr} – 0.83\ p_{pnr})]$$

$$= 1- [0.365 \times (1.0– 0.72(0.517) – 0.83 \times 0.483)]$$

$$= \mathbf{0.917}$$

- Lighting adds light poles at 160 foot spacing on one side (the other side) set back 2 feet from back of curb

► Recompute CMF_{2r}

CMF for Roadside Fixed Objects: Example

For one mile of 4-Ln Urban undivided commercial curbed street (4U) with power poles on *one* side on 150 foot spacing 2 feet from edge of travel way + street lighting on other side on 160 foot spacing 2 feet from edge of travel way:

$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})$$

= 0.232((5280/150)(1)+ (5280/160)(1))(0.037) + (1 – 0.037)

= 0.232 x (35.2+33.0) x 0.037+ (0.963)

= 0.232 x 68.2 x 0.037 + 0.963

= 0.585 + 0.963 = **1.548**

CMF for Roadside Fixed Objects – combined effect of trees and luminaire supports

Exercise: For one mile of 4-Ln Urban undivided commercial curbed street with trees (12” dia) spaced 80 feet apart 5 feet from edge of travel way both sides + Street lighting (non-breakaway) at 160 foot spacing at 5 feet from edge of travel way both sides:

$$\mathbf{CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})}$$

trees lighting

$= 0.133 \times ((5280/80)(2)+(5280/160)(2)) \times 0.037 + (1 - 0.037)$

$= 0.133(132 + 66)(0.037) + (0.963)$

$= \mathbf{1.937}$

CMF for Roadside Fixed Objects – combined effect of trees and luminaire (breakaway)

Exercise: For one mile of 4-Ln Urban undivided commercial curbed street with trees (12” dia) spaced 80 feet apart 5 feet from edge of travel way both sides + Street lighting (breakaway) at 160 foot spacing at 5 feet from edge of travel way both sides:

$$CMF_{2r} = f_{offset} \times D_{fo} \times p_{fo} + (1 - p_{fo})$$

trees lighting

$$= 0.133 \times ((5280/80)(2)+(5280/160)(2)) \times 0.037 + (1 - 0.037)$$

$$= 0.133(132 + 0)(0.037) + (0.963)$$

$$= 1.937 \quad = \mathbf{1.613}$$

CMF for Automated Speed Enforcement

CMF_{5r} is:

1.00 for no automated speed enforcement;

0.95 for automated speed enforcement

Applying Crash Modification Factors to Prediction of Crash Frequency for Urban/Suburban Roadway Segments

$$N_{br} = N_{spf\ rs}\ (CMF_{1r} \times CMF_{2r\ldots\ldots}CMF_{nr})$$

Where:

N_{br} = Predicted number of total roadway segment crashes per year with effects of conditions other than base conditions

Applying Crash Modification Factors to Prediction of Crash Frequency for Urban/Suburban Roadway Segments

Example:

- Commercial on-street parallel parking both sides — CMF = 1.613
- Roadside Fixed Objects (trees@80' and non-breakaway light poles@160' both sides) — CMF = 1.937
- Lighting — CMF = 0.917
- Transversible 15 foot wide median — CMF = 1.00
- No speed enforcement — CMF = 1.00

$$\mathbf{N_{br}} = N_{spf\ rs}\ (CMF_{1r} \times CMF_{2r} \times \ldots\ CMF_{nr})$$

$$= \mathbf{32.8}\ (1.613 \times 1.937 \times 0.917 \times 1.00 \times 1.00)$$

= ________ crashes per year

Predicting Crash Frequency for Peds + Bikes on Urban/Suburban Streets

3rd Step

$$N_{predicted\ rs} = (N_{br} + N_{pedr} + N_{biker})\ C_r$$

Where:

- $N_{predicted\ rs}$ = predicted average crash frequency of an individual roadway segment for the selected year
- N_{br} = predicted average crash frequency of an individual roadway segment excluding vehicle-pedestrian and vehicle-bicycle crashes
- N_{pedr} = predicted average crash frequency of vehicle-pedestrian crashes for an individual roadway segment
- N_{biker} = predicted average crash frequency of vehicle-bicycle crashes for an individual roadway segment
- C_r = calibration factor for roadway segments of a specific type developed for use for a particular geographical area

Predicting Crash Frequency for Peds + Bikes on Urban/Suburban Streets

$$N_{pedr} = N_{br} \times f_{pedr}$$

Exhibit 12-17: Pedestrian Accident Adjustment Factor for Roadway Segments

Road type	Pedestrian Accident Adjustment Factor (f_{pedr})	
	Posted Speed 30 mph or Lower	Posted Speed Greater than 30 mph
2U	0.036	0.005
3T	0.041	0.013
4U	0.022	0.009
4D	0.067	0.019
5T	0.030	0.023

Predicting Crash Frequency for Peds + Bikes on Urban/Suburban Streets

From continued Example:

4-Ln Undivided

40 mph

Exhibit 12-17: Pedestrian Accident Adjustment Factor for Roadway Segments

Road type	Pedestrian Accident Adjustment Factor (f_{pedr})	
	Posted Speed 30 mph or Lower	Posted Speed Greater than 30 mph
2U	0.036	0.005
3T	0.041	0.013
4U	0.022	0.009
4D	0.067	0.019
5T	0.030	0.023

$$N_{pedr} = N_{br} \times f_{pedr}$$

= 93.9 crashes per year x 0.009

= 0.85 crashes per year

Predicting Crash Frequency for Peds + Bikes on Urban/Suburban Streets

$$N_{biker} = N_{br} \times f_{biker}$$

Exhibit 12-18: Bicycle Accident Adjustment Factors for Roadway Segments

Road type	Bicycle Accident Adjustment Factor (f_{biker})	
	Posted Speed 30 mph or Lower	Posted Speed Greater than 30 mph
2U	0.018	0.004
3T	0.027	0.007
4U	0.011	0.002
4D	0.013	0.005
5T	0.050	0.012

Predicting Crash Frequency for Peds + Bikes on Urban/Suburban Streets

Exhibit 12-18: Bicycle Accident Adjustment Factors for Roadway Segments

Road type	Bicycle Accident Adjustment Factor (f_{biker})	
	Posted Speed 30 mph or Lower	Posted Speed Greater than 30 mph
2U	0.018	0.004
3T	0.027	0.007
4U	0.011	0.002
4D	0.013	0.005
5T	0.050	0.012

From continued Example:

$$N_{biker} = N_{br} \times f_{biker}$$

4-Ln Undivided **= 93.9 crashes per year x 0.002**

40 mph = high speed **= 0.19 crashes per year**

Predicting Crash Frequency for Peds + Bikes on Urban/Suburban Streets

4th Step

$$N_{predicted\ rs} = (N_{br} + N_{pedr} + N_{biker})\ C_r$$

$$N_{predicted\ rs} = (93.9 + 0.85 + 0.19)\times 1$$

$$= 94.94 \text{ crashes per year}$$

Predicting Crash Frequency of Suburban/Urban Multilane Streets

Learning Outcomes:

- ►Described Crash Modification Factors for Multilane Suburban/Urban Streets
- ►Applied Crash Modification Factors (CMF's) to Predicted Crash Frequency for Multilane Suburban/Urban Streets

Introduction and Background

Questions and Discussion: