

# HSM Applications to Suburban/Urban Multilane Intersections

## Applying Crash Modification Factors to Predicted Crashes for Suburban/Urban Multilane Intersections

### - Session #11



# Applying Crash Modification Factors for Suburban/Urban Multilane Intersections

## Learning Outcomes:

- ▶ Describe the Crash Modification Factors for Multilane Suburban/Urban Intersections
- ▶ Apply Crash Modification Factors to Predicted Crash Frequency for Multilane Suburban/Urban Intersections

# Predicting Crash Frequency for Urban/Suburban At-Grade Intersections

$$N_{bi} = N_{spf\ int} (CMF_{1i} \times CMF_{2i} \dots CMF_{ni})$$

**Where:**

- $N_{bi}$  = Predicted number of total roadway segment crashes per year with CMFs applied
- $N_{spf\ int}$  = Predicted number of total roadway segment crashes per year for base conditions
- $CMF_{1i} \times CMF_{2i} \dots CMF_{ni}$  = Crash Modification Factors for intersections

# CMF's for Urban Multilane Intersections

- ▶ Left-Turn Lanes
- ▶ Left-Turn Signal phasing
- ▶ Right Turn Lanes
- ▶ Right Turn on Red
- ▶ Lighting
- ▶ Red Light Camera Photo Enforcement

# CMF<sub>1i</sub> for Presence of Left-Turn Lanes at Urban/Suburban Multilane Intersections:

**Table 12-24.** Crash Modification Factor (CMF<sub>1i</sub>) for Installation of Left-Turn Lanes on Intersection Approaches

Intersection Type	Intersection Traffic Control	Number of Approaches with Left-Turn Lanes <sup>a</sup>			
		One Approach	Two Approaches	Three Approaches	Four Approaches
Three-leg intersection	Minor-road stop control <sup>b</sup>	0.67	0.45	—	—
	Traffic signal	0.93	0.86	0.80	—
Four-leg intersection	Minor-road stop control <sup>b</sup>	0.73	0.53	—	—
	Traffic signal	0.90	0.81	0.73	0.66

<sup>a</sup> Stop-controlled approaches are not considered in determining the number of approaches with left-turn lanes.

<sup>b</sup> Stop signs present on minor-road approaches only.

**For STOP-Controlled Intersections: CMF applies only on uncontrolled major-road approaches**

# CMF<sub>1i</sub> for Left Turn Lane on one approach for a three-Leg Intersection:

**Table 14-10.** Potential Crash Effects of Providing a Left-Turn Lane on One Approach to Three-Leg Intersections (15,16)

Treatment	Setting (Intersection Type)	Traffic Volume AADT (veh/day)	Crash Type (Severity)	CMF	Std. Error
Provide a left-turn lane on one major-road approach	Urban (Minor-road, stop-controlled three-leg intersection) (16)	Major road 1,500 to 40,600, minor road 200 to 8,000	All types (All severities)	0.67	0.2
	i	Unspecified	All types (All severities)		
	Urban (Signal-controlled three- leg intersection) (16)			0.93	N/A°
	Urban (Signal-controlled three-leg intersection) (15)			0.94	N/A°
	Urban (Minor-road, stop-controlled three-leg intersection) (15)	Unspecified	All types (Injury)	0.65	N/A°

# CMF<sub>1i</sub> for Left Turn Lane on one approach for a four-Leg Intersection:

**Table 14-11.** Potential Crash Effects of Providing a Left-Turn Lane on One Approach to Four-Leg Intersections (16)

Treatment	Setting (Intersection Type)	Traffic Volume AADT (veh/day)	Crash Type (Severity)	CMF	Std. Error
Provide a left-turn lane on one major-road approach	Urban (Four-leg, minor-road stop-controlled intersection)	Major road 1,500 to 40,600, minor road 200 to 8,000	All types (All severities)	<b>0.73</b>	<b>0.04</b>
			All types (Injury)	<b>0.71</b>	<b>0.05</b>
	Urban (Four-leg signalized intersection)	Major road 7,200 to 55,100, minor road 550 to 2,600	All types (All severities)	<b>0.90*</b>	<b>0.1</b>
			All types (Injury)	<b>0.91</b>	<b>0.02</b>
	Urban (Four-leg newly signalized intersection)	Major road 4,600 to 40,300, minor road 100 to 13,700	All types (All severities)	<b>0.76</b>	<b>0.03</b>
			All types (Injury)	<b>0.72</b>	<b>0.06</b>

# CMF<sub>1i</sub> for Left Turn Lane on two approaches for a four-Leg Intersection:

**Table 14-12.** Potential Crash Effects of Providing a Left-Turn Lane on Two Approaches to Four-Leg Intersections (16)

Treatment	Setting (Intersection Type)	Traffic Volume AADT (veh/day)	Crash Type (Severity)	CMF	Std. Error
Provide a left-turn lane on both major-road approaches	Urban (Four-leg, minor-road stop-controlled intersection)	Major road 1,500 to 40,600, minor road 200 to 8,000	All types (All severities)	0.53	0.04
			All types (Injury)	0.50	0.06
	Urban (Four-leg Signalized intersection)	Major road 7,200 to 55,100, minor road 550 to 2,600	All types (All severities)	0.81	0.1
			All types (Injury)	0.83	0.02
	Urban (Four-leg newly signalized <sup>a</sup> intersection)	Major road 4,600 to 40,300, minor road 100 to 13,700	All types (All severities)	0.58	0.04
			All types (Injury)	0.52	0.07

# CMF<sub>2i</sub> for Type of Left-Turn Signal Phasing at Urban/Suburban Multilane Intersections:

Table 12-25. Crash Modification Factor (CMF<sub>2i</sub>) for Type of Left-Turn Signal Phasing

Type of Left-Turn Signal Phasing	CMF <sub>2i</sub>
Permissive	1.00
Protected/permissive or permissive/protected	0.99
Protected	0.94

**If several approaches have left-turn phasing:**

- **CMF values for each approach should be multiplied together**
- **CMF<sub>2 approaches protected</sub> = 0.94 x 0.94 = 0.88**

# CMF<sub>3i</sub> for Presence of Right-Turn Lanes at Urban/Suburban Multilane Intersections:

**Table 12-26.** Crash Modification Factor (CMF<sub>3i</sub>) for Installation of Right-Turn Lanes on Intersection Approaches

Intersection Type	Type of Traffic Control	Number of Approaches with Right-Turn Lanes <sup>a</sup>			
		One Approach	Two Approaches	Three Approaches	Four Approaches
Three-leg intersection	Minor-road stop control <sup>b</sup>	0.86	0.74	—	—
	Traffic signal	0.96	0.92	—	—
Four-leg intersection	Minor-road stop control <sup>b</sup>	0.86	0.74	—	—
	Traffic signal	0.96	0.92	0.88	0.85

# CMF<sub>4i</sub> for Prohibiting Right-Turn On Red at Urban/Suburban Multilane Intersections:

$$\text{CMF}_{4i} = (0.98)^{n_{\text{prohib}}}$$



Where,

CMF<sub>4i</sub> = CMF for the effect of prohibiting right turns on red on total crashes

n<sub>prohib</sub> = number of signalized intersection approaches for which right turn on red is prohibited

- **Example: For 2 approaches, n=2**

$$\text{CMF}_{4i} = (0.98)^n = (0.98)^2 = 0.96$$

# CMF<sub>5i</sub> for Lighting at Urban/Suburban Multilane Intersections:

**Table 12-27.** Nighttime Crash Proportions for Unlighted Intersections

Intersection Type	Proportion of Crashes that Occur at Night
	P <sub>ni</sub>
3ST	0.238
4ST	0.229
3SG and 4SG	0.235

Where:

$$\text{CMF}_{5i} = 1 - 0.38P_{ni}$$

CMF<sub>5i</sub> = CMF for the effect of lighting on total crashes

P<sub>ni</sub> = proportion of total crashes for unlighted intersections that occur at night

# CMF<sub>5i</sub> for Lighting

**Example: For 4 Approach Signalized Intersection  
Signalized (4SG) with no lighting:**

$$\begin{aligned} \text{CMF}_{5i} &= 1 - 0.38p_{nr} \\ &= 1 - 0.38 \times 0.235 = 0.9107 \\ &= 1.00 \text{ as the base condition is unlit} \end{aligned}$$

**Example: For 4 Approach Signalized Intersection  
Signalized (4SG) with lighting:**

$$\begin{aligned} \text{CMF}_{5i} &= 1 - 0.38 p_{nr} \\ &= 1 - 0.38 \times 0.235 \\ &= 0.9107 \end{aligned}$$

# CMF<sub>6i</sub> for Red Light Running Automated Enforcement:

Exhibit 14-38: Potential Crash Effects of Installing Red-Light Cameras at Intersections<sup>(23,30)</sup>

Treatment	Setting (Intersection type)	Traffic Volume	Accident type (Severity)	AMF	Std. Error
Install red light cameras	Urban (Unspecified)	Unspecified	Right-angle and left-turn opposite direction (All severities) <sup>(23,30)</sup>	<b>0.74<sup>2+</sup></b>	<b>0.03</b>
			Right-angle and left-turn opposite direction (Injury) <sup>(23)</sup>	<b>0.84<sup>2</sup></b>	<b>0.07</b>
			Rear-end (All severities) <sup>(23,30)</sup>	<b>1.18<sup>2+</sup></b>	<b>0.03</b>
			Rear-end (Injury) <sup>(23)</sup>	<b>1.24<sup>2</sup></b>	<b>0.1</b>

Base Condition: A signalized intersection without red-light cameras



# Applying CMF's to Urban Multilane Intersection: Exercise

## Four-Leg Signalized Intersection:

- 25,000 ADT and 5,000 ADT
- Lt & Rt Turn Lanes on Major Approaches
- Protected Left-Turn Phasing on Major Road
- Lighted

$$N_{\text{spf int}} = 6.44 \text{ crashes/yr}$$

$$CMF_{1i} = \underline{\quad ? \quad}$$

$$CMF_{2i} = \underline{\quad ? \quad}$$

$$CMF_{3i} = \underline{\quad ? \quad} \quad CMF_{4i} = \underline{\quad ? \quad} \quad CMF_{5i} = \underline{\quad ? \quad} \quad CMF_{6i} = \underline{\quad ? \quad}$$



# Applying CMF's to Urban Multilane Intersection: Exercise

## Four-Leg Signalized Intersection:

- 25,000 ADT and 5,000 ADT
- Lt & Rt Turn Lanes on Major Approaches
- Protected Left-Turn Phasing on Major Road
- Lighted

$$\begin{aligned}
 N_{bi} &= N_{spf\ int} (CMF_{1i} \times CMF_{2i} \dots CMF_{6i}) \\
 &= 6.44 \left( \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \right. \\
 &\quad \left. \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \right) \\
 &= \underline{\hspace{2cm}} \text{ crashes per year}
 \end{aligned}$$

# Predicting Crash Frequency for Urban/Suburban At-Grade Intersections

$$N_{int} = (N_{bi} + N_{pedi} + N_{bikei}) C_i$$

**Where:**

**$N_{int}$  = Predicted number of total intersection crashes per year after application of CMF's**

**$N_{bi}$  = Predicted number of total intersection crashes per year (excluding ped and bike crashes)**

**$N_{pedi}$  = Predicted number of vehicle-ped crashes per year**

**$N_{bikei}$  = Predicted number of vehicle-bicycle collisions per year**

**$C_i$  = calibration factor for a particular geographical area**

# Applying Crash Modification Factors for Suburban/Urban Multilane Intersections

## Learning Outcomes:

- ▶ Described the Crash Modification Factors for Multilane Suburban/Urban Intersections
- ▶ Applied Crash Modification Factors to Predicted Crash Frequency for Multilane Suburban/Urban Intersections

# Applying Crash Modification Factors for Suburban/Urban Multilane Intersections

Questions and Discussion:

