Data-Driven Safety Training
Urban 4-Leg Signalized Intersection
Part 3 Example

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Outline

1 U4SG required data

2 Landing observed intersection crashes

3 Desired/optional data

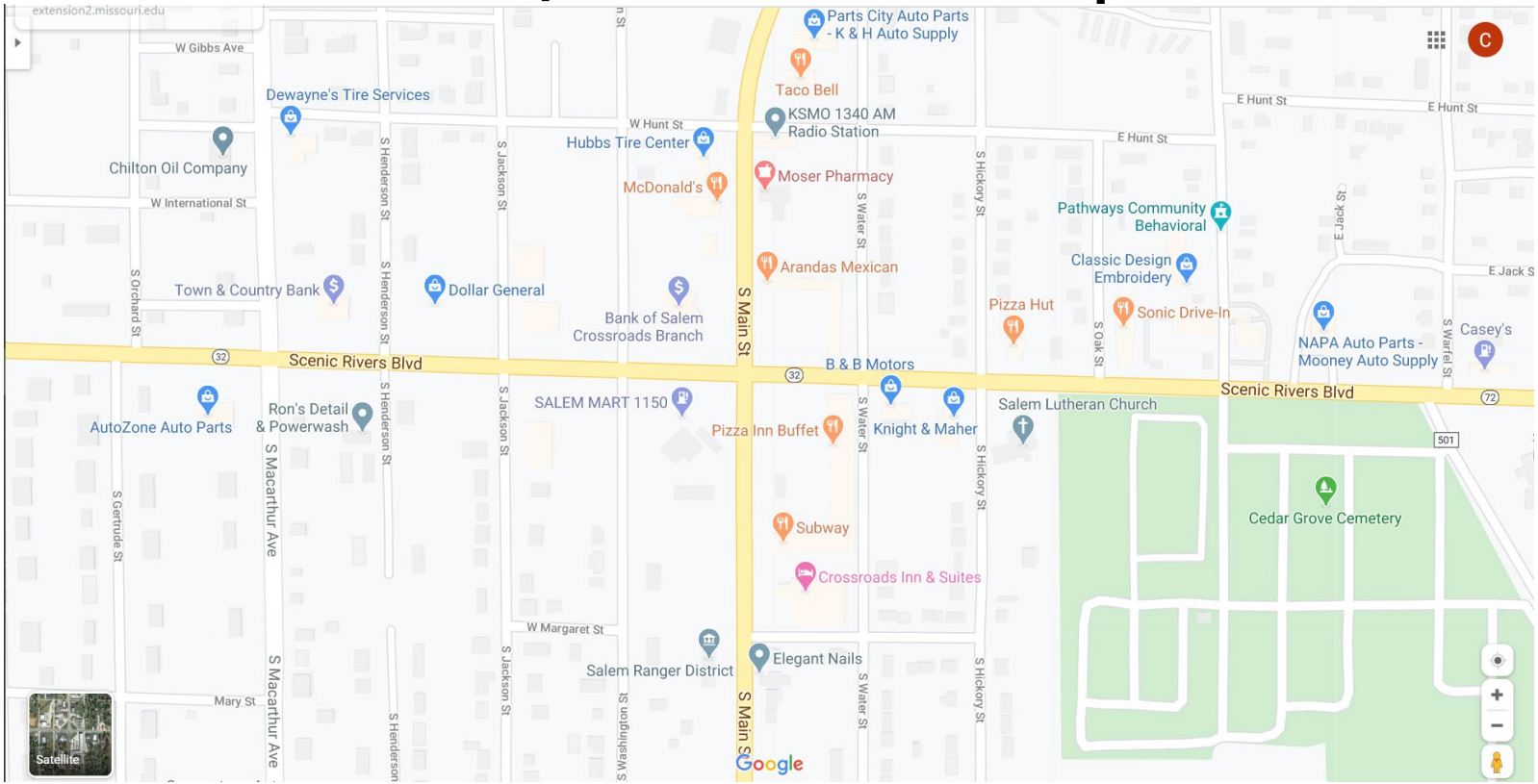
4 Predictive structure

5 Salem MO-32/MO-19 example

Salem MO-32/MO-19 Example

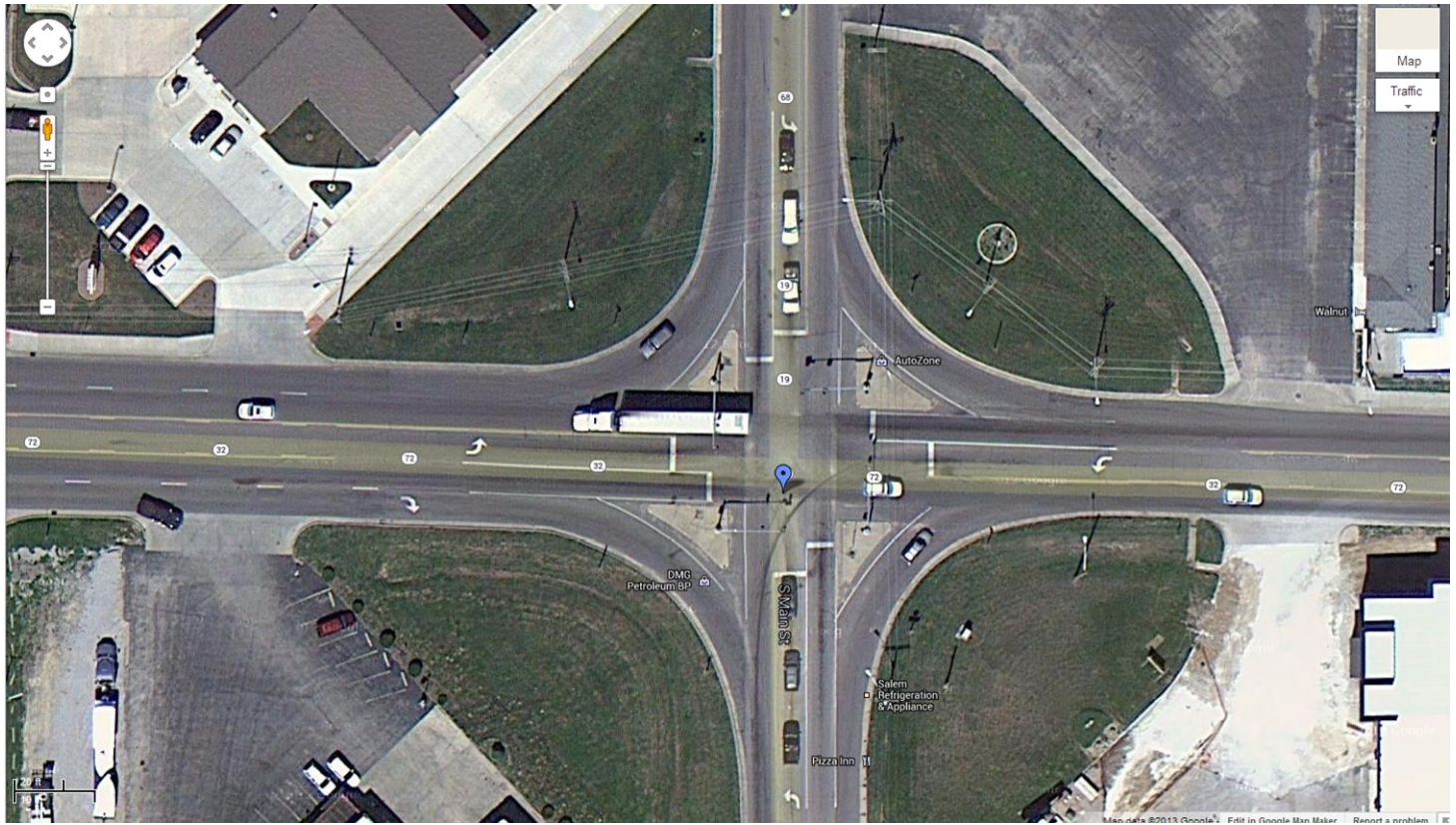
- Urban 4-leg signalized intersection
- In Salem, Dent County
- MoDOT Intersection #458532
- MO 32 and MO 19 (Main St.)
- Year of analysis 2015

Salem MO-32/MO-19 Example



Google 2020

MO-32


Map
Traffic
Walnut
AutoZone
DMG
Petroleum BP
S Main St
Salem
Refrigeration
& Appliance
Pizza Inn

MO-32/MO-19 Data

- MO-32 AADT 11,535 vpd
- MO-19 AADT 6,908
- Lighting present, e.g. streetview picture
- Urban 4-leg signalized intersection calibration 5.21
- Severity distribution F 0.002, Sev Inj 0.021, Min Inj 0.228, PDO 0.749
- LT lane approaches 4 (as seen in aerial)
- RT lane approaches 4 (as seen in aerial)

MO-32/MO-19 Data

- All 4 LT are permissive/protected
- obtain signal info from district or streetview
- No RTOR
- NO RLC
- Pedvol = 240 (medium-low activity)
- Max # lanes crossed by ped = 3 (note refuge islands)

MO-32/MO-19 Data

- # bus stops w/in 1000 ft = 0
- # schools w/in 1000 ft = 0
- # alcohol establishments w/in 1000 ft = 3
- # observed crashes = 7 crashes/year

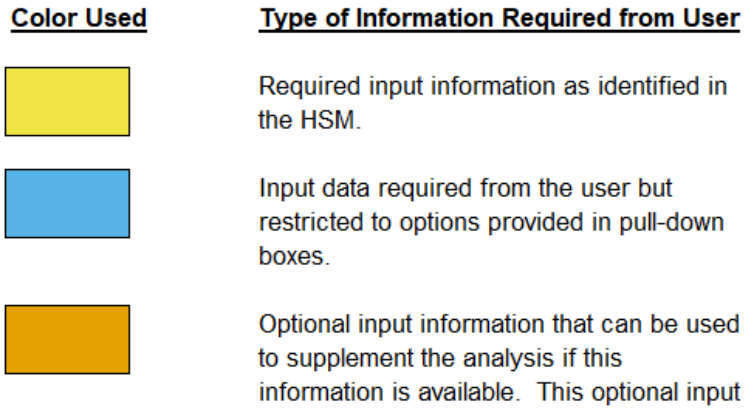
MO-32/MO-19 Exercise

Learning recommendation

- Given data collected for MO-32/MO-19 intersection, attempt the modeling on your own first
- Review the modeling performed by the instructor
- Compare and note any differences

HSM Spreadsheet

- HSM_CPM_UrbanSuburbanArterials_v3.0.xlsx
- Download from
  - http://www.highwaysafetymanual.org/Pages/Tools.aspx
- **Instructions** worksheet provides an overview of the spreadsheet
  - e.g. colors indicate info needed



Color Used	Type of Information Required from User
	Required input information as identified in the HSM.
	Input data required from the user but restricted to options provided in pull-down boxes.
	Optional input information that can be used to supplement the analysis if this information is available. This optional input

HSM Spreadsheet Solution

- Spreadsheet set up to model entire urban segment, including intersections
- Our example focuses on urban 4-leg signalized
- Use worksheet **Intersection_1**
- Enter General Information

Worksheet 2A -- General Information and Input Data for Urban and Suburban Arterial Intersections				
General Information			Location Information	
Analyst		Carlos Sun	Roadway	MO 32
Agency or Company		Mizzou	Intersection	MO-32/MO-19
Date Performed		01/18/20	Jurisdiction	Salem, Dent County
			Analysis Year	2015

HSM Spreadsheet Solution

8	Input Data		Base Conditions	Site Conditions
9	Intersection type (3ST, 3SG, 4ST, 4SG)		--	4SG
10	AADT $_{major}$ (veh/day)	$AADT_{MAX}$ = 67,700 (veh/day)	--	11,535
11	AADT $_{minor}$ (veh/day)	$AADT_{MAX}$ = 33,400 (veh/day)	--	6,908
12	Intersection lighting (present/not present)		Not Present	Present
13	Calibration factor, C_i		1.00	5.21
14	Data for unsignalized intersections only:		--	--
15	Number of major-road approaches with left-turn lanes (0,1,2)		0	0
16	Number of major-road approaches with right-turn lanes (0,1,2)		0	0
17	Data for signalized intersections only:		--	--
18	Number of approaches with left-turn lanes (0,1,2,3,4) [for 3SG, use maximum value of 3]		0	4
19	Number of approaches with right-turn lanes (0,1,2,3,4) [for 3SG, use maximum value of 3]		0	4
20	Number of approaches with left-turn signal phasing [for 3SG, use maximum value of 3]		--	4
21	Type of left-turn signal phasing for Leg #1		Permissive	Protected / Permissive
22	Type of left-turn signal phasing for Leg #2		--	Protected / Permissive
23	Type of left-turn signal phasing for Leg #3		--	Protected / Permissive
24	Type of left-turn signal phasing for Leg #4 (if applicable)		--	Protected / Permissive
25	Number of approaches with right-turn-on-red prohibited [for 3SG, use maximum value of 3]		0	0
26	Intersection red light cameras (present/not present)		Not Present	Not Present
27	Sum of all pedestrian crossing volumes (PedVol) -- Signalized intersections only			240
28	Maximum number of lanes crossed by a pedestrian (n_{lanesx})		--	3
29	Number of bus stops within 300 m (1,000 ft) of the intersection		0	0
30	Schools within 300 m (1,000 ft) of the intersection (present/not present)		Not Present	Not Present
31	Number of alcohol sales establishments within 300 m (1,000 ft) of the intersection		0	3

CMF Results

- LT lanes -> 0.66
- LT permissive/protected phasing -> 0.96
- RT lanes -> 0.85
- Lighting -> 0.91
- Combined -> 0.49

Worksheet 2B -- Crash Modification Factors for Urban and Suburban Arterial Intersections						
(1)	(2)	(3)	(4)	(5)	(6)	(7)
CMF for Left-Turn Lanes	CMF for Left-Turn Signal Phasing	CMF for Right-Turn Lanes	CMF for Right Turn on Red	CMF for Lighting	CMF for Red Light Cameras	Combined CMF
CMF 1i	*CMF 2i*	*CMF 3i*	*CMF 4i*	*CMF 5i*	*CMF 6i*	CMF_{COMB}
from Table 12-24	from Table 12-25	from Table 12-26	from Equation 12-35	from Equation 12-36	from Equation 12-37	(1)*(2)*(3)*(4)*(5)*(6)
0.66	0.96	0.85	1.00	0.91	1.00	0.49

Predicted Crashes MV

- SPF predicts base crashes = 2.861 crashes/year
- Multiply by CMFs and calibration factor,
  - total crashes = 7.310 crashes/year
- FI crashes also predicted

Worksheet 2C -- Multiple-Vehicle Collisions by Severity Level for Urban and Suburban Arterial Intersections

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(8)	(9)
Crash Severity Level	**SPF Coefficients**			**Overdispersion Parameter, k**	**Initial N_{bimv}**	**Proportion of Total Crashes**	**Adjusted N_{bimv}**	**Combined CMFs**	**Calibration Factor, C_i**	**Predicted N_{bimv}**
	from Table 12-10			from Table 12-10	from Equation 12-21		$(4)_{TOTAL}$*(5)	(7) from Worksheet 2B		(6)*(7)*(8)
	a	b	c							
Total	-10.99	1.07	0.23	0.39	2.861	1.000	2.861	0.49	5.21	7.310
Fatal and Injury (FI)	-13.14	1.18	0.22	0.33	0.854	$\frac{(4)_{FI}/((4)_{FI}+(4)_{PDO})}{0.310}$	0.887	0.49	5.21	2.266
Property Damage Only (PDO)	-11.02	1.02	0.24	0.44	1.900	$\frac{(5)_{TOTAL}-(5)_{FI}}{0.690}$	1.974	0.49	5.21	5.044

Predicted Crashes SV

- SPF predicts base crashes = 0.232 crashes/year
- Multiply by CMFs and calibration factor,
  - total crashes = 0.592 crashes/year
- Much fewer SV crashes at intersection vs. MV

Worksheet 2E -- Single-Vehicle Collisions by Severity Level for Urban and Suburban Arterial Intersections

(1)	(2)			(3)	(4)	(5)	(6)	(7)	(8)	(9)
Crash Severity Level	**SPF Coefficients** from Table 12-12			**Overdispersion Parameter, k** from Table 12-12	**Initial N_{bisv}** from Eqn. 12-24; (FI) from Eqn. 12-24 or 12-27	**Proportion of Total Crashes**	**Adjusted N_{bimv}** $(4)_{TOTAL}*(5)$	**Combined CMFs** (7) from Worksheet 2B	**Calibration Factor, C_i**	**Predicted N_{bisv}** (6)*(7)*(8)
	a	b	c							
Total	-10.21	0.68	0.27	0.36	0.232	1.000	0.232	0.49	5.21	0.592
Fatal and Injury (FI)	-9.25	0.43	0.29	0.09	0.070	$(4)_{FI}/((4)_{FI}+(4)_{PDO})$ 0.304	0.070	0.49	5.21	0.180
Property Damage Only (PDO)	-11.34	0.78	0.25	0.44	0.160	$(5)_{TOTAL}-(5)_{FI}$ 0.696	0.161	0.49	5.21	0.412

By Collision Type

- Countermeasures could be specific to collision types
- MV - Rear-end and angle crashes

(1)	(2)	(6)
Collision Type	**Proportion of Collision Type$_{(FI)}$**	**Predicted N $_{bimv\ (TOTAL)}$ (crashes/year)**
	from Table 12-11	(9)$_{PDO}$ from Worksheet 2C
Total	1.000	7.310
		(3)+(5)
Rear-end collision	0.450	3.456
Head-on collision	0.049	0.262
Angle collision	0.347	2.017
Sideswipe	0.099	0.386
Other multiple-vehicle collision	0.055	1.189

Empirical Bayes Adjustment

- Summary Tables Worksheet
- Expected crashes from observed and predicted
- Here, w=0.260, prediction has lower reliability
- From prediction = 7.310 down to expected = 7.080 crashes/year

Worksheet 3A -- Predicted Crashes by Severity and Site Type and Observed Crashes Using the Site-Specific EB Method for Urban and Suburban Arterials

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Collision type / Site type	**Predicted average crash frequency (crashes/year)**			**Observed crashes, $N_{observed}$ (crashes/year)**	**Overdispersion Parameter, k**	**Weighted adjustment, w**	**Expected average crash frequency,**
	$N_{predicted}$ (TOTAL)	$N_{predicted}$ (FI)	$N_{predicted}$ (PDO)			Equation A-5 from Part C Appendix	Equation A-4 from Part C Appendix
INTERSECTIONS							
Multiple-vehicle							
Intersection_1	7.310	2.266	5.044	7.000	0.390	0.260	7.080

Ped CMFs

- Alcohol establishment increase by 1.12

Worksheet 2H -- Crash Modification Factors for Vehicle-Pedestrian Collisions for Urban and Suburban Arterial Signalized Intersections			
(1)	(2)	(3)	(4)
CMF for Bus Stops	CMF for Schools	CMF for Alcohol Sales Establishments	Combined CMF
CMF_{1p}	CMF_{2p}	CMF_{3p}	
from Table 12-28	from Table 12-29	from Table 12-30	(1)*(2)*(3)
1.00	1.00	1.12	1.12

Ped & Bike Crashes

- Few ped & bike crashes predicted

Worksheet 2I -- Vehicle-Pedestrian Collisions for Urban and Suburban Arterial Signalized Intersections

(1)	(2)					(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**SPF Coefficients** from Table 12-14					**Overdispersion Parameter, k**	**$N_{pedbase}$** from Equation 12-29	**Combined CMF** (4) from Worksheet 2H	**Calibration factor, C_i**	**Predicted N_{pedi}** (4)*(5)*(6)
	a	b	c	d	e					
Total	-9.53	0.40	0.26	0.45	0.04	0.24	0.043	1.12	5.21	0.251
Fatal and Injury (FI)	--	--	--	--	--	--	--	--	5.21	0.251

Worksheet 2J -- Vehicle-Bicycle Collisions for Urban and Suburban Arterial Intersections

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Crash Severity Level	**Predicted N_{bimv}** (9) from Worksheet 2C	**Predicted N_{bisv}** (9) from Worksheet 2E	**Predicted N_{bi}** (2) + (3)	**f_{bikei}** from Table 12-17	**Calibration factor, C_i**	**Predicted N_{bikei}** (4)*(5)*(6)
Total	7.310	0.592	7.901	0.015	5.21	0.617
Fatal and injury (FI)	--	--	--	--	5.21	0.617

Treatments

- Analyze expected crashes by severity and type
- High percentage of rear end (45%) and angle (35%) MV crashes
  - Explore signal improvements, e.g. signal backplate for greater visibility
  - Explore conversion to roundabout
- Pedestrian crashes
  - Explore pedestrian countermeasures, e.g. pedestrian head, lead pedestrian interval