Collaborative Sciences Center for ROAD SAFETY

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An Enhanced Systemic Approach to Safety

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Where does a systemic safety approach fit in?

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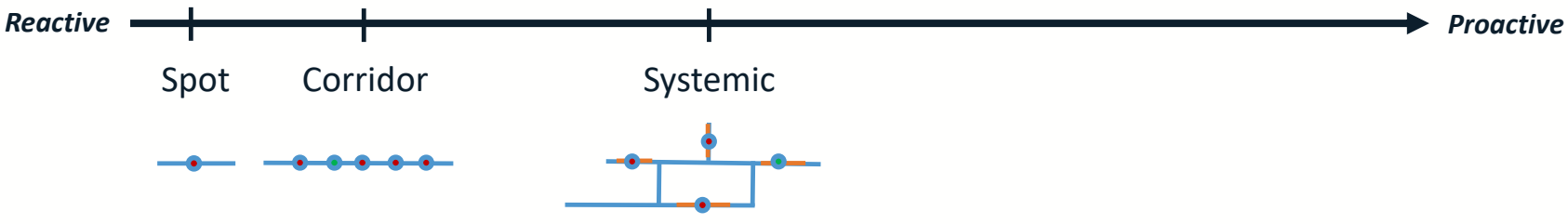
<u>Spot approach:</u>
Improvement at a specific location in response to a-higher-than-expected crash rate at a site

Where does a systemic safety approach fit in?

Corridor approach:
Improvement across a corridor in response to a-higher-than-expected crash rate, or recurring safety concerns along a corridor

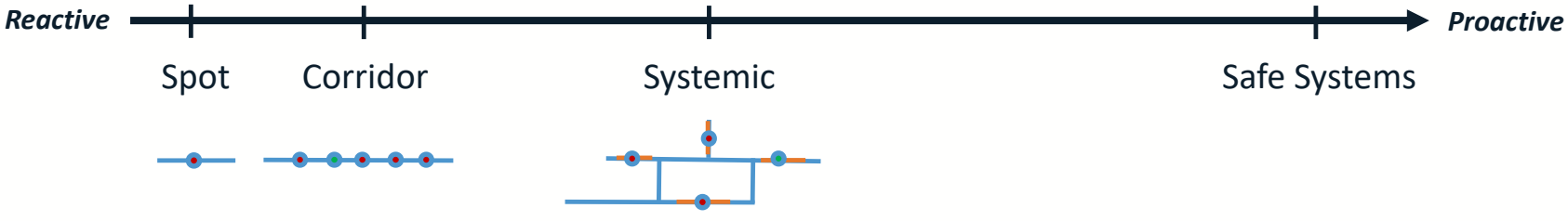
Where does a systemic safety approach fit in?



Systemic approach:

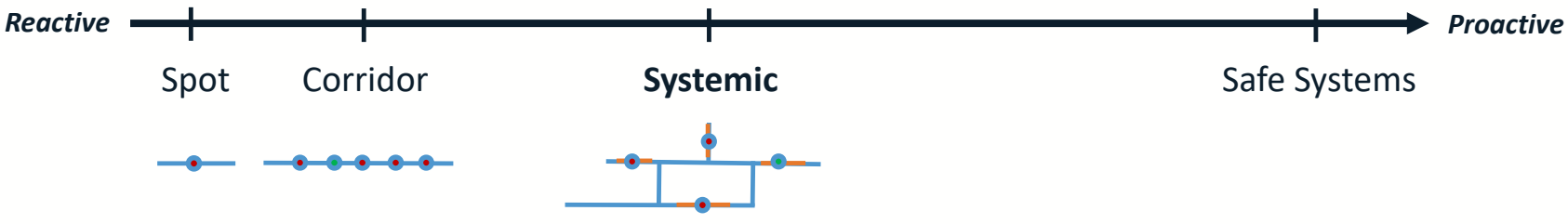
"An improvement that is widely implemented based on high-risk roadway features that are correlated with particular crash types" *FHWA*

Where does a systemic safety approach fit in?



<u>Safe Systems approach:</u>
"Building a system in which people cannot be fatally or severely injured on despite human error" *Soames Job*

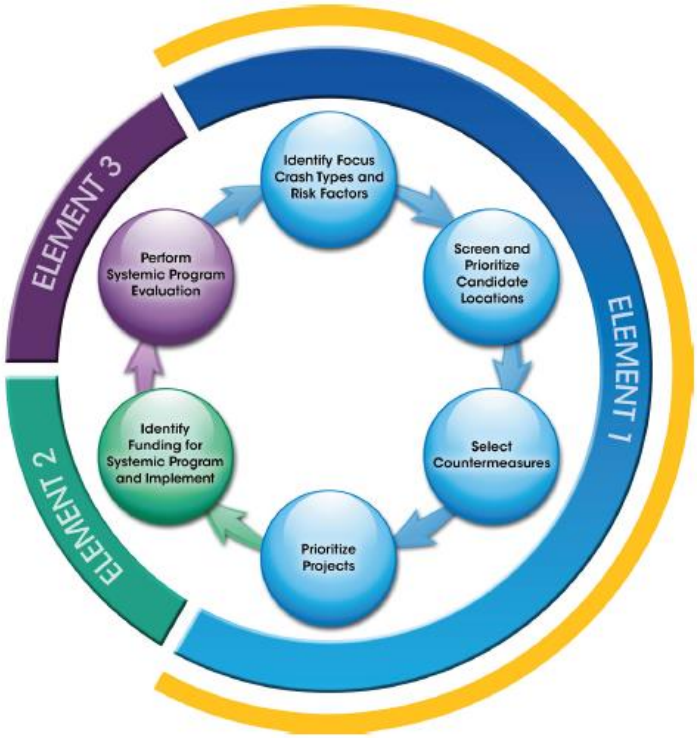
Where does a systemic safety approach fit in?



Systemic approach:

- reactive - it uses historical crash data to identify priorities
- proactive - make improvements also at low or non-crash sites

FHWA's Systemic Safety Program



A systemic matrix approach

Example of a pedestrian safety matrix

Urban and Urbanized, Conventional Highway and City One-Way Street, 2009-2013	Control Type	STEP 2 FILLL IN MATR	Unsignalized					Signalized											Total
	# of Lanes - Main		<=3		>3			<=3		>3									
	# of Lanes - Cross		<=3		<=3		>3	<=3		>3									
	AADT - Main		<50,000	>=50,000	<50,000	>=50,000	<50,000	<50,000		<50,000		<50,000		>=50,000		< 50,000		>= 50,000	
	AADT - Cross		<12,000					<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	
# of Intersections			1197	15	2347	335	3	166	22	23	21	901	54	148	15	271	208	56	67	5876

Facility Types

Pedestrian Movements	Primary Collision Factors
Xing Xwalk – Intersection	Influence of Alcohol
	Following too close
	Failure to Yield
	Improper Turn
	Speeding
	Other Violations
	Failure to Yield
	Improper Turn
	Other Violations
Xing – Not Xwalk	Influence of Alcohol
	Failure to Yield
	Improper Turn
	Speeding
	Other Violations
Roadway – Include Shoulder	Influence of Alcohol
	Failure to Yield
	Improper Turn
	Speeding
	Other Violations
Not in Roadway	Influence of Alcohol
	Failure to Yield
	Improper Turn
	Speeding
	Other Violations
Total	
Rate (crashes/intersection)	

Crash Types

** Systemic pedestrian matrix developed by SafeTREC for Caltrans*

A systemic matrix approach

What type of crashes are happening on what type of facilities?

Urban and Urbanized, Conventional Highway and City One-Way Street, 2009-2013	Control Type	STEP 2 FILLL IN MATR	Unsignalized					STEP 3 SYSTEMIC	Signalized										Total
	# of Lanes - Main		<=3		>3				<=3		>3								
	# of Lanes - Cross		<=3		<=3				<=3		>3								
	AADT - Main		<50,000	>=50,000	<50,000	>=50,000			<50,000		<50,000								
	AADT - Cross		<12,000						<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	
# of Intersections			1197	15	2347	335	3		166	22	23	21	901	54	148	15	271	208	56	67	5876
Pedestrian Movements	Primary Collision Factors																				
Xing Xwalk – Intersection	Influence of Alcohol		1		1						1						1				4
	Following too close				1																1
	Failure to Yield		45	1	67	5	2		34	3	1	3	94	4	12	1	28	28	4	16	348
	Improper Turn				6								2					2		1	11
	Speeding		1		2								2		1						6
	Other Violations		12		36	1			12		4	2	35	3	9	2	14	14	4	8	156
	Failure to Yield				2	1				1										2	6
	Improper Turn				1																1
	Other Violations				1							1									2
Xing – Not Xwalk	Influence of Alcohol				1																1
	Failure to Yield		6		10	2							3				1				22
	Improper Turn				1									1	1					1	4
	Speeding		4		2								1					1			8
	Other Violations		31		51	1	2		3	2	1		22	1	4		16	3	1	4	142
Roadway – Include Shoulder	Influence of Alcohol		3										1				1		1		6
	Failure to Yield		1		1	1									1			2			6
	Improper Turn		4		3								1								8
	Speeding		5		4								1								10
	Other Violations		11	1	9	1					1		5		1		2	3		1	35
Not in Roadway	Influence of Alcohol														1			1			2
	Failure to Yield		3		1	1							7				1	2		3	18
	Improper Turn		2		1	1											3				7
	Speeding		2		4				1									2			9
	Other Violations				2				1				6	1	2		1	1			14
Total			131	2	207	14	4		51	6	8	6	180	10	32	3	68	59	10	36	827
Rate (crashes/intersection)			0.11	0.13	0.09	0.04	1.33		0.31	0.27	0.35	0.29	0.20	0.19	0.22	0.20	0.25	0.28	0.18	0.54	0.14

Facility Types

Crash Types

** Systemic pedestrian matrix developed by SafeTREC for Caltrans*

A systemic matrix approach

What type of crashes are happening on what type of facilities?

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	AADT - Main		<50,000	>=50,000	<50,000	>=50,000		<50,000		<50,000			<50,000				< 50,000		>= 50,000	
	AADT - Cross		<12,000					<12,000	>=12,000	<12,000	>=12,000		<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	
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	Following too close				1															1
	Failure to Yield		45	1	67	5	2	34	3	1	3	94	4	12	1	28	28	4	16	348
	Improper Turn				6							2					2		1	11
	Speeding		1		2							2		1						6
	Other Violations		12		36	1		12		4	2	35	3	9	2	14	14	4	8	156
Xing – Not Xwalk	Failure to Yield				2	1			1										2	6
	Improper Turn				1															1
	Other Violations				1						1									2
	Influence of Alcohol				1															1
	Failure to Yield		6		10	2						3				1				22
	Improper Turn				1							1							1	4
	Speeding		4		2							1					1			8
	Other Violations		31		51	1	2	3	2	1		22	1	4		16	3	1	4	142
Roadway – Include Shoulder	Influence of Alcohol		3									1				1		1		6
	Failure to Yield		1		1	1								1			2			6
	Improper Turn		4		3							1								8
	Speeding		5		4							1								10
	Other Violations		11	1	9	1				1		5		1		2	3		1	35
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	Failure to Yield		3		1	1						7				1	2		3	18
	Improper Turn		2		1	1										3				7
	Speeding		2		4			1									2			9
	Other Violations				2			1				6	1	2		1	1			14
Total			131	2	207	14	4	51	6	8	6	180	10	32	3	68	59	10	36	827
Rate (crashes/intersection)			0.11	0.13	0.09	0.04	1.33	0.31	0.27	0.35	0.29	0.20	0.19	0.22	0.20	0.25	0.28	0.18	0.54	0.14

Facility Types

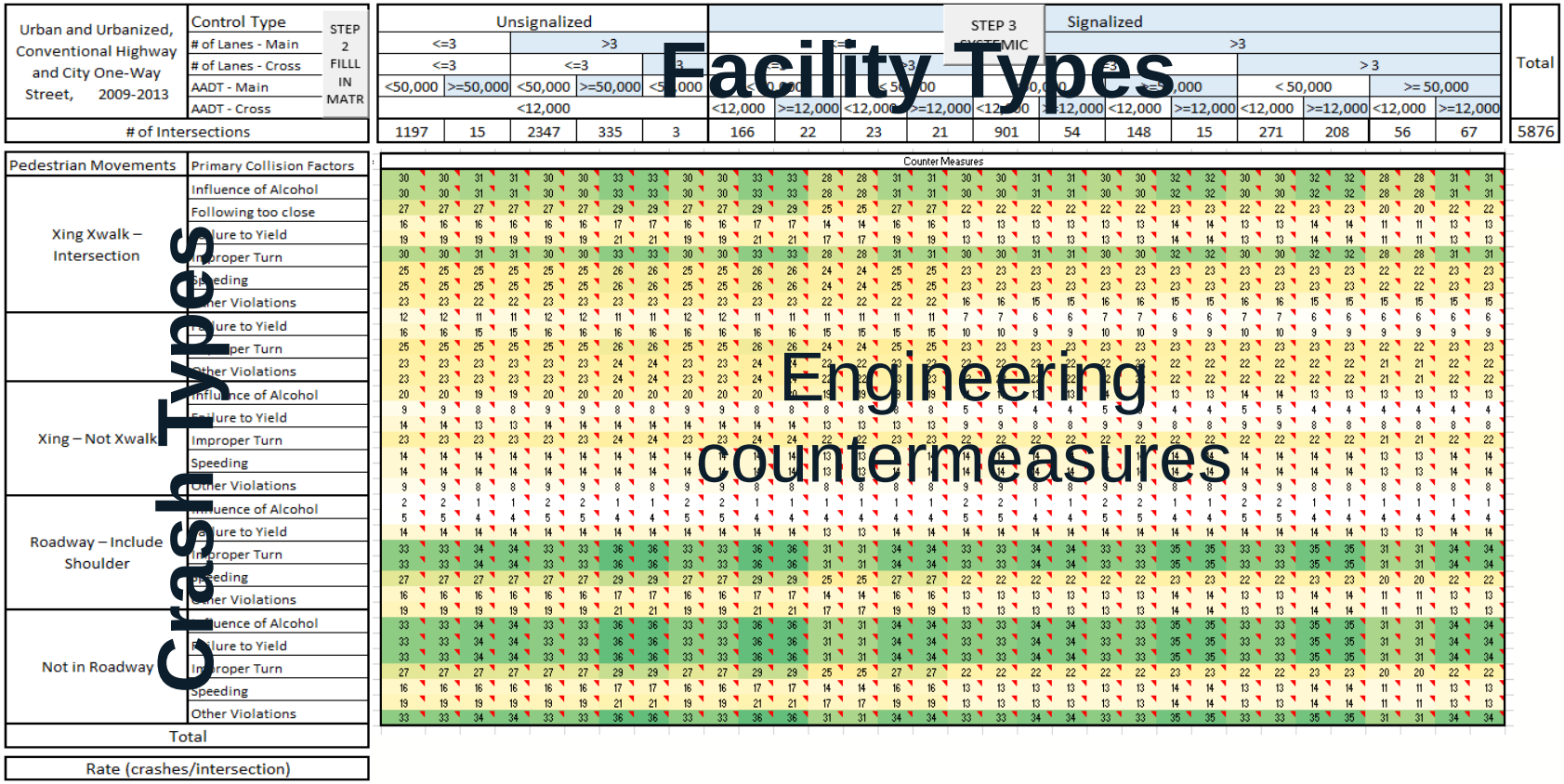
Crash Types

Systemic hotspots

** Systemic pedestrian matrix developed by SafeTREC for Caltrans*

A systemic matrix approach

What are the relevant countermeasures for each matrix cell?



** Systemic pedestrian matrix developed by SafeTREC for Caltrans*

An Enhanced Systemic Approach to Safety

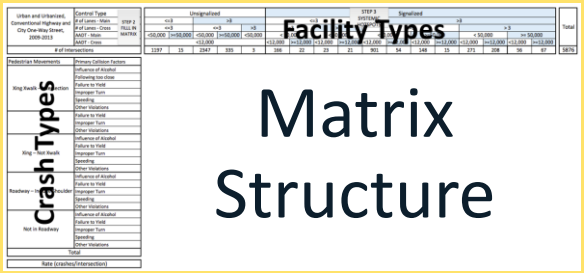
Three overarching objectives:

1. Enhance methods to identify systemic safety concerns
2. Enhance countermeasure scope to include engineering and non-engineering improvements
3. Enhance process to determine high priority locations

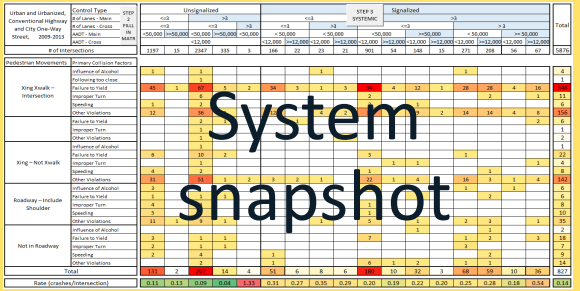
Project goals and activities

1 Enhance methods to identify systemic safety concerns

Develop method to determine crash types and the facility types that need to be included in a matrix for a specific mode



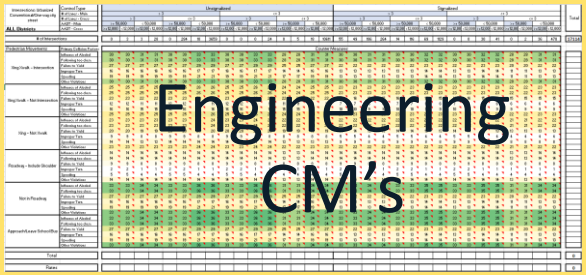
populate mode-specific crash matrices using the data from multiple states



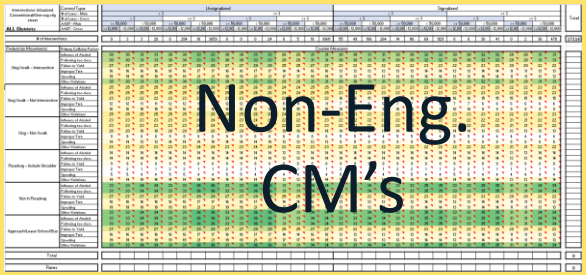
Project goals and activities

2 Enhance countermeasure scope to include engineering and non-engineering improvements

develop a list of engineering safety countermeasures to address crash profiles identified for the different matrices



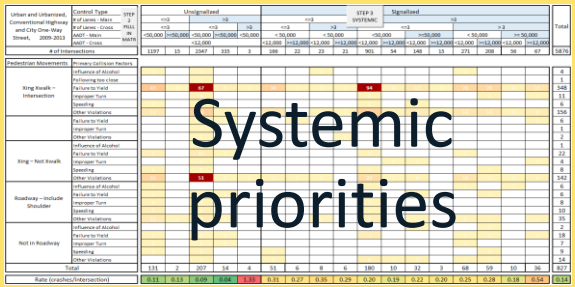
develop a list of non-engineering improvements to address crash profiles identified for the different matrices



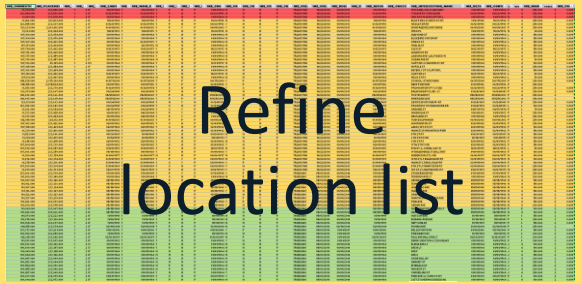
Project goals and activities

3 Enhance process to determine high priority locations

explore the advantages and disadvantages of different methods to identify systemic hotspots

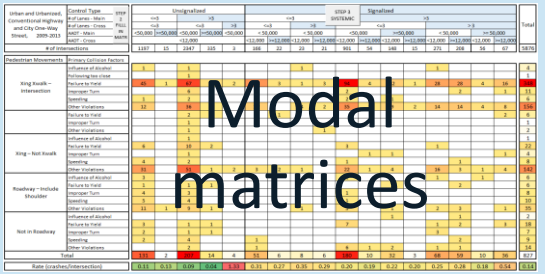


define guidelines for determining upper and lower thresholds for systemic projects

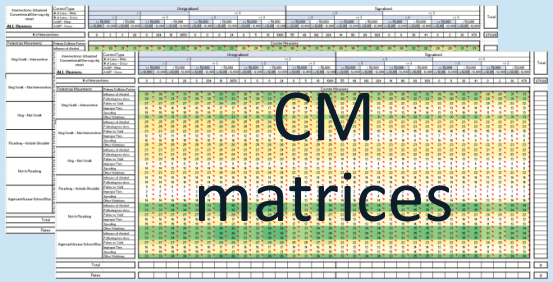


Expected outcomes

1 Guidelines for determining matrix structure across different modes



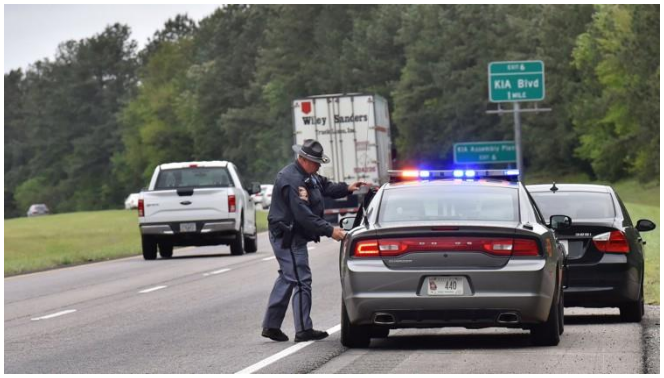
2 Basic toolbox for engineering and non-engineering improvements



3 Considerations for screening criteria for systemic projects

Enforcement countermeasures

- How can it be used?
  - Police enforcement targeted at the identified problematic facilities
- What is the promise?
  - Filling the gaps in the driving code
- What are the limitations?
  - Burdensome state by state legislative analysis
- Guidelines for future considerations



Education countermeasures

- How can it be used?
  - Elaborating an educational countermeasures matrix
- What are the limitations?
  - Multitude of entities involved in road safety trainings
- What is the promise?
  - Lead the development of learning modules
- Guidelines for future considerations

Data requirements

- Three categories of data
  - Crash data (rows)
  - Roadway data (columns)
  - Operations data (columns or risk)
- Source: HSIS (Highway Safety Information System) files
  - accident subfile
  - vehicle/occupant subfiles
  - roadway file
  - intersection file

Challenge: linking the data

Data collection

HSIS Data for 5 years across 7 states:

- California 2010 - 2014
- North Carolina 2010 - 2014
- Ohio 2011 - 2015
- Washington 2011 - 2015
- Illinois 2006 - 2010
- Minnesota 2006- 2010
- Maine 2011 - 2015

Data cleaning in Python

name	year	info	numb_records	numb_variables	variables						
ca10acc	2010	acc	154438	56	'acc_date'	'acctype'	'accyr'	'alch_flg'	'bike_flg'	'caseno'	'cause1'
ca11acc	2011	acc	150465	56	'acc_date'	'acctype'	'accyr'	'alch_flg'	'bike_flg'	'caseno'	'cause1'
ca12acc	2012	acc	145776	56	'ACC_DATE'	'ACCTYPE'	'ACCYR'	'ALCH_FLG'	'BIKE_FLG'	'CASENO'	'CAUSE1'
ca13acc	2013	acc	146529	56	'ACC_DATE'	'ACCTYPE'	'ACCYR'	'ALCH_FLG'	'BIKE_FLG'	'CASENO'	'CAUSE1'
ca14acc	2014	acc	150587	56	'ACC_DATE'	'ACCTYPE'	'ACCYR'	'ALCH_FLG'	'BIKE_FLG'	'CASENO'	'CAUSE1'
ca10int	2010	int	17795	38	'cntyrte'	'county'	'district'	'hwy_grp'	'int_dte'	'int_popgrp'	'int_prf'
ca11int	2011	int	17484	38	'cntyrte'	'county'	'district'	'hwy_grp'	'int_dte'	'int_popgrp'	'int_prf'
ca12int	2012	int	17224	38	'cntyrte'	'county'	'DISTRICT'	'HWY_GRP'	'int_dte'	'INT_POPGRP'	'int_prf'
ca13int	2013	int	0	0							
ca14int	2014	int	17145	38	'cntyrte'	'county'	'DISTRICT'	'HWY_GRP'	'int_dte'	'INT_POPGRP'	'int_prf'
ca10road	2010	road	47399	54	'aadt'	'acc_dte'	'access'	'begmp'	'city'	'cntyrte'	'county'
ca11road	2011	road	49523	54	'aadt'	'acc_dte'	'access'	'begmp'	'city'	'cntyrte'	'county'
ca12road	2012	road	54354	54	'AADT'	'ACC_DTE'	'ACCESS'	'BEGMP'	'CITY'	'cntyrte'	'COUNTY'
ca13road	2013	road	54721	54	'AADT'	'ACC_DTE'	'ACCESS'	'BEGMP'	'CITY'	'cntyrte'	'COUNTY'
ca14road	2014	road	55196	54	'AADT'	'ACC_DTE'	'ACCESS'	'BEGMP'	'CITY'	'cntyrte'	'COUNTY'
ca10veh	2010	veh	308297	29	'accyr'	'caseno'	'cause'	'contrib1'	'contrib2'	'defect'	'dir_trvl'
ca11veh	2011	veh	304266	29	'accyr'	'caseno'	'cause'	'contrib1'	'contrib2'	'defect'	'dir_trvl'
ca12veh	2012	veh	293992	29	'ACCYR'	'CASENO'	'CAUSE'	'CONTRIB1'	'CONTRIB2'	'DEFECT'	'DIR_TRVL'
ca13veh	2013	veh	301104	29	'ACCYR'	'CASENO'	'CAUSE'	'CONTRIB1'	'CONTRIB2'	'DEFECT'	'DIR_TRVL'
ca14veh	2014	veh	307395	29	'ACCYR'	'CASENO'	'CAUSE'	'CONTRIB1'	'CONTRIB2'	'DEFECT'	'DIR_TRVL'

Choosing the Rows and Columns

Facilities

Crash Types

Intersections: Urbanized Conventional/One-way city street	Control Type	Unsignalized																Signalized																Total
	# of Lanes - Main	> 3								<= 3								> 3								<= 3								
	# of Lanes - Cross	> 3				<= 3				> 3				<= 3				> 3				<= 3				> 3				<= 3				
	AADT - Main	>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		
ALL Districts	AADT - Cross	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	>= 12,000	< 12,000	
# of Intersections		0	3	3	28	0	284	10	3659	0	0	0	24	0	5	18	10611	55	49	186	264	14	116	69	1129	0	0	30	41	0	2	36	478	17114
Pedestrian Movements	Primary Collision Factors																																	
Xing Xwalk – Intersection	Influence of Alcohol																																	
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Roadway – Include Shoulder	Influence of Alcohol																																	
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	Speeding																																	
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Not in Roadway	Influence of Alcohol																																	
	Following too close																																	
	Failure to Yield																																	
	Improper Turn																																	
	Speeding																																	
	Other Violations																																	
Approach/Leave School Bus	Influence of Alcohol																																	
	Following too close																																	
	Failure to Yield																																	
	Improper Turn																																	
	Speeding																																	
	Other Violations																																	
Total																																		0
Rates																																		0

Iterative, data-driven process to determine:

- ROWS: **representation of the crash dynamics**
  - collision factors, violations, collision type, movements, etc.
- COLUMNS: **built-environment conditions**
  - traffic controls, volume, speed, number of lanes, median presence, parking, crosswalk, etc.

Decision-making factors: road safety expertise, share of blank cells, kurtosis, table size, etc.

The Countermeasure Matrix

Intersections, Zone:ALL, Road: Conventional/One-way city street	Control Type	Unsignalized														Signalized													
	# of Lanes - Main	> 3						<= 3								> 3				<= 3				> 3				<= 3			
	# of Lanes - Cross	> 3				<= 3				> 3				<= 3		> 3				<= 3				> 3				<= 3			
	AADT - Main	>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000		>= 50,000		< 50,000	
ALL Districts	AADT - Cross	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000	>=12,000	<12,000
# of Intersections		0	3	3	28	0	284	10	3659	0	0	0	24	0	5	18	10611	55	49	186	264	14	116	69	1129	0	0	30	41	0	2	36	478

Pedestrian Movements	Primary Collision Factors
Xing Xwalk – Intersection	Influence of Alcohol
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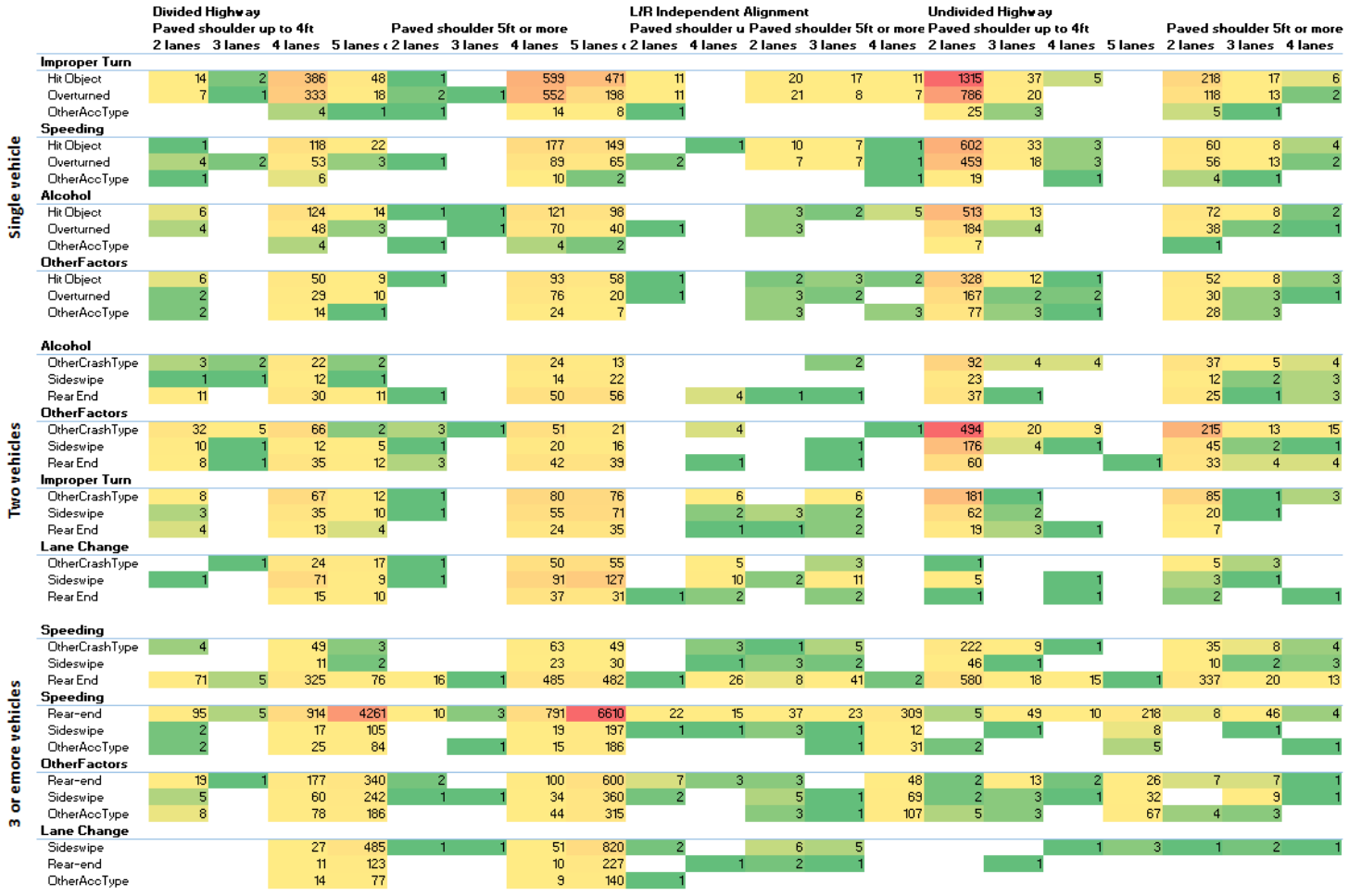
	Improper Turn
	Speeding
	Other Violations
Approach/Leave School Bus	Influence of Alcohol
	Following too close
	Failure to Yield
	Improper Turn
	Speeding
	Other Violations

SUMMARY	
District # or All	ALL
Total # of crashes in district	1302
# of Null crashes (not counted)	125

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		**Countermeasures**	**Locations**												
2		ID & Countermeasures	Urban	Rural	Intersections	Midblock Crossings	Along roadways	Expressway/Freeway	Conventional/One-way city street	Signalized	Unsignalized	High design speed	Low design speed	High volume	Low volu
3	1	Install sidewalks and walkways	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
4	14	Widen sidewalks	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
5	59	Maintain a sidewalk level across the	Y	Y	N	N	Y	N	Y	N	N	Y	Y	Y	Y
6	18	install bike lanes	Y	Y	N	N	Y	N	Y	N	N	Y	Y	Y	Y
7	2	Curb ramps	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
8	11	Curb-extensions	Y	N	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y
9	23	Curb radius reduction	Y	N	Y	N	N	N	Y	Y	Y	N	Y	Y	Y
10	3	Marked crosswalks at signalized	Y	N	Y	N	N	N	Y	Y	N	Y	Y	Y	Y
11	6	Marked crosswalks at unsignalized	Y	N	Y	N	N	N	Y	N	Y	Y	Y	Y	Y
12	12	marked crosswalks at midblock crossings	Y	Y	N	Y	N	N	Y	N	N	Y	Y	Y	Y
13	4	Non-motorist guiding signs	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
14	5	warning signs for motorists(	Y	N	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y
15	53	Adult Crossing Guards	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
16	52	School zone signals	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
17	54	Safe routes to school	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
18	7	Advanced "STOP" markings	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y
19	44	Advanced stop line	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y
20	45	Sign "Stop here for pedestrians"	Y	N	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y

Creating Systemic Matrices



		Divided Highway								L/R Independent Alignment					Undivided Highway						
		Paved shoulder up to 4ft				Paved shoulder 5ft or more				Paved shoulder u		Paved shoulder 5ft or more			Paved shoulder up to 4ft				Paved shoulder 5ft or more		
		2 lanes	3 lanes	4 lanes	5 lanes	2 lanes	3 lanes	4 lanes	5 lanes	2 lanes	4 lanes	2 lanes	3 lanes	4 lanes	2 lanes	3 lanes	4 lanes	5 lanes	2 lanes	3 lanes	4 lanes
Single vehicle	**Improper Turn**																				
	Hit Object	14	2	386	48	1		599	471	11		20	17	11	1315	37	5		218	17	6
	Overturned	7	1	333	18	2	1	552	198	11		21	8	7	786	20			118	13	2
	OtherAccType			4	1	1		14	8	1					25	3			5	1	
	Speeding																				
	Hit Object	1		118	22			177	149		1	10	7	1	602	33	3		60	8	4
	Overturned	4	2	53	3	1		89	65	2		7	7	1	459	18	3		56	13	2
	OtherAccType	1		6				10	2					1	19		1		4	1	
	Alcohol																				
	Hit Object	6		124	14	1	1	121	98			3	2	5	513	13			72	8	2
	Overturned	4		48	3		1	70	40	1		3			184	4			38	2	1
	OtherAccType			4		1		4	2						7				1		
	OtherFactors																				
	Hit Object	6		50	9	1		93	58	1		2	3	2	328	12	1		52	8	3
	Overturned	2		29	10			76	20	1		3	2		167	2	2		30	3	1
	OtherAccType	2		14	1			24	7			3		3	77	3	1		28	3	
Two vehicles	**Alcohol**																				
	OtherCrashType	3	2	22	2			24	13				2		92	4	4		37	5	4
	Sideswipe	1	1	12	1			14	22						23				12	2	3
	Rear End	11		30	11	1		50	56		4	1	1		37	1			25	1	3
	OtherFactors																				
	OtherCrashType	32	5	66	2	3	1	51	21		4			1	494	20	9		215	13	15
	Sideswipe	10	1	12	5	1		20	16				1		176	4	1		45	2	1
	Rear End	8	1	35	12	3		42	39		1		1		60			1	33	4	4
	Improper Turn																				
	OtherCrashType	8		67	12	1		80	76		6		6		181	1			85	1	3
	Sideswipe	3		35	10	1		55	71		2	3	2		62	2			20	1	
	Rear End	4		13	4			24	35		1	1	2		19	3	1		7		
	Lane Change																				
	OtherCrashType		1	24	17	1		50	55		5		3		1				5	3	
	Sideswipe	1		71	9	1		91	127		10	2	11		5		1		3	1	
	Rear End			15	10			37	31	1	2		2		1		1		2		1
3 or emore vehicles	**Speeding**																				
	OtherCrashType	4		49	3			63	49		3	1	5		222	9	1		35	8	4
	Sideswipe			11	2			23	30		1	3	2		46	1			10	2	3
	Rear End	71	5	325	76	16	1	485	482	1	26	8	41	2	580	18	15	1	337	20	13
	Speeding																				
	Rear-end	95	5	914	4261	10	3	791	6610	22	15	37	23	309	5	49	10	218	8	46	4
	Sideswipe	2		17	105			19	197	1	1	3	1	12		1		8		1	
	OtherAccType	2		25	84		1	15	186				1	31	2			5			1
	OtherFactors																				
	Rear-end	19	1	177	340	2		100	600	7	3	3		48	2	13	2	26	7	7	1
	Sideswipe	5		60	242	1	1	34	360	2		5	1	69	2	3	1	32		9	1
	OtherAccType	8		78	186			44	315			3	1	107	5	3		67	4	3	
	Lane Change																				
	Sideswipe			27	485	1	1	51	820	2		6	5				1	3	1	2	1
	Rear-end			11	123			10	227		1	2	1			1					
	OtherAccType			14	77			9	140	1											

Creating Systemic Matrices

Single vehicle	Divided Highway								L/R Independent Alignment					Undivided Highway						
	Paved shoulder up to 4ft			Paved shoulder 5ft or more					Paved shoulder up to 4		Paved shoulder 5ft or more			Paved shoulder up to 4ft				Paved shoulder 5ft or more		
	2 lanes	3 lanes	4 lanes	5 lanes or r	2 lanes	3 lanes	4 lanes	5 lanes or r	2 lanes	4 lanes	2 lanes	3 lanes	4 lanes	2 lanes	3 lanes	4 lanes	5 lanes	2 lanes	3 lanes	4 lanes
Improper Turn																				
Hit Object	14	2	386	48	1		599	471	11		20	17	11	1315	37	5		218	17	6
Overturned	7	1	333	18	2	1	552	198	11		21	8	7	786	20			118	13	2
OtherAccType			4	1	1		14	8	1					25	3			5	1	
Speeding																				
Hit Object	1		118	22			177	149		1	10	7	1	602	33	3		60	8	4
Overturned	4	2	53	3	1		89	65	2		7	7	1	459	18	3		56	13	2
OtherAccType	1		6				10	2					1	19		1		4	1	
Alcohol																				
Hit Object	6		124	14	1	1	121	98			3	2	5	513	13			72	8	2
Overturned	4		48	3		1	70	40	1		3			184	4			38	2	1
OtherAccType			4		1		4	2						7				1		
OtherFactors																				
Hit Object	6		50	9	1		93	58	1		2	3	2	328	12	1		52	8	3
Overturned	2		29	10			76	20	1		3	2		167	2	2		30	3	1
OtherAccType	2		14	1			24	7			3		3	77	3	1		28	3	

Creating Systemic Matrices

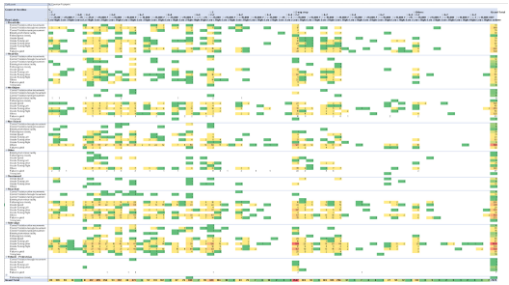
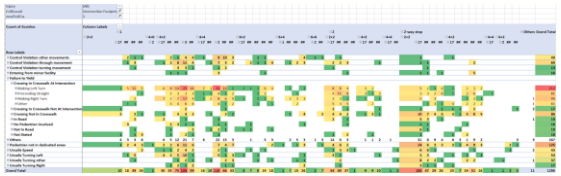
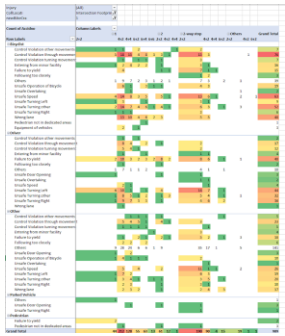
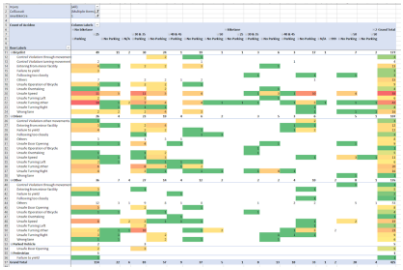
		Divided Highway								L/R Independent Alignment					Undivided Highway						
		Paved shoulder up to 4ft			Paved shoulder 5ft or more					Paved shoulder up to 4		Paved shoulder 5ft or more			Paved shoulder up to 4ft				Paved shoulder 5ft or more		
		2 lanes	3 lanes	4 lanes	5 lanes or r	2 lanes	3 lanes	4 lanes	5 lanes or r	2 lanes	4 lanes	2 lanes	3 lanes	4 lanes	2 lanes	3 lanes	4 lanes	5 lanes	2 lanes	3 lanes	4 lanes
Two vehicles	**Alcohol**																				
	OtherCrashType	3	2	22	2			24	13				2		92	4	4		37	5	4
	Sideswipe	1	1	12	1			14	22						23				12	2	3
	Rear End	11		30	11	1		50	56		4	1	1		37	1			25	1	3
	OtherFactors																				
	OtherCrashType	32	5	66	2	3	1	51	21		4			1	494	20	9		215	13	15
	Sideswipe	10	1	12	5	1		20	16				1		176	4	1		45	2	1
	Rear End	8	1	35	12	3		42	39		1		1		60			1	33	4	4
	Improper Turn																				
	OtherCrashType	8		67	12	1		80	76		6		6		181	1			85	1	3
	Sideswipe	3		35	10	1		55	71		2	3	2		62	2			20	1	
	Rear End	4		13	4			24	35		1	1	2		19	3	1		7		
	Lane Change																				
	OtherCrashType		1	24	17	1		50	55		5		3		1				5	3	
	Sideswipe	1		71	9	1		91	127		10	2	11		5		1		3	1	
	Rear End			15	10			37	31	1	2		2		1		1		2		1

Creating Systemic Matrices

3 or emore vehicles

	Divided Highway								L/R Independent Alignment					Undivided Highway						
	Paved shoulder up to 4ft			Paved shoulder 5ft or more					Paved shoulder up to 4		Paved shoulder 5ft or more			Paved shoulder up to 4ft				Paved shoulder 5ft or more		
	2 lanes	3 lanes	4 lanes	5 lanes or r	2 lanes	3 lanes	4 lanes	5 lanes or r	2 lanes	4 lanes	2 lanes	3 lanes	4 lanes	2 lanes	3 lanes	4 lanes	5 lanes	2 lanes	3 lanes	4 lanes
Speeding																				
OtherCrashType	4		49	3			63	49		3	1	5		222	9	1		35	8	4
Sideswipe			11	2			23	30		1	3	2		46	1			10	2	3
Rear End	71	5	325	76	16	1	485	482	1	26	8	41	2	580	18	15	1	337	20	13
Speeding																				
Rear-end	95	5	914	4261	10	3	791	6610	22	15	37	23	309	5	49	10	218	8	46	4
Sideswipe	2		17	105			19	197	1	1	3	1	12		1		8		1	
OtherAccType	2		25	84		1	15	186				1	31	2			5			1
OtherFactors																				
Rear-end	19	1	177	340	2		100	600	7	3	3		48	2	13	2	26	7	7	1
Sideswipe	5		60	242	1	1	34	360	2		5	1	69	2	3	1	32		9	1
OtherAccType	8		78	186			44	315			3	1	107	5	3		67	4	3	
Lane Change																				
Sideswipe			27	485	1	1	51	820	2		6	5				1	3	1	2	1
Rear-end			11	123			10	227		1	2	1			1					
OtherAccType			14	77			9	140	1											

Different Matrices Reveal Different Insights

	VEHICLE	PEDESTRIAN	BICYCLE
INTERSECTION			
SEGMENT			

Bicycle-involved matrix for intersection crashes in California (2010-2011)

CALIFORNIA	INFRASTI																																				
	Timed Signals																							4 way Stop signs			2 way Stop signs								No controls		Others	Grand Total
Collision	2+2		3+2		3+3		4+2		4+3	4+4		5+2	5+4	6+2	6+3	6+4	6+5	6+6	8+2	8+3	8+4	2+2	4+2	2+2		3+2		4+2	4+4	5+2	6+2	6+3	8+2	4+1			
B																																					
Alcohol	1						2			2														5				3			1		1				15
Control Violation	1		1				12			9		1	1	4	2	3								4		1		5									44
Failure to yield	1						12			4				1		3					4			4		1		14			6			1			51
Improper Turn					1		5			1						3						1		9				5									25
Other Improper Driving	5		1				29		1	16				12	1	11	3		1	1	1		1	1	13		4		33	1	3	12	1	2				153
Other than driving										1				1										3				2									7
Pedestrian Violation							1			1																											2
Speeding	1						4							2	1	1		1						2				4									16
Others							3			1						1					1			1				5		1							13
Other																																					
Control Violation	1						1			1				1										1				1									5
Failure to yield							2		1																			1		1						1	6
Improper Turn	1						1			1								1						3				1			2						10
Other Improper Driving							1			2				2			1																				6
Other than driving																								4				1									5
Speeding							1			2		1				1															1						6
Others	1						5		1	2		1	1			1		1						3				8			1						25
V																																					
Alcohol							1			1																		1									3
Control Violation							2							2		1								2				1		1	1						10
Failure to yield	3		1				10			3		1	1	3		5								21		2		33			2				1		86
Following too closely							1																														1
Improper Turn	1		3				9			9				1		4						1	1	2				4			1						36
Other Improper Driving	1						5			2		1		3	1			4								1		1		1			1				21
Pedestrian Violation														1																							1
Speeding																		1						1											1		3
Others																1															1						2
Grand Total	17		6		1		107		3	58		3	5	33	5	35	4	8	1	1	6	3	2	78		9		122	1	8	27	1	4	1	3		552

Pedestrian-involved matrix for intersection crashes in California (2010-2011)

CALIFORNIA	INFRASTI																				
	Timed Signals																				
	2+2	3+2	3+3	4+0	4+2		4+3	4+4		5+2	5+4		6+2		6+3	6+4		6+6		8+4	
Collision	<= 50000	<= 50000	<= 50000	<= 50000	<= 50000	> 50000	<= 50000	<= 50000	> 50000	<= 50000	<= 50000	> 50000	<= 50000	> 50000	<= 50000	<= 50000	> 50000	<= 50000	> 50000	> 50000
Alcohol					1																
Control Violation								1			1		1	1	1	2		1			
Failure to yield	6	2	2	1	28		2	16	3	2	7		7		2	8	5	3		1	
Improper Turn					3			1					1			1					
Other Improper Driving					2			2							1	1					
Other than driving								1					1								
Pedestrian Violation	1				17	2	1	4	2	1		1	6	1	3	6	1	3		1	
Speeding					2						1		1							1	
Others	1				3			3					3			1			2		
Grand Total	**8**	**2**	**2**	**1**	**56**	**2**	**3**	**28**	**5**	**3**	**9**	**1**	**20**	**2**	**7**	**19**	**6**	**7**	**2**	**3**	

4 way Sto	2 way Stop signs											Yield signs	No controls		Grand Total
2+2	2+2	3+2	4+1	4+2		5+0	5+2	5+4	6+2		6+3	8+2	2+2	2+1	2+2	
<= 50000	<= 50000	<= 50000	<= 50000	<= 50000	> 50000	<= 50000	<= 50000	> 50000	<= 50000	> 50000	<= 50000	> 50000	<= 50000	<= 50000	<= 50000	
	2															3
	2			2					2			1				15
1	12	5	1	28	1		1	1	10	1		1			1	158
	2			2												10
	2			1					1							10
																2
1	16	5		21		1								1	1	96
	3			3							1		1			13
	2	1		2	1											19
2	**41**	**11**	**1**	**59**	**2**	**1**	**1**	**1**	**13**	**1**	**1**	**2**	**1**	**1**	**2**	**326**

Left portion of the non-PDO auto-only matrix for intersection crashes in California (2010-2011)

CALIFORNIA	INFRASTI																												
	Timed Signals																												
	2+0	2+1	2+2		3+0	3+2			3+3	4+1	4+2				4+3			4+4			5+2				5+3		5+4		
	<= 50000	<= 50000	<= 50000		<= 50000	<= 50000		> 50000	<= 50000	<= 50000	<= 50000			> 50000	<= 50000		> 50000	<= 50000		> 50000	<= 50000		> 50000		<= 50000	> 50000	<= 50000		> 50000
Collision	> 400	> 400	<= 400	> 400	> 400	<= 400	> 400	> 400	> 400	> 400	<= 400	> 400	(blank)	> 400	<= 400	> 400	> 400	<= 400	> 400	> 400	<= 400	> 400	<= 400	> 400	> 400	> 400	<= 400	> 400	> 400
A																													
Alcohol				4			1					7							3										
Control Violation			2	8			1	1		1		20						1	9	2		1						1	1
Failure to yield	1		1	15			3				2	49	1	1		4		4	20	1		2						3	1
Improper Turn							1					9							4										
Other Improper Driving				5			1					7							1										
Other than driving				1								2							1										
Speeding												8				1			1										
Others				1								5							3									2	
B																													
Alcohol												2				1			2										
Control Violation		1		2			2				2	11							9									1	
Failure to yield				1			1				1	6						1	5										
Improper Turn	1					5	1					9				1			9	1									1
Other Improper Driving		1		4		2						13							3										1
Other than driving																													
Speeding										1		1														1			
Others				1			1					5							1									1	
C																													
Alcohol				4							1	17			1				9				1						
Control Violation							1					1							1										
Failure to yield				1															1			1							
Following too closely		2		5							1	13		1		2		1	11	3		1						1	
Improper Turn				1								1							1										
Other Improper Driving			2	7		1					4	16		1		3		1	11	2	1								
Other than driving												1																	
Speeding		2	5	27	1	2	10		2	3	4	104		9	1	3	4		67	9		4	1					5	
Others												1							4	1									1
D																													
Alcohol			1	7		1	1		1	1	6	23		1		1		1	14	3		2					1	2	
Control Violation	7	8	15	71		2	36	5	17	7	15	272		7	4	24	4	5	126	20	1	9	2		4		2	19	2
Failure to yield	1	2	4	23			4				5	129		6		9	1	3	61	3		4		2	1			8	2
Following too closely																													
Improper Turn	1		1	7			3					16		1					9			1						2	
Other Improper Driving		1		4			1					11		2	1	1			7					1					3
Other than driving		1		1								2							2	1								1	
Speeding			2	5								7							5										
Others			1	5			2	1		1	3	31				2	1	2	20			2			1			1	1
E																													
Alcohol				4			1				1	5				1			5										
Control Violation												1																	
Failure to yield				1														1											
Improper Turn				1			1					5			1				2										
Other Improper Driving				2								1																	
Other than driving												2				1													
Speeding			1	2			2					4		2		1			2			1							
Others				1			1					2																	
F																													
Alcohol				1								1							4										
Control Violation																			1									1	
Failure to yield												2							1										
Following too closely																													
Improper Turn	1		1	2								1										1							
Other Improper Driving				1								1		1															
Other than driving																													
Speeding												3							1										
Others								1											1										
Other				7			2		1		2	19	1			4			4									2	
Grand Total	12	18	36	232	1	13	77	8	21	14	47	846	2	32	8	59	10	20	441	46	2	29	4	3	6	1	3	50	13

Right portion of the non-PDO auto-only matrix for intersection crashes in California (2010-2011)

																				Yield signs				No controls										Others	Grand Total
4+2					4+3	4+4	5+2				5+4	6+2				7+2		8+2		2+2	4+1	4+2		2+1	2+2		3+2		4+1	4+2			6+2		
<= 50000			> 50000		<= 50000	<= 50000	<= 50000		> 50000		> 50000	<= 50000		> 50000		> 50000		> 50000		<= 5000(	<= 50000	<= 50000		<= 5000(	<= 50000		<= 50000		<= 50000	<= 50000		> 50000	> 50000		
<= 400	> 400	(blank)	<= 400	> 400	> 400	> 400	<= 400	> 400	<= 400	> 400	> 400	<= 400	> 400	<= 400	> 400	<= 400	> 400	<= 400	> 400	> 400	> 400	<= 400	> 400	<= 400	<= 400	> 400	<= 400	> 400	<= 400	<= 400	> 400	<= 400	> 400		
2	6																																		32
2	4																																		76
10	23			1				1					4	1	3				2	1					1							1	1	2	257
	5																		1																32
	2																								1										31
																																			6
1	1		1				1				1		1												1										22
	1																																		19
1	4			1									1																						18
1	3																																		40
7	19			1									3						1				1												76
2	6											1											1		1					1	1				72
2	6			1	1								1								1				2										65
																																			1
2	2		1					1																											21
	4																								1										20
	4												1																						63
	1																																		10
3	8			1								1										1													28
8	8		1										3		2							1													90
2	2																											1							14
4	9		1									1	1		1												1							1	103
	1																																		6
25	52			4		1		2			2	3	5		5							2			2		1				2		1	1	649
	1												1																						20
13	17							1		1					3				1		1	1			1									3	200
21	56	1	1	2				2		1	2		5		4						1				1				1					4	1197
137	378	1	6	24	5	2	5	7		6		6	48	6	26	1	1	1	24						6	1	3			2		1		4	1766
				1																															2
6	26			1						1		2	1		1				2						1					1					135
	14			1					1				1									1			5									1	96
	2																																		13
3	9		2	1									1												1					1				1	70
1	12												2						1		1		1											1	133
2	6			1				1					1							1					2	1									74
																																			8
	2			1											1																				11
4	6																							1	4										68
																			1						1										11
	1							1																											8
6	5		2					1					1												1									3	80
	1												1																						6
1	1																								3									1	20
	1																																		6
1																																			19
																																			1
1	3																								2										27
																																			6
																			1																2
3	2			1																														3	34
																																			3
4	12			1											1										1					1					100
275	726	2	15	43	6	3	6	17	1	9	5	14	82	7	47	1	1	1	34	2	4	6	3	1	38	2	5	1	1	6	3	2	2	25	5867

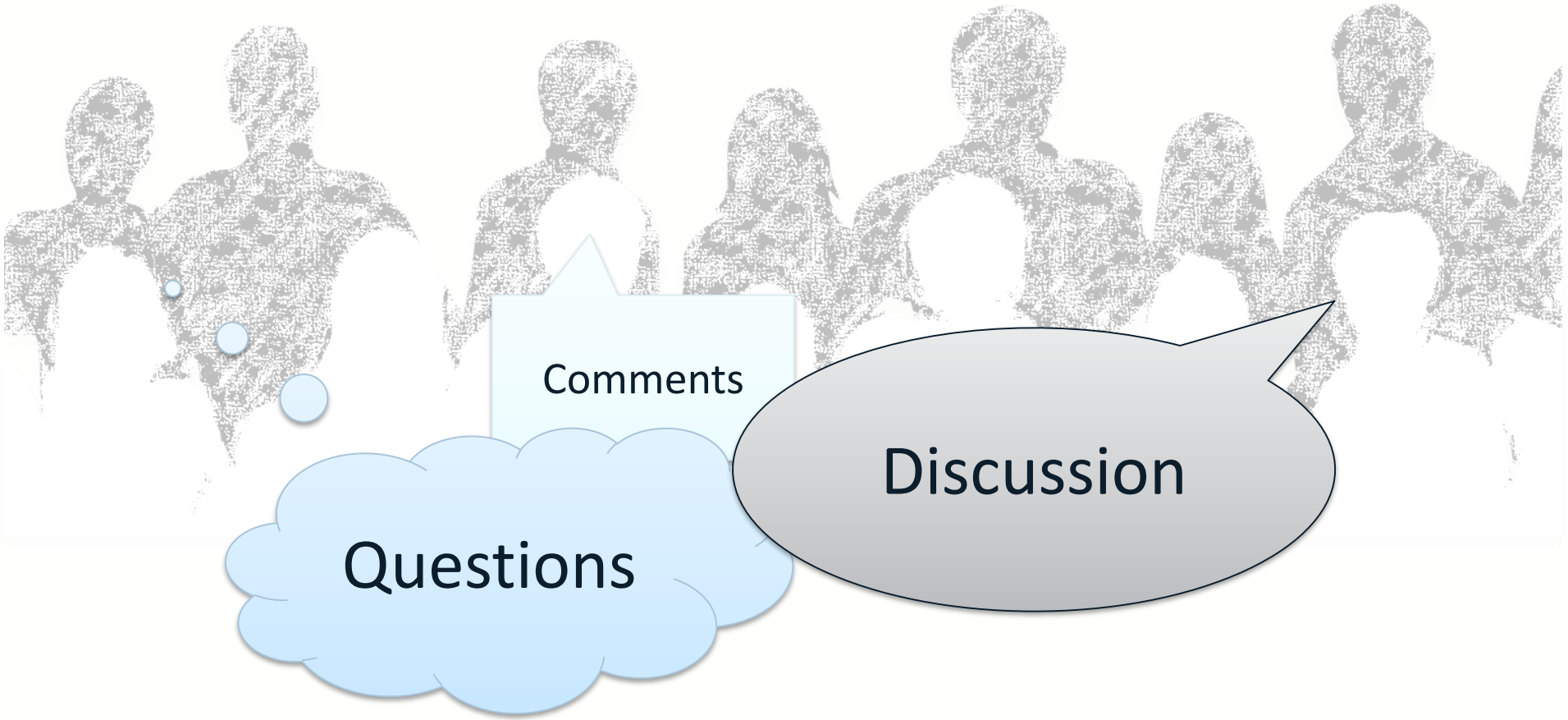
Considerations for Screening

Trade-offs when setting safety screening priorities:

Inclusive approach	**Restrictive approach**
Capturing all potential systemic safety challenges	Higher cost-effectiveness
Lower cost-effectiveness	Potentially missing valuable safety-improving opportunities

Summary

- Data-driven methodology to identify recurring safety concerns within a road network, by identifying the crash profiles that are associated with certain roadway features
- Flexible enough to allow agencies with varying degrees of data availability to implement it—regardless of the level of performance their data management systems
- Provide aggregate information on the crashes that occurred to identify systemic hotspots, which then allows to target blanket improvements across an entire facility type.
- Support transition from existing practices in road safety to approaches such as safe systems


Comments
Discussion
Questions