TxDOT Research Project 0-6961

Evaluation of Highway Safety Improvement Projects and Countermeasures

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0-6961 Project Team

TxDOT

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Outline

- Research Goal and Objectives
- Safety Management Process
- Evaluation Tools
- Effectiveness of Projects and Work Codes
- Recommendations

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- Effectiveness of Projects and Work Codes
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Research Goal and Objectives

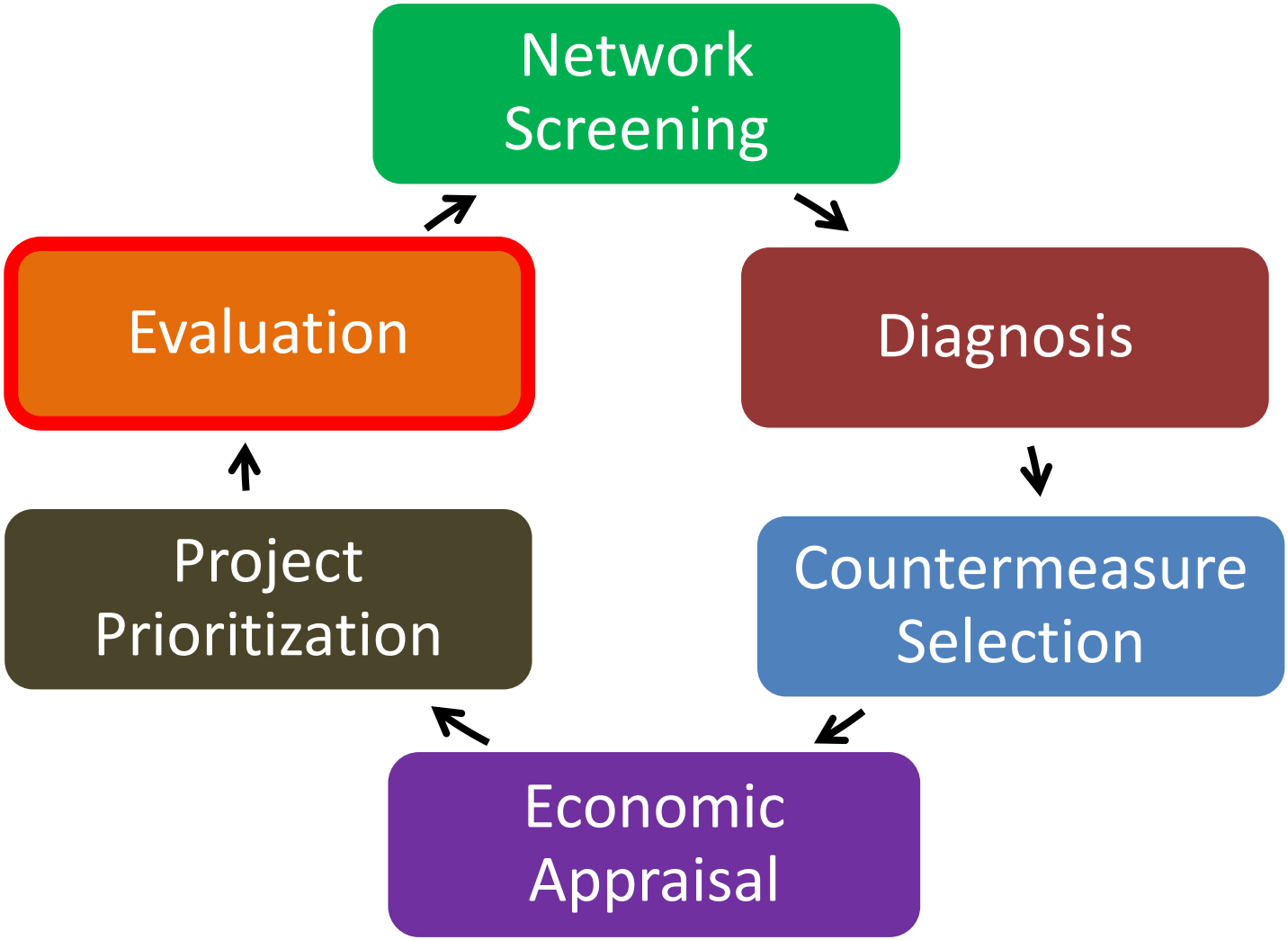
Goal: Advance HSIP evaluation practices at TxDOT

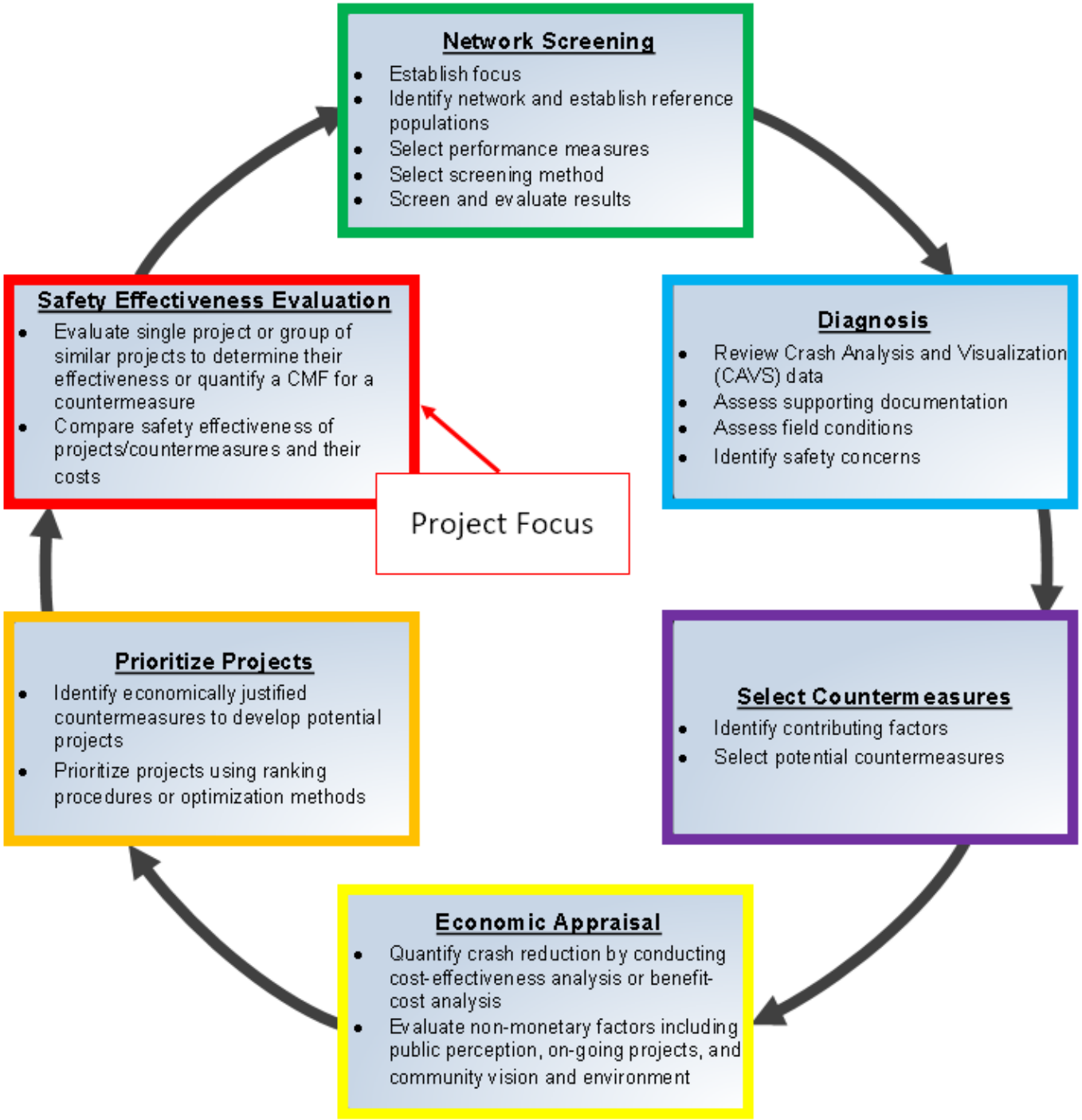
- Develop evaluation tools for:
  - Individual HSIP projects
  - Groups of similar projects or countermeasures or work codes (WCs)
- Evaluate effectiveness of implemented projects and WCs

Outline

- Research Goal and Objectives
- Safety Management Process
- Evaluation Tools
- Effectiveness of Projects and Work Codes
- Recommendations

Safety Management Framework




Network Screening
Establish focus
Identify network and establish reference populations
Select performance measures
Select screening method
Screen and evaluate results
Diagnosis
Review Crash Analysis and Visualization (CAVS) data
Assess supporting documentation
Assess field conditions
Identify safety concerns
Select Countermeasures
Identify contributing factors
Select potential countermeasures
Economic Appraisal
Quantify crash reduction by conducting cost-effectiveness analysis or benefit-cost analysis
Evaluate non-monetary factors including public perception, on-going projects, and community vision and environment
Prioritize Projects
Identify economically justified countermeasures to develop potential projects
Prioritize projects using ranking procedures or optimization methods
Safety Effectiveness Evaluation
Evaluate single project or group of similar projects to determine their effectiveness or quantify a CMF for a countermeasure
Compare safety effectiveness of projects/countermeasures and their costs
Project Focus

Outline

- Research Goal and Objectives
- Safety Management Process
- Evaluation Tools
- Effectiveness of Projects and Work Codes
- Recommendations

Evaluation Tools

Purpose: Evaluate safety and cost effectiveness of individual projects and groups of similar projects

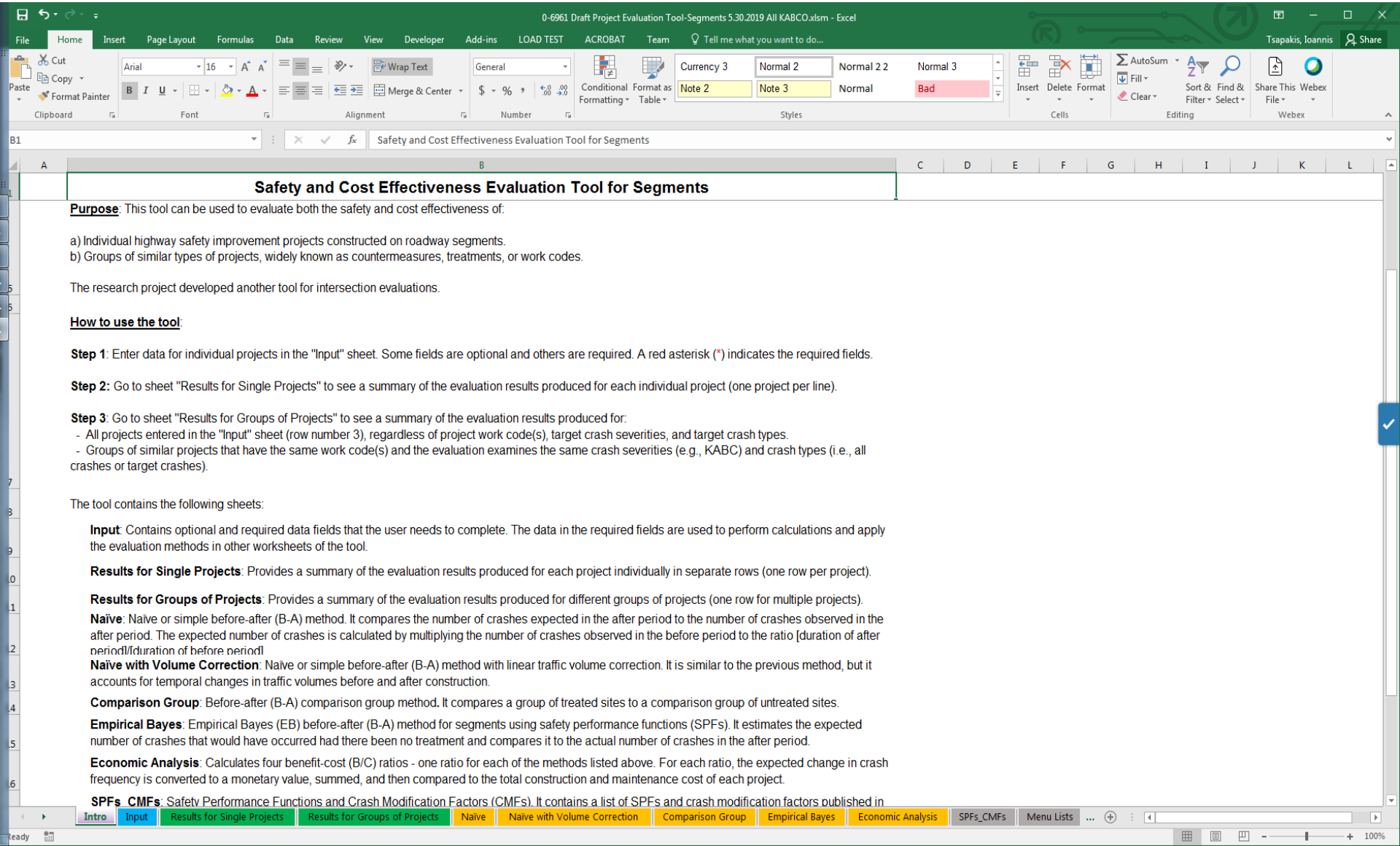
TTI developed two tools:

- Tool for segment evaluations
- Tool for intersection evaluations

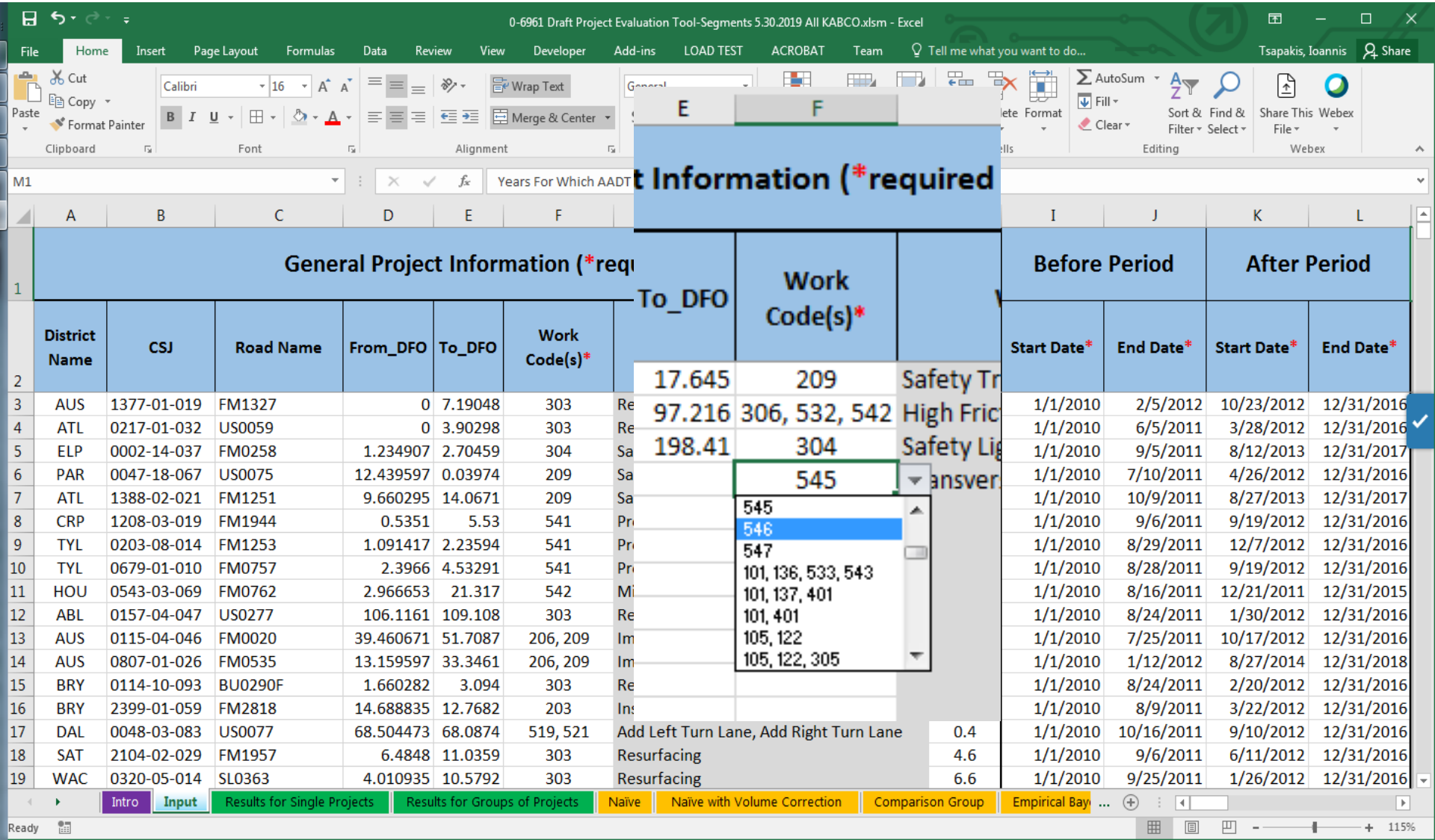
TxDOT Data Inputs for Evaluations

Required Data Type		TxDOT Data Source
HSIP project construction data	Highway name	• Category 8 (CAT8) project database • Design and Construction Information System (DCIS) • SiteManager
	Geographic coordinates and distance from origin (DFO)	• CAT8 project database • DCIS • Other District data
	Construction (start and end) dates	• SiteManager • Other District data
	Implemented work code(s)	• CAT8 project database • DCIS • Other District databases
	Construction cost	• SiteManager • Other District databases
Linear reference system (LRS) network and roadway data		• Road-Highway Inventory Network (RHiNo)
Traffic data		• RHiNO
Crash data		• Crash Record Information System (CRIS)
Safety Performance Functions (SPFs)		• TxDOT Roadway Safety Design Workbook

Intro Sheet


0-6961 Draft Project Evaluation Tool-Segments 5.30.2019 All KABCO.xlsm - Excel
Safety and Cost Effectiveness Evaluation Tool for Segments
Purpose: This tool can be used to evaluate both the safety and cost effectiveness of:
a) Individual highway safety improvement projects constructed on roadway segments.
b) Groups of similar types of projects, widely known as countermeasures, treatments, or work codes.
The research project developed another tool for intersection evaluations.
How to use the tool:
Step 1: Enter data for individual projects in the "Input" sheet. Some fields are optional and others are required. A red asterisk (*) indicates the required fields.
Step 2: Go to sheet "Results for Single Projects" to see a summary of the evaluation results produced for each individual project (one project per line).
Step 3: Go to sheet "Results for Groups of Projects" to see a summary of the evaluation results produced for:
- All projects entered in the "Input" sheet (row number 3), regardless of project work code(s), target crash severities, and target crash types.
- Groups of similar projects that have the same work code(s) and the evaluation examines the same crash severities (e.g., KABC) and crash types (i.e., all crashes or target crashes).
The tool contains the following sheets:
Input: Contains optional and required data fields that the user needs to complete. The data in the required fields are used to perform calculations and apply the evaluation methods in other worksheets of the tool.
Results for Single Projects: Provides a summary of the evaluation results produced for each project individually in separate rows (one row per project).
Results for Groups of Projects: Provides a summary of the evaluation results produced for different groups of projects (one row for multiple projects).
Naïve: Naïve or simple before-after (B-A) method. It compares the number of crashes expected in the after period to the number of crashes observed in the after period. The expected number of crashes is calculated by multiplying the number of crashes observed in the before period to the ratio [duration of after period]/[duration of before period]
Naïve with Volume Correction: Naïve or simple before-after (B-A) method with linear traffic volume correction. It is similar to the previous method, but it accounts for temporal changes in traffic volumes before and after construction.
Comparison Group: Before-after (B-A) comparison group method. It compares a group of treated sites to a comparison group of untreated sites.
Empirical Bayes: Empirical Bayes (EB) before-after (B-A) method for segments using safety performance functions (SPFs). It estimates the expected number of crashes that would have occurred had there been no treatment and compares it to the actual number of crashes in the after period.
Economic Analysis: Calculates four benefit-cost (B/C) ratios - one ratio for each of the methods listed above. For each ratio, the expected change in crash frequency is converted to a monetary value, summed, and then compared to the total construction and maintenance cost of each project.
SPFs_CMFs: Safety Performance Functions and Crash Modification Factors (CMFs). It contains a list of SPFs and crash modification factors published in
Intro
Input
Results for Single Projects
Results for Groups of Projects
Naïve
Naïve with Volume Correction
Comparison Group
Empirical Bayes
Economic Analysis
SPFs_CMFs
Menu Lists

Input Sheet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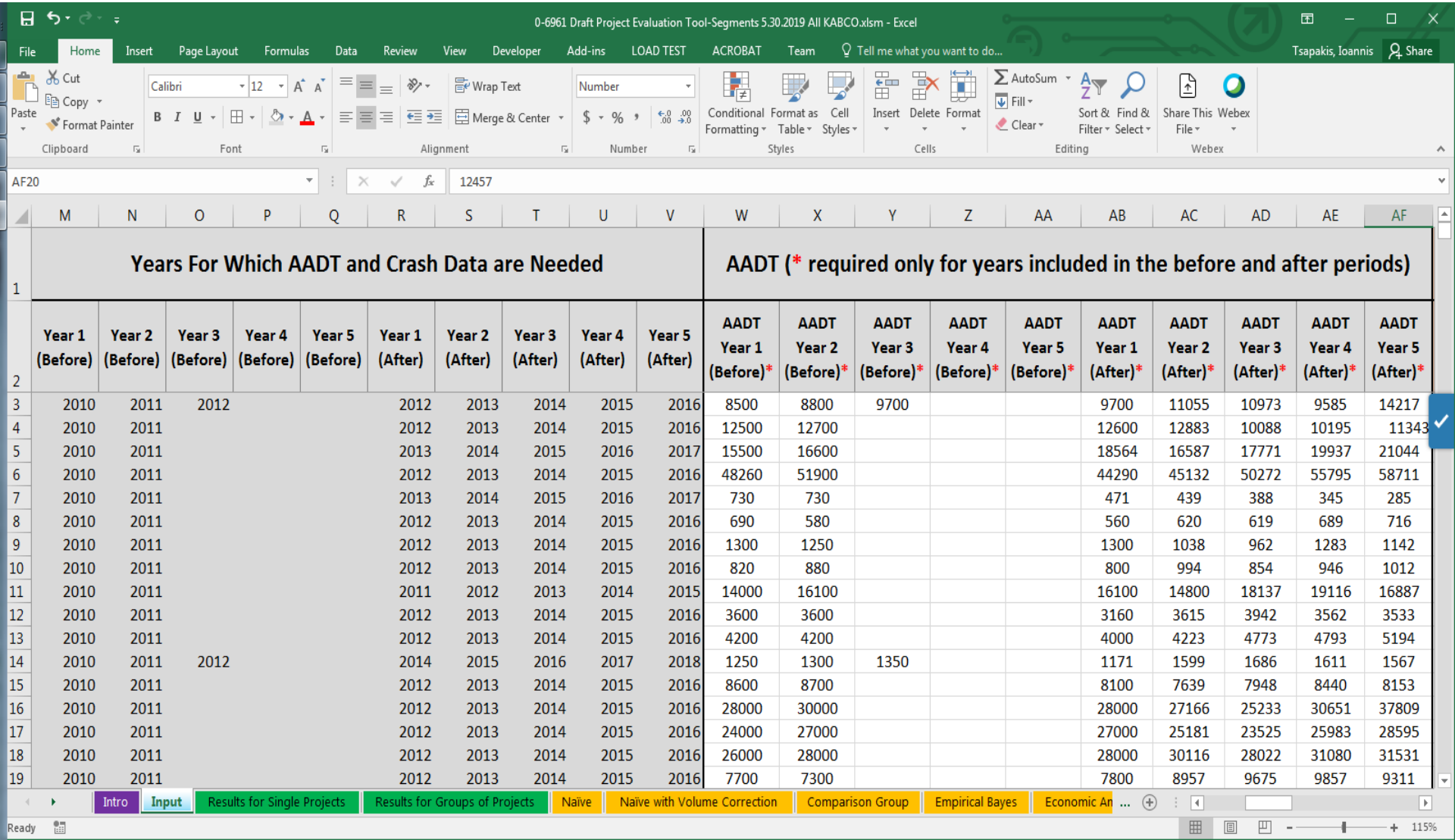
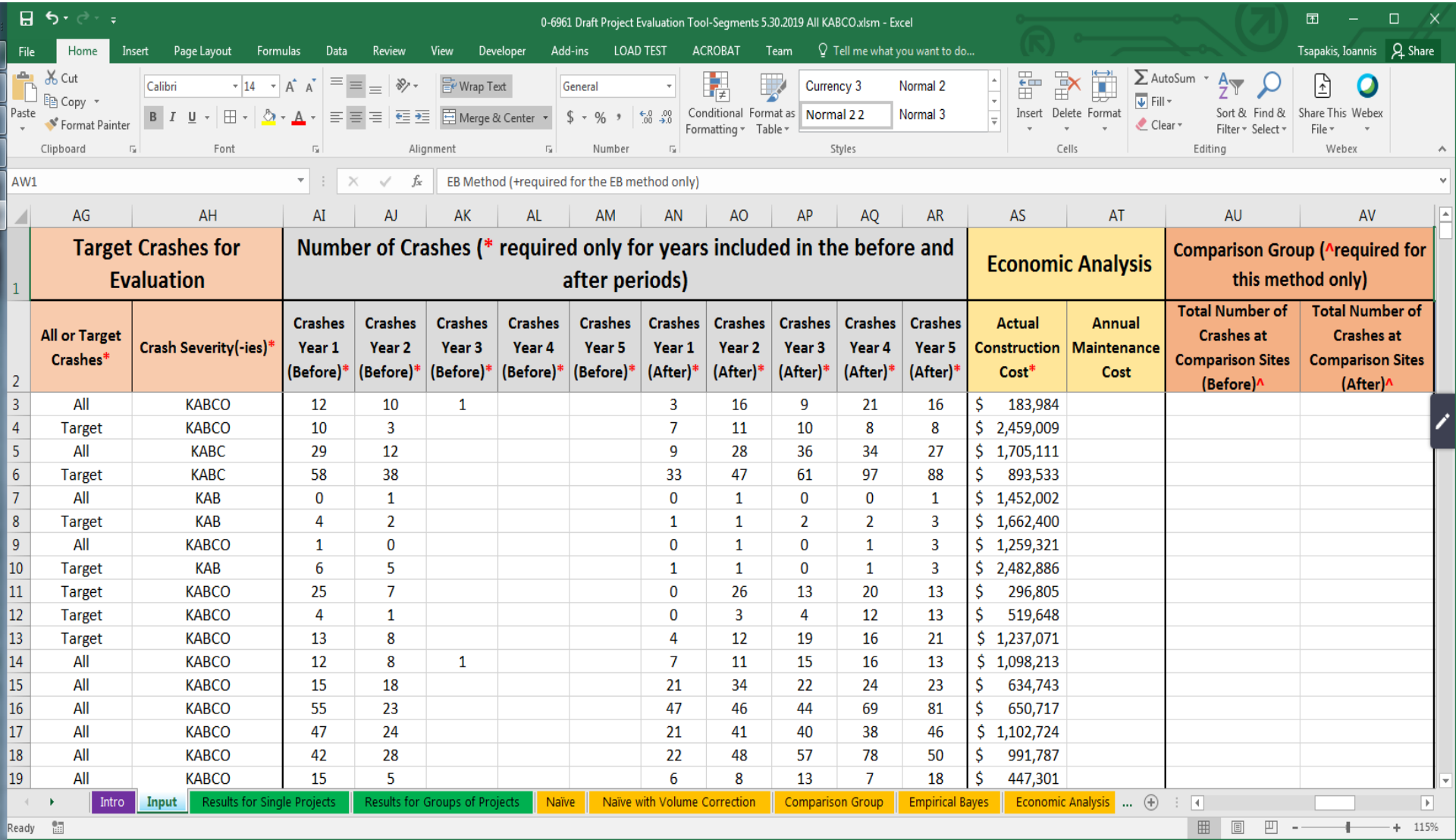
General Project Information (*requ
Before Period
After Period
District Name
CSJ
Road Name
From_DFO
To_DFO
Work Code(s)*
Start Date*
End Date*
Start Date*
End Date*
AUS 1377-01-019 FM1327 0 7.19048 303 1/1/2010 2/5/2012 10/23/2012 12/31/2016
ATL 0217-01-032 US0059 0 3.90298 303 1/1/2010 6/5/2011 3/28/2012 12/31/2016
ELP 0002-14-037 FM0258 1.234907 2.70459 304 1/1/2010 9/5/2011 8/12/2013 12/31/2017
PAR 0047-18-067 US0075 12.439597 0.03974 209 1/1/2010 7/10/2011 4/26/2012 12/31/2016
ATL 1388-02-021 FM1251 9.660295 14.0671 209 1/1/2010 10/9/2011 8/27/2013 12/31/2017
CRP 1208-03-019 FM1944 0.5351 5.53 541 1/1/2010 9/6/2011 9/19/2012 12/31/2016
TYL 0203-08-014 FM1253 1.091417 2.23594 541 1/1/2010 8/29/2011 12/7/2012 12/31/2016
TYL 0679-01-010 FM0757 2.3966 4.53291 541 1/1/2010 8/28/2011 9/19/2012 12/31/2016
HOU 0543-03-069 FM0762 2.966653 21.317 542 1/1/2010 8/16/2011 12/21/2011 12/31/2015
ABL 0157-04-047 US0277 106.1161 109.108 303 1/1/2010 8/24/2011 1/30/2012 12/31/2016
AUS 0115-04-046 FM0020 39.460671 51.7087 206, 209 1/1/2010 7/25/2011 10/17/2012 12/31/2016
AUS 0807-01-026 FM0535 13.159597 33.3461 206, 209 1/1/2010 1/12/2012 8/27/2014 12/31/2018
BRY 0114-10-093 BU0290F 1.660282 3.094 303 1/1/2010 8/24/2011 2/20/2012 12/31/2016
BRY 2399-01-059 FM2818 14.688835 12.7682 203 1/1/2010 8/9/2011 3/22/2012 12/31/2016
DAL 0048-03-083 US0077 68.504473 68.0874 519, 521 Add Left Turn Lane, Add Right Turn Lane 0.4 1/1/2010 10/16/2011 9/10/2012 12/31/2016
SAT 2104-02-029 FM1957 6.4848 11.0359 303 Resurfacing 4.6 1/1/2010 9/6/2011 6/11/2012 12/31/2016
WAC 0320-05-014 SL0363 4.010935 10.5792 303 Resurfacing 6.6 1/1/2010 9/25/2011 1/26/2012 12/31/2016
545
546
547
101, 136, 533, 543
101, 137, 401
101, 401
105, 122
105, 122, 305
Intro
Input
Results for Single Projects
Results for Groups of Projects
Naïve
Naïve with Volume Correction
Comparison Group
Ready

Input Sheet



	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1	Years For Which AADT and Crash Data are Needed										AADT (* required only for years included in the before and after periods)									
2	Year 1 (Before)	Year 2 (Before)	Year 3 (Before)	Year 4 (Before)	Year 5 (Before)	Year 1 (After)	Year 2 (After)	Year 3 (After)	Year 4 (After)	Year 5 (After)	AADT Year 1 (Before)*	AADT Year 2 (Before)*	AADT Year 3 (Before)*	AADT Year 4 (Before)*	AADT Year 5 (Before)*	AADT Year 1 (After)*	AADT Year 2 (After)*	AADT Year 3 (After)*	AADT Year 4 (After)*	AADT Year 5 (After)*
3	2010	2011	2012			2012	2013	2014	2015	2016	8500	8800	9700			9700	11055	10973	9585	14217
4	2010	2011				2012	2013	2014	2015	2016	12500	12700				12600	12883	10088	10195	11343
5	2010	2011				2013	2014	2015	2016	2017	15500	16600				18564	16587	17771	19937	21044
6	2010	2011				2012	2013	2014	2015	2016	48260	51900				44290	45132	50272	55795	58711
7	2010	2011				2013	2014	2015	2016	2017	730	730				471	439	388	345	285
8	2010	2011				2012	2013	2014	2015	2016	690	580				560	620	619	689	716
9	2010	2011				2012	2013	2014	2015	2016	1300	1250				1300	1038	962	1283	1142
10	2010	2011				2012	2013	2014	2015	2016	820	880				800	994	854	946	1012
11	2010	2011				2011	2012	2013	2014	2015	14000	16100				16100	14800	18137	19116	16887
12	2010	2011				2012	2013	2014	2015	2016	3600	3600				3160	3615	3942	3562	3533
13	2010	2011				2012	2013	2014	2015	2016	4200	4200				4000	4223	4773	4793	5194
14	2010	2011	2012			2014	2015	2016	2017	2018	1250	1300	1350			1171	1599	1686	1611	1567
15	2010	2011				2012	2013	2014	2015	2016	8600	8700				8100	7639	7948	8440	8153
16	2010	2011				2012	2013	2014	2015	2016	28000	30000				28000	27166	25233	30651	37809
17	2010	2011				2012	2013	2014	2015	2016	24000	27000				27000	25181	23525	25983	28595
18	2010	2011				2012	2013	2014	2015	2016	26000	28000				28000	30116	28022	31080	31531
19	2010	2011				2012	2013	2014	2015	2016	7700	7300				7800	8957	9675	9857	9311

Input Sheet



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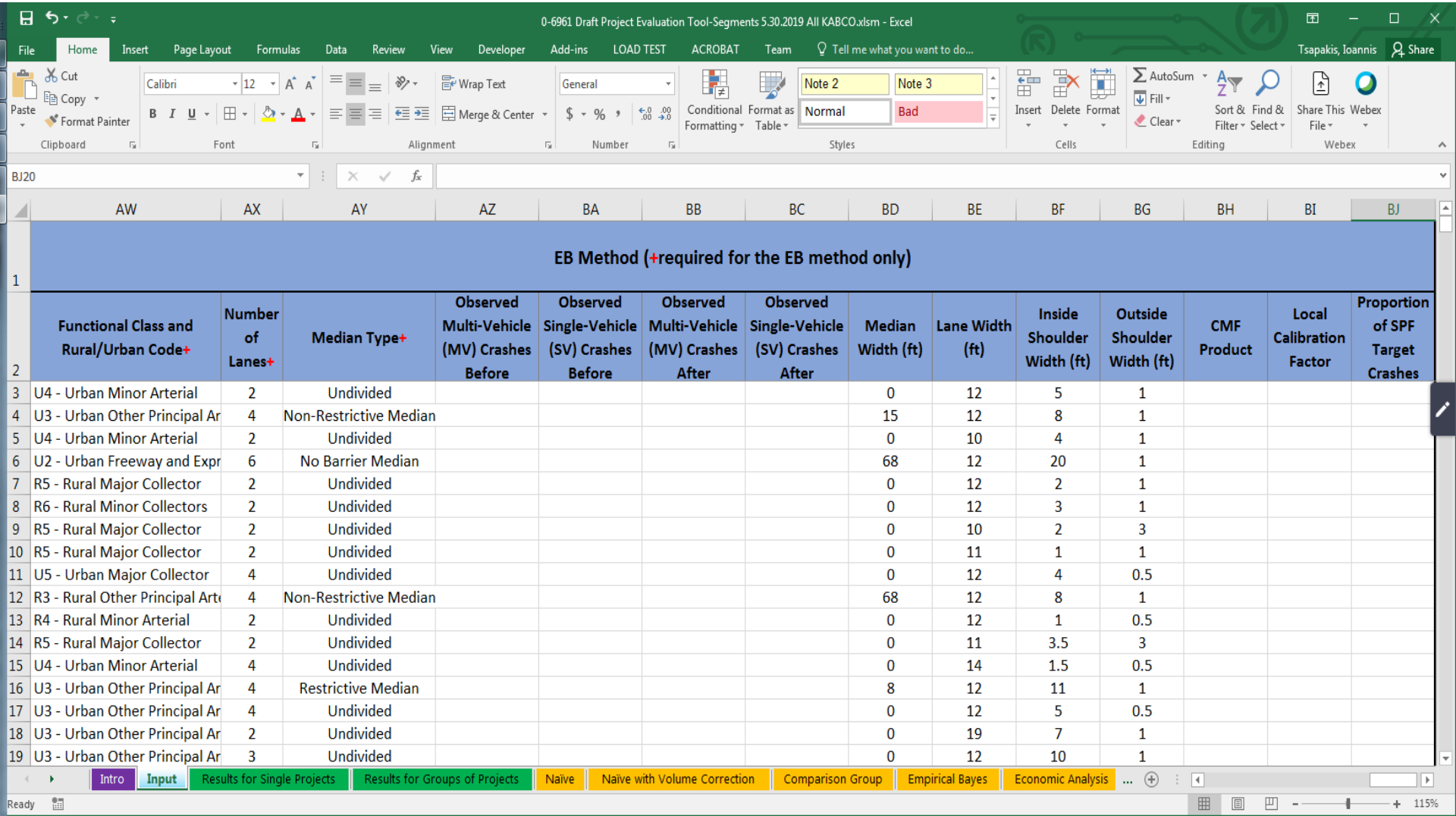
	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV
1	Target Crashes for Evaluation		Number of Crashes (* required only for years included in the before and after periods)										Economic Analysis		Comparison Group (^required for this method only)	
2	All or Target Crashes*	Crash Severity(-ies)*	Crashes Year 1 (Before)*	Crashes Year 2 (Before)*	Crashes Year 3 (Before)*	Crashes Year 4 (Before)*	Crashes Year 5 (Before)*	Crashes Year 1 (After)*	Crashes Year 2 (After)*	Crashes Year 3 (After)*	Crashes Year 4 (After)*	Crashes Year 5 (After)*	Actual Construction Cost*	Annual Maintenance Cost	Total Number of Crashes at Comparison Sites (Before)^	Total Number of Crashes at Comparison Sites (After)^
3	All	KABCO	12	10	1			3	16	9	21	16	$ 183,984			
4	Target	KABCO	10	3				7	11	10	8	8	$ 2,459,009			
5	All	KABC	29	12				9	28	36	34	27	$ 1,705,111			
6	Target	KABC	58	38				33	47	61	97	88	$ 893,533			
7	All	KAB	0	1				0	1	0	0	1	$ 1,452,002			
8	Target	KAB	4	2				1	1	2	2	3	$ 1,662,400			
9	All	KABCO	1	0				0	1	0	1	3	$ 1,259,321			
10	Target	KAB	6	5				1	1	0	1	3	$ 2,482,886			
11	Target	KABCO	25	7				0	26	13	20	13	$ 296,805			
12	Target	KABCO	4	1				0	3	4	12	13	$ 519,648			
13	Target	KABCO	13	8				4	12	19	16	21	$ 1,237,071			
14	All	KABCO	12	8	1			7	11	15	16	13	$ 1,098,213			
15	All	KABCO	15	18				21	34	22	24	23	$ 634,743			
16	All	KABCO	55	23				47	46	44	69	81	$ 650,717			
17	All	KABCO	47	24				21	41	40	38	46	$ 1,102,724			
18	All	KABCO	42	28				22	48	57	78	50	$ 991,787			
19	All	KABCO	15	5				6	8	13	7	18	$ 447,301			

Intro | Input | Results for Single Projects | Results for Groups of Projects | Naïve | Naïve with Volume Correction | Comparison Group | Empirical Bayes | Economic Analysis

Input Sheet



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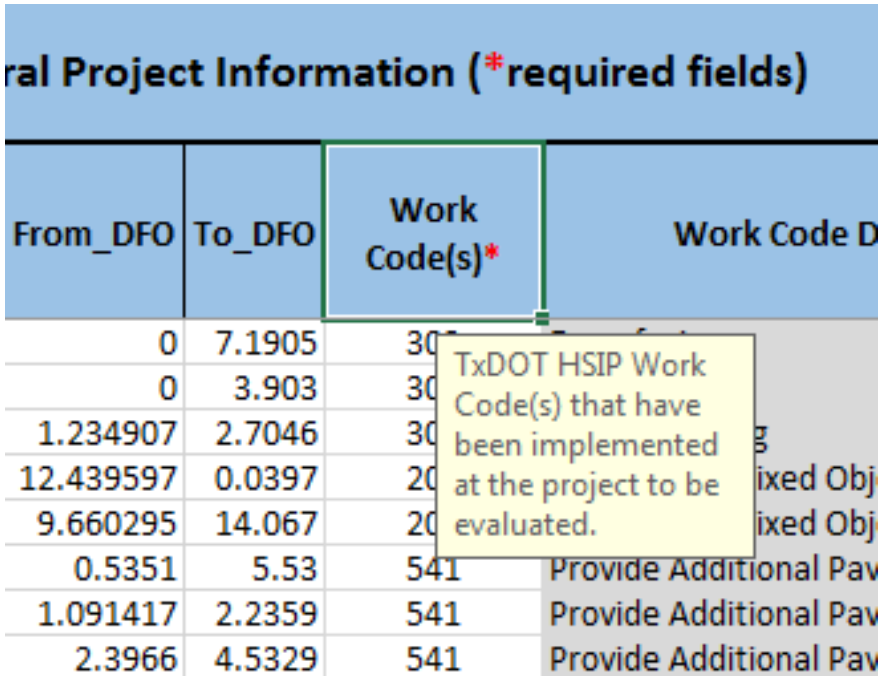
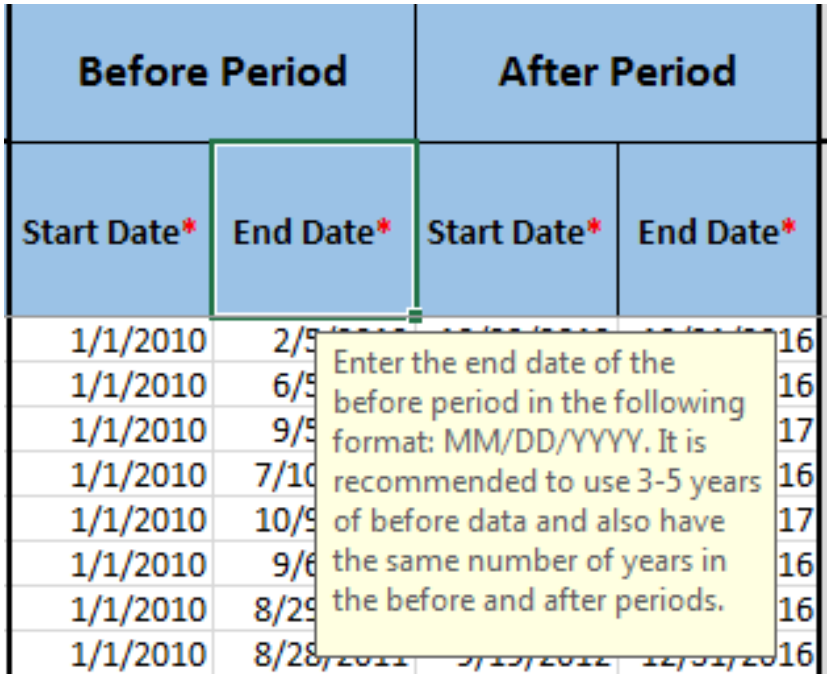
	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ
1	EB Method (+required for the EB method only)													
2	Functional Class and Rural/Urban Code+	Number of Lanes+	Median Type+	Observed Multi-Vehicle (MV) Crashes Before	Observed Single-Vehicle (SV) Crashes Before	Observed Multi-Vehicle (MV) Crashes After	Observed Single-Vehicle (SV) Crashes After	Median Width (ft)	Lane Width (ft)	Inside Shoulder Width (ft)	Outside Shoulder Width (ft)	CMF Product	Local Calibration Factor	Proportion of SPF Target Crashes
3	U4 - Urban Minor Arterial	2	Undivided					0	12	5	1			
4	U3 - Urban Other Principal Ar	4	Non-Restrictive Median					15	12	8	1			
5	U4 - Urban Minor Arterial	2	Undivided					0	10	4	1			
6	U2 - Urban Freeway and Expr	6	No Barrier Median					68	12	20	1			
7	R5 - Rural Major Collector	2	Undivided					0	12	2	1			
8	R6 - Rural Minor Collectors	2	Undivided					0	12	3	1			
9	R5 - Rural Major Collector	2	Undivided					0	10	2	3			
10	R5 - Rural Major Collector	2	Undivided					0	11	1	1			
11	U5 - Urban Major Collector	4	Undivided					0	12	4	0.5			
12	R3 - Rural Other Principal Arte	4	Non-Restrictive Median					68	12	8	1			
13	R4 - Rural Minor Arterial	2	Undivided					0	12	1	0.5			
14	R5 - Rural Major Collector	2	Undivided					0	11	3.5	3			
15	U4 - Urban Minor Arterial	4	Undivided					0	14	1.5	0.5			
16	U3 - Urban Other Principal Ar	4	Restrictive Median					8	12	11	1			
17	U3 - Urban Other Principal Ar	4	Undivided					0	12	5	0.5			
18	U3 - Urban Other Principal Ar	2	Undivided					0	19	7	1			
19	U3 - Urban Other Principal Ar	3	Undivided					0	12	10	1			

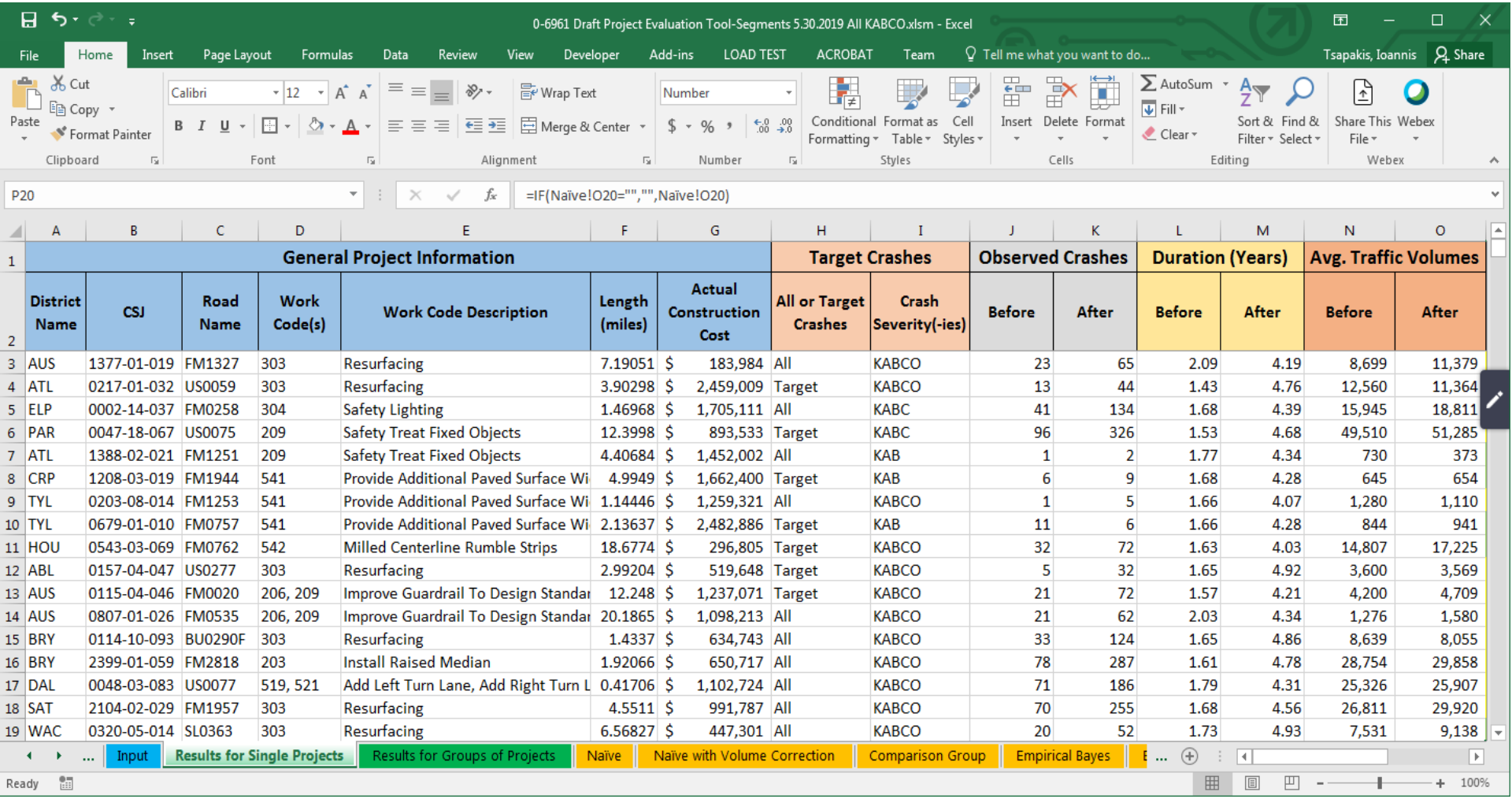
Intro | Input | Results for Single Projects | Results for Groups of Projects | Naïve | Naïve with Volume Correction | Comparison Group | Empirical Bayes | Economic Analysis

Input Sheet


ral Project Information (*required fields)
From_DFO
To_DFO
Work Code(s)*
Work Code D
0
7.1905
1.234907
2.7046
12.439597
0.0397
9.660295
14.067
0.5351
5.53
541
Provide Additional Pav
1.091417
2.2359
541
Provide Additional Pav
2.3966
4.5329
541
Provide Additional Pav
TxDOT HSIP Work Code(s) that have been implemented at the project to be evaluated.

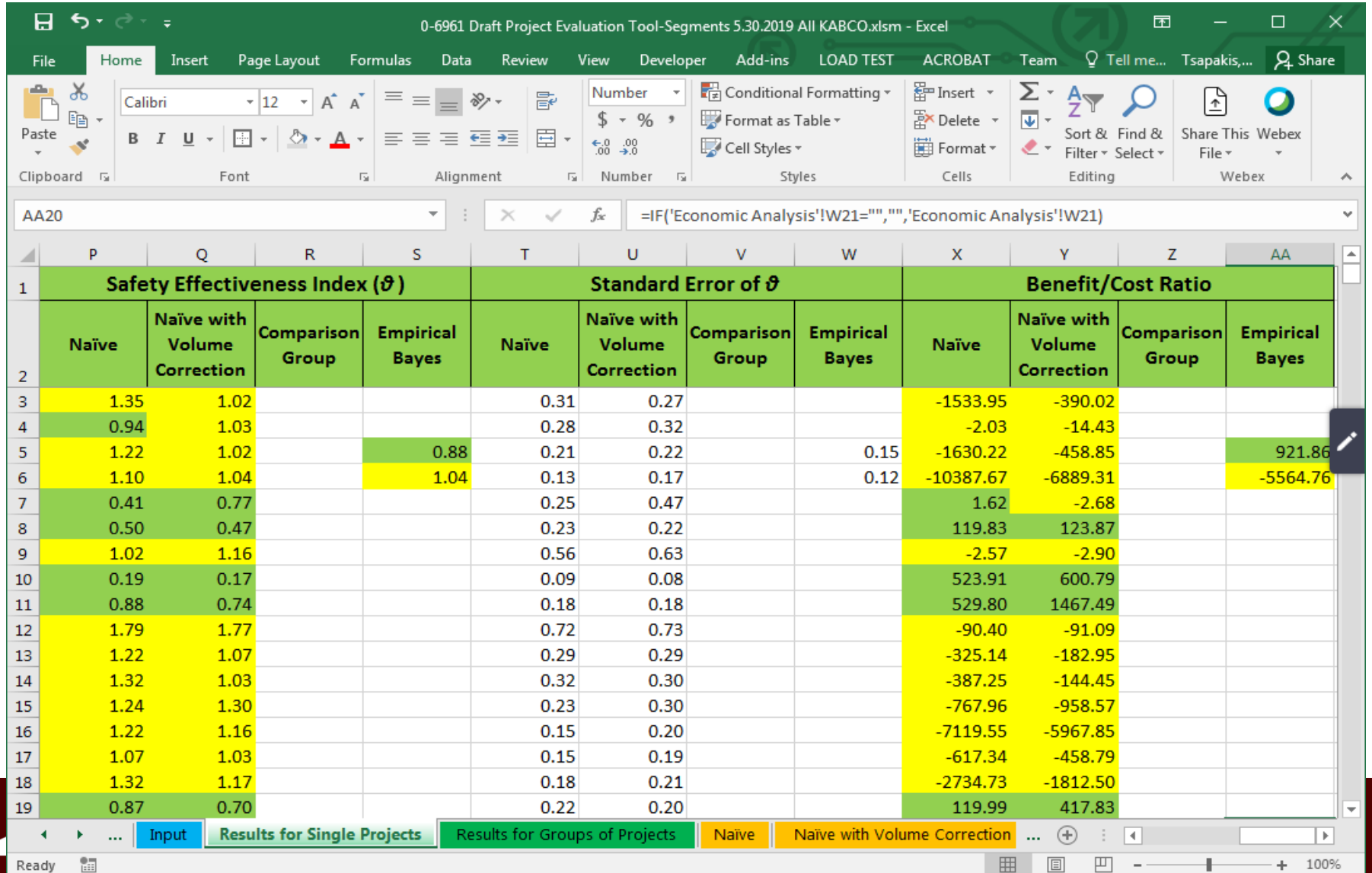

Before Period
After Period
Start Date*
End Date*
Start Date*
End Date*
1/1/2010
1/1/2010
1/1/2010
1/1/2010
1/1/2010
1/1/2010
1/1/2010
Enter the end date of the before period in the following format: MM/DD/YYYY. It is recommended to use 3-5 years of before data and also have the same number of years in the before and after periods.

Results for Single Projects Sheet



	General Project Information							Target Crashes		Observed Crashes		Duration (Years)		Avg. Traffic Volumes	
	District Name	CSJ	Road Name	Work Code(s)	Work Code Description	Length (miles)	Actual Construction Cost	All or Target Crashes	Crash Severity(-ies)	Before	After	Before	After	Before	After
3	AUS	1377-01-019	FM1327	303	Resurfacing	7.19051	$ 183,984	All	KABCO	23	65	2.09	4.19	8,699	11,379
4	ATL	0217-01-032	US0059	303	Resurfacing	3.90298	$ 2,459,009	Target	KABCO	13	44	1.43	4.76	12,560	11,364
5	ELP	0002-14-037	FM0258	304	Safety Lighting	1.46968	$ 1,705,111	All	KABC	41	134	1.68	4.39	15,945	18,811
6	PAR	0047-18-067	US0075	209	Safety Treat Fixed Objects	12.3998	$ 893,533	Target	KABC	96	326	1.53	4.68	49,510	51,285
7	ATL	1388-02-021	FM1251	209	Safety Treat Fixed Objects	4.40684	$ 1,452,002	All	KAB	1	2	1.77	4.34	730	373
8	CRP	1208-03-019	FM1944	541	Provide Additional Paved Surface Wi	4.9949	$ 1,662,400	Target	KAB	6	9	1.68	4.28	645	654
9	TYL	0203-08-014	FM1253	541	Provide Additional Paved Surface Wi	1.14446	$ 1,259,321	All	KABCO	1	5	1.66	4.07	1,280	1,110
10	TYL	0679-01-010	FM0757	541	Provide Additional Paved Surface Wi	2.13637	$ 2,482,886	Target	KAB	11	6	1.66	4.28	844	941
11	HOU	0543-03-069	FM0762	542	Milled Centerline Rumble Strips	18.6774	$ 296,805	Target	KABCO	32	72	1.63	4.03	14,807	17,225
12	ABL	0157-04-047	US0277	303	Resurfacing	2.99204	$ 519,648	Target	KABCO	5	32	1.65	4.92	3,600	3,569
13	AUS	0115-04-046	FM0020	206, 209	Improve Guardrail To Design Standar	12.248	$ 1,237,071	Target	KABCO	21	72	1.57	4.21	4,200	4,709
14	AUS	0807-01-026	FM0535	206, 209	Improve Guardrail To Design Standar	20.1865	$ 1,098,213	All	KABCO	21	62	2.03	4.34	1,276	1,580
15	BRY	0114-10-093	BU0290F	303	Resurfacing	1.4337	$ 634,743	All	KABCO	33	124	1.65	4.86	8,639	8,055
16	BRY	2399-01-059	FM2818	203	Install Raised Median	1.92066	$ 650,717	All	KABCO	78	287	1.61	4.78	28,754	29,858
17	DAL	0048-03-083	US0077	519, 521	Add Left Turn Lane, Add Right Turn L	0.41706	$ 1,102,724	All	KABCO	71	186	1.79	4.31	25,326	25,907
18	SAT	2104-02-029	FM1957	303	Resurfacing	4.5511	$ 991,787	All	KABCO	70	255	1.68	4.56	26,811	29,920
19	WAC	0320-05-014	SL0363	303	Resurfacing	6.56827	$ 447,301	All	KABCO	20	52	1.73	4.93	7,531	9,138

Results for Single Projects Sheet



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File Home Insert Page Layout Formulas Data Review View Developer Add-ins LOAD TEST ACROBAT Team Tell me... Tsapakis,... Share

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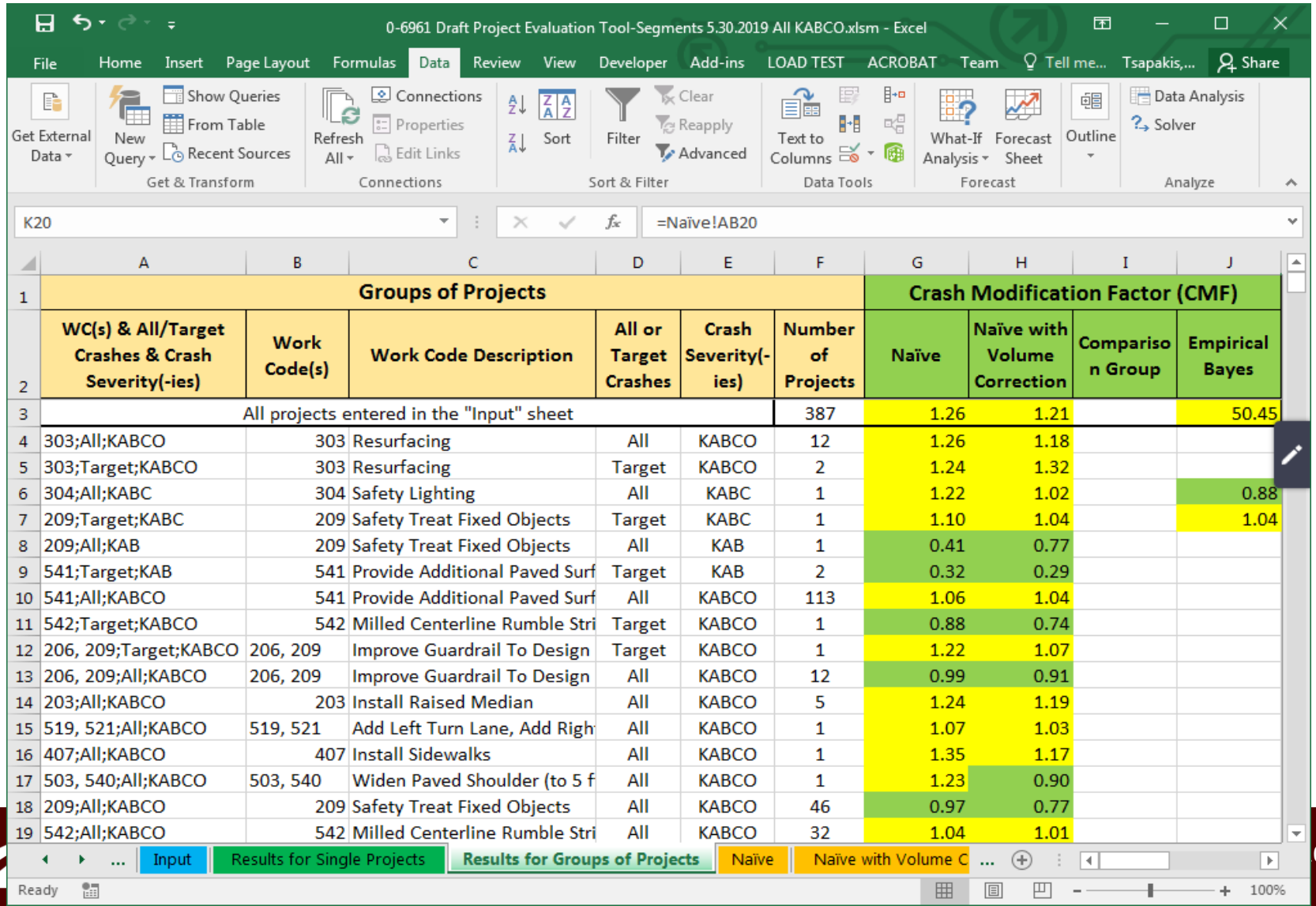
AA20 =IF('Economic Analysis'!W21="","",'Economic Analysis'!W21)

	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	Safety Effectiveness Index (ϑ)				Standard Error of ϑ				Benefit/Cost Ratio			
2	Naïve	Naïve with Volume Correction	Comparison Group	Empirical Bayes	Naïve	Naïve with Volume Correction	Comparison Group	Empirical Bayes	Naïve	Naïve with Volume Correction	Comparison Group	Empirical Bayes
3	1.35	1.02			0.31	0.27			-1533.95	-390.02		
4	0.94	1.03			0.28	0.32			-2.03	-14.43		
5	1.22	1.02		0.88	0.21	0.22		0.15	-1630.22	-458.85		921.86
6	1.10	1.04		1.04	0.13	0.17		0.12	-10387.67	-6889.31		-5564.76
7	0.41	0.77			0.25	0.47			1.62	-2.68		
8	0.50	0.47			0.23	0.22			119.83	123.87		
9	1.02	1.16			0.56	0.63			-2.57	-2.90		
10	0.19	0.17			0.09	0.08			523.91	600.79		
11	0.88	0.74			0.18	0.18			529.80	1467.49		
12	1.79	1.77			0.72	0.73			-90.40	-91.09		
13	1.22	1.07			0.29	0.29			-325.14	-182.95		
14	1.32	1.03			0.32	0.30			-387.25	-144.45		
15	1.24	1.30			0.23	0.30			-767.96	-958.57		
16	1.22	1.16			0.15	0.20			-7119.55	-5967.85		
17	1.07	1.03			0.15	0.19			-617.34	-458.79		
18	1.32	1.17			0.18	0.21			-2734.73	-1812.50		
19	0.87	0.70			0.22	0.20			119.99	417.83		

Input | Results for Single Projects | Results for Groups of Projects | Naïve | Naïve with Volume Correction

Ready 100%

Results for Groups of Projects Sheet



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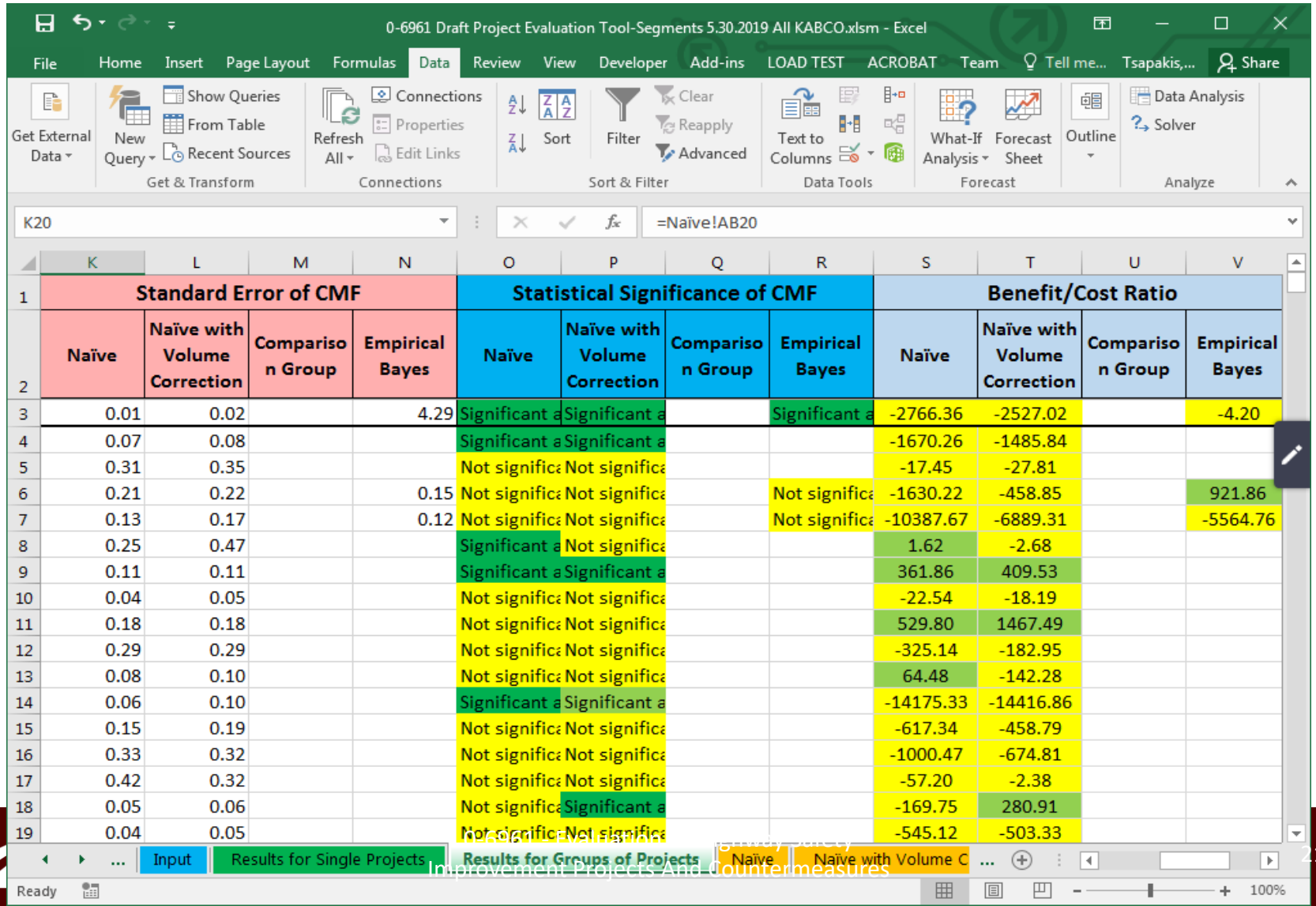
K20 =Naïve!AB20

	A	B	C	D	E	F	G	H	I	J
1	Groups of Projects						Crash Modification Factor (CMF)			
2	WC(s) & All/Target Crashes & Crash Severity(-ies)	Work Code(s)	Work Code Description	All or Target Crashes	Crash Severity(-ies)	Number of Projects	Naïve	Naïve with Volume Correction	Comparison Group	Empirical Bayes
3	All projects entered in the "Input" sheet					387	1.26	1.21		50.45
4	303;All;KABCO	303	Resurfacing	All	KABCO	12	1.26	1.18		
5	303;Target;KABCO	303	Resurfacing	Target	KABCO	2	1.24	1.32		
6	304;All;KABC	304	Safety Lighting	All	KABC	1	1.22	1.02		0.88
7	209;Target;KABC	209	Safety Treat Fixed Objects	Target	KABC	1	1.10	1.04		1.04
8	209;All;KAB	209	Safety Treat Fixed Objects	All	KAB	1	0.41	0.77		
9	541;Target;KAB	541	Provide Additional Paved Surf	Target	KAB	2	0.32	0.29		
10	541;All;KABCO	541	Provide Additional Paved Surf	All	KABCO	113	1.06	1.04		
11	542;Target;KABCO	542	Milled Centerline Rumble Stri	Target	KABCO	1	0.88	0.74		
12	206, 209;Target;KABCO	206, 209	Improve Guardrail To Design	Target	KABCO	1	1.22	1.07		
13	206, 209;All;KABCO	206, 209	Improve Guardrail To Design	All	KABCO	12	0.99	0.91		
14	203;All;KABCO	203	Install Raised Median	All	KABCO	5	1.24	1.19		
15	519, 521;All;KABCO	519, 521	Add Left Turn Lane, Add Righ	All	KABCO	1	1.07	1.03		
16	407;All;KABCO	407	Install Sidewalks	All	KABCO	1	1.35	1.17		
17	503, 540;All;KABCO	503, 540	Widen Paved Shoulder (to 5 f	All	KABCO	1	1.23	0.90		
18	209;All;KABCO	209	Safety Treat Fixed Objects	All	KABCO	46	0.97	0.77		
19	542;All;KABCO	542	Milled Centerline Rumble Stri	All	KABCO	32	1.04	1.01		

Input | Results for Single Projects | Results for Groups of Projects | Naïve | Naïve with Volume C ...

Ready 100%

Results for Groups of Projects Sheet



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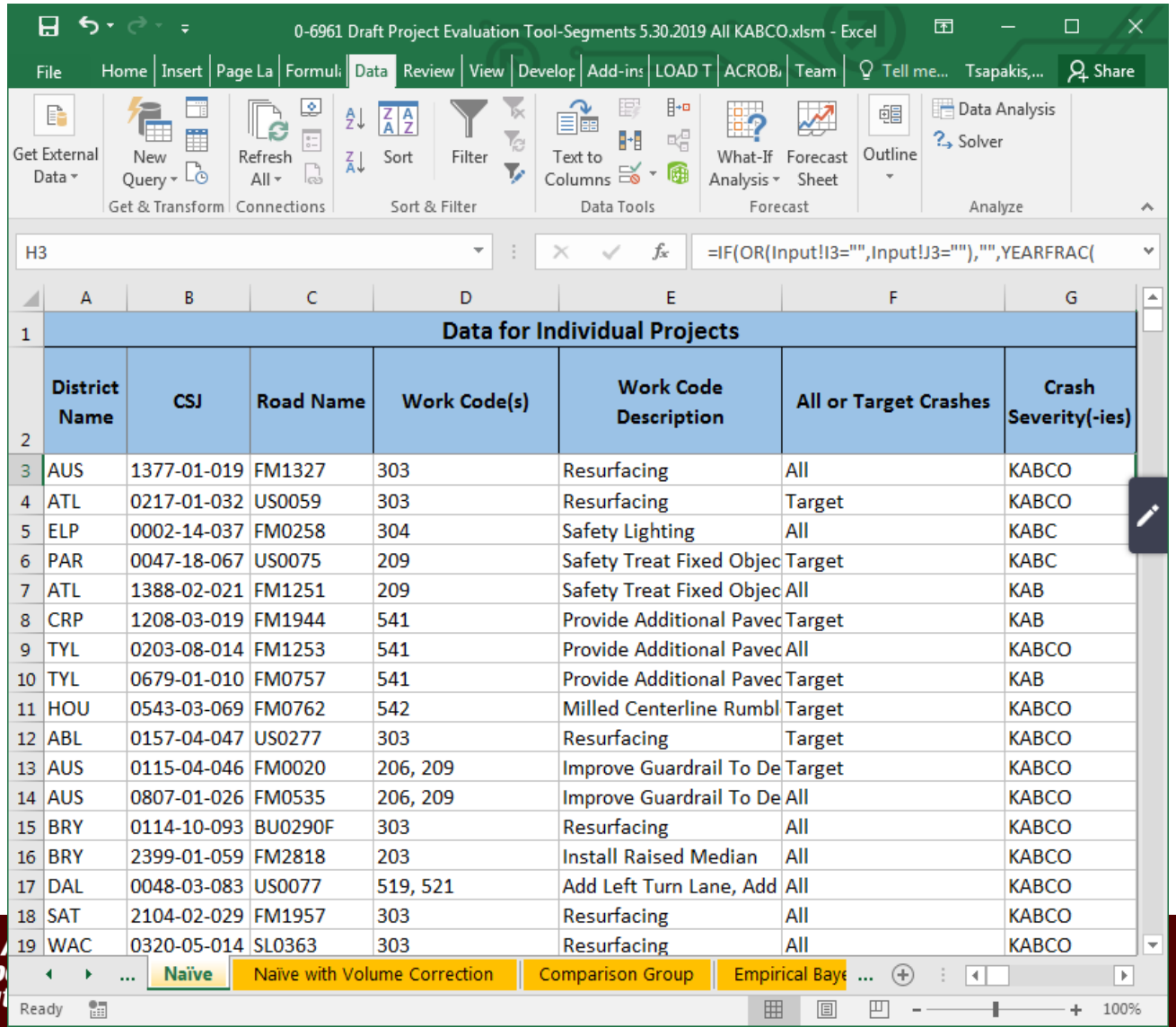
K20 =Naïve!AB20

	Standard Error of CMF				Statistical Significance of CMF				Benefit/Cost Ratio			
	Naïve	Naïve with Volume Correction	Comparison Group	Empirical Bayes	Naïve	Naïve with Volume Correction	Comparison Group	Empirical Bayes	Naïve	Naïve with Volume Correction	Comparison Group	Empirical Bayes
3	0.01	0.02		4.29	Significant a	Significant a		Significant a	-2766.36	-2527.02		-4.20
4	0.07	0.08			Significant a	Significant a			-1670.26	-1485.84		
5	0.31	0.35			Not significa	Not significa			-17.45	-27.81		
6	0.21	0.22		0.15	Not significa	Not significa		Not significa	-1630.22	-458.85		921.86
7	0.13	0.17		0.12	Not significa	Not significa		Not significa	-10387.67	-6889.31		-5564.76
8	0.25	0.47			Significant a	Not significa			1.62	-2.68		
9	0.11	0.11			Significant a	Significant a			361.86	409.53		
10	0.04	0.05			Not significa	Not significa			-22.54	-18.19		
11	0.18	0.18			Not significa	Not significa			529.80	1467.49		
12	0.29	0.29			Not significa	Not significa			-325.14	-182.95		
13	0.08	0.10			Not significa	Not significa			64.48	-142.28		
14	0.06	0.10			Significant a	Significant a			-14175.33	-14416.86		
15	0.15	0.19			Not significa	Not significa			-617.34	-458.79		
16	0.33	0.32			Not significa	Not significa			-1000.47	-674.81		
17	0.42	0.32			Not significa	Not significa			-57.20	-2.38		
18	0.05	0.06			Not significa	Significant a			-169.75	280.91		
19	0.04	0.05			Not significa	Not significa			-545.12	-503.33		

Input | Results for Single Projects | Results for Groups of Projects | Naïve | Naïve with Volume C

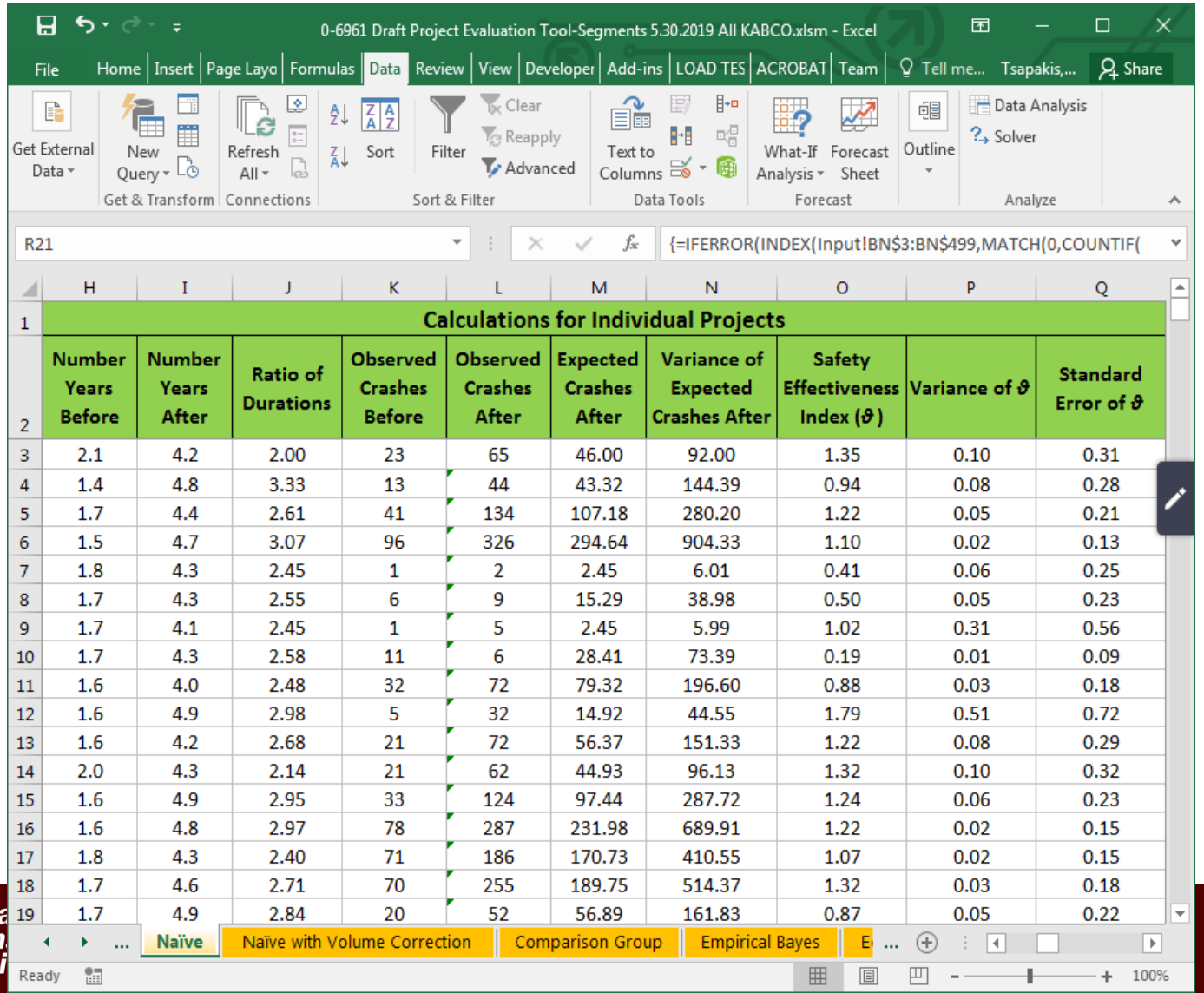
Ready 100%

Calculation Sheets (Orange Tabs)



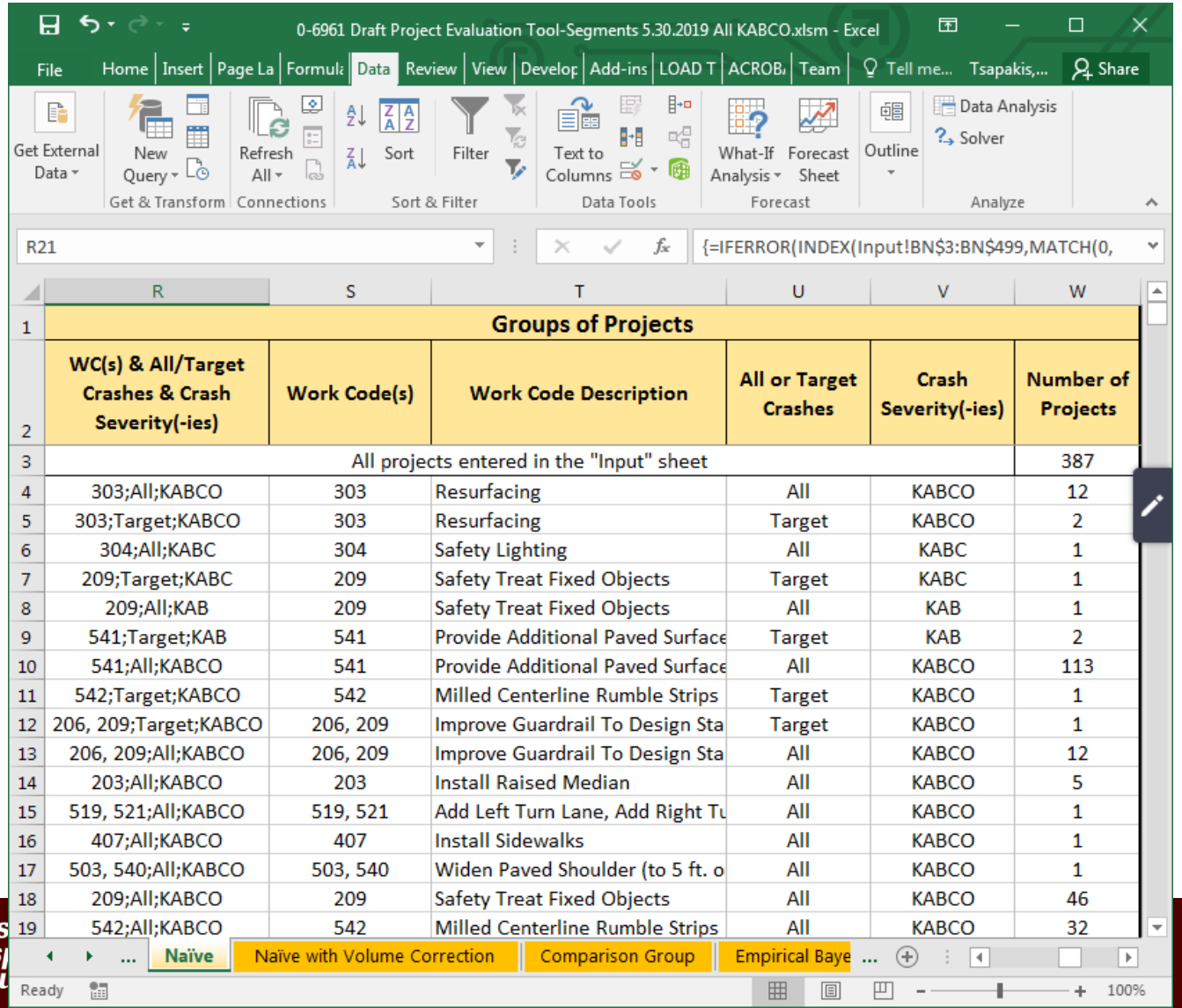
	A	B	C	D	E	F	G
1	Data for Individual Projects						
2	District Name	CSJ	Road Name	Work Code(s)	Work Code Description	All or Target Crashes	Crash Severity(-ies)
3	AUS	1377-01-019	FM1327	303	Resurfacing	All	KABCO
4	ATL	0217-01-032	US0059	303	Resurfacing	Target	KABCO
5	ELP	0002-14-037	FM0258	304	Safety Lighting	All	KABC
6	PAR	0047-18-067	US0075	209	Safety Treat Fixed Objec	Target	KABC
7	ATL	1388-02-021	FM1251	209	Safety Treat Fixed Objec	All	KAB
8	CRP	1208-03-019	FM1944	541	Provide Additional Paved	Target	KAB
9	TYL	0203-08-014	FM1253	541	Provide Additional Paved	All	KABCO
10	TYL	0679-01-010	FM0757	541	Provide Additional Paved	Target	KAB
11	HOU	0543-03-069	FM0762	542	Milled Centerline Rumbl	Target	KABCO
12	ABL	0157-04-047	US0277	303	Resurfacing	Target	KABCO
13	AUS	0115-04-046	FM0020	206, 209	Improve Guardrail To De	Target	KABCO
14	AUS	0807-01-026	FM0535	206, 209	Improve Guardrail To De	All	KABCO
15	BRY	0114-10-093	BU0290F	303	Resurfacing	All	KABCO
16	BRY	2399-01-059	FM2818	203	Install Raised Median	All	KABCO
17	DAL	0048-03-083	US0077	519, 521	Add Left Turn Lane, Add	All	KABCO
18	SAT	2104-02-029	FM1957	303	Resurfacing	All	KABCO
19	WAC	0320-05-014	SL0363	303	Resurfacing	All	KABCO

Calculation Sheets (Orange Tabs)

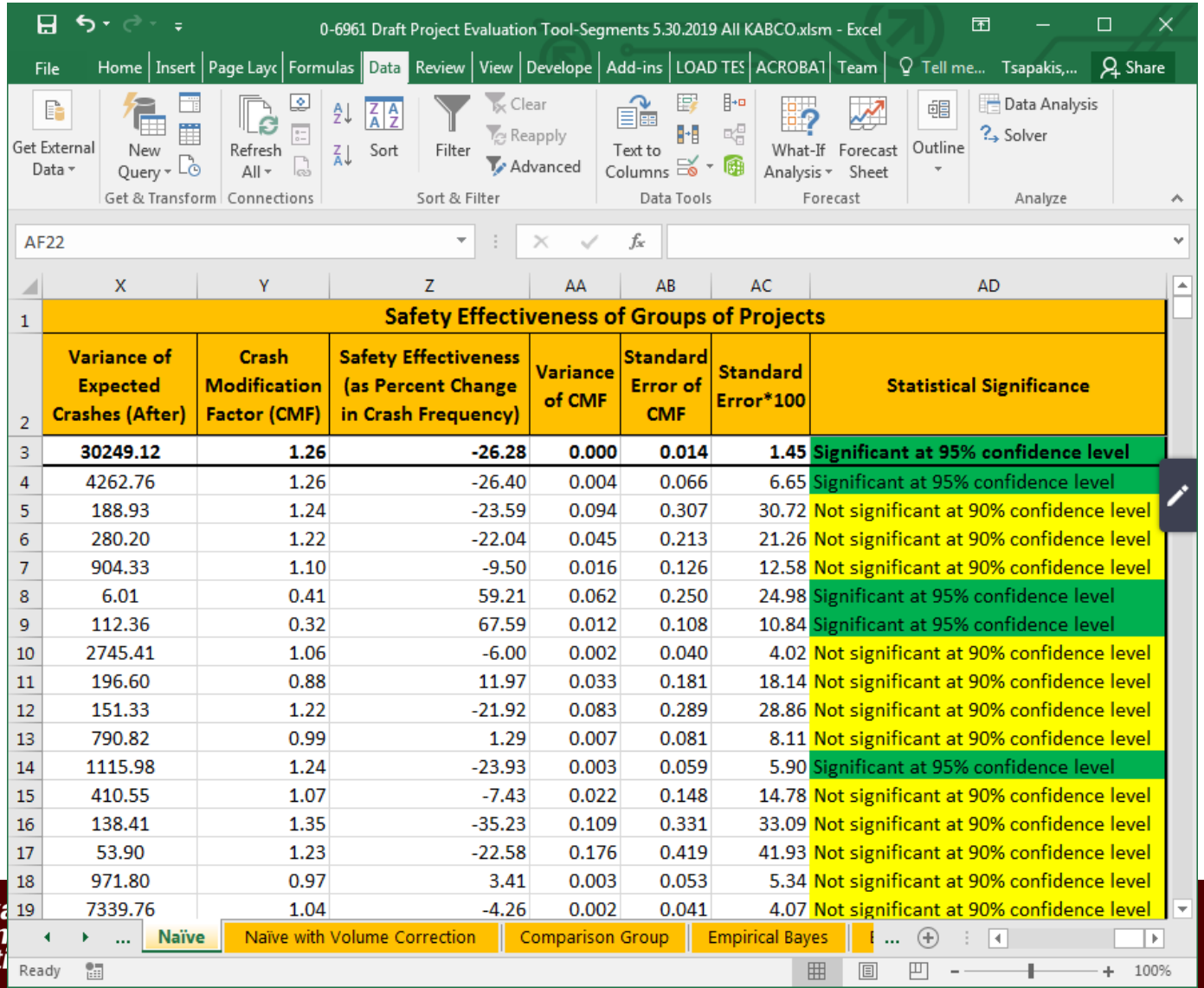


	H	I	J	K	L	M	N	O	P	Q
1	Calculations for Individual Projects									
2	Number Years Before	Number Years After	Ratio of Durations	Observed Crashes Before	Observed Crashes After	Expected Crashes After	Variance of Expected Crashes After	Safety Effectiveness Index (θ)	Variance of θ	Standard Error of θ
3	2.1	4.2	2.00	23	65	46.00	92.00	1.35	0.10	0.31
4	1.4	4.8	3.33	13	44	43.32	144.39	0.94	0.08	0.28
5	1.7	4.4	2.61	41	134	107.18	280.20	1.22	0.05	0.21
6	1.5	4.7	3.07	96	326	294.64	904.33	1.10	0.02	0.13
7	1.8	4.3	2.45	1	2	2.45	6.01	0.41	0.06	0.25
8	1.7	4.3	2.55	6	9	15.29	38.98	0.50	0.05	0.23
9	1.7	4.1	2.45	1	5	2.45	5.99	1.02	0.31	0.56
10	1.7	4.3	2.58	11	6	28.41	73.39	0.19	0.01	0.09
11	1.6	4.0	2.48	32	72	79.32	196.60	0.88	0.03	0.18
12	1.6	4.9	2.98	5	32	14.92	44.55	1.79	0.51	0.72
13	1.6	4.2	2.68	21	72	56.37	151.33	1.22	0.08	0.29
14	2.0	4.3	2.14	21	62	44.93	96.13	1.32	0.10	0.32
15	1.6	4.9	2.95	33	124	97.44	287.72	1.24	0.06	0.23
16	1.6	4.8	2.97	78	287	231.98	689.91	1.22	0.02	0.15
17	1.8	4.3	2.40	71	186	170.73	410.55	1.07	0.02	0.15
18	1.7	4.6	2.71	70	255	189.75	514.37	1.32	0.03	0.18
19	1.7	4.9	2.84	20	52	56.89	161.83	0.87	0.05	0.22

Calculation Sheets (Orange Tabs)



Calculation Sheets (Orange Tabs)



Effectiveness of Implemented HSIP Projects and WCs

Purpose: Evaluate safety and cost effectiveness of completed:

- Individual HSIP projects
  - 387 segment projects
  - 70 intersection projects
- WCs
  - 46 segment WCs
  - 21 intersection WCs

Evaluated Crash Types

- All KABCO crashes
- All KABC crashes
- All KAB crashes
- Target KABCO crashes
- Target KABC crashes
- Target KAB crashes

Safety Effectiveness Evaluation Results for Individual Segment Projects

Safety Effectiveness of Individual Projects			Number of Project Evaluations			Percent of All
			Naïve	Naïve with Vol. Correct.	EB	
θ<1.0		Effective	1,084	1,153	287	46.6%
θ>1.0		Not effective	662	593	241	27.6%
θ cannot be determined	# Crashes before > 0 # Crashes after = 0	Potentially Effective	405	405	144	17.6%
	# Crashes before = 0 # Crashes after > 0	Potentially Not effective	98	98	5	3.7%
	# Crashes before = 0 # Crashes after = 0	Effectiveness cannot be determined	73	73	23	3.1%
	# Crashes before > 0 # Crashes after > 0	Effectiveness cannot be determined	-	-	74	1.4%
Subtotal			**2,322**	**2,322**	**774**	**100%**
Total				**5,418**		**100%**

Cost Effectiveness Evaluation Results for Individual Segment Projects

B/C Ratio of Individual Projects			Number of Project Evaluations			Percent of All
			Naïve	Naïve with Vol. Correct.	EB	
B/C>1.0		Effective	1,277	1,315	340	54%
B/C<1.0		Not effective	874	836	271	37%
B/C cannot be determined	# Crashes before > 0 # Crashes after = 0	Potentially Effective	-	-	29	1%
	# Crashes before = 0 # Crashes after > 0	Potentially Not effective	98	98	37	4%
	# Crashes before = 0 # Crashes after = 0	Effectiveness cannot be determined	73	73	23	3%
	# Crashes before > 0 # Crashes after > 0	Effectiveness cannot be determined	-	-	74	1%
Subtotal			**2,322**	**2,322**	**774**	**100%**
Total			**5,418**			**100%**

Top 10 Work Codes for Segments

WC(s)	WC Description	Sample Size
541	Provide Additional Paved Surface Width	115
209	Safety Treat Fixed Objects	48
502	Widen Lane(s)	39
542	Milled Centerline Rumble Strips	33
532	Milled Edgeline Rumble Strips	17
303	Resurfacing	14
532, 542	Milled Edgeline Rumble Strips, Milled Centerline Rumble Strips	14
206, 209	Improve Guardrail To Design Standards, Safety Treat Fixed Objects	13
201	Install Median Barrier	12
533, 542	Profile Edgeline Markings, Milled Centerline Rumble Strips	11

Evaluation Results for WC 541

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
541 Provide Additional Paved Surface Width	All KABCO	1.04	1.02	Not Sig.	Not Sig.	-21.4	-17.0
	All KABC	0.98	0.95	Not Sig.	Not Sig.	0.2	5.9
	All KAB	0.92	0.90	Not Sig.	Not Sig.	15.3	17.7
	Target KABCO	0.89	0.88	Sig.	Sig.	11.4	10.4
	Target KABC	0.87	0.85	Sig.	Sig.	9.1	8.2
	Target KAB	0.82	0.81	Sig.	Sig.	12.8	11.1

Evaluation Results for WC 209

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
209 Safety Treat Fixed Objects	All KABCO	1.00	0.85	Not Sig.	Sig.	-224.6	227.1
	All KABC	0.92	0.73	Not Sig.	Sig.	369.3	636.3
	All KAB	0.94	0.73	Not Sig.	Sig.	417.3	613.1
	Target KABCO	0.93	0.77	Not Sig.	Sig.	142.1	209.9
	Target KABC	0.78	0.62	Sig.	Sig.	176.0	238.9
	Target KAB	0.84	0.65	Not Sig.	Sig.	146.6	196.8

Evaluation Results for WC 502

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
502 Widen Lane(s)	All KABCO	0.78	0.79	Sig.	Sig.	16.6	17.0
	All KABC	0.68	0.69	Sig.	Sig.	21.4	22.4
	All KAB	0.55	0.56	Sig.	Sig.	27.3	27.6
	Target KABCO	0.61	0.62	Sig.	Sig.	13.8	14.2
	Target KABC	0.56	0.57	Sig.	Sig.	18.0	18.7
	Target KAB	0.48	0.48	Sig.	Sig.	17.4	17.7

Evaluation Results for WC 542

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
542 Milled Centerline Rumble Strips	All KABCO	1.04	1.00	Not Sig.	Not Sig.	-530.4	-476.3
	All KABC	1.01	0.97	Not Sig.	Sig.	50.5	93.1
	All KAB	0.90	0.85	Not Sig.	Sig.	145.8	193.7
	Target KABCO	0.84	0.82	Sig.	Sig.	134.5	153.6
	Target KABC	0.80	0.77	Sig.	Sig.	154.0	174.4
	Target KAB	0.74	0.70	Sig.	Sig.	160.7	179.0

Evaluation Results for Top 4 Segment-Related WCs (Treated as One Group)

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
Top 4 WCs as a Single Group (235 projects)	All KABCO	1.03	0.97	Not Sig.	Not Sig.	-18.4	-1.7
	All KABC	0.97	0.90	Not Sig.	Sig.	40.3	70.2
	All KAB	0.91	0.83	Sig.	Sig.	59.4	80.7
	Target KABCO	0.87	0.83	Sig.	Sig.	10.4	12.9
	Target KABC	0.82	0.77	Sig.	Sig.	31.6	37.7
	Target KAB	0.78	0.73	Sig.	Sig.	31.5	35.7

Safety Effectiveness Evaluation Results for Intersection Projects

Safety Effectiveness of Individual Projects			Number of Project Evaluations			Percent of All
			Naïve	Naïve with Vol. Correct.	EB	
θ<1.0		Effective	194	209	73	48.6%
θ>1.0		Not effective	139	124	41	31.0%
θ cannot be determined	# Crashes before > 0 # Crashes after = 0	Potentially Effective	34	34	12	8.2%
	# Crashes before = 0 # Crashes after > 0	Potentially Not effective	26	26	6	5.9%
	# Crashes before = 0 # Crashes after = 0	Effectiveness cannot be determined	27	27	8	6.3%
	# Crashes before > 0 # Crashes after > 0	Effectiveness cannot be determined	-	-	-	0.0%
Subtotal			**420**	**420**	**140**	**100%**
Total			**980**			**100%**

Cost Effectiveness Evaluation Results for Intersection Projects

B/C Ratio of Individual Projects			Number of Project Evaluations			Percent of All
			Naïve	Naïve with Vol. Correct.	EB	
B/C>1.0		Effective	199	216	71	50%
B/C<1.0		Not effective	168	151	49	38%
B/C cannot be determined	# Crashes before > 0 # Crashes after = 0	Potentially Effective	-	-	1	0%
	# Crashes before = 0 # Crashes after > 0	Potentially Not effective	26	26	9	6%
	# Crashes before = 0 # Crashes after = 0	Effectiveness cannot be determined	27	27	8	6%
	# Crashes before > 0 # Crashes after > 0	Effectiveness cannot be determined	-	-	2	0%
Subtotal			**420**	**420**	**140**	**100%**
Total			**980**			**100%**

Intersection WCs

Work Code	Work Code Description	Sample Size
108	Improve Traffic Signals	26
107	Install Traffic Signal	13
105	Install Intersection Flashing Beacon	7
105, 305	Install Intersection Flashing Beacon, Safety Lighting at Intersection	4
519	Add Left Turn Lane	3
108, 508, 519, 520	Improve Traffic Signals, Realign Intersection, Add Left Turn Lane, Lengthen Left Turn Lane	2
132, 305	Install Advance Warning Signals, Signs, Safety Lighting	1
108, 132	Improve Traffic Signals, Install Advance Warning Signals and Signs	1
105, 307	Install Intersection Flashing Beacon, High Friction Surface Treatment	1
122	Install Advance Warning Signals (Existing Warning Signs)	1
305, 520	Safety Lighting at Intersection, Lengthen Left Turn Lane	1
107, 305	Install Traffic Signal, Safety Lighting at Intersection	1
105, 521	Install Intersection Flashing Beacon, Add Right Turn Lane	1
105, 545	Install Intersection Flashing Beacon, Transverse Rumble Strips	1
108, 520	Improve Traffic Signals, Lengthen Left Turn Lane	1
508	Realign Intersection	1
108, 519	Improve Traffic Signals, Add Left Turn Lane	1
132	Install Advance Warning Signals and Signs	1
105, 519	Install Intersection Flashing Beacon, Add Left Turn Lane	1
105, 124	Install Intersection Flashing Beacon, Install Advance Warning Signals and Signs (Intersection)	1
305	Safety Lighting at Intersection	1

Evaluation Results for WC 108

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
108 Improve Traffic Signals	All KABCO	1.11	1.06	Sig.	Not Sig.	-848.6	-541.0
	All KABC	1.10	1.04	Not Sig.	Not Sig.	444.6	491.2
	All KAB	1.10	1.04	Not Sig.	Not Sig.	91.4	130.3
	Target KABCO	1.02	0.98	Not Sig.	Not Sig.	141.4	297.7
	Target KABC	1.03	0.98	Not Sig.	Not Sig.	227.5	239.5
	Target KAB	0.99	0.94	Not Sig.	Not Sig.	93.6	122.4

Evaluation Results for WC 107

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
107 Install Traffic Signal	All KABCO	0.87	0.76	Not Sig.	Sig.	329.0	523.5
	All KABC	0.71	0.61	Sig.	Sig.	691.7	938.3
	All KAB	0.49	0.42	Sig.	Sig.	737.3	963.9
	Target KABCO	0.79	0.69	Sig.*	Sig.	281.5	415.3
	Target KABC	0.65	0.55	Sig.	Sig.	578.2	770.8
	Target KAB	0.43	0.36	Sig.	Sig.	601.5	779.1

*Statistically significant CMF at 90 percent confidence level.

Results for All 70 Intersection Projects

WC	Crash Type	CMF		Significance of CMF		B/C	
		Naïve	Naïve with Correct.	Naïve	Naïve with Correct.	Naïve	Naïve with Correct.
All 21 WCs as a Single Group (70 projects)	All KABCO	1.05	0.98	Not Sig.	Not Sig.	-256.0	-119.3
	All KABC	0.95	0.88	Not Sig.	Sig.	293.5	345.2
	All KAB	0.87	0.79	Not Sig.	Sig.	137.6	183.7
	Target KABCO	0.97	0.91	Not Sig.	Sig.*	83.4	159.1
	Target KABC	0.88	0.82	Sig.*	Sig.	188.9	221.5
	Target KAB	0.81	0.74	Sig.	Sig.	111.9	145.6

*Statistically significant CMF at 90 percent confidence level.

Implementation Recommendations

- Find missing data for completed HSIP projects
- Develop new CMFs
- Establish safety and cost effectiveness evaluation process, incorporate it into HSIP, and update TxDOT *HSIP Manual*
- Implement 0-6961 evaluation tools statewide
- Apply advanced data-driven evaluation methods (e.g., Empirical Bayes method)

Implementation Recommendations

- Assess the need for calibrating existing SPFs and develop new SPFs
- Assess the need for collecting more roadway inventory and other types of data
- Develop intersection inventory
- Update process of geolocating frontage road crashes in CRIS
- Save the version of RHiNo that is used to determine the distance from origin of each crash in CRIS

Thank You!

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