Safety Evaluation Framework: Techniques and Tools

2026 TexITE Dallas

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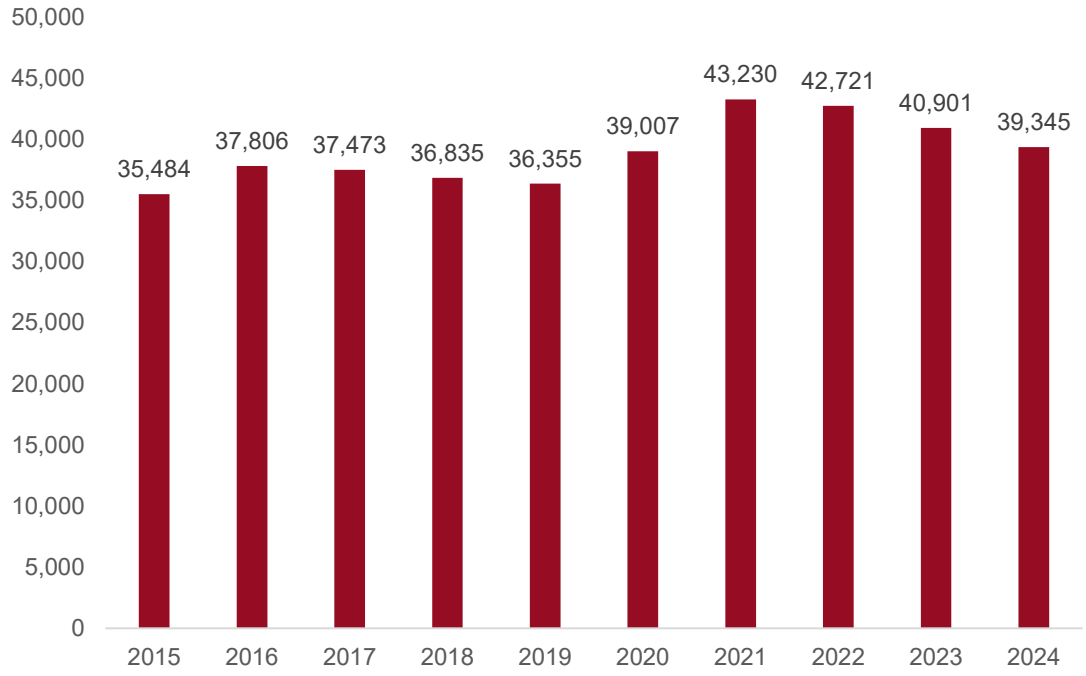
January 2026

Motor Vehicle Fatalities

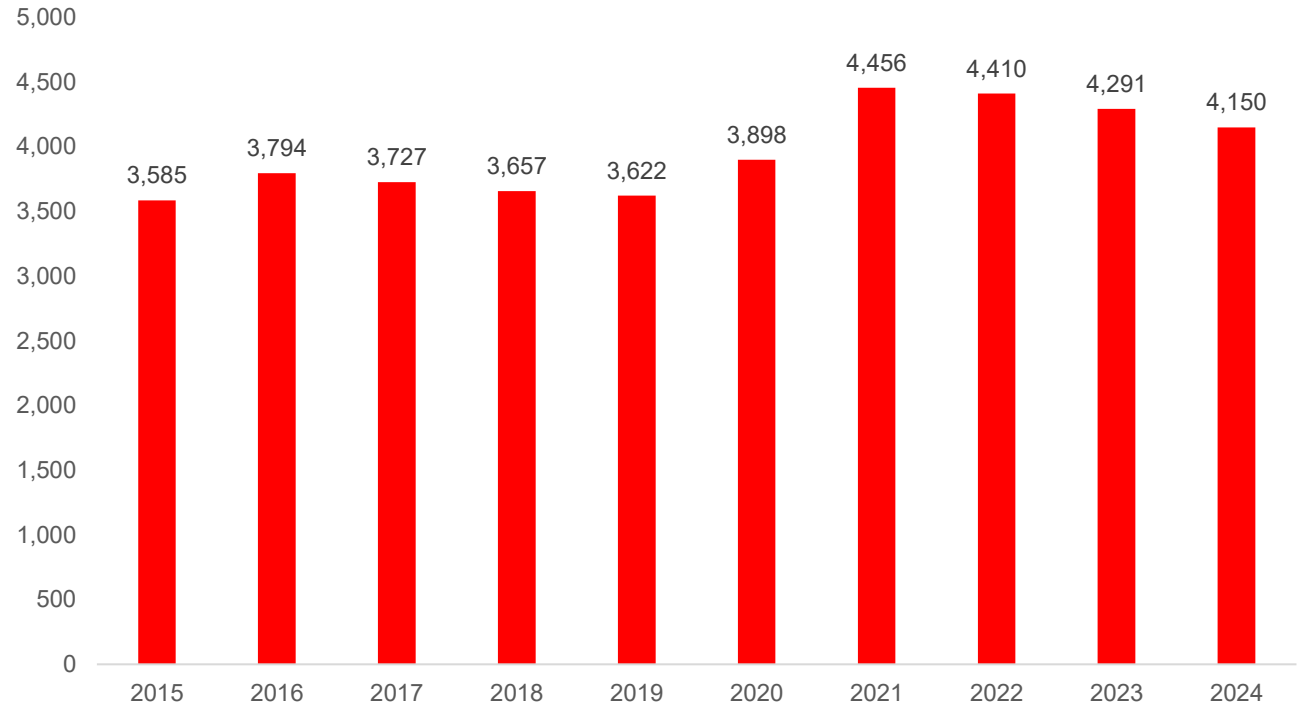
Thousands of lives are lost each year:

US Motor Vehicle Fatalities 2015-2024*



Source: NHTSA

Texas Motor Vehicle Fatalities 2015-2024**



Source: TxDOT

2015
$36.7B

2024
$56.9B

Estimated economic loss of all motor vehicle crashes in Texas is increasing every year.

Road to Zero …

- HSIP- Vulnerable Road Users
- Systemic safety analysis
- Safety Action Plans
- Safety Assessments:

    Nominal and Substantive safety

Traditional Safety Approach

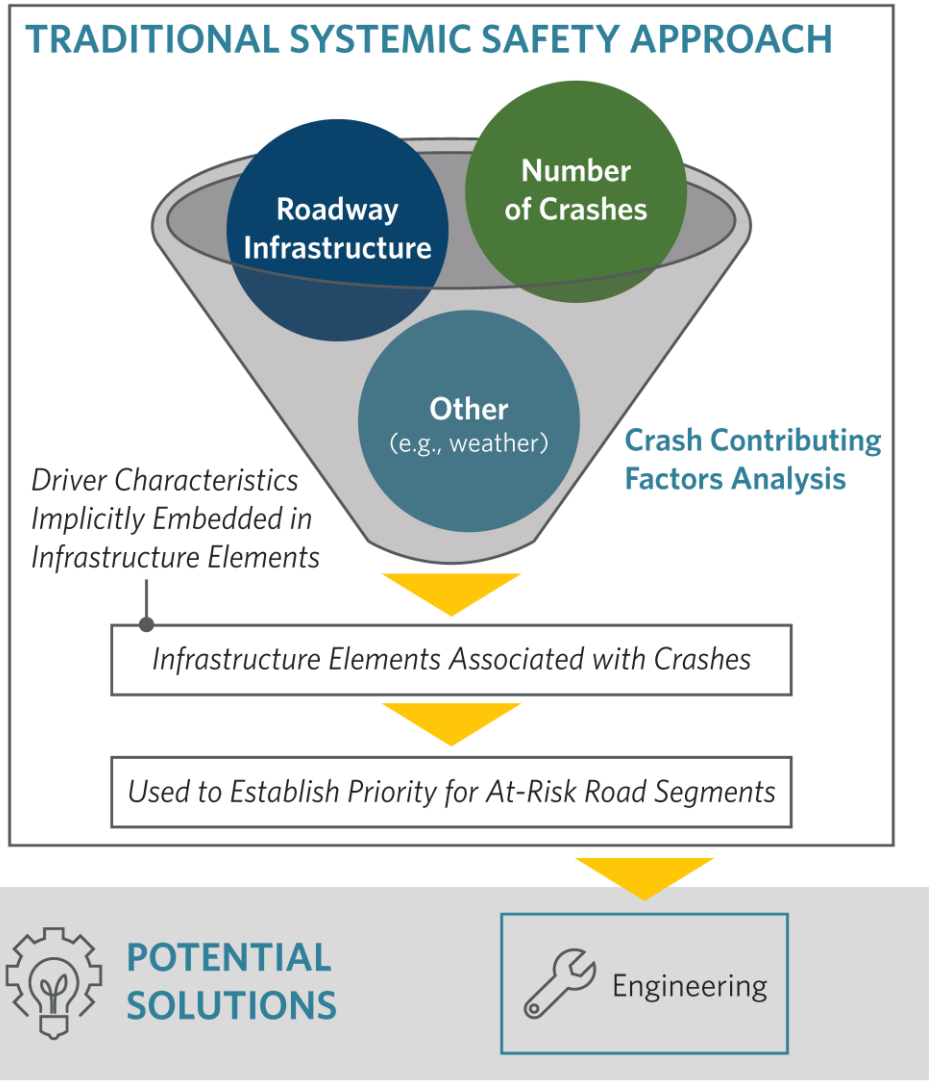
Data Collection
- TxDOT/Agencies
- TxDOT CRIS database

Detailed Data Analysis
- Highway Safety Manual (HSM)
- Safety Evaluation Tools

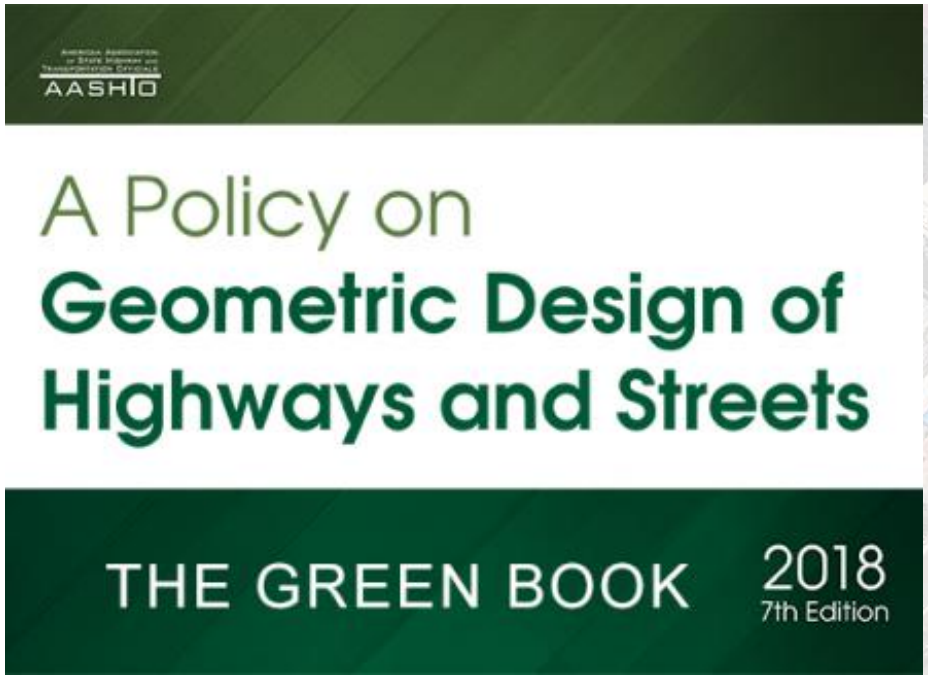
Comparison with Statewide Averages
- Corridor to Statewide Ratio
- Type of Facilities

Identify Countermeasures
- Crash Modification Clearinghouse
- FHWA Proven Safety Countermeasures
- HSM

Comparison of Safety Benefits
- Benefit Cost Analysis
- Prioritization

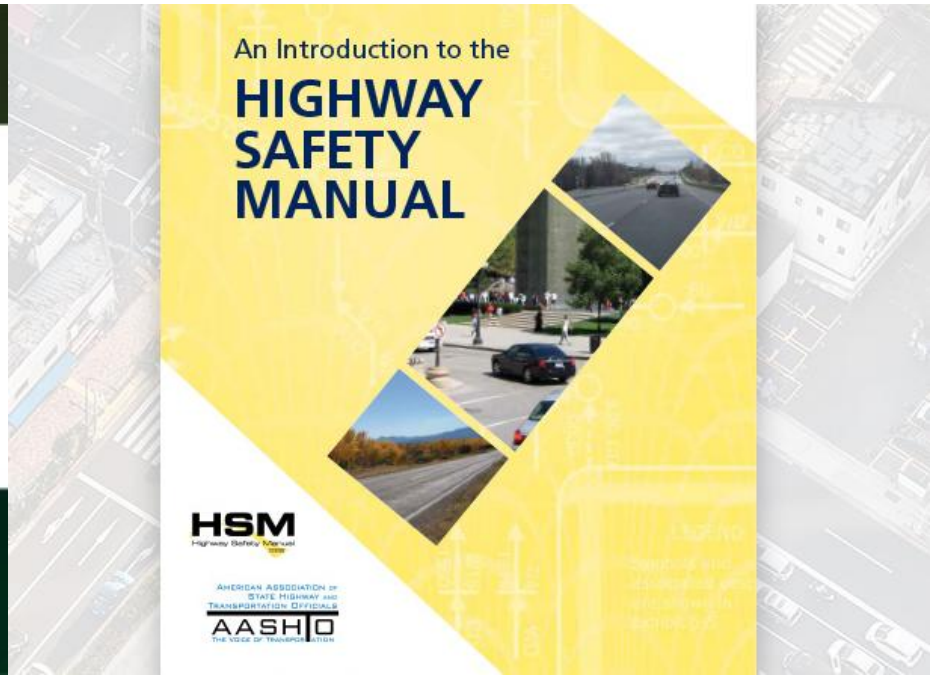


Manuals and Guidelines



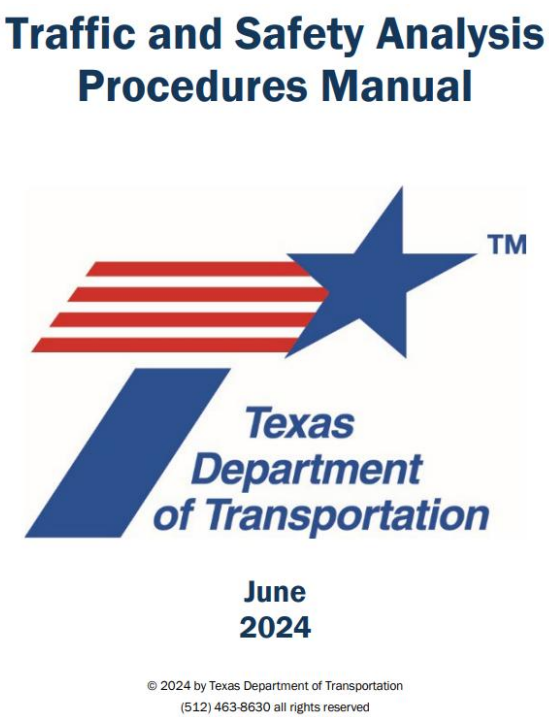
AASHTO Greenbook

- Standards Compliance



AASHTO Highway Safety Manual

- Quantify crash frequency based on geometry



Traffic and Safety Analysis Procedures Manual

HSM -2nd Edition… Coming Soon

HSM2 Chapter Overview

American Association of State Highway and Transportation Officials
AASHTO

Part A - Fundamentals
- Ch 1 – Intro and Overview to HSM
- Ch 2 - Road Safety Principles
- Ch 3 - Human Factors
- **Ch 4 - Pedestrians & Bicyclists**

Part B – Roadway Safety Management
- **Ch 5 - Areawide Planning**
- Ch 6 - Network Screening
- Ch 7 - Diagnosis
- Ch 8 - Countermeasure Selection
- Ch 9 - Economic Appraisal
- Ch 10 - Project Prioritization
- Ch 11 - Safety Effectiveness Evaluation
- **Ch 12 - Systemic Safety Management**

Part C – Predictive Methods
- **Ch 13 – General Concepts for Applying the Part C Predictive Methods**
- Ch 14 - Rural Two-Lane Roads
- Ch 15 - Rural Multilane Highways
- Ch 16 - Urban & Suburban Arterials
- Ch 17 - Freeways
- Ch 18 – Ramps

Part D – Crash Modification Factors
- **Ch 19 - Selecting CMFs**
- **Ch 20 - Applying CMFs**

NEW HSM2 CHAPTERS

Highway Safety Manual 2nd Edition Update 6

(Source: AASHTO)

Predictive Safety Evaluation

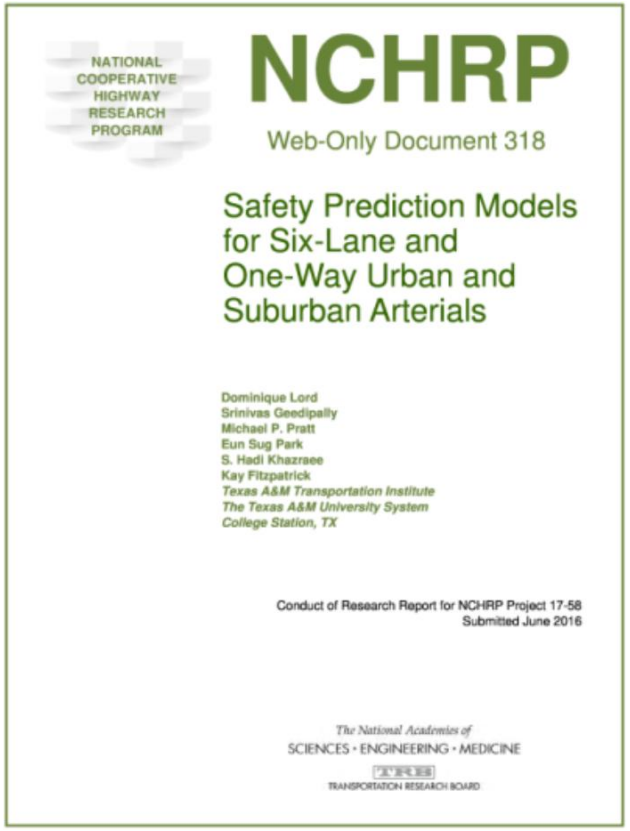
- Predictive safety tools – SPICE, IHSDM, HSS, ISATe
- IHSDM used extensively
- Highway Safety Software
- New predictive safety tools for Texas – Safer by Design, Texas Specific SPF tools
- NCHRP 948- VRU assessments

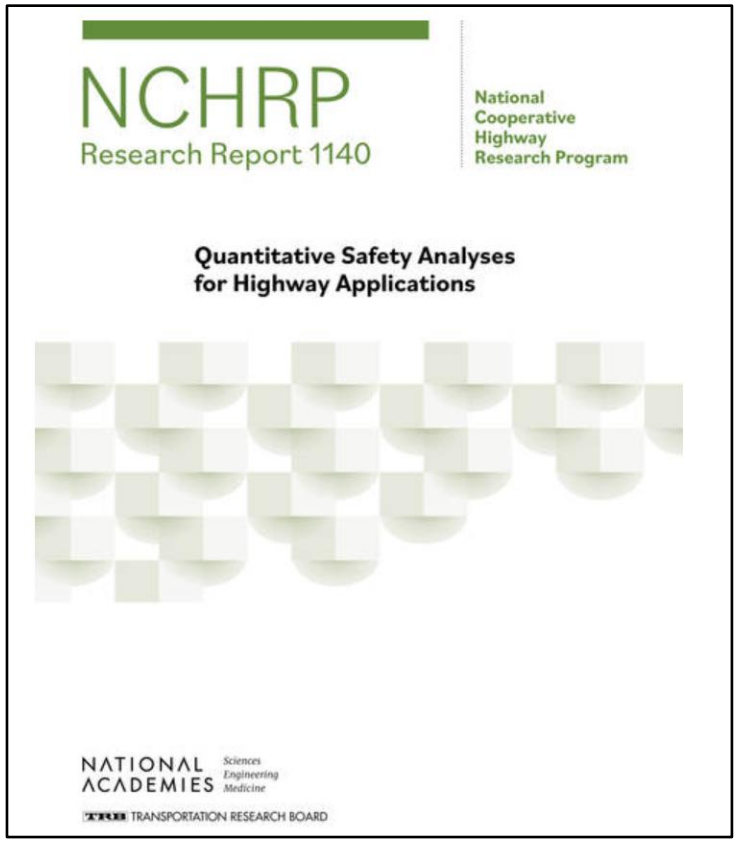
Comparison of IHSDM and HSS

IHSDM	HSS
No software updates (FHWA)	Incorporate HSM 2nd edition changes
Run evaluations	Results are instantaneous
Alignments can be imported	Geometric data needs to be manually input
Automatic segmentation of the facility	Manual segmentation of the facility
Multi-year analysis supported	No Multi-year analysis
Increasing and decreasing milepost separately	Both directions coded together
KABCO scale	FI and PDO Crashes
Same limitation as HSM – Managed Lanes, Frontage Roads, Frontage Road intersections 6-lane Divided arterials	

HSM Limitations

- Ramps limited to two lanes
- No coding of auxiliary lanes less than 0.85 miles
- No predictive method for U turn facilities
- No Frontage road specific intersection SPFs
- No predictive method for Urban six-lane divided arterial segments

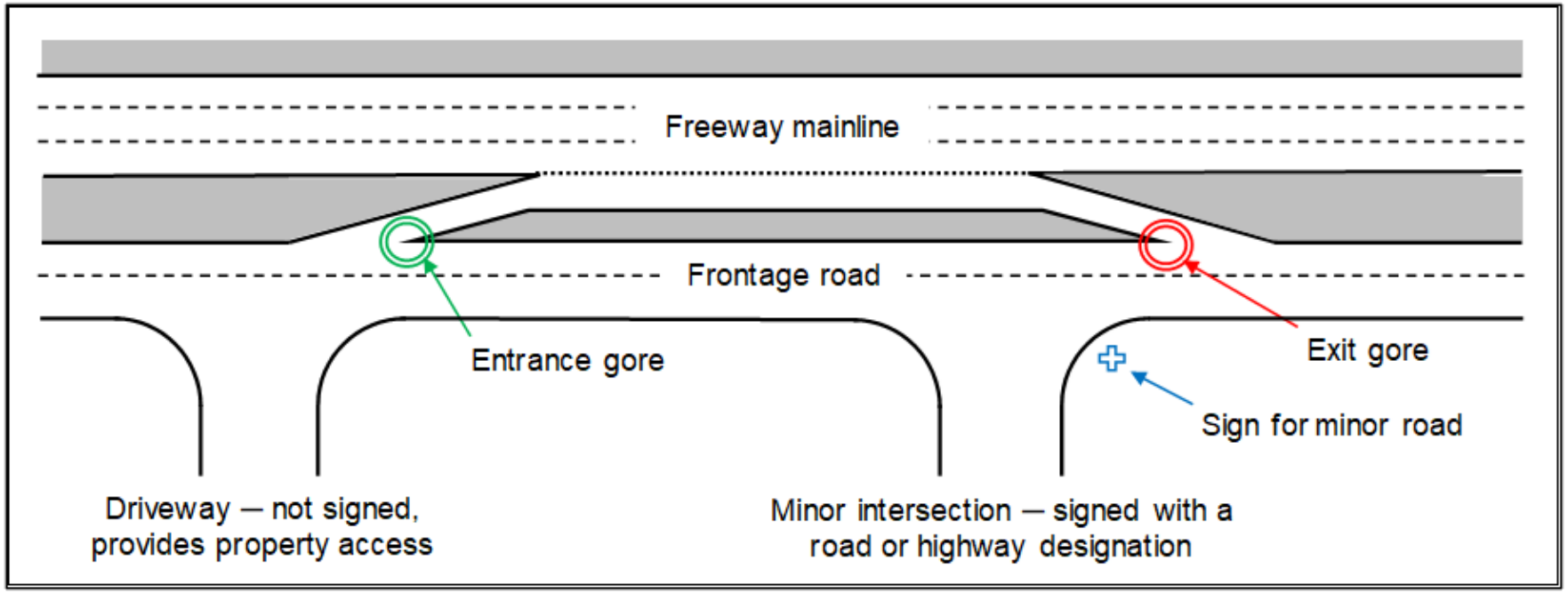




Texas Frontage Roads Analysis

Texas Specific SPF Spreadsheet

- Frontage Road Traffic Operations
- Area Type
- TxDOT District (25 districts)
- AADT
- Number of horizontal curves in segment
- Left and Right Shoulder Widths
- Access Data



HDR Projects

US 75 Peak Hour Technology Lanes Conversion Project

TxDOT Dallas District

Kaufman County Outer Loop IAJR

Kaufman County/TxDOT Dallas District

FM 1325 (Burnet Road) Safety Study

City of Austin

Socorro Road /FM 258 Transportation Safety Study

Cities of El Paso, Socorro, Fabens and San Elizario

TxDOT Dallas District, US 75 Peak Hour Technology Lanes Conversion Project

Project Location Limits: SH 121 – I 635

Scope of Study

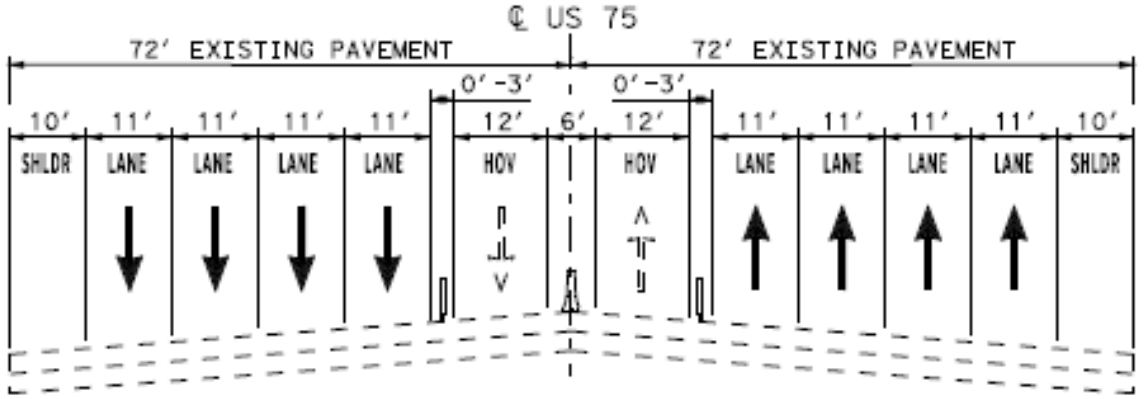
- Looking at operational and safety impacts of converting limited access HOV lanes to continuous access “Technology” lanes
- Ramp reconfiguration
- Increased weaving distance between on and off ramps
- Added auxiliary lanes

Existing Conditions

- 18-centerline-mile corridor
- Ten-lane, four general-purpose (GP) lanes, one high-occupancy-vehicle (HOV) lane
- The HOV lane was separated from GP lanes by pylons and available for HOV 2+ users only

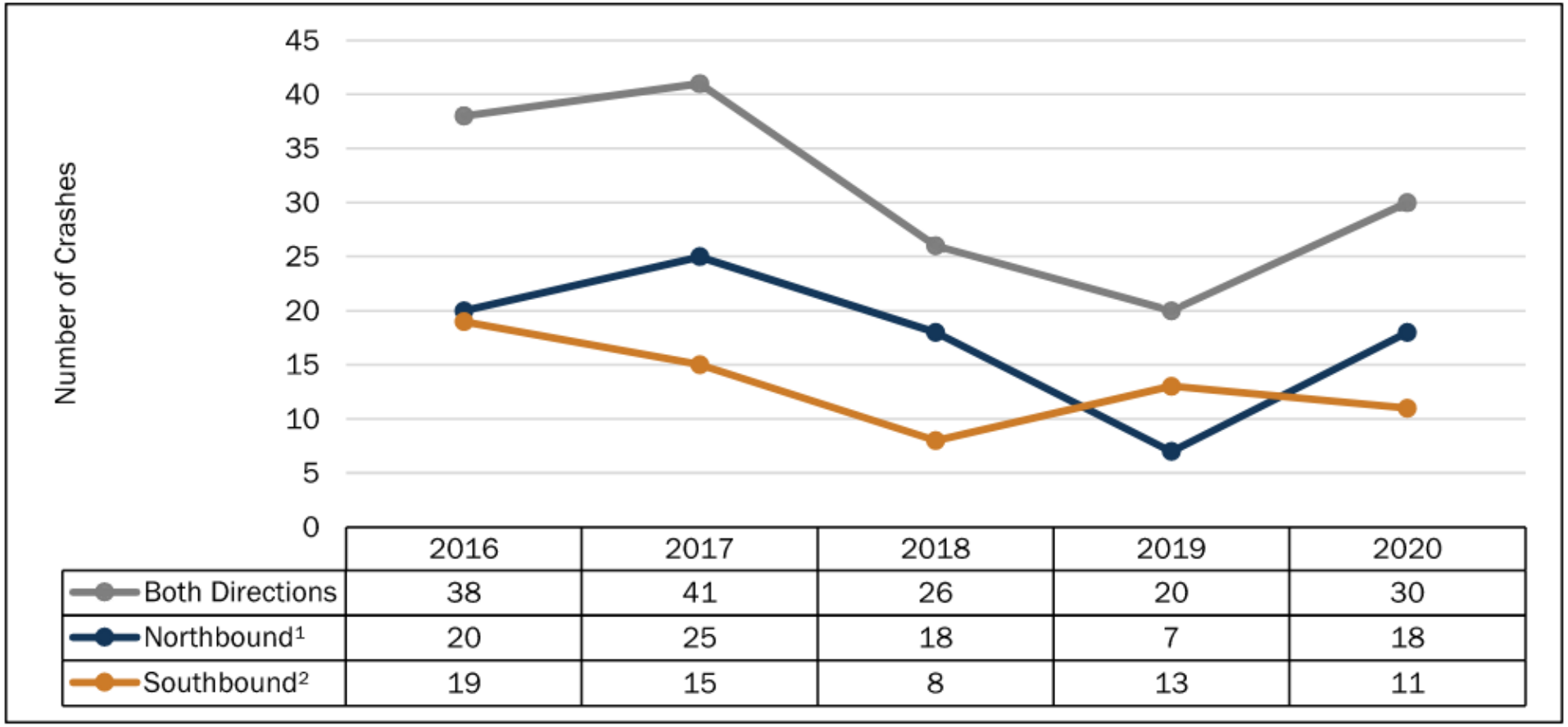
Proposed Conditions

- The HOV lane getting converted to a peak hour/technology lane with no pylons
  - Separated by broken white stripes as continuous access
- Two Options



EXISTING TYPICAL SECTION
IH 635 TO SOUTH OF BETHANY

US 75 Fatal and Serious Injury Mainlane and Ramp Crashes by Year



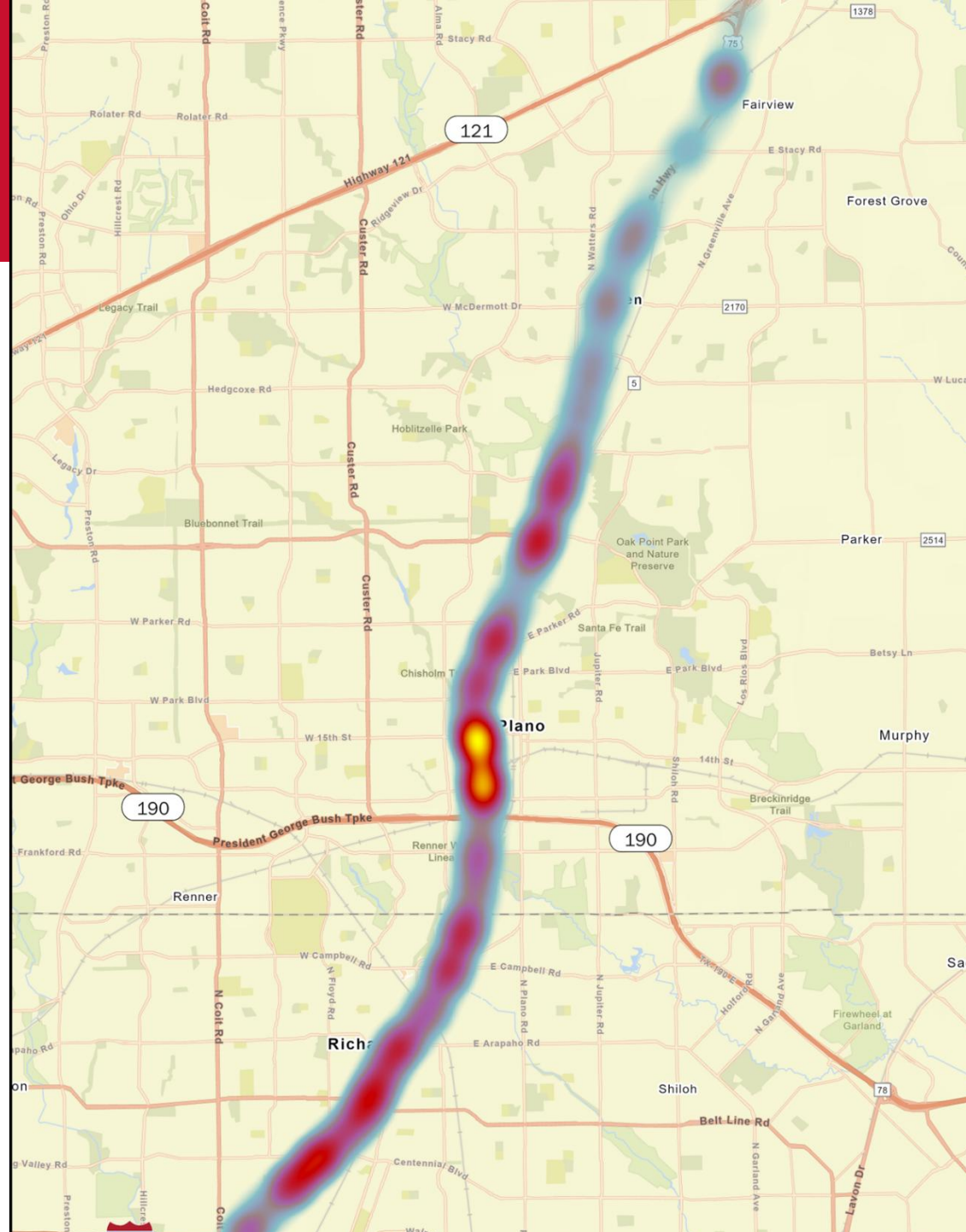
	2016	2017	2018	2019	2020
Both Directions	38	41	26	20	30
Northbound[1]	20	25	18	7	18
Southbound[2]	19	15	8	13	11

[1]Includes crashes in which the vehicles involved were traveling in opposite directions (northbound and southbound)

[2]Includes crashes in which the vehicles involved were traveling in opposite directions (northbound and southbound)

Historic & Predictive Safety Analysis

- US 75 Corridor segmented into subregions
  - Observed crashes from study period aggregated based on subregions
    - Subregion containing President George Bush Turnpike, Plano Pkwy, and 15th Street historically the greatest safety concern within study limits
  - Research **CMFs** for proposed countermeasures



Predictive Safety Analysis

Predictive Crash Analysis –Qualitative Screening Analysis

- CMFs applied to observed crashes for each subregion alternative
    - Vehicle Travel Direction
    - Crash Severity
    - Percentage of subregion to which countermeasure is applied
  - CMFs multiplied together

- Predicted Crashes calculated for roadway alternatives (including no-build)

Predictive Safety Analysis

Predictive Safety Analysis

- CMF Literature Review and Research Conducted

- CMFs most relevant to countermeasures implemented in the build concept options were applied

Florida Department of Transportation Research Center	*Crash Prediction Method for Freeway Facilities with High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) lanes* July 5, 2015	• 25-mph speed differential was associated with 130% increase in crash rate. • Concluded that facilities with **continuous HOV access** were found to have **16% fewer fatal and injury crashes** than the facilities with limited HOV access. • Fewer crashes associated to 2- to 3-foot buffer lanes as compared to painted stripes for ten lane freeways • Continuous access resulted in more sideswipe crashes and limited access resulted in rear-end type of crashes. • CMF for converting continuous access HOV lanes to limited access HOV lanes is **1.54** for all levels of severity crashes and **1.20** for fatal and serious injury crashes.

Summary of Safety Countermeasures and Selected CMFs

Countermeasure	Crash Modification Factor	Crash Severity	CMF Clearinghouse ID	Source
Converting limited access HOV lanes to continuous access HOV lanes	0.65	All	N/A	FDOT
Increase freeway on-ramp density from X to Y ramps per mile	$e^{0.0492(Y-X)}$	Fatal and Injury	2444	Park, Fitzpatrick, Lord, 2010
Modify spacing between entrance and exit ramps from S1 (ft) to S2 (ft)	$e^{(\frac{450}{S_2}-\frac{450}{S_1})}$	All	7444	Ray et al., 2011
Provide an auxiliary lane between an entrance ramp and exit ramp	0.8	All	3898	Ray et al., 2010
Adjust freeway inside shoulder width from W1 (ft) to W2 (ft)	$\frac{e^{-0.0172(W_2-6)}}{e^{-0.0172(W_1-6)}}$	Fatal and Injury	N/A	Highway Safety Manual
Adjust freeway inside shoulder width from W1 (ft) to W2 (ft)	$\frac{e^{-0.0153(W_2-6)}}{e^{-0.0153(W_1-6)}}$	No Injury	N/A	Highway Safety Manual

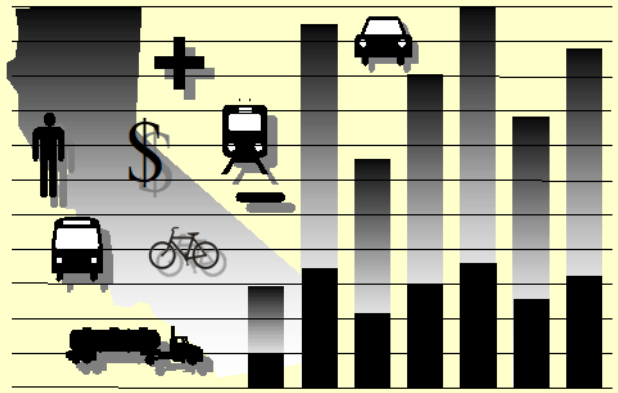
Predictive Safety Analysis Results (Percent Change from No-Build)

Options	K (Fatal)	A (Suspected Serious Injury)	B (Suspected Minor Injury)	C (Possible Injury)	O (Property Damage Only)	Fatal and Injury Crashes (Percent Change)	Total Crashes (Percent Change)
Option A	-3.8%	-4.7%	-4.9%	-4.6%	-3.5%	**-4.7%**	**-4.0%**
Option B	-2.2%	-3.6%	-3.4%	-3.4%	-2.5%	**-3.4%**	**-2.8%**

Benefit-Cost Analysis

California Department Of Transportation

California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C Corridor) Version 8.1



Office of Transportation Economics
Division of Transportation Planning
March 2022

District: TxDOT Dallas District

PROJECT: US 75 Option B

3

BENEFIT - COST ANALYSIS (20-YEAR PERIOD (2035-2054))

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$145.0
Life-Cycle Benefits (mil. $)	$683.1
Net Present Value (mil. $)	$538.1
Benefit / Cost Ratio:	4.71
Rate of Return on Investment:	23.0%
Payback Period:	5 years

ITEMIZED BENEFITS (mil. $)	Total Over 20 Years	Average Annual
Travel Time Savings ($/hr)	$656.4	$21.9
Veh. Op. Cost Savings ($/mile)	-$19.9	-$0.7
Accident Cost Savings ($/fatality and $/injury per crash by severity)	$46.6	$1.6
TOTAL BENEFITS	$683.1	$22.8
Person-Hours of Time Saved	140,834,926	4,694,498
Fatalities Avoided	0	0
Injuries Avoided	0	0
PDO Avoided	0	0

Should benefit-cost results include:

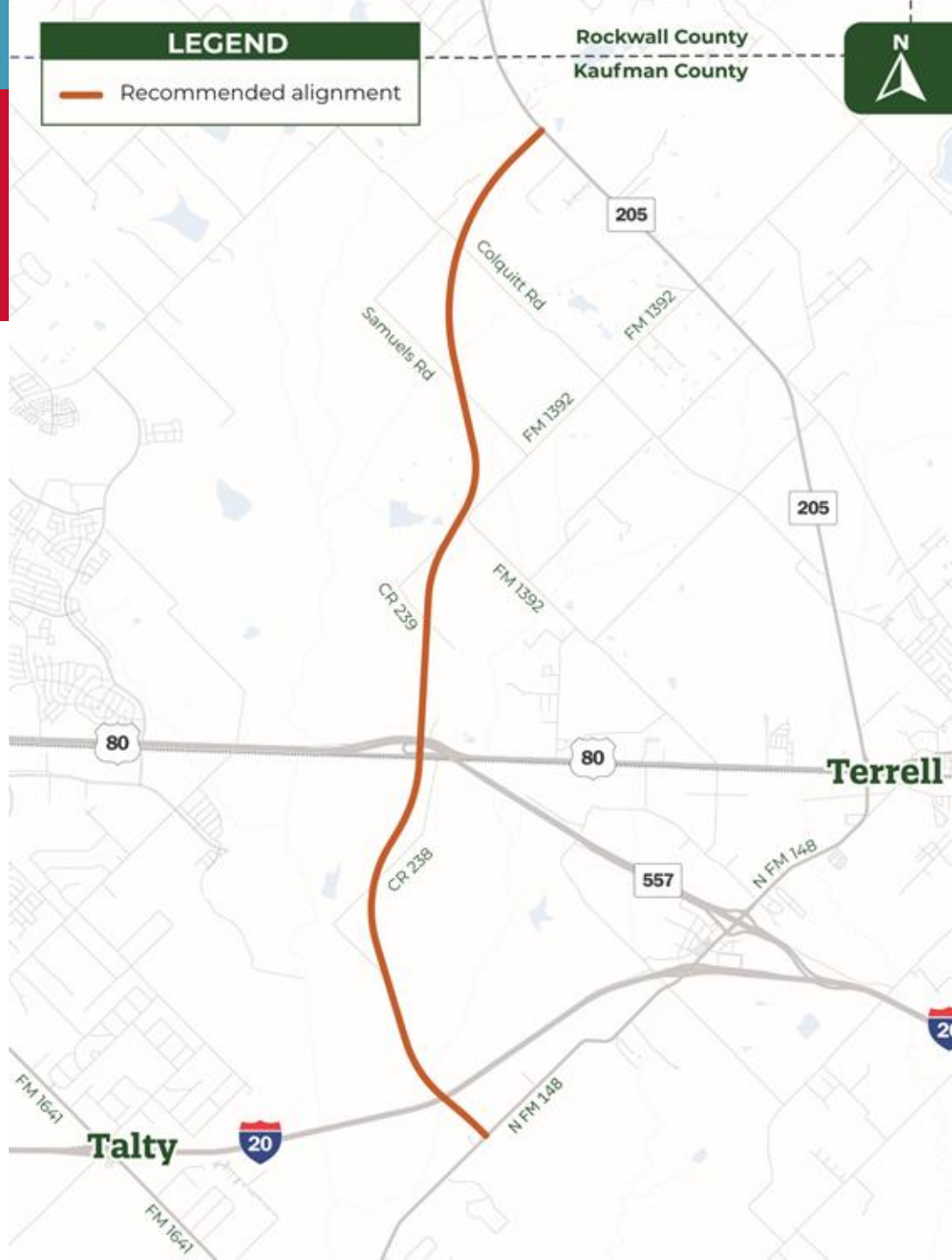
1) Induced Travel? (y/n)	Y	Default = Y
2) Travel Time Reliability? (y/n)	N	Default = Y
3) Vehicle Operating Costs? (y/n)	Y	Default = Y
3) Accident Costs? (y/n)	Y	Default = Y
4) Vehicle Emissions? (y/n) includes value for CO_2e	N	Default = Y

	Tons		Value (mil. $)	
EMISSIONS REDUCTION	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
CO Emissions Saved	-173	-6	$0.0	$0.0
CO_2 Emissions Saved	21,979	733	$0.7	$0.0
NO_X Emissions Saved	22	1	$0.6	$0.0
PM_{10} Emissions Saved	2	0	$0.5	$0.0
$PM_{2.5}$ Emissions Saved	2	0		
SO_X Emissions Saved	0	0	$0.0	$0.0
VOC Emissions Saved	12	0	$0.0	$0.0

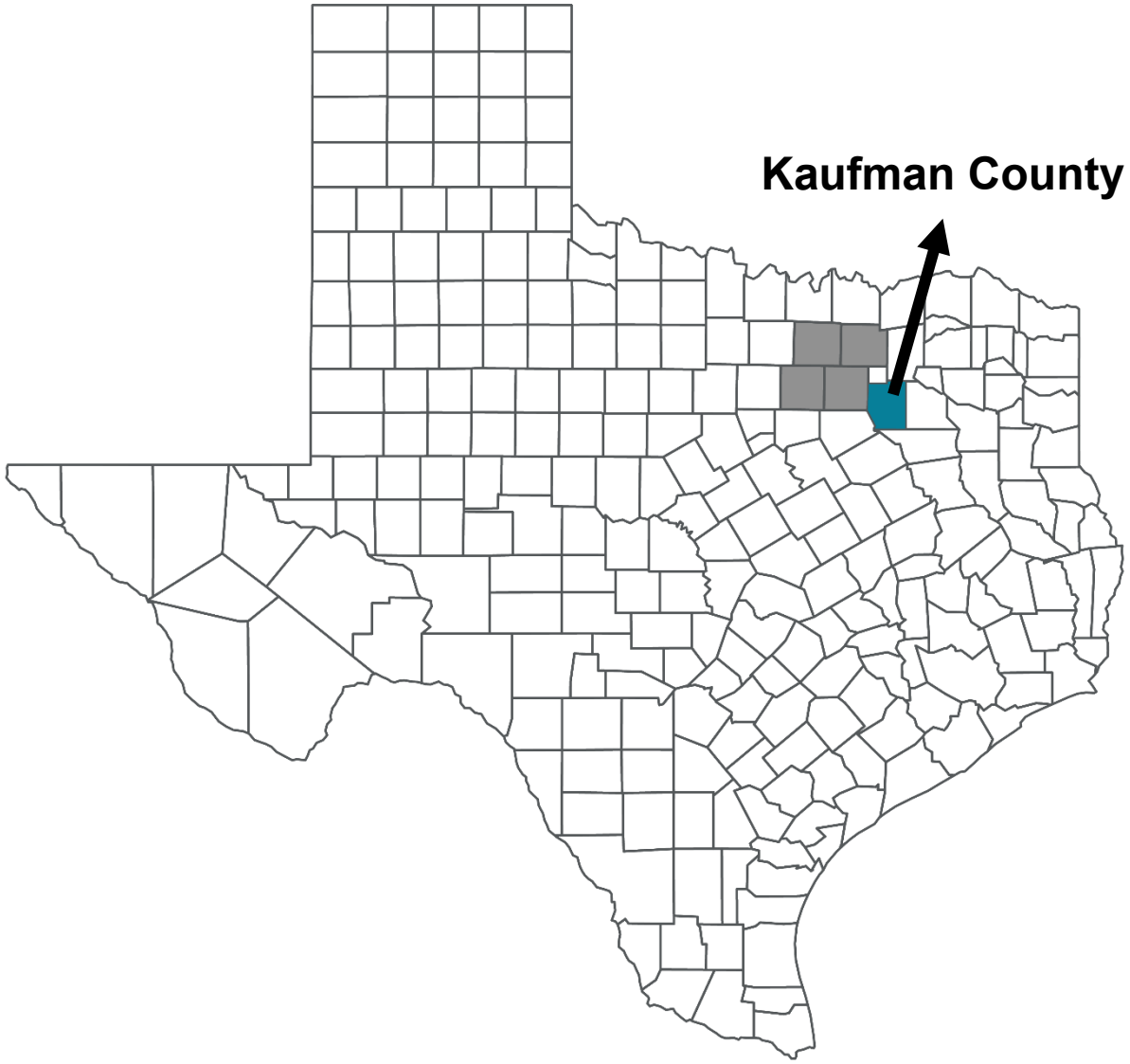
Notes on Assumptions:
1 No O&M costs included
2 Uniform cost distribution considered for the years of construction (based on total capital costs)
3 Model data inputs represent AM & PM peak hours from the network-wide VISSIM model
4 250-day annualization used on model data inputs
5 USDOT BCA Guidance parameters used: VOT, AVO, unit fatality/injury cost parameters, and crash statistics (fatalities per fatal crash, injuries per injury crash)

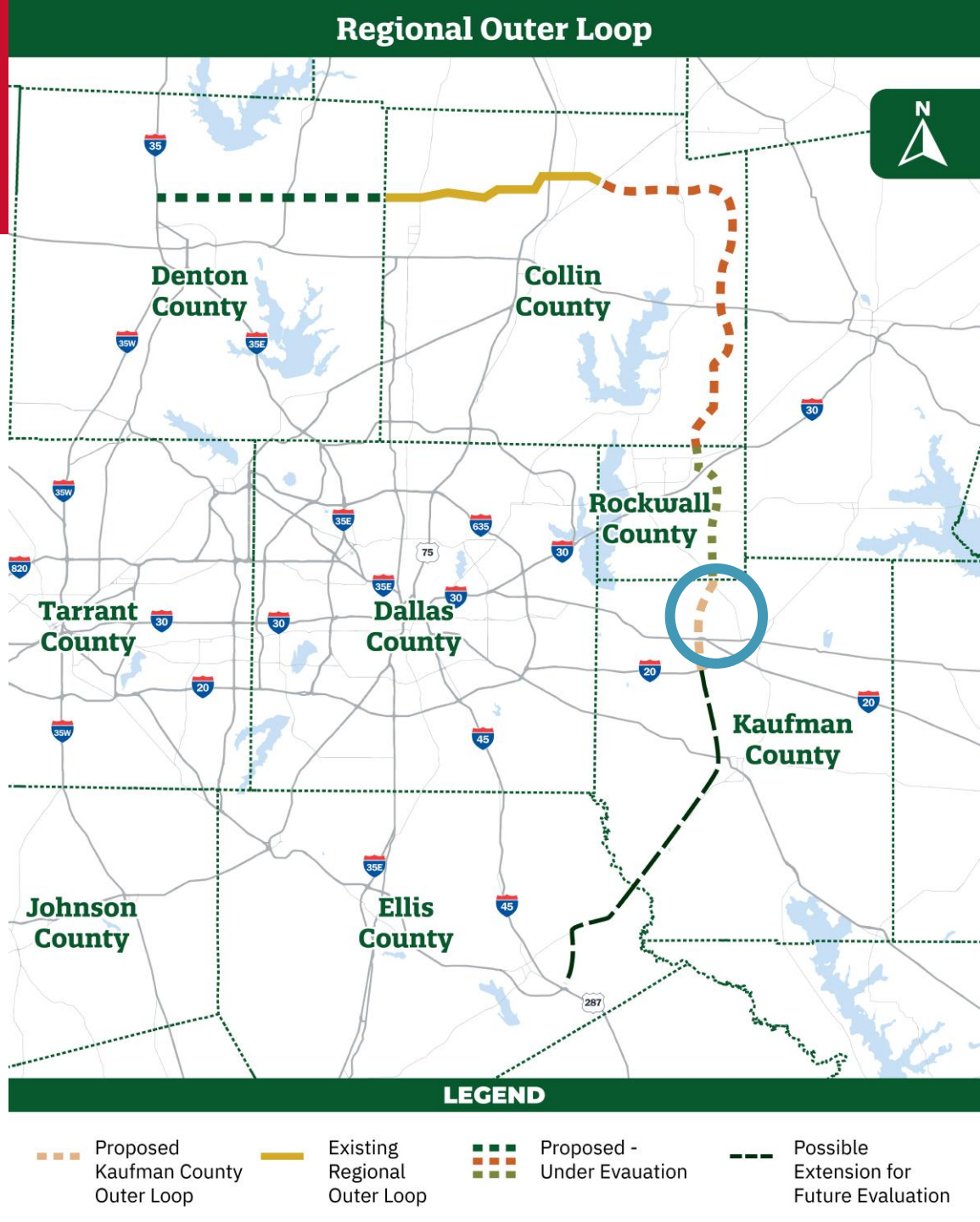
TxDOT Dallas/Kaufman County KCOL IAJR

- Kaufman County Outer Loop (KCOL)
  - New alignment in Kaufman County
    - From SH 205 to south of IH 20, till FM 148
- Project Length
  - 8.31 miles
- Proposed 4-lane freeway with a wide median and 10-foot shared use paths

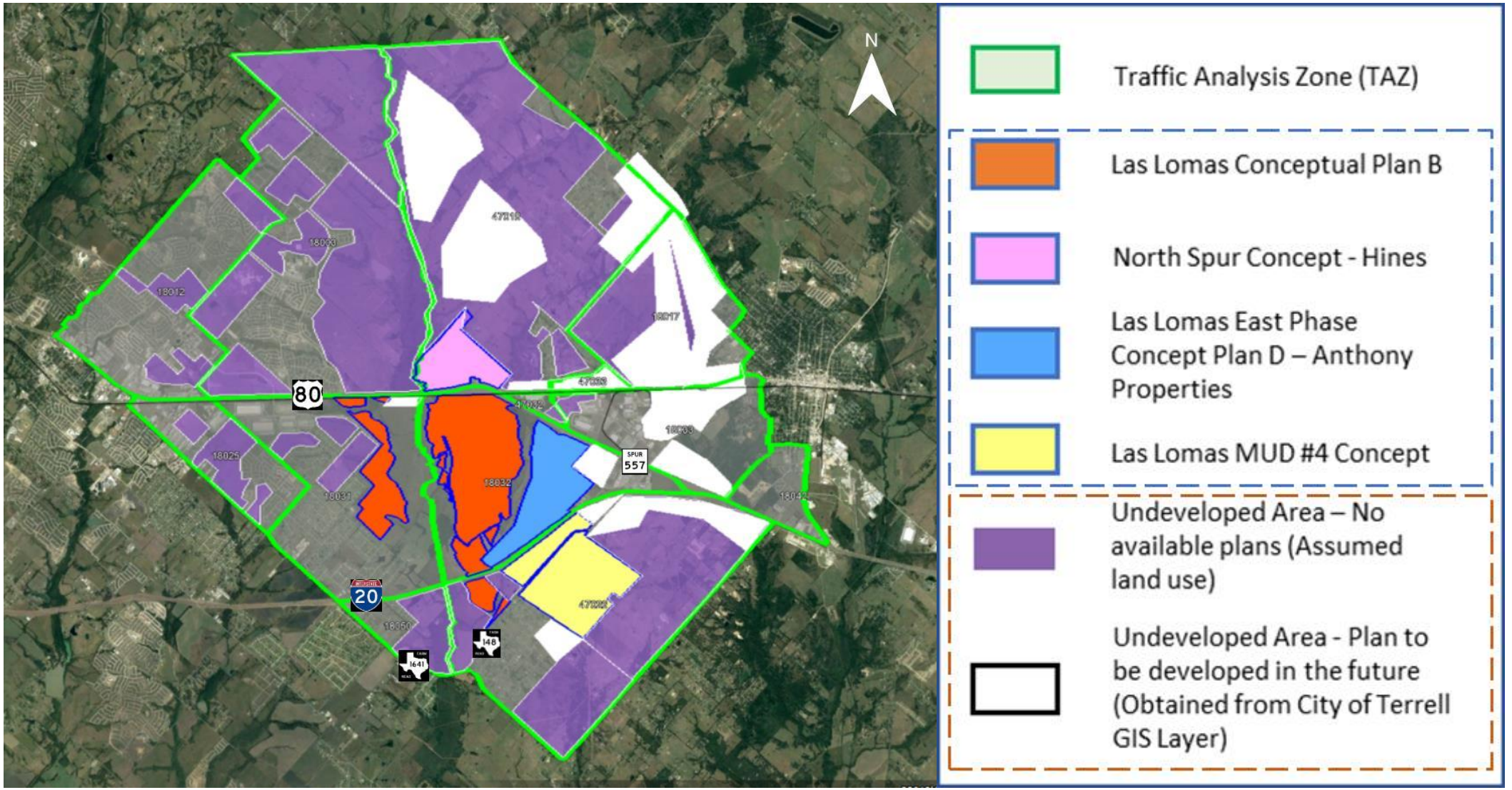


Regional Outer Loop



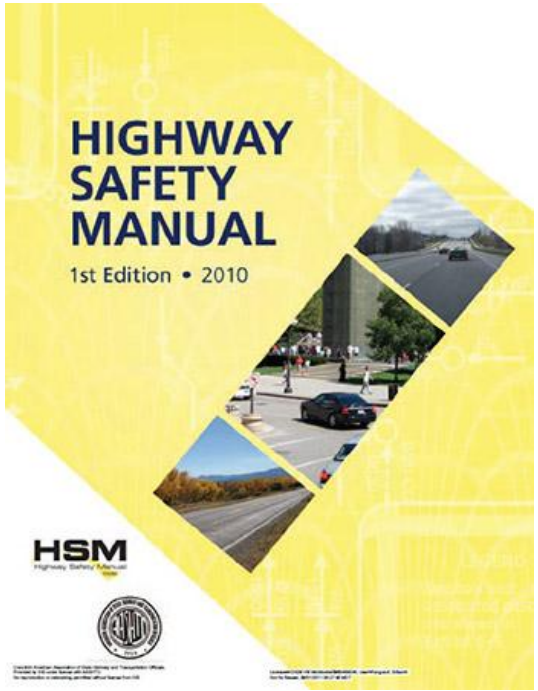


Proposed Land Use Developments



Safety Analysis

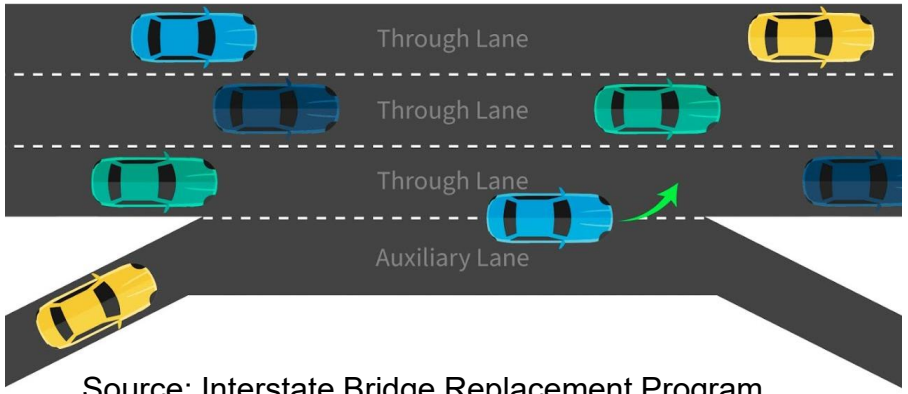
- Option A – Historical Crash Analysis and Highway Safety Manual (HSM) Predictive Method
- Historical Crash Analysis
  - 5 years (2019-2023) crash data in the AOI
  - Crash rate and KABCO scale calculations
  - Primary contributing factors and manner of collision
- Predictive Safety Analysis
  - No Build and Build conditions



Texas A&M Transportation Institute | Center for Transportation Safety

Safety Improvements

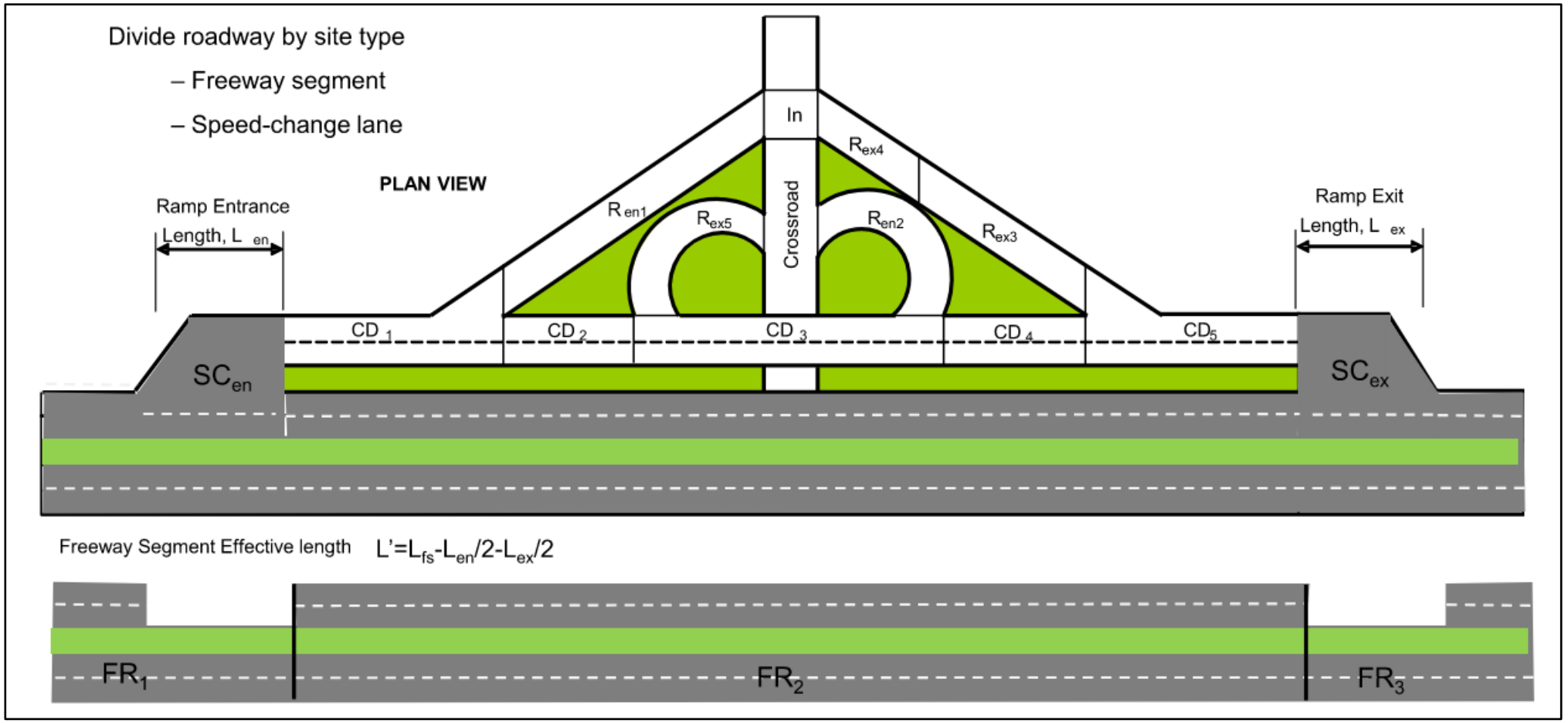
- Rumble strips
- Auxiliary lanes
- Increased shoulder width
- Presence of metal beam guard fence and attenuators in the bridge sections
- Frontage Road alignment, and Arterial Improvements
- Shared Use Paths
- Enhanced crosswalk with visibility for pedestrians



Source: Interstate Bridge Replacement Program

HSS Freeways

- Freeway Segmentation Process
- Number of through lanes
- Speed-Change Lanes
- Presence of nearby ramps



Source: HSM Figure 18-10

HSS Freeway Results

Highway Safety Software Freeway Segment Report			
Project Information			
Analyst	Sayantan	Date	8/7/2024
Jurisdiction	Kaufman County	Analysis Year	2048
Project Description	KCOL Build	Section Number	1

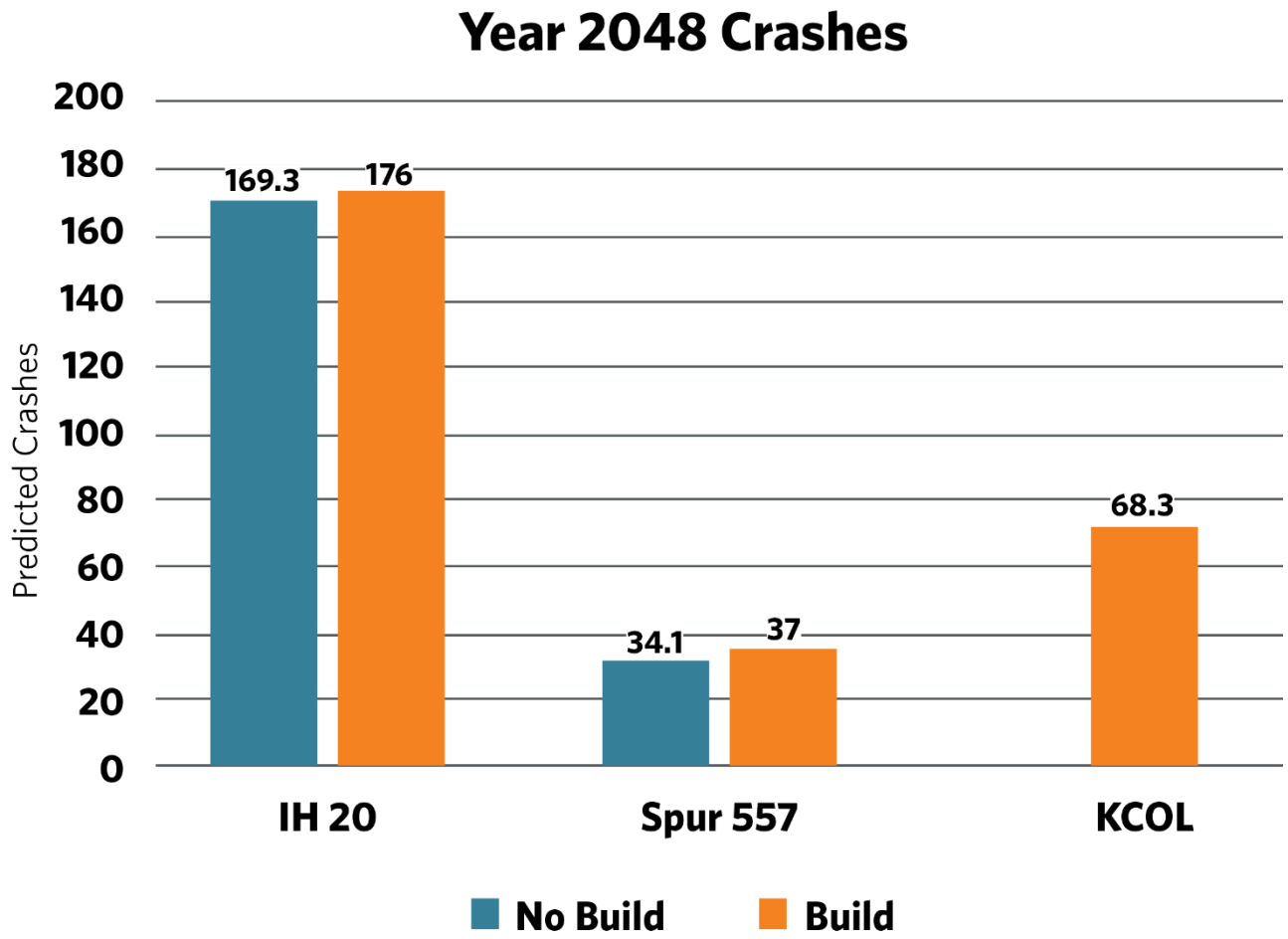
Input Data			
Length of Segment (mi)	0.220	Number of Through Lanes	5
Number of Curves	1	Clear Zone Width (ft)	30
Lane Width (ft)	12.0	Median Width (ft)	168
Outside Shoulder Width (ft)	10	Inside Shoulder Width (ft)	12
Proportion of Rumble Strips (Outside Shoulder)	0.000	Proportion of Rumble Strips (Inside Shoulder)	0.000
Barrier in Median	No	Barrier on Roadside	No
Freeway AADT (veh/day)	23600	Proportion of AADT (High-volume)	0.000

	Travel in Increasing Milepost Direction		Travel in Decreasing Milepost Direction	
	Entrance Ramp	Exit Ramp	Entrance Ramp	Exit Ramp
Distance to Upstream Ramp (mi)	999.000	999.000	999.000	0.000
AADT (veh/day)	9999	9999	9999	2300
Presence of Type B Weave	None		None	
Length of Weave (mi)	-		-	
Length of Weave in Segment (mi)	-		-	

Crash Modification Factors				
	Combined CMF		Calibration Factor	
	Fatal and Injury	Property Damage Only	Fatal and Injury	Property Damage Only
Multiple Vehicle	1.415	1.495	1.00	1.00
Single Vehicle	1.374	1.684	1.00	1.00

Predicted Roadway Section Crashes			
	Predicted Crash Frequency		
Crash Severity	Multiple Vehicle	Single Vehicle	Total
Fatal and Injury (FI)	0.139	0.288	0.427
Property Damage Only (PDO)	0.189	0.620	0.809
Total	0.328	0.908	1.236

Economic Analysis (Predicted Crashes)			
Crash Severity	Per Crash Societal Crash Cost	Predicted Annual Crashes	Total Societal Crash Cost
Fatal and Injury (FI)	$158,200.00	0.427	$67,551.40
Property Damage Only (PDO)	$7,400.00	0.809	$5,986.60
Total	-	1.236	$73,538.00



Texas Frontage Roads

Limitations

- One way frontage road AADT 7,800
- Two-way frontage roads AADT 18,000
- Single AADT

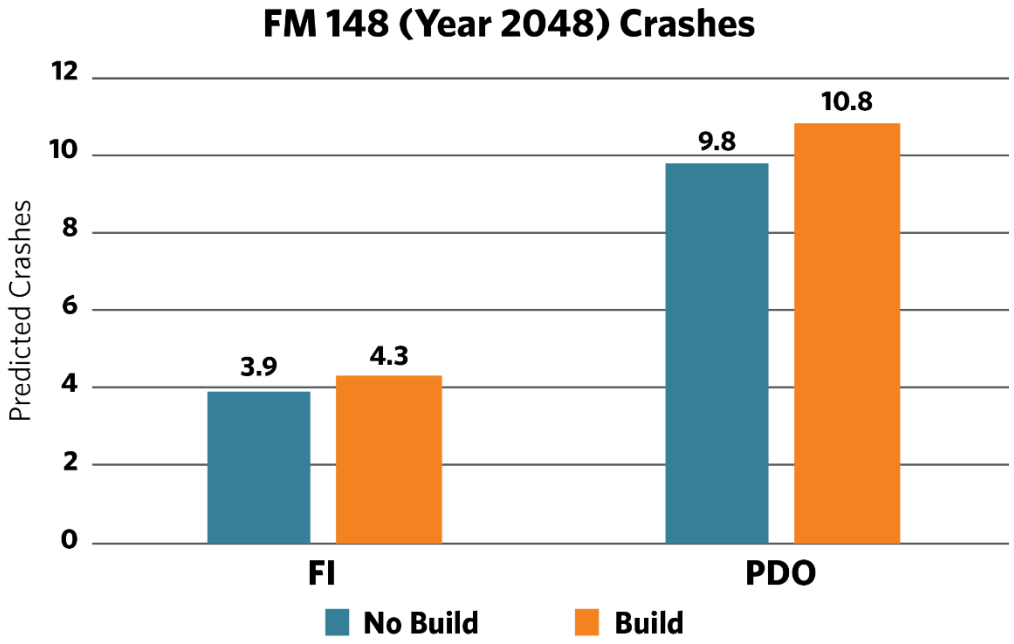
IH 20 crashes broken down by KABCO scale

Crashes	K	A	B	C	O	Total
Build	0.1	0.3	2.8	4.9	18.6	26.7
No Build	-	-	0.2	0.3	1.1	1.6

Crash exposure – crashes/miles/year

- Total crashes/mile reduced by 47.1%

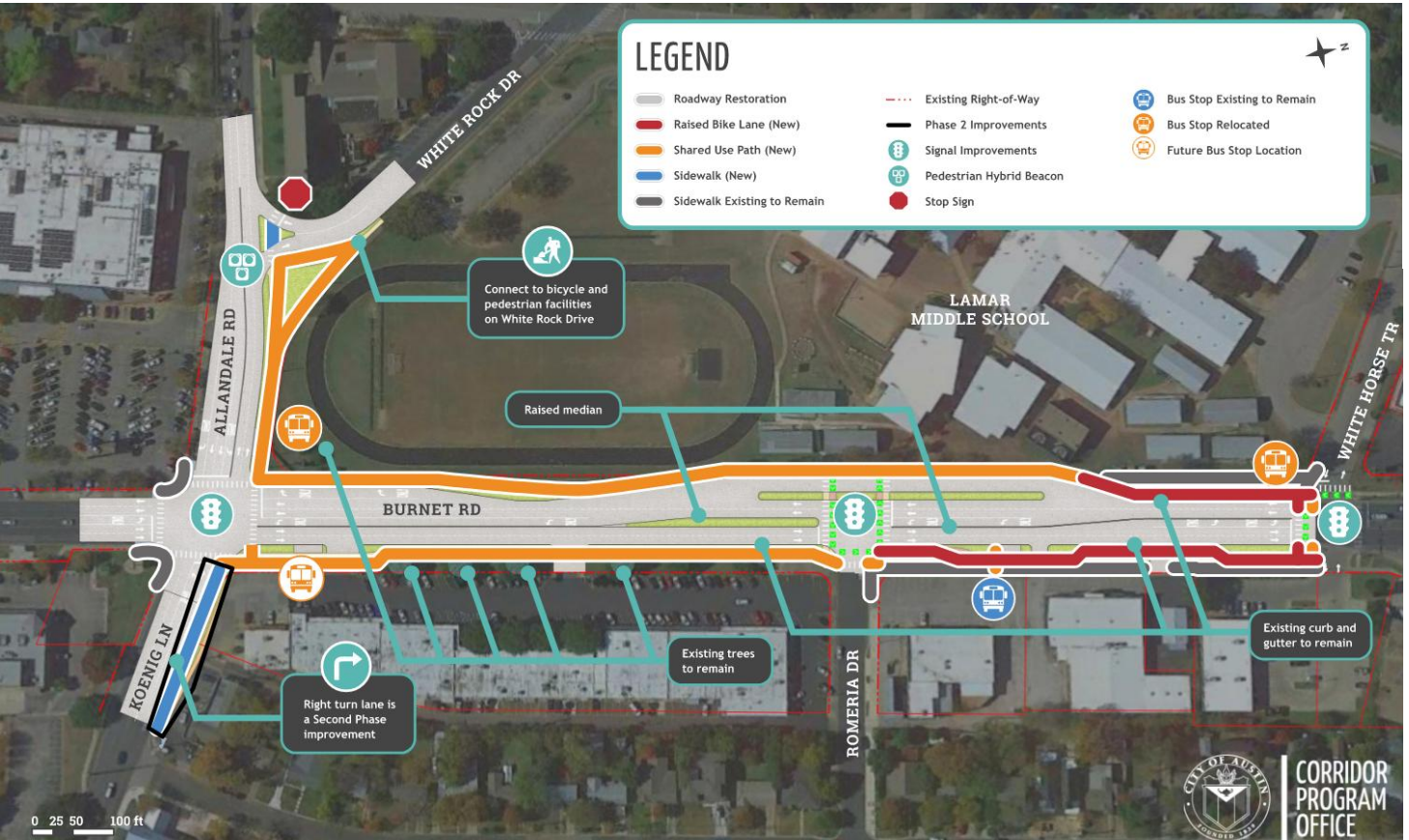
Arterials

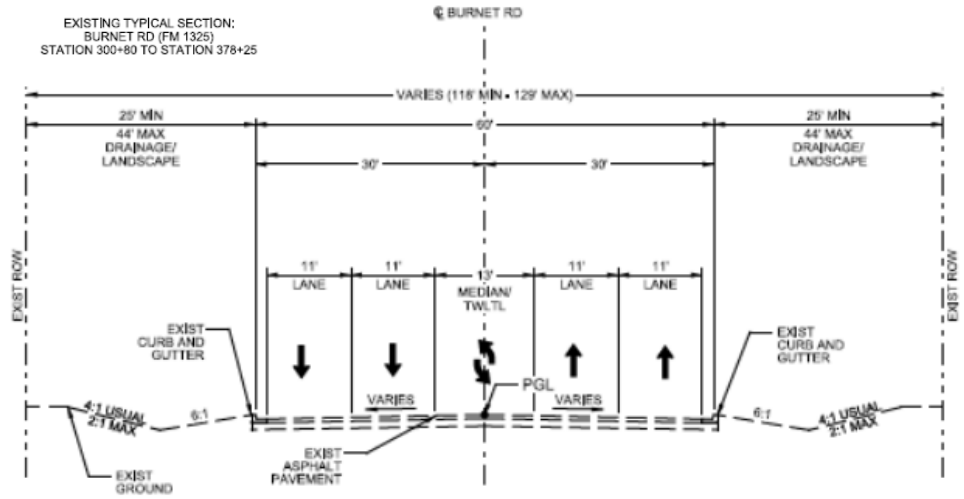


City of Austin, FM 1325 (Burnet Road) Safety Study

Burnet Rd from Bright Verde Way to Loop 1:

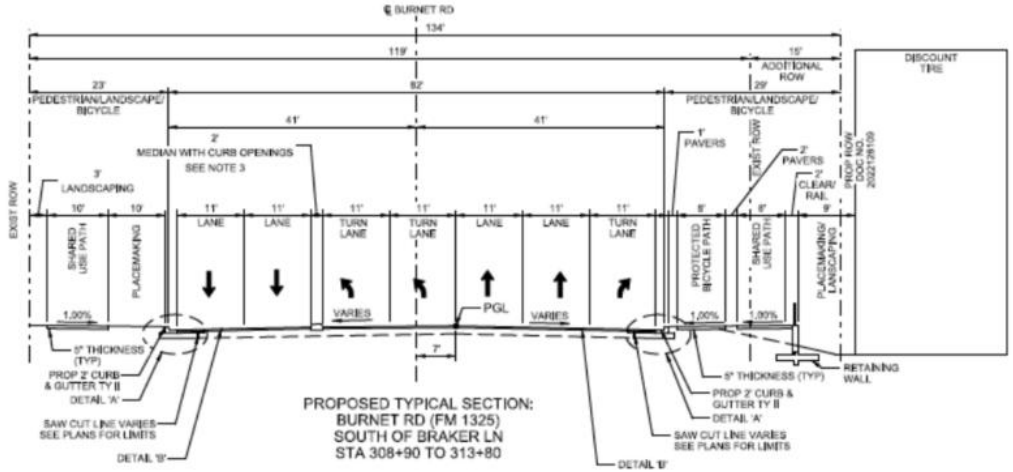
Existing 4 lane roadway with a continuous center turn lane.





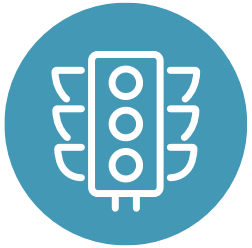
Proposed Corridor/Typical Section

4-LN with TWLTL and approx. 3700' of raised median



Predictive Safety Analysis: Inputs

Basic Elements



Control Elements

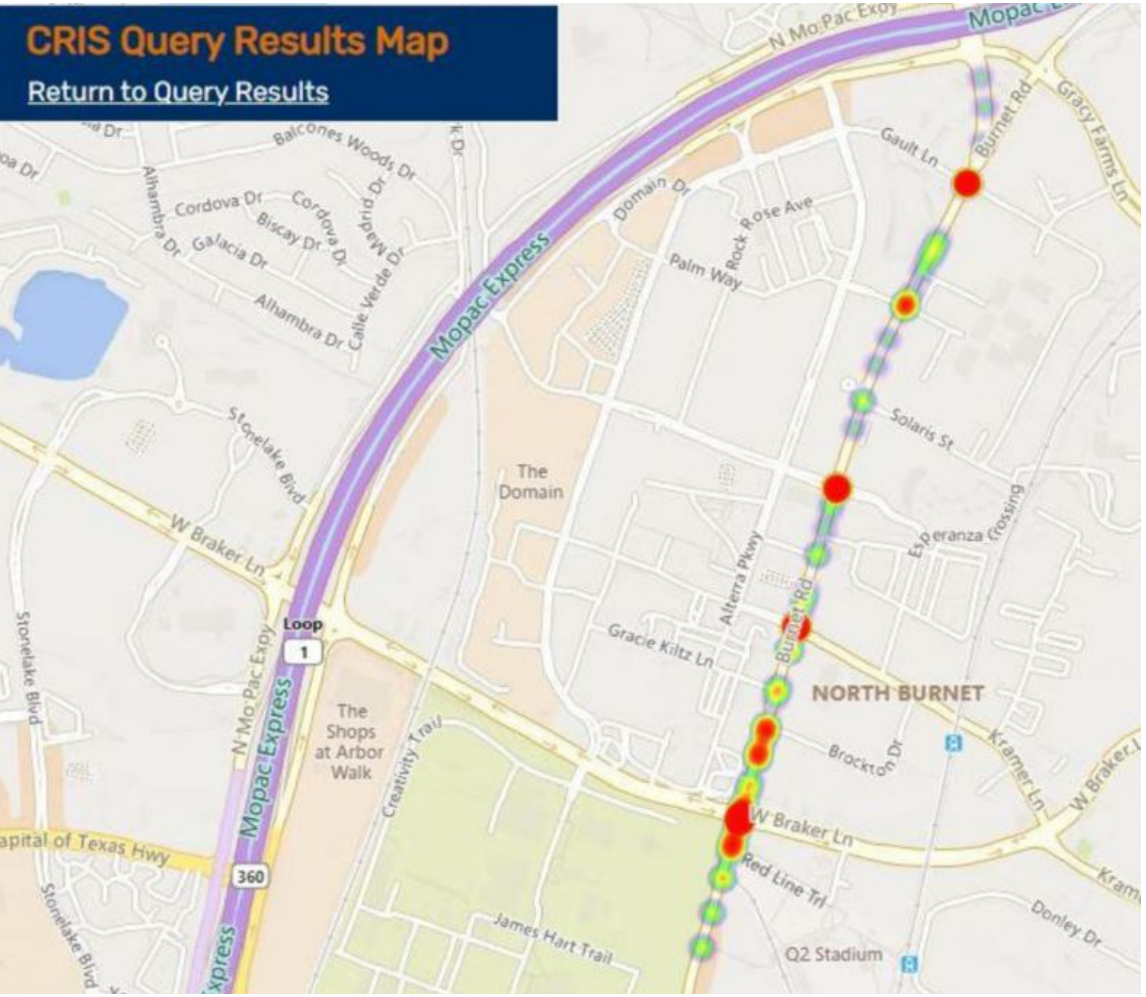
Geometric Elements

Traffic Elements

Pedestrian Elements

Bicyclist Elements

Predictive Safety Analysis: Outputs



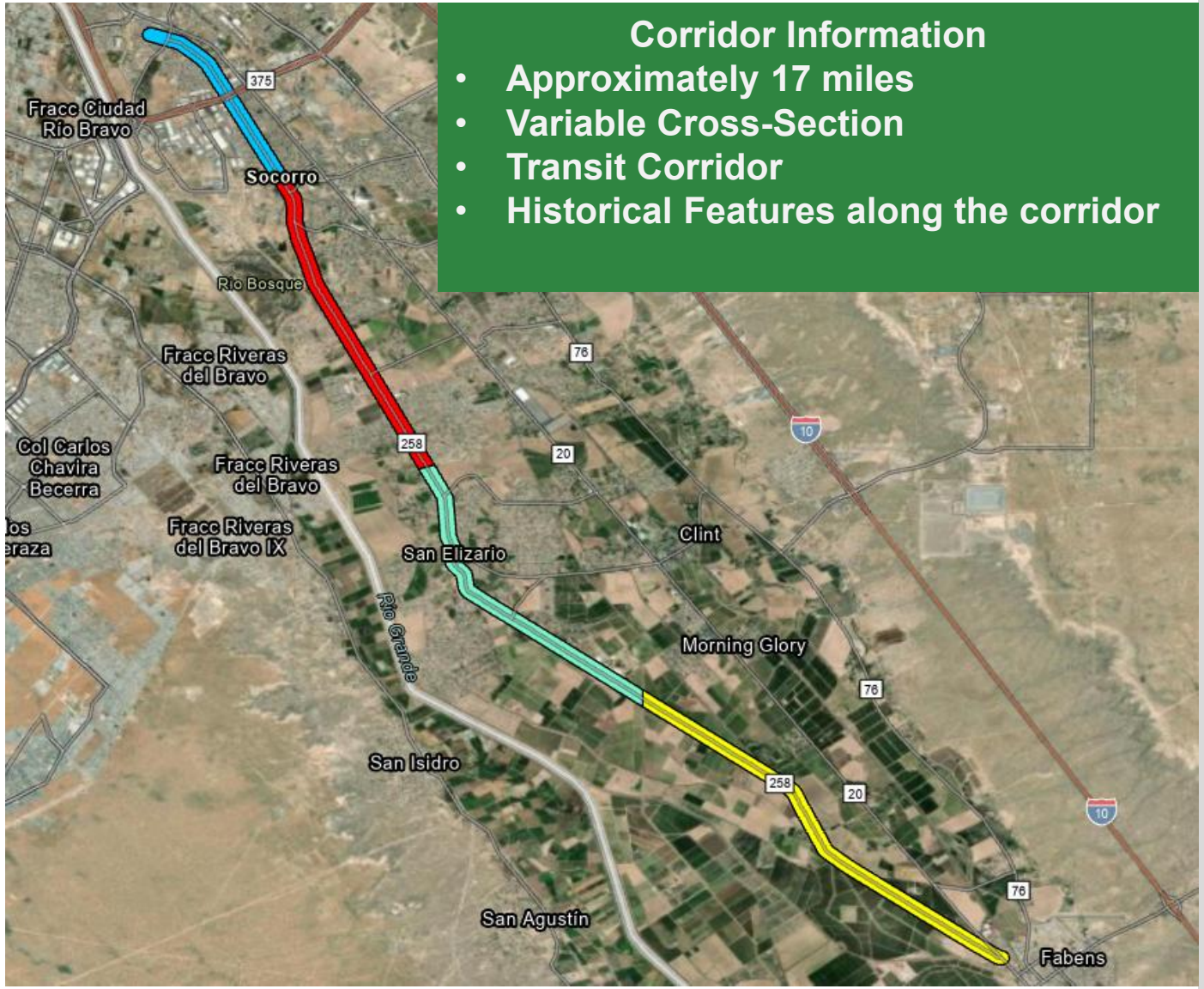
Summary Table

Entity	Id	Alias	Location	Extg	D1	D2	Extg	D1	D2
Segment	1	1	0 - 0.11	60.0	59.0		3.9	4.5	
Segment	2		0.25 - 0.36	63.0	59.0		1.6	2.3	
Segment	3		0.46 - 0.52	67.0	66.0		2.3	2.7	
Segment	4		0.62 - 0.65	62.0	60.0		1.3	1.8	
Segment	5		0.75 - 0.76	69.0	67.0		3.5	5.3	
Segment	6		0.86 - 0.87	69.0	68.0		6.0	7.8	
Segment	7		0.97 - 1	69.0	67.0		4.4	5.5	
Segment	8		1.13 - 1.17	67.0	62.0		2.4	4.2	
Segment	9		1.31 - 1.37	69.0	68.0		6.4	7.5	
Segment	10		1.47 - 1.53	66.0	66.0		2.4	2.4	
Intersection	1		Burnet Rd @ Gault Ln	65.0	67.0		1.7	1.6	
Intersection	2		Burnet Rd @ Palm Way	82.0	82.0		1.3	1.3	
Intersection	3		Burnet Rd @ Solaris St	63.0	65.0		1.2	1.2	
Intersection	4		Burnet Rd @ Esperanza Crossing	68.0	81.0		2.6	2.2	
Intersection	5		Burnet Rd @ Derek PL	81.0	87.0		1.1	1.0	
Intersection	6		Burnet Rd @ Kramer Ln	60.0	75.0		7.5	5.0	
Intersection	7		Burnet Rd @ Gracie Kiltz Ln	92.0	92.0		0.9	0.9	
Intersection	8		Burnet Rd @ Brockton Dr	88.0	93.0		1.0	0.8	
Intersection	9		Burnet Rd @ Braker Ln	72.0	72.0		8.8	8.8	
Intersection	10		Burnet Rd @ Panhandle Rd	76.0	76.0		1.3	1.3	
Intersection	11		Burnet Rd @ Bright Verde Way	62.0	62.0		2.1	2.1	
Weighted Total				68.0	69.7		63.7	70.0	

Selected Design

Design 1

TxDOT/City of El Paso
FM 258/Socorro Road Safety Study



Corridor Deficiencies

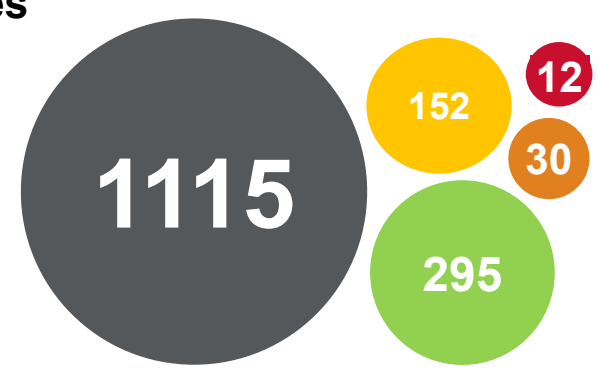
- Faded lane and crosswalk markings
- Objects including utilities poles are close to the edge of traveling lane
- Marking and signage are not complaint with TMUTCD
- Skewed intersections with sharp turning movement and limited sight distance
- Discontinuous and missing sidewalks
- Outdated signals, no APS units
- Sidewalks blocked with obstructions
- Over speeding in sections of corridor
- Poor lighting

FM 258/Socorro Road Safety Study

Crash Data (2013-2022)

1653 Total Crashes

- Property damage only
- Possible injury
- Minor injury
- Severe injury
- Fatality



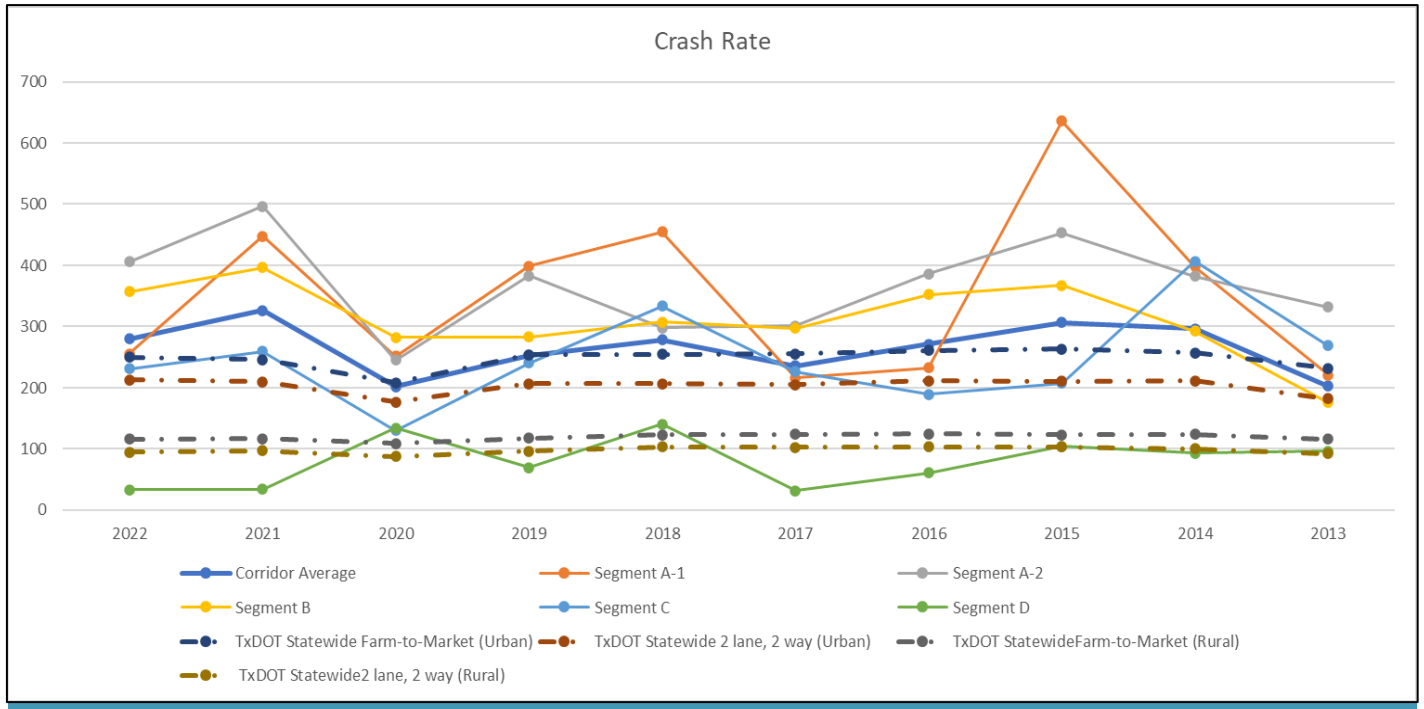
Socorro Rd. has crash rates are about **2 times** that of similar facilities statewide in Texas.

Key fatal and severe injury crash patterns:

43%
occurred at intersections

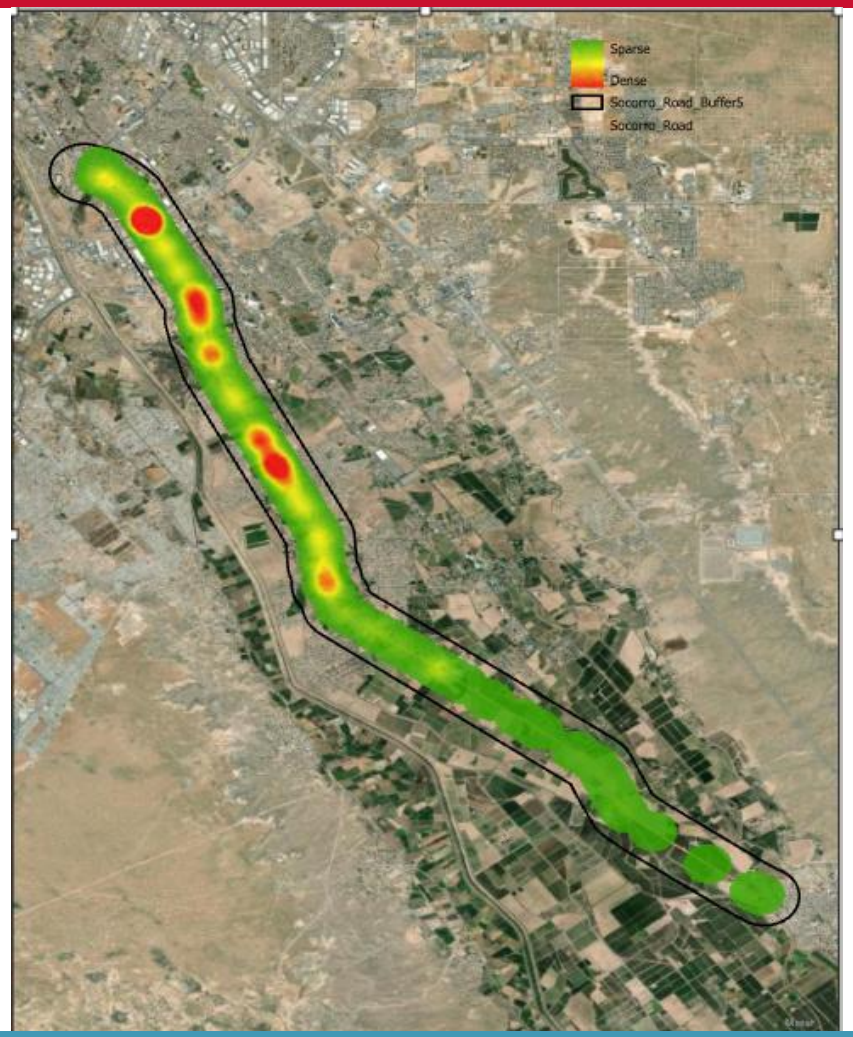
55%
occurred during the nighttime hours

10%
were fixed object crashes

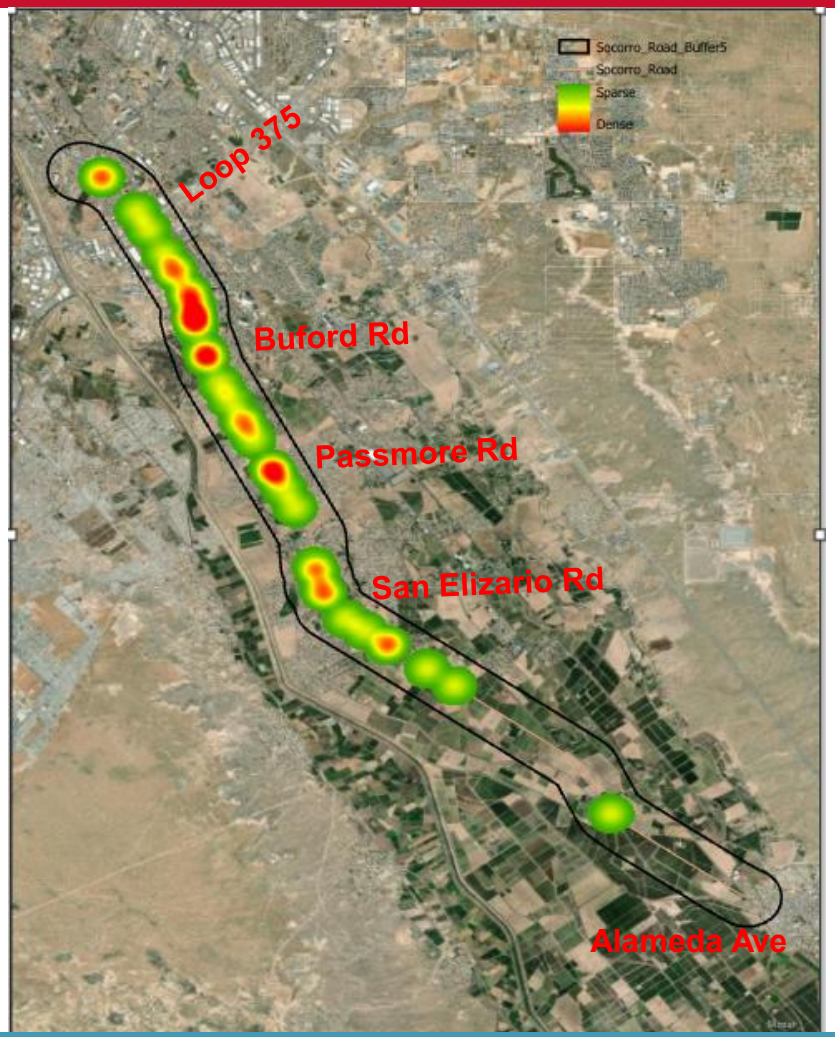


Crash Rate

FM 258/Socorro Road Safety Study



Hotspot- All Crashes



Hotspot- Severe Crashes

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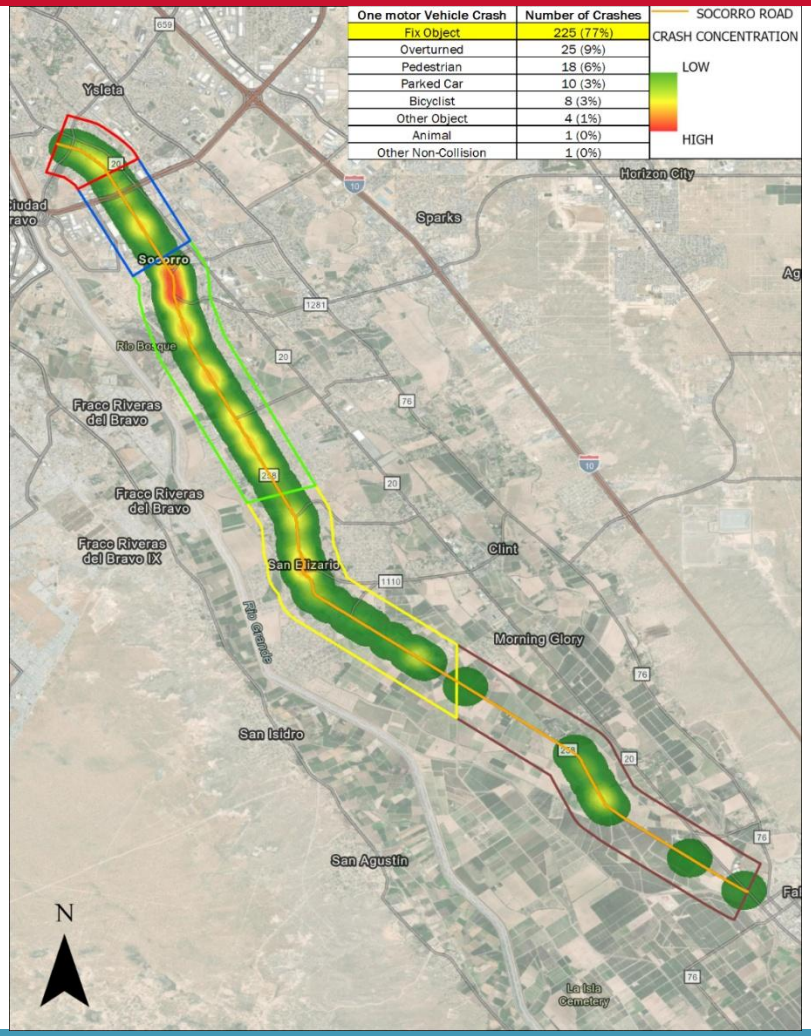
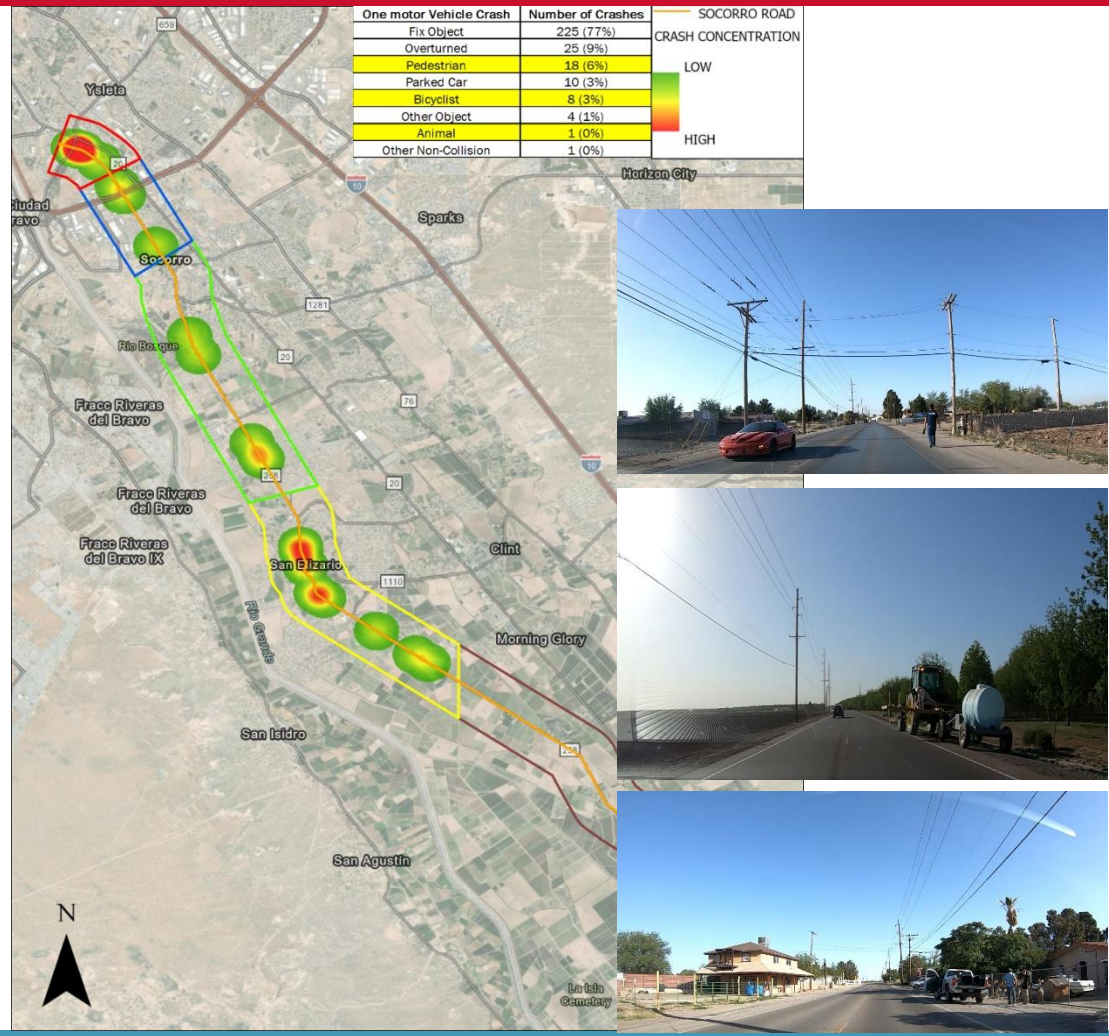


Fixed Object



Moving Object

Proposed Countermeasures

Short-Term Improvements (Less than 2 years)

Install/refresh signs

Install or update the signs to improve visibility and enhance safety throughout the corridor.

Improve pavement markings and crosswalks with retroreflectivity

Improve pavement markings and crosswalks with retroreflectivity throughout the corridor

Permanent speed feedback signs

Installing permanent dynamic speed feedback signs has been shown to reduce total crashes by 7%.**

Public education and outreach

Share safety tips with the community through flyers, events, or social media to encourage people to drive and walk safely.

Enhanced traffic enforcement

Increase law enforcement personnel dedicated to traffic enforcement.

New traffic signal

Where warranted, traffic signals can reduce crashes by 35%.*

Signal backplates with retroreflective border

Install on all traffic signal heads.

Tree trimming

Cut back overgrown trees and bushes that block signs.

Flashing yellow arrow

Upgrade yield-on-green indications to flashing yellow arrows.

School zone backflashers

Ensure all school zones have back flashers.

Install stop ahead sign

Supplement stop ahead signs with LED enhanced stop signs as they have the most right-angle crashes.

Proposed Improvements

Medium-term Improvements: 3-5 years

High-visibility pedestrian crosswalk

High-visibility crosswalks can reduce pedestrian injury crashes up to 40%.**

Install/improve sidewalks

Repair existing sidewalks and widen/repave deficient sidewalks to enhance walkability along the corridor.

Access management

One driveway each recommended to be closed at Lake June Road intersection and Bruton Road intersection.

Curb ramp improvements

Install or upgrade curb ramps to meet ADA standards.

Signal retiming

Adequately time yellow change and all red intervals to reduce angle crashes and implement leading pedestrian intervals (LPIs)

New rectangular rapid flashing beacon (RRFB)

RRFBs have been shown to reduce pedestrian crashes by 47%** at the entertainment district

Long-term Improvements: Over 5 years

Application of high friction surface treatment (HFST)

To reduce wet pavement and run-off crashes at intersection approaches.

Install/improve lighting

Install streetlights between Sam Houston Road and Military Parkway. City of Dallas has recently upgraded the lighting to LED fixtures along the corridor.

Mailbox consolidation

Consolidate mailboxes which are abutting into sidewalks.

Trash Pickup Timing Coordination

Coordinate with Cities

Dedicated turn lanes

Installing dedicated right-turn lane has been shown to reduce total crashes by 14-26%. Installing a dedicated left-turn lane has been shown to reduce total crashes by 28-48%.**

Partnership with TxDOT, Cities, Transit, ISD and other stakeholders

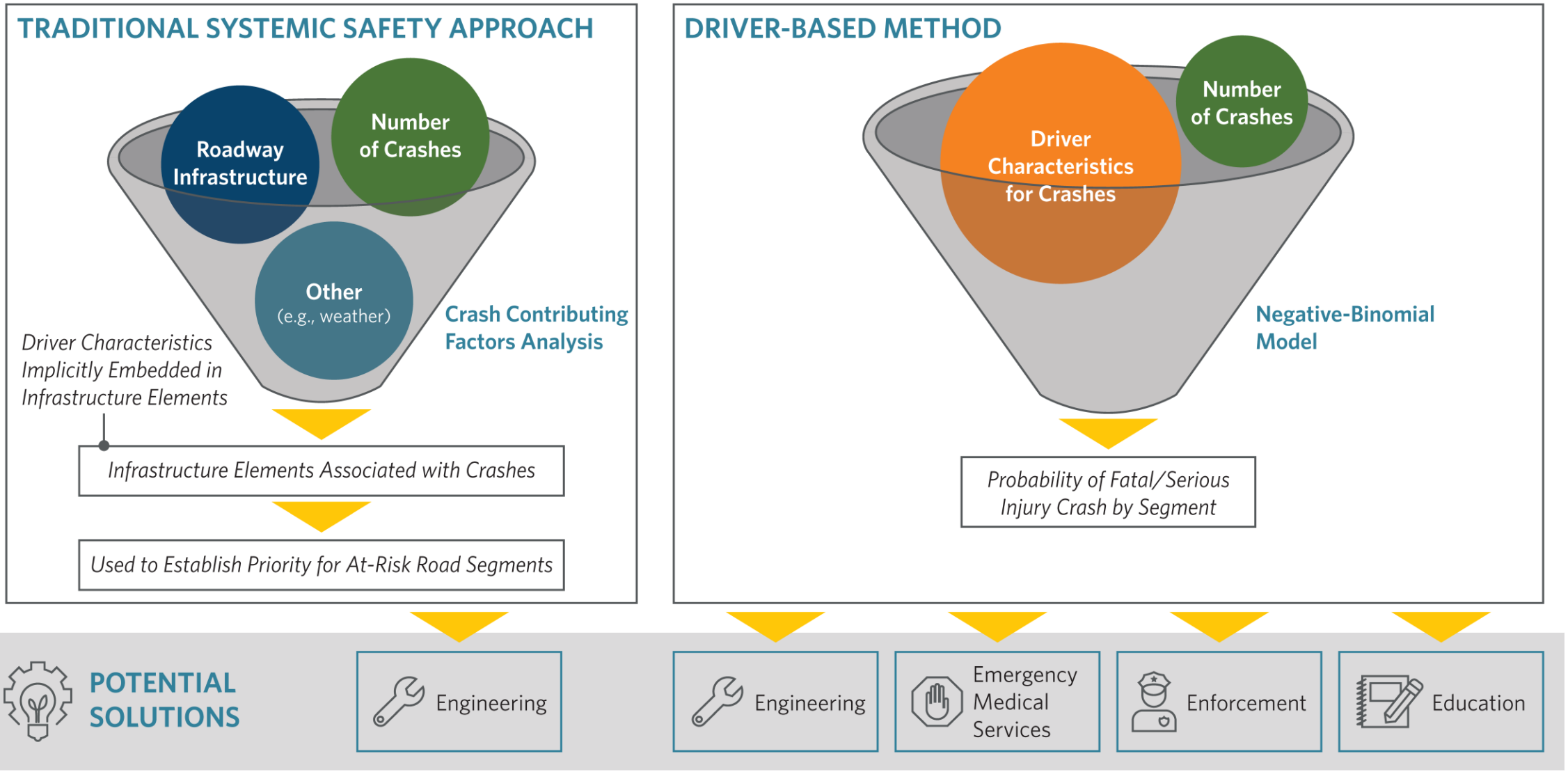
Coordination with various stakeholders for safety improvements.

Trail

Construct a trail to provide safe and comfortable space for pedestrians and bicyclists along the corridor.

*Source: TxDOT HSIP Guidelines
** Source: FHWA Proven Safety Countermeasures

A New Direction for Proactive Screening



Thank you

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