Exploring the Choice of Sliding Window Parameters for Network Screening of Roadway Segments

TRB Safety Performance and Analysis Committee (ACS20)

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Outline

- SAFE STRIDES 2 Zero Program
- Network Screening
- Data and Methodology
- Results and Discussion
- Summary

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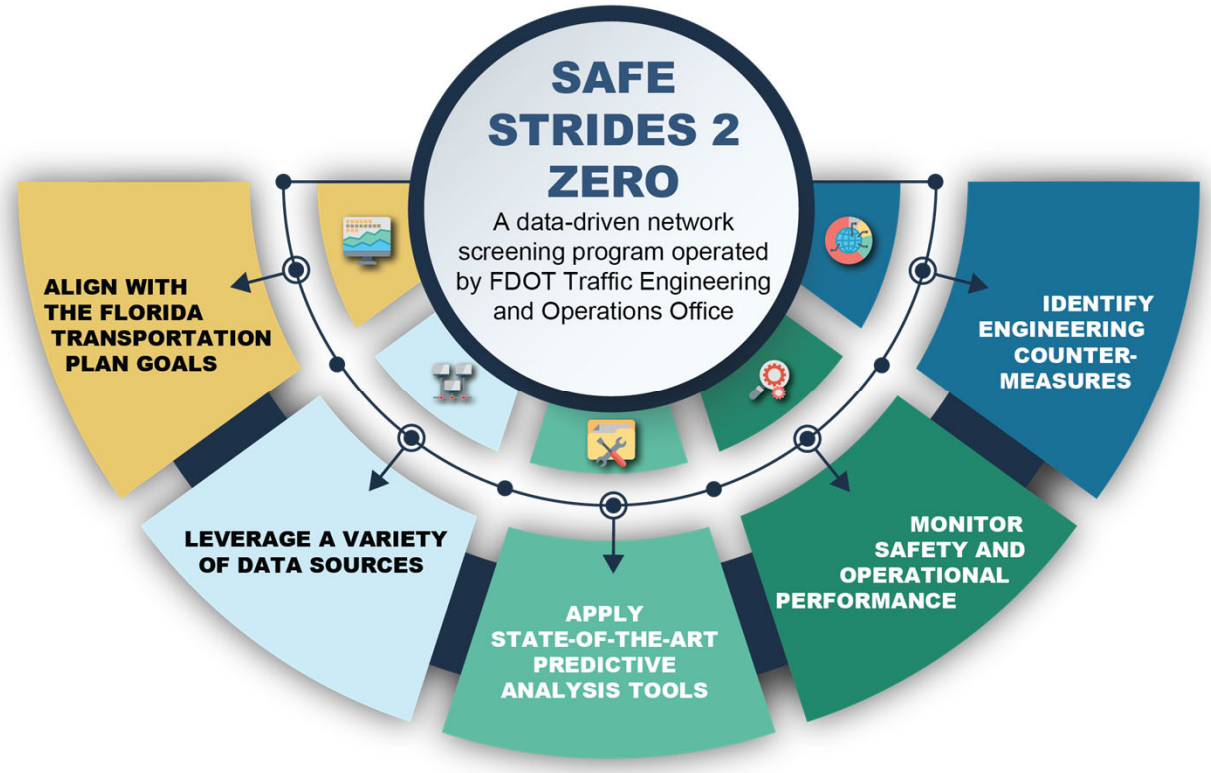

STRIDES: State Traffic Roadway and Intersection Data Evaluation System

SAFE: System Analysis and Forecast Evaluation

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SAFE STRIDES 2 Zero Program Phases

1. Signalized intersections on State Highway System

   Network screening analysis done each year since 2020 by developing Florida-specific Safety Performance Functions (SPFs) using most recent three-years of crash and traffic data

2. Roadway segments on State Highway System

   Focus of this presentation:

   - Network screening
   - Sliding window parameters' recommendations

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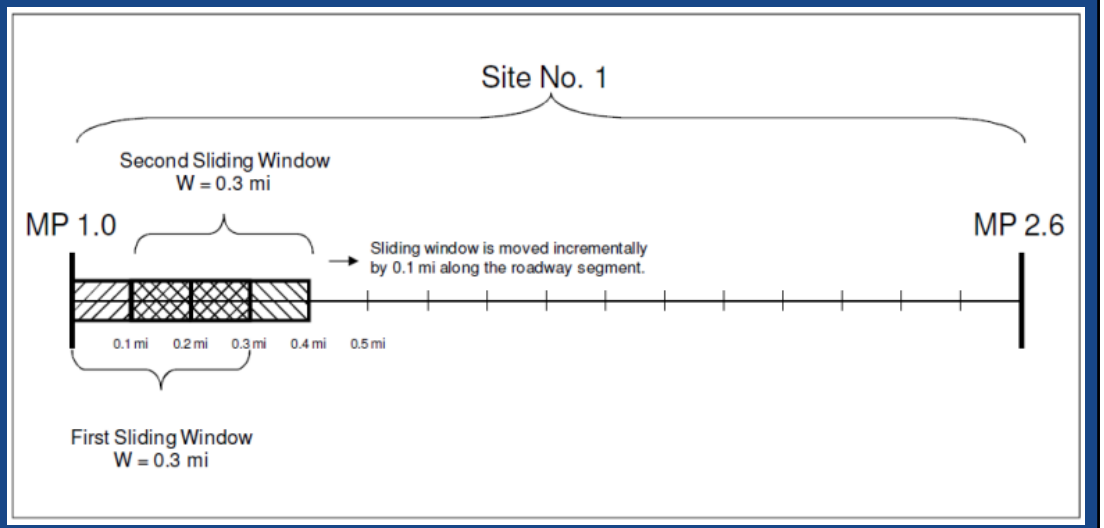
Sliding Window Method

- Network screening method
- Moves a window incrementally along a roadway segment
- Too short a window may produce false positives, identifying sites as hotspots when they are not.
- Too long a window may produce false negatives, failing to identify true high-collision concentration locations.
- Optimal parameters?



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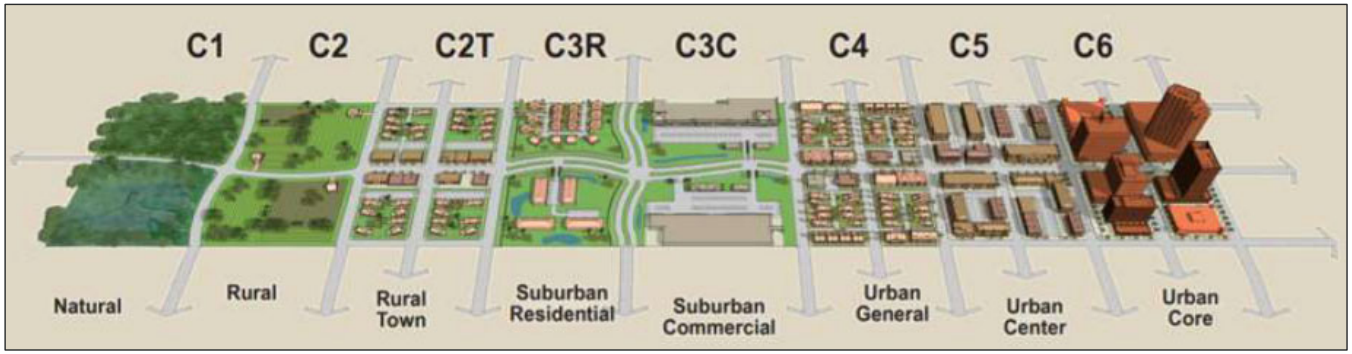
Segmentation Variables

- Number of lanes
- Median type
- Posted speed limits in both directions
- Presence of signalized intersection or roundabout
- Annual average daily traffic (AADT)
- Context classification



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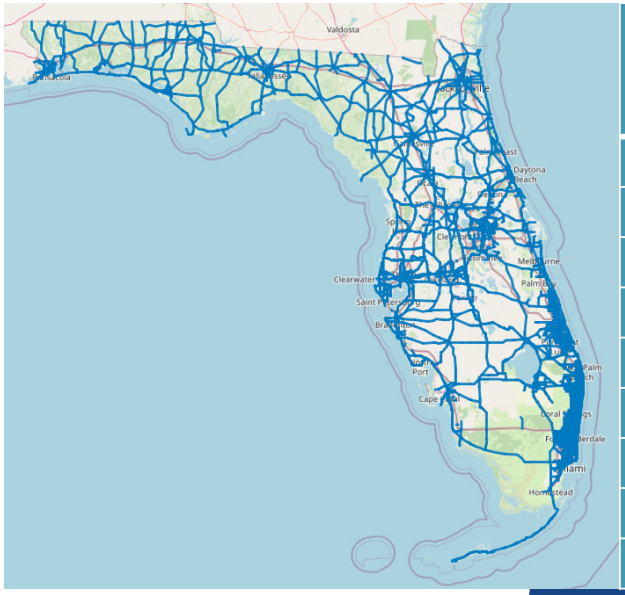
Roadway Segments Stats



Context Class	Number of Segments	Total Length of Segments (miles)	Miles per Segment	Proportion (by Total Length of Segments, %)
C1	1,026	946.4	0.92	7.3
C2	5,104	4,866.4	0.95	37.7
C2T	745	195.5	0.26	1.5
C3R	6,258	2,146.9	0.34	16.6
C3C	6,618	2,739.6	0.41	21.2
C4	6,203	1,888.6	0.30	14.6
C5	457	96.7	0.21	0.7
C6	215	36.5	0.17	0.3
Total	**26,626**	**12,916.6**	**0.49**	**100.0**

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Sliding Window Parameters

Distribution of Segments by Context Class

Context Class	Length (miles)				
	≤ 0.1	≤0.2	≤0.3	≤0.4	≤0.5
C1	24%	43%	52%	58%	62%
C2	24%	41%	53%	62%	67%
C2T	38%	59%	72%	79%	86%
C3C	32%	53%	65%	73%	78%
C3R	36%	57%	68%	75%	80%
C4	42%	62%	72%	78%	82%
C5	45%	70%	81%	85%	88%
C6	57%	74%	86%	91%	93%

- 24% of C1 segments have a length of 0.1 mi or less.
- 93% of C6 segments have a length of 0.5 mi or less.
- If two-thirds (2/3) of the segments are shorter than the window length, it would not be suitable for sliding window analysis.
- Minimum segment length was 0.1 mi.

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Sliding Window Parameters

Preliminary Sets of Parameters

Context Class	Set 1		Set 2		Set 3		Set 4		Set 5		Set 6		Set 7		Set 8	
	WL	IL	WL	IL	WL	IL	WL	IL	WL	IL	WL	IL	WL	IL	WL	IL
C1	0.2	0.05	0.2	0.1	0.3	0.1	0.3	0.15	0.4	0.1	0.4	0.2	0.5	0.1	0.5	0.25
C2	0.2	0.05	0.2	0.1	0.3	0.1	0.3	0.15	0.4	0.1	0.4	0.2	0.5	0.1	0.5	0.25
C2T	0.2	0.05	0.2	0.1	0.1	0.05	0.3	0.1								
C3R	0.2	0.05	0.2	0.1	0.1	0.05	0.3	0.1								
C3C	0.2	0.05	0.2	0.1	0.1	0.05	0.3	0.1								
C4	0.2	0.05	0.2	0.1	0.1	0.05										
C5	0.2	0.05	0.2	0.1	0.1	0.05										
C6	0.2	0.05	0.2	0.1	0.1	0.05										

WL: Window length
IL: Incremental length

Crash Data Stats

- Crashes with 350 ft of signalized intersections are excluded
- Crashes within 350 ft of roundabouts are excluded

Year	Fatal and Injury Crashes (FI)	Property Damage Only Crashes (PDO)
2016	69,949	165,558
2017	70,294	168,203
2018	71,066	314,123
Total	**211,309**	**647,884**

Source: FDOT Crash Analysis Reporting System (CARS)

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Sliding Window Analysis

Florida-specific Safety Performance Functions (SPFs):

- Total eight SPFs by context class and crash severity
- Four context class groups:
  - C1, C2, C2T
  - C3R, C3C
  - C4
  - C5, C6
- Two crash severity levels:
  - FI
  - PDO

$$N_{p,fi,c4} = L_s \times \exp[-2.246 + 1.306 \times \ln\left(\frac{AADT_s}{1000}\right) - 0.03354 \times I_{rm} - 0.01473 \times (S_{sl} - 40)]$$

$$N_{p,pdo,c4} = L_s \times exp[-2.444 + 1.475 \times ln\left(\frac{AADT_s}{1000}\right) - 0.04341 \times (S_{sl} - 40)]$$

I_{rm} = Restrictive median indicator
S_{sl} = Speed limit (mph)
L_s = Segment length (mi)
$AADT$ = Annual average daily traffic (veh/day)

Performance Measures:

- Excess predicted average crash frequency using SPFs
- Excess expected average crash frequency with empirical Bayes (EB) adjustments

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Analysis Results (Example 1)

Parameters: WL = 0.5 mi; IL = 0.1 mi

Segment ID	Sub-segment ID	BMP	EMP	Length (mi)	N_{excess} (PDO)
S20633	S20633_AA	0.0	0.5	0.5	21.92
S20633	S20633_AB	0.1	0.6	0.5	-1.08
S20633	S20633_AC	0.2	0.7	0.5	-1.08
S20633	S20633_AD	0.3	0.8	0.5	-1.08
S20633	S20633_AE	0.4	0.9	0.5	-1.08
S20633	S20633_AF	0.5	1.0	0.5	-1.08
S20633	S20633_AG	0.6	1.1	0.5	-1.08
S20633	S20633_AH	0.608	1.108	0.5	-1.08

Parameters: WL = 0.2 mi; IL = 0.05 mi

Segment ID	Sub-segment ID	BMP	EMP	Length (mi)	N_{excess} (PDO)
S20633	S20633_BA	0.0	0.2	0.2	22.57
S20633	S20633_BB	0.05	0.25	0.2	-0.43
S20633	S20633_BC	0.1	0.3	0.2	-0.43
S20633	S20633_BD	0.15	0.35	0.2	-0.43
S20633	S20633_BE	0.2	0.4	0.2	-0.43
S20633	S20633_BF	0.25	0.45	0.2	-0.43
S20633	S20633_BG	0.3	0.5	0.2	-0.43
S20633	S20633_BH	0.35	0.55	0.2	-0.43
S20633	S20633_BI	0.4	0.6	0.2	-0.43
S20633	S20633_BJ	0.45	0.65	0.2	-0.43
S20633	S20633_BK	0.5	0.7	0.2	-0.43
S20633	S20633_BL	0.55	0.75	0.2	-0.43
S20633	S20633_BM	0.6	0.8	0.2	-0.43
S20633	S20633_BN	0.65	0.85	0.2	-0.43
S20633	S20633_BO	0.7	0.9	0.2	-0.43
S20633	S20633_BP	0.75	0.95	0.2	-0.43
S20633	S20633_BQ	0.8	1.0	0.2	-0.43
S20633	S20633_BR	0.85	1.05	0.2	-0.43
S20633	S20633_BS	0.9	1.1	0.2	-0.43
S20633	S20633_BT	0.908	1.108	0.2	-0.43

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Analysis Results (Example 2)

Parameters: WL = 0.5 mi; IL = 0.1 mi

Segment ID	Sub-segment ID	BMP	EMP	Length (mi)	N_{excess} (PDO)
S26623	S26623_AA	0.0	0.5	0.5	11.56
S26623	S26623_AB	0.1	0.6	0.5	11.56
S26623	S26623_AC	0.2	0.7	0.5	11.56
S26623	S26623_AD	0.3	0.8	0.5	11.56
S26623	S26623_AE	0.4	0.9	0.5	-1.01
S26623	S26623_AF	0.47	0.97	0.5	-1.01

Parameters: WL = 0.2 mi; IL = 0.05 mi

Segment ID	Sub-segment ID	BMP	EMP	Length (mi)	N_{excess} (PDO)
S26623	S26623_BA	0.0	0.2	0.2	-0.76
S26623	S26623BB	0.05	0.25	0.2	-0.76
S26623	S26623_BC	0.1	0.3	0.2	-0.76
S26623	S26623_BD	0.15	0.35	0.2	14.86
S26623	S26623_BE	0.2	0.4	0.2	14.86
S26623	S26623_BF	0.25	0.45	0.2	14.86
S26623	S26623_BG	0.3	0.5	0.2	14.86
S26623	S26623_BH	0.35	0.55	0.2	-0.76
S26623	S26623_BI	0.4	0.6	0.2	-0.76
S26623	S26623_BJ	0.45	0.65	0.2	-0.76
S26623	S26623_BK	0.5	0.7	0.2	-0.76
S26623	S26623_BL	0.55	0.75	0.2	-0.76
S26623	S26623_BM	0.6	0.8	0.2	-0.76
S26623	S26623_BN	0.65	0.85	0.2	-0.76
S26623	S26623_BO	0.7	0.9	0.2	-0.76
S26623	S26623_BP	0.75	0.95	0.2	-0.76
S26623	S26623_BQ	0.77	0.97	0.2	-0.76

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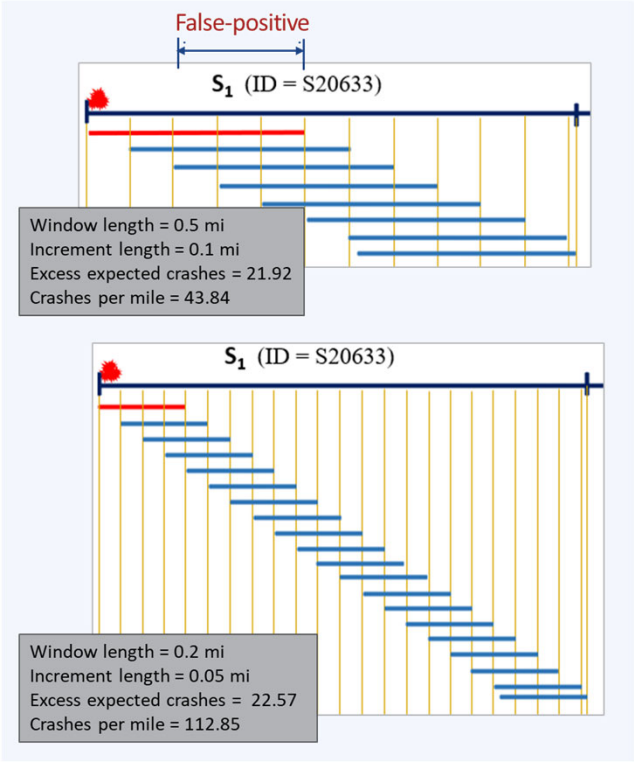
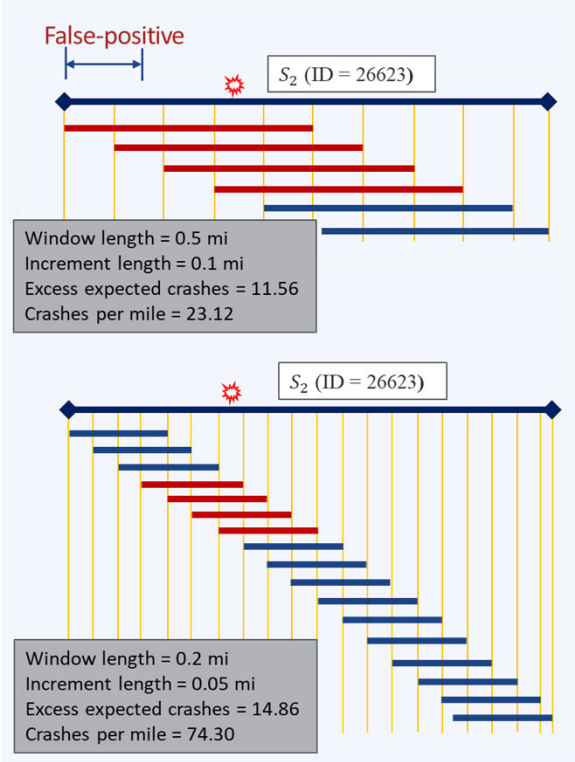
Selection of Optimal Parameters

- High crash frequency (excess expected or excess predicted) per mile within a window





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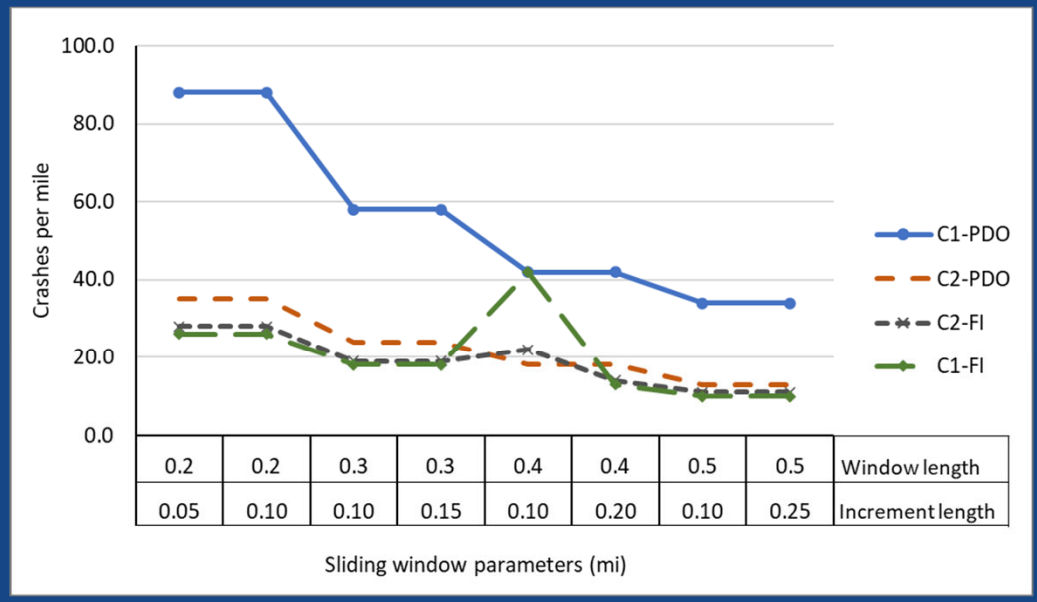
Trends Test

- Mann-Kendall trend test.
- Shorter window is proportional to high crash per mile.
- Window length vs crash per mile is statistically significant.
- Increment length has no significant difference in crash per mile of the same window.



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Optimal Sets of Parameters by Context Class

Context Class	Excess Predicted Average Crash Frequency using SPFs		Excess Expected Average Crash Frequency with EB Adjustments	
	WL (mi)	IL (mi)	WL (mi)	IL (mi)
C1	0.2	0.05	0.2	0.05
C2	0.2	0.05	0.2	0.05
C2T	0.1	0.05	0.1	0.05
C3R	0.1	0.05	0.1	0.05
C3C	0.1	0.05	0.1	0.05
C4	0.1	0.05	0.1	0.05
C5	0.1	0.05	0.1	0.05
C6	0.1	0.05	0.1	0.05

Comparison between Different Sets of Parameters

Performance Measure	Parameters	Context Class	WL (mi)	IL (mi)	Number of Segments	Number of Subsegments	Number of Subsegments with Nexcess FI > 0	Percent	Number of Subsegments with Nexcess PDO > 0	Percent
Excess Expected Crash Frequency with EB Adjustment	Optimal Set	C1	0.2	0.05	1,026	16,892	2,338	13.8%	2,532	15.0%
		C2	0.2	0.05	5,104	86,925	15,182	17.5%	15,983	18.4%
		C2T	0.1	0.05	745	3,687	512	13.9%	650	17.6%
		C3R	0.1	0.05	6,258	40,229	3,718	9.2%	3,873	9.6%
		C3C	0.1	0.05	6,618	51,783	9,152	17.7%	9,520	18.4%
		C4	0.1	0.05	6,203	35,161	3,903	11.1%	3,956	11.3%
		C5	0.1	0.05	457	1,788	97	5.4%	149	8.3%
		C6	0.1	0.05	215	682	25	3.7%	63	9.2%
	Next Set	C1	0.2	0.1	1,026	8,044	1,123	14.0%	1,256	15.6%
		C2	0.2	0.1	5,104	39,511	7,101	18.0%	7,365	18.6%
		C2T	0.2	0.1	745	1,880	236	12.6%	322	17.1%
		C3R	0.2	0.1	6,258	20,343	2,010	9.9%	2,230	11.0%
		C3C	0.2	0.1	6,618	25,945	4,743	18.3%	4,393	16.9%
		C4	0.2	0.1	6,203	18,093	1,741	9.6%	1,968	10.9%
		C5	0.2	0.1	457	872	51	5.8%	75	8.6%
		C6	0.2	0.1	215	333	14	4.2%	32	9.6%
	Last Set	C1	0.5	0.25	1,026	3,770	805	21.4%	807	21.4%
		C2	0.5	0.25	5,104	19,368	5,163	26.7%	5,417	28.0%
		C2T	0.3	0.1	745	1,246	166	13.3%	221	17.7%
		C3R	0.3	0.1	6,258	13,472	1,372	10.2%	1,502	11.1%
		C3C	0.3	0.1	6,618	17,182	3,181	18.5%	2,959	17.2%
		C4	--	--						
		C5	--	--						
		C6	--	--						

Summary

- Network screening is a vital step in roadway safety management.
- Analysis was done using different set of parameters depending on the lengths of the segments in that context class.
- The optimal sets of sliding window parameters were selected based on the ratio of the excess expected crash frequency to the window length.
- Optimal sets for natural (C1) and rural (C2) are 0.2 mi window with 0.05 mi increments. Optimal sets for rural town (C2T) through urban core (C6) context classes are 0.1 mi window with 0.05 mi increments.
- Despite having no significant difference between the increment lengths, a shorter increment was preferred as the best choice based on the need to capture every change in crash frequency and location.

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Thank You

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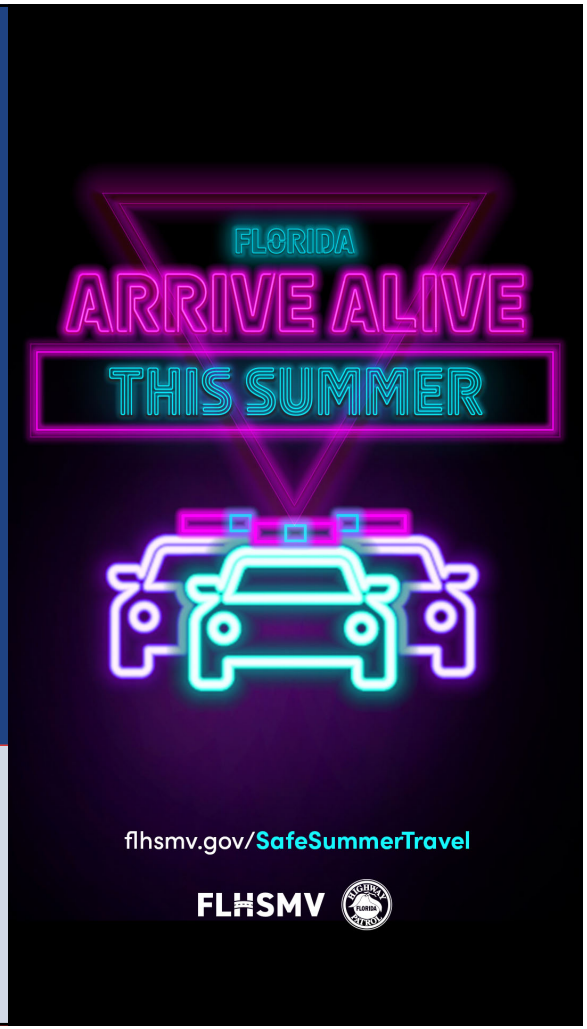

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