City of Tyler Flashing Yellow Arrow – Before and After

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August 31, 2012

Objectives

- Discuss why Tyler adopted Flashing Yellow Arrow displays.
- Review the FYA's affect on safety.

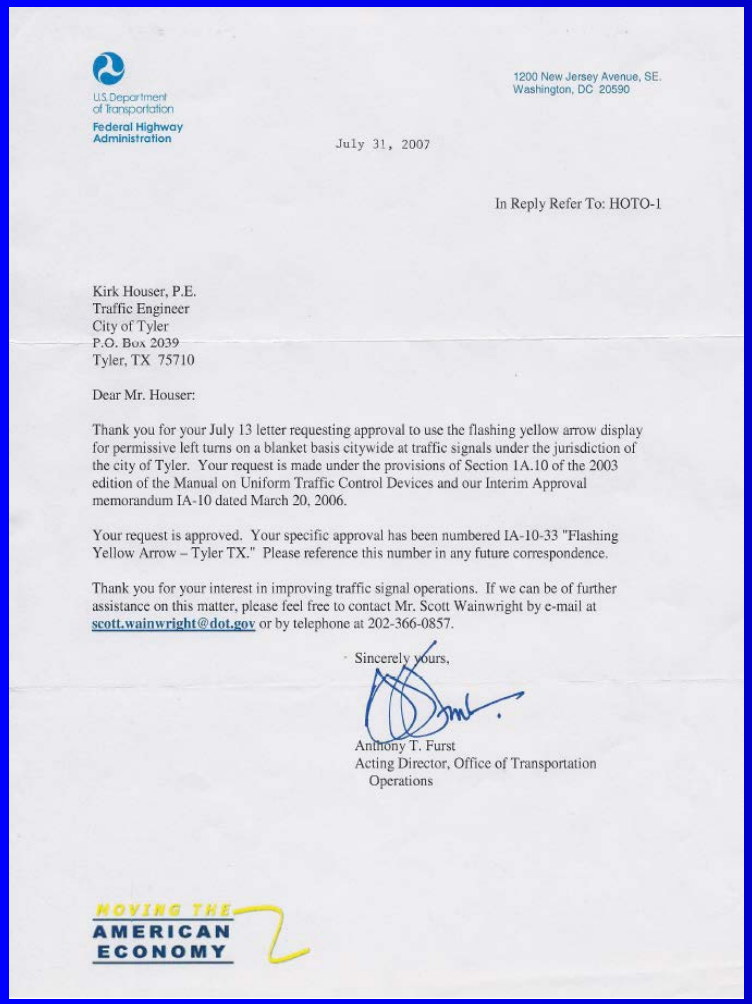
What is FYA?

- A type of Protected/Permissive Left Turn Display
- Uses a 4-section signal head
- 2011 TMUTCD compliant

NCHRP Report 493

- Sponsored by American Association of State Highway and Transportation Officials (AASHTO) and Federal Highway Administration (FHWA)
- Performed by Kittelson & Associates
- Identify the “best” or most appropriate display for PPLT control
- Recommended the use of a 4 section display using a Flashing Yellow Arrow (FYA)

City of Tyler Installations



U.S. Department of Transportation
Federal Highway Administration

1200 New Jersey Avenue, SE.
Washington, DC 20590

July 31, 2007

In Reply Refer To: HOTO-1

Kirk Houser, P.E.
Traffic Engineer
City of Tyler
P.O. Box 2039
Tyler, TX 75710

Dear Mr. Houser:

Thank you for your July 13 letter requesting approval to use the flashing yellow arrow display for permissive left turns on a blanket basis citywide at traffic signals under the jurisdiction of the city of Tyler. Your request is made under the provisions of Section 1A.10 of the 2003 edition of the Manual on Uniform Traffic Control Devices and our Interim Approval memorandum IA-10 dated March 20, 2006.

Your request is approved. Your specific approval has been numbered IA-10-33 "Flashing Yellow Arrow – Tyler TX." Please reference this number in any future correspondence.

Thank you for your interest in improving traffic signal operations. If we can be of further assistance on this matter, please feel free to contact Mr. Scott Wainwright by e-mail at scott.wainwright@dot.gov or by telephone at 202-366-0857.

Sincerely yours,

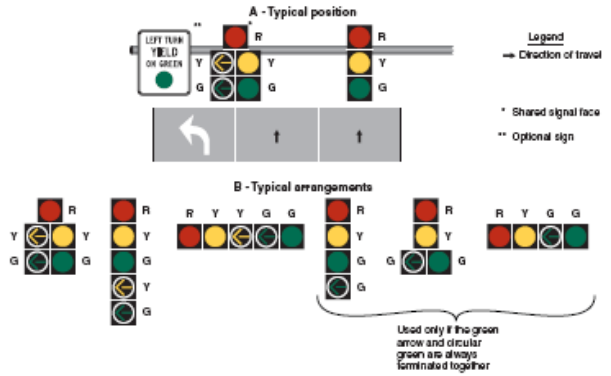
Anthony T. Furst
Acting Director, Office of Transportation Operations

MOVING THE AMERICAN ECONOMY

- Approval from FHWA July 2007
- 1st installation January 2008
- 40+ Locations
  - South Broadway
  - Troup Hwy
  - Beckham St
  - Loop 323

2011 TMUTCD

Figure 4D-11. Typical Position and Arrangements of Shared Signal Faces for Protected/Permissive Mode Left Turns



03 If a separate left-turn signal face is being operated in a protected/permissive left-turn mode and a flashing left-turn yellow arrow signal indication is provided, it shall meet the following requirements (see Figure 4D-12):

A. It shall be capable of displaying the following signal indications: steady left-turn RED ARROW, steady left-turn YELLOW ARROW, flashing left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time.

B. During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.

C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication.

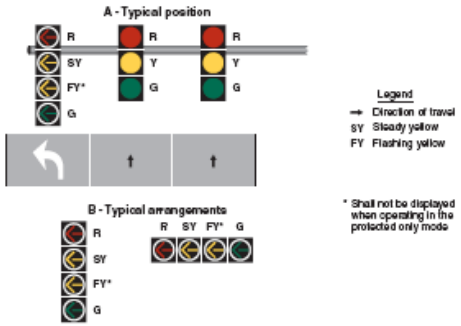
D. During the permissive left-turn movement, a flashing left-turn YELLOW ARROW signal indication shall be displayed.

E. A steady left-turn YELLOW ARROW signal indication shall be displayed following the flashing left-turn YELLOW ARROW signal indication if the permissive left-turn movement is being terminated and the separate left-turn signal face will subsequently display a steady left-turn RED ARROW indication.

F. It shall be permitted to display a flashing left-turn YELLOW ARROW signal indication for a permissive left-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement.

G. When a permissive left-turn movement is changing to a protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed immediately upon the termination of the flashing left-turn YELLOW ARROW signal indication. A steady left-turn YELLOW ARROW signal indication shall not be displayed between the display of the flashing left-turn YELLOW ARROW signal indication and the display of the steady left-turn GREEN ARROW signal indication.

Figure 4D-12. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Protected/Permissive Mode and Protected Only Mode Left Turns



H. The display shall be a four-section signal face except that a three-section signal face containing a dual-arrow signal section shall be permitted where signal head height limitations (or lateral positioning limitations for a horizontally-mounted signal face) will not permit the use of a four-section signal face. The dual-arrow signal section, where used, shall display a GREEN ARROW for the protected left-turn movement and a flashing YELLOW ARROW for the permissive left-turn movement.

I. During steady mode (stop-and-go) operation, the signal section that displays the steady left-turn YELLOW ARROW signal indication during change intervals shall not be used to display the flashing left-turn YELLOW ARROW signal indication for permissive left turns.

J. During flashing mode operation (see Section 4D.30), the display of a flashing left-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady left-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

Option:

04 A separate left-turn signal face with a flashing left-turn RED ARROW signal indication during the permissive left-turn movement may be used for unusual geometric conditions, such as wide medians with offset left-turn lanes, but only when an engineering study determines that each and every vehicle must successively come to a full stop before making a permissive left turn.

Standard:

05 If a separate left-turn signal face is being operated in a protected/permissive left-turn mode and a flashing left-turn RED arrow signal indication is provided, it shall meet the following requirements (see Figure 4D-8):

A. It shall be capable of displaying the following signal indications: steady or flashing left-turn RED ARROW, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time.

B. During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.

C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication.

D. During the permissive left-turn movement, a flashing left-turn RED ARROW signal indication shall be displayed.

Why use FYA?

- Allows Lead/Lag operations without causing a "yellow trap"
- Can be used on span wire intersections.

The Yellow Trap

Left Turn Indication	Through Movement	Opposing Through	Description
			All Red
			Protected Left Turn
			Change Interval (End Protected Left Turn)
			Permissive Phase
			Change Interval (Yellow Trap)
			Opposing Through Phase Indication Still Green

Eliminate the Yellow Trap

Left Turn Indication	Through Movement	Opposing Through	Description
			All Red
			Protected Left Turn
			Clearance Interval (End Protected Left Turn)
			Permissive Phase
			Change Interval
			Opposing Through Phase Indication Still Green
			Change Interval

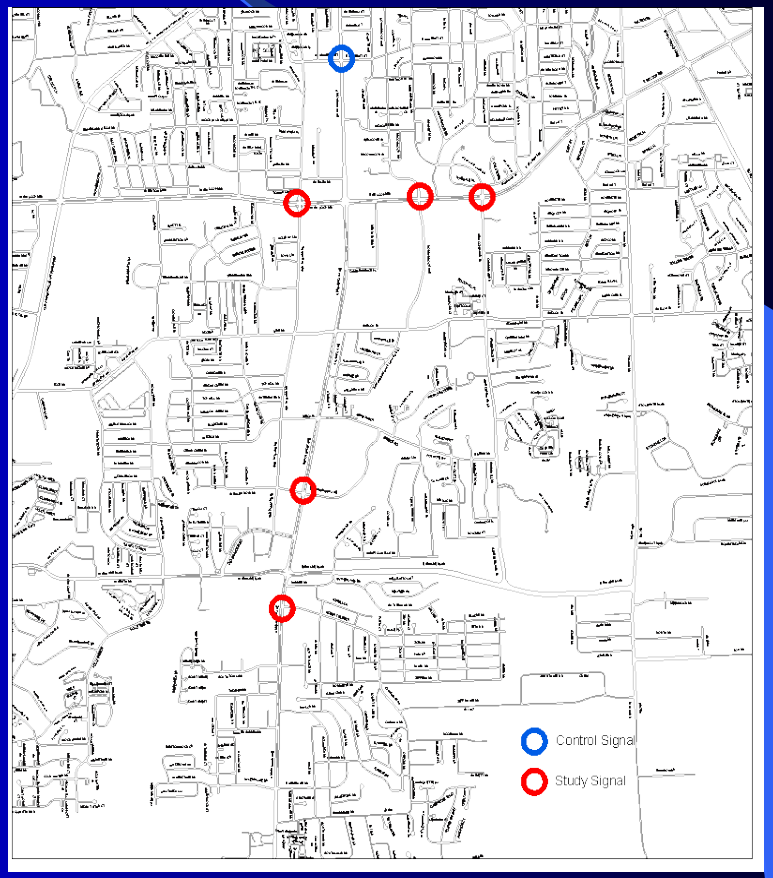
Does FYA Affect Safety?

Site Selection

- At least 12 months of crash data available after the FYA display was installed.
- Intersections located on the same coordinated system.
- All intersections originally operated as PPLT operations.
- Turning movement counts were available for each intersection.

Study Locations

1. Broadway / Donnybrook / Chimney Rock
2. Loop 323 / Old Bullard
3. Loop 323 / Donnybrook
4. Loop 323 / Copeland
5. Broadway / Robert E. Lee



Data Collection

- Traffic Counts
  - Saturation counts from TxDot
  - TM counts from City of Tyler
- Crash Data
  - Rear End Collisions
  - Improper Left Turn
  - Other
  - Total

Volume Data Analysis

- Establish ADT for each of the study years.
- Use TM data to apportion the data out by movement.

Volume Calculations - Broadway Ave @ Chimney Rock Dr/Donnybrook Ave

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
North	44156	44048	43940	43832	43724	43616	43508	43400	43292	43184
South	44328	44694	45060	45426	45792	46158	46524	46890	47256	47622
East	3946	3848	3750	3652	3554	3456	3358	3260	3162	3064
West	3582	3666	3750	3834	3918	4002	4086	4170	4254	4338
Total	48006	48128	48250	48372	48494	48616	48738	48860	48982	49104
NBLT	249	250	251	251	252	253	253	254	255	255
NBT	7097	7115	7133	7151	7169	7187	7205	7223	7241	7259
NBRT	1373	1377	1380	1384	1387	1390	1394	1397	1401	1404
SBLT	318	319	319	320	321	322	323	323	324	325
SBT	6364	6380	6397	6413	6429	6445	6461	6478	6494	6510
SBRT	392	393	394	395	396	397	398	399	400	401
EBLT	339	339	340	341	342	343	344	345	345	346
EBT	347	348	349	350	351	352	353	354	355	355
EBRT	505	506	507	509	510	511	513	514	515	516
WBLT	1000	1002	1005	1007	1010	1013	1015	1018	1020	1023
WBT	294	295	296	296	297	298	298	299	300	301
WBRT	122	122	122	123	123	123	124	124	124	125
Total	18400	18446	18493	18540	18587	18634	18681	18728	18774	18820

Calculated ADT by Turning Movement										
NBLT	650	652	655	655	657	660	660	663	665	665
NBT	18516	18563	18610	18657	18704	18751	18798	18845	18892	18939
NBRT	3582	3593	3600	3611	3619	3627	3637	3645	3655	3663
SBLT	830	832	832	835	837	840	843	843	845	848
SBT	16604	16646	16690	16732	16773	16815	16857	16901	16943	16985
SBRT	1023	1025	1028	1031	1033	1036	1038	1041	1044	1046
EBLT	884	884	887	890	892	895	898	900	900	903
EBT	905	908	911	913	916	918	921	924	926	926
EBRT	1318	1320	1323	1328	1331	1333	1338	1341	1344	1346
WBLT	2609	2614	2622	2627	2635	2643	2648	2656	2661	2669
WBT	767	770	772	772	775	777	777	780	783	785
WBRT	318	318	318	321	321	321	324	324	324	326
Total	48006	48125	48248	48372	48493	48616	48739	48863	48982	49101

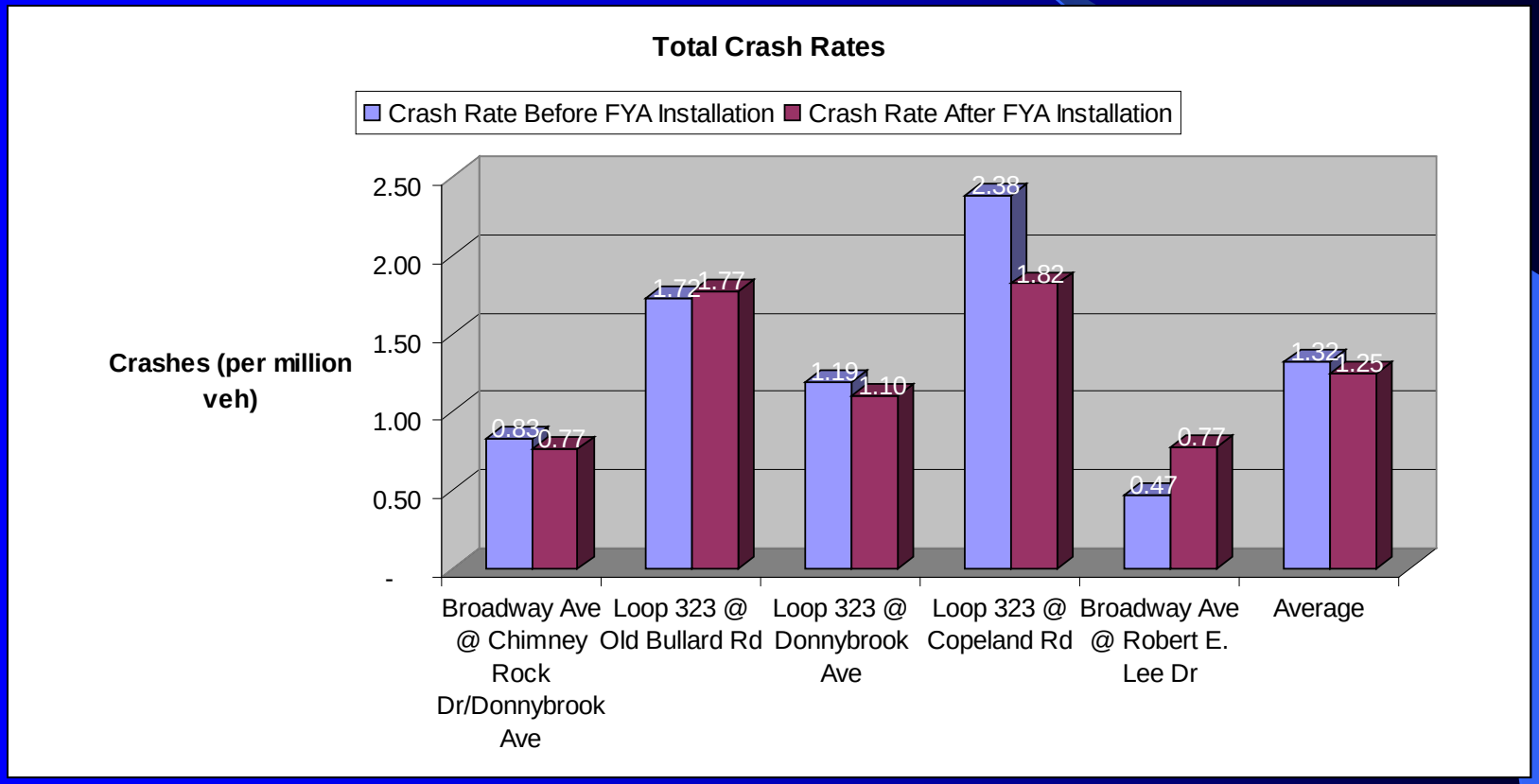
Crash Data Analysis

- Calculations:
  - Total Crash Rate
  - Rear End Crash Rate
  - Improper Left Turn Crash Rate

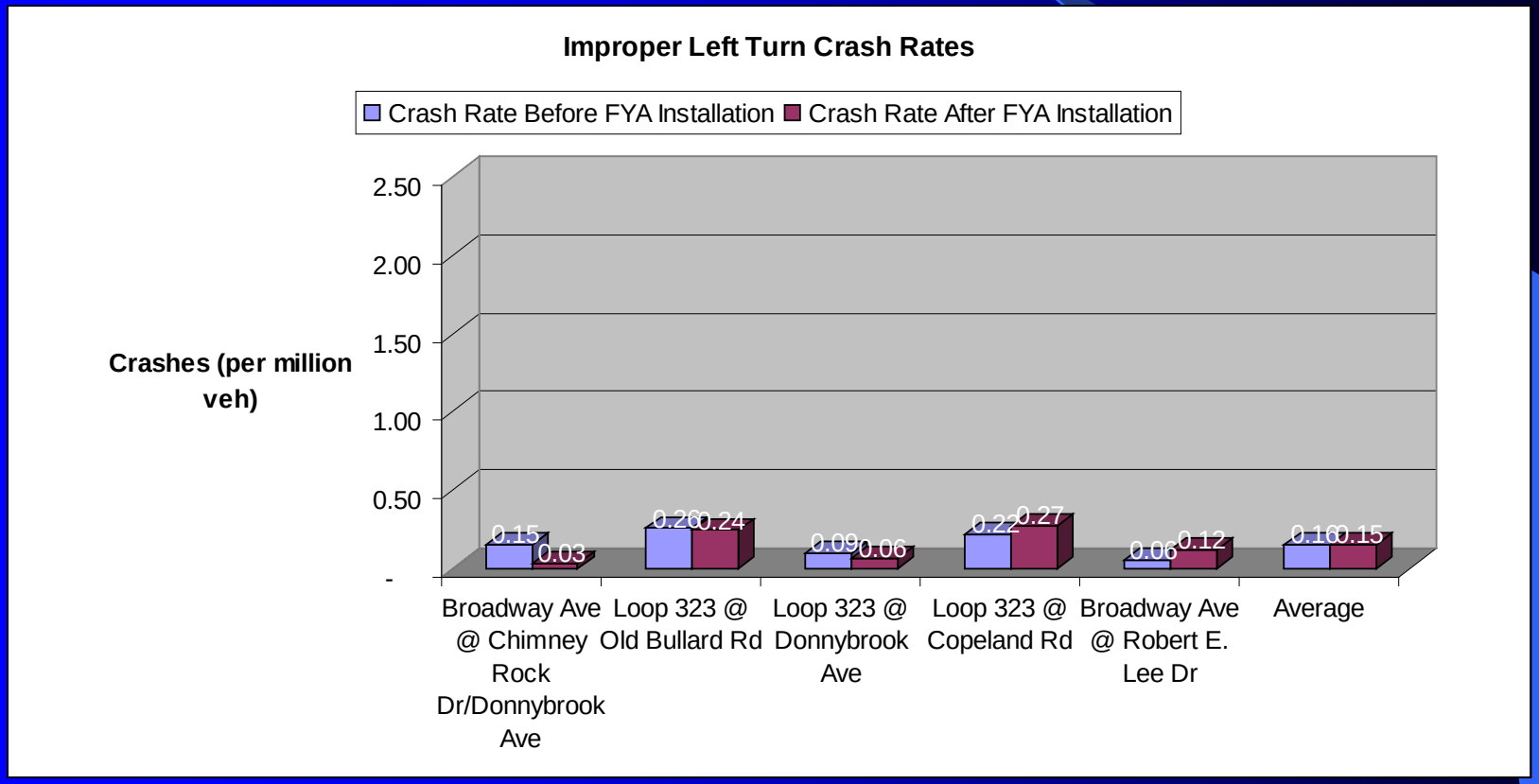
Statistical Analysis

Crash Rate Before FYA Installation						Crash Rate After FYA Installation								
Rear End		Improper LT		Total		Rear End			Improper LT			Total		
Rate	SD	Rate	SD	Rate	SD	Rate	Difference	Significant	Rate	Difference	Significant	Rate	Difference	Significant
0.58	0.750	0.15	0.338	0.83	1.039	0.67	0.09	No	0.03	(0.12)	No	0.77	(0.06)	No
1.27	0.846	0.26	0.399	1.72	1.010	1.46	0.19	No	0.24	(0.01)	No	1.77	0.05	No
0.81	0.851	0.09	0.239	1.19	1.063	0.95	0.13	No	0.06	(0.03)	No	1.10	(0.09)	No
1.90	1.324	0.22	0.330	2.38	1.283	1.35	(0.55)	No	0.27	0.05	No	1.82	(0.56)	No
0.37	0.470	0.06	0.196	0.47	0.531	0.62	0.24	No	0.12	0.06	No	0.77	0.30	No
0.99		0.16		1.32		1.01	0.02		0.15	(0.01)		1.25	(0.07)	

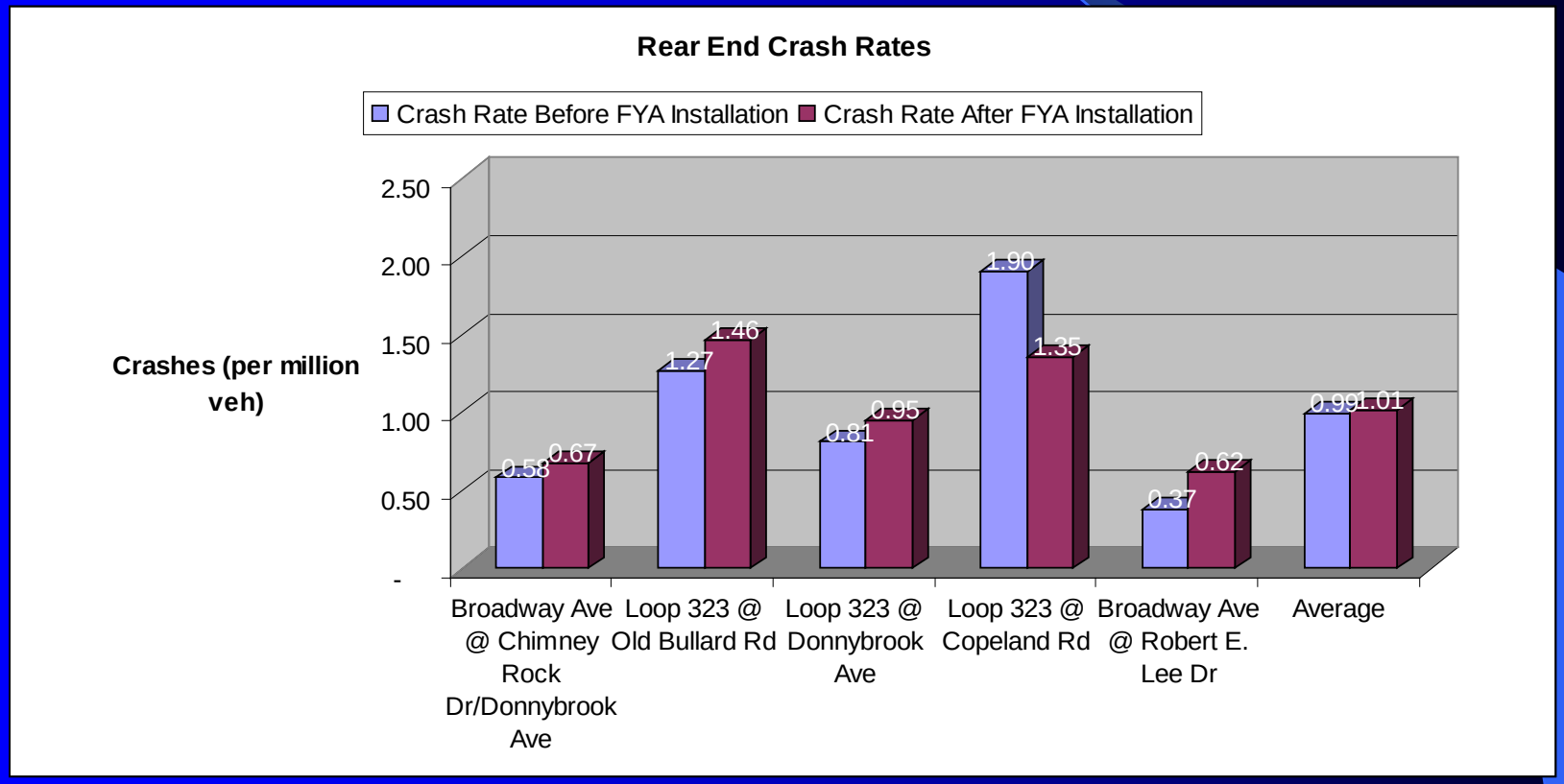
Total Crash Rate



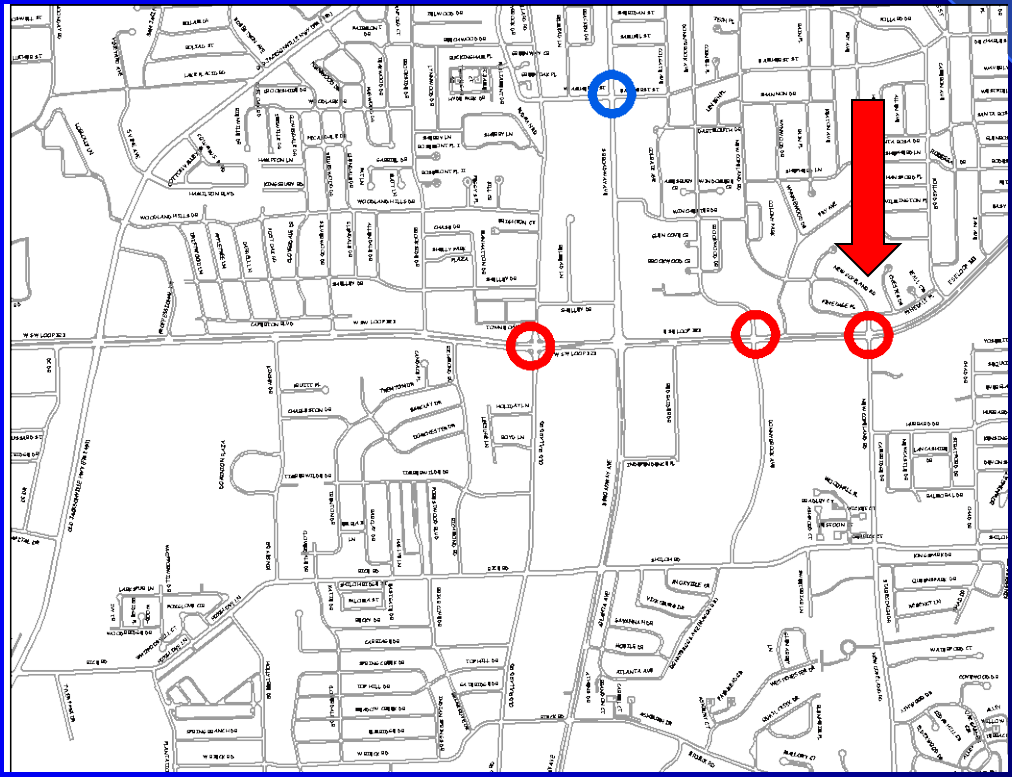
Improper LT Crash Rate

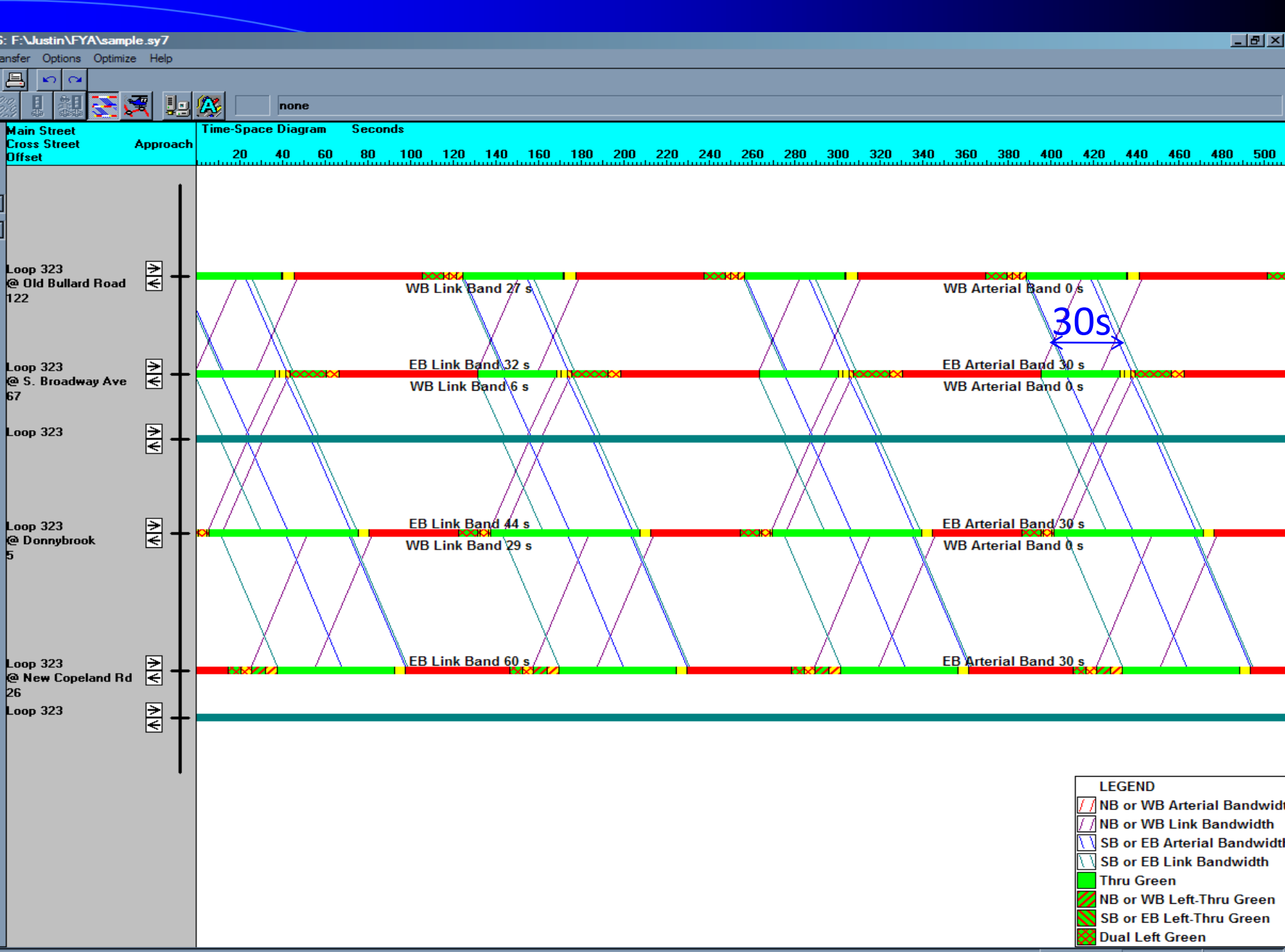


Rear End Crash Rate



Copeland Rd. Intersection

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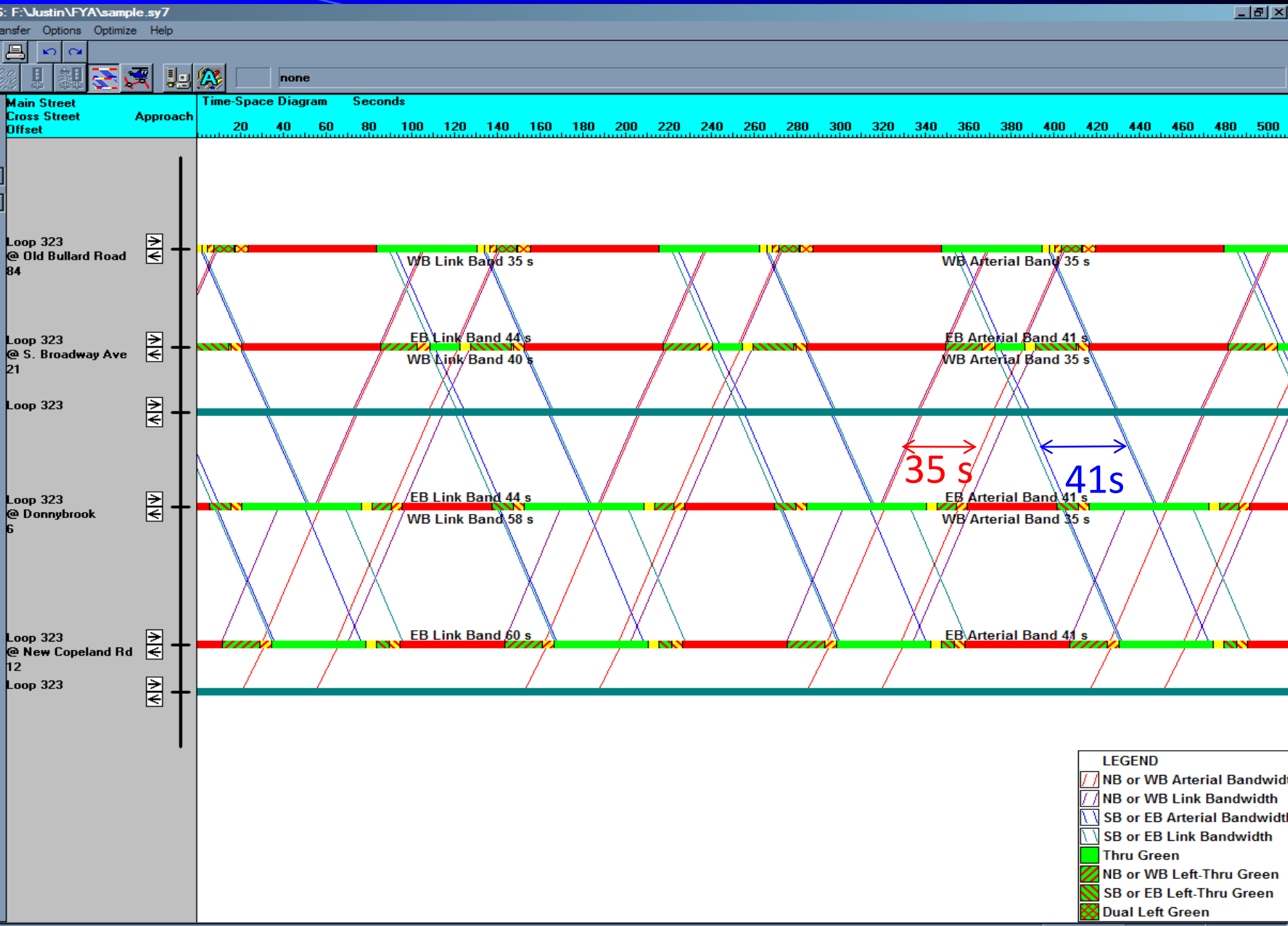
Main Street
Cross Street
Offset
Approach
Time-Space Diagram
Seconds
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
Loop 323
@ Old Bullard Road
122
WB Link Band 27 s
WB Arterial Band 0 s
30s
Loop 323
@ S. Broadway Ave
67
EB Link Band 32 s
WB Link Band 6 s
EB Arterial Band 30 s
WB Arterial Band 0 s
Loop 323
Loop 323
@ Donnybrook
5
EB Link Band 44 s
WB Link Band 29 s
EB Arterial Band 30 s
WB Arterial Band 0 s
Loop 323
@ New Copeland Rd
26
EB Link Band 60 s
EB Arterial Band 30 s
Loop 323
LEGEND
NB or WB Arterial Bandwidt
NB or WB Link Bandwidth
SB or EB Arterial Bandwidt
SB or EB Link Bandwidth
Thru Green
NB or WB Left-Thru Green
SB or EB Left-Thru Green
Dual Left Green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none
Main Street
Cross Street
Offset
Approach
Time-Space Diagram
Seconds
20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
Loop 323
@ Old Bullard Road
84
WB Link Band 35 s
WB Arterial Band 35 s
Loop 323
@ S. Broadway Ave
21
EB Link Band 44 s
WB Link Band 40 s
EB Arterial Band 41 s
WB Arterial Band 35 s
Loop 323
35 s
41s
Loop 323
@ Donnybrook
6
EB Link Band 44 s
WB Link Band 58 s
EB Arterial Band 41 s
WB Arterial Band 35 s
Loop 323
@ New Copeland Rd
12
EB Link Band 60 s
EB Arterial Band 41 s
Loop 323
LEGEND
NB or WB Arterial Bandwid
NB or WB Link Bandwidth
SB or EB Arterial Bandwidt
SB or EB Link Bandwidth
Thru Green
NB or WB Left-Thru Green
SB or EB Left-Thru Green
Dual Left Green

Conclusions

- Up to 33% reduction in delay on the corridor.*
  - FYA installations
  - Adaptive control system
- No significant change in the overall crash rates for:
  - Total Crash Rate
  - Rear End Crash Rate
  - Left Turn Crash Rate
- Copeland Rd intersection showed a significant reduction in rear end crashes.

Questions???