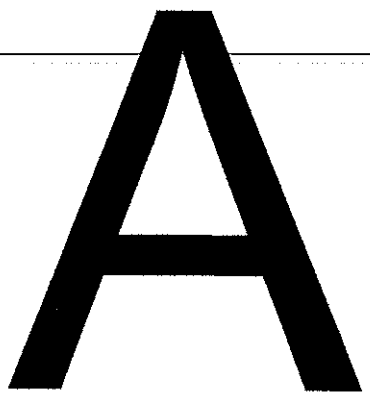


Columbus Focus on Safety Photo Red Light Program

Citations Issued Per Intersection

	4th & Mt. Vernon N/B March 7, 2006	5th & 4th E/B & W/B March 8, 2006	Cleveland & Spring S/B June 14, 2006	Henderson & Gettysburg E/B September 1, 2006	Broad & Sylvan E/B September 1, 2006	Summit & Chittenden S/B September 30, 2006	Livingston & Fairwood E/B October 18, 2006	Town & 4th W/B February 1, 2007	3rd & Fulton N/B & S/B Posted "No Turn on Red" February 1, 2007	Broad & Grant E/B February 27, 2007	4th & Main N/B October 4, 2007	Parsons & Frebis N/B October 4, 2007	4th & Long N/B Posted "No Turn on Red" October 8, 2007	Main & Eastmoor W/B November 1, 2007	Summit & Maynard S/B November 1, 2007	Indianola & Cooke S/B November 21, 2007	Central & Sullivant S/B December 31, 2007	3rd & Main S/B December 31, 2007	E. Livingston & Yearling E/B & W/B Posted "No Turn on Red" June 1, 2011	Rey. New Albany & E Broad E/B June 1, 2011	Hard & Sawmill W/B July 8, 2011	N 4th & Hudson W/B July 15, 2011	Roosevelt & Livingston E/B August 1, 2011
2006	5829	3153	1044	1172	1517	667	644																
2007	2495	2834	1483	866	2388	1914	2761	1049	4102	491	594	681	1540	426	298	205							
2008	4273	2420	1471	814	1754	1414	2353	1063	3391	578	2319	1936	4845	2442	1853	2031	1464	1761					
2009	3067	1620	2187	797	421	1133	1020	1038	2117	467	1514	1092	1041	977	968	687	942	617					
2010	2450	1467	1706	887	400	867	608	509	1516	413	1312	921	304	569	610	398	1700	381					
2011	2785	1801	2575	697	420	941	765	967	1874	363	1584	868	547	560	599	391	867	346	1985	842	2144	404	181
2012	2996	1151	1503	618	474	1076	631	753	2177	407	1404	825	626	544	795	351	2003	353	1944	3978	2777	550	342
2013	1628	785	503	546	616	968	630	451	1852	254	774	718	573	324	635	235	1709	261	1338	2196	2023	481	283
2014	1939	838	987	363	346	970	315	498	2637	227	1482	789	560	311	641	317	362	345	1366	2142	1908	571	291
2015	775	104	98	33	11	194	99	65	714	116	95	62	123	22	112	62	85	87	295	322	26	111	71
Total	28237	16173	13557	6793	8347	10144	9826	6393	20380	3316	11078	7892	10159	6175	6511	4677	9132	4151	6928	9480	8878	2117	1168

March 31, 2015

Reduction in Red Light Crashes per Intersection

2006	-71%	-91%	-40%	0%	0%	0%	-100%																
2007	-58%	-49%	-64%	-79%	-71%	-65%	-100%	-100%	-39%	-100%													
2008	-60%	-54%	-64%	-89%	-85%	-72%	-100%	-100%	-44%	-100%	-75%	-100%	-79%	-100%	-100%	-100%	-78%	-100%					
2009	-65%	-63%	-48%	-92%	-89%	-80%	-100%	-100%	-64%	-100%	-86%	-100%	-88%	-100%	-100%	-100%	-74%	-100%					
2010	-69%	-71%	-60%	-94%	-91%	-85%	-92%	-88%	-67%	-100%	-91%	-100%	-93%	-100%	-100%	-84%	-83%	-100%					
2011	-62%	-71%	-64%	-93%	-90%	-84%	-93%	-81%	-63%	-100%	-94%	-93%	-89%	-100%	-100%	-88%	-100%	-87%	-32%	0%	0%	-100%	-100%
2012	-60%	-74%	-70%	-88%	-83%	-83%	-94%	-77%	-69%	-100%	-85%	-89%	-77%	-100%	-94%	-81%	-100%	-90%	-32%	0%	0%	-100%	-100%

December 31, 2012

Mobile Speed Citations Issued Per Month

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
2011	217	349	557	272	365	57	200	448	294	254	172	235	**3420**
2012	281	200	176	94	140	109	66	389	117	239	207	74	**2092**
2013	244	201	268	413	497	153	307	615	468	239	172	197	**3774**
2014	160	282	340	253	216	173	108	454	349	251	179	155	**2920**
2015	57	65	25										**147**
Total	**959**	**1097**	**1366**	**1032**	**1218**	**492**	**681**	**1906**	**1228**	**983**	**730**	**661**	**12353**

* July 2013: A 3rd mobile speed van was put in service

February 28, 2015

Hearings per Year and Disposition

2006: Total number of cases: 134
- * Responsible: 108
- * Not Responsible : 26

2007: Total number of cases: 362
- * Responsible: 301
- * Not Responsible: 61

2008: Total number of cases: 507
- * Responsible: 436
- * Not Responsible: 71

2009: Total number of cases: 668
- * Responsible: 594
- * Not Responsible: 60

2010: Total number of cases: 568
- * Responsible: 213
- * Not Responsible: 43
- * Rescheduled: 48
- * No Show/Canc: 264

2011: Total number of cases: 1196
- * Responsible: 426
- * Not Responsible: 101
- * Rescheduled: 132
- * No Show/Canc: 537

2012: Total number of cases: 2659
- * Responsible: 865
- * Not Responsible: 196
- * Rescheduled: 99
- * No Show/Canc: 1499

2013: Total number of cases: 2,281
- * Responsible: 767
- * Not Responsible: 251
- * Rescheduled: 177
- * No Show/Canc: 1,102

2014: Total number of cases: 2,252
- * Responsible: 731
- * Not Responsible: 238
- * Rescheduled: 242
- * No Show/Canc: 1,041

December 31, 2014

Revenue per Year

2006	$141,505
2007	$375,158
2008	$838,322
2009	$666,247
2010	$619,868
2011	$1,094,993
2012	$2,299,038
2013	$2,130,726
2014	$2,094,583
2015	$224,026
Total	$10,484,466

March 31, 2015

Prior contract

original 18: 62%
20 new: 55%
Mobile speed: 55%

2015: Total number of cases:
- * Responsible:
- * Not Responsible:
- * Rescheduled:
- * No Show/Canc:

Distribution of Revenue

Contract expires June 3, 2017
City receives 68.7% or $65.26 of each citation issued for red light and mobile speed citations

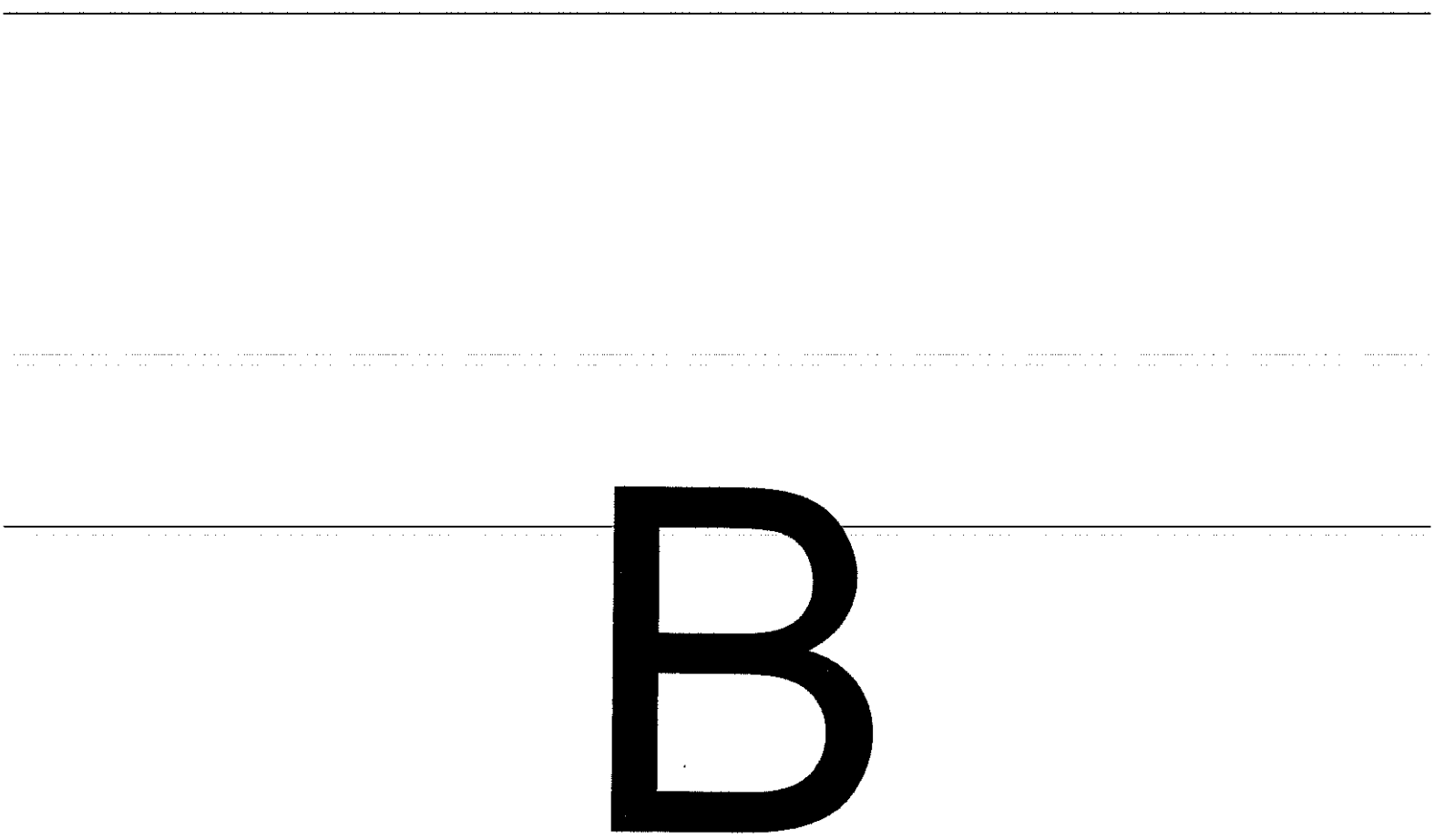
Use of Red Light Funds

Marked Cruisers
Overtime in 2008 for Summer Initiative
Contract -Leads On Line for Scrap Metal Information System - 2008
Community Crime Patrol in 2009
SRB Operating Expense in 2009
SRB Operating Expense in 2010
SRB Operating Expense in 2011
Internal Billing, Construction Inspection for cameras in 2011/2012
Photo Red Light violation Hearing officers in 2012
Outfit six SUV Cruisers for traffic Patrol in 2012
SRB Operating Funds in 2012
15 Panasonic Arbitrator 360 video cameras and accessories in 2012
198 Fujitsu laptops for Patrol, Canine and Traffic in 2013

3rd & Spring W/B Posted "No Turn on Red" except crub August 1, 2011	Brice & Scarborough/Tussing N/B August 22, 2011	Cleveland & Dublin Granville W/B Posted "No Turn on Red" August 22, 2011	Binns & Sullivant N/B Posted "No Turn on Red" between 8-4 August 31, 2011	Olentangy & Henderson N/B September 27, 2011	Dublin Granville & Maple Canyon W-E/B Posted "No Turn on Red" November 30, 2011	Hamilton & Refugee S/B December 31, 2011	Busch Blvd & Shapter Ave N/B S/B Posted "No Turn on Red" January 21, 2012	Northwest & Fifth W/B February 29, 2012	Broad & Taylor Station E/B & S/B Posted "No Turn on Red" except crub March 1, 2012	Main & McNaughten N/B March 1, 2012	Hilliard Rome & Renner E/B March 14, 2012	Sawmill Place & Sawmill N/B March 31, 2012	Refugee & Gender E/B May 25, 2012	Morse & Sunbury W/B September 14, 2012	Total	
															14026	**2006**
															24127	**2007**
															38182	**2008**
															21705	**2009**
															17018	**2010**
788	1307	243	48	1532	241	0									**28665**	**2011**
1109	3716	1334	232	3294	3771	1919	3581	1172	9910	2336	2215	1053	751	153	**64824**	**2012**
504	1312	1231	274	1812	2860	984	1713	902	5232	1383	1661	1472	870	419	**42412**	**2013**
352	824	1417	278	1513	3887	938	1570	921	5025	1939	736	1223	1042	483	**42353**	**2014**
39	48	194	40	314	304	437	286	109	475	272	0	170	107	20	**6497**	**2015**
2792	7207	4419	872	8465	11063	4278	7150	3104	20642	5930	4612	3918	2770	1075	**299809**	**Total**

															-47%	**2006**
															-65%	**2007**
															-77%	**2008**
															-80%	**2009**
															-81%	**2010**
-79%	-100%	-100%	0%	0%	-100%	0%									**-78%**	**2011**
-55%	-100%	-100%	0%	0%	-41%	-100%	-45%	-100%	-100%	0%	0%	-100%	-100%	-100%	**-73%**	**2012**

NOTE: Crash data for 2011 & 2012 may not be 100% accurate due to reporting issues.


B

City of Columbus

Focus on Safety

Photo Red Light Camera Project

2006 Year End Report

COLUMBUS FOCUS ON SAFETY

DEPARTMENT OF PUBLIC SAFETY

Table of Contents

City of Columbus
Department of Public Safety
50 W. Gay Street, 2nd Floor
Columbus, Ohio 43215-9035
(614) 645-8210 FAX 645-8268

Director
Mitchell J. Brown

Mayor
Michael B. Coleman

A Message from the Safety Director

I am pleased to report that the City of Columbus "Focus on Safety" photo red light camera project has achieved significant success in 2006. From March to December, a total of eight cameras were installed and activated at seven intersections in the City of Columbus (See pg. 5). These intersections were chosen based upon the highest incidences of crashes due to red light running and constructability. As a warning to drivers approaching these intersections, multiple traffic signs were installed to warn drivers as they approach intersections monitored by red light cameras.

The photo red light camera system saves lives by reducing deadly right-angle crashes due to drivers attempting to "beat the light." The success of this system is demonstrated by a dramatic change in driver behavior as shown by an overall reduction of 62% in the running of red lights and a 47% (prorated) decrease in right-angle crashes at the seven intersections.

Red light running has been significantly reduced (See pg. 5). Specifically, when comparing the number of notices issued during the 30-day warning period when the cameras are first activated and the number of notices issued during the last 30-day period, there were over 2,200 fewer citations issued. This represents an overall reduction of 62%. The notices issued at individual intersections during each month of the year are depicted in the enclosed bar graphs (See pgs. 6-9).

Deadly right-angle or "T-bone" crashes have also been significantly reduced (See pg. 10). When comparing the average number of crashes per year pre-camera with the prorated crashes per year post-camera, there is an overall reduction of 47%. More importantly, there has not been an increase in rear-end crashes at camera locations (See pg. 14).

.....Division of Fire.....3675 Parsons Avenue.....Columbus, Ohio 43207-4054.....(614) 645-8308.....FAX 645-3040
.....Division of Police.....120 Marconi Boulevard.....Columbus, Ohio 43215-0009.....(614) 645-4545.....FAX 645-4551
.....Division of Support Services....220 Greenlawn Avenue.....Columbus, Ohio 43223-2694.....(614) 645-7710.....FAX 645-4819

As I write this message, I note a recent article in the USA TODAY entitled "Research: Red-light Cameras Work" (See Exhibit E). This article cites two recent studies. One was conducted by the Insurance Institute for Highway Safety and the other by Old Dominion University. Both studies conclude that photo technology dramatically reduces red light running. These multi-year studies underscore the importance of this project and they coincide with the dramatic, positive results we have experienced at our inception.

With respect to payments, the City of Columbus received approximately $141,505 in fines from payment of 6,085 paid notices (See pg. 11). This represents a 64% pay rate. Unpaid notices in default are sent to collections and/or the City Attorney's Office. Lastly, the $141,505 represents .024% of the City's 2006 General Fund of $598,235,219.

With respect to hearings, 134 administrative hearing were requested out of the 13,171 notices issued. The Administrative Law Judge found 108 individuals or 81% to be responsible for the notice and 29 or 19% resulted in dismissal of the notice (See pg. 12).

The most significant challenge of 2006 was proposed legislation by the General Assembly that would have made this lifesaving technology useless. Former Governor Taft, in his last official act, vetoed this ill conceived legislation.

As we move into 2007, we plan to install and activate an additional 12 cameras for a total of 20. The criteria for selecting these intersections are once again based on the highest incidence of crashes due to red light running and constructability. We hope to achieve the same dramatic success with the new intersections as with the ones activated in 2006. Moreover, our Department of Public Safety will continue to work with Department of Public Service to study and improve traffic patterns and make our streets safer.

I would like to thank members of the Columbus Division of Police who have worked for a number of years bringing this project to fruition. I would also like to thank the Department of Public Service, Traffic Engineering, City Attorneys Office, the Auditors Office, and Columbus Public Health for their expertise and assistance in getting this project off the ground. Finally, I would like to thank our vendor, Redflex, whose camera system we utilize without any upfront investment of public dollars on the part of the City of Columbus.

In closing, drive safe and do not try to "beat the light."

Mitchell J. Brown, Director of Public Safety

Camera Locations and Activation Date

Camera Location	Date Activated
4th Street & Mt. Vernon Avenue	March 7, 2006
5th Avenue & 4th Street (eastbound)	March 7, 2006
5th Avenue & 4th Street (westbound)	March 7, 2006
Cleveland Avenue & Spring Street	June 14, 2006
Henderson Road & Gettysburg Road	September 1, 2006
Broad Street & Sylvan Avenue	September 1, 2006
Summit Avenue & Chittenden Avenue	September 30, 2006
Livingston Avenue & Fairwood Avenue	October 18, 2006

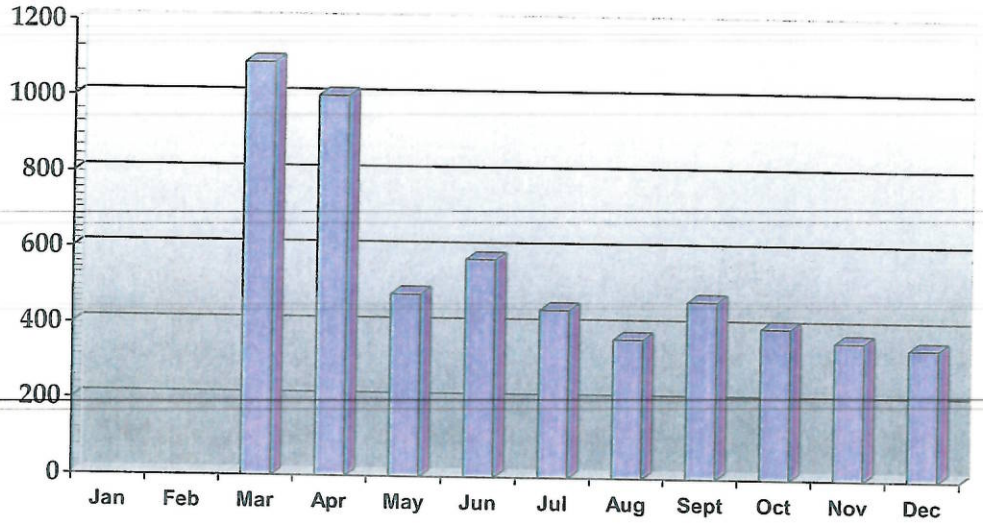
Reduction in Notices Issued

Location	Notices Issued 1st 30 Days	Notices Issued Last 30 Days	Difference	Change
4th Street & Mt. Vernon Avenue	1,370	348	-1,022	-74.5%
5th Avenue & 4th Street (eastbound)	128	66	-62	-48.4%
5th Avenue & 4th Street (westbound)	136	82	-54	-38.8%
Cleveland Avenue & Spring Street	155	103	-52	-33.5%
Henderson Road & Gettysburg Road	676	53	-623	-92.1%
Broad Street & Sylvan Avenue	621	215	-406	-65.3%
Summit Avenue & Chittenden Avenue	189	275	+86	+45.5%
Livingston Avenue & Fairwood Avenue	333	206	-127	-38.1%
Totals	**3,608**	**1,348**	**-2,260**	**-62.6%**

Notices Issued at Individual Intersections

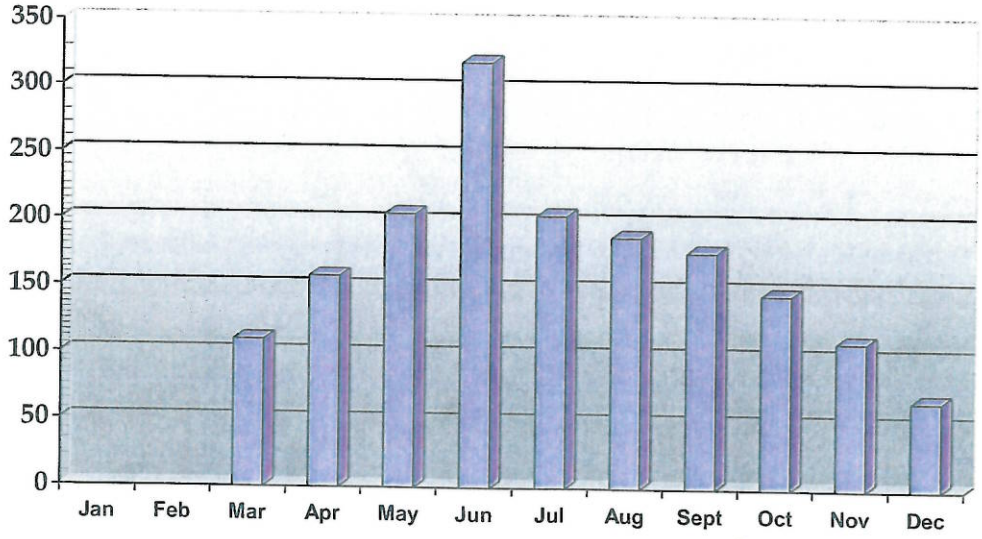
4th Street & Mt. Vernon Avenue

Activated March 7, 2006



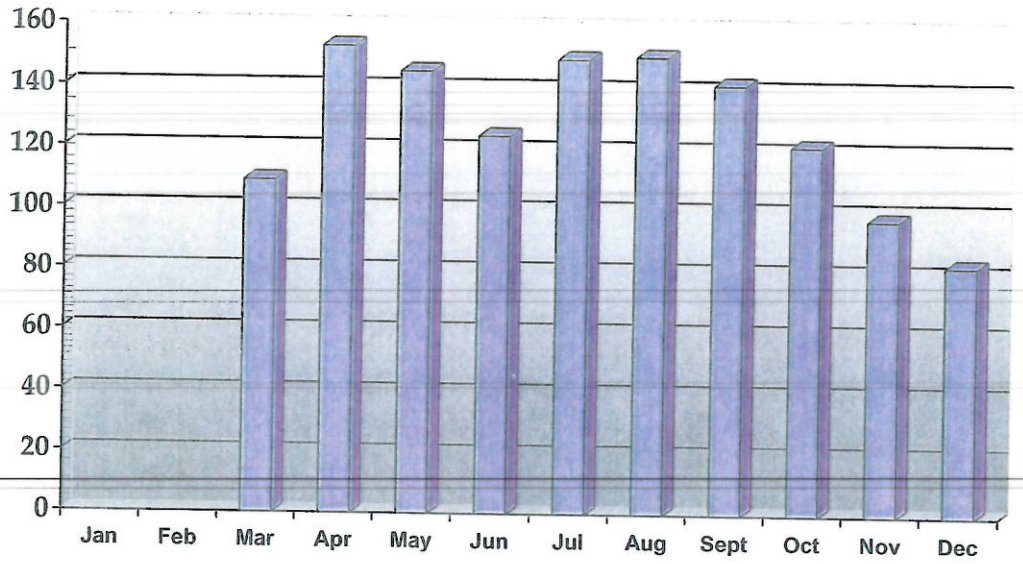
5th Avenue & 4th Street - E/B

Activated March 7, 2006



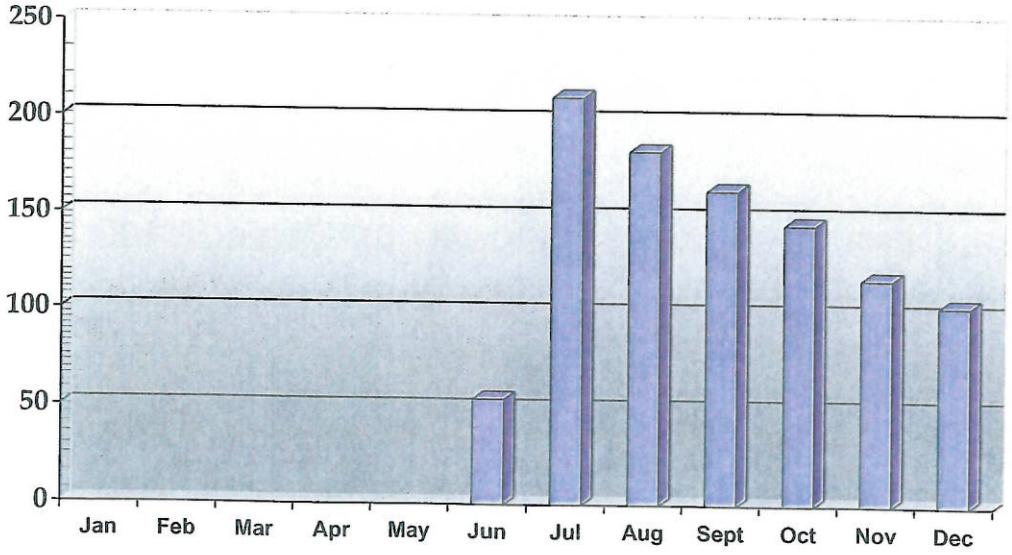
5th Avenue & 4th Street - W/B

Activated March 7, 2006



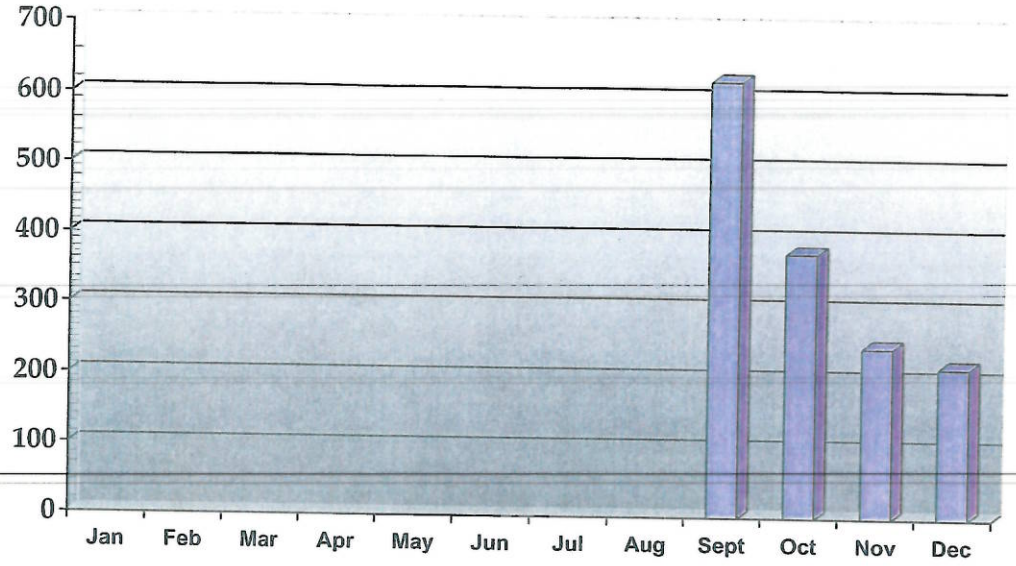
Cleveland Avenue & Spring Street

Activated June 14, 2006



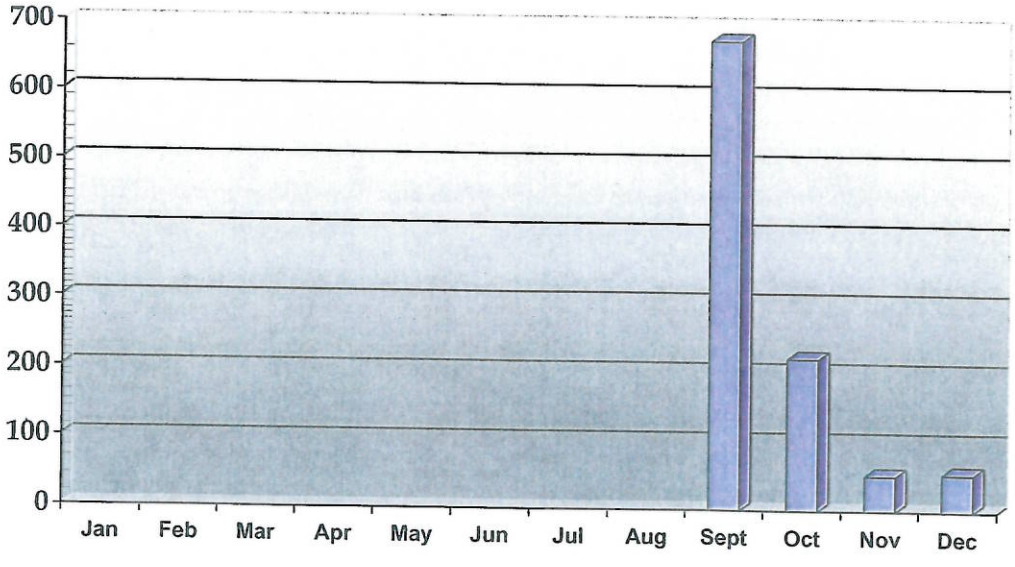
Broad Street & Sylvan Avenue

Activated September 1, 2006



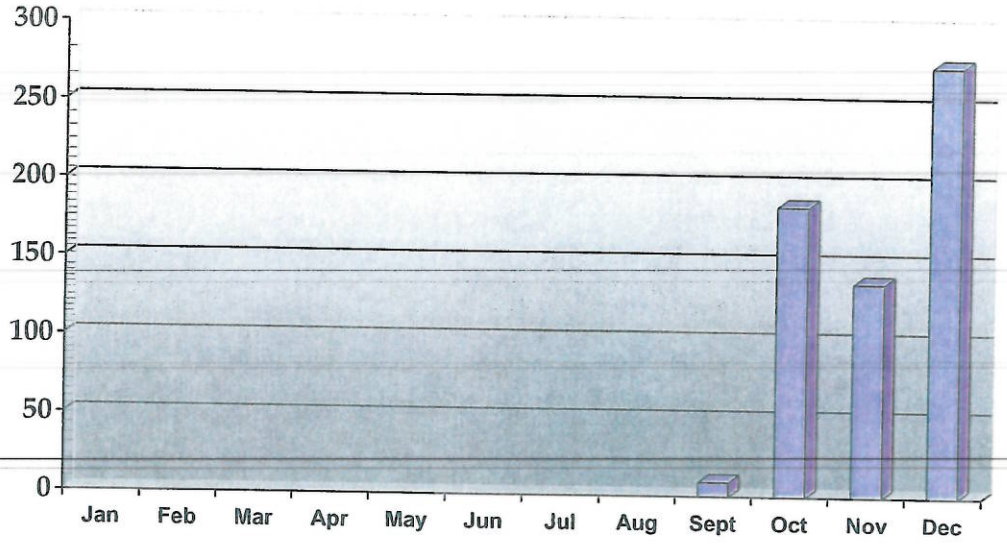
Henderson Road & Gettysburg Road

Activated September 1, 2006



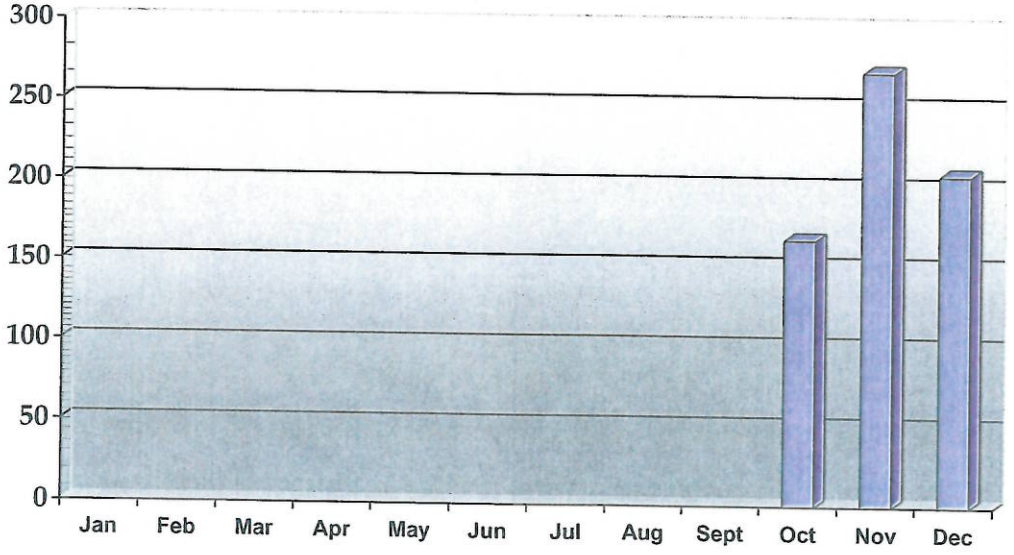
Summit Avenue & Chittenden Avenue

Activated September 30, 2006



Livingston Avenue & Fairwood Avenue

Activated October 18, 2006



Pre and Post-Camera Installation Vehicle Crash Data

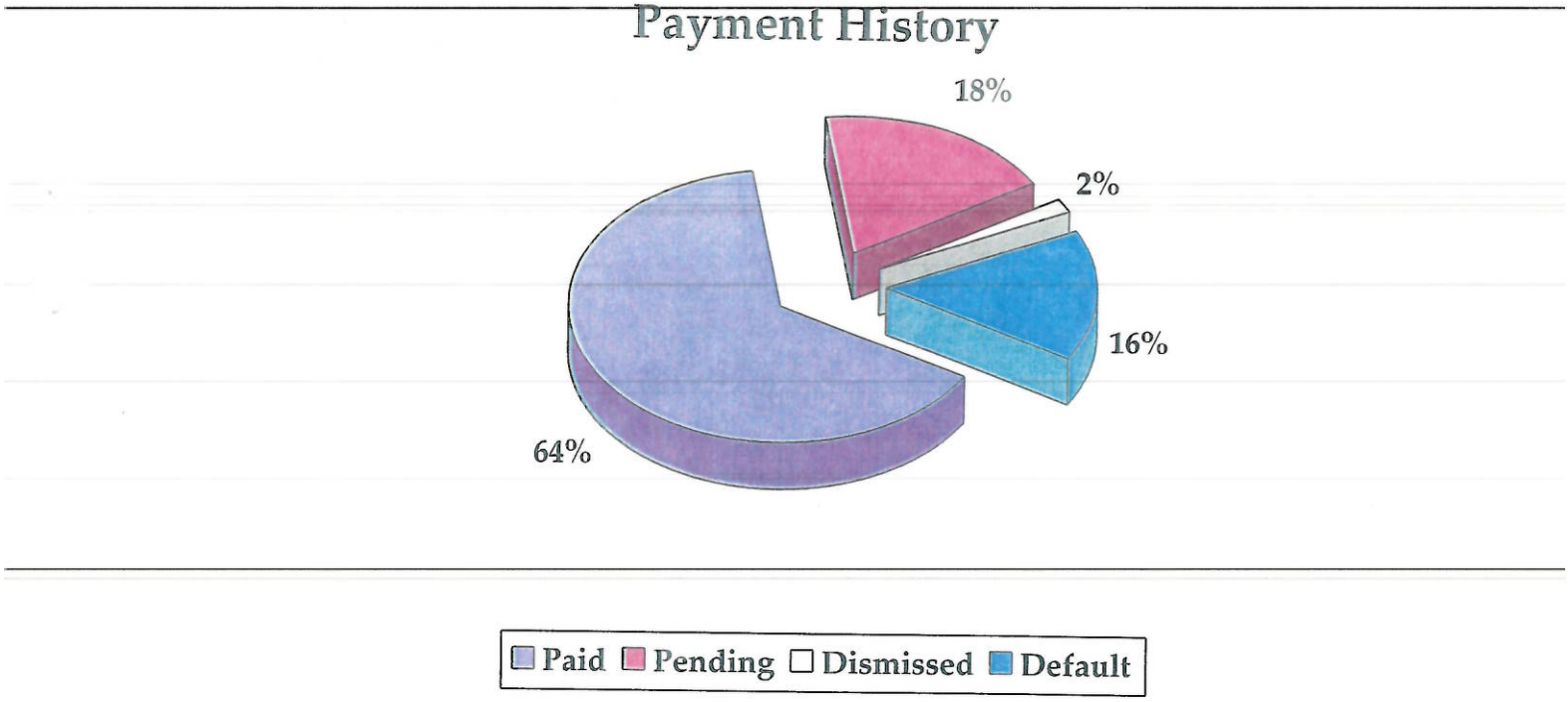
Location	Average Crashes Per Year Pre-Camera*	Actual Number of Crashes Post-Camera	Prorated Crashes Per Year Post-Camera**	Difference	Change
4th Street & Mt. Vernon Northbound	8	2	2	-6	-71%
5th Avenue & 4th Street East and West Bound	8	1	1	-7	-91%
Cleveland & Spring Southbound	7	3	5	-2	-40%
Henderson & Gettysburg Eastbound	4	1	4	0	No Change
Broad & Sylvan Eastbound	4	1	4	0	No Change
Summit & Chittenden Southbound	4	1	4	0	No Change
Livingston & Fairwood Eastbound	3	0	0	-3	-100%
Totals	**38**	**9**	**20**	**-18**	**-47%**

* To determine the average of crashes per year during the pre-camera period, the total number of crashes - divided by number of months - times 12 (example - 24 crashes with a 35 month period) 24/35=0.685x12 = 8.2 or 8 crashes a year.

** To determine the average of crashes per year after the installation of cameras. The total number of crashes - divided by number of months of operation – times 12 (example - 2 crashes for a 10 month period) 2/10=0.2 x 12 = 2.4 or 2 crashes a year.

Collision reduction

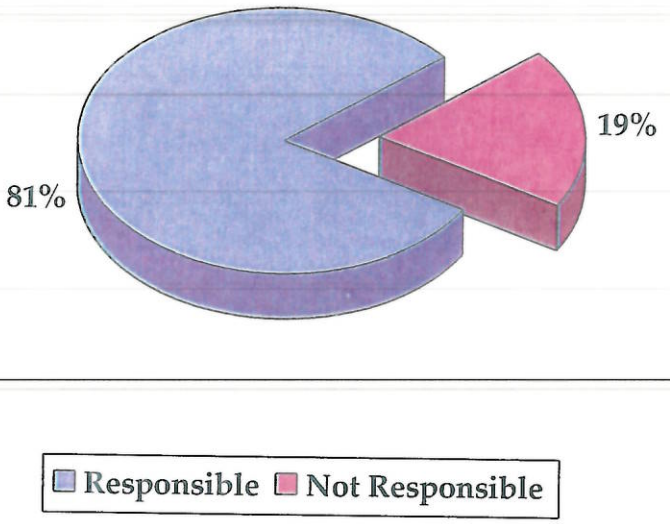
- A review of the 38-48 month period prior to the installation of red light cameras indicated that the eight (8) monitored approaches had on average a total of 38 right-angle or red light violation crashes per year.
- The 3-10 month period after the installation of the red light cameras indicated that the eight (8) monitored approached had a yearly average total of 20 red light violation crashes.
- This represents a reduction of 47% in crashes involving red light running at the monitored approaches.
- Any fear of an increase in rear-end crashes at camera locations has been disproved.



Payment History

- In 2006, the City of Columbus received over $141,505.00 in fines from payment of 6,085 paid Notices of Liability. This represents approximately a 64% pay rate. However, there are 1,749 pending notices and 1,473 Notice recipients who have failed to pay the fine.
- Currently, the City of Columbus and Redflex Traffic Systems is working with Capital Recovery Systems for the collections of default notices which exceed 91 days of delinquency.

Administrative Hearing Disposition



Hearing Disposition

- Between May and December the City of Columbus received 134 administrative hearing requests.
- The City of Columbus conducted 18 sessions of Administrative Hearings.
- Out of the 134 individuals that requested a hearing, 108 individuals were found to be responsible.
- Currently, only 29 individuals have been found not responsible for their notice.

"Focus on Safety"
2006 Notice Disposition

- Notices Printed 13,127
    - Warning Letters 3,672
    - Notices Issued 9,455
- Notices Paid in Full 6,085
- Pending Notices 1,749
    - Unpaid Notices 737
    - Rejected Payments 12
    - Re-issued/Nominations 493
    - No Forwarding Address 507
- Dismissed Notices 148
- In Default 1,473

Right-Angle Crashes

	Direction Captured	Active Date 2006	Pre-Camera Activation 2003	Pre-Camera Activation 2004	Pre-Camera Activation 2005-2006	Average Crashes Per Year 2003-2006	Post-Camera Activation 2006
4th Street & Mt Vernon Avenue	N/B	March-06	9	12	5	8	2
5th Avenue & 4th Street	E/B & W/B	March-06	11	8	7	8	1
Cleveland Avenue & Spring Street	S/B	June-06	15	11	1	7	3
Henderson Road & Gettysburg Road	E/B	September-06	6	7	3	4	1
Broad Street & Sylvan Avenue	E/B	September-06	5	7	5	4	1
Summit Avenue & Chittenden Avenue	S/B	September-06	8	2	7	4	1
Livingston Avenue & Fairwood Avenue	E/B	October-06	3	4	7	3	0
Total Crashes			**57**	**51**	**35**	**38**	**9**

Rear-End Crashes

	Direction Captured	Active Date 2006	Pre-Camera Activation 2003	Pre-Camera Activation 2004	Pre-Camera Activation 2005-2006	Post-Camera Activation 2006
4th Street & Mt Vernon Avenue	N/B	March-06	8	7	10	3
5th Avenue & 4th Street	E/B & W/B	March-06	2	1	5	3
Cleveland Avenue & Spring Street	S/B	June-06	1	0	0	0
Henderson Road & Gettysburg Road	E/B	September-06	1	0	2	0
Broad Street & Sylvan Avenue	E/B	September-06	0	0	1	0
Summit Avenue & Chittenden Avenue	S/B	September-06	1	1	2	0
Livingston Avenue & Fairwood Avenue	E/B	October-06	2	1	1	0
Total Crashes			**15**	**10**	**21**	**6**

Customer Management Report (Columbus) All Detection Types

07-Mar-2006 to 31-Dec-2006 Operator Id: %

		4th & Mt. Vernon	5th & 4th E/B	5th & 4th W/B	Broad & Sylvan	Cleveland & Spring	Henderson & Gettysburg	Livingston & Fairwood	Summit & Chittenden	Total
Total Violations		7,110	2,211	1,885	1,937	2,052	1,434	1,040	968	**18,637**
Less Uncontrollable Factors										
Obstruction	Plate Obstruction	214	53	27	52	23	24	19	35	**447**
	Signal Obstruction	0	0	1	0	0	1	0	0	**2**
	Vehicle Obstruction	53	4	5	13	6	3	2	19	**105**
Police Rejects	Citation Issued Manually	2	1	1	2	1	0	0	1	**8**
	DMV – Not on File	47	7	2	0	0	0	0	0	**56**
	DMV Mismatch	14	2	2	0	0	0	0	0	**18**
	Emergency Vehicle (PD)	86	86	22	16	106	11	21	64	**412**
	Incorrect/Incomplete DMV	68	17	10	12	9	5	6	6	**133**
	Invalid Offence	1	0	0	0	0	0	0	1	**2**
	Multiple vehicles in frame	30	1	0	8	0	3	3	3	**48**
	Plate Unidentifiable	2	0	1	1	1	2	0	0	**7**
	Plate lost or stolen	0	1	0	0	0	0	0	0	**1**
	Police Discretion	437	160	82	213	75	54	94	46	**1161**
	Safe Turn on Red	0	0	278	16	682	75	220	83	**1354**
	Weather Conditions	1	3	1	3	1	0	3	0	**12**
Policy/Weather	Extended Vehicle	81	13	16	5	12	4	6	2	**139**
	Sun Glare	8	5	2	15	1	6	0	3	**40**
	Weather/Nature	1	0	0	1	0	3	0	6	**11**
	Yellow with Red Light	0	0	0	0	0	26	0	0	**26**
Registration Issues	Can Not Identify State	61	8	10	12	5	5	2	3	**106**
	Out of Country Plate	9	2	1	0	0	1	0	0	**13**
	Paper Plates	73	25	27	32	42	23	15	27	**264**
	Wrong or No DMV	93	36	31	19	44	16	5	2	**246**
Total		1,281	424	519	420	1,008	262	396	301	**4,611**
Sub Total Violations		5,829	1,787	1,366	1,517	1,044	1,172	644	667	**14,026**
Less in Progress		0	0	0	0	0	0	0	0	**0**

		4th & Mt. Vernon	5th & 4th 01	5th & 4th 02	Broad & Sylvan	Cleveland & Spring	Henderson & Gettysburg	Livingston & Fairwood	Summit & Chittenden	Total
Available for Prosecution Less Rejects		5,829	1,787	1,366	1,517	1,044	1,172	644	667	**14,026**
Camera Malfunction	Databar Unreadable/Incorrect	0 0%	0 0%	0 0%	1 0%	0 0%	0 0%	0 0%	0 0%	**1 0%**
	Digital Distortion	5 0%	0 0%	1 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**6 0%**
	Face Not in Frame	1 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**1 0%**
	Image Missing	2 0%	0 0%	2 0%	0 0%	1 0%	0 0%	1 0%	0 0%	**6 0%**
	Misc Camera Issue	62 1%	4 0%	2 0%	1 0%	1 0%	1 0%	0 0%	0 0%	**71 1%**
	Plate Burn Out	7 0%	9 1%	10 1%	6 0%	0 0%	7 1%	0 0%	0 0%	**39 0%**
	Plate Not in Frame	43 1%	7 0%	0 0%	1 0%	0 0%	7 1%	0 0%	53 8%	**111 1%**
	Rear Plate Camera Blurry	70 1%	0 0%	9 1%	5 0%	0 0%	8 1%	0 0%	2 0%	**94 1%**
	Rear Plate Flash Inapprop.	2 0%	0 0%	2 0%	1 0%	1 0%	0 0%	0 0%	1 0%	**7 0%**
	Rear Plate No Flash	5 0%	4 0%	14 1%	0 0%	0 0%	0 0%	0 0%	0 0%	**23 0%**
	Scene Image Flash Inapprop.	2 0%	8 0%	2 0%	0 0%	7 1%	0 0%	0 0%	0 0%	**19 0%**
	Scene Image No Flash	9 0%	42 2%	37 3%	8 1%	48 5%	6 1%	0 0%	0 0%	**150 1%**
Police Rejects	Equipment Malfunction	2 0%	1 0%	1 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**4 0%**
	Incorrect Speed	2 0%	1 0%	0 0%	1 0%	0 0%	0 0%	0 0%	1 0%	**5 0%**
	Insufficient Strobe Lighting	8 0%	2 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**10 0%**
	No Images	0 0%	0 0%	0 0%	0 0%	1 0%	1 0%	0 0%	0 0%	**2 0%**
	No Video	1 0%	0 0%	0 0%	0 0%	1 0%	0 0%	0 0%	0 0%	**2 0%**
	Plate Unclear	1 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	**1 0%**
	Red-light not visible in Sun Glare	15 0%	0 0%	1 0%	35 2%	1 0%	140 12%	0 0%	0 0%	**192 1%**
	Unclear Scene Image	0 0%	0 0%	0 0%	0 0%	0 0%	4 0%	0 0%	5 1%	**9 0%**
	Vehicle On/ Passed Stop Line	47 1%	26 1%	13 1%	3 0%	6 1%	2 0%	2 0%	0 0%	**99 1%**
Total		0 0%	1 0%	1 0%	0 0%	1 0%	0 0%	0 0%	0 0%	**3 0%**
Notices Printed		284 5%	105 6%	95 7%	62 4%	68 7%	176 15%	3 0%	62 9%	**855 6%**
		5,545 95%	**1,682 94%**	**1,271 93%**	**1,455 96%**	**976 93%**	**996 85%**	**641 100%**	**605 91%**	**13,171 094%**

Feb. 15, 2007

windows, and the buildings are Please see COVER STORY next page ▶

Research: Red-light cameras work

They're changing behavior, but some see infringement

By Larry Copeland
USA TODAY

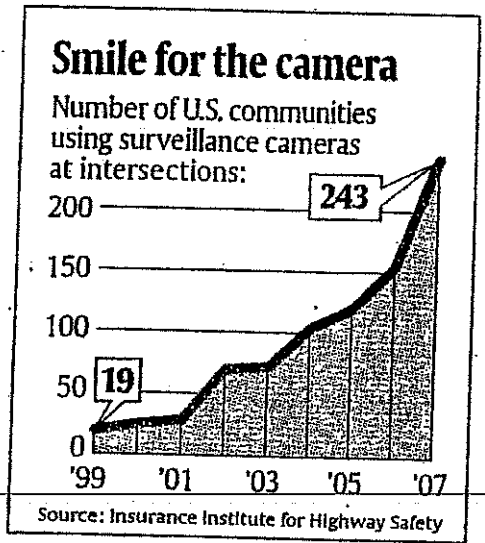
ATLANTA — Surveillance cameras at major intersections dramatically reduce the number of drivers who barrel through red lights, two new research reports say.

The findings come as debate about the controversial devices continues a decade after they were introduced. The battles include a proposal to ban the cameras here in Georgia, litigation in at least three states and legislative efforts to permit them in six other states.

The cameras automatically photograph vehicles that drive into intersections after the light turns red. Vehicle owners are then mailed citations instructing them to pay a fine or sign an affidavit that they weren't driving at the time.

More than 850 people die and and about 170,000 are injured each year in crashes caused by drivers running red lights, the National Highway Traffic Safety Adminstration says.

Researchers studied the effectiveness of red light cameras in Philadelphia and Virginia Beach.



By Adrienne Lewis, USA TODAY

Debate across the USA

Concerns over cameras, 3A

The Philadelphia study, conducted by the Insurance Institute for Highway Safety (IIHS), an industry group, examined red light violations using a two-step approach. First, researchers found that violations dropped by 36% after yellow lights were extended to give drivers more warning that the light was about to turn red. After red light cameras were added, remaining violations dropped by 96%.

"There's a dramatic change in driver behavior when red light cameras are used," says Richard Retting, senior transportation safety engineer for IIHS. "The jury is in on that question."

The Virginia Beach study, conducted by Old Dominion University, examined signal violations at four intersections before red light cameras were installed, while they were operating and after they were removed in 2005. Violations more than tripled by August 2006.

"That's a huge jump," says lead researcher Bryan Porter, an associate professor of psychology at Old Dominion. "The rate of red light running was actually higher" than before the cameras were installed.

The popularity of the cameras is growing rapidly despite oppostion that centers on constitutional grounds. About 250 communities around the USA use the devices, according to the Insurance Institute. Just 10 years ago, only New York and San Francisco had them.

Opponents say the cameras deny drivers their right to confront their accusers in court and are a ploy by local governments to raise revenue.

"There is a lot of money to be made with them," says Howard Bass, a Minnesota attorney who successfully challenged Minneapolis' red-light camera system in a case that will be argued before the state Supreme Court next month. "Ultimately, this is an issue that may have to be decided in the court of public opinion rather than courts of law. It's a public policy issue of how much surveillance creep we will tolerate in the 21st century."

C

Porter, Bryan E., Thomas D. Berry, and Jeff Harlow. "A Nationwide Survey of Red-light Running: Measuring Driver Behaviors for the "Stop Red-light Running" Program." (1999): 1-57. Print.

Preusser, D. F., Leaf, W. A., DeBartolo, K. B., & Blomberg, R. D. (1981). *The Effect of Right-Turn-On-Red on Pedestrian and Bicyclist Accidents* (pp. 1-87, Publication). Darien, CT: U.S. Department of Transportation Federal Highway Administration.

PR Newswire. (2010, July 15). Traffic Safety Coalition Encourages Ohio Drivers to Obey Traffic Safety Laws During Busy... -- COLUMBUS, Ohio, July 15 /PRNewswire/. *PR Newswire: Press Release Distribution, Targeting, Monitoring and Marketing*. Retrieved September 26, 2011, from http://www.prnewswire.com/news-releases/traffic-safety-coalition-encourages-ohio-drivers-to-obey-traffic-safety-laws-during-busy-summer-months-98533589.html

Redflex Traffic Systems Incorporated (2011). SMARTops Online Reports – Redlight Offender Report [Excel File]. Privately available from, https://login.redflex.com/Login.aspx?ReturnUrl=%2fMembers%2fDefault.aspx

Retting, R. A., Chapline, J. F., & Williams, A. F. (March 01, 2002). Changes in crash risk following re-timing of traffic signal change intervals. *Accident Analysis & Prevention, 34,* 2.

Retting, R. A., & Kyrychenko, S. Y. (January 01, 2002). Reductions in injury crashes associated with red-light camera enforcement in Oxnard, California. *American Journal of Public Health, 92,* 11, 1822-5.

Retting, R. A., Persaud, B. N., Garder, P. E., & Lord, D. (January 01, 2001). Crash and injury reduction following installation of roundabouts in the United States. *American Journal of Public Health, 91,* 4, 628-31.

Retting, R. A., Williams, A. F., Farmer, C. M., & Feldman, A. F. (January 01, 1999). Evaluation of red-light camera enforcement in Oxnard, California. *Accident Analysis and Prevention, 31,* 3, 169.

Retting, R. A., Williams, A. F., & Greene, M. A. (January 01, 1998). Red-light running and sensible countermeasures: Summary of research findings. *Transportation Research Record,* 1640.

Rodegerdts, L. A., Kittelson & Associates., & Turner-Fairbank Highway Research Center. (2004). *Signalized intersections: Informational guide*. McLean, Va: Turner-Fairbank Highway Research Center.

Shannon, K. P., Speeding Towards Disaster: How Cleveland's Traffic Cameras Violate the Ohio Constitution, 55 Clev. St. L.Rev. 607, 610 (2007).

Shin, K., & Washington, S. (November 01, 2007). The impact of red-light cameras on safety in Arizona. *Accident Analysis & Prevention, 39,* 6.

StataCorp. 2009. *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.

Tarawneh, T. M., Singh, V. A., & McCoy, P. T. (January 01, 1999). Investigation of effectiveness of media advertising and police enforcement in reducing red-light violations. *Transportation Research Record,* 1693.

Transmap Corporation. "GIS - Downloadable Files." Mid-Ohio Regional Planning Commission (MORPC). Mid-Ohio Regional Planning Commission, 2 Mar. 2009. Web. 28 Oct. 2011. <http://www.morpc.org/info_center/dataport/gis_downloadble.asp>.

United States Department of Transportation - Federal Highway Administration. (n.d.). Red-Light Running Fatalities (2000-2009) - FHWA Safety Program. *Home - FHWA Safety Program*. Retrieved September 26, 2011, from http://safety.fhwa.dot.gov/intersection/redlight/data/rlr_fatal/

United States., & John A. Volpe National Transportation Systems Center (U.S.). (2006). Analysis of red-light violation data collected from intersections equipped with red-light photo enforcement cameras. Washington, D.C: U.S. Dept of Transportation, National Highway Traffic Safety Administration.

United States., & Turner-Fairbank Highway Research Center. (2004). *A Review of the signalized intersections: Informational guide*. McLean, VA: Federal Highway Administration.

U.S. Census Bureau. "American FactFinder." *American FactFinder*. U.S. Census Bureau. Web. 15 Nov. 2011. <http://factfinder.census.gov/servlet/DTTable?_bm=y>.

USDA FSA APFO. "The Geospatial Data Gateway." USDA:NRCS:Geospatial Data Gateway:Home. USDA Natural Resources Conservation Service, 11 Aug. 2004. Web. 23 Nov. 2011. <http://datagateway.nrcs.usda.gov/GDGHome.aspx>.

Vitale, Robert. "City Wants to Add Red-light Cameras in Outlying Areas | Columbus Dispatch Politics." Ohio Political News & Opinion | Columbus Dispatch Politics. 7 Dec. 2010. Web. 06 Mar. 2011. <http://www.dispatchpolitics.com/live/content/local_news/stories/2010/12/07/copy/red-alert.html?sid=101>.

Vitale, Robert. "Red-light Cameras Monitor Turns, Too | Columbus Dispatch Politics." Ohio Political News & Opinion | Columbus Dispatch Politics. 13 Dec. 2010. Web. 06 Mar. 2011. <http://www.dispatchpolitics.com/live/content/local_news/stories/2010/12/13/copy/red-light-cameras-monitor-turns-too.html?sid=101>.

Wissinger, L. M., Hummer, J. E., & Milazzo, J. S. (2000). USING FOCUS GROUPS TO INVESTIGATE ISSUES OF RED-LIGHT RUNNING. *Transportation Research Record, 1734*, 8-9.

Yan, X., Richards, S., Radwan, E., & Guo, D. (January 01, 2009). Impact of "Signal Ahead" pavement marking on driver behavior at signalized intersections. *Transportation Research Part F: Traffic Psychology and Behaviour, 12,* 1, 50-67.

Zador, P. L. (August 01, 1984). Right-turn-on-red laws and motor vehicle crashes: A review of the literature. *Accident Analysis & Prevention, 16,* 4, 241-245.

CITY OF COLUMBUS

"FOCUS ON SAFETY"

PHOTO RED LIGHT CAMERA PROJECT

2008 YEAR END REPORT

TABLE OF CONTENTS

City of Columbus
Department of Public Safety
50 W. Gay Street, 2nd Floor
Columbus, Ohio 43215-9035
(614) 645-8210 FAX 645-8268

Director
Mitchell J. Brown

Mayor
Michael B. Coleman

Message From The Director

I am pleased to report for the third consecutive year, that our City of Columbus "Focus on Safety" photo-red-light enforcement project continues to prove to be outstandingly effective. Twenty cameras are installed at eighteen high-risk intersections. Intersections were chosen based primarily upon the highest incidences of severe right-angle crashes. In some cases, constructability issues forced the selection of sites lower on that list of high-risk locations identified.

The photo red light camera system saves lives by reducing deadly right-angle crashes due to drivers attempting to "beat the light." The success of this system is demonstrated by a dramatic change in driver behavior as shown by an average overall annual reduction from 68 to 16 crashes at the camera protected intersections which is tantamount to a 76.3 percent reduction of right-angle crashes. For example, the intersections of South Third Street and East Main Street had 18 right-angle crashes from 2002 to 2007 and had no (zero) crashes post camera installation (see page 26). Moreover, there has not been an increase in rear-end crashes known as Assured Clear Distance Accidents (ACDA) at these camera locations. In fact, there were 21 ACDA crashes at these intersections in 2008 compared to a combined annual ACDA crash rate of 27.4 prior to camera installation (See page 27).

The reduction of Notices of Liability sent out in December of 2008 compared to the number in the first month of operations for each intersection demonstrates that there is a significant decrease in the number of red light violations. Comparing the number of notices issued during the 30-day warning period when the cameras are first activated versus the number of notices issued during December 2008, there were 3900 fewer Notices of Liability than warning letters. This represents an overall reduction of 58.9 percent.

The City of Columbus received approximately $820,041.00 from the payment of fines associated with Notices of Liability. (See page 22). These funds were used to subsidize various Public Safety Initiatives such as the purchase of police cruisers and our Police Strike Force Initiative.

.....Division of Fire.....3675 Parsons Avenue.....Columbus, Ohio 43207-4054.....(614) 645-8308.....FAX 645-3040
.....Division of Police.....120 Marconi Boulevard.....Columbus, Ohio 43215-0009.....(614) 645-4545.....FAX 645-4551
..... Division of Support Services....220 Greenlawn Avenue.....Columbus, Ohio 43223-2694.....(614) 645-7710.....FAX 645-4819

With respect to appeals, 507 administrative hearings were requested out of the 38,182 notices issued – fewer than 1.5 percent. The Administrative Law Judges found 436 individuals or 86 percent of those people requesting hearings to be responsible for the violation. The appeals hearings resulted in 71 dismissals of liability or 14 percent.

These dismissals do not imply errors on the part of the system. Rather, the Hearing Officers take into consideration mitigating or extenuating circumstances not observable in the photographs and videos of the violations. (See page 23).

I would be remiss if I did not thank our vendor, Redflex Traffic Systems, whose camera system we utilize without any upfront investment of public dollars on the part of the City of Columbus.

In closing, drive safely and do not try to "beat the light."

M. J. Brown

Mitchell J. Brown, Director of Public Safety

CITY OF COLUMBUS
"FOCUS ON SAFETY"

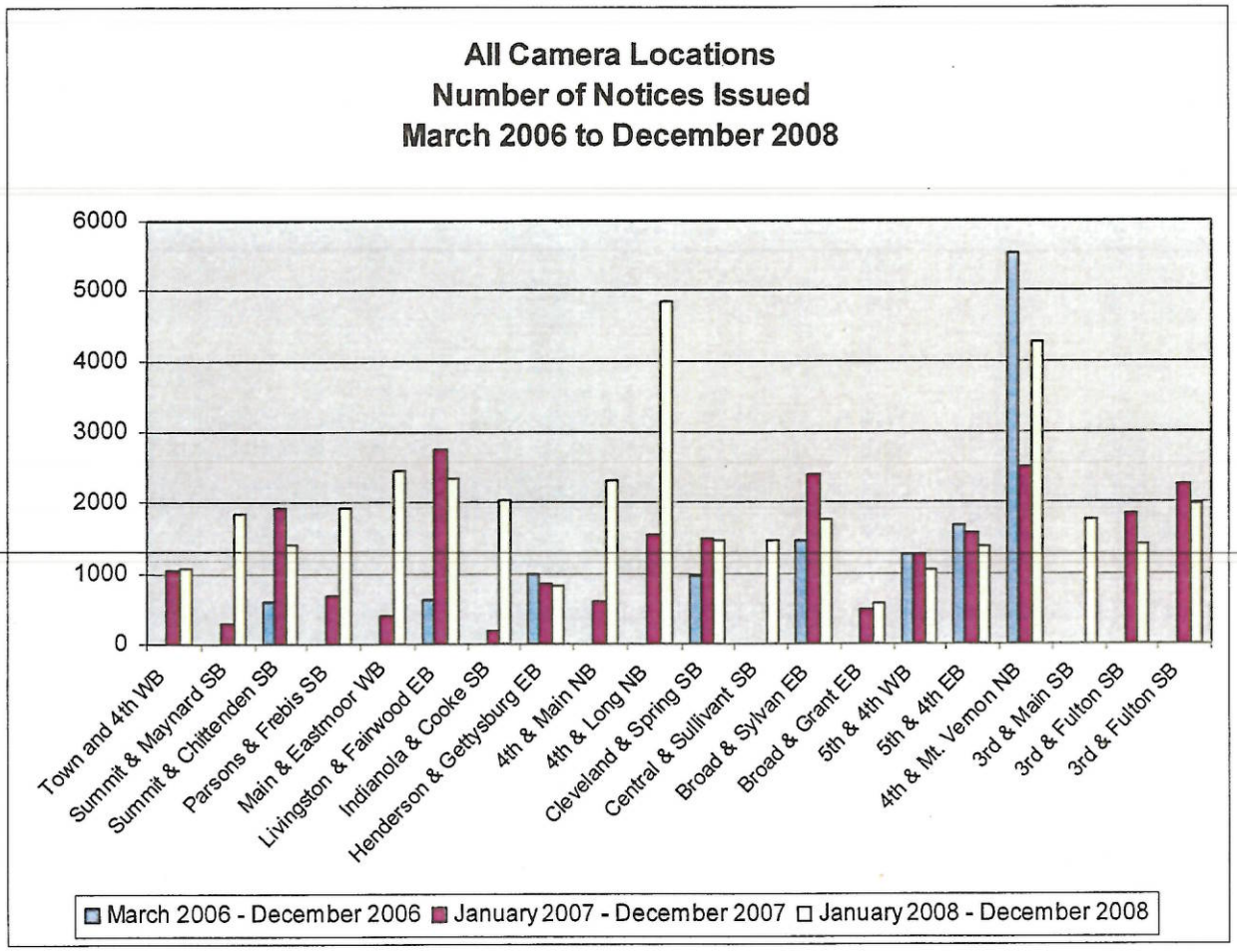
We have equipped 18 high risk intersections with 20 cameras.

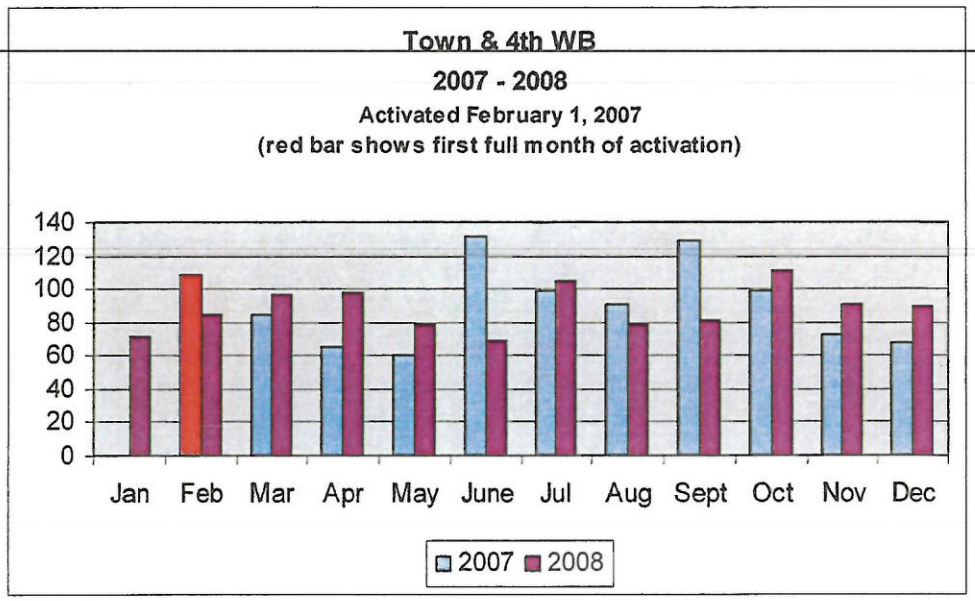
Location	Date Activated
4th Street & Mt. Vernon Ave. (NB)	March 7, 2006
5th Avenue & 4th Street (WB)	March 7, 2006
5th Avenue & 4th Street (EB)	March 8, 2006
Cleveland Ave & Spring Street (SB)	June 14, 2006
Henderson Road & Gettysburg Road (EB)	September 1, 2006
Broad Street & Sylvan Avenue (EB)	September 1, 2006
Summit Street & Chittenden Avenue (SB)	September 30, 2006
Livingston Avenue & Fairwood Avenue (EB)	October 18, 2006
Town Street & 4th Street (WB)	February 1, 2007
3rd Street & Fulton Street 01 (SB)	February 1, 2007
3rd Street & Fulton Street 02 (SB)	February 1, 2007
Broad Street & Grant Avenue (EB)	February 27, 2007
4th Street & Main Street (NB)	October 4, 2007
Parsons Ave. & Frebis Avenue (NB)	October 4, 2007
4th Street & Long Street (NB)	October 8, 2007
Main Street & Eastmoor Avenue (WB)	November 1, 2007
Summit Street & Maynard Avenue (SB)	November 1, 2007
Indianola & Cooke/Overbrook (SB)	November 21, 2007
Central Avenue& Sullivant Avenue (SB)	December 31, 2007
3rd Street & Main Street (SB)	December 31, 2007

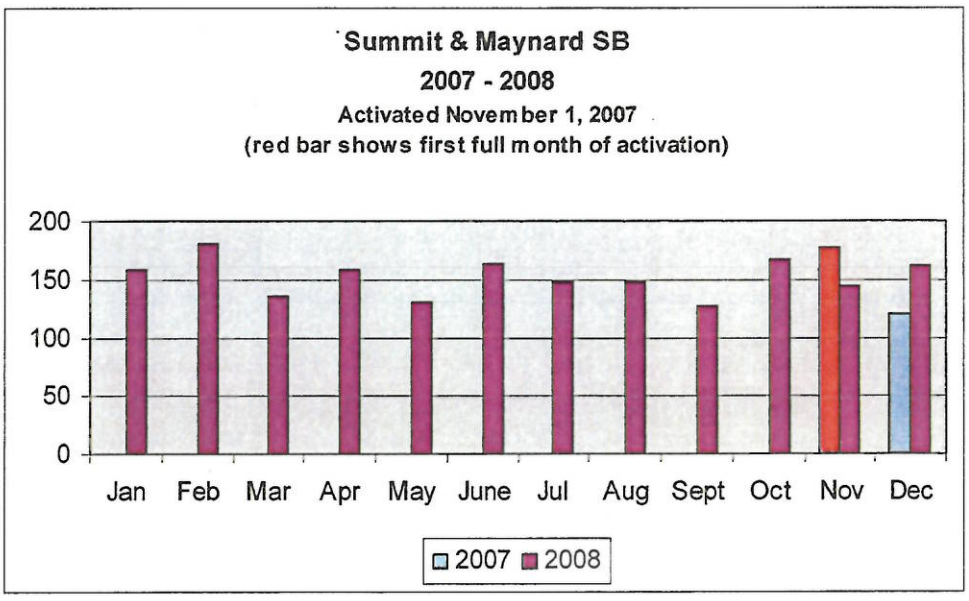
Red light running has been significantly reduced (See page 6). Specifically, when comparing the number of notices issued during the 30-day warning period when the cameras are first activated versus the number of notices issued during the last 30-days of December, there were over 3,900 fewer citations issued. This represents an overall reduction of 58.9 percent. Likewise, reductions increase over time as demonstrated by the 27 percent decrease in citations when comparing the 4th quarter of 2007 with the 4th quarter of 2008. The notices issued at individual intersections during each month of the project are depicted in the enclosed bar graphs (See pages 7-17).

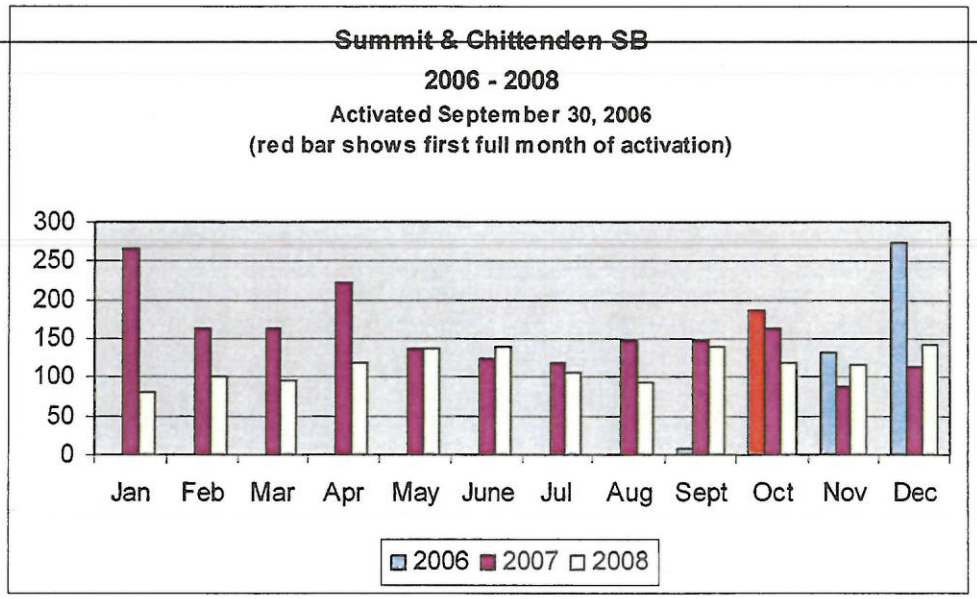
Reduction In Notices Issued

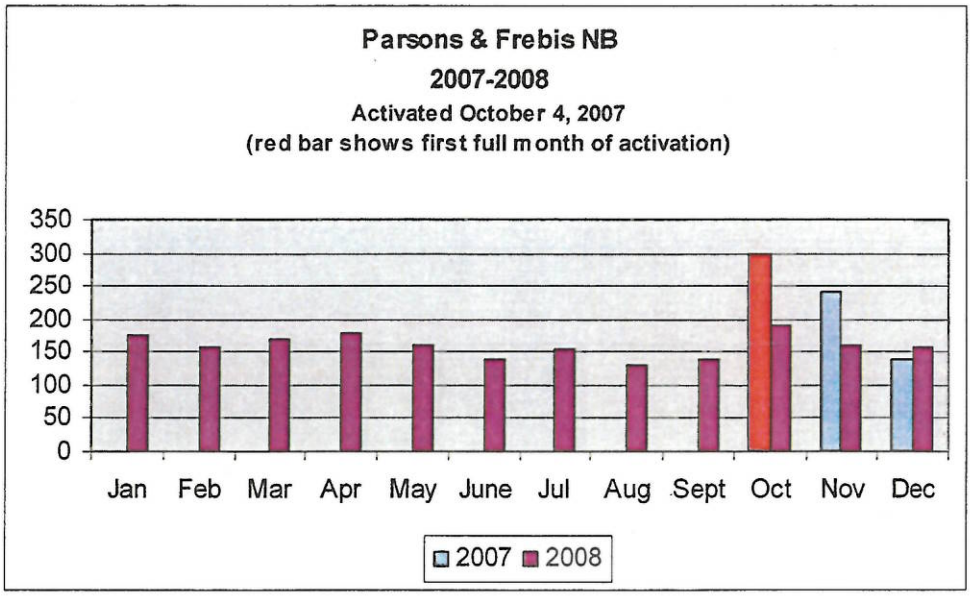
LOCATION	Activation Date	Notices Issued 1st 30 days	Notices Issued Last 30 Days December 08	Difference	Change
Town Street & 4th Street (WB)	2/1/2007	124	89	-35	-28.2%
Summit Street & Maynard Avenue (SB)	11/1/2007	168	162	-6	-3.6%
Summit Street & Chittenden Avenue (SB)	9/30/2006	189	141	-48	-25.4%
Parsons Avenue & Frebis Avenue (NB)	10/4/2007	331	156	-175	-52.9%
Main Street & Eastmoor Avenue (WB)	11/1/2007	266	169	-97	-36.5%
Livingston Avenue & Fairwood Avenue (EB)	10/18/2006	333	146	-187	-56.2%
Indianola Avenue & Cooke/Overbrook (SB)	11/21/2007	202	137	-65	-32.2%
Henderson Road & Gettysburg Road (EB)	9/1/2006	676	39	-637	-94.2%
4th Street & Main Street (NB)	10/4/2007	320	143	-177	-55.3%
4th Street & Long Street (NB)	10/8/2007	848	354	-494	-58.3%
Cleveland Avenue & Spring Street (SB)	6/14/2006	155	103	-52	-33.5%
Central Avenue & Sullivant Avenue (SB)	12/31/2007	111	133	22	19.8%
Broad Street & Sylvan Avenue (EB)	9/1/2006	621	59	-562	-90.5%
Broad Street & Grant Avenue (EB)	2/27/2007	30	89	59	196.7%
5th Avenue & 4th Street (WB)	3/7/2006	128	79	-49	-38.3%
5th Avenue & 4th Street (EB)	3/8/2006	136	71	-65	-47.8%
4th Street & Mt. Vernon Avenue (NB)	3/7/2006	1370	327	-1043	-76.1%
3rd Street & Main Street (SB)	12/31/2007	85	107	22	25.9%
3rd Street & Fulton Street - 01 (SB)	2/1/2007	253	73	-180	-71.1%
3rd Street & Fulton Street - 02 (SB)	2/1/2007	277	146	-131	-47.3%
TOTALS		6623	2723	-3900	-58.9%

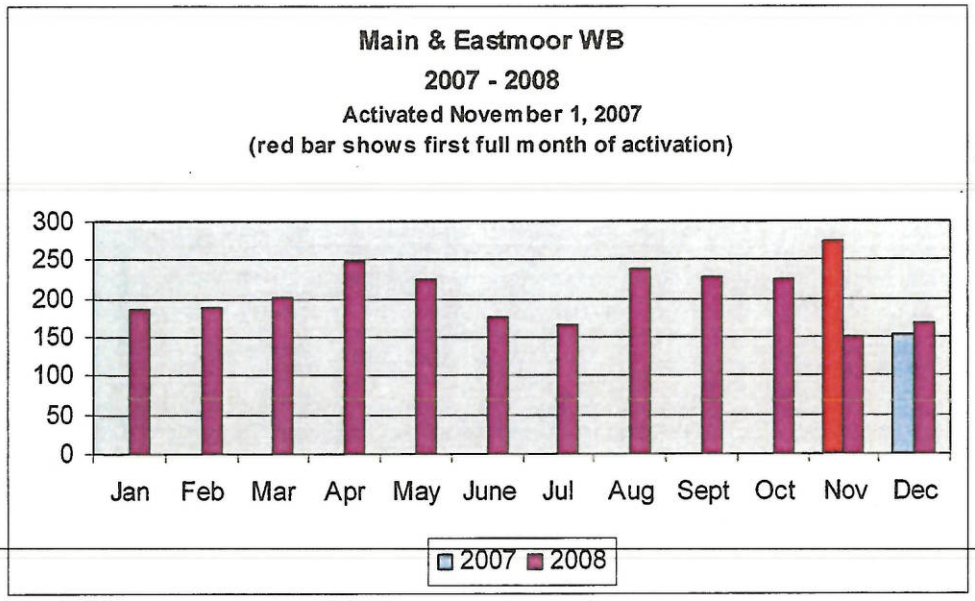

All Camera Locations
Number of Notices Issued
March 2006 to December 2008
6000
5000
4000
3000
2000
1000
0
Town and 4th WB
Summit & Maynard SB
Summit & Chittenden SB
Parsons & Frebis SB
Main & Eastmoor WB
Livingston & Fairwood EB
Indianola & Cooke SB
Henderson & Gettysburg EB
4th & Main NB
4th & Long NB
Cleveland & Spring SB
Central & Sullivant SB
Broad & Sylvan EB
Broad & Grant EB
5th & 4th WB
5th & 4th EB
4th & Mt. Vernon NB
3rd & Main SB
3rd & Fulton SB
3rd & Fulton SB
March 2006 - December 2006
January 2007 - December 2007
January 2008 - December 2008

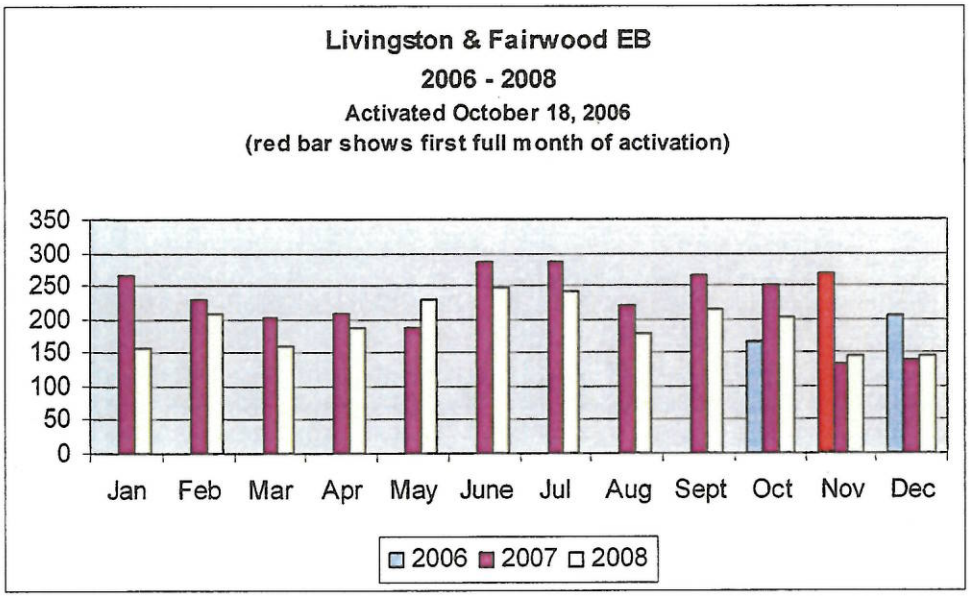

Town & 4th WB
2007 - 2008
Activated February 1, 2007
(red bar shows first full month of activation)
140
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008

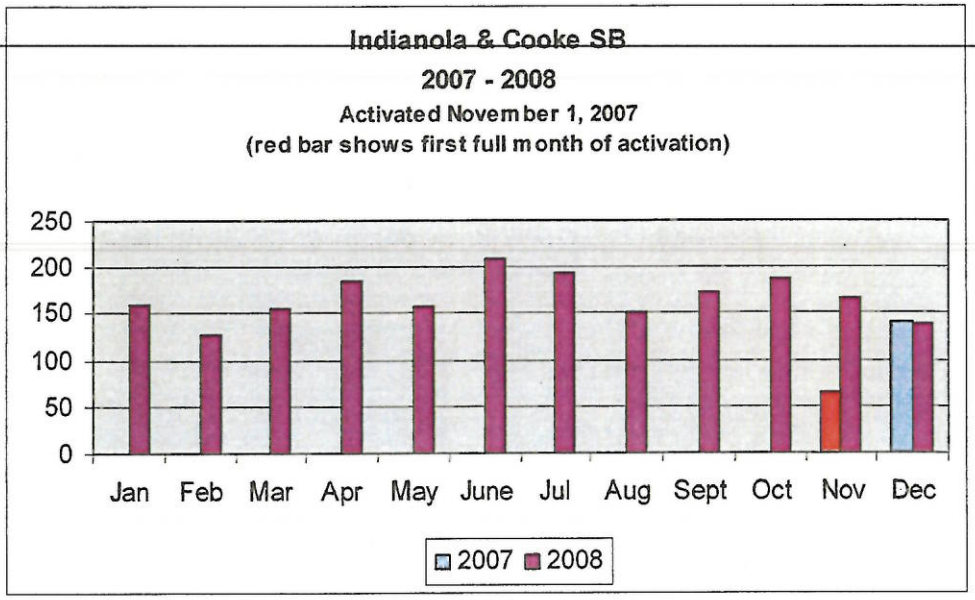

Summit & Maynard SB
2007 - 2008
Activated November 1, 2007
(red bar shows first full month of activation)
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008

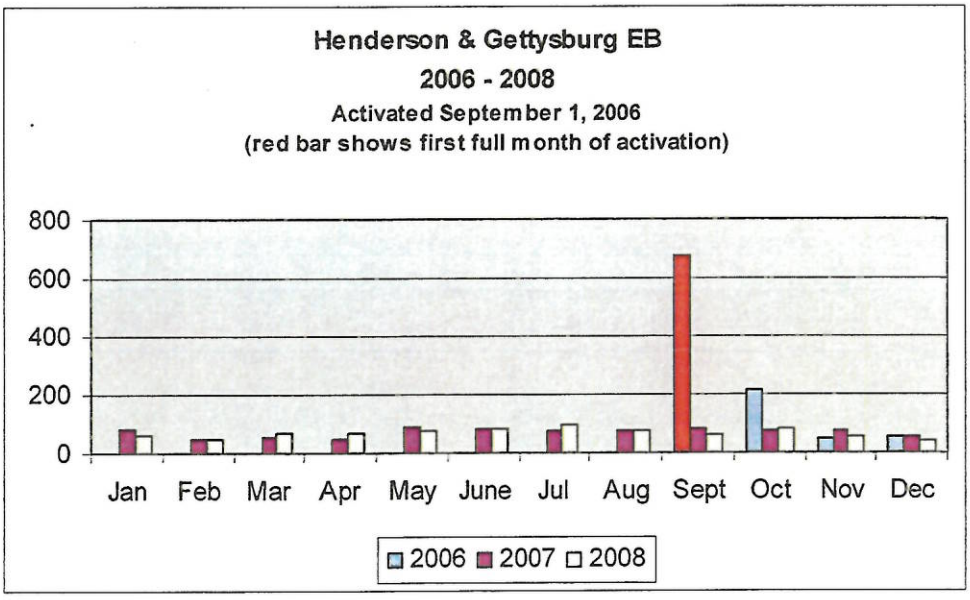

Summit & Chittenden SB
2006 - 2008
Activated September 30, 2006
(red bar shows first full month of activation)
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2006
2007
2008

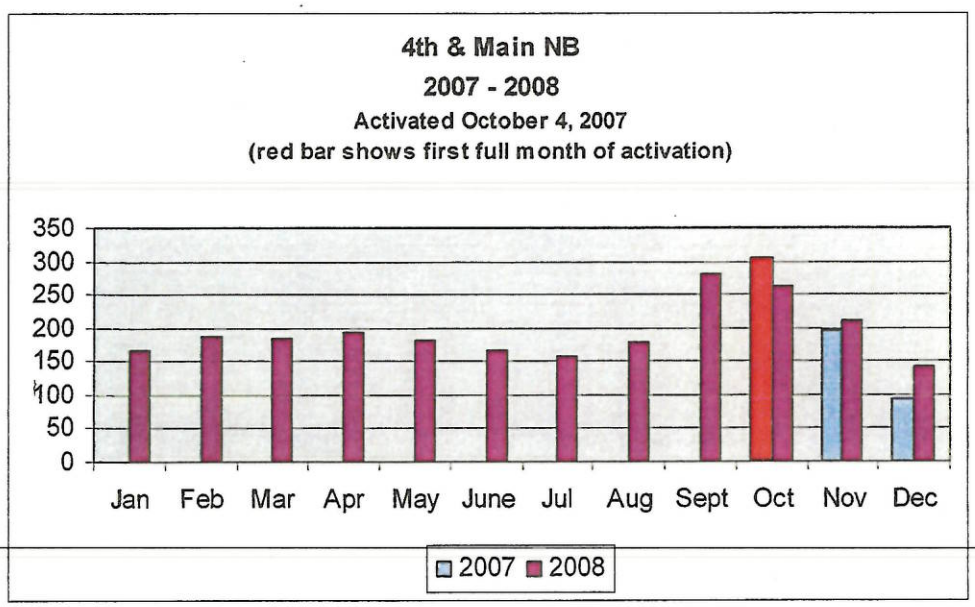

Parsons & Frebis NB
2007-2008
Activated October 4, 2007
(red bar shows first full month of activation)
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008

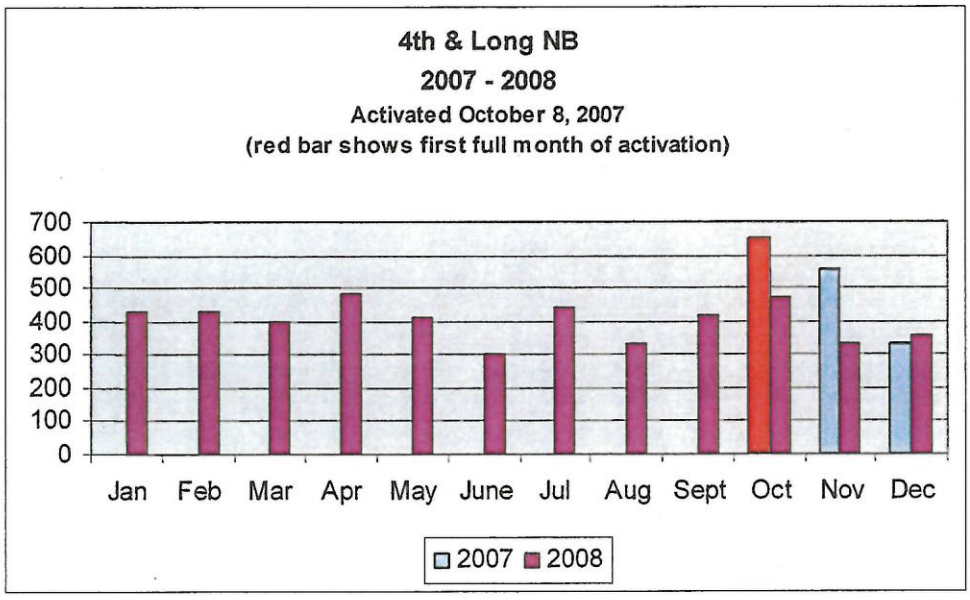

Main & Eastmoor WB
2007 - 2008
Activated November 1, 2007
(red bar shows first full month of activation)
300
250
200
150
100
50
0
Jan Feb Mar Apr May June Jul Aug Sept Oct Nov Dec
2007 2008

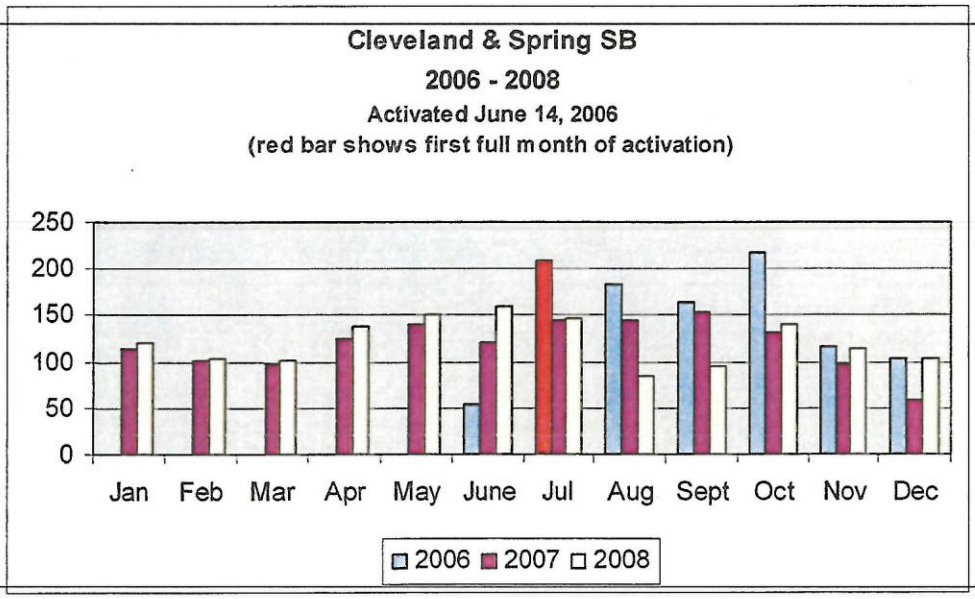

Livingston & Fairwood EB
2006 - 2008
Activated October 18, 2006
(red bar shows first full month of activation)
350
300
250
200
150
100
50
0
Jan Feb Mar Apr May June Jul Aug Sept Oct Nov Dec
2006 2007 2008

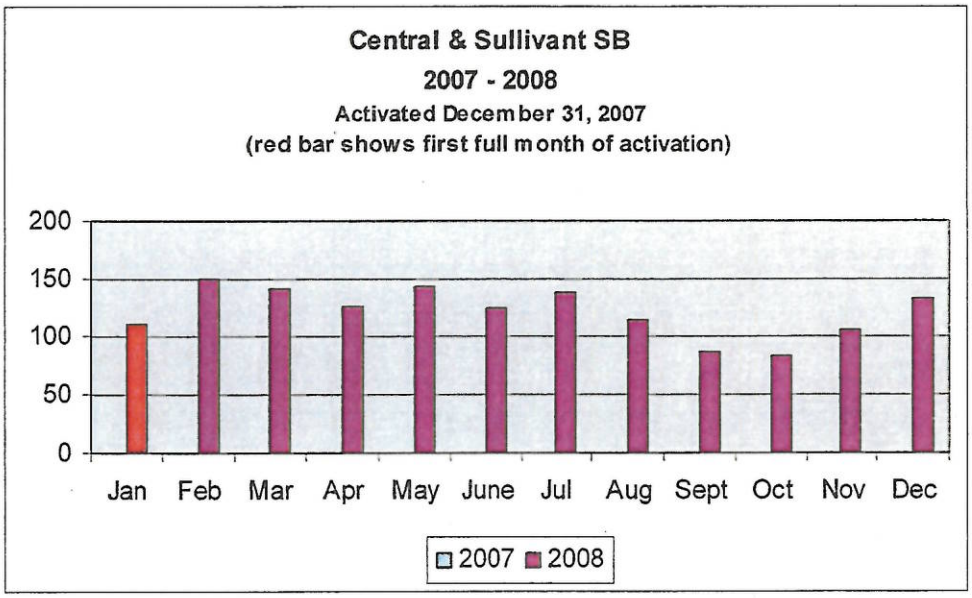

Indianola & Cooke SB
2007 - 2008
Activated November 1, 2007
(red bar shows first full month of activation)
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008

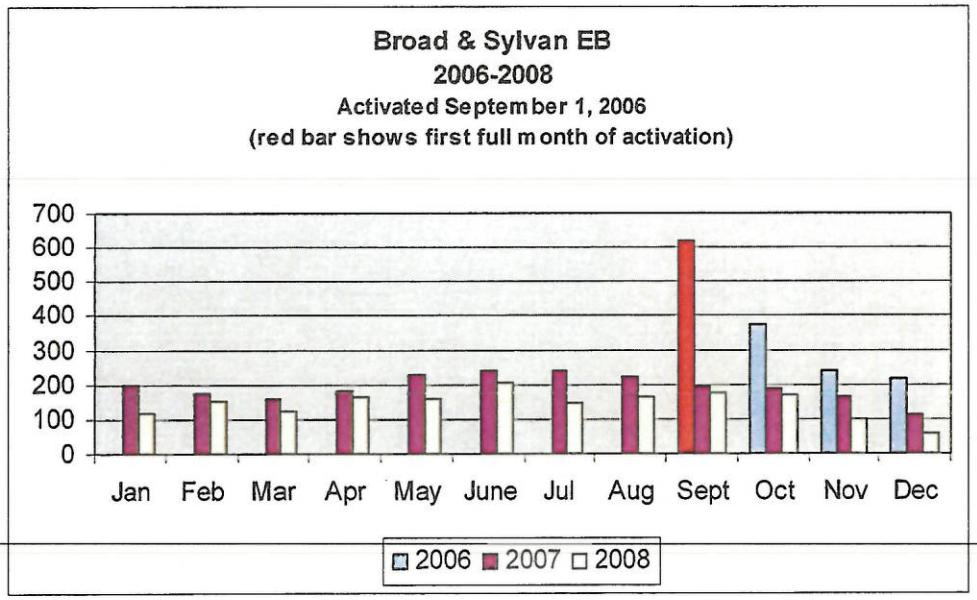

Henderson & Gettysburg EB
2006 - 2008
Activated September 1, 2006
(red bar shows first full month of activation)
800
600
400
200
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2006
2007
2008

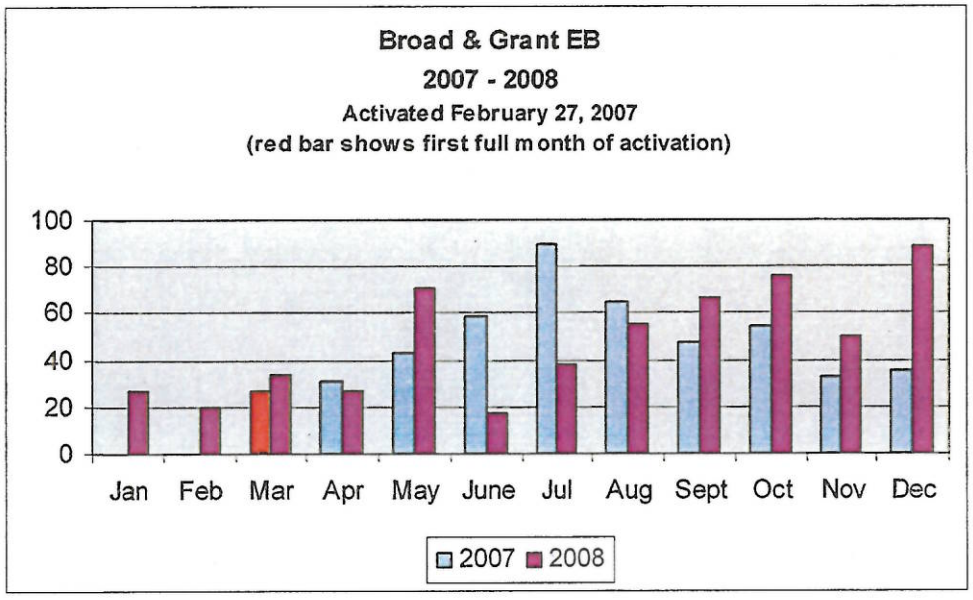

4th & Main NB
2007 - 2008
Activated October 4, 2007
(red bar shows first full month of activation)
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008

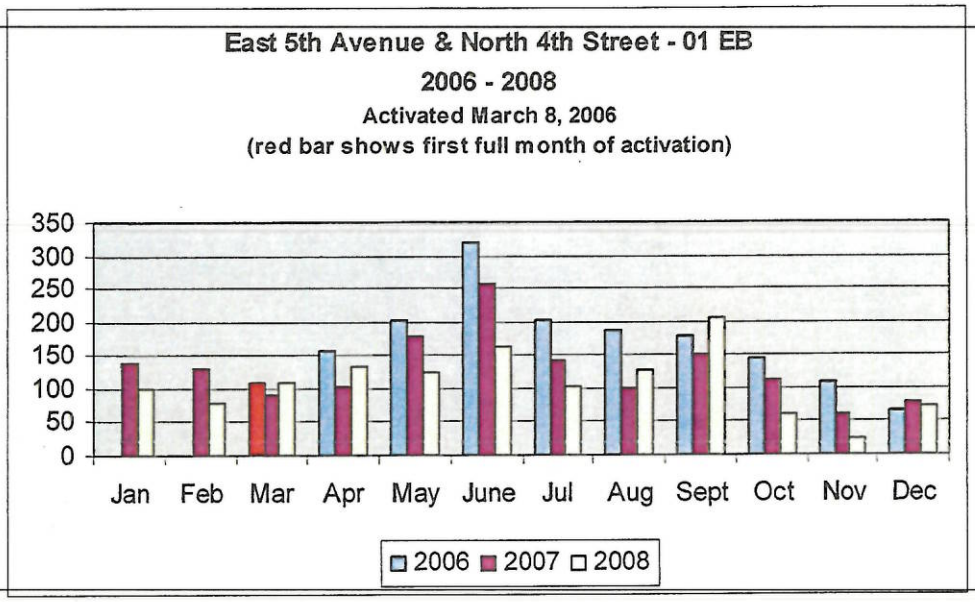

4th & Long NB
2007 - 2008
Activated October 8, 2007
(red bar shows first full month of activation)
700
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008

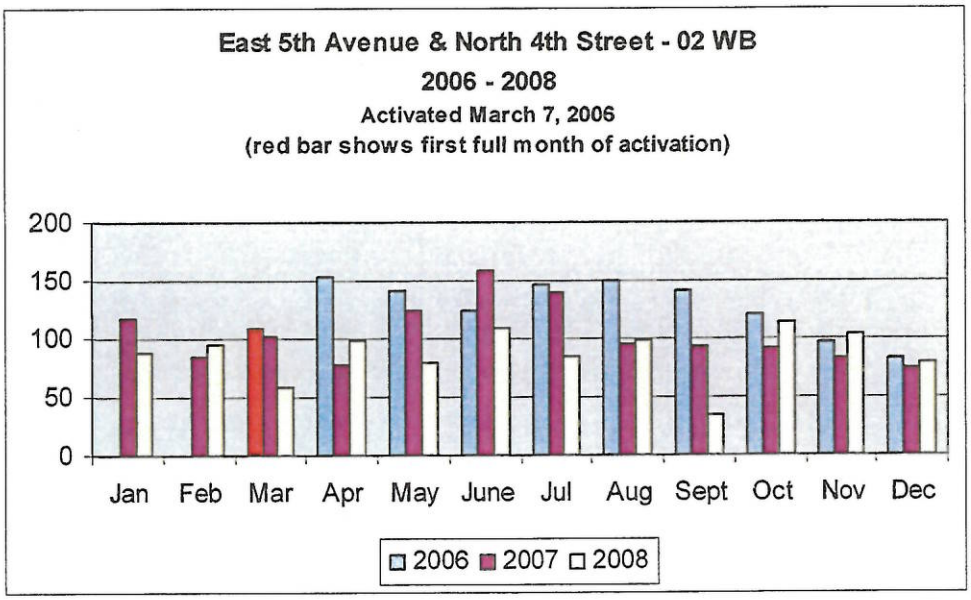

Cleveland & Spring SB
2006 - 2008
Activated June 14, 2006
(red bar shows first full month of activation)
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2006
2007
2008

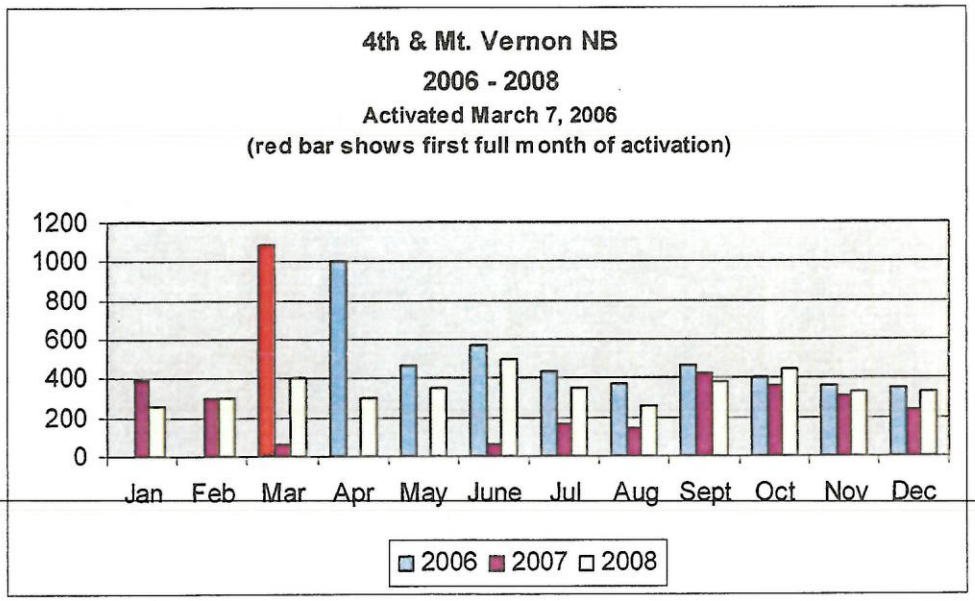

Central & Sullivant SB
2007 - 2008
Activated December 31, 2007
(red bar shows first full month of activation)
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008


Broad & Sylvan EB
2006-2008
Activated September 1, 2006
(red bar shows first full month of activation)
700
600
500
400
300
200
100
0
Jan Feb Mar Apr May June Jul Aug Sept Oct Nov Dec
2006 2007 2008

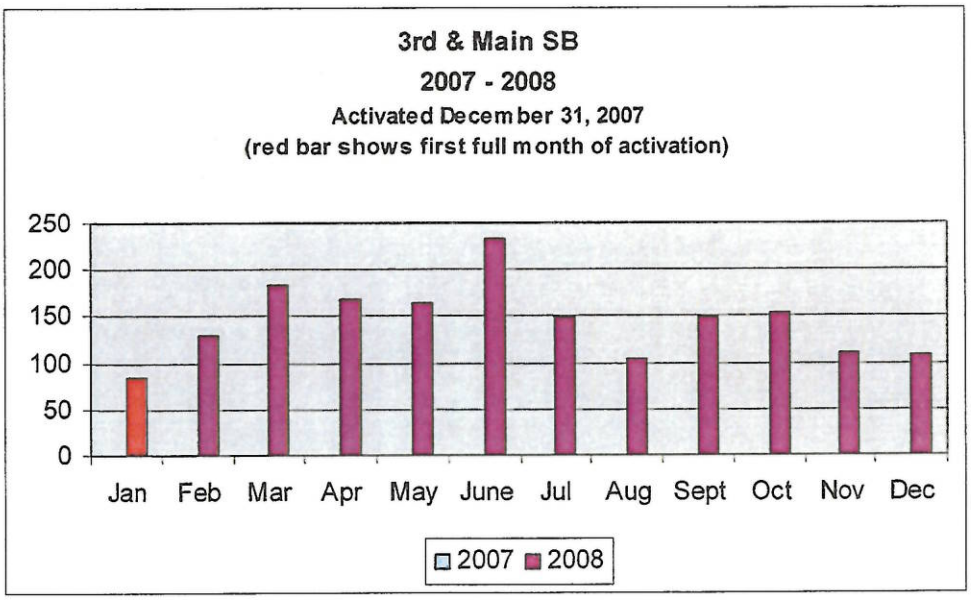

Broad & Grant EB
2007 - 2008
Activated February 27, 2007
(red bar shows first full month of activation)
100
80
60
40
20
0
Jan Feb Mar Apr May June Jul Aug Sept Oct Nov Dec
2007 2008

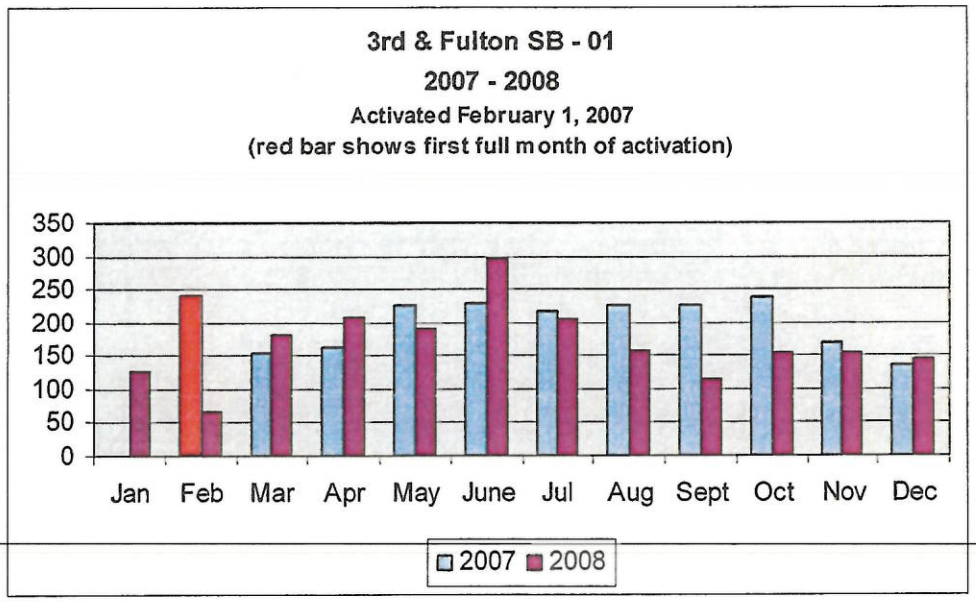

East 5th Avenue & North 4th Street - 01 EB
2006 - 2008
Activated March 8, 2006
(red bar shows first full month of activation)
350
300
250
200
150
100
50
0
Jan Feb Mar Apr May June Jul Aug Sept Oct Nov Dec
2006 2007 2008


East 5th Avenue & North 4th Street - 02 WB
2006 - 2008
Activated March 7, 2006
(red bar shows first full month of activation)
200
150
100
50
0
Jan Feb Mar Apr May June Jul Aug Sept Oct Nov Dec
2006 2007 2008



*Please note March, April, May and June 2007 this camera was largely inoperable.




3rd & Fulton SB - 01
2007 - 2008
Activated February 1, 2007
(red bar shows first full month of activation)
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
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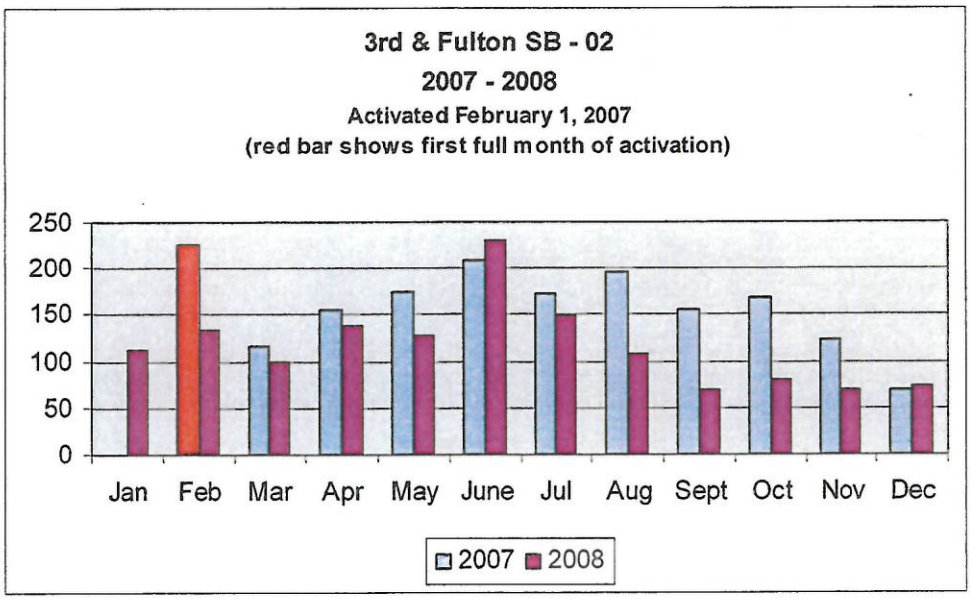
Sept
Oct
Nov
Dec
2007
2008


3rd & Fulton SB - 02
2007 - 2008
Activated February 1, 2007
(red bar shows first full month of activation)
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
June
Jul
Aug
Sept
Oct
Nov
Dec
2007
2008

COMPARISON OF 4th QUARTER 2007 WITH 4th QUARTER 2008

Town Street & 4th Street (WB)	**2007**	**2008**	**Percentage/Change**
October	99	111	12.12%
November	73	90	23.29%
December	68	89	30.88%
Totals	240	290	20.83%
Summit Street & Maynard Avenue (SB)	**2007**	**2008**	**Percentage/Change**
October	N/A	167	N/A
November	178	144	-19.10%
December	120	162	35.00%
Totals	298	473	58.72%
Summit Street & Chittenden Avenue (SB)	**2007**	**2008**	**Percentage/Change**
October	162	118	-27.16%
November	89	116	30.34%
December	113	141	24.78%
Totals	364	375	3.02%
Parsons Avenue & Frebis Avenue (NB)	**2007**	**2008**	**Percentage/Change**
October	300	191	-36.33%
November	242	160	-33.88%
December	139	156	12.23%
Totals	681	507	-25.55%
Main Street & Eastmoor Avenue (WB)	**2007**	**2008**	**Percentage/Change**
October	N/A	224	N/A
November	273	151	-44.69%
December	152	169	11.18%
Totals	425	544	28.00%
Livingston Avenue & Fairwood Avenue (EB)	**2007**	**2008**	**Percentage/Change**
October	73	201	175.34%
November	76	145	90.79%
December	54	146	170.37%
Totals	203	492	142.36%
Indianola Avenue & Cooke/Overbrook (SB)	**2007**	**2008**	**Percentage/Change**
October	N/A	187	N/A
November	64	166	159.38%
December	141	137	-2.84%
Totals	205	490	139.02%
Henderson Road & Gettysburg Road (EB)	**2007**	**2008**	**Percentage/Change**
October	73	65	-10.96%
November	76	56	-26.32%
December	54	39	-27.78%
Totals	203	160	-21.18%

4th Street & Main Street (NB)	**2007**	**2008**	**Percentage/Change**
October	304	263	-13.49%
November	196	210	7.14%
December	94	143	52.13%
Totals	594	616	3.70%
4th Street & Long Street (NB)	**2007**	**2008**	**Percentage/Change**
October	654	473	-27.68%
November	557	330	-40.75%
December	329	354	7.60%
Totals	1540	1157	-24.87%
Cleveland Avenue & Spring Street (SB)	**2007**	**2008**	**Percentage/Change**
October	132	141	6.82%
November	96	114	18.75%
December	58	103	77.59%
Totals	286	358	25.17%
Central Avenue & Sullivant Avenue (SB)	**2007**	**2008**	**Percentage/Change**
October	N/A	82	N/A
November	N/A	105	N/A
December	N/A	133	N/A
Totals	N/A	320	N/A
Broad Street & Sylvan Avenue (EB)	**2007**	**2008**	**Percentage/Change**
October	188	168	-10.64%
November	164	102	-37.80%
December	110	59	-46.36%
Totals	462	329	-28.79%
Broad Street & Grant Avenue (EB)	**2007**	**2008**	**Percentage/Change**
October	54	76	40.74%
November	33	50	51.52%
December	35	89	154.29%
Totals	122	215	76.23%
5th Avenue & 4th Street (WB)	**2007**	**2008**	**Percentage/Change**
October	92	163	77.17%
November	82	103	25.61%
December	75	79	5.33%
Totals	249	345	38.55%
5th Avenue & 4th Street (EB)	**2007**	**2008**	**Percentage/Change**
October	113	121	7.08%
November	61	23	-62.30%
December	77	71	-7.79%
Totals	251	215	-14.34%
4th Street & Mt. Vernon Avenue (NB)	**2007**	**2008**	**Percentage/Change**
October	358	446	24.58%
November	315	329	4.44%
December	243	327	34.57%
Totals	916	1102	20.31%

3rd Street & Main Street (SB)	2007	2008	Percentage/Change
October	N/A	153	N/A
November	N/A	110	N/A
December	N/A	107	N/A
Totals	N/A	370	N/A
3rd Street & Fulton Street - 01 (SB)	**2007**	**2008**	**Percentage/Change**
October	168	80	-52.38%
November	123	69	-43.90%
December	68	73	7.35%
Totals	359	222	-38.16%
3rd Street & Fulton Street - 02 (SB)	**2007**	**2008**	**Percentage/Change**
October	238	153	-35.71%
November	169	155	-8.28%
December	135	146	8.15%
Totals	542	454	-16.24%

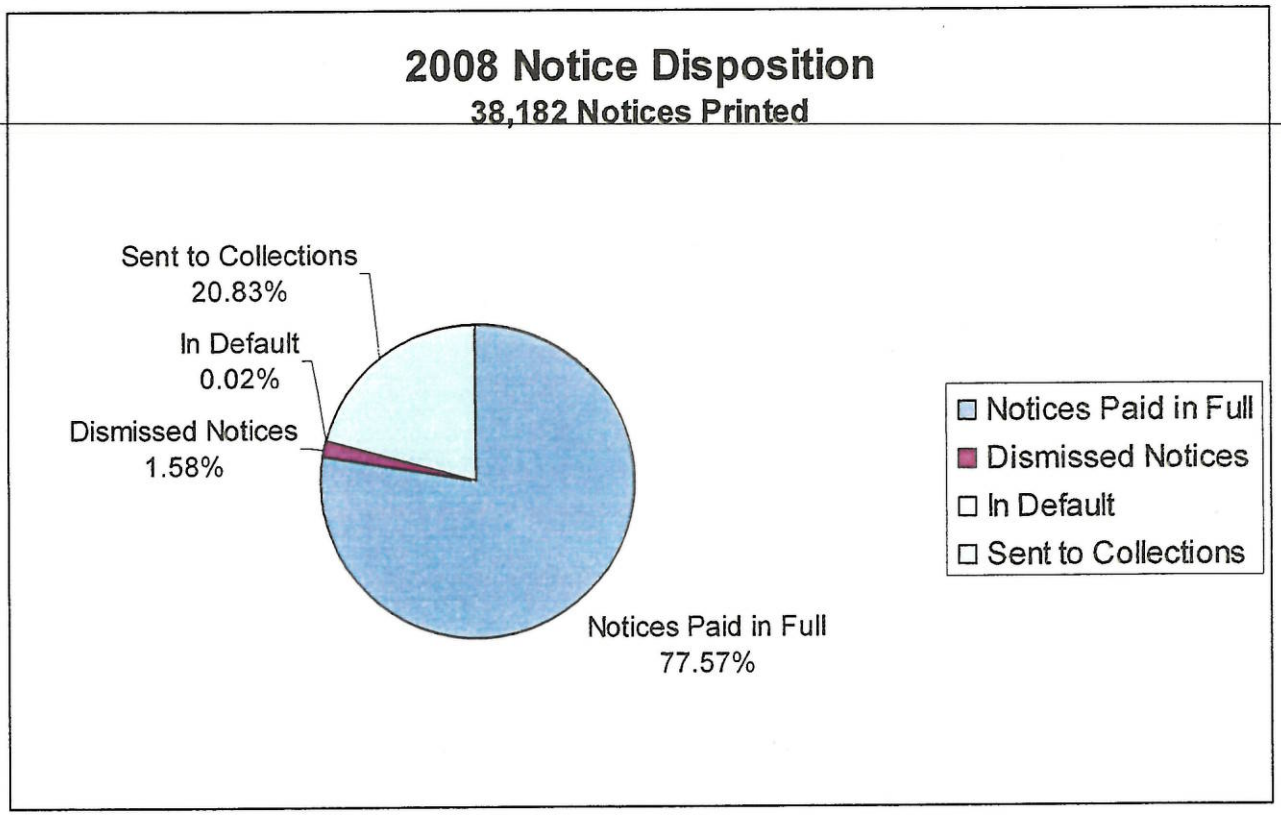
PRE AND POST CAMERA VEHICLE CRASH DATA

- A review of the 38-49 month period prior to the installation of red light cameras indicated that the eighteen (18) monitored approaches had on average a total of 67.7 right-angle or red light violation crashes per year.
- The 10-30 month period after the installation of the red light cameras indicated the eighteen (18) monitored intersections had a yearly average total of 15.8 right-angle or red light violation crashes per year.
- This represents a reduction of 76.7 percent in crashes involving red light running at these monitored intersections.

LOCATION	AVERAGE CRASHES PER YEAR PRE-CAMERA	ACTUAL NUMBER OF CRASHES POST-CAMERA	AVERAGE CRASHES PER YEAR POST-CAMERA	DIFFERENCE	CHANGE
Town St. & 4th St. (WB)	2.2	0	0.0	-2.2	-100%
Summit St. & Maynard Av. (SB)	1.7	0	0.0	-1.7	-100%
Summit St. & Chittenden Av. (SB)	4.6	3	1.3	-3.3	-72%
Parsons Av. & Frebis Av. (NB)	3.4	0	0.0	-3.4	-100%
Main Street & Eastmoor Avenue (WB)	2.5	0	0.0	-2.5	-100%
Livingston Av. & Fairwood Av. (EB)	2.9	0	0.0	-2.9	-100%
Indianola Av. & Cooke Rd. (SB)	2.1	0	0.0	-2.1	-100%
Henderson Rd. & Gettysburg Rd. (EB)	3.8	1	0.4	-3.4	-89%
4th St. & Main St. (NB)	3.6	1	0.9	-2.7	-75%
4th St. & Long St. (NB)	4.2	1	0.9	-3.3	-79%
Cleveland Av. & Spring St. (SB)	5.6	5	2.0	-3.6	-64%
Central Av. & Sullivant Av. (SB)	3.5	1	0.8	-2.7	-78%
Broad St. & Sylvan Av. (EB)	2.7	1	0.4	-2.3	-85%
Broad St. & Grant Av. (EB)	1.2	0	0.0	-1.2	-100%
5th Av. & 4th St. (WB) & (EB)	7.9	10	3.6	-4.3	-54%
4th St. & Mt. Vernon Av. (NB)	8.2	9	3.3	-4.9	-60%
3rd St. & Main St. (SB)	3..7	0	0.0	-3.7	-100%
3rd St. & Fulton St. - 01 & 02 (SB)	3.9	4	2.2	-1.7	-44%

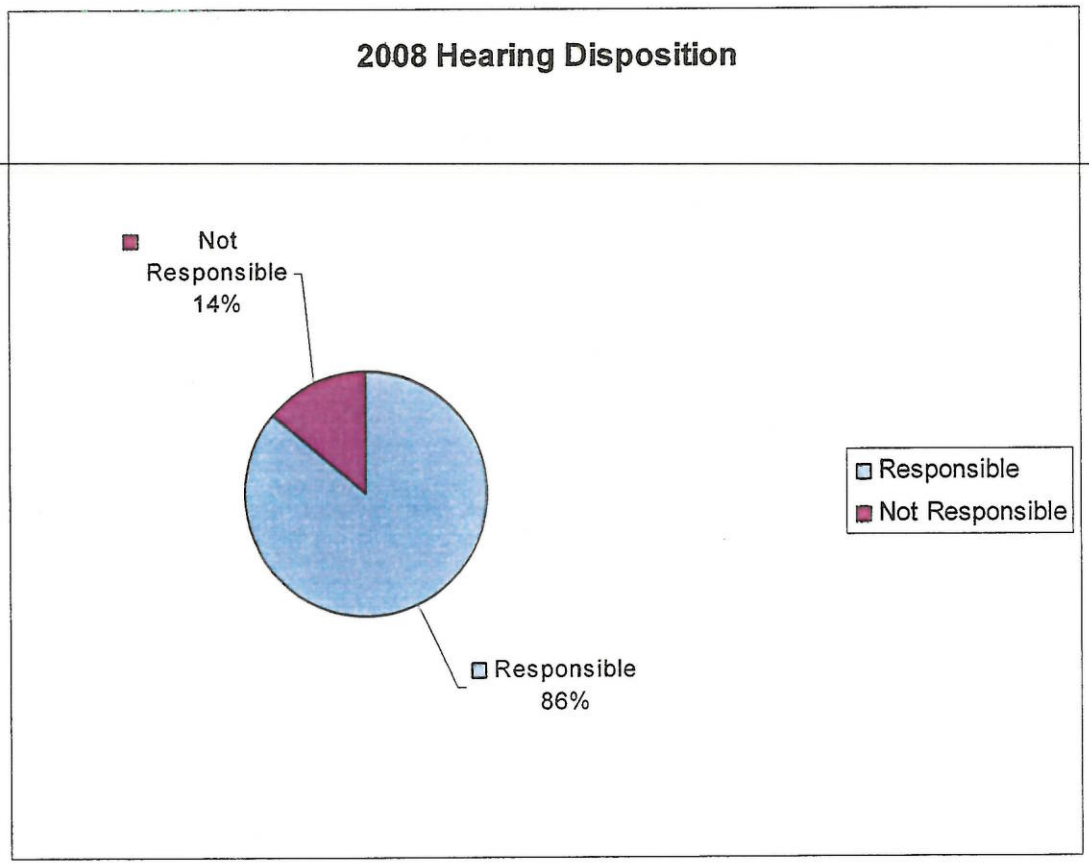
Payment History

In 2008, the City of Columbus received $820,041. Approximately 77% of the tickets were paid, 2% were dismissed, and 21% are in default or collections. Monies received are being utilized for Public Safety Initiatives such as the purchase of police cruisers and our Police Strike Force Initiative.



Hearing Disposition

- In 2008, the City of Columbus received 507 administrative hearing requests.
- City of Columbus conducted 29 sessions of Administrative Hearings.
- 436 individuals were found to be responsible.
- 71 people were found not responsible.



NOTES:

Detections:

- Source of information – Redflex Customer Management Report from January–December, 2008 (copy attached).

Crash Data

- Source of information – Columbus Police. Pre and Post camera crashes are based on: Red light causing crashes, traveling the same direction as monitored approach only and on average of crashes both pre and post cameras per year.
  - To determine the average of crashes per year during the pre camera period, the total number of crashes divided by number of months times 12 (example - 24 crashes with a 35 month period) 24/35 = 0.685 x 12 = 8.2 or 8 crashes a year.
  - To determine the average of crashes per year after the installation of cameras. The total number of crashes divided by number of months of operation times 12 (example - 2 crashes for a 10 month period) 2/10 = 0.2 x 12 = 2.4 or 2 crashes a year.

Payment Notice Disposition

- Source of Information – Redflex. Paid citations include Paid in Full, Re-issued and Payment Rejected or No Forwarding address that were not in default (copy attached).

Hearing Disposition

- Source of Information – Columbus Division of Police (See page 25).

Exhibits:
2008 Notice Disposition Report
Right Angle Crash
Rear Crash Data
Customer Management Report

Columbus Ohio
"Focus On Safety"
2008 Notice Disposition

Notices Printed*	38,182
Warning Letters Printed**	0
Pending	0
Notices Paid in Full	27,485
Dismissed Notices	561
In Default	6
Sent to Collections	7,382

*per Redflex, this means the number of detections/incidents captured that were approved by the police for notice generation. Each detection/incident generates at least one notice (a warning letter, a first notice, etc.) but can generate more than one notice (a nomination, a re-address, etc.).

** There were no new approaches for 2008.

Right Angle Crashes

Location	Direction Captured	Active Date 2006	Pre-Cameras Activation 2003	Pre-Cameras Activation 2004	Pre-Cameras Activation 2005-2006	Pre-Cameras Activation 2007	Average Crashes Per Year 2003-2007	Post-Cameras Activation 2006	Post-Cameras Activation 2007	Post-Cameras Activation 2008	Average Crashes Per Year 2006-2008
Town St & S. 4th St	W/B	02/01/07	3	2	4	0	2.2	0	0	0	0.0
Summit & Maynard	S/B	11/01/07	3	5	0	0	1.7	0	0	0	0.0
Summit & Chittenden	S/B	09/30/06	7	2	8	0	4.6	0	2	1	1.3
Parsons & Frebis	N/B	10/04/07	5	6	4	1	3.4	0	0	0	0.0
E. Main St & Eastmoor	W/B	11/01/07	0	7	5	0	2.5	0	0	0	0.0
Livingston & Fairwood	E/B	10/18/06	3	2	6	0	2.9	0	0	0	0.0
Indianola & Cooke	S/B	11/21/07	2	2	6	0	2.1	0	0	0	0.0
Henderson & Gettysburg	E/B	09/01/06	6	7	1	0	3.8	1	0	0	0.4
S. 4th St & Main St.	N/B	10/04/07	5	7	4	1	3.6	0	0	1	0.9
N. 4th St & Long St.	N/B	10/08/07	4	10	5	1	4.2	0	0	1	0.9
Cleveland & Spring	S/B	06/14/06	13	5	1	0	5.6	3	0	2	2.0
Central Ave & Sullivant	S/B	12/31/07	10	3	4	0	3.5	0	0	1	1.0
Broad & Sylvan	E/B	09/01/06	2	4	4	0	2.7	1	0	0	0.4
Broad St & Grant Ave	E/B	02/27/07	2	1	2	0	1.2	0	0	0	0.0
5th & 4th	E/B & W/B	03/07/06	9	7	9	0	7.9	4	3	3	3.6
4th & Mt Vernon	N/B	03/07/06	6	12	8	0	8.2	3	3	3	3.3
S. 3rd St & E. Main St.	S/B	12/31/07	7	6	3	2	3.7	0	0	0	0.0
S. 3rd St & Fulton St 01 & 02	S/B	02/01/07	11	0	5	0	3.9	0	2	2	2.2
Total Crashes			**98**	**88**	**79**	**5**		**12**	**10**	**14**	

Grand Total of Crashes Pre-Cameras: 270
Grand Total of Crashes Post-Cameras: 36

To determine the average of crashes per year **during** the pre camera period, the total number of crashes divided by number of months times 12 (example - 24 crashes with a 35 month period) 24/35 = 0.685 x 12 = 8.2 or 8 crashes a year.

To determine the average of crashes per year **after** the installation of cameras. The total number of crashes divided by number of months of operation times 12 (example - 2 crashes for a 10 month period) 2/10 = 0.2 x 12 = 2.4 or 2 crashes a year.

Rear-End Crashes

Location	Direction Captured	Active Date 2006	Pre-Cameras Activation 2003	Pre-Cameras Activation 2004	Pre-Cameras Activation 2005-2006	Pre-Cameras Activation 2007	Average Crashes per year 2003-2007	Post-Cameras Activation 2006	Post-Cameras Activation 2007	Post-Cameras Activation 2008	Average Crashes Per Year 2006-2008
Town St & S. 4th St	W/B	02/01/07	0	0	1	0	0.2	0	0	0	**0.0**
Summit & Maynard	S/B	11/01/07	1	1	2	1	1.0	0	0	0	**0.0**
Summit & Chittenden	S/B	09/30/06	0	0	0	0	0.3	0	0	0	**0.0**
Parsons & Frebis	N/B	10/04/07	2	0	2	1	1.1	0	0	0	**0.0**
E. Main St & Eastmoor	W/B	11/01/07	0	1	3	1	1.0	0	0	2	**1.8**
Livingston & Fairwood	E/B	10/18/06	1	0	2	0	0.8	0	1	1	**0.9**
Indianola & Cooke	S/B	11/21/07	3	1	2	0	1.2	0	0	1	**0.9**
Henderson & Gettysburg	E/B	09/01/06	2	1	1	0	1.1	0	0	0	**0.0**
S. 4th St & Main St.	N/B	10/04/07	0	0	2	0	0.4	0	0	1	**0.9**
N. 4th St & Long St.	N/B	10/08/07	5	0	5	1	2.3	0	0	0	**0.0**
Cleveland & Spring	S/B	06/14/06	1	0	0	0	0.3	0	1	0	**0.4**
Central Ave & Sullivant	S/B	12/31/07	0	1	2	1	0.8	0	0	0	**0.0**
Broad & Sylvan	E/B	09/01/06	1	1	2	0	1.1	0	0	1	**0.4**
Broad St & Grant Ave	E/B	02/27/07	0	0	0	0	0.0	0	1	0	**0.5**
5th & 4th	E/B & W/B	03/07/06	2	1	4	0	2.2	4	1	3	**2.9**
4th & Mt Vernon	N/B	03/07/06	8	7	10	0	7.9	3	9	6	**6.5**
S. 3rd St & E. Main St.	S/B	12/31/07	1	0	4	0	1.0	0	0	1	**1.0**
S. 3rd St & Fulton St 01 & 02	S/B	02/01/07	8	3	7	1	4.7	0	0	5	**2.7**
Total Crashes			**35**	**17**	**50**	**6**		**7**	**13**	**21**	

Grand Total of Crashes Pre-Cameras: 108
Grand Total of Crashes Post-Cameras: 41

Customer Management Report (Columbus) Redlight Incidents

01-Jan-2008 to 31-Dec-2008 Operator Id: %

		3rd & Fulton SB	3rd & Fulton SB	3rd & Main SB	4th & Mt. Vernon NB	5th & 4th EB	5th & 4th WB	Broad & Grant EB	Broad & Sylvan EB	Central & Sullivant SB	Cleveland & Spring SB
Total Violations		2885	1971	2911	5935	2039	2196	1168	2499	3902	2628
Less Uncontrollable Factors											
Obstruction	Plate Obstruction	64	56	151	251	32	46	59	68	214	53
	Signal Obstruction	1	0	1	2	1	3	0	4	6	0
	Vehicle Obstruction	6	4	32	29	1	6	13	13	35	13
Police Rejects	Citation Issued Manually	0	2	0	1	1	1	1	0	2	3
	Emergency Vehicle (PD)	44	45	70	104	98	49	206	27	668	217
	Funeral Procession	0	1	2	1	1	3	3	0	0	1
	Incorrect Plate on Vehicle	1	1	0	3	0	2	1	0	1	2
	Incorrect/Incomplete DMV	34	24	24	48	12	11	10	22	27	13
	Invalid Offence	0	2	1	5	0	0	1	0	0	0
	Multiple vehicles in frame	12	21	38	73	5	5	5	11	8	1
	Non Violation - Funeral	0	0	1	0	0	0	0	0	0	0
	Plate Obstruction (PD)	0	0	0	0	0	0	0	0	0	0
	Plate Unidentifiable	1	4	5	4	1	0	1	0	0	0
	Police Discretion	208	263	403	444	277	196	145	399	160	207
	Safe Turn on Red	52	0	23	0	2	452	40	2	978	557
	Weather Conditions	16	45	73	88	39	17	26	34	13	15
	Yielding to an Emergency	0	0	0	0	0	1	0	0	1	0
Policy/Weather	Extended Vehicle	7	10	44	74	10	9	10	23	17	9
	Sun Glare	36	9	0	6	5	5	0	7	5	0
	Weather/Nature	19	22	46	110	9	18	20	13	20	5
	Yellow with Red Light	0	0	2	0	2	3	0	2	2	0
Registration Issues	Can Not Identify State	4	0	7	3	1	1	1	2	2	0
	Out of Country Plate	0	0	2	17	0	1	1	0	1	2
	Paper Plates	19	19	32	44	23	28	14	28	118	35
	Wrong or No DMV	10	9	9	13	7	3	2	10	16	12
Total		534	537	966	1320	527	860	559	665	2294	1145
Sub Total Violations		2351	1434	1945	4615	1512	1336	609	1834	1608	1483
Less in Progress		0	0	0	0	0	0	0	0	0	0

Available for Prosecution		2351	1434	1945	4615	1512	1336	609	1834	1608	1483
Less Rejects											
Camera Malfunction	Databar Unreadable/Incorrect	0-00%	0-00%	0-00%	1-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	Digital Distortion	6-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	Image Missing	86-04%	1-00%	2-00%	44-01%	78-05%	94-07%	2-00%	29-02%	1-00%	1-00%
	Misc Camera Issue	79-03%	4-00%	2-00%	2-00%	7-00%	52-03%	164-12%	2-00%	31-02%	0-00%
	Plate Burn Out	33-01%	5-00%	0-00%	14-00%	0-00%	0-00%	0-00%	0-00%	54-03%	1-00%
	Plate Not in Frame	8-00%	4-00%	5-00%	39-01%	0-00%	0-00%	5-01%	1-00%	0-00%	0-00%
	Rear Plate Camera Blurry	16-01%	8-01%	109-06%	140-03%	1-00%	3-00%	15-02%	5-00%	55-03%	0-00%
	Rear Plate Flash Inappropriate	4-00%	1-00%	8-00%	24-01%	0-00%	0-00%	2-00%	2-00%	5-00%	0-00%
	Rear Plate No Flash	1-00%	1-00%	3-00%	11-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	Scene Image Blurry	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%	0-00%	0-00%	1-00%	1-00%
	Scene Image Flash Inappropriate	58-02%	0-00%	1-00%	15-00%	0-00%	3-00%	3-00%	3-00%	1-00%	0-00%
	Scene Image No Flash	52-02%	1-00%	5-00%	5-00%	0-00%	4-00%	0-00%	0-00%	4-00%	0-00%
Police Rejects	Driver Unidentifiable Images Poor	1-00%	0-00%	0-00%	2-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	Incorrect Speed	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	Insufficient Strobe Lighting	0-00%	0-00%	1-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	No Images	0-00%	0-00%	0-00%	1-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	No Video	1-00%	0-00%	1-00%	4-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	Plate Unclear	0-00%	0-00%	1-00%	1-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%
	Red Light not visible in picture	4-00%	2-00%	13-01%	16-00%	6-00%	8-01%	0-00%	5-00%	18-01%	2-00%
	Sun Glare	2-00%	1-00%	2-00%	0-00%	3-00%	1-00%	1-00%	2-00%	0-00%	2-00%
	Unclear Scene Image	2-00%	6-00%	28-01%	16-00%	1-00%	3-00%	0-00%	0-00%	3-00%	0-00%
	Vehicle On or Passed Stop Line	5-00%	2-00%	2-00%	2-00%	0-00%	6-00%	1-00%	2-00%	2-00%	3.00%
Total		358-15%	36-03%	184-09%	342-07%	141-09%	287-21%	31-05%	80-04%	144-09%	12-01%
Notices Printed		1993-85%	1398-97%	1761-91%	4273-93%	1371-91%	1049-79%	578-95%	1754-96%	1464-91%	1471-99%

Customer Management Report (Columbus) Redlight Incidents (CONT.)

01-Jan-2008 to 31-Dec-2008 Operator Id: %

		4th & Long NB	4th & Main NB	Henderson & Gettysburg EB	Indianola & Cooke SB	Livingston & Fairwood EB	Main & Eastmoor WB	Parsons & Frebis NB	Summit & Chittenden SB	Summit & Maynard SB	Town & 4th WB	Totals
Total Violations		7245	4607	1168	2776	3548	3422	3159	2394	2874	2576	61903
Less Uncontrollable Factors												
Obstruction	Plate Obstruction	300	201	21	96	62	75	86	139	150	55	2179
	Signal Obstruction	0	0	0	0	1	0	0	0	1	1	21
	Vehicle Obstruction	121	38	2	8	12	29	35	29	9	34	469
Police Rejects	Citation Issued Manually	2	1	0	0	2	0	0	3	1	0	20
	Emergency Vehicle (PD)	137	591	72	16	100	103	548	196	68	79	3438
	Funeral Procession	0	0	0	0	2	0	0	0	0	0	14
	Incorrect Plate on Vehicle	2	0	0	0	1	0	0	0	2	0	16
	Incorrect/Incomplete DMV	65	44	7	24	34	16	28	13	22	9	487
	Invalid Offence	1	5	1	3	4	0	0	0	0	1	24
	Multiple vehicles in frame	141	26	0	13	8	20	6	5	9	2	409
	Non Violation - Funeral	0	0	0	0	0	0	0	0	0	0	1
	Plate Obstruction (PD)	1	0	0	0	0	0	1	0	0	0	2
	Plate Unidentifiable	6	0	0	0	1	0	0	4	3	0	30
	Police Discretion	1070	500	104	364	508	505	299	183	367	116	6718
	Safe Turn on Red	2	349	42	22	277	9	49	106	69	705	3736
	Weather Conditions	153	43	15	41	49	56	44	84	67	9	927
	Yielding to an Emergency	1	1	0	0	0	0	0	1	1	0	6
Policy/Weather	Extended Vehicle	70	54	3	11	28	15	38	14	19	1	466
	Sun Glare	5	10	1	3	3	6	0	5	3	5	114
	Weather/Nature	34	23	4	17	15	32	12	31	32	23	505
	Yellow with Red Light	0	0	1	23	3	1	0	3	6	2	50
Registration Issues	Can Not Identify State	8	3	0	1	3	2	1	5	2	1	47
	Out of Country Plate	8	1	0	0	1	2	0	1	2	3	42
	Paper Plates	74	84	15	13	40	40	53	22	28	17	746
	Wrong or No DMV	26	14	3	11	11	9	10	7	5	6	193
Total		2227	1988	291	666	1165	920	1210	851	866	1069	20660
Sub Total Violations		5018	2619	877	2110	2383	2502	1949	1543	2008	1507	41243

Less in Progress		0	0	0	0	0	0	0	0	0	0	0
Available for Prosecution		5018	2619	877	2110	2383	2502	1949	1543	2008	1507	41243
Less Rejects												
Camera Malfunction	Databar Unreadable/Incorrect	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%	0-00%	0-00%	0-00%	0-00%	2-00%
	Digital Distortion	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	6-00%
	Image Missing	1-00%	3-00%	2-00%	30-01%	7-00%	1-00%	3-00%	0-00%	4-00%	277-18%	666-02%
	Misc Camera Issue	1-00%	6-00%	7-01%	8-00%	1-00%	1-00%	2-00%	1-00%	1-00%	92-08%	483-01%
	Plate Burn Out	3-00%	66-03%	1-00%	0-00%	2-00%	19-01%	0-00%	2-00%	12-01%	1-00%	213-01%
	Plate Not in Frame	18-00%	9-00%	0-00%	1-00%	0-00%	3-00%	0-00%	10-01%	0-00%	10-01%	113-00%
	Rear Plate Camera Blurry	95-02%	63-02%	2-00%	3-00%	2-00%	18-01%	1-00%	68-04%	115-08%	7-00%	726-02%
	Rear Plate Flash Inappropriate	6-00%	13-00%	1-00%	1-00%	0-00%	5-00%	1-00%	21-01%	6-00%	13-01%	113-00%
	Rear Plate No Flash	2-00%	8-00%	0-00%	0-00%	0-00%	0-00%	0-00%	3-00%	0-00%	9-01%	38-00%
	Scene Image Blurry	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%	0-00%	0-00%	4-00%
	Scene Image Flash Inappropriate	4-00%	15-01%	17-02%	0-00%	0-00%	0-00%	1-00%	1-00%	0-00%	4-00%	128-00%
	Scene Image No Flash	4-00%	19-01%	21-02%	4-00%	1-00%	3-00%	0-00%	2-00%	2-00%	7-00%	134-00%
Police Rejects	Driver Unidentifiable Images Poor	1-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%	1-00%	1-00%	7-00%
	Incorrect Speed	0-00%	2-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	2-00%	2-00%	7-00%
	Insufficient Strobe Lighting	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%
	No Images	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%
	No Video	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%	0-00%	0-00%	0-00%	7-00%
	Plate Unclear	0-00%	0-00%	0-00%	0-00%	0-00%	0-00%	1-00%	0-00%	0-00%	0-00%	3-00%
	Red Light not visible in picture	8-00%	86-03%	8-01%	23-01%	7-00%	2-00%	0-00%	7-00%	4-00%	12-01%	231-01%
	Sun Glare	2-00%	0-00%	2-00%	2-00%	5-00%	2-00%	0-00%	0-00%	0-00%	5-00%	32-00%
	- Unclear Scene Image	15-00%	4-00%	1-00%	2-00%	4-00%	4-00%	3-00%	7-00%	7-00%	1-00%	107-00%
	Vehicle On or Passed Stop Line	13-00%	6-00%	1-00%	5-00%	1-00%	1-00%	0-00%	5-00%	1-00%	3-00%	61-00%
Total		17-03%	300-11%	63-07%	79-04%	30-01%	60-02%	13-01%	129-08%	155-08%	444-29%	3081-07%
Notices Printed		4845-97%	2319-89%	814-93%	2031-96%	2353-99%	2442-98%	1936-99%	1414-92%	1853-92%	1063-71%	38182-93%

Total Citations Issued in 2008: **(18 Intersections with 20 Cameras)**	**38,182**
Total Number of Photo Red Light Hearings Held:	**29**
Total Number of Photo Red Light Cases:	**507**
Disposition: Responsible	**436**
Not Responsible	**71**

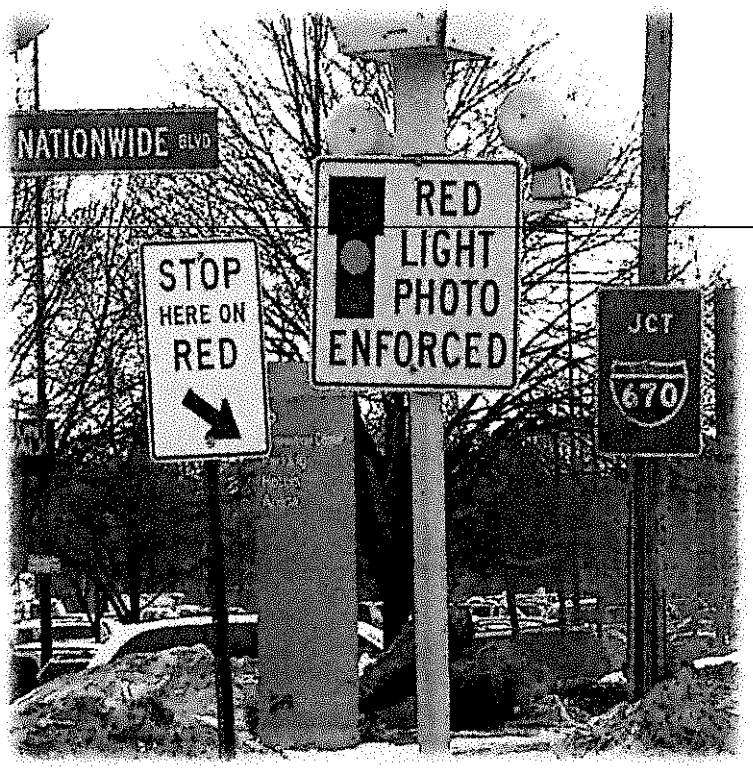
Note: No new cameras were installed in 2008.

D

The Ohio State University

John Glenn School of Public Affairs

No Cop, No Stop? A Quantitative Program Evaluation of the Columbus, Ohio *Focus on Safety* Red-Light Camera Enforcement Program



[1]

By

Christopher Adam Brunner

A policy/management paper submitted in partial fulfillment for the Master of Public Administration Degree

Autumn, 2011

[1] Figure 1: Red Light Photo Enforced signage picture courtesy the City of Columbus, Ohio Department of Public Safety (2011).

NO COP, NO STOP?

Executive Summary

In the period between 2006 and 2010, approximately 11 people were killed and 2,100 were injured in as many as 5,174 red-light running crashes in Columbus, Ohio. These tragedies are not only tribulations for the victims, but also for the family, loved ones, and communities of those injured or killed. Although red-light running crashes and their adverse consequences have occurred since the advent of signalized intersections, the countermeasures, public policies, and technologies designed to mitigate their effects have increased in the last 30 years. In an attempt to moderate the problem of red-light running over the years, a multitude of transportation safety advocacy organizations representing all sectors of industry have published numerous guides that focus on the ways in which local governments can improve intersection safety. Repeatedly found within these guidelines are mechanisms that address changes in intersection engineering, enforcement, and education; to include the automated enforcement of red-light running.

A city ordinance took effect in Columbus, Ohio in October 2005, permitting the Columbus Department of Public Safety to implement the *Focus on Safety* red-light camera enforcement program. Camera site selection was based on two criteria: the ranking of dangerous intersections and camera constructability. Actual enforcement and the issuing of civil traffic citations began in April 2006. Of approximately 15,000 intersections in Columbus, 1,008 are signalized and 20 were equipped with red-light cameras. The first two cameras were activated on March 7, 2006 and the last two of the combined 20 cameras were activated December 31, 2007. This paper examined what impact the *Focus on Safety* program has had on red-light running crashes and violation rates. These findings may help government leaders and managers formulate and implement successful camera programs of their own and thus make cities safer to drive in.

After estimating the negative binomial regression, it was found that red-light cameras are associated with significant reductions in crash rates at the intersections where they are installed. This result was statistically significant at the 0.1 percent level however, the p-value equaled 0.059 and the sample size was small, so it fell just shy of significant at the 0.05 percent level. This suggests the true effect could easily be significant and future research on the topic should be done. The effects of cameras on safety at citywide non-red-light camera intersections however, could not be determined based on the regression and an inadequate baseline measure. In addition, this examination found that red-light running violation rates increased following the program's implementation, though not to initial violation levels.

Although this evaluation has its limitations, it also offers meaningful and usable information to localities around the globe as they try to alleviate the problem of red-light running. While many recognize the utility of red-light cameras and their contributions to public safety, there are a myriad of alternatives government leaders and managers should explore in order to find the best solution for their community's needs. Future research could answer the limitations of this evaluation by including a longer study period for both before-and-after the camera activation, as well as by testing whether the cameras have an impact on safety at adjacent approaches or at intersections immediately upstream and downstream of the camera sites. If so, city officials could strategically position the cameras to maximize their collective impact.

Acknowledgements

I am grateful to Steven Naber, Robert Greenbaum, Alexander Roberts, Erin Sainato, David Cook, Grey Evenson, Craig Boardman, and Reena Uppal, each of whom has taken a personal interest in my intellectual and professional growth. For their love, support, and encouragement, I thank my parents, John Brunner and Charlene Brunner, my in-laws, Brian and Kathleen Hurley, and my brothers, Jeffery and Timothy Brunner. Special thanks to George Speaks, Alesia Zacher, and Cathy Coblentz for their time, assistance, and dedication to this project. Thoughtful thanks to Carl Booth Jr., Kevin Keel, Stephen Thompson, Joe Curmode, Jessica Green, and Amanda Ford for their hard work and contributions to this project. Most importantly, I thank my wife, Lauren Brunner, for her patience, wisdom, and grace.

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Acronyms

RLC – Red-Light Camera
RLR – Red-Light Running
RTOR – Right-Turn(s)-on-Red
IRR – Incidence Rate Ratio
CI – Confidence Interval
ODPS – Ohio Department of Public Safety
IIHS – Insurance Institute for Highway Safety
FHWA – Federal Highway Administration
ITE – Institute of Transportation Engineers
Redflex – Redflex Traffic Systems, Inc.
PDO – Property Damage Only
GIS – Geographic Information Systems

Introduction

In the period between 2000 and 2009, approximately 8,845 people (885 per year) within the United States lost their lives in red-light running crashes and an estimated 165,000 individuals were injured annually in crashes that involved red-light running. Although the annual proportion of red-light running (RLR) fatalities to total crash fatalities during the same time period was a mere two percent, the annual proportion of RLR fatalities to total signalized intersection crash fatalaities was more than 10 percent (U.S. Department of Transportation Federal Highway Administration, 2009). Others have estimated the annual proportion of RLR fatalities to total signalized intersection crash fatalaities to be as high as 44 percent (McGee & Eccles, 2003). In Ohio in 2009, there were 10,883 crashes associated with RLR, of which 49 resulted in death (PR Newswire, 2010). The Insurance Institute for Highway Safety (IIHS) estimates that roughly half of those victims killed or injured by RLR crashes are not the drivers running the red-lights themselves, but rather they are the innocent occupants of vehicles and pedestrians struck by motorists committing the violations (IIHS, 2007).

A number of reasons have been identified that help to explain why motorists sometimes run red-lights despite the danger involved. Wissinger, Hummer and Milazzo (2000) noted that drivers intentionally run red-lights in an attempt to reduce delay if they are pressed for time. In other words, the perceived benefit or time gained from running the red-light exceeds the cost or time lost in complying with the traffic signal. Secondly, drivers sometimes understand or interpret the law concerning RLR incorrectly as it varies by state and is dependent on both individual traffic regulation knowledge and experiences driving. Third, motorists may sometimes run a red-light due to inappropriate traffic signal timing, such as at intersections where the duration of the yellow light is too low given the roadway's visibility, grade, and prescribed speed (Wissinger, Hummer & Milazzo, 2000). In addition, both vehicle malfunctions

and inclement weather have been recognized as contributing factors. In any case, whether it can be attributed to driver behavior, a misunderstanding of the traffic law, or insufficient traffic signal timing, there are too many RLR crashes, fatalities, and injuries at intersections in the United States.

In order to help government leaders and managers better understand and evaluate the impact of RLR, this paper seeks to examine the effects of the Columbus, Ohio *Focus on Safety* red-light camera (RLC) enforcement program on RLR citation, crash, and crash type rates using a before-and-after study with a nonequivalent comparison group with repeated treatment. The evaluation questions are: What impact has the *Focus on Safety* program had on the rate of intersection-level RLR violations, crashes, and crash types in the City of Columbus, Ohio? The preliminary research hypothesis suggests that lower rates of intersection-level red-light running violations, crashes, and crash types are associated with the *Focus on Safety* program. The Difference-in-Differences (DinD) regression model, a popular instrument to assess the effects of public interventions on some relevant outcome variables, compares the differences between 18 RLC intersections in Columbus, Ohio and 10 non-RLC intersections in Cincinnati, Ohio on various traffic safety outcome variables before-and-after enforcement. The counterfactual is explained by the outcomes of the Cincinnati comparison group because Cincinnati does not have photo red-light enforcement cameras whatsoever. In addition, consider the proximal similarity shared between Columbus and Cincinnati. The distance between Columbus and Cincinnati, approximately 110 miles, is close enough as to expect similar patterns of changes associated with external factors such as weather, fuel prices, economic conditions, and traffic laws. Further, the 18 experimental intersections in Columbus are closely matched to the 10 comparison intersections in Cincinnati. This research uses datasets accessed from the City of Columbus

Department of Public Service, Redflex Traffic Systems, and the City of Cincinnati Police Department. Such research utilizes crash data for a period of 12 months before-and-after enforcement and RLR violation data for a period ranging from 2,048 to 1,384 days of enforcement.

In addition, this paper will examine the impact of the *Focus on Safety* program on spillover or *halo* effects using a five year annual trend analysis with a nonequivalent comparison group with repeated treatment. Halo effects have been identified as the effect of RLC intersections on safety at non-RLC intersections in the jurisdiction by jurisdiction-wide publicity. In other words, if RLCs have an effect on driver behavior that extends beyond the RLC equipped intersections, then other intersections in the area will also experience decreases in adverse traffic outcomes (Shin & Washington, 2007). The evaluation questions are: What impact has the *Focus on Safety* program had on the rate of intersection crash, crash type, and crash severity rates in Columbus? The preliminary research hypothesis suggests that lower rates of citywide intersection crash, crash type, and crash severity are associated with the *Focus on Safety* program. The trend analysis compares the differences between the Columbus Police Department jurisdiction intersections and the Cincinnati Police Department jurisdiction intersections on crash, crash type, and crash severity rates for a period ranging five years, using datasets obtained from the Ohio Department of Public Safety's statewide *Crash Statistics* database. Such research utilizes data from January 1, 2006, a period before the treatment period, and December 31, 2010, 1,761 days of enforcement.

The next section of this policy/management paper presents a background of the *Focus on Safety* program and defines both the problem of RLR and use of RLCs using evidence found within the appropriate political, organizational, economical, and technological contexts.

Following this portion is a robust review of the literature relevant to RLR and RLC programs specifically. Next, statistical models and a geographic information systems spatial distribution trend analysis are developed that evaluate the impact of the *Focus on Safety* program on various public safety traffic outcomes in Columbus and Cincinnati. The concluding segment of the paper presents and discusses the detailed results of the regression and trend analyses. Inferences are drawn that may help government leaders and managers formulate and implement successful camera programs of their own and thus make cities as a whole safer to drive in by influencing driver behavior.

Background

In response to the oil crisis of 1973, and in acknowledgment of the United States ever-increasing consumption and consequent dependence upon overseas sources of oil, the U.S. Congress enacted the Energy Policy and Conservation Act of 1975 (Public Law 94-163, 1975). This act encouraged states to formulate a state energy conservation plan in exchange for continued federal energy assistance. In addition, the act mandated that states adopt "a traffic law or regulation which, to the maximum extent practicable consistent with safety, permits the operator of a motor vehicle to turn such a vehicle right at a red stop sign [light] after stopping" (P.L. 94-163, 1975). At the time of implementation, the issue of allowing right-turns-on-red (RTOR) was a novel and controversial idea. On the one hand, energy conservation proponents argued that legalized RTOR would save motorists time, increase fuel efficiency, reduce vehicle emissions, decrease intersection congestion, reduce intersection delays, and improve the overall levels of service and satisfaction experienced by drivers. Such benefits had been experienced and become popular in California and several other Western States that allowed permissive RTOR prior to the 1975 act (Preusser, Leaf, DeBartolo & Blomberg, 1981). On the other hand,

public safety advocates were concerned that the overall degree of hazardousness–such as increased vehicular, bicycle, and pedestrian accidents–would far exceed any of the supposed economic and time-savings. Nevertheless, feelings of consumer dissatisfaction with energy costs coupled with national security discontent were shared throughout the country and the federal and state governments responded. By January 1, 1980, all 50 states, the District of Columbia, and Puerto Rico implemented laws in accordance with the Energy Policy and Conservation Act of 1975 permitting RTOR at a very high percentage of all signalized intersections (Office of Program Development and Evaluation Traffic Safety Programs, 1994).

Although red-light running (RLR) crashes and their adverse consequences have occurred since the advent of signalized intersections, the countermeasures, public policies, and technologies designed to mitigate their effects, as well as their overall incidence, increased considerably following passage of the 1975 act. For instance, one of the first studies evaluating the total impact of RTOR on intersection safety discovered that all right turning crashes increased by 23 percent for motor vehicles, 60 percent for pedestrians, and 100 percent for bicyclists (Zador, 1984). It is important to note however that this study was based on the implementation of RTOR laws more than three decades ago. As a result, it is impossible to infer whether the increased rates in right turning crashes was just an issue of motorists becoming acclimated to the changes, or if the rates persisted with time. To be explicit, RTOR crashes and RLR are not mutually exclusive events, but rather the former are examples of the latter. For example, at intersections where a RTOR is allowed, motorists who fail to come to a complete stop behind the stop line or crosswalk at any red traffic signal before turning may be considered red-light runners. Consequently, in the three decades following the 1975 act, a myriad of transportation safety advocacy organizations and government agencies both domestic and abroad

have endorsed and implemented numerous traffic engineering countermeasures and programs designed to improve intersection safety, to include the automated enforcement of RLR. Automated enforcement includes the use of image capture technology, such as a still-frame, digital, or video camera, to monitor and enforce traffic control laws, ordinances, or restrictions.

One of the first countries to use photo red-light enforcement cameras was Sweden, while New York City is credited with having the first camera program in the United States in 1993 (Andreassen, 1995). Since then, currently 21 states, the District of Columbia, and the U.S. Virgin Islands enacted laws permitting some form of red-light camera (RLC) use, while nine states statutorily forbid their use, and 20 states have no state law regarding RLC enforcement (See Appendix A, Figure 7 for nationwide RLC laws by state) (Governors Highway Safety Association, 2011). At present, 25 states and approximately 556 localities have adopted RLC programs across the country (See Appendix A, Figure 8 for states using RLCs). Likewise, in Ohio 13 local governments and cities have authorized their use and currently employ camera programs of their own (IIHS, 2011). The Columbus, Ohio *Focus on Safety* RLC enforcement program, which aims to "dramatically reduce red-light running by using education, engineering, and enforcement," was approved by the Columbus City Council with a vote of six to one on October 17, 2005 (Ferenchik, 2005, p. 01A). City officials were confident that RLCs would reduce red-light violations and crashes, so they authorized the installation and use of 20 cameras at 18 of the city's approximately 1,008 signalized intersections (See Appendix A, Table 11 for intersection location dates of camera activation). Since the first camera was activated on March 7, 2006, the city has generated more than $2.9 million in revenue from the program via civil traffic citations (Dennis, 2011). More notably, the program's most recently published year-end report (2009) highlighted a combined annual decrease from 68 to 14 crashes at the original 18

intersections where 20 cameras were installed between March 2006 and December 2007. This indicates more than an 80 percent reduction in right-angle or *T-bone* crashes involving RLR at the 18 monitored intersections. In addition, the city reported a 79.3 percent overall reduction of civil traffic violations issued and "sent out in December of 2009 compared to the number in the first month of operations for each intersection" (Brown, 2009, p. 3). Moreover, the report estimates that in 2009 there were almost 48 percent fewer combined rear-end crashes at the monitored intersections compared to overall rates prior to the program's implementation (Brown, 2009). Authorized by Columbus City Code Chapter 2115, the *Focus on Safety* program has seemingly met its stated objectives of reducing RLR crashes, accidents, and injuries by positively influencing driver behavior and increasing intersection safety. Despite its successes in Columbus, similar enforcement initiatives such as the *Focus on Safety* program have stirred controversy in many areas of the country including in Ohio.

The same state law that preceded the cameras installation in Columbus has continually been contested and voted against by Cincinnati residents. Common arguments against RLC programs advocate that the technology is never 100 percent accurate. Case in point, Vitale (2010) reported that in Columbus drivers making legally permissible RTOR have often been falsely cited due to inaccurate or miscalculated camera measurements. These misfortunes result in a direct cost to a particular driver of a $95 fine, but more importantly, the unreported indirect costs such as the time motorists spend in the appeal process or communicating with city officials are unaccounted for (Vitale, 2010). More enthused opponents of RLC programs argue that the cameras erode citizens' civil liberties, suggesting local governments are more interested in the citation revenue rather than the publics' safety and even motorists' constitutional rights.

NO COP, NO STOP?

Legal scholars have argued that RLCs violate drivers' due process rights since those caught by the cameras are presumed guilty and thus are not provided a fair and impartial hearing. In addition, another criticism against RLC programs is that the local ordinances authorizing them often shift the burden of proof on the driver (Shannon , 2008). For instance, Columbus' ordinance states that "the fact that a person is the owner of a vehicle shall be prima facie [first face or accepted as correct until proved otherwise] evidence that said person was operating the vehicle at the time of the violation recorded by a photo traffic enforcement system" (The City of Columbus, Ohio, 2005, Code 2115.03 D). Interestingly, in one of his last official acts as Governor of Ohio, on January 5, 2007, Bob Taft vetoed Ohio House Bill 56 which would have effectively banned the use of RLCs statewide. The state legislators who overwhelmingly supported and passed the bill 72 to 23 were concerned that the camera programs being proposed by local governments across Ohio were in direct conflict with Ohio's Constitutional Home Rule Amendment. Home Rule, added to the Ohio Constitution in 1912, gives local governments the authority to enact their own laws with the exception of many police powers exclusively dictated by and reserved to the state. Specifically, state legislators contested "whether a municipality had the authority to enact civil penalties for the offense of violating a traffic signal" which at the time was historically a criminal offense under the Ohio Revised Code (Mendenhall v. Akron, 2008, p. 2). The key distinctions between civil versus criminal red-light violations include: smaller monetary fines, zero points are assessed to an individual's driving record, violations are not reported to insurance companies, no additional fines are added for multiple citations occurring within one year, and a law enforcement officer need not be present to cite the driver. Contrary to both Ohio House Bill 56 and the will of the Ohio Legislature, Governor Taft's veto was supported and lauded by numerous mayors and city executives throughout Ohio who sought

camera programs of their own. The issue came to a close on January 31, 2008 when the Ohio Supreme Court (2008, pp. 1-2) ruled in Mendenhall v. Akron that "an Ohio municipality does not exceed its home-rule authority when it creates an automated system for enforcement of traffic laws that imposes civil liability upon violators, provided that the municipality does not alter statewide traffic regulations." After discussing both the introduction and background, one can see the timeliness and potential for essential examination of the Columbus *Focus on Safety* program.

Literature Review

According to the Federal Highway Administration (FHWA), in 2002, one-in-five vehicular crashes and one-in-four of all fatalities and injury collisions occurred at or within signalized intersections (Rodegerdts, 2004). Furthermore, approximately 21 percent of fatalities and 58 percent of injuries to pedestrians occur at intersections (Rodegerdts, 2004). The geometric design of this type of roadway often introduces a unique set of dangers for motorists, pedestrians, and bicyclists alike. For example, most traffic accidents that occur at signalized intersections can be defined as either rear-end or right-angle crashes. Frequently referred to in Ohio as an Assured Cleared Distance Ahead or ACDA crash, rear-end collisions generally occur at intersections when a driver fails to maintain a safe driving distance and follows the vehicle in front of them too closely. Similarly, right-angle or T-bone crashes typically occur at intersections where vehicles from adjacent approaches collide at a 90-degree or right-angle.

In attempt to moderate the dangers inherent in intersections over the years, a multitude of transportation safety advocacy organizations representing all sectors of industry have published numerous guides that focus on ways in which government leaders and managers can improve signalized intersection safety. Repeatedly found within these guidelines are mechanisms that

address and encourage changes in intersection engineering, enforcement, and education. Commonly referred to as the "Three E's," engineering, enforcement, and education constitute the standard treatment for most contemporary traffic safety campaigns; to include the *Focus on Safety* program (Burkey & Obeng, 2002, p. 5). In fact, the words are explicitly delineated within the *Focus on Safety* program's mission statement. In order to fully respect the magnitude of literature that exists on red-light camera (RLC) programs, it is essential to assess the relevant literature that addresses signalized intersection engineering, enforcement, and education within the context of both alleviating red-light running (RLR) and evaluating the effectiveness of RLC programs. Thus, the review of the relevant literature is categorized into three sections:

1. Research on Red-light Running Education Campaigns
2. Research on Red-light Running Engineering Countermeasures
3. Research on Red-light Camera Enforcement Programs

Research on Red-Light Running Education Campaigns

In a small scale study, Tarawneh, Singh and McCoy (1999) examined the effects of a planned public information and education program together with targeted police enforcement in preventing RLR at six, single intersection approaches in Lincoln, Nebraska. They compared the rate of RLR during the yellow and red phases of the traffic signal, before-and-after the implementation of a one month public information and education program. Initiated and sponsored by the FHWA, the City of Lincoln, Nebraska was competitively awarded a RLR grant used for purchasing and distributing campaign materials that were prepared by the FHWA. The campaign materials included broadcast television commercials, radio advertisements, artwork, and several promotional giveaways such as small household trinkets. They concluded that the public information and education program was associated with a significant reduction in drivers' mean entry time into intersections after the onset of the yellow traffic signal phase. It should be

noted however, that the differences between the public information and education program versus the effects of the same campaign combined with targeted police enforcement were determined to be insignificant (Tarawneh, Singh & McCoy, 1999).

In a larger study of 5,024 telephone survey respondents nationwide, Porter, Berry and Harlow (1999) asked 58 questions pertaining to driver behavior and various ideas for preventing RLR in order to provide data for the national *Stop Red-light Running Week* in September of 1999. Most interestingly, the number two response offered by participants to change driver behavior and reduce RLR was the need for more and ongoing driver improvement clinics and education campaigns highlighting and addressing the adverse consequences of RLR. Moreover, 55.8 percent of respondents admitted having run red-lights while more than 20 percent of those surveyed claimed to have no ideas to combat RLR (Porter, Berry & Harlow, 1999).

In a review of the research literature, the IIHS (2001) noted that there are a few instances when publicity and traffic safety education alone can be effective in changing motorists' behavior. For example, when the messages are aimed at adults that have something tangible at stake–such as associating an individual's driving privilege with their livelihood and ability to provide for their family–education campaigns alone can work. Oftentimes, knowledge is not enough because all drivers understand it is illegal to run red-lights, yet the issue persists as a leading cause of intersection fatalities. As such, according to the IIHS, the most effective methods for changing driver behavior combines high-stakes traffic safety laws with publicity and education campaigns (IIHS, 2001).

Research on Red-Light Running Engineering Countermeasures

Yan, Radwan, Guo and Richards (2009) examined the impact of "Signal Ahead" pavement markings on traffic light compliance and traffic safety at intersections in a simulator-

based environment. Their objective was to determine whether a pavement marking countermeasure could assist in reducing the dilemma zone motorists often encounter at the onset of the yellow light. As defined by the Maryland State Highway Administration, given a roadway's prevailing speed if the time a driver needs to stop is greater than the yellow light signal time, then a dilemma zone exists. As a result, a driver may hesitate when deciding whether to abruptly stop or move more quickly through an intersection. This study concluded that there were substantial and positive safety benefits associated with "Signal Ahead" pavement markings which include: lower decelerating rates for stopping motorists at higher speed limit intersections, lower incidences of RLR, as well as reductions in both hasty-stop and the more dangerous-go spilt second decisions (Yan, Radwan, Guo & Richards, 2009, pp. 50-67).

In their landmark study, "Changes in Crash Risk Following Re-timing of Traffic Signal Change Intervals," Retting, Chapline and Williams (2002) found that setting "the duration of traffic signal change intervals to" the recommended values dictated by the Institute of Transportation Engineers (ITE) significantly increased intersection safety (p. 216). This suggests that lengthening yellow light timing to help vehicles avoid the dilemma zone and the addition of brief, all red-light intervals at intersections would allow roadways to fully clear. They measured vehicular, pedestrian, and bicycle crash rates at 122 randomly assigned intersections. For the three year period following the re-timing of the traffic signals to the prescribed ITE standards at 40 of the total 51 treatment sites, they found an eight percent reduction in vehicular crashes, a 12 percent reduction in injury collisions, and a 37 percent reduction in both pedestrian and bicycle crashes relative to the control sites. Further, the authors suggested additional countermeasures and remedies known to be positively associated with safer intersections, such as installing larger traffic light lenses and brighter signals, adding additional

signal heads, and repositioning the overhead static traffic control devices to provide drivers optimum vantage and limit sight distance restrictions (Retting, Chapline & Williams, 2002).

Retting, Williams and Greene (1998) in an analysis of previously published data reported that the removal of unnecessary traffic signals at intersections with low traffic volumes can reduce both vehicle collisions and injuries. Such low-volume intersections are more likely to be found in smaller urban and rural areas. Based on a review of the literature, the authors estimate when less busy signal controlled intersections are converted to a stop sign, overall crash rates are reduced by about 24 percent. Conversely, installing traffic signals at awkward intersections where traffic volumes vary irregularly and sight distance or blind spot restrictions exist can increase traffic safety as well (Retting, Williams & Greene, 1998).

Retting, Persaud, Garder and Lord (2001) looked at vehicular crash, fatality, and injury rates at 24 signal and stop sign controlled intersections before-and-after their conversion to roundabouts. Their objective was to determine the usefulness of roundabouts for city planners and transportation engineers as an alternative to traditional intersections. They concluded that roundabouts are associated with a large and significant reduction in collisions, fatalities, and injuries because there are fewer points where motorists can collide with each other and when they do, the accidents are less severe as vehicles tend to sideswipe each other as opposed to the more dangerous angle crash. Specifically, the authors noted reductions of 38 percent for all injury collisions, while a 90 percent decrease was noted in both fatal and incapacitating injury accidents (Retting, Persaud, Garder & Lord, 2001). While the fixed cost of a roundabout varies widely and is dependent on a project's scale and scope, the variable costs are often cheaper than signalized intersections over the long run as they require less operational and maintenance attention.

In a three year study of *Random Road Watch*, a traffic policing program which randomly assigned low levels of police enforcement in two-hour increments across Queensland, Australia's road network in order to provide maximum law enforcement coverage, Newstead, Cameron and Leggett (2001) noted that there was a 31 percent decrease in fatal crashes across the monitored area. However, while the severity of vehicle collisions declined over time their overall incidence increased after the program's implementation. The moderate or low level targeted police enforcement campaigns such as *Random Road Watch* is preferred and recommended over the more high intensity "blitz" approaches because resources can be expended at levels that can be sustained by local governments in the long run (Newstead, Cameron & Leggett, 2001, pp. 393-406).

Research on Red-Light Camera Enforcement Programs

Shin and Washington (2007) examined the impact of RLCs on safety in Arizona. The authors compared the change in crashes for RLC intersections in two Arizona cities, Phoenix and Scottsdale. Twenty-four RLC intersections in both cities were examined and the authors differentiated between "all approaches" and "target approaches" at each intersection. For illustration, at a traditional four-way intersection if only one of the possible four approaches was monitored by camera, then that approach was considered the "target approach" while the other three were categorized as "all approaches" or "non-target approaches." Using a before-and-after study, they found that RLCs reduced the frequency of angle (both left- and right-angle) collisions at both target and non-target approaches however, the rate of rear-end crashes showed some increase. The authors presumed the increase in rear-end crashes was due to motorists breaking abruptly in attempt to avoid receiving a traffic citation and subsequent fine. In addition, although the rate of rear-end crashes increased their severity was reduced as a result of the RLCs.

That is, there were more property damage only rear-end collisions and less fatality or injury collisions after the cameras installation. Further, the authors tested whether any spillover or halo effects occurred by testing the impact of target approaches on safety at adjacent non-target approaches. Shin and Washington concluded that the Scottsdale non-target approaches exhibited effects almost equal in degree to the Scottsdale target approaches impact. However, halo effects in Phoenix were not statistically significant. Furthermore, in an economic analysis the authors estimated the annual mean economic-savings in crash benefits in Scottsdale were $1,520,594, while the increase in rear-end crashes and property damage resulted in an annual mean net loss of $320,332 for Phoenix (Shin and Washington, 2007, pp. 1212-1221). An area for future examination could test whether there is a negative halo effect where motorists avoid RLC enforced intersections and more heavily use others in attempt to avoid being ticketed. For example, companies such as "GPS Angel" have developed and sell legal and updateable dashboard-mounted detectors which alert drivers of nearby RLC locations (http://gpsangel.com).

In a Scottish Office Home and Health Department sponsored study to examine the effects of RLCs on traffic signal compliance, the MVA Consultancy (1995) measured the level of compliance with traffic signals before-and-after the adoption of RLCs at six camera sites and six control sites in Strathclyde, Scotland from September 1991 to September 1994. They found that the total number of infringements or traffic signal violations fell by approximately 69 percent at the treatment sites and 37 percent at the control sites. In addition, they reported a "substantial reduction in the number of infringements which occurred more than 0.5 seconds into the" onset of the red signal phase suggesting the cameras encouraged drivers to stop while in the dilemma zone (p. 23). In addition, both accident rates and driver non-compliance were reduced at the

camera sites and at intersections immediately "upstream and downstream of the camera sites" which is evidence of the halo effect (MVA Consultancy, 1995, pp. 1-26).

In one of the most widely publicized studies of RLCs, "Evaluation of Red-light Camera Enforcement in Oxnard, California," Retting, Williams, Farmer and Feldman (1999) evaluated the before-and-after impact of RLCs on RLR violation rates at 14 intersections. They found that drivers' compliance with red-lights increased at both the RLC and non-RLC intersections, and the combined RLR violation rate decreased by 42 percent. In addition, the authors examined Oxnard residents' support of RLCs as a supplement to law enforcement in a public opinion survey. They found that 80 percent of Oxnard residents supported the automated enforcement of traffic signal laws in conjunction with traditional law enforcement. This relationship was found to remain even after controlling for demographic and confounding variables (Retting, Williams, Farmer & Feldman, 1999).

In a second Oxnard, California-based study, Retting and Kyrychenko (2002) this time evaluated the before-and-after impact of a RLR camera system on RLR crash rates at both signalized and non-signalized intersections in four similar California cities: Santa Barbara, San Bernardino, Bakersfield, and Oxnard. These cities shared similarity across contexts and individuals meaning the cities themselves and their respective drivers. For example, all were California cities which shared similar weather, traffic rules and regulations, fuel prices, and economic conditions. They found that overall crashes at signalized intersections were reduced by seven percent, while a 29 percent decrease was noted in collisions involving an injury. In addition, for right-angle crashes there was a statistically significant 32 percent reduction, as well as a significant 68 percent decrease in right-angle crashes involving an injury (Retting and Kyrychenko, 2002).

In sum, the public safety and economic significance of RLR is clear. It is an ongoing and practical problem that relates to a wide population and the human and material costs of RLR are tremendous, and more often than not, entirely avoidable. These findings may help government leaders and managers mitigate or prevent their causes and thus make cities as a whole safer to drive in. RLR public information and education programs combined with high-stakes consequences are effective. In addition, many low cost countermeasures can address and discourage RLR, such as pavement markings, properly positioned and calibrated traffic lights, and the removal or installation of appropriate traffic signals. More expensive and longer term measures exist as well, such as constructing roundabouts as alternatives to traditional intersections and funding moderately leveled and sustainable targeted police enforcement campaigns. Driving is a privilege, not a right. Yet, RLR is a public health problem and its true economic cost is difficult to collect from those who violate the law. As a result, 25 states and 556 cities and municipalities have passed legislation and implemented RLC programs across the country. This type of automated enforcement technology is positively associated with significant reductions in RLR crash, fatality, and injury rates. In addition, the RLCs have been shown to influence driver behavior, increase traffic signal compliance, alleviate the dangers of the dilemma zone, and improve intersection safety at nearby non-RLC intersections. Moreover, the public has encouraged and supported RLC programs in the cities where they have been established.

Methods

In order to help government leaders and managers better understand and evaluate the impact of red-light running, this paper seeks to examine the effects of the Columbus, Ohio *Focus*

on Safety red-light camera enforcement program on influencing driver behavior and improving intersection safety. The evaluation questions are:

1. **What impact has the *Focus on Safety* program had on the rate of intersection-level red-light running violations, crashes, and crash types in the City of Columbus, Ohio?**

2. **What impact has the *Focus on Safety* program had on the rate of citywide intersection crash, crash type, and crash severity rates in Columbus?**

The preliminary research hypotheses suggest that:

H_1: The Focus on Safety program is associated with (a) lower rates of intersection-level red-light running violations, (b) fewer crashes, and (c) different crash types.

H_2: Lower rates of citywide intersection crash, crash type, and crash severity are associated with the Focus on Safety program.

In one before-and-after evaluation with a nonequivalent comparison group with repeated treatment, changes in both the number and type of motor vehicle crash rates were evaluated in Columbus and Cincinnati, Ohio. Likewise in a trend analysis, changes in both the number and type of motor vehicle crash and crash severity rates were evaluated in Columbus and Cincinnati. In a second trend analysis, changes in both the number and type of red-light running (RLR) violation rates were evaluated in Columbus alone. A city red-light camera (RLC) ordinance took effect in Columbus in October 2005, permitting the Columbus Department of Public Safety to implement the *Focus on Safety* program. RLC site selection was based on two criteria: the ranking of dangerous intersections with high incidences of right-angle crashes and camera constructability (Brown, 2009). The first two RLCs were activated on March 7, 2006 and the last two of the combined 20 cameras evaluated were activated December 31, 2007 (See Appendix A, Table 11 for intersection location dates of camera activation). Once the camera pole, camera, and flash are installed and connected to the in-ground flush mount sensor, they are connected to the signalized intersection traffic control device. When a vehicle passes over the

in-ground sensor with sufficient speed after the light has turned red multiple digital photos and a 12-second video is taken capturing the violation and rear license plate. Under this city ordinance, a vehicle owner is presumed to be the driver and is charged with a civil traffic violation (The City of Columbus, Ohio, 2005, Code 2115.03 D). Under Ohio law, civil traffic violations issued through automated programs such as the *Focus on Safety* program carry very different and less severe monetary fines and driver's license sanctions as those resulting from conventional law enforcement (Mendenhall v. Akron, 2008, p. 2).

As required by statute, a 30-day warning period, during which RLCs captured violators but no notices of liability were issued, preceded each of the 20 RLCs' enforcement in Columbus. "Red-light Photo Enforced" signage advising motorists of the automated enforcement of traffic signals were posted at every approach of the 18 monitored intersections where 20 cameras were installed (See Title Page for actual signage photograph) (The City of Columbus, Ohio, Code 2115.03 A & B). In addition, a public information and education campaign was produced and broadcasted to inform citizens and drivers of the new program. Actual enforcement and the issuing of civil traffic citations began in April 2006. Of approximately 15,000 intersections in Columbus, 1,008 are signalized and 20 were equipped with RLCs. At all but two of the camera locations, only one of the typical four approaches to an intersection was RLC enforced while two intersections had two cameras monitoring both directions of travel respectively.

Controls and Data

One proximally situated Ohio City that did not implement RLC enforcement during the study period was used as a comparison group to control for potentially confounding factors that might affect both the frequency and type of motor vehicle crash and crash severity rates. Cincinnati was selected because the distance between Columbus and Cincinnati, approximately

110 miles, is close enough as to expect similar patterns of variance associated with external factors such as weather, gasoline prices, economic conditions, and statewide traffic laws. In addition, because Cincinnati does not have RLCs whatsoever and is more than 100 miles away, it is unlikely that the *Focus on Safety* program affected driver behavior in Cincinnati. Further, the 18 experimental intersections in Columbus are closely matched to the 10 comparison intersections in Cincinnati in terms of their levels of hazard. The Cincinnati City Council considered implementing a RLC program of their own in 2005 and designated the 10 comparison intersections as problematic and suitable for camera enforcement based on discussions with Cincinnati police and an accident frequency analysis (See Appendix A, Table 12 for the 10 Cincinnati comparison group intersection locations) (Osborne, 2005, p. A1).

Crash data for the two cities were obtained from the Ohio Department of Public Safety's (ODPS) statewide *Crash Statistics* database, the City of Columbus Department of Public Service, and the City of Cincinnati Police Department. Signal violation data were obtained from Redflex Traffic Systems (Redflex). Citywide crash, crash type, and crash severity rates were analyzed for sixty-four days preceding camera enforcement (January 1, 2006 to March 6, 2006) and for more than 57 months of enforcement (March 7, 2006 to December 31, 2010). Intersection-level crash and crash type rates were analyzed for 12 months preceding camera enforcement (January 1, 2005 to December 31, 2005) and for 12 months of enforcement (January 1, 2008 to December 31, 2008). Redflex RLR violation type and rates were evaluated for a period ranging from 2,048 to 1,384 days (March 7, 2006 and December 31, 2007 to October 14, 2011 respectively). In sum, the three analyses conducted were:

1. RLR Violation Type and Rates GIS Trend Analysis
2. Citywide Level Crash, Crash Type, and Crash Severity Rates Trend Analysis
3. Intersection-Level Crash and Crash Type Rates Before-and-After Study

RLR Violation Type and Rates GIS Trend Analysis

The impact of RLC programs are often evaluated by the local government agencies that manage them through the use of descriptive statistics and trend analysis. This type of simple and less formal examination monitors the changes in univariate data as a function of time and a program's implementation. This subsection details all contextual statistics related to the *Focus on Safety* program RLR violation data used in this trend analysis. Data from a combined 237,727 Columbus RLR violation records were obtained from Redflex's *SMARTops Online Reports–Redlight Offender Report* database for a period ranging from 2,048 to 1,384 days of enforcement. The following variables were included in the *Focus on Safety* program's RLR violation dataset: time into red by seconds; hour of the day; day of the week; RLC intersection location; RLC intersection location Redflex code; and dates when the violations occurred. Summary statistics and a geographic information systems spatial distribution trend analysis will be used to display and discuss the frequencies and percentage of RLR violations as a function of time and RLC activation by time elapsed since the red-light onset; violations by time of day; violations by day of week; and a six year daily average and annual analysis of RLR violation rates at each of the 18 original *Focus on Safety* intersections.

RLR violation rates are examined in Columbus alone as these data were not available for Cincinnati. As a result, without a control or comparison group, this paper's RLR violation type and trend analysis cannot be attributed to the *Focus on Safety* program or the treatment of RLCs. However, it stands to reason that intersection safety will have been improved if there is a decrease in RLR violations. It was hypothesized that lower rates of intersection-level red-light running violations are associated with the *Focus on Safety* program. Table 1 displays a distribution of these data and their collection periods by camera site location as the City of

Columbus and Redflex did not install all of the 20 RLCs at the same time, while Figure 2 illustrates the comparative location of these 18 intersections in the City of Columbus (See Appendix A, Figure 10 for a uniquely different map detailing the same camera locations). It was hypothesized that lower rates of intersection-level red-light running violations are associated with the *Focus on Safety* program. If overall violation rates decrease, then one concludes that the *Focus on Safety* program is effective. Such results would confirm the hypothesis. Conversely, if overall violation rates increase, then one concludes that the *Focus on Safety* program evidence is inconsistent with the hypothesis. Such results would reject the hypothesis.

Table 1: Distribution of Red-Light Violation Records and their Collection Period [2]

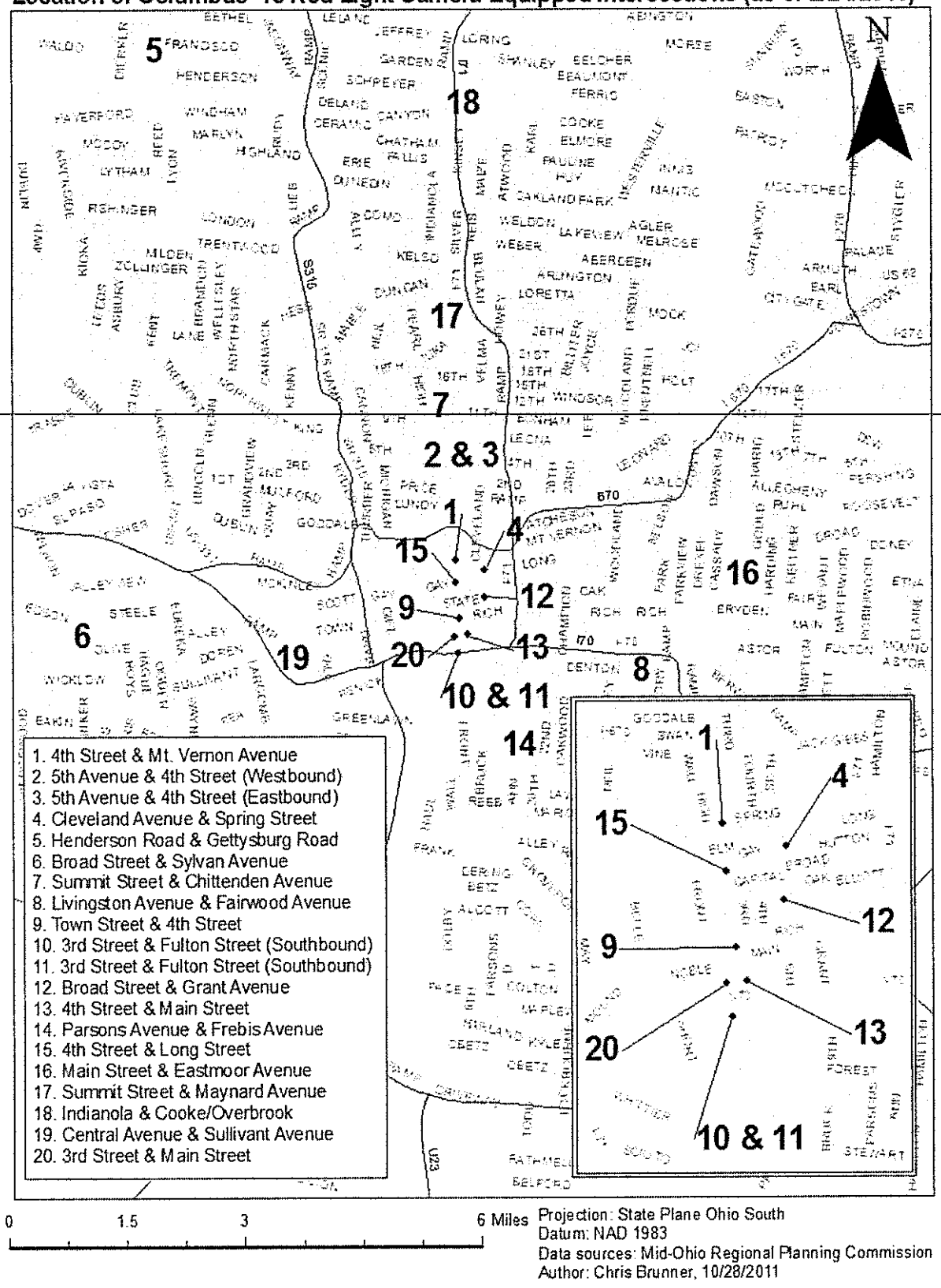
Red-light Camera Enforced Intersection	No. of Red-light Violation Records	Date of the First Violation Record	Date of the Last Violation Record
4th Street & Mt. Vernon Avenue	26,738	3/7/2006	10/14/2011
5th Avenue & 4th Street (Westbound)	9,674	3/7/2006	10/14/2011
5th Avenue & 4th Street (Eastbound)	15,665	3/8/2006	10/14/2011
Cleveland Avenue & Spring Street	25,713	6/14/2006	10/14/2011
Henderson Road & Gettysburg Road	7,118	9/1/2006	10/14/2011
Broad Street & Sylvan Avenue	9,547	9/1/2006	10/14/2011
Summit Street & Chittenden Avenue	11,469	9/30/2006	10/14/2011
Livingston Avenue & Fairwood Avenue	13,537	10/18/2006	10/14/2011
Town Street & 4th Street	11,072	2/1/2007	10/14/2011
3rd Street & Fulton Street (Southbound)	11,195	2/1/2007	10/14/2011
3rd Street & Fulton Street (Southbound)	6,357	2/1/2007	10/14/2011
Broad Street & Grant Avenue	5,027	2/27/2007	10/14/2011
4th Street & Main Street	15,965	10/4/2007	10/14/2011
Parsons Avenue & Frebis Avenue	10,674	10/4/2007	10/14/2011
4th Street & Long Street	12,263	10/8/2007	10/14/2011
Main Street & Eastmoor Avenue	7,752	11/1/2007	10/14/2011
Summit Street & Maynard Avenue	7,065	11/1/2007	10/14/2011
Indianola & Cooke/Overbrook	5,033	11/21/2007	10/14/2011
Central Avenue & Sullivant Avenue	20,863	12/31/2007	10/14/2011
3rd Street & Main Street	5,000	12/31/2007	10/14/2011
Total	237,727	***	***

Source: Redflex Traffic Systems (2011).

[2] *Note.* Table 1: Distribution of Red-Light Violation Records and their Collection Period. Adapted from Analysis of red-light violation data collected from intersections equipped with red-light photo enforcement cameras (p. 13), by United States & J. A. Volpe, 2006, Washington, D.C: U.S. Dept. of Transportation, National Highway Traffic Safety Administration. Copyright 2006 by the National Highway Traffic Safety Administration. Adapted without permission.

Figure 2:

Location of Columbus' 18 Red Light Camera Equipped Intersections (as of 2/24/2011)



Projection: State Plane Ohio South
Datum: NAD 1983
Data sources: Mid-Ohio Regional Planning Commission
Author: Chris Brunner, 10/28/2011

Citywide Impact Trend Analysis

To evaluate the impact the *Focus on Safety* program has had on intersection crash and crash severity rates in Columbus, Ohio, intersection crashes in both Columbus and Cincinnati were divided into two types, angle and rear-end. Because the Columbus Department of Public Safety and Redflex did not install all of the RLCs at the same time, the distribution of crashes for these periods would be to some degree affected by seasonal variations; however, these disparities were not expected to bias estimates of the effect of RLCs as the statistical models utilized identical time periods for both Columbus and Cincinnati and for crash type as well as crash severity.

Changes in citywide crash, crash type, and crash severity rates before and during enforcement were compared for Columbus and Cincinnati. Utilizing the ODPS' *Crash Statistics* database, two parameterized reports were queried for each year 2006, 2007, 2008, 2009, and 2010. Two types of multiple vehicle crashes rear-end and angle, were defined by means found on the Ohio Traffic Crash Report (Form OH-1). The OH-1 Form is the standardized and mandatory incident report used by police officers statewide at the scene of each accident. As required by statute, these crash report forms are scanned, uploaded, and read onto the ODPS' *Electronic Crash Submission* database annually by reporting law enforcement agencies (Ohio Revised Code, Section 5502.01). Angle crashes, expected to be reduced by RLCs, were queried by means of OH-1 codes as angle collisions involving two or more vehicles at four-way, T-, and Y-intersections and attributed to traffic signal non-compliance (ran red-light or stop sign). Likewise rear-end collisions, which might increase due to motorists stopping more abruptly at RLC enforced intersections to avoid being ticketed, were defined and retrieved by means of OH-1 codes as rear-end collisions involving two or more vehicles at four-way, T-, and Y-

intersections though not attributed to RLR specifically. Crash statistics were generated using the respective Columbus and Cincinnati National Criminal Information Center law enforcement agency codes.

While the methodology used in this trend analysis is quite stringent, accurately estimating the safety impact of RLCs is challenging for several reasons. First, consider the availability and quality of data used in the Citywide Impact Trend Analysis. McGee and Eccles (2003) noted "the quality of crash data used will directly affect the quality of any findings of the evaluation" (p. 30). For example, the secondary data used in this evaluation came from the ODPS' *Crash Statistics* database rather than from the original OH-1 Traffic Crash Report Forms. As a result, errors could have occurred when the reporting law enforcement agencies transferred the data from the OH-1 Forms into ODPS' *Electronic Crash Submission* database. Second, albeit with good intentions, the quality of objective police report-writing remains an issue. For instance, crashes can be attributed to intersections or RLR when they are not intersection related or when no violation has been committed. In addition, the documented manner of collision and severity type can be erroneous and misleading. It was hypothesized that lower rates of citywide intersection crash, crash type, and crash severity are associated with the *Focus on Safety* program. If overall citywide intersection crash, crash type, and crash severity rates decrease, then one concludes that the *Focus on Safety* program is effective. Such results would confirm the hypothesis. Conversely, if overall citywide intersection crash, crash type, and crash severity rates increase, then one concludes that the *Focus on Safety* program evidence is inconsistent with the hypothesis. Such results would reject the hypothesis.

Intersection-Level Impact Before-and-After Study

To evaluate the impact the *Focus on Safety* program has had on crash rates at intersection approaches equipped with cameras in Columbus, Ohio, intersection crashes were characterized into two types, angle and rear-end, while intersection crashes in Cincinnati were distinguished by severity, such as fatality, injury, property damage only (PDO), and unknown. Because the Columbus Department of Public Service aggregates crash rates by type and the Cincinnati Police Department aggregates crash rates by severity, it is assumed for the purposes of this evaluation that unknown and PDO crashes are more likely associated with rear-end crashes, while injury and fatal crashes are generally associated with the more severe angle collisions. For example, utilizing the Citywide Impact Trend Analysis data, a five year frequency distribution of the Cincinnati crash severity rates by crash type is shown in Table 2.

Table 2: Five Year Distribution of Cincinnati Crash Severity Rates by Crash Type (2006-2010)

Severity Type	Number of Rear-End Crashes	Rear-End Crashes Percent of Distribution	Number of Angle Crashes	Angle Crashes Percent of Distribution	Total Crashes	Cumulative Percent
Fatal	1	0.02%	4	0.11%	5	0.05%
Injury	1,062	18.47%	1,062	29.8%	2,124	22.9%
Property Damage Only	4,666	81.13%	2,491	69.87%	7,157	76.82%
Unknown	22	0.38%	8	0.22%	30	0.32%
Total	5,751	100%	3,565	100%	9,316	100%

Source: Ohio Department of Public Safety (2011).

A total 0.11 percent of fatal and 29.8 percent of injury crashes were associated with angle crashes, whereas just 0.02 percent of fatal and 18.47 percent of injury crashes were attributed to rear-end collisions. Likewise, a total 81.13 percent of PDO and 0.38 percent of unknown crashes were associated with rear-end crashes, while just 69.87 percent of PDO and 0.22 percent of unknown crashes were attributed to angle collisions. Therefore, the assumptions that unknown and PDO crashes are more likely associated with rear-end crashes, while injury and fatal crashes

are generally associated with the more severe angle collisions are reasonable, justified, and consistent with the secondary data used in the Citywide Impact Trend Analysis. This methodology, similar to the citywide data evaluation, compares the changes in intersection crash and crash type rates at the 18 Columbus treatment and 10 Cincinnati comparison intersections for a period of 12 months both before-and-after enforcement.

Regression Model

One Difference-in-Differences (DinD) regression model was developed to evaluate and compare the different periods in a simple before-and-after study. If the total crash and specific crash type rates for the 18 treatment and 10 comparison intersections are found to be Poisson distributed, the mean equals the variance. As a result, the percent decrease and the standard deviation of the decrease can be calculated between the before-and-after time periods in a simple before-and-after evaluation. The model used the natural logarithm of crash counts as the dependent variable (intersection_crashcount). Independent variables were city (Columbus and Cincinnati), angle type (rear and angle), and period (pre and post). One interaction variable of Columbus times Post was included as collision tendencies were dissimilar in the two cities due to factors such as population, land area, miles of roadway, average daily traffic counts, traffic signal timing, signage, etc. Analysis of variance was used to determine statistical significance. This model can be estimated by the following equation, Equation 1.

Equation 1: Intersection-Level Crash and Crash Type Rates Before-and-After Study

- $ln^{\Delta}\textbf{intersection\_crashcount}_t = \alpha + \beta 1\textbf{Columbus}_t + \beta 2\textbf{rear}_t + \beta 3\textbf{post}_t + \beta 1\textbf{Columbus}_t * \beta 3\textbf{post}_t + \textbf{e}$

Where intersection_crashcount is the percent reduction of total crash and specific crash type as a function of the dummy variable Columbus (Columbus = 1 and Cincinnati = 0); the dummy

variable rear (rear = 1 and angle = 0); the dummy variable post (post = 1 and pre = 0); and the interaction variable, Columbus times Post. The units of analysis are 18 Columbus and 10 Cincinnati intersections and the years included in the analysis are 2005 and 2008. It was hypothesized that lower rates of intersection-level crash and crash type are associated with the *Focus on Safety* program. If the directionality of the relationship between any of the explanatory variables and intersection_crashcount decreases, then one concludes that the *Focus on Safety* program is effective. Such results would confirm the hypothesis. Conversely, if the directionality of the relationship between any of the explanatory variables and intersection_crashcount increases, then one concludes that the *Focus on Safety* program evidence is inconsistent with the hypothesis. Such results would reject the hypothesis.

The dummy variable Columbus was included in the regression to capture whether the set of intersections was in Columbus. The dummy variable rear was included in the regression to capture whether the crash was an angle or rear-end collision. The dummy variable post was included in the regression to capture whether or not the crash counts were before or during enforcement. Finally, the interaction variable Columbus times Post was included as crash tendencies were different in the two cities.

While the methodology used in this model is quite rigorous, the estimated regression fails to include all of the relevant variables. Previous literature has shown that both crash data and supporting data–such as population, land area, traffic signal timing, miles of roadway, and average daily traffic count–are associated with driver behavior and intersection safety. In addition, the secondary data used in this evaluation were collected and aggregated by Cities of Columbus and Cincinnati personnel. As a result, albeit with good intentions, these data are subject to some observer error and thus uncertainty. Prior to performing any regression analysis,

various statistical analyses were conducted to examine the individual variables. First, descriptive statistics were performed in order to analyze the model to find the most appropriate fit for these data. Already described in detail above, these data are illustrated in Table 3 below.

Table 3: Descriptive Statistics for the Intersection-Level Impact Before-and-After Study Dependent and Independent Variables Used

Variables	Observations	Mean	Standard Deviation	Range (Min-Max)
intersection_crashcount	112	2.26	2.87	0-12
Columbus	72	1.63	1.84	0-8
Cincinnati	40	3.4	3.9	0-12
angle	56	1.85	2.15	0-8
rear	56	2.66	3.41	0-12
pre	56	2.71	2.86	0-12
post	56	1.8	2.83	0-12
Columbus * Post	112	.321	.469	0-1

Source: Cincinnati Police Department & Columbus Department of Public Service (2011).

An analysis of the correlation of independent variables to the dependent variable was also undertaken. A high correlation however was not found amongst these variables. In addition, a test for multicollinearity was performed. The variance inflation factor was found to be 2.4, meaning that no evidence of multicollinearity was found. In terms of heteroscedasticity, Allison (1999) stated that "if the sampling method involves any kind of clustering...the possibility of correlated disturbances should be seriously considered" which is the case in this regression's sample (p. 129). Thus, to assist in detection of heteroscedasticity, the Breusch-Pagan test was utilized, while the White's test was used to check for homoscedasticity. Based on the White's test, no evidence of homoscedasticity was found as the p-value was greater than .05. However, the Breusch-Pagan test showed the chi-square value to be 31.67 with a p-value of 0. As a result, the robust function was deployed in the Intersection-Level Impact Before-and-After Study regression equation to address the issue of heteroskedasticity. Finally, the Poisson goodness of fit was used to find the most appropriate fit for these data. The Poisson goodness of fit showed the chi-square value to be 293.5322 with a p-value of 0. This suggests that there was over-

dispersion, meaning that the variance for the dependent variable intersection_crashcount was much greater than the mean. As a result, the negative binomial model was used to estimate the Intersection-Level Impact Before-and-After Study (See Appendix A, Figure 9 to compare the fit for Poisson versus the negative binomial model). The results of further statistical and regression analyses performed in this policy/management paper are discussed in the following section.

Results

In order to help government leaders and managers better understand and evaluate the impact of red-light running (RLR), this paper examined the effects of the Columbus, Ohio *Focus on Safety* red-light camera (RLC) enforcement program on influencing driver behavior and improving intersection safety. One Difference-in-Differences (DinD) regression analysis was conducted to provide evidence regarding the relationship between the program and various intersection traffic safety outcome variables before-and-after enforcement. Similar to the citywide data evaluation, the DinD regression compared the changes in intersection-level crash and crash type rates at 18 Columbus treatment and 10 Cincinnati comparison intersections for a period of one year before-and-after enforcement (2005 & 2008). In addition, the DinD regression results were preceded by summary statistics that present the frequency rates and distribution over time for the secondary data used in the regression. Next, a trend analysis was performed by examining the frequency and distribution of both cities' crash numbers, crash type, and crash severity rates for a period ranging five years (2006 to 2010). Lastly, a trend analysis and geographic information systems (GIS) spatial distribution trend analysis were conducted by examining the frequency and distribution of RLR violation rates at the 18 Columbus treatment intersections for a period ranging from 2,048 to 1,384 days.

Two hypotheses drawn from the research on RLR education campaigns, RLR engineering countermeasures, and RLC enforcement programs are outlined below and will guide the presentation of the Intersection-Level Impact Before-and-After Study, the Citywide Impact Trend Analysis, and the RLR Violation Type and Rates GIS Trend Analysis.

H_1: The Focus on Safety program is associated with (a) lower rates of intersection-level red-light running violations, (b) fewer crashes, and (c) different crash types.

H_2: Lower rates of citywide intersection crash, crash type, and crash severity are associated with the Focus on Safety program.

Intersection-Level Impact Before-and-After Study

Summary statistics are used to examine the relationship between total crashes by crash type before-and-after enforcement. In addition, a negative binomial regression was run to examine the relationship between the *Focus on Safety* program and intersection-level crash and crash type rates before-and-after the RLC treatment. These analyses serve to test the first hypothesis detailed above, H_1b and H_1c. The results are depicted in Tables 4 and 5 below.

Table 4: Columbus & Cincinnati 2005/2008 Intersection-Level Total Crashes by Crash Type Before-and-After Enforcement and Its Estimated Effects

Measure	Before	After	Percent Change
Columbus			
Angle	54	14	-74.07
Rear-End	28	21	-25
Columbus Total	82	35	-57.31
Cincinnati			
Angle	19	17	-10.52
Rear-End	51	49	-3.92
Cincinnati Total	70	66	-5.71

Source: Cincinnati Police Department & Columbus Department of Public Service (2011).

As shown in Table 4, while the summary statistics are consistent with findings in other regions, some dispute the findings of earlier work. The model found a total 74.07 percent decrease in angle and a 25 percent decrease in rear-end crashes associated exclusively with the treatment intersections and the *Focus on Safety* program, relative to a 10.52 percent decrease in angle and a 3.92 percent decrease in rear-end crashes at the 10 Cincinnati comparison intersections. In addition, Columbus experienced a combined before-and-after decrease from 82 to 35 crashes or 57.31 percent less, while Cincinnati experienced a combined before-and-after decrease from 70 to 66 crashes or 5.71 percent less. Interestingly, these findings dispute the findings of Shin and Washington (2007) who found that the rate of rear-end crashes increased in Phoenix and Scottsdale, Arizona by 20 and 41 percent respectively after the introduction of RLCs.

Table 5: Columbus & Cincinnati 2005/2008 Intersection-Level Crash Count Incidence Rate Ratios and Odds Ratios for Total Crash and Crash Type

Variables	Intersection-Level Crash Count IRR†	95% CI†	Odds Ratios
Columbus	0.705 (.2000)	.4045, 1.22	-29.5 [-1.23]
Rear	1.348 (.2835)	.8923, 2.03	34.8 [1.42]
Post	0.940 (.3189)	.4838, 1.82	-6 [-0.18]
Columbus * Post	0.432* (.1916)	.1811, 1.03	-56.8* [-1.89]
Observations	112		
Wald chi-square (4)	21.25		
p-value > chi-square	0.0003		

Robust standard errors in parentheses†
Robust z statistics in brackets
*** p<0.01, ** p<0.05, * p<0.1

† IRR, incidence rate ratio; CI, confidence interval
Source: Cincinnati Police Department & Columbus Department of Public Service (2011).

NO COP, NO STOP?

The Equation 1, negative binomial regression results detailed in Table 5 provide further insight into the impact of the *Focus on Safety* program in meeting its stated objectives of improving intersection safety by influencing driver behavior and reducing RLR. To ease interpretation, all coefficients, standard errors, and confidence intervals were exponentiated and were presented in incident rate ratio (IRR) form, that is, exponentiate(β). While all of the results are consistent with those found in earlier studies, it is clear there are limitations to this analysis. As such, areas for future examination will be discussed as well. The interaction variable Columbus times Post was the single variable found to be statistically significant in the DinD regression model. This interaction variable calculated the change in crash rates for both the 18 Columbus treatment and 10 Cincinnati comparison intersections, and then calculated the simple difference before-and-after the program's implementation by subtracting the simple difference of the treatment group from the comparison group. This is the parallel trend assumption and accounts for the counterfactual or what would have happened in the program's absence.

The IRR for the interaction of city and period (Columbus times Post) is 0.432. This indicates that the relative rate of crashes at Columbus intersections post-program as compared to Columbus intersections pre-program is 0.432. This means for every one additional crash experienced at a Columbus intersection in the pre-period, Columbus *Focus on Safety* intersections experienced on average 0.43 crashes in the post-period, all else constant. In addition, the regression output indicates that the odds of a motorist being involved in a crash at one of the 10 Cincinnati intersections are approximately 56.8 percent greater than the odds of a driver experiencing a crash at one of the Columbus intersections, all else equal. This result was statistically significant at the 0.1 percent level however, the p-value equaled 0.059 and the sample size was small, so it fell just shy of significant at the 0.05 percent level. This suggests the

true effect could easily be significant and future research on the topic should be done. Taken together, the results in Tables 4 and 5 confirm the hypothesis (H_1b and H_1c) that the *Focus on Safety* program is associated with lower rates of intersection-level crashes as well as lower rates of different crash types.

Citywide Impact Trend Analysis

An annual trend analysis was performed to examine the frequency and distribution of citywide crash, crash type, and crash severity rates from 2006 to 2010. These descriptive and bivariate results serve to test the second hypothesis detailed above, H_2. The results are depicted in Table 6 and Figure 3 below.

Table 6: Citywide Crash, Crash Type, and Crash Severity Rates Annual Trend Analysis

Measure	2006	2007	2008	2009	2010
Columbus Angle					
Fatal	3	1	2	1	4
Injury	470	470	388	373	399
PDO [a]	661	561	645	524	531
Unknown	32	38	34	33	4
Total Angle	1,166	1,070	1,069	931	938
Columbus Rear-End					
Fatal	0	0	1	1	1
Injury	913	897	801	782	847
PDO	2,511	2,571	2,423	2,425	2,462
Unknown	148	110	124	83	15
Total Rear-End	3,572	3,578	3,349	3,291	3,325
Columbus Total	**4,738**	**4,648**	**4,418**	**4,222**	**4,263**
Cincinnati Angle					
Fatal	1	1	0	1	1
Injury	250	218	217	195	182
PDO	554	570	492	444	431
Unknown	0	1	2	3	2
Total Angle	805	790	711	643	616
Cincinnati Rear-End					
Fatal	0	0	0	0	1
Injury	246	220	212	201	183
PDO	1,030	981	943	884	828
Unknown	10	4	1	5	2
Total Rear-End	1,286	1,205	1,156	1,090	1,014
Cincinnati Total	**2,091**	**1,995**	**1,867**	**1,733**	**1,630**

[a] PDO, property damage only

Source: Ohio Department of Public Safety (2011).

Figure 3: Citywide Crash Count by City, Angle Type, Population Per 100k, and Year

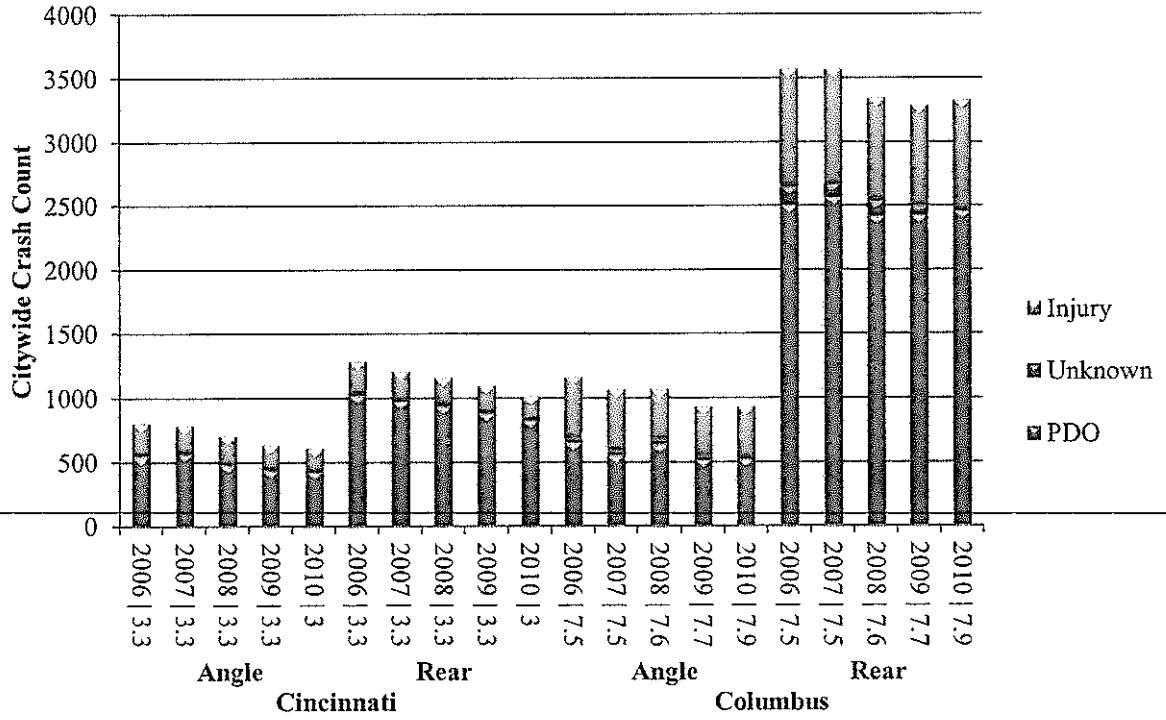


Table 6 summarizes changes in citywide crash, crash type, and crash severity rates from a period before the *Focus on Safety* program's implementation through the enforcement period. Likewise, Figure 3 illustrates the same data as presented in Table 6 except the annual population per 100,000 people for both Cincinnati and Columbus is displayed on the x-axis following each city's year (U.S. Census Bureau, 2011). For both Columbus and Cincinnati, the frequency changed in approximately a comparable manner, though Cincinnati experienced sharper declines and had less than half the population of Columbus in the years examined. In addition, the ordinal ranking of crash severity by crash type was consistent in both cities across the years examined. However, while property damage only (PDO) rear-end crashes consisted of nearly half of all crashes in Cincinnati, Columbus experienced disproportionately higher rates of the same occurrence. As noted by Sharon Township, Ohio Police Department Constable Carl Booth

Jr., cities within even the same state can have unequal traffic crash reporting thresholds, different injury level descriptions, and different law enforcement agency accident reporting requirements and priorities (C.R. Booth Jr., personal communication, November 18, 2011). In other words, a Cincinnati motorist involved in PDO rear-end collision is less likely to receive an Ohio Traffic Crash Report than a Columbus driver involved in a similar incident due to a number of varying factors. Taken together, the results in Table 6 and Figure 3 are not enough to confirm or reject the hypothesis (H_2) that lower rates of citywide intersection crash, crash type, and crash severity are associated with the *Focus on Safety* program. As previously mentioned, both research limitations as well as areas for future research will be discussed in a coming section.

RLR Violation Type and Rates GIS Trend Analysis

The impact of RLC programs are often evaluated by the local government agencies that manage them through the use of descriptive statistics and trend analysis. This type of simple and less formal examination monitors the changes in univariate data as a function of time and a program's implementation. Summary statistics and a GIS spatial distribution trend analysis are used to display and discuss the frequencies and percentage of RLR violations as a function of time and RLC activation by time elapsed since the red-light onset; violations by time of day; violations by day of week; and a six year daily average and annual analysis of RLR violation rates at each of the 18 *Focus on Safety* intersections. These analyses serve to test the first hypothesis (H_1a) detailed above. The results are depicted in Tables 7, 8, and 9 as well as in Figures 4, 5, and 6 below.

Table 7: Columbus Six Year Daily Analyses of Red-Light Running Violation Rates at Each of the 18 Original *Focus on Safety* Intersections

Intersection	Evaluation Period (days)	Year						Total
		2006	2007	2008	2009	2010	2011	
4th St. & Mt. Vernon Ave.	2,048	24	11	16	11	9	10	14
5th Ave. & 4th St. (Westbound)	2,048	7	6	6	3	3	3	5
5th Ave. & 4th St. (Eastbound)	2,047	6	6	6	5	9	14	8
Cleveland Ave. & Spring St.	1,949	10	9	7	11	15	28	14
Henderson Rd. & Gettysburg Rd.	1,870	12	4	3	3	3	3	5
Broad St. & Sylvan Ave.	1,870	16	9	7	2	1	2	6
Summit St. & Chittenden Ave.	1,841	10	9	7	4	4	6	7
Livingston Ave. & Fairwood Ave.	1,823	14	13	10	4	3	5	8
Town St. & 4th St.	1,717	***	10	7	5	4	7	7
3rd St. & Fulton St. 01 (Southbound)	1,717	***	10	8	5	4	5	6
3rd St. & Fulton St. 02 (Southbound)	1,717	***	8	5	2	1	2	4
Broad St. & Grant Ave.	1,691	***	3	3	3	3	3	3
4th St. & Main St.	1,472	***	14	13	9	9	13	12
Parsons Ave. & Frebis Ave.	1,472	***	12	9	5	4	10	8
4th St. & Long St.	1,468	***	26	20	5	1	2	11
Main St. & Eastmoor Ave.	1,444	***	11	10	4	3	3	6
Summit St. & Maynard Ave.	1,444	***	8	8	4	3	3	5
Indianola & Cooke/Overbrook	1,424	***	6	8	3	2	2	4
Central Ave. & Sullivant Ave.	1,384	***	2	12	7	22	21	13
3rd St. & Main St.	1,384	***	2	8	3	2	2	3
Totals		99	179	173	98	105	144	149

Source: Redflex Traffic Systems (2011).

Table 7 summarizes changes in the annual intersection-level daily RLR violation rates from March 7, 2006 after the first camera was activated through October 14, 2011. Likewise, Figure 4 illustrates the same data as presented in Table 7 except the GIS spatial distribution models the comparative location of the 18 *Focus on Safety* intersections in Columbus. As such, these data results are discussed immediately following Figure 3 (See Appendix A, Table 10 for the secondary data used to calculate Table 7).

Figure 4:

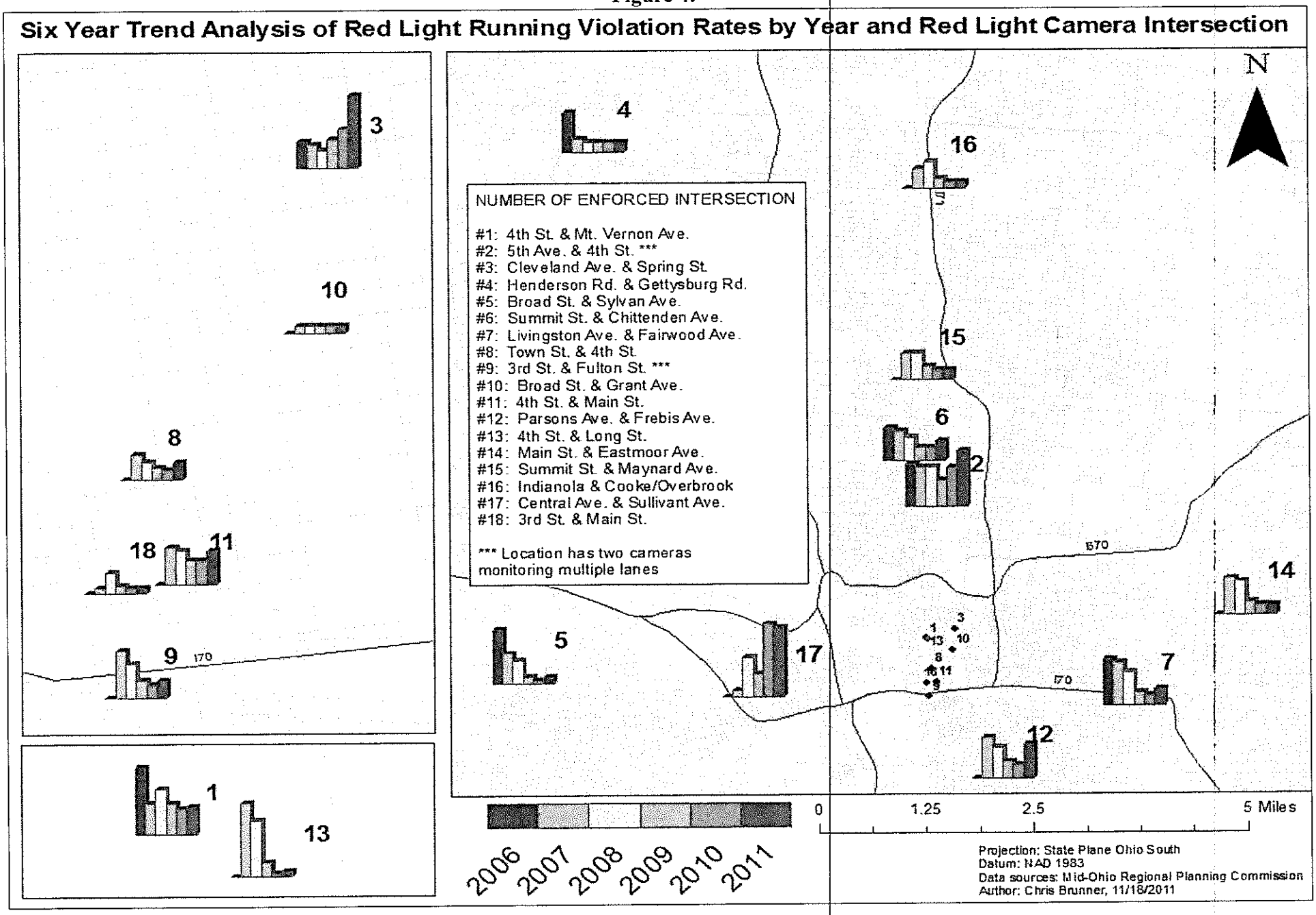

Six Year Trend Analysis of Red Light Running Violation Rates by Year and Red Light Camera Intersection
NUMBER OF ENFORCED INTERSECTION
#1: 4th St. & Mt. Vernon Ave.
#2: 5th Ave. & 4th St. ***
#3: Cleveland Ave. & Spring St.
#4: Henderson Rd. & Gettysburg Rd.
#5: Broad St. & Sylvan Ave.
#6: Summit St. & Chittenden Ave.
#7: Livingston Ave. & Fairwood Ave.
#8: Town St. & 4th St.
#9: 3rd St. & Fulton St. ***
#10: Broad St. & Grant Ave.
#11: 4th St. & Main St.
#12: Parsons Ave. & Frebis Ave.
#13: 4th St. & Long St.
#14: Main St. & Eastmoor Ave.
#15: Summit St. & Maynard Ave.
#16: Indianola & Cooke/Overbrook
#17: Central Ave. & Sullivant Ave.
#18: 3rd St. & Main St.
*** Location has two cameras monitoring multiple lanes
N
0
1.25
2.5
5 Miles
2006
2007
2008
2009
2010
2011
Projection: State Plane Ohio South
Datum: NAD 1983
Data sources: Mid-Ohio Regional Planning Commission
Author: Chris Brunner, 11/18/2011

Table 7 and Figure 3 indicate many differences in the patterns between camera location and RLR violation rates. First, not all of the highest violation intersections were selected first for RLC installation. As seen below in Table 8, seven camera locations experienced three to five violations a day (colored green), while eight intersections captured six to eight violations per day (colored yellow), and five intersections had 11 to 14 violations triggered per day (colored red). As previously mentioned, the Columbus Department of Public Safety and Redflex Traffic Systems (Redflex) determine camera site selection on two criteria: the ranking of dangerous intersections and constructability. According to the Columbus Department of Public Safety, historical crash data are reviewed and those intersections with the highest frequency of right-angle crashes are targeted first. In other words, the program's goal is to install RLCs at the city's "most dangerous" intersections (G.E. Speaks, personal communication, August 23, 2011). In this instance, the program's statutory mandate, stated goal, and camera site selection methodology were consistent with the secondary data used in the Intersection-Level Impact Before-and-After Study.

Next, Table 7 and Figure 4 also provide information about the changing violation rates and the changing disparity in violation rates over time. For example, the RLR violation rates over time are humped-back or mostly downward sloping. Using the severity group scale in Table 8, the five intersections with the highest violation rates are uniquely disparate. For instance, the intersection of Cleveland Avenue & Spring Street has experienced a considerable increase in violation rates in the past few years. Interestingly, local roadway construction projects, such as the *Columbus Crossroads Project*, often create detours which increase the average daily traffic count at RLC enforced intersections. This is the case at the Cleveland Avenue & Spring Street location. On the other hand, with the exception of Central Avenue &

Sullivant Avenue, the three other intersections with the highest violation rates have either decreased or maintained violation rates over time.

Further, an impressive 75 percent or 15 of the combined 20 camera sites experienced a large decrease in violation rates in the start followed typically by gradual increases over time, though not to initial violation levels. However, beginning in 2010 the overall violation rates increased over time relative to 2009. Ideally, violation rates should continually decrease over time as the cameras succeed in deterring motorists from running red-lights. In this instance, Columbus drivers may have become complacent and used to the cameras or the average daily traffic counts at these intersections could have increased as well. According to the United States Census Bureau, increasing numbers of people moved into both the Central Ohio region and the City of Columbus each year during the observation period (U.S. Census Bureau, 2011). Nonetheless, because the total annual violation rates increased over time (though not to 2006 levels), taken together, the results in Tables 7 and 8 as well as in Figure 4 reject the hypothesis (H_1a) that the *Focus on Safety* program is associated with lower rates of intersection-level RLR violations. Again, both research limitations as well as areas for future research will be discussed in a coming section.

Table 8: Ordinal Rank of Red-Light Camera Installation by 6 Year Daily Violation Rates and Order of Installation

Red-Light Camera Enforced Intersection	Date of Camera Activation	6 Year Daily Violation Rate	Order Installed and Severity Group
Cleveland Ave. & Spring St.	6/14/2006	14	3
4th St. & Mt. Vernon Ave.	3/7/2006	14	1
Central Ave. & Sullivant Ave.	12/31/2007	13	13
4th St. & Main St.	10/4/2007	12	9
4th St. & Long St.	10/8/2007	11	10
5th Ave. & 4th St. (Eastbound)	3/8/2006	8	2
Parsons Ave. & Frebis Ave.	10/4/2007	8	9
Livingston Ave. & Fairwood Ave.	10/18/2006	8	6
Town St. & 4th St.	2/1/2007	7	7
Summit St. & Chittenden Ave.	9/30/2006	7	5
3rd St. & Fulton St. 01 (Southbound)	2/1/2007	6	7
Main St. & Eastmoor Ave.	11/1/2007	6	11
Broad St. & Sylvan Ave.	9/1/2006	6	4
5th Ave. & 4th St. (Westbound)	3/7/2006	5	1
Henderson Rd. & Gettysburg Rd.	9/1/2006	5	4
Summit St. & Maynard Ave.	11/1/2007	5	11
3rd St. & Fulton St. 02 (Southbound)	2/1/2007	4	7
Indianola & Cooke/Overbrook	11/21/2007	4	12
Broad St. & Grant Ave.	2/27/2007	3	8
3rd St. & Main St.	12/31/2007	3	13

Source: Redflex Traffic Systems (2011).

Table 9: Distribution of Red-Light Violation Records by Selected Categories of Time Elapsed Since Red-Light Onset [3]

After-Red Time	No. of Violation Records	Percent of Distribution	Cumulative Violation Records	Cumulative Percent
≤ 1.0 seconds	117,969	49.6%	117,969	49.6%
1.1 to 2.0 seconds	24,091	10.1%	142,060	59.8%
2.1 to 3.0 seconds	7,030	3.0%	149,090	62.7%
> 3.0 seconds	88,637	37.3%	237,727	100.0%

Source: Redflex Traffic Systems (2011).

Table 9 shows that 59.8 percent of RLR violations happened within two-seconds after the signal had turned red. As previously discussed, given a roadway's prevailing speed if the time a driver needs to stop is greater than the yellow light signal time, then a dilemma zone exists. As a result, a driver may hesitate when deciding whether to abruptly stop or move more quickly through an intersection. It stands to reason that the influence of the dilemma zone may help to explain why the highest percentage of RLR violations occurred within two-seconds of the onset of the red-light. On the other hand, 37.3 percent of violations occurred three or more seconds after the signal had turned red. Lum and Wong (2003) noted that most drivers who attempt to beat the light and deliberately commit a violation typically do so after the light has been red for two or more seconds. By this standard, more than 40 percent of Columbus violations are committed by those motorists whose perceived benefit or time gained from running the red-light exceeds the cost or time lost in complying with the traffic signal.

[3] *Note.* Table 9: Distribution of Red-Light Violation Records by Selected Categories of Time Elapsed Since Red-light Onset adapted from ibid. (p. 23). Adapted without permission.

Figure 5: Distribution of Red-Light Violations by Time of Day [4]

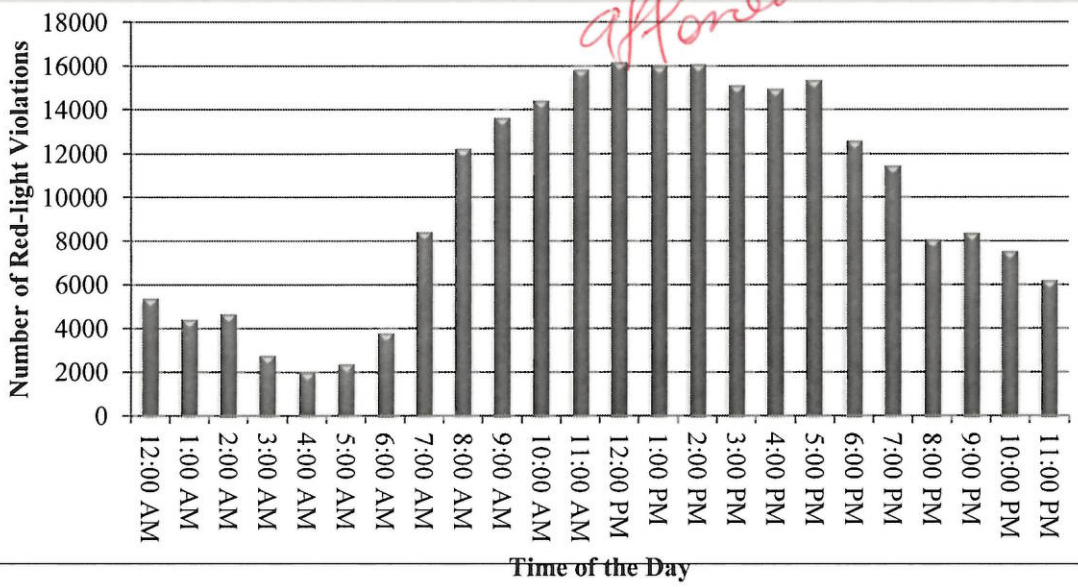
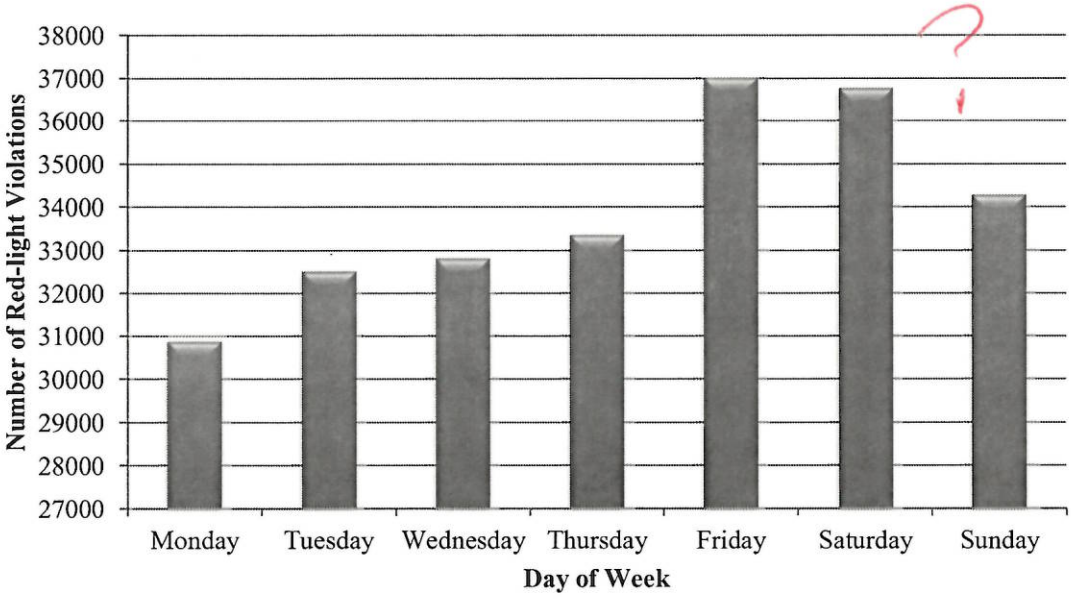


Figure 6: Distribution of Red-Light Violations by Day of Week



Figures 5 and 6 illustrate the distribution of RLR violations by time of day and day of week. The over time trend appears consistent and reflective of daytime hours when most work-

[4] *Note.* Figure 5: Distribution of Red-Light Violations by Time of Day adapted from ibid. (p. 17). Adapted without permission.

related commuting and driving is done from 7:00 a.m. to 7:00 p.m. In addition, the uptick of violations during the time period from 5:00 p.m. to 6:00 p.m. is not surprising. On the other hand, the distribution of RLR violations by day of week seems counterintuitive. Most interestingly, the majority of violations occurred on Fridays and during the weekend. Again, taken together, the results in Tables 7 and 8 as well as in Figure 4 reject the hypothesis (H_1a) that the *Focus on Safety* program is associated with lower rates of intersection-level RLR violations.

Conclusions

After estimating the negative binomial regression, it was found that red-light cameras are associated with significant reductions in crash rates at the intersections where they are installed. The effects of cameras on safety at citywide non-red-light camera intersections however, could not be determined based on the regression and an inadequate baseline measure. In addition, this examination found that red-light running violation rates increased following the program's implementation, though not to initial violation levels.

Research Limitations

As previously mentioned, the data used for this quantitative program evaluation presented some limitations. First, RLR violation rates were examined in only Columbus as these data were not available for the City of Cincinnati. As a result, without a control or comparison group, this paper's RLR violation type and trend analysis cannot be attributed to the *Focus on Safety* program or the treatment of RLCs. In addition, due to time and resource constraints, intersection violation and crash rates were examined collectively whereas it would have been interesting to examine and discuss each intersection individually.

Next, the secondary data used in the Citywide Impact Trend Analysis were only available from January 1, 2006, to present. This was especially problematic in terms of identifying or

testing for any halo effects because the first camera was activated on March 7, 2006. When doing this type of RLC program evaluation one should use as long a study period for both before-and-after the camera activation as possible. In this instance, 64 days provided an inadequate baseline measure. In addition, there was a large disparity between the Columbus and Cincinnati PDO rear-end crash rates and it would have been beneficial to have known why. As it is common for different police departments to have varying traffic crash report thresholds, this could bias the results of this study.

Additionally, the regression model did not include all of the crash data and supporting data known to be associated with driver behavior and intersection safety. Such data includes the population, land area, traffic signal timing, miles of roadway, and average daily traffic counts. Further, a longer study period for both before-and-after the program's implementation would have provided more adequate baseline measures.

Areas for Future Research

An important and unanswered question is whether or not the *Focus on Safety* program intersections has had an effect on driver behavior at non-RLC intersections in Columbus. This answer is crucial because it can be used to determine the marginal benefit and cost of adding one additional camera to impact driver behavior citywide. In addition, if a halo effect does exist, then city officials could strategically position cameras to maximize their collective impact range similar to how storm sirens and cell phone base stations are positioned for emergency management and communication purposes. Two studies mentioned previously found that RLCs had an impact on safety at adjacent approaches as well as at intersections immediately upstream and downstream of the camera sites (Shin and Washington, 2007) (MVA Consultancy, 1995). On the contrary, one could test whether there is a negative halo effect where motorists avoid

RLC enforced intersections and more heavily use other non-enforced intersections in an attempt to avoid being ticketed. As previously mentioned, companies such as "GPS Angel" develop, market, and sell legal and updateable dashboard-mounted detectors that alert drivers of nearby RLC locations (http://gpsangel.com). The negative halo effect provides a plausible and alternative explanation to this study's findings. Therefore, the halo effect warrants further investigation.

Policy Implications and Recommendations

The findings of this policy/management paper may help government leaders and managers formulate and implement successful camera programs of their own, and thus make cities safer to drive in by influencing driver behavior. The issue of RLCs is a controversial one and those on either side are generally conflicted by the issue of government accountability and public management versus efficiency in the private provision of public safety and traffic enforcement.

On the one hand, opponents argue that camera programs erode citizens' civil liberties and suggest local governments are more interested in the citation revenue than the publics' safety and even motorists' constitutional rights. However, at present in approximately 25 states and 556 localities their contention is a moot point (Governors Highway Safety Association, 2011). In Ohio, the state Supreme Court ruled a municipality does not exceed its authority when it implements an automated traffic enforcement system of its own, so long as it does not conflict with statewide traffic regulations. For those passionate enough to rid such camera programs, Cincinnati stands as a stellar example. The same state law and ruling that preceded the cameras installation in Columbus has twice been contested and voted against by Cincinnati residents. Beyond these intricate and delicate problems, the bottom line issue is one of efficiency,

economy, and effectiveness. While it may now be clear that the drawbacks to the use of RLCs are controversial, it should also be apparent that the long-term benefits of camera programs would reward investment. Simply put, RLCs penalize motorists in violation of the law and have been shown to significantly reduce intersection crashes. What's more, by obtaining a driver's license, a motorist agrees to abide by certain rules and regulations, such as to obey traffic signals. A main objective of RLC programs is to deter those trying to "beat the light," rather than catch them. Similar to Columbus, in most cities, public hearings, signage, publicity campaigns, and warning periods typically advise drivers that photo enforcement is in use. Revenue is generated from fines paid by drivers who continue to run red-lights however; this is a central component of all traffic enforcement programs. Ideally, citation revenue should decline over time as the cameras succeed in dissuading those trying to "beat the light."

To address these issues, government leaders and managers could consider implementing a progressive violation fine where fines are assessed based off of a driver's income. Similar traffic enforcement initiatives have been successfully applied in European countries, such as in Finland (BBC News, 2002). In addition, governments could mandate stiffer driver's license sanctions and monetary fines, such as assessing points to an individual's driving record; reporting violations to insurance companies; adding additional fines for multiple violations occurring in one year; or requiring habitual offenders attend a driver's improvement course. With limited resources available to local governments and a burgeoning demand for the public goods and services they provide, camera programs contribute additional revenue without applying any added burden on taxpayers. In addition, they promote the effective use of police time and resources. As noted by Columbus, Ohio Police Department Sergeant Joe Curmode, on average it takes a police officer seven to ten minutes to write and issue a traffic citation (J.

Curmode, personal communication, August 23, 2011). It stands to reason that camera programs free up police from administrative duties and improve efficiency.

In sum, the public safety and economic significance of RLR is clear. It is an ongoing and practical problem that relates to a wide population and the human and material costs of RLR are tremendous, and more often than not, entirely avoidable. These findings may help government leaders and managers mitigate or prevent their causes and thus make cities safer to drive in. RLR public information and education programs combined with high-stakes consequences are effective. In addition, many low cost countermeasures can address and discourage RLR, such as pavement markings, properly positioned and calibrated traffic lights, and the removal or installation of appropriate traffic signals. More expensive and longer term measures exist as well, such as constructing roundabouts as alternatives to traditional intersections and funding moderately leveled and sustainable targeted police enforcement campaigns. Driving is a privilege, not a right. Yet, RLR is a public health problem and its true economic cost is difficult to collect from those who violate the law. As a result, 25 states and 556 cities and municipalities have passed legislation and implemented RLC programs across the country. This type of automated enforcement technology is positively associated with significant reductions in RLR crash, fatality, and injury rates. In addition, RLCs have been shown to influence driver behavior, increase traffic signal compliance, alleviate the dangers of the dilemma zone, and improve intersection safety at nearby non-RLC intersections. Moreover, the public has encouraged and supported RLC programs in the cities where they have been established. In conclusion, this quantitative program evaluation demonstrates that the Columbus, Ohio *Focus on Safety* red-light camera enforcement program has met its stated objective of reducing red-light running crashes by influencing driver behavior and improving intersection safety.

Appendix A

Table 10: Columbus Six Year Annual Analyses of Red-Light Running Violation Rates at Each of the 18 Original *Focus on Safety* Intersections

Intersection	Evaluation Period (days)	Year						Total
		2006	2007	2008	2009	2010	2011	
4th St. & Mt. Vernon Ave.	2,048	7,115	3,922	5,952	3,849	3,134	2,766	26,738
5th Ave. & 4th St. (Westbound)	2,048	2,214	2,274	2,040	1,059	1,108	979	9,674
5th Ave. & 4th St. (Eastbound)	2,047	1,892	2,342	2,212	2,001	3,325	3,893	15,665
Cleveland Ave. & Spring St.	1,949	2,052	3,450	2,628	4,041	5,573	7,969	25,713
Henderson Rd. & Gettysburg Rd.	1,870	1,434	1,467	1,168	1,052	1,199	798	7,118
Broad St. & Sylvan Ave.	1,870	1,937	3,454	2,499	599	540	518	9,547
Summit St. & Chittenden Ave.	1,841	968	3,392	2,397	1,606	1,491	1,615	11,469
Livingston Ave. & Fairwood Ave.	1,823	1,040	4,770	3,551	1,535	1,246	1,395	13,537
Town St. & 4th St.	1,717	***	3,361	2,588	1,741	1,390	1,992	11,072
3rd St. & Fulton St. 01 (Southbound)	1,717	***	3,295	2,897	1,976	1,555	1,472	11,195
3rd St. & Fulton St. 02 (Southbound)	1,717	***	2,586	1,972	806	468	525	6,357
Broad St. & Grant Ave.	1,691	***	909	1,169	1,001	1,118	830	5,027
4th St. & Main St.	1,472	***	1,224	4,616	3,141	3,281	3,703	15,965
Parsons Ave. & Frebis Ave.	1,472	***	1,080	3,176	1,969	1,600	2,849	10,674
4th St. & Long St.	1,468	***	2,169	7,249	1,672	490	683	12,263
Main St. & Eastmoor Ave.	1,444	***	695	3,520	1,552	1,107	878	7,752
Summit St. & Maynard Ave.	1,444	***	489	2,875	1,583	1,218	900	7,065
Indianola & Cooke/Overbrook	1,424	***	250	2,778	950	565	490	5,033
Central Ave. & Sullivant Ave.	1,384	***	2	4,306	2,535	8,063	5,957	20,863
3rd St. & Main St.	1,384	***	2	2,915	985	620	478	5,000
Totals		18652	41133	62508	35653	39091	40690	237,727

Source: Redflex Traffic Systems (2011).

Figure 7:

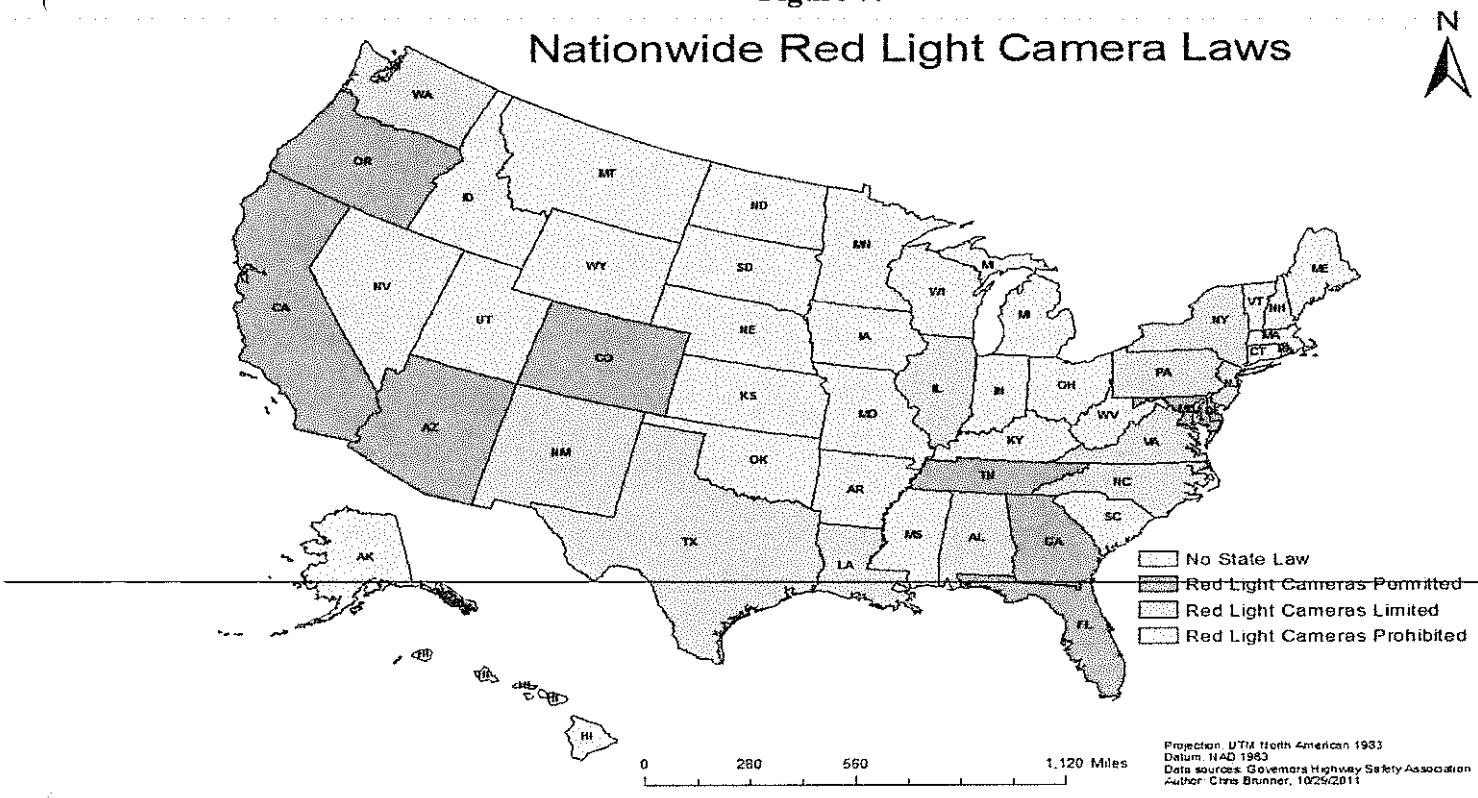


Figure 8:

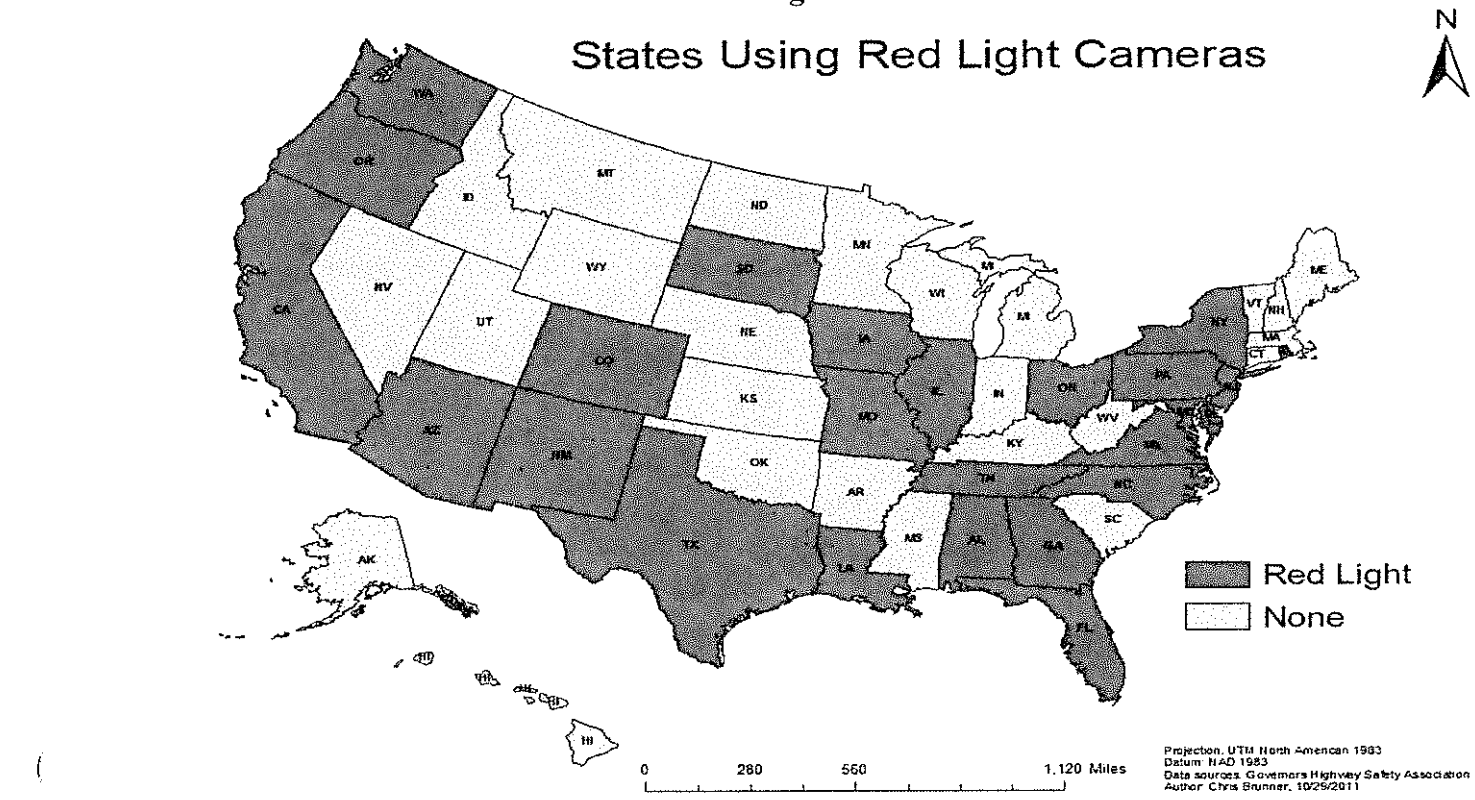


Table 11: Treatment Intersection Location Dates of Camera Activation in Columbus, Ohio

Columbus Treatment Intersection Location	Date Activated
4th Street & Mt. Vernon Avenue	March 7, 2006
5th Avenue & 4th Street (Westbound)	March 7, 2006
5th Avenue & 4th Street (Eastbound)	March 8, 2006
Cleveland Avenue & Spring Street	June 14, 2006
Henderson Road & Gettysburg Road	September 1, 2006
Broad Street & Sylvan Avenue	September 1, 2006
Summit Street & Chittenden Avenue	September 30, 2006
Livingston Avenue & Fairwood Avenue	October 18, 2006
Town Street & 4th Street	February 1, 2007
3rd Street & Fulton Street 01 (Southbound)	February 1, 2007
3rd Street & Fulton Street 02 (Southbound)	February 1, 2007
Broad Street & Grant Avenue	February 27, 2007
4th Street & Main Street	October 4, 2007
Parsons Avenue & Frebis Avenue	October 4, 2007
4th Street & Long Street	October 8, 2007
Main Street & Eastmoor Avenue	November 1, 2007
Summit Street & Maynard Avenue	November 1, 2007
Indianola & Cooke/Overbrook	November 21, 2007
Central Avenue & Sullivant Avenue	December 31, 2007
3rd Street & Main Street	December 31, 2007

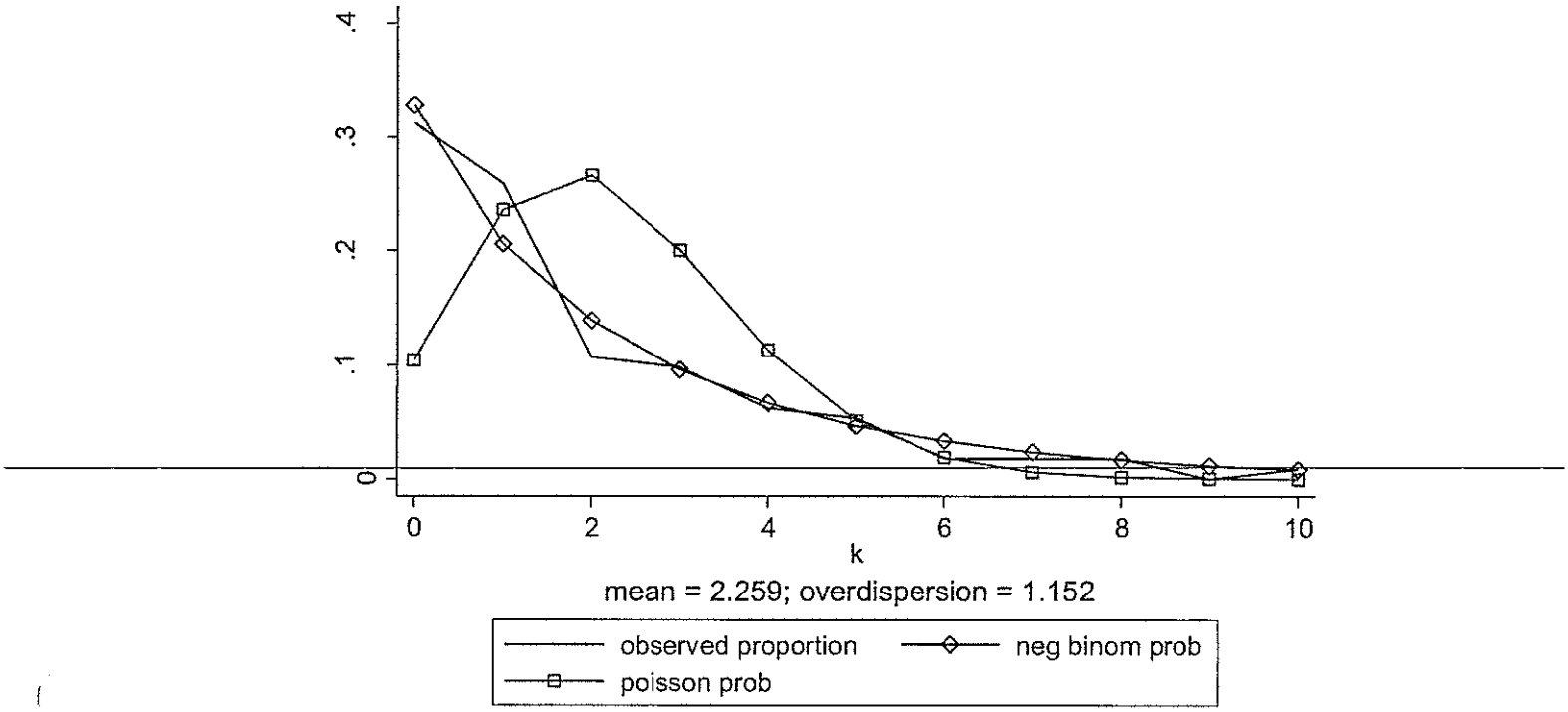
Source: A. Ford, personal communication, February 24, 2011.

Table 12: Comparison Intersections Location and Neighborhood in Cincinnati, Ohio

Cincinnati Comparison Intersection Location (and neighborhood)
Queen City and Harrison (South Fairmount)
Madison and Observatory (Hyde Park)
Third and Race (downtown)
Gilbert and Eden Park (Mount Adams)
Seventh and Plum (downtown)
Reading and McGregor (Mount Auburn)
Liberty and Reading (Over-the-Rhine)
Paddock and Seymour (Bond Hill)
Colerain and West North Bend (Mount Airy)
Glenway and Werk (Westwood)

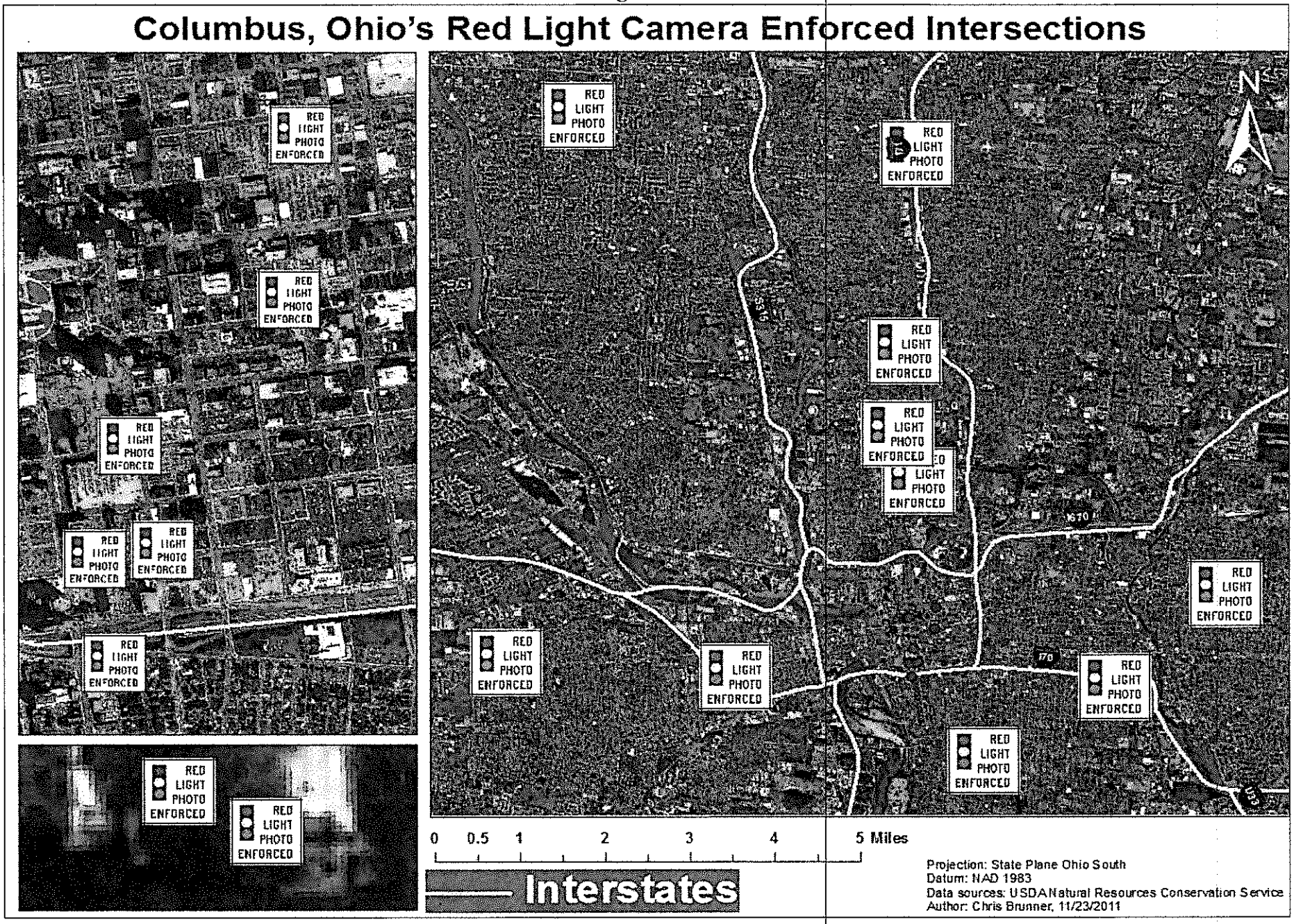
Source: Cincinnati Police Department (2011).

Figure 9: Intersection-Level Impact Before-and-After Study Fit for Poisson versus Negative Binomial Model



Source: StataCorp. 2009. *Stata Statistical Software: Release 11.* College Station, TX: StataCorp LP.

Figure 10:


Columbus, Ohio's Red Light Camera Enforced Intersections
RED LIGHT PHOTO ENFORCED
N
0 0.5 1 2 3 4 5 Miles
Interstates
Projection: State Plane Ohio South
Datum: NAD 1983
Data sources: USDA Natural Resources Conservation Service
Author: Chris Brunner, 11/23/2011

References

Allison, Paul David. *Multiple Regression: a Primer*. Thousand Oaks, CA: Pine Forge, 1999. Print.

Andreassen, D., & Australian Road Research Board. (1995). *A long term study of red-light cameras and accidents*. Vermont South, Vic: Australian Road Research Board.

BBC News. "BBC News | EUROPE | Nokia Boss Gets Record Speeding Fine." *BBC News – Home*. BBC News, 14 Jan. 2002. Web. 30 Nov. 2011. <http://news.bbc.co.uk/2/hi/europe/1759791.stm>.

Burkey, M. L., Obeng, K., United States., North Carolina Agricultural and Technical State University., & North Carolina Agricultural and Technical State University. (2002). A detailed investigation of crash risk reduction resulting from red-light cameras in small urban areas. Greensboro, N.C: Transportation Institute, North Carolina Agricultural and Technical State University, Urban Transit Institute, Transportation Institute.

City of Cincinnati, Ohio Police Department (2011). [Excel File]. Provided by City of Cincinnati, Ohio Police Department personnel.

City of Columbus, Ohio Department of Public Service (2011). [Excel File]. Provided by City of Columbus, Ohio Department of Public Service personnel.

Energy Policy and Conservation Act of 1975, United States Code §§ 329-32901-32919 (1975).

Environmental Systems Research Institute, Inc. (ESRI). 20020401. Environmental Systems Research Institute, Inc. (ESRI), Redlands, California, USA. ESRI Data & Maps, Series issue: 2002

Ferenchik, M. (2005, October 18). Council snaps up traffic cameras - Amendments ease concerns of some over privacy issues. *The Columbus Dispatch*, p. 01A.

Governors Highway Safety Association. (2011, October). State Speed and Red-light Camera Laws. *Governors Highway Safety Association (GHSA)*. Retrieved October 29, 2011, from http://www.ghsa.org/html/stateinfo/laws/auto_enforce.html

IIHS-HLDI. (2011, September). *IIHS-HLDI: Crash Testing & Highway Safety*. Retrieved September 26, 2011, from http://www.iihs.org/laws/auto_enforce_cities.aspx

Insurance Institute for Highway Safety. "Communities Using Red Light And/or Speed Cameras." *IIHS-HLDI: Crash Testing & Highway Safety*. Insurance Institute for Highway Safety, Dec. 2011. Web. 01 Dec. 2011. <http://www.iihs.org/laws/auto_enforce_cities.aspx>.

Insurance Institute for Highway Safety. "Education Alone Won't Make Drivers Safer. It Won't Reduce Crashes." *Status Report* 36.May 9 (2001): 1-8. Print.

Insurance Institute for Highway Safety. (2007). *Status Report: Mind Those Traffic Lights.* (1st ed., Vol. 42, pp. 1-8, Publication). Insurance Institute for Highway Safety.

Lum, K. M., & Wong, Y. D. (November 01, 2003). Impacts of Red-light Camera on Violation Characteristics. *Journal of Transportation Engineering, 129,* 6.)

McGee, H. W., Eccles, K. A., National Cooperative Highway Research Program., American Association of State Highway and Transportation Officials., United States., & National Research Council (U.S.). (2003). *Impact of red-light camera enforcement on crash experience*. Washington, D.C: National Academy Press.

Mendenhall v. Akron, 117 Ohio St.3d 33, 2008-Ohio270., pp. 1-16.

MVA Consultancy., Strathclyde Police., & Great Britain. (1995). *Running the red: An evaluation of the Strathclyde Police Red-light Camera Initiative*. Edinburgh: Central Research Unit, Scottish Office.

Newstead, S. V., Cameron, M. H., & Leggett, L. M. (January 01, 2001). The crash reduction effectiveness of a network-wide traffic police deployment system. *Accident Analysis and Prevention, 33,* 3.)

Office of Program Development and Evaluation Traffic Safety Programs. (1994). *Study Regarding the Impact of Permitting Right and Left Turns on Red-lights.* (pp. 1-25, Rep.). Washington, D.C.

Ohio. City of Columbus, Ohio Department of Public Safety. Director of Public Safety. *City of Columbus "Focus On Safety" Photo Red Light Camera Project 2009 Year End Report*. By Mitchell J. Brown. Columbus: Department of Public Safety, 2009. Print.

Ohio. City of Columbus, Ohio Department of Public Safety. Fiscal Manager. *June, 2011 Bi-Weekly Report*. By Dennis Ekow. Columbus: City of Columbus, Ohio Department of Public Safety, 2011. Print.

Ohio Department of Public Safety (2011). Crash Statistics (Crash Statistics Version) [PDF File]. Publically available from Ohio Department of Public Safety website, https://ext.dps.state.oh.us/crashreports/crashreports.aspx

Osborne, Kevin. "TRAFFIC CAMERA DEAL SET FOR VOTE." *Cincinnati Post* 22 July 2005, Final ed., News sec.: A1. Print.