City of Wilmington Red Light Camera Safety Program

2016 Crash Data Review and Site Analysis

February 1, 2017

In 2016, the 148th General Assembly of the Delaware Legislature amended State Code Title 21 §4101(b) in reference to red light camera programs to state: "All existing locations erected without the Department of Transportation prior approvals shall be reviewed by the Department of Transportation using same recognized safety and accident criteria used to authorize new locations. Any location which fails to meet the criteria shall be removed upon end of the contract with the camera operator vendor." The City of Wilmington currently operates 34 monitored approaches at 30 intersections and these locations were not previously approved by DelDOT and/or the corresponding prior approval period has since expired. This report describes the safety-driven process used to review crash data at signalized locations within the City of Wilmington and analyze the existing monitored locations and movements with similar engineering methodologies as DelDOT's nationally-recognized program.

DelDOT's Electronic Red Light Safety Program (ERLSP) uses red-light-running crash data to identify candidate intersections and monitor safety benefits to the traveling public at existing camera locations. This methodology allows the program to be safety data-driven, rather than revenue- or public request-driven. Publicized annual reports continue to show a significant reduction in angle and red-light-running crashes at the existing DelDOT ERLSP camera sites, as compared to the "before" study periods.

Initial Screening

In 2010, the Delaware Criminal Justice Information System (DelJIS) implemented a new crash reporting system called E-Crash. In response to E-Crash, DelDOT implemented Crash Analysis Reporting System (CARS). This process results in a more accurate method of establishing the location of crashes and provides more complete crash data. The CARS system has been in use since 2010 and contains crash data from 2005 through present. Crash data from 2005 through 2009 was migrated from the former crash system into the new CARS system. However, Wilmington's Red Light Camera Safety Program and associated camera installations began in 2001. Therefore, it is not feasible to efficiently obtain comprehensive "before" crash data from the CARS system. Consequently, citywide crash data for calendar year 2011 through 2015 was obtained from CARS to assess the City's signalized intersections in a manner consistent with DelDOT's ERLSP site selection process. To select the crashes that were most likely to be red light running, the crash data was reduced to those crashes coded as "Primary Contributing Circumstance: Disregard Traffic Signal" or "Driver Action: Ran Red Light." This resulted in a list of 887 citywide crashes that then had location data cross-referenced to a traffic signal database provided by the City of Wilmington. For the initial screening, crash information was reviewed at the summary level; however, specific crash report narratives were not reviewed, so inaccuracies in reported location and crash variables may cause initial crash totals to be marginally imprecise. Of the 887 citywide crashes at the summary level, 790 were matched with a City signalized intersection.

The initial list was then sorted by total crashes, and a preliminary ranking of all 186 intersections with at least 1 cross-referenced crash was created. Of these intersections, 24 were existing red light camera program locations. The remaining 6 camera locations did not have a cross-referenced crash and are included at the end of the initial ranking list as ranks 187 to 192. **Appendix A** includes the preliminary ranking of City intersections.

Final Ranking

Once the preliminary ranking list was established, full crash data analysis was performed on each candidate intersection beginning with the highest rank. At-fault movement was noted, when determined in the crash narrative, for each red-light-running crash. The analysis included:

- Reviewing each of the crashes from the initial data set to confirm location and crash type and identifying the at-fault movement
- Obtaining additional crash data from CARS of all crashes occurring at each candidate intersection over the 5-year analysis period to identify any red-light-running crashes that were missed in the original data set – i.e., for this set of crash data, narratives for all reported crashes with "Manner of Impact: Angle, Front-to-front, or Sideswipe Opposite Direction" were reviewed for red light running

A similar approach to DelDOT's current ERLSP site selection process was used, where the sites with the highest crash totals are reviewed in greater depth. Full crash data reviews were conducted at intersections with 4 or more cross-referenced crashes and all remaining intersections with red light camera monitoring. This included all intersections through preliminary rank 41, plus 22 additional existing camera locations, resulting in 63 fully-analyzed intersections. The evaluation breakdown is illustrated in the left-hand margin of **Appendix A**.

Because cameras are installed on an intersection approach, the at-fault information obtained through the crash data review was summarized by approach. A final ranking of candidate sites was created by ranking the sites by most red-light-running crashes by at-fault approach, with "ties" sub-ranked by total red-light-running crashes. This ranked list is presented in **Appendix B**. A timeline of crashes within the 5-year study period was also provided.

Recommendations – Monitored Intersections

The crash data compiled for the final ranking list in Appendix B suggests that the City has an opportunity to target safety improvements and correct motorist behavior at many intersections that are currently unmonitored. This could be accomplished without significant expansion of their current program by "phasing out" cameras and monitoring at the sites with little to no crash history. For example, there are 5 intersections, including SR 52 (Pennsylvania Avenue) at Woodlawn Avenue which has 2 monitored approaches, with no recorded red-light-running crashes in the 5-year study period. Conversely, there are 6 currently unmonitored sites with 18 or more red-light-running crashes in the 5-year study period. Transitioning cameras to these higher-priority sites should result in significant safety benefits and reductions in angle crashes. While there is the possibility that the City's monitoring has been so effective at the existing camera sites to reduce the red-light-running crash rates to zero, DelDOT has found that in their ERLSP, a low "baseline" of red-light-running crashes remains at virtually all monitored sites, particularly those that originally had the highest crash totals (i.e., regression to a relatively low and more anticipated crash history).

Further, to comply with the requirements outlined in State Code Title 21 §4101(b), the City of Wilmington will need to assess all programmed yellow change intervals at existing sites and any proposed candidate sites to ensure the timings meet requirements described in the *DelDOT Traffic Design Manual 2015*. Additionally, the City's camera vendor should perform video validation at all new candidate locations to quantify red-light-running violations along unmonitored candidate approaches and to compare the violation rates at these unmonitored approaches to the violation rates along monitored approaches as presented in the City's *FY2015 Traffic Light Signal Violation Monitoring System Program Report*. Lastly, the City should investigate other appropriate engineering countermeasures (e.g., installing signing and/or warning beacons, improving sight distance, adjusting signal timings) prior to recommending a site for red light monitoring. Once a final list of sites recommended for monitoring is developed and documented by the City, formal DelDOT approval will be required prior to commencing construction.

Right-Turn on Red Enforcement

State Code Title 21 §4101(c) was also amended to include the provision: "Jurisdictions operating an Electronic Red Light Safety Program can only issue right turn on red violations if there is safety and crash data to support it as determined by the Department of Transportation." Similar to red light enforcement programs in general, there are proponents and detractors of monitoring right-turn movements at signalized locations. A review of industry "best practices" found that while some municipalities monitor right turns and some do not, support for and arguments against monitoring typically are very similar regardless of the location. Critics of right-turn on red monitoring highlight the typically higher percentage of violations issued to right turns compared to through and left-turn movements, the relatively lower-speed and less-severe crashes associated with right-turning movements, and ambiguity of right-turn on red laws. Supporters of right-turn monitoring claim that crashes involving right-turning vehicles are more likely to involve pedestrians and bicyclists and note that violations are typically not issued unless a motorist was traveling above a certain speed threshold (typically 10-15 miles per hour). DelDOT reviewed research often cited by proponents of right-turn on red monitoring, a 1995 report to Congress by the National Highway Traffic Safety Administration (NHTSA) (see **Appendix D**). Although the NHTSA study found that right-turn on red crashes frequently involved pedestrians and bicyclists, the occurrence of these crashes is exceedingly rare. The report stated that only 0.2 percent of all fatalities over a 10-year study period involved a right-turning movement at an intersection where right-turn on red is permitted; however, the data did not discern whether or not the signal was red for the right-turning vehicle.

DelDOT reviewed right-turn crash history at the 30 City of Wilmington camera locations from January 2005 to December 2010 before right-turn enforcement began in 2011 and January 2012 to October 2016 after right-turn enforcement was established. Right-turn on red monitoring commenced on July 15, 2011; consequently, calendar year 2011 was excluded from the crash data analysis to account for a "buffer" period for motorists to learn and adapt to the updated enforcement policy (e.g., a 6-month warning period was in effect prior to July 15, 2011). At-fault vehicle information was determined for right-turn crashes as well as right-turn on red behavior if the crash involved a right-turn on red. Additionally, intersection crashes involving pedestrians or bicyclists were reviewed and those that involved a right-turn on red vehicle were noted. The summarized table of "before" and "after" right-turn and pedestrian or bicyclist crashes is included in **Appendix C**. As shown, right-turn crashes represent a very small number of crashes at the 30 camera locations. Also, while crashes involving pedestrians and bicyclists increased from the "before" period to the "after" period, very few of these involved right-turn on red vehicles.

Recommendations – Right-Turn on Red Monitoring

No monitored City intersection had more than 4 right-turn-related crashes in the nearly 11-year study period, suggesting that right-turn crashes are not a significant safety concern for the City at these locations relative to the more severe citywide red-light-running safety concerns at unmonitored intersections. There is also a lack of evidence in the City's "before" and "after" crash history to support the historical, albeit relatively anecdotal, NHTSA claim that right-turn on red violations are particularly problematic for pedestrians and bicyclists. **This data further supports DelDOT's decision to not enforce right-turn on red movements as part of their ERLSP and warrants a rather definitive recommendation that the City of Wilmington should discontinue right-turn on red monitoring as part of their Red Light Camera Safety Program.**

APPENDIX
A

2016 City of Wilmington Red Light Camera Safety Program
Initial Ranking of Signalized Intersections by Coded Red Light Running Crash Totals
August 22, 2016

Legend
- Crash Reports Analyzed (6+ Crashes)
- Crash Reports Analyzed (Existing Camera Location)

Initial City Rank	Intersection	Red Light Running Crashes ('11-'15)*	Comments
1	N. Walnut St @ E. Front St	54	
2	N. Walnut St @ E. 11th St	39	
3	N. Adams St @ 11th St / I-95 SB off-ramp	29	
4	N. Jackson St @ W. 10th St	24	
5	W. 2nd St @ N. Adams St	23	Red light camera location (WB)
6	SR 52 (Delaware Ave) @ N. Jackson St	16	
7	W. 2nd St @ N. Orange St	14	
8	N. Union St @ W. 2nd St	14	
9	4th St @ Jackson St / I-95 SB off-ramp	12	
10	N. Lincoln St @ W. 2nd St	12	
11	MLK Blvd @ Market St	11	
12	W. 4th St @ N. Lincoln St	11	
13	MLK Blvd @ Monroe St	10	
14	MLK Blvd @ N. Washington St / Justison St	9	
15	W. 2nd St @ N. Tatnall St	9	
16	W. 2nd St @ N. Van Buren St	9	
17	N. Walnut St @ E. 4th St	9	
18	Lincoln St @ Lancaster Ave	8	Red light camera location (EB)
19	W. 4th St @ N. Adams St	8	Red light camera location (WB)
20	N. Washington St @ W. 12th St	8	Red light camera location (WB)
21	SR 52 (Pennsylvania Ave) @ N. Lincoln St	8	Red light camera location (WB)
22	N. Adams St @ 9th St / I-95 NB off-ramp	8	
23	MLK Blvd @ Madison St / SR 4 (Maryland Ave)	8	
24	Union St @ Lancaster Ave	8	
25	W. 2nd St @ N. Jackson St	8	
26	W. 2nd St @ N. Franklin St	8	
27	W. 2nd St @ N. Broom St	8	
28	W. 4th St @ N. Dupont St	8	
29	N. King St @ E. 9th St	8	
30	W. 4th St @ N. Franklin St	7	
31	MLK Blvd @ West St	6	Red light camera location (WB)
32	W. 4th St @ N. Washington St	6	Red light camera location (WB)
33	SR 52 (Pennsylvania Ave) @ N. Franklin St	6	Red light camera location (EB)
34	W. 2nd St @ N. Scott St	6	
35	N. Jackson St @ W. 9th St	6	
36	W. 4th St @ N. Madison St	6	
37	W. 4th St @ N. Van Buren St	6	
38	W. 4th St @ Greenhill Ave	6	
39	Vandever Ave @ Jessup St	6	
40	Delaware Ave @ N. Broom St	6	
41	SR 52 (Pennsylvania Ave) @ N. Dupont St	6	
42	SR 48 (Lancaster Ave) @ Cleveland Ave	5	Red light camera location (EB & WB)
43	W. 4th St @ N. Orange St	5	Red light camera location (EB)
44	MLK Blvd @ Adams St	5	
45	N. King St @ E. 12th St	5	
46	Lea Blvd @ N. Washington St	5	
47	Delaware Ave / W. 11th St @ N. Washington St	5	
48	Lancaster Ave / MLK Blvd @ Jackson St	4	Red light camera location (EB)
49	Lancaster Ave @ Harrison St	4	
50	N. King St / MLK Blvd @ E. 2nd St	4	
51	W. 2nd St @ N. Harrison St	4	

Full Crash Report Reviews of All Sites

Full Crash Report Reviews of Existing Camera Sites

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August 22, 2016

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Crash Reports Analyzed (Existing Camera Location)

Initial City Rank	Intersection	Red Light Running Crashes ('11-'15)*	Comments
52	W. 2nd St @ N. Dupont St	4	
53	N. Union St @ W. 8th St	4	
54	N. Orange St @ W. 8th St	4	
55	N. Washington St @ W. 8th St	4	
56	Delaware Ave @ N. Rodney St	4	
57	SR 52 (Pennsylvania Ave) @ N. Harrison St	4	
58	SR 52 (Pennsylvania Ave) @ N. Broom St	4	
59	SR 52 (Pennsylvania Ave) @ N. Clayton St	4	
60	SR 52 (Pennsylvania Ave) @ Greenhill Ave	4	
61	N. Walnut St @ E. 2nd St / MLK Blvd "sweep"	3	Red light camera location (NB)
62	N. King St @ E. 4th St	3	Red light camera location (SB)
63	S. Walnut St @ A St	3	Red light camera location (NB)
64	US 13 (E. 4th St / S. Heald St) @ Christina Ave	3	Red light camera location (SB)
65	SR 52 (Pennsylvania Ave) / Delaware Ave @ N. Van Buren St	3	Red light camera location (EB & WB)
66	N. Adams St @ 10th St / I-95 NB on-ramp	3	
67	S. Broom St @ Maple St	3	
68	S. Broom St @ Oak St	3	
69	Lancaster Ave @ Van Buren St	3	
70	Lancaster Ave @ Franklin St	3	
71	Lancaster Ave @ Broom St	3	
72	SR 48 (Lancaster Ave) @ Greenhill Ave	3	
73	W. 2nd St @ N. Washington St	3	
74	W. 2nd St @ N. Madison St	3	
75	W. 2nd St @ N. Rodney St	3	
76	N. Market St @ 4th St	3	
77	W. 4th St @ N. Shipley St	3	
78	W. 4th St @ N. West St	3	
79	N. Orange St @ W. 10th St	3	
80	N. King St @ E. 11th St	3	
81	W. 11th St @ N. Orange St	3	
82	E. 10th St @ N. Lombard St	3	
83	N. Walnut St @ E. 9th St	3	
84	N. Jefferson St @ W. 12th St	3	
85	N. Washington St @ W. 7th St	3	
86	Justison St @ S. West St	3	
87	S. Market St @ S. Shipley St / Rosa Parks Dr	3	
88	US 13 SB (S. Heald St) @ A St	3	
89	US 13 (E. 4th St) @ US 13 NB (N. Church St)	3	
90	US 13 (Northeast Blvd) @ E. 12th St	3	
91	US 13 (Northeast Blvd) @ Vandever Ave	3	
92	N. Washington St @ W. 36th St	3	
93	SR 202 (Concord Ave) @ N. Madison St	3	
94	Delaware Ave @ N. Harrison St	3	
95	S. Union St @ Maple St	2	Red light camera location (SB)
96	S. Union St @ Prospect Rd / Rodman Rd / Elsmere Blvd	2	Red light camera location (NB)
97	N. Market St @ Concord Ave/ Vandever Ave	2	Red light camera location (SB)
98	SR 202 (Concord Ave) @ N. Broom St	2	Red light camera location (NB & SB)
99	S. Broom St @ Chestnut St	2	
100	SR 4 (Maryland Ave) @ 5th Ave / Banning St	2	
101	S. Lincoln St @ Linden St	2	
102	S. Lincoln St @ Sycamore St	2	

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Crash Reports Analyzed (Existing Camera Location)

Initial City Rank	Intersection	Red Light Running Crashes ('11-'15)*	Comments
103	E. Front St @ French St / MLK Blvd "sweep"	2	
104	SR 48 (Lancaster Ave) @ SR 100 (S. Dupont Rd)	2	
105	N. Market St @ 2nd St	2	
106	W. 2nd St @ N. West St	2	
107	W. 2nd St @ N. Clayton St	2	
108	N. Union St @ W. 7th St	2	
109	N. Adams St @ W. 8th St	2	
110	SR 52 (Delaware Ave) @ N. Adams St	2	
111	N. Jackson St @ W. 8th St	2	
112	N. Jackson St @ W. 3rd St	2	
113	W. 4th St @ N. Monroe St	2	
114	W. 4th St @ N. Harrison St	2	
115	W. 4th St @ N. Broom St	2	
116	W. 4th St @ N. Rodney St	2	
117	N. King St @ E. 8th St	2	
118	N. King St @ E. 10th St	2	
119	N. Market St @ 10th St	2	
120	N. Orange St @ W. 9th St	2	
121	E. 11th St @ N. French St	2	
122	N. Market St @ 11th St	2	
123	N. Walnut St @ E. 12th St	2	
124	E. 12th St @ N. French St	2	
125	N. Washington St @ W. 9th St	2	
126	US 13 NB (N. Church St) @ E. 8th St	2	
127	US 13 NB (N. Church St) @ E. 7th St	2	
128	US 13 SB (N. Spruce St) @ E. 11th St	2	
129	Vandever Ave @ N. Locust St	2	
130	N. Market St @ 26th St	2	
131	N. Market St @ 24th St	2	
132	SR 202 (Concord Ave) @ N. Washington St	2	
133	SR 202 (Concord Ave) @ N. Jefferson St	2	
134	SR 52 (Pennsylvania Ave) @ N. Union St	2	
135	N. Lincoln St @ W. 9th St	1	Red light camera location (NB)
136	W. 4th St @ N. Union St	1	Red light camera location (SB)
137	N. Walnut St @ E. 8th St	1	Red light camera location (NB)
138	US 13 SB (S. Heald St) @ D St	1	Red light camera location (SB)
139	Marlyand Ave @ I-95 NB off-ramp / S. Adams St	1	
140	S. Broom St @ Banning St	1	
141	SR 4 (Maryland Ave) @ S. Jackson St / Sycamore St	1	
142	SR 4 (Maryland Ave) @ Beech St	1	
143	SR 4 (Maryland Ave) @ Stroud St	1	
144	MLK Blvd @ King St	1	
145	MLK Blvd @ Orange St	1	
146	W. 2nd St @ N. Shipley St	1	
147	N. Lincoln St @ W. 7th St	1	
148	N. Lincoln St @ W. 6th St	1	
149	E. 4th St @ N. Lombard St	1	
150	W. 4th St @ N. Clayton St	1	
151	N. Shipley St @ W. 9th St	1	
152	E. 11th St @ N. Lombard St	1	
153	N. Walnut St @ E. 10th St	1	

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- Crash Reports Analyzed (Existing Camera Location)

Initial City Rank	Intersection	Red Light Running Crashes ('11-'15)*	Comments
154	N. Walnut St @ E. 14th St	1	
155	N. French St @ E. 16th St	1	
156	12th St @ N. Market St	1	
157	W. 12th St @ N. Orange St	1	
158	W. 12th St @ N. West St	1	
159	N. Washington St @ W. 13th St	1	
160	Justison St @ Beech St	1	
161	S. Madison St @ Beech St	1	
162	S. West St @ Water St	1	
163	S. Walnut St @ Christina Crossing	1	
164	US 13 NB (New Castle Ave) @ A St	1	
165	US 13 SB (N. Spruce St) @ E. 4th St	1	
166	US 13 SB (N. Spruce St) @ Taylor St	1	
167	US 13 SB (N. Spruce St) @ E. 10th St	1	
168	US 13 SB (N. Spruce St) / E. 11th St @ Bennett St	1	
169	US 13 (Northeast Blvd) @ E. 26th St	1	
170	N. Market St @ 28th St	1	
171	N. Market St @ 19th St	1	
172	N. Washington St @ W. 18th St	1	
173	N. Washington St @ W. 20th St	1	
174	N. Washington St @ W. 24th St	1	
175	N. Washington St @ W. 27th St	1	
176	N. Washington St @ W. 30th St	1	
177	N. Washington St @ W. 38th St	1	
178	Baynard Blvd @ N. Van Buren St	1	
179	Baynard Blvd @ W. 20th St	1	
180	SR 202 (Concord Ave) @ N. Van Buren St	1	
181	SR 202 (Concord Ave) @ Baynard Blvd / W. 25th St / N. Harrison St	1	
182	Delaware Ave @ N. Jefferson St / W. 11th St	1	
183	S. Park Dr @ N. Van Buren St	1	
184	Delaware Ave @ N. Franklin St	1	
185	SR 52 (Pennsylvania Ave) @ N. Rodney St	1	
186	SR 52 (Pennsylvania Ave) @ University of Delaware Wilmington Campus	1	
187	SR 4 (Maryland Ave) @ 7th Ave	0	Red light camera location (EB)
188	Lancaster Ave @ Dupont St	0	Red light camera location (EB)
189	W. 4th St @ N. Scott St	0	Red light camera location (WB)
190	US 13 NB (N. Church St) @ US 13 SB (N. Spruce St) / E. 11th St	0	Red light camera location (EB)
191	N. Market St @ 30th St / Danby St	0	Red light camera location (WB)
192	SR 52 (Pennsylvania Ave) @ Woodlawn Ave	0	Red light camera location (EB & WB)

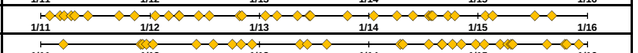
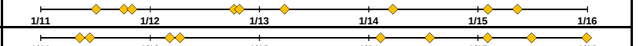
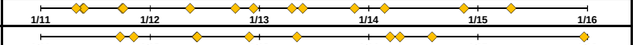
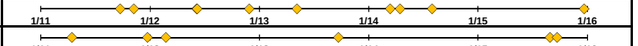
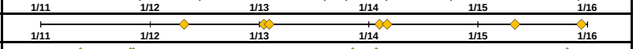
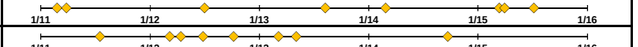
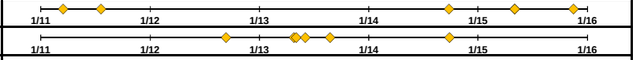
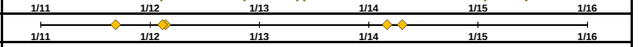
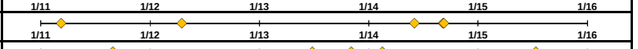
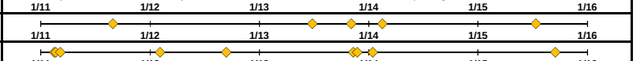
*DelDOT's recent 2015 ERLSP site selection process resulted in a screening (evaluation) threshold of greater than or equal to 8 red light running crashes per intersection, resulting in an initial screening of 59 "candidates"

APPENDIX
B

Delaware Department of Transportation

2016 City of Wilmington Red Light Camera Safety Program
Identification of Candidate Locations
October 12, 2016

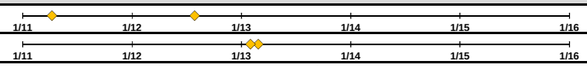
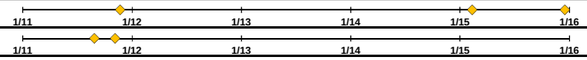
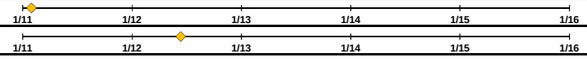
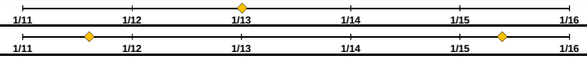
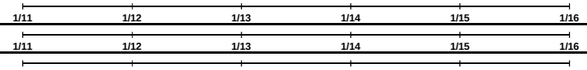
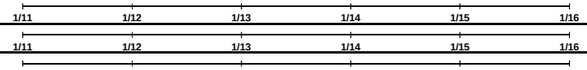
Legend
Red Light Camera Location / Enforced Approach

City Rank	Intersection	Signal Phasing		RLR Crashes By At-Fault Approach										Maximum Crashes by At-Fault Approach	Total Angle Crashes (1/11-12/15)	Angle Crash Timeline
				NB		SB		EB		WB		5th Leg	Unk.			
		Major	Minor	Left	Thru	Left	Thru	Left	Thru	Left	Thru					
1	Walnut St @ E. Front St	One-Way	One-Way	0	52	0	0	3	2	0	0	0	1	52	58	
2	N. Walnut St @ E. 11th St	One-Way	One-Way	0	25	0	0	0	6	0	0	0	9	25	40	
3	N. Adams St @ 11th St / I-95 SB off-ramp	One-Way	One-Way	0	18	0	0	0	9	0	0	0	7	18	34	
4	N. Jackson St @ W. 10th St	One-Way	One-Way	0	0	0	17	0	0	0	5	0	8	17	30	
5 / R1	W. 2nd St @ N. Adams St	One-Way	One-Way	0	17	0	0	0	0	0	6	0	4	17	27	
6	W. 2nd St @ N. Orange St	One-Way	One-Way	0	1	0	0	0	0	0	14	0	3	14	18	
7	MLK Blvd @ Monroe St	One-Way	One-Way	0	0	0	1	0	9	0	0	0	1	9	11	
8	SR 52 (Delaware Ave) @ N. Jackson St	No Left Turns	One-Way	0	0	0	3	0	3	0	8	0	7	8	21	
9	N. Lincoln St @ W. 2nd St	One-Way	One-Way	0	1	0	0	0	0	0	8	0	4	8	13	
10	MLK Blvd @ N. Washington St / Justison St	Prot-Only	Split	0	0	0	0	0	8	0	1	0	0	8	9	
11	N. Union St @ W. 2nd St	One-Way	One-Way	0	0	0	7	0	0	0	5	0	2	7	14	
12	W. 2nd St @ N. Broom St	One-Way	One-Way	0	0	0	7	0	0	0	1	0	3	7	11	
13	W. 2nd St @ N. Van Buren St	One-Way	One-Way	0	2	0	0	0	0	0	7	0	1	7	10	
14	Union St @ Lancaster Ave	One-Way	One-Way	0	0	0	6	0	2	0	0	0	2	6	10	
15	W. 2nd St @ N. Franklin St	One-Way	One-Way	0	6	0	0	0	0	0	1	0	3	6	10	
16 / R2	W. 4th St @ N. Adams St	Concurrent	One-Way	0	1	0	0	0	1	0	6	0	1	6	9	
17	W. 4th St @ N. Lincoln St	Concurrent	One-Way	0	3	0	0	0	4	0	5	0	2	5	14	
18	W. 2nd St @ N. Tatnall St	One-Way	One-Way	0	0	0	5	0	0	0	4	0	1	5	10	
19	SR 52 (Pennsylvania Ave) @ N. Dupont St	Concurrent	One Way	0	0	0	0	0	1	0	5	0	0	5	6	
20 / R3	Lincoln St @ Lancaster Ave	One-Way	One-Way	0	5	0	0	0	0	0	0	0	0	5	5	
21	4th St @ Jackson St / I-95 SB off-ramp	WB Prot-Perm	One-Way/5th Leg	0	0	0	4	0	2	0	0	4	3	4	13	
22	N. Adams St @ 9th St / I-95 NB off-ramp	One-Way	One-Way/5th Leg	0	4	0	0	1	2	0	0	0	3	4	10	
23	W. 2nd St @ N. Jackson St	One-Way	One-Way	0	0	0	4	0	0	0	4	0	2	4	10	
24	MLK Blvd @ Madison St / SR 4 (Maryland Ave)	One-Way	Concurrent/5th Leg	0	0	0	3	0	4	0	0	0	1	4	9	
25 / R4	N. Washington St @ W. 12th St	One-Way	Concurrent	0	0	0	1	0	0	0	4	0	3	4	9	
26	N. King St @ E. 9th St	One-Way	One-Way	0	0	0	4	0	3	0	0	0	2	4	9	
27 / R5	W. 4th St @ N. Washington St	Concurrent	One-Way	0	0	2	0	0	4	0	0	0	1	4	7	
28	W. 4th St @ N. Franklin St	Concurrent	One-Way	0	2	0	0	0	4	0	0	0	1	4	7	
R6	Lancaster Ave / MLK Blvd @ Jackson St	One-Way	One-Way	0	0	0	4	0	2	0	0	0	0	4	6	
29 / R7	SR 52 (Pennsylvania Ave) @ N. Franklin St	Concurrent	One-Way	0	0	0	0	0	4	0	1	0	1	4	6	
30	Delaware Ave @ N. Broom St	Concurrent	One Way	0	0	0	4	0	1	0	1	0	0	4	6	
31 / R8	SR 52 (Pennsylvania Ave) @ N. Lincoln St	Concurent	Concurrent	0	3	0	0	0	1	0	3	0	2	3	9	
32	N. Walnut St @ E. 4th St	One-Way	EB Prot-Perm	0	3	0	0	0	3	0	2	0	0	3	8	
33	W. 4th St @ Greenhill Ave	Concurrent	Concurrent	0	1	1	0	0	3	0	2	0	1	3	8	
R9	W. 4th St @ N. Orange St	EB Prot-Perm	One-Way	0	1	0	0	0	1	0	3	0	1	3	6	
34	W. 4th St @ N. Madison St	Concurrent	One Way	0	2	0	0	0	3	0	1	0	0	3	6	
35	W. 4th St @ N. Van Buren St	Concurrent	One Way	0	0	0	0	0	1	0	3	0	2	3	6	
R10	SR 48 (Lancaster Ave) @ Cleveland Ave	Concurrent	Concurrent	0	0	0	1	0	3	0	0	0	1	3	5	
36	W. 2nd St @ N. Scott St	One-Way	Concurrent	0	2	0	3	0	0	0	0	0	0	3	5	
37	N. Jackson St @ W. 9th St	One-Way	One-Way	0	0	0	1	0	3	0	0	0	1	3	5	
38 / R11	MLK Blvd @ West St	Prot-Only	One-Way	0	1	0	0	0	1	0	2	0	5	2	9	
39	W. 4th St @ N. Dupont St	Concurrent	One-Way	0	1	0	2	0	1	0	1	0	4	2	9	
40	Vandever Ave @ Jessup St	Concurrent	One Way	0	0	0	1	0	2	0	2	0	1	2	6	
41	MLK Blvd @ Market St	Split	One-Way	0	0	0	2	0	2	1	0	0	0	2	5	

DelDOT
Delaware Department of Transportation

2016 City of Wilmington Red Light Camera Safety Program
Identification of Candidate Locations
October 12, 2016

Legend
Red Light Camera Location / Enforced Approach

City Rank	Intersection	Signal Phasing		RLR Crashes By At-Fault Approach										Maximum Crashes by At-Fault Approach	Total Angle Crashes (1/11-12/15)	Angle Crash Timeline
				NB		SB		EB		WB		5th Leg	Unk.			
		Major	Minor	Left	Thru	Left	Thru	Left	Thru	Left	Thru					
R12	S. Union St @ Maple St	One-Way	T-Intersection	0	0	0	2	0	0	0	0	0	0	2	2	
R13	SR 202 (Concord Ave) @ N. Broom St	Prot-Only	EB Prot-Perm	0	2	0	0	0	0	0	0	0	0	2	2	
R14	N. Walnut St @ E. 2nd St / MLK Blvd "sweep"	One-Way	One-Way/5th Leg	0	1	0	0	0	0	0	0	1	1	1	3	
R15	N. King St @ E. 4th St	One-Way	WB Prot-Perm	0	0	0	0	0	1	0	1	0	1	1	3	
R16	S. Walnut St @ A St	One-Way	Concurrent	0	1	0	0	0	1	0	0	0	1	1	3	
R17	S. Union St @ Prospect Rd / Rodman Rd / Elsmere Blvd	WB Prot-Perm	5th Leg	0	0	0	0	0	1	0	0	1	0	1	2	
R18	US 13 (E. 4th St / S. Heald St) @ Christina Ave	SB Prot-Perm	T-Intersection	0	1	0	1	0	0	0	0	0	0	1	2	
R19	SR 52 (Pennsylvania Ave) / Delaware Ave @ N. Van Buren St	No Left Turns	One-Way	0	0	0	0	0	1	0	0	0	1	1	2	
R20	Lancaster Ave @ Dupont St	One-Way	One-Way	0	0	0	1	0	0	0	0	0	0	1	1	
R21	N. Lincoln St @ W. 9th St	One-Way	One-Way	0	1	0	0	0	0	0	0	0	0	1	1	
R22	W. 4th St @ N. Scott St	One-Way	Concurrent	0	0	0	0	0	0	0	1	0	0	1	1	
R23	W. 4th St @ N. Union St	Concurrent	One-Way	0	0	0	0	0	1	0	0	0	0	1	1	
R24	N. Walnut St @ E. 8th St	One-Way	One-Way	0	1	0	0	0	0	0	0	0	0	1	1	
R25	N. Market St @ Concord Ave/ Vandever Ave	EB Prot-Perm	Concurrent	0	0	0	0	0	0	0	0	0	2	0	2	
R26	SR 4 (Maryland Ave) @ 7th Ave	Concurrent	T-Intersection	0	0	0	0	0	0	0	0	0	0	0	0	
R27	US 13 SB (S. Heald St) @ D St	One-Way	One-Way	0	0	0	0	0	0	0	0	0	0	0	0	
R28	US 13 NB (N. Church St) @ US 13 SB (N. Spruce St) / E. 11th St	Concurrent	T-Intersection	0	0	0	0	0	0	0	0	0	0	0	0	
R29	N. Market St @ 30th St / Danby St	Concurrent	One-Way	0	0	0	0	0	0	0	0	0	0	0	0	
R30	SR 52 (Pennsylvania Ave) @ Woodlawn Ave	Concurrent	Concurrent	0	0	0	0	0	0	0	0	0	0	0	0	

APPENDIX
C

DelDOT
Delaware Department of Transportation

2016 City of Wilmington Red Light Camera Safety Program
Right Turn Safety Assessment - Right-Turn and Pedestrian/Bicyclist Crash Totals
December 15, 2016

City Rank	Intersection	Monitored Approach	Before RTOR Monitoring Crashes*								After RTOR Monitoring Crashes*							
			2005 - 2010 Totals (6 yr)								2012 - October 2016 Totals (4.8 yr)							
			Right-Turn Crashes					Ped/Bike Crashes			Right-Turn Crashes					Ped/Bike Crashes		
			Right-Turn Total	Other Mvmt. At-Fault	RT At-Fault	RTOR after stop	RTOR not stopped	Ped/ Bike Total	Ped/Bike RTOR after stop	Ped/Bike RTOR not stopped	Right-Turn Total	Other Mvmt. At-Fault	RT At-Fault	RTOR after stop	RTOR not stopped	Ped/ Bike Total	Ped/Bike RTOR after stop	Ped/Bike RTOR not stopped
5 / R1	W. 2nd St @ N. Adams St	WB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 / R2	W. 4th St @ N. Adams St	WB	1	0	1	0	1	3	0	0	1	0	0	1	0	5	1	0
20 / R3	Lincoln St @ Lancaster Ave	EB	0	0	0	0	0	0	0	0	1	0	1	1	0	3	1	0
25 / R4	N. Washington St @ W. 12th St	WB	1	0	1	0	1	3	0	1	0	0	0	0	0	0	0	0
27 / R5	W. 4th St @ N. Washington St	WB	0	0	0	0	0	1	0	0	1	0	1	0	1	4	0	0
R6	Lancaster Ave / MLK Blvd @ Jackson St	EB	1	0	1	1	0	1	1	0	3	0	3	2	0	4	2	0
29 / R7	SR 52 (Pennsylvania Ave) @ N. Franklin St	EB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 / R8	SR 52 (Pennsylvania Ave) @ N. Lincoln St	WB	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
R9	W. 4th St @ N. Orange St	EB	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
R10	SR 48 (Lancaster Ave) @ Cleveland Ave	EB & WB	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0
38 / R11	MLK Blvd @ West St	WB	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0
R12	S. Union St @ Maple St	SB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R13	SR 202 (Concord Ave) @ N. Broom St	NB & SB	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
R14	N. Walnut St @ E. 2nd St / MLK Blvd "sweep"	NB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R15	N. King St @ E. 4th St	SB	0	0	0	0	0	5	0	0	0	0	0	0	0	15	0	0
R16	S. Walnut St @ A St	NB	2	0	2	1	1	0	0	0	1	0	1	1	0	1	0	0
R17	S. Union St @ Prospect Rd / Rodman Rd / Elsmere Blvd	WB	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
R18	US 13 (E. 4th St / S. Heald St) @ Christina Ave	SB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R19	SR 52 (Pennsylvania Ave) / Delaware Ave @ N. Van Buren St	EB & WB	0	0	0	0	0	0	0	0	1	0	1	1	0	4	0	0
R20	Lancaster Ave @ Dupont St	EB	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
R21	N. Lincoln St @ W. 9th St	NB	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
R22	W. 4th St @ N. Scott St	WB	1	0	1	0	1	3	0	0	0	0	0	0	0	1	0	0
R23	W. 4th St @ N. Union St	SB	1	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0
R24	N. Walnut St @ E. 8th St	NB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R25	N. Market St @ Concord Ave/ Vandever Ave	SB	0	0	0	0	0	1	0	0	2	1	1	1	0	7	1	0
R26	SR 4 (Maryland Ave) @ 7th Ave	EB	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0
R27	US 13 SB (S. Heald St) @ D St	SB	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
R28	US 13 NB (N. Church St) @ US 13 SB (N. Spruce St) / E. 11th St	EB	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
R29	N. Market St @ 30th St / Danby St	WB	0	0	0	0	0	3	0	0	1	0	1	1	0	4	0	0
R30	SR 52 (Pennsylvania Ave) @ Woodlawn Ave	EB & WB	2	1	1	1	0	0	0	0	0	0	0	0	0	3	0	0
Total (30 Intersections)			**10**	**1**	**7**	**3**	**4**	**28**	**1**	**2**	**14**	**1**	**12**	**10**	**2**	**60**	**5**	**0**

*Right Turn on Red monitoring commenced on July 15, 2011; consequently, calendar year 2011 was excluded from the crash data analysis to account for a "buffer" period for motorists to learn and adapt to the updated enforcement policy (e.g., a six-month warning period was in effect prior to July 15, 2011)

APPENDIX D

This report was prepared by the

Office of Program Development and Evaluation

Traffic Safety Programs

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Executive Summary

Since January 1, 1980, all 50 states and the District of Columbia and Puerto Rico have had laws permitting right-turn-on-red (RTOR) unless a sign prohibits the turn (New York's law does not apply in New York City). As of January 1, 1994, 43 jurisdictions provided for left-turn-on-red (LTOR) and nine did not. LTOR is permitted only at intersections of a one-way street with another one-way street. The Energy Policy Act of 1992 required a study to be conducted by NHTSA of the safety impact of permitting right and left turns on red lights. This report presents a brief summary of the current status of state implementation of laws permitting right and left turns at red lights, a brief review of previous research, and presents the results of analyses of currently available data assessing the safety impact of permitting right turns on red.

Previous research conducted in the mid to late 1970's showed that there appeared to be an increase in right-turning crashes at signalized intersections where RTOR was adopted. These studies suggested there was an approximately 23 percent increase in right-turning crashes at intersections where drivers were allowed to turn right on red. Right-turning crashes involving pedestrians were estimated to have increased by about 60 percent and bicyclist crashes by about 100 percent (Zador, 1984). The reader is cautioned that in these studies the actual number of right-turning crashes at signalized intersections involving pedestrians and bicyclists was relatively small so that a small increase in numbers yielded a large percentage increase.

It is important to note that these studies were all based on the adoption of RTOR laws almost twenty years ago. Estimates of the current safety impact of RTOR derived from these older studies and data are clearly not appropriate. Unfortunately, it is not possible to know or estimate the extent the observed increases in right-turning crashes resulting from adoption of RTOR during the 1970's is predictive of the current situation.

Ideally, determining the safety impact of RTOR and LTOR would involve measuring the extent that permitting RTOR and LTOR have increased the number of fatalities, injuries and crashes. Unfortunately, the current number of crashes due to RTOR or LTOR can not be determined from available data. However, using fatal crash data we can measure the potential magnitude of the problem in terms of the number of fatalities in right-turning crashes, and using state crash data we can ascertain the relative frequency, nature and characteristics of RTOR crashes.

Two sources of data were used in completing this report: the Fatal Accident Reporting

System (FARS) and data from four state crash data files (Illinois, Indiana, Maryland, and Missouri). The FARS includes a code for a right-turn-on-red (RTOR) vehicle maneuver. However, the FARS does not include information on whether a vehicle was turning right on red at the time of the crash, only that the vehicle was turning right at the time of the crash at an intersection where RTOR is permitted.

The four-state files include on their accident report form either a code for a right-turn-on-red (RTOR) vehicle maneuver or other codes that make it possible to determine that a RTOR maneuver was executed. With one exception, data used in the analysis cover the years 1989-1992. From Illinois, only 1989-1991 data were available.

Neither FARS nor any state crash files include information for a left-turn-on-red vehicle maneuver. In addition, there are relatively few intersections where a left-turn-on-red is permissible. Thus, the incidence of LTOR crashes is undoubtedly extremely low. Consequently, this report does not include an analysis of the safety impact of LTOR vehicle maneuvers.

The analysis of FARS data showed that:

- Approximately 84 fatal crashes occurred per year during the 1982-1992 time period involving a right-turning vehicle at an intersection where RTOR is permitted. During this same time period there were 485,104 fatalities. Thus, less than 0.2 percent of all fatalities involved a right-turning vehicle maneuver at an intersection where RTOR is permitted. FARS, however, does not discern whether the traffic signal indication was red. Therefore, the actual number of fatal RTOR crashes is somewhere between zero and 84 and may be closer to zero than 84.

- Slightly less than half of the fatal RTOR crashes involve a pedestrian (44 percent), 10 percent a bicyclist and in 33 percent one vehicle striking another vehicle.

The results of the data analysis from the four state crash files suggest the following:

- Right-Turn-On-Red (RTOR) crashes represent a very small proportion of the total number of traffic crashes in the four states (0.05 percent).

- RTOR injury and fatal crashes represent a fraction of 1 percent of all fatal and injury crashes (0.06 percent).

- RTOR crashes represent a very small proportion of signalized intersection crashes (0.4 percent).

- When a RTOR crash occurs, a pedestrian or bicyclist is frequently involved. For all states for all years studied, the proportion of RTOR pedestrian or bicyclist crashes to all RTOR crashes was 22 percent.

- RTOR pedestrian and bicyclist crashes usually involve injury. Ninety-three percent of RTOR pedestrian or bicyclist crashes resulted in injury.

- Only 1 percent of RTOR pedestrian and bicyclist crashes resulted in fatal injury. However, less than one percent (0.2 percent) of all fatal pedestrian and bicyclist crashes result from a RTOR vehicle maneuver.

- RTOR pedestrian crashes are about evenly split between females and males, while RTOR bicyclist crashes predominately involve males.

- Most RTOR crashes occur between 6 a.m. and 6 p.m.

In conclusion, there are a relatively small number of deaths and injuries each year caused by RTOR crashes. These represent a very small percentage of all crashes, deaths and injuries. Because the number of crashes due to RTOR is small, the impact on traffic safety, therefore, has also been small. Insufficient data exist to analyze LTOR.

Preface

On behalf of the Administrator of the National Highway Traffic Safety Administration (NHTSA), the Office of Traffic Safety Programs has prepared this report on the safety impact of permitting right-turn-on-red (RTOR). This report to Congress and the Secretary of Transportation was undertaken in response to a requirement in the Energy Policy Act of 1992 (P.L. 102-486, signed 10/24/92) §141(d) which states:

> *(d) Study Regarding Impact of Permitting Right and Left Turns on Red Lights.*
>
> *(1) In General. - The Administrator of the National Highway Traffic Safety Administration, in consultation with State agencies with jurisdiction over traffic safety issues, shall conduct a study on the safety impact of the requirement specified in section 362(c)(5) of the Energy Policy and Conservation Act (42 U.S.C. 6322(c)(5)), particularly with respect to the impact on pedestrian safety.*
>
> *(2) REPORT. - The Administrator shall report the findings of the study conducted under paragraph (1) to the Congress and Secretary not later than 2 years after the date of the enactment of this Act.*

This report contains a brief summary of the current status of state implementation of laws permitting right and left turns at red lights, presents the results of analysis of currently available data and an assessment of the safety impact of permitting RTOR.

No data or prior research were discovered pertaining to left-turns-on-red (LTOR). In addition, LTOR is permitted only at intersections of a one-way street with another one-way street, and there are few such intersections. Thus, the incidence of LTOR crashes is undoubtedly extremely low. Consequently, this study and report focuses almost exclusively on RTOR.

Introduction

In 1975, an Energy Policy and Conservation Act was signed into law (on 12/22/75) which required the states to develop an energy conservation plan if they wished to qualify for Federal assistance. A part of the Department of Energy's policy to achieve greater energy efficiency and conservation nationally was to encourage all states which had not implemented RTOR to do so. By 1977, virtually all states permitted RTOR at a very high percentage of all signalized intersections.

Most states have adopted the definition and treatment of RTOR and LTOR as specified in the Uniform Vehicle Code (UVC) established by the National Committee on Uniform Traffic Laws and Ordinances (NCUTLO). The UVC restricts RTOR by requiring the driver to stop first and then to yield to approaching vehicles and to all pedestrians within the intersection:

> UVC §11-202(c)3: *"Except when a sign is in place prohibiting a turn, vehicular traffic facing any steady red signal may cautiously enter the intersection to turn right, or to turn left from a one-way street into a one-way street, after stopping as required by subsection (c)1 or subsection (c)2. After stopping, the driver shall yield the right of way to any vehicle in the intersection or approaching on another roadway so closely as to constitute an immediate hazard during the time such driver is moving across or within the intersection or junction of roadways. Such driver shall yield the right of way to pedestrians within the intersection or an adjacent crosswalk." (REVISED 1979)*

In 1992, the Energy Policy and Conservation Act was amended (in the Energy Policy Act of 1992). The 1992 law contained a requirement that each state permit both RTOR and left-turn-on-red (LTOR) where safe:

> 42 USCS Sec. 6332 (c) -- *Each proposed State energy conservation plan to be eligible for Federal assistance under this part shall include:*
>
> > *(5) a traffic law or regulation which, to the maximum extent practicable consistent with safety, permits the operator of a motor vehicle to turn such vehicle right at a red stop light after stopping, and to turn such vehicle left from a one-way street onto a one-way street at a red light after stopping.*

[This LTOR provision is to take effect January 1, 1995.]

By January 1, 1980, all 52 jurisdictions in the U.S. (50 states, District of Columbia and Puerto Rico) had passed laws complying with the Energy Policy Act permitting RTOR unless a sign prohibits the turn (New York's law does not apply in New York City). As of January 1, 1994, 43 jurisdictions provided for LTOR and 9 did not.

Previous Research

After the original 1975 act encouraging states to adopt RTOR was passed, the Federal Highway Administration (FHWA) published a study that examined the economic and safety consequences of permitting RTOR. This study (McGee *et al.,* 1976) concluded that there were substantial economic benefits associated with permitting RTOR (including reducing delays, fuel consumption and auto emissions, increasing intersection capacity and improving level of service) while resulting in an insignificant or no increase in crashes.

McGee *et al.* (1976) looked at crashes in a number of cities and counties that had adopted RTOR. They compare the number of crashes involving vehicles turning right during the red and green phases of the traffic signal cycle, before and after RTOR was permitted. They concluded that RTOR is associated with only a small and insignificant number of crashes. In their report they estimated that if RTOR was adopted at 80 percent of all signalized intersections nationwide at most "... about 11,200 accidents could result annually".

Parker *et al.* (1976) in a very small scale study of RTOR looked at crashes at 20 intersections in Virginia before and after adoption of RTOR. They reported a small but statistically insignificant increase in the number of crashes following RTOR.

In a larger study of 732 signalized intersection in 14 large cities, the American Association of state Highway and Transportation Officials (AASHTO, 1979) noted that there was an increase in the annual rate of right-turning crashes after adoption of right-turn-on-red. No increase in crashes overall was reported, while a 37 percent increase was noted in vehicles performing a right-turning maneuver.

Zador *et al.* (1982) examined crash data from six states where RTOR laws were adopted during 1974-1977, as well as data from three states where the law in effect was

unchanged throughout the same period. Zador *et al.* compared the frequency of crashes involving right-turning maneuvers at signalized intersections both before and after adoption of RTOR and with comparison states that did not change their laws with respect to RTOR during the study period.

Both the RTOR and comparison states experienced an increase in the overall frequency of right-turning crashes during the study period. However, there was a 21 percent greater increase in the frequency of right-turning crashes in the states adopting RTOR that the authors attributed to the adoption of RTOR.

In a NHTSA sponsored study to examine the effects of RTOR on pedestrian and bicyclist crashes at signalized intersections, Preusser *et al.*, (1981) looked at right- turning crashes before and after adoption of RTOR in three states plus one city in a fourth state. They found that the frequency of pedestrian and bicyclist crashes involving right-turning vehicles at signalized intersections increased significantly following RTOR. The increases ranged from 43 percent to 107 percent for pedestrians and ranged from 72 percent to 123 percent for bicyclists in the three states studied. As a percentage of all pedestrian crashes, right-turning crashes at signalized intersections increased 55 percent (from 1.47 percent before RTOR to 2.28 percent after RTOR). As a percentage of all bicyclist crashes, right-turning crashes at signalized intersections increased 99 percent (from 1.40 percent before RTOR to 2.79 percent after RTOR).

Zador (1984) in a reanalysis of previously published data reported that RTOR laws led to an 18 percent increase in right-turning crashes at signalized intersections in the study sites. Based on a review of the literature, Zador (1984) estimates that right-turning crashes increase by about 23 percent at signalized intersections where drivers are allowed to turn right on red. Pedestrian crashes are estimated by Zador to increase by about 60 percent and bicyclist crashes by about 100 percent.

The reader is cautioned that the studies reviewed above involve the use of indirect measures of RTOR crashes, typically **right-turning crashes at signalized intersections**. These involve both vehicles turning right on the green light phase and red light phase of the traffic signal. One cannot assume all right-turning crashes at intersections where RTOR is prohibited (by sign or statute) involve right turns on the green light phase. Many right-turning crashes occur at intersections where it is prohibited by law (in the same way vehicles "running" a red light may crash).

Also, it should be noted that some of these studies looked at right-turning crashes at **all**

signalized intersections while some of the studies looked only at signalized intersections where **RTOR** was adopted. Since it has been estimated that approximately 80 percent of all signalized intersections are appropriate for RTOR, the former will tend to lead to estimates that are 20 percent lower than in the latter studies.

It is important to note that these studies are all based on the adoption of RTOR laws almost twenty years ago. Estimates of the current safety impact of RTOR derived from these older studies and data are clearly not appropriate. Unfortunately, it is not possible to know or estimate the extent the observed increases in right-turning crashes resulting from adoption of RTOR during the 1970's is predictive of the current situation.

Approach

One of the implications of the fact that all states have had RTOR for some time is that it makes it extremely difficult to determine the current safety impact of this law. Ideally, determining the safety impact of RTOR would involve measuring the extent that permitting RTOR has increased the number of fatalities, injuries and crashes. This requires either comparing crash data from essentially identical intersections where RTOR is and is not permitted or having crash data from before and after adoption of RTOR at the same intersections. Neither of these approaches can be meaningfully used for the reasons discussed briefly below.

Because RTOR is almost universally allowed, we do not know what would happen in the absence of the RTOR law. Presumably there are crashes that occur as a result of permitting RTOR that would not occur if RTOR were universally prohibited or permitted only where designated. Unfortunately, current information regarding crash rates where RTOR is universally not allowed is unavailable. While many intersections are signed to prohibit RTOR, these are selected on the basis of fairly explicit traffic engineering criteria that suggested allowing RTOR would be hazardous or disruptive. Thus, crash rates from intersections where RTOR is currently prohibited cannot provide any indication of what the crash rate would be at intersections where RTOR is now allowed, if it were prohibited.

Data on crash rates at intersections from before RTOR was allowed would be at least 20 or more years old and not meaningfully comparable to current crash rates. Changes in

vehicle characteristics, traffic volume, driver behavior, etc. cannot be measured readily. Thus, crash rate data for signalized intersections from a period prior to the adoption of RTOR, that could meaningfully be compared to crash rate data after adoption of RTOR is not available.

While it is not possible to determine the current safety impact of RTOR in terms of the number of increased fatalities, injuries, and crashes, it is possible to measure the potential magnitude of the problem in terms of the number of fatalities in right-turning crashes. In addition, by using state crash data, where available, we can ascertain the relative frequency, nature and characteristics of RTOR crashes.

Two sources of data were used in completing this study and report: the Fatal Accident Reporting System (FARS) and data from four state crash data files. The FARS includes a code for a right-turn-on-red (RTOR) vehicle maneuver. However, the FARS does not include information on whether a vehicle was turning right on red at the time of the crash, only that the vehicle was turning right at the time of the crash at an intersection where RTOR is permitted. The four state files include on their accident report form a code for a right-turn-on-red (RTOR) vehicle maneuver and other codes that make it possible to determine that a RTOR maneuver was executed. Neither FARS nor any state accident files include information for a left-turn-on-red (LTOR) vehicle maneuver. This report, consequently, does not include analysis of the safety impact of LTOR vehicle maneuvers.

Data from sources other than FARS and the four state files were considered, but none of these provide information about a RTOR vehicle maneuver. Other data sources considered include: the General Estimates System, the Crashworthiness Data System, the Crash Avoidance Research Data File, and crash data from the other 46 states.

Results

Fatal Crashes

Figures 1-3 present FARS data for 1982-1992 on crashes involving right-turning vehicle maneuvers. Figure 1 shows the number of fatal crashes by year where a right-turning vehicle maneuver was involved and where RTOR was permitted. An average of approximately 84 fatal crashes occurred per year during this time period involving a right-turning vehicle at an intersection where RTOR is permitted. The FARS data system does not contain information about the traffic signal indication (i.e., whether it was red, green, or yellow) at the time the right-turning vehicle was involved in the crash. Thus, it is impossible to know if the turning vehicles were turning right on a green or red indication. It is reasonable to assume some were turning right on a green indication when they were involved in the crash (e.g., striking a pedestrian, bicyclist, or some fixed object like a parked car or light pole). Therefore, the actual number of RTOR fatal crashes is undoubtedly something less than the number of right-turning fatal crashes as shown in Figure 1.

Figure 1

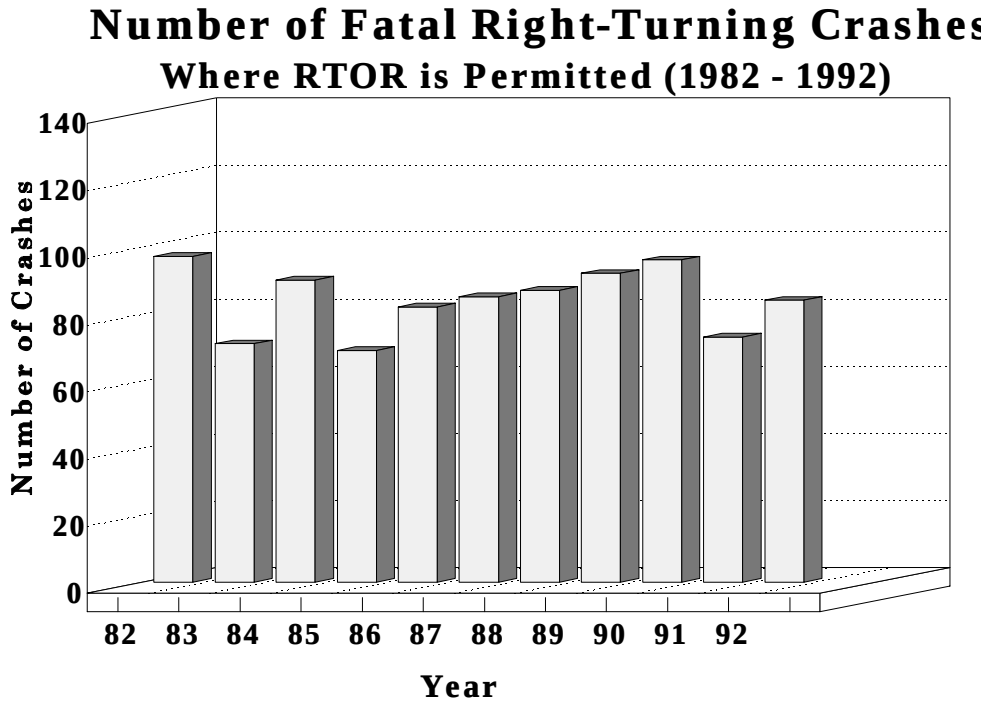

Figure 2

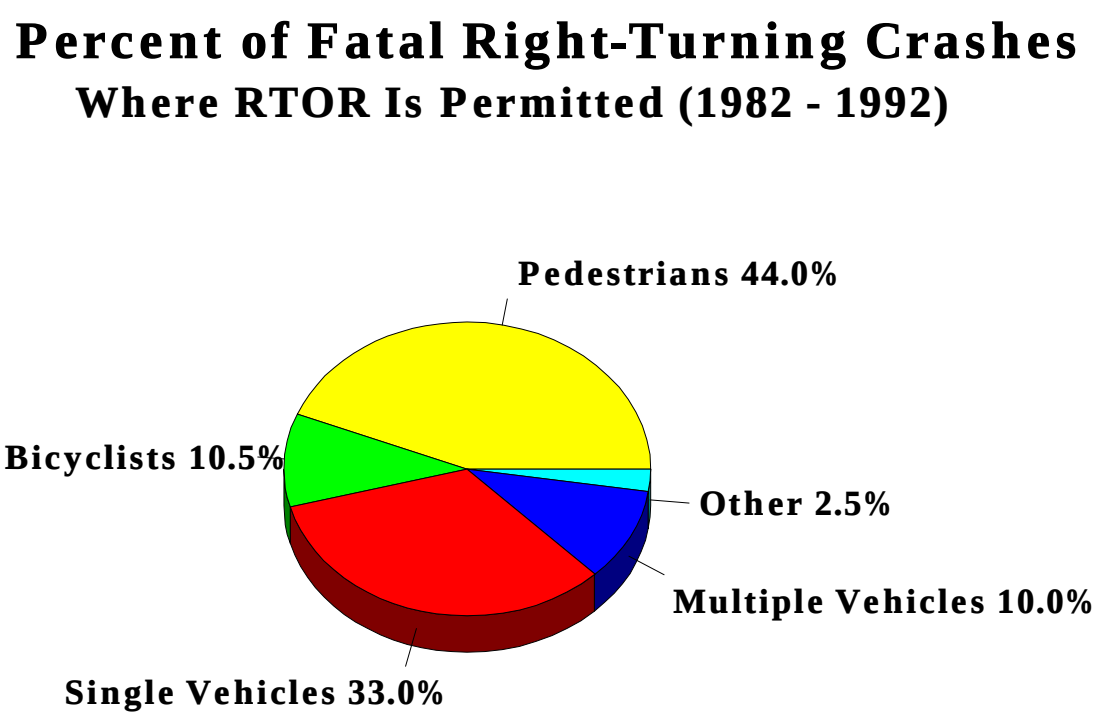

Figure 2 shows the percent of fatal right-turning crashes over the 11 year period by crash type (pedestrian, bicyclist, single vehicle, multiple vehicle, and other). Slightly less than half of these crashes involve a pedestrian (44 percent), 10 percent a bicyclist, and in 33 percent one vehicle striking another vehicle. Table 1 shows the number of fatal crashes by crash type for each year (1982-1992). Of the 926 fatal crashes over the 11 year period, 504 or about 54 percent involve either a pedestrian or bicyclist crash. Over the same 11 year period there were 82,286 pedestrian and bicyclist fatal crashes. Thus, approximately one-half of 1 percent (0.6 percent) of all pedestrian and bicyclist fatal crashes for this 11 year period involved a right-turning vehicle maneuver at an intersection where RTOR is permitted.

Table 1
Number and Type of Fatal Right-Turning Crashes
Where RTOR is Permitted (1982-1992)

Year	Crashes	Peds	Bikes	Multiple Vehicle	Single Vehicle	Other
1982	97	37	11	33	10	6
1983	71	34	4	16	11	6
1984	90	36	10	26	9	9
1985	69	33	6	22	8	
1986	82	31	10	32	8	1
1987	85	43	7	30	5	
1988	87	39	6	34	8	
1989	92	44	14	27	7	
1990	96	43	8	36	9	
1991	73	32	7	26	8	
1992	84	35	14	24	10	1
Totals	926	407 43.95%	97 10.48%	306 33.05%	93 10.04	23 2.48%

State Data

The National Center for Statistical Analysis maintains crash data files from 17 states. Of these, seven states were initially selected as possible candidates for obtaining RTOR data. After review of the actual data files, however, three states were removed from consideration because of missing data. Included in this analysis are data from four states. They are Illinois, Indiana, Maryland, and Missouri.

With one exception, data used in the analysis cover the years 1989-1992. From Illinois, only 1989-1991 data were available. The following analysis of state data looked at all crashes within a state, crashes at signalized intersections, RTOR crashes, and pedestrian and bicyclist crashes by year. RTOR, pedestrian, and bicyclist crashes are further broken down by time of day. Data involving crashes at signalized intersections for Illinois were unavailable.

Note that for each type of crash data analyzed, succeeding crash data are subsets of preceding crash data sets. Thus, crashes at signalized intersections are a subset of all crashes. RTOR crashes are a subset of signalized intersection crashes. And pedestrian and bicyclist crash data are subsets of RTOR crashes. Unfortunately, crash data are not always coded consistently so the numbers discussed below must be interpreted with caution as estimates. For example, a RTOR crash by definition occurs at a signalized intersection, however the roadway variable for signalized intersection is not always checked when a crash is coded as RTOR. For the purposes of this report, we used the vehicle maneuver code for RTOR as the determining factor (rather than the variable for intersection type) in counting a crash as RTOR. Thus, the number of signalized intersection crashes shown in the tables below are undoubtedly somewhat lower than the actual number of such crashes.

An analysis by each of the four states by year is presented in the Appendix. The patterns and relationships between the states and over the years studied were remarkably similar. Because no significant differences were revealed in the analysis by state, only the analyses combining the states and years is presented below.

Table 2

Number and Percent of All Crashes, Signalized Intersection Crashes, and RTOR Crashes by Severity (Indiana, Maryland & Missouri for 1989 - 1992)

	All Crashes		Signalized Intersection		RTOR	
	#	%	#	%	#	%
Property Damage	1,338,089	69.8	197,001	62.3	836	65.5
Injury	570,349	29.7	118,580	37.5	437	34.2
Fatal	9,765	0.5	688	0.2	4	0.3
Total	1,918,203	100.0	316,269	100.0	1277	100.0

Table 2 shows the total number of police reported crashes in Indiana, Maryland, and Missouri for the years 1989-1992 by crash severity (i.e., property damage only, injury and fatal). In these three states, during the 4 year period, there were 1,918,203 police

reported crashes. More relevant to understanding the frequency with which RTOR crashes occur are the frequency of signalized intersection crashes. There were 316,269 signalized intersection crashes, of which 1277 (0.4 percent) involved a RTOR. Looking at crash severity, approximately one third of all crashes (30.2 percent) involve an injury or fatality. The percentage of crashes involving an injury or fatality is approximately 25 percent higher at signalized intersections (37.7 percent versus 30.2 percent) and somewhat lower for RTOR crashes (34.5 percent). Thus, RTOR crashes seem to involve slightly less injuries and fatalities than other crashes at signalized intersections.

To understand the relative frequency with which RTOR crashes occur, Table 3 shows the number and percentage of all crashes and RTOR crashes by crash severity. This table shows that RTOR crashes are five one-hundredths of 1 percent of all crashes.

Table 3

Percentage of All Crashes That Are
Right-Turn-On-Red (RTOR) Crashes*

	All Crashes	RTOR Crashes	% RTOR
Property Damage	2,408,664	1,163	0.048
Injury	892,985	558	0.062
Fatal	14,029	4	0.029
TOTAL	3,315,678	1,725	0.052

* Data from Indiana, Maryland, and Missouri, 1989-1992; Illinois, 1989-1991

Table 4 shows the number and percentage of fatal and injury crashes to RTOR fatal and injury crashes. This table indicates that fatal and injury crashes represent about six one-hundredths of 1 percent of all fatal and injury crashes. Fatal RTOR crashes represent less than three one-hundredths of 1 percent of all fatal crashes.

Table 4

Percentage of All Fatal and Injury Crashes That Are
Right-Turn-On-Red (RTOR) Fatal And Injury Crashes

	Fatal & Injury Crashes	Fatal & Injury RTOR Crashes	% Fatal & Injury RTOR Crashes To Fatal & Injury Crashes
Injury	892,985	558	0.062
Fatal	14,029	4	0.029
TOTAL	907,014	562	0.062

By definition, RTOR crashes must occur at signalized intersections. Table 5 shows the number and percentage of all crashes and RTOR crashes at signalized intersections by crash severity. Table 5 indicates that RTOR crashes are about four tenths of 1 percent of all signalized intersection crashes. The proportions of property damage only and injury crashes are approximately the same. The proportion of fatal RTOR to all fatal crashes at signalized intersections, is less than six tenths of 1 percent.

Table 5

Percentage of All Crashes At Signalized Intersections
That Are Right-Turn-On-Red (RTOR) Crashes*

	Signalized Intersection Crashes	RTOR Crashes	% RTOR to Signalized Intersection Crashes
Property Damage	197,001	836	0.42
Injury	118,580	437	0.37
Fatal	688	4	0.58
TOTAL	316,269	1277	0.40

* Data from Indiana, Maryland, and Missouri, 89-92; no signalized intersection data available for Illinois.

RTOR crashes frequently involve pedestrians and bicyclists. Table 6 shows the number and percent of all RTOR crashes to RTOR crashes involving pedestrians and bicyclists. Slightly more than 22 percent of all RTOR crashes involve either a pedestrian or bicyclist.

Table 6

Percentage of Right-Turn-On-Red (RTOR) Crashes
That Involve A Pedestrian or Bicyclist*

	RTOR Crashes	RTOR Pedestrian/ Bicyclist Crashes	% Pedestrian/ Bicyclist RTOR Crashes to RTOR Crashes
Property Damage/No Injury	1163	27	2.3
Injury	558	352	63.1
Fatal	4	4	100.0
TOTAL	1,725	383	22.2

* Data from Indiana, Maryland, and Missouri, 1989-1992; Illinois, 1989-1991

Table 7 shows the distribution of RTOR crashes involving pedestrians and bicyclist by crash type. RTOR crashes involving pedestrians or bicyclist usually result in some degree of injury (approximately 93 percent).

Table 7

Pedestrian/Bicyclist Right-Turn-On-Red (RTOR)
Crashes By Crash Type

	RTOR Pedestrian/ Bicyclist Crashes	Percent
Property Damage/No Injury	27	7.1
Injury	352	91.9
Fatal	4	1.0
TOTAL	383	100.0

Table 8 gives the number and percent of all pedestrian and bicyclist fatal crashes to RTOR fatal crashes. The percentage of RTOR pedestrian and bicyclist fatal crashes to all pedestrian and bicyclist crashes is approximately two tenths of a percent.

Table 8

Percentage of All Fatal Pedestrian and Bicyclist Crashes That Are
Right-Turn-On-Red (RTOR)*

	All Fatal Pedestrian/ Bicyclist Crashes	RTOR Fatal Pedestrian/ Bicyclist Crashes	Percent RTOR
Fatal	2194	4	0.18%

* Data from Indiana, Maryland and Missouri, 1989 - 1992; Illinois, 1989 - 1991

Table 9 gives the number and proportion of RTOR crashes by time of day. Almost 76 percent of RTOR crashes occur from around 6 a.m. to 6 p.m.

Table 9

Right-Turn-On-Red (RTOR) Crashes
By Time of Day

TIME	NUMBER	PERCENT
6:01 a.m. - 6 p.m.	1303	75.5
6:01 p.m. - 6 a.m.	412	23.9
Unknown	10	0.6
TOTAL	1725	100.0

Tables 10 and 11 show that the preponderance of pedestrian and bicyclist RTOR crashes also occur from 6 a.m. to 6 p.m.

Table 10

Pedestrian Right-Turn-On-Red Crashes
By Time of Day

TIME	NUMBER	PERCENT
6:01 a.m. - 6 p.m.	185	74.6
6:01 p.m. - 6 a.m.	63	25.4
Unknown	0	0.0
TOTAL	248	100.0

Table 11

Bicyclist Right-Turn-On-Red Crashes
By Time of Day

TIME	NUMBER	PERCENT
6:01 a.m. - 6 p.m.	101	74.0
6:01 p.m. - 6 a.m.	33	24.5
Unknown	1	0.0
TOTAL	135	100.0

Table 12 gives the number and percent of pedestrian RTOR crashes by age. Table 12 shows that most RTOR pedestrian crashes involve pedestrians in the 16-64 age group.

Table 12

Pedestrian Right-Turn-On-Red Crashes
By Age

AGE	NUMBER	PERCENT
0 - 15	51	20.6
16 - 64	143	57.7
> 64	42	16.9
Unknown	12	4.8
TOTAL	248	100.0

Table 13 shows the number and percent of RTOR crashes involving bicyclist by age. The

largest proportion of RTOR bicyclist crashes involve bicyclists under 16 years of age. However, almost 42 percent of the RTOR bicyclist crashes involved those in the 16-64 age category.

Table 13

Bicyclist Right-Turn-On-Red Crashes
By Age

AGE	NUMBER	PERCENT
0 - 15	65	48.2
16 - 64	56	41.5
> 64	6	4.4
Unknown	8	5.9
TOTAL	135	100.0

Tables 14 and 15 provide information about pedestrian and bicyclist RTOR crashes by gender. Table 14 shows that RTOR pedestrian crashes involve both females and males about equally. Table 15 shows that the preponderance of RTOR bicyclist crashes involve males (almost 80 percent).

Table 14

Pedestrian Right-Turn-On-Red (RTOR) Crashes By Gender

SEX	NUMBER	PERCENT
FEMALE	124	50.0
MALE	120	48.4
Unknown	4	1.6
TOTAL	248	100.0

Table 15
Bicyclist Right-Turn-On-Red (RTOR) Crashes
By Gender

SEX	NUMBER	PERCENT
FEMALE	27	20.0
MALE	105	77.8
Unknown	3	2.2
TOTAL	135	100.0

Summary

RTOR vehicle maneuvers that result in crashes represent failed maneuvers. It would be informative if the number of failed RTOR maneuvers could be compared with the number of successful RTOR maneuvers. Data concerning successful RTOR maneuvers, however, are not readily available and the collection of such data would require considerable time and effort.

The results of the FARS data analysis indicate the following:

- Approximately 84 fatal crashes occurred per year during the 1982-1992 time period involving a right-turning vehicle at an intersection where RTOR is permitted. During this same time period, there were 485,104 fatalities. Thus, less than 0.2 percent of all fatalities involved a right-turning vehicle maneuver at an intersection where RTOR is permitted. FARS, however, does not discern whether the traffic signal indication was red. Therefore, the actual number of fatal RTOR crashes is somewhere between zero and 84 and may be closer to zero than 84.

- Slightly less than half of the fatal RTOR crashes involve a pedestrian (44 percent), 10 percent a bicyclist, and in 33 percent one vehicle striking another vehicle.

The results of the data analysis from the four state crash files suggest the following:

- Right-Turn-On-Red (RTOR) crashes represent a very small proportion of the total number of traffic crashes in the four states (0.05 percent), and similarly a very small fraction all fatal (0.03 percent), injury (0.06 percent) and signalized intersection crashes (0.40 percent).

- Pedestrians and bicyclists are involved in about 22 percent of all RTOR crashes. RTOR pedestrian and bicyclist crashes usually involve injury. Ninety-three percent of RTOR pedestrian or bicyclist crashes resulted in injury.

- Only 1 percent of RTOR pedestrian and bicyclist crashes resulted in fatal injury. However, less than 1 percent (0.2 percent) of all fatal pedestrian and bicyclist

crashes result from a RTOR vehicle maneuver.

- Most RTOR crashes occur between 6 a.m. and 6 p.m. (during daylight hours).
- RTOR pedestrian crashes are about evenly split between females and males, while RTOR bicyclist crashes predominately involve males.

- While most pedestrian's involved in RTOR crashes are 16 - 64 years of age (58 percent), a fair number are under 16 years old (21 percent), or 65 years old and over (17 percent).

- About half of the bicyclist's involved in RTOR crashes are less than 16 years of age (48 percent), slightly fewer between 16-64 years old (42 percent), with very few 65 years old and over (4 percent).

Conclusion

In conclusion, there are a relatively small number of deaths and injuries each year caused by RTOR crashes. These represent a very small percentage of all crashes, deaths and injuries. Because the number of crashes due to RTOR is small, the impact on traffic safety, therefore, has also been small. Insufficient data exist to analyze LTOR.

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APPENDIX

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List of Tables

Missouri

Illinois

Tables 1-7 present crash data from Illinois. From 1989-1991 there were 1,397,475 reported crashes (Table 1)[1]. There were 326,900 injury and fatal crashes in Illinois over this three year period. For the same three years, there were 121 injury and no fatal crashes where a RTOR vehicle maneuver was involved (Table 2). The proportion of RTOR injury and fatal crashes to total injury and fatal crashes for the three years was approximately 0.04 percent (121/326,900). Table 3 shows that most (approximately 76 percent) of RTOR crashes occurred between the hours of 6 a.m. and 6 p.m.

Tables 4-7 indicate the number of RTOR pedestrian and bicyclist crashes. There were 42 RTOR pedestrians crashes from 1989-1991 (Table 4). All were injury crashes (there were no fatal crashes). Table 5 shows that about 74 percent of RTOR crashes involving pedestrians occurred between 6 a.m. and 6 p.m.

There were 48 RTOR crashes involving bicyclists from 1989-1991 (Table 6). Of these, seven resulted in no injury, 41 resulted in an injury, and there were no fatalities[2]. Table 7 indicates that most (approximately 73 percent) RTOR crashes involving bicyclists occurred between 6 a.m. and 6 p.m.

Indiana

Tables 8-15 show crash data for Indiana for 1989-1992. There were 834,264 reported crashes from 1989 - 1992 (Table 8). Of these, 202,132 were either an injury or fatal crash. There were 122,773 crashes at signalized intersections (Table 9) including 36,300 injury and fatal crashes. Injury and fatal crashes at signalized intersections represent approximately 18 percent (36,300/202,132) of the total injury and fatal crashes.

Table 10 shows RTOR crashes. There were 212 total crashes of which 94, or about 44 percent, were either injury or fatal crashes. The proportion of RTOR injury and fatal

[1]Note that because of property damage only (PDO) reporting thresholds, not all PDO crashes are reported in a state. PDO crash reporting thresholds vary by state, and consequently, the number and proportion of PDO crashes to injury and fatal crashes will differ as a factor of the reporting threshold. All states require that crashes involving injuries or fatalities be reported.

[2]While a state may have a PDO crash reporting threshold, most states allow a citizen involved in a crash to request that a law enforcement official complete and submit an accident report. Further, most pedestrian and a majority of bicyclist cashes involve some degree of injury. Consequently, it is likely that a greater proportion of pedestrian and bicyclist crashes will be reported than other crashes where only property damage is involved.

crashes to total injury and fatal crashes is approximately 0.05 percent (94/202,132). The proportion of RTOR injury and fatal crashes to injury and fatal crashes at signalized intersections is about 0.25 percent (94/36,300).

Table 11 gives RTOR crashes by time of day. Almost 78 percent of the RTOR crashes in Indiana occurred between 6 a.m. and 6 p.m.

Table 12 shows the number of RTOR crashes where a pedestrian was involved. There was a total of 55 crashes, and with the exception of 1 crash, all were either injury or fatal crashes. Pedestrian injury and fatal crashes represent about 57 percent (54/94) of all RTOR injury and fatal crashes. From 1989-1992 there were 344 fatal crashes involving pedestrians. RTOR pedestrians crashes accounted for 1.2 percent (4/344) of these fatal crashes.

Table 13 indicates that about 76 percent of RTOR crashes involving pedestrians occur between 6 a.m. and 6 p.m.

Table 14 shows the number of RTOR crashes involving bicyclists. There were 18 injury and no fatal crashes over the 4 year period. RTOR injury bicyclist crashes represent about 19 percent (18/94) of all RTOR injury and fatal crashes. From 1989-1992, there was a total of 70 fatal bicyclist crashes in Indiana. None of these were related to a RTOR vehicle maneuver.

Table 15 shows that most RTOR crashes involving bicyclist occurred between 6 a.m. and 6 p.m.

Maryland

Table 16-23 provide crash data for Maryland from 1989-1992. From 1989-1992, there were 417,480 reported crashes (Table 16). Of these, 193,718 or about 46 percent were either injury or fatal crashes. Over this same period of time, there were 86,627 crashes at signalized intersections (Table 17), of which 48,972 (57 percent) were injury or fatal crashes. The proportion of injury and fatal crashes at signalized intersections to all injury and fatal crashes is about 25 percent (48,972/193,718) for this four-year period.

Table 18 shows the number of RTOR crashes in Maryland from 1989-1992. There was a total of 145 crashes of which 102, or 70 percent were injury crashes. There were no fatal RTOR crashes. The proportion of RTOR injury crashes to total injury and fatal crashes

is 0.05 percent (102/193,718). The proportion of RTOR injury crashes to injury and fatal crashes at signalized intersections is approximately 0.2 percent (102/48,972).

Table 19 shows that about 63 percent of RTOR crashes occur between 6 a.m. and 6 p.m.

Table 20 shows the number of RTOR crashes involving pedestrians. There were 58 crashes, and with the exception of 1 crash, all resulted in injury. There were no fatal RTOR crashes involving pedestrians over the four-year period. Pedestrian injury crashes represent about 56 percent (57/102) of all RTOR injury crashes.

As indicated, from 1989-1992, there were 498 fatal pedestrian crashes in Maryland. None involved a RTOR vehicle maneuver.

Table 21 indicates that most (about 59 percent) of RTOR crashes involving pedestrians occurred between 6 a.m. and 6 p.m.

Table 22 shows the number of RTOR crashes involving bicyclists in Maryland from 1989-1992. There were 19 crashes of which 16, or about 84 percent, were injury crashes. There were no fatal RTOR crashes involving bicyclist over the four-year period. RTOR Bicyclist crashes where injury results represent about 16 percent (16/102) of the total RTOR injury crashes. In Maryland from 1989-1992, there were 41 fatal bicyclist crashes. None involved a RTOR vehicle maneuver.

Table 23 shows that about 63 percent of RTOR bicyclist crashes occur between 6 a.m. and 6 p.m.

Missouri

Tables 24-31 show crash data for the State of Missouri for 1989-1992.

Table 24 indicates that there were 666,459 reported crashes from 1989-1992. Of these, 184,264 or about 28 percent were injury or fatal crashes.

Table 25 provides information about signalized intersection crashes in Missouri from 1989-1992. Of the 106,869 reported crashes, 33,996 or about 32 percent, were recorded as injury or fatal crashes. The proportion of injury and fatal crashes at signalized intersections to total injury and fatal crashes was about 18 percent (33,996/184,264).

Table 26 gives information about RTOR crashes from 1989-1992. There was a total of 920 crashes. There were no fatal RTOR crashes and of the total RTOR crashes, 245 or about 27 percent were injury crashes. The proportion of RTOR injury crashes to total injury and fatal crashes is 0.13 percent (245/184,264). The proportion of RTOR injury crashes to injury and fatal crashes at signalized intersections is 0.72 percent (245/33,996).

Table 27 shows that about 77 percent of the RTOR crashes occurred from 6 a.m. - 6 p.m.

Table 28 indicates that there was a total of 93 RTOR crashes involving pedestrians. Of these, 86 or about 92 percent were injury crashes. There were no fatal RTOR crashes involving pedestrians over the four year period. RTOR pedestrian injury crashes represent about 35 percent (86/245) of the total RTOR injury crashes.

From 1989-1992, there was a total of 351 fatal pedestrians crashes in Missouri. None of these involved a RTOR vehicle maneuver.

Table 29 shows that most (about 80 percent) of RTOR pedestrian crashes occurred between 6 a.m. and 6 p.m.

Table 30 shows RTOR bicyclist crashes from 1989-1992. There were 50 crashes of which 42, or 84 percent were injury related. RTOR bicyclist crashes where injury results represent about 17 percent (42/245) of the total RTOR injury crashes.

From 1989-1992, there were 31 fatal bicyclist crashes. None of these involved a RTOR vehicle maneuver.

Table 31 shows that the bulk (74 percent) of RTOR crashes involving bicyclist occur between 6 a.m. - 6 p.m.

Table 1

Illinois
All Crashes By Severity

	1989	1990	1991	Total
Property Damage *	397,416	345,534	327,625	1,070,575
Injury	117,666	105,924	99,046	322,636
Fatal	1545	1430	1289	4264
Total	516,627	452,888	427,960	1,397,475

* The reporting threshold for property damage only (PDO) crashes in Illinois before 1992 was $250. Consequently, not all PDO crashes were reported.

Table 2

Illinois
Right Turn on Red Crashes

	1989	1990	1991	Total
Property Damage	151	82	94	327
Injury	48	35	38	121
Fatal	0	0	0	0
Total	199	117	132	448

Table 3

Illinois
Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	Total
6:01 a.m. - 6 p.m.	155	85	100	340
6:01 p.m. - 6 a.m.	42	32	31	105
Unknown Time	2	0	1	3
Total	199	117	132	448

Table 4

Illinois
Pedestrians Involved in Right Turn on Red Crashes

	1989	1990	1991	Total
No Injury	0	0	0	0
Injury	18	9	15	42
Fatal	0	0	0	0
Total	18	9	15	42

Table 5

Illinois
Pedestrians Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	Total
6:01 a.m. - 6 p.m.	13	6	12	31
6:01 p.m. - 6 a.m.	5	3	3	11
Total	18	9	15	42

Table 6

Illinois
Bicyclists Involved in Right Turn on Red Crashes

	1989	1990	1991	Total
No Injury	5	1	1	7
Injury	16	15	10	41
Fatal	0	0	0	0
Total	21	16	11	48

Table 7

Illinois
Bicyclists Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	Total
6:01 a.m. - 6 p.m.	20	8	7	35
6:01 p.m. - 6 a.m.	1	8	4	13
Total	21	16	11	48

Table 8

Indiana
All Crashes By Severity

	1989	1990	1991	1992	Total
Property Damage *	191,820	140,618	132,004	167,690	632,132
Injury	53,816	48,901	45,646	50,258	198,621
Fatal	883	924	904	800	3511
Total	246,519	190,443	178,554	218,748	834,264

* The reporting threshold for property damage only (PDO) crashes in Indiana from 1989-1992 was $750.00. Consequently, not all PDO crashes were reported.

Table 9

Indiana
Signalized Intersection Crashes

	1989	1990	1991	1992	Total
Property Damage	26,593	21,020	19,365	19,495	86,473
Injury	9808	8893	8410	8967	36,078
Fatal	55	54	54	59	222
Total	36,456	29,967	27,829	28,521	122,773

Table 10

Indiana
Right Turn on Red Crashes

	1989	1990	1991	1992	Total
Property Damage	50	20	30	18	118
Injury	19	28	19	24	90
Fatal	0	2	1	1	4
Total	69	50	50	43	212

Table 11

Indiana
Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	49	38	41	37	165
6:01 p.m. - 6 a.m.	18	11	9	4	42
Unknown Time	2	1	0	2	5
Total	69	50	50	43	212

Table 12

Indiana
Pedestrians Involved in Right Turn on Red Crashes

	1989	1990	1991	1992	Total
No Injury	0	1	0	0	1
Injury	9	15	11	15	50
Fatal	0	2	1	1	4
Total	9	18	12	16	55

Table 13

Indiana
Pedestrians Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	6	14	9	13	42
6:01 p.m. - 6 a.m.	3	4	3	3	13
Total	9	18	12	16	55

Table 14

Indiana
Bicyclists Involved in Right Turn on Red Crashes

	1989	1990	1991	1992	Total
No Injury	0	0	0	0	0
Injury	5	4	6	3	18
Fatal	0	0	0	0	0
Total	5	4	6	3	18

Table 15

Indiana
Bicyclists Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	4	4	6	3	17
6:01 p.m. - 6 a.m.	0	0	0	0	0
Unknown Time	1	0	0	0	1
Total	5	4	6	3	18

Table 16

Maryland
All Crashes By Severity

	1989	1990	1991	1992	Total
Property Damage *	62,160	57,884	52,010	51,708	223,762
Injury	50,248	48,893	44,802	47,180	191,123
Fatal	676	681	645	593	2595
Total	113,084	107,458	97,457	99,481	417,480

* The reporting threshold for property damage only (PDO) crashes in Maryland is that one or more vehicles be towed away. Consequently, not all PDO crashes are reported.

Table 17

Maryland
Signalized Intersection Crashes

	1989	1990	1991	1992	Total
Property Damage	10,004	9508	8988	9155	37,655
Injury	12,102	12,436	11,723	12,433	48,694
Fatal	71	80	65	62	278
Total	22,177	22,024	20,776	21,650	86,627

Table 18

Maryland
Right Turn on Red Crashes

	1989	1990	1991	1992	Total
Property Damage	9	11	8	15	43
Injury	27	21	27	27	102
Fatal	0	0	0	0	0
Total	36	32	35	42	145

Table 19

Maryland
Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	19	24	18	30	91
6:01 p.m. - 6 a.m.	17	8	17	12	54
Total	36	32	35	42	145

Table 20

Maryland
Pedestrians Involved in Right Turn on Red Crashes

	1989	1990	1991	1992	Total
No Injury	1	0	0	0	1
Injury	13	15	18	11	57
Fatal	0	0	0	0	0
Total	14	15	18	11	58

Table 21

Maryland
Pedestrians Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	5	12	11	10	38
6:01 p.m. - 6 a.m.	9	3	7	1	20
Total	14	15	18	11	58

Table 22

Maryland
Bicyclists Involved in Right Turn on Red Crashes

	1989	1990	1991	1992	Total
No Injury	0	1	0	2	3
Injury	4	2	3	7	16
Fatal	0	0	0	0	0
Total	4	3	3	9	19

Table 23

Maryland
Bicyclists Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	2	2	1	7	12
6:01 p.m. - 6 a.m.	2	1	2	2	7
Total	4	3	3	9	19

Table 24

Missouri
All Crashes By Severity

	1989	1990	1991	1992	Total
Property Damage *	123,878	123,914	117,236	117,167	482,195
Injury	44,593	46,700	43,917	45,395	180,605
Fatal	936	943	906	874	3659
Total	169,407	171,557	162,059	163,436	666,459

* The reporting threshold for property damage only (PDO) crashes in Missouri from 1989-1992 was $500. Consequently, not all PDO crashes were reported.

Table 25

Missouri
Signalized Intersection Crashes

	1989	1990	1991	1992	Total
Property Damage	17,498	17,781	18,290	19,304	72,873
Injury	7948	8683	8274	8903	33,808
Fatal	41	44	47	56	188
Total	25,487	26,508	26,611	28,263	106,869

Table 26

Missouri
Right Turn on Red Crashes

	1989	1990	1991	1992	Total
Property Damage	156	178	171	170	675
Injury	64	57	56	68	245
Fatal	0	0	0	0	0
Total	220	235	227	238	920

Table 27

Missouri
Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	173	177	177	180	707
6:01 p.m. - 6 a.m.	47	57	50	57	211
Unknown Time	0	1	0	1	2
Total	220	235	227	238	920

Table 28

Missouri
Pedestrians Involved in Right Turn on Red Crashes

	1989	1990	1991	1992	Total
No Injury	0	2	1	4	7
Injury	24	24	19	19	86
Fatal	0	0	0	0	0
Total	24	26	20	23	93

Table 29

Missouri
Pedestrians Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	20	22	13	19	74
6:01 p.m. - 6 a.m.	4	4	7	4	19
Total	24	26	20	23	93

Table 30

Missouri
Bicyclists Involved in Right Turn on Red Crashes

	1989	1990	1991	1992	Total
No Injury	1	3	1	3	8
Injury	13	10	5	14	42
Fatal	0	0	0	0	0
Total	14	13	6	17	50

Table 31

Missouri
Bicyclists Involved in Right Turn on Red Crashes
By Time of Day

	1989	1990	1991	1992	Total
6:01 a.m. - 6 p.m.	11	10	4	12	37
6:01 p.m. - 6 a.m.	3	3	2	5	13
Total	14	13	6	17	50