Red-light camera literature review

Prepared by the Ministry of Transport

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Summary

1. This document represents a brief review of the literature on the effectiveness of traffic signal-mounted red-light cameras. There are several difficulties for the evaluation of red-light camera programmes which reduce the quality of any conclusions reached about their effectiveness. The literature has shown conclusively that red-light running is a substantial safety issue, being related to crash types with a high likelihood of injury. Certain types of driver are more likely to run red lights, suggesting that education and awareness campaigns would be effective. There are also certain characteristics of intersections which are correlated with red-light running. This suggests that engineering and timing changes are important tools to improve intersection safety and should be considered prior to red-light camera installation.

2. Recent reviews have shown that red-light cameras are effective in reducing red-light violations and the associated crashes. Red-light cameras are most likely to effectively target intentional red-light runners. They have also been found to have a positive cost-benefit ratio, although the relative cost-benefit ratios of other interventions would also be relevant. It should also be borne in mind that our situation is different from most (perhaps all) other jurisdictions where the literature originates. This is because here “amber” means stop if you can do so safely, while elsewhere it is a warning that a red signal follows. This may affect red light running behaviour.

3. Some key references are identified for further reading. This review ends with brief information on the operational details of other jurisdictions’ red-light camera programmes such as fines, demerit points and the uses of the resulting revenue.

Methodology and definition

4. Studies of the effectiveness of red-light cameras range from the opportunistic, evaluating installations of red-light cameras which are often introduced at those intersections with high levels of red-light running and/or crashes, to the purposive. This tends to introduce a systematic bias which, along with the low numbers of treated intersections and crashes, may reduce the quality of any conclusions reached.

5. More recent studies of red-light running depend on induction loops placed on the road, which allow for the identification of vehicle speeds and times of entry into the intersection relative to the beginning of the red-phase. This is a potential problem, as induction loops designed for setting signal phases may not always be precise enough for doing these other tasks properly.

6. The operational definition of red-light running for red-light cameras tends to have a buffer so that vehicles entering the intersection less than, say 0.5 seconds after the beginning of the red-phase, would not be identified as red-light runners. Similarly, vehicles crossing the entry to the intersection at a low speed (below 15 km/h) would also not be identified as running a red-light. This is because these slow-moving vehicles tend to stop rather than continue across the intersection.

Extent of the problem

7. Red-light running is directly implicated in many intersection crashes. In addition it is suggested that angle crashes, the type of crash often resulting from red-light running, tend to be more severe (FHWA, 2005), and are more likely to result in injury than other crashes (Retting et al., 1998).

8. The extent of the problem has been defined in several ways:

    - Zaal (1994) cites two studies which provide figures for the percentage of all crashes which occur at signalised intersections: Lawson estimates that 8 percent of all crashes occur at signalised intersections; South et al. give estimates of injury crashes at signalised intersections: 10 percent of fatal crashes and 18 percent of all injury crashes (the equivalent figures for NZ would be about two percent and nine percent, respectively).

    - Several studies have given figures of around 20 percent of crashes at signalised intersections being due to red-light running (e.g. Mohamedshah et al., in Bonneson and Son, 2003; Halcrow Fox, 1996; Croft, in Zaal 1994). The equivalent figure for NZ is about 30 percent.

    - Most studies note large variations in the rates of red-light running between intersections. As discussed below this highlights the importance of the physical features of the intersection in the rate of red-light running.

    - Green (2003) finds little variation in red-light violation rates throughout the daytime. Several studies show a peak in numbers of violations with peaks in traffic flow. This is likely to be a function of exposure to red-light running opportunities and situational pressures. Red-light running rates at night time, when traffic flows are low, are subject to large variations between studies.

9. MUARC (1995) notes that the extent of the problem is easily under-estimated. Many studies consider a small number of intersections over a limited time period. If these are extrapolated across an urban network with many hundreds of intersections, the result is a very large number of red-light violations.

10. Many studies note the (small) percentage of red-light runners who enter the intersection so long after the beginning of the red phase that an alternative approach would have a green light. These are clearly the most dangerous violations. For example, a study by MUARC (1995) noted 123 red-light violations in observations of 38,000 vehicles – 93 percent of those (115 of the 123) occurred in the all-red phase, a period in which other vehicles were unlikely to be moving in the intersection; the remaining seven percent (eight of the 123 red-light violations) were entering the intersection while another approach had a green light. The authors noted that a longer all-red phase could be a solution, although drivers' behavioural responses would require careful consideration. Adopting good practice in signal phasings (in particular adequate amber and all-red times), as set out in the appropriate design guidelines, should limit these types of behaviour. Innovative approaches like off peak rest in red may also limit red light running off peak[1]

Characteristics of red-light running behaviour

11. As with other traffic violations, certain types of driver are more likely than others to run a red light. Red-light runners are more likely to have previous convictions for moving violations; they are also more likely to be young and to be under the influence of alcohol, and they are less likely to have a valid full licence. The evidence is less clear that males are more likely than females to run a red light, with different studies having contradictory conclusions (Green, 2003; DoT, 2006). ITE (2003) cites telephone surveys undertaken in the US which indicate that more than 50 percent of respondents had run a red light, and that situational variables such as being in a hurry and fear of causing a rear-end crash were factors in respondents' decisions to do so.

12. Some of those who enter an intersection may do so unintentionally, whether through indecision or inattention, or possibly due to being unable to stop in time. Unintentional violations are likely to be best

[1] Rest in red, or dwell in red, refers to a situation where, in off-peak times, all approaches to a signal show a red signal in the absence of traffic on any approach. When the next vehicle arrives it is detected far enough up-stream of the signal for it to be given a green signal, allowing it to cross the intersection without stopping.

managed by engineering and phase adjustments. Intentional violations in which the driver makes a conscious decision to get through an intersection regardless of the traffic signals, may be better managed by enforcement. This may also be a symptom of an all-red period which is too long and could be addressed by adjustments to the signal settings.

13. Many studies note the large variation in red-light running rates between intersections (or approaches to intersections). It is likely that many features of the intersection layout play a part in red-light running rates. Aspects noted include signal sight distance and signal visibility, as well as physical features such as the width of cross and approach streets. Higher flow rates correlate with higher red-light violation rates.

Complementary interventions

14. Red light cameras are just one of several interventions available to improve safety at a signalised intersection. These cameras might be expected to reduce intentional violations so it their selection would normally come at the end of an assessment of the problem and a review of other possible reasons for an intersection's poor safety record. Alternative, often complementary, interventions include:

    - Signage (advance warning of lights ahead, especially where sight distances are poor, and signs warning of red-light cameras in the area)
    - Education and advertising
    - Police enforcement. Generally such enforcement is personnel-intensive and relatively dangerous, given the need to have officers in the roadway near intersections stopping individual vehicles.
    - Engineering (turning lanes, sight distances, backboards, LED lights, etc.)
    - Adjustments in the light cycle. There are substantial differences between junctions depending on the phasing of the lights. For example, given that almost all red-light runners enter the intersection less than half a second after the beginning of the red phase, a longer amber or all-red phase should reduce the number of opportunities for conflict. However, careful consideration would be needed to account for drivers' responses in terms of the impact on intersection capacity and red-light running behaviour (MUARC, 1995). Golob et al. (2003) found red-light running rates decreased when the amber phase was increased (by an amount ranging from 0.2 to 1.6 seconds).

15. While studies tend to show positive cost-benefit ratios for red-light cameras (FHWA, 2005), they are expensive relative to other interventions which may be equally successful. In addition to assessment prior to installation, ongoing evaluation after installation is generally required (e.g. Austroads, 2004).

Crash reduction effectiveness

16. FHWA (2005) is an extensive review which argues that the overall effectiveness of red-light cameras in relation to red-light running crashes tends to be slightly lower than the reduction in violations. There is often also an increase in rear-end crashes. In further defence of the positive impact of red-light cameras, it has been argued that angle crashes tend to be more severe than rear-end crashes. The report gives the following percentages of effectiveness:

    - 25 percent decrease in total right-angle crashes
    - 16 percent decrease in injury right-angle crashes
    - 15 percent increase in total rear-end crashes
    - 24 percent increase in injury rear-end crashes

17. The extent of crash reduction tends to be lower than the reduction in red-light violations. As noted above, there are many features of individual intersections which underlie red-light running behaviour.

    "In general, it appears that the aggregate economic benefit increases with total entering AADT, an increasing ratio of right-angle crashes to rear end crashes, an increasing proportion of total traffic being on the major road, shorter cycle lengths, and shorter inter-green periods, and is greater for locations with one or more protected left-turn phases as opposed to intersections without such protection. Other factors such as traffic signal actuation, signal coordination, presence of turn restrictions, major road speed limit, and number of approach legs were also investigated; for these, the inability to detect a clear-cut effect may have been caused by the small samples for one level of the factor." (FHWA, 2005).

18. Evidence of the effectiveness of red-light cameras focuses on individual treated intersections. There is some discussion in the literature on whether or not red-light cameras have a 'spillover' effect, reducing red-light violations across a network but little positive evidence has been found for such an (FHWA, 2005). Efforts to maximise their impact across a network tend to focus on using a small number of cameras across a larger number of intersections. It is also argued that signage is an important part of reducing red-light violations across an area (e.g. Halcrow Fox, 1996). An alternative approach might be to use covert red-light cameras (see Keall et al., 2001, 2002; NHTSA, 2007).

19. Red-light cameras are likely to be effective in relation to driver behaviour in two ways: retrospectively for those who have run a red light and are presented with a ticket; And prospectively for those who are aware of the presence, or possible presence, of a red light camera and wish to avoid a ticket. Many studies support the prospective influence of red light cameras, promoting the use of signage and education campaigns alongside the introduction of cameras. It is also common practice to increase their deterrence effect by rotating cameras between sites while leaving their housings permanently installed at intersections (whether or not the cameras are in place at the time). The behavioural impact of red-light cameras is likely to be a function of the perceived change in the level of enforcement.

20. While red-light cameras detect entry into the intersection on a red light, many jurisdictions are using cameras which are able to detect both speed and red-light violations. This enables the monitoring and enforcement of a broader range of dangerous behaviours at intersections.

21. Red light cameras should not be used at intersections with unprotected right turns. There is evidence of blocked right-turners being afraid of being caught in an intersection by a camera & choosing dangerous gaps, leading to an increase in crashes. (Austroads, 2004).

Key studies

22. There are a small number of reviews which represent the best sources of evidence on the effectiveness of red-light camera enforcement. The methodology used has improved over time, and many of these use the empirical Bayesian technique set out in Hauer (1997), but the availability of quality data continues to be a problem. In alphabetical order:

    Austroads (2004) 'Guidelines for setting up and operation of signalised intersections with red light cameras.' Austroads report AP-R247/04.

    CTRE (2007) The effectiveness of Iowa's Automated red light running enforcement programs. Centre for Transportation Research and Education report 05-226 for Iowa Department of Transport. Available online at: http://www.intrans.iastate.edu/reports/rlr-phase2.pdf

    FHWA (2005) Safety evaluation of red light cameras. Available online at: http://www.tfhrc.gov/safety/pubs/05048/05048.pdf

ITE (2003) Making intersections safer: A toolbox of engineering countermeasures to reduce red-light running. Institute of Transportation Engineers. Available online: http://safety.fhwa.dot.gov/intersection/redlight/rlr_report/rlrbook.pdf

NHTSA (2007) Automated enforcement: A compendium of worldwide evaluations of results. Report HS 810-763. Available online from www.nhtsa.gov

Efficiency effects of red-light cameras

23. Red-light running sometimes occurs in a congested junction as a result of a group (platoon) of vehicles turning across the opposite lane. If the turn is on to a congested road, there can be vehicles stuck in the intersection blocking lanes and causing further congestion. This may or may not be a case of red-light running but once again adopting good practice in signal phasings, as set out in the appropriate design guidelines, should limit the incidence of these events.

Operation of red-light camera programmes in other jurisdictions

24. The following section has notes on the operation of red-light camera programmes in other jurisdictions.

Camera ownership and operation

25. **The USA** tends to have private vendors running camera systems under contract to city/county authorities, although some organisations run their own systems or have a contractor operate an agency-administered camera programme. In the USA, a city or state ordnance is required to enable camera operations and citations (see Appendix 1 for a state-by-state review). Photo evidence of violations is usually reviewed by a police officer who then issues citations (fines and/or demerits, usually fixed penalty). There is a significant opportunity for unintended incentives with this system, especially with increased input from the camera vendors on such details as camera location. A similar issue with unintended incentives arises if vendors receive a fee per citation rather than a flat fee.

26. **Canada** also employs provincial legislation to allow automated enforcement. Unlike the US, where there is substantial variation between States, it appears that all provinces in Canada have enabling legislation.

27. **UK** operations are usually operated and administered by the Police for local government, with the revenue being distributed to the Department for Transport. Enforcement cameras have been used in the UK since the introduction of the Road Traffic Act (1991, Scotland 1993), enabling enforcement of traffic law using detection devices such as cameras. According to the DfT there were 600 red-light cameras in operation in the UK in 2006.

Country/state in which operated

28. According to the Insurance Institute for Highway Safety (IIHS), over 400 counties in 25 States and the District of Columbia use or have used red-light cameras. See the appendix for enforcement camera use by US state.

29. According to SCDB.info, many **European countries** use traffic light cameras:

    Austria, Belgium, Switzerland, Czech Republic, Germany, Spain, France, UK, Greece, Hungary, Italy, Iceland, Netherlands, Poland, Romania, Sweden, Slovakia, Slovenia, Serbia, Ireland, Luxembourg, Lichtenstein, Finland and Turkey.

30. Red light cameras are used in most provinces across **Canada**. Provincial legislation enables County/ Municipal authorities to use red-light cameras. Authorities contract commercial camera operators to install and operate the cameras. For example, the City of Ottawa (Province of Ontario) uses red light camera enforcement. Violations carry a fine of up to $180 which goes to the vehicle owner, no demerit

points are attached to violations caught on camera. This differs from a police-issued citation which carries three demerit points.

What fine/demerit system is used?

31. **USA:** See IIHS table in the appendix for US state information.

32. **Canada:** Provincial legislation enables County/Municipal authorities to use red-light cameras. Authorities contract commercial camera operators to install and operate the cameras. For example, the City of Ottawa (Province of Ontario) uses red-light camera enforcement. Violations carry a fine of up to $180 which goes to the vehicle owner and no demerit points are attached to violations caught on camera. This differs from a police-issued citation which carries three demerit points.

33. **UK.** GBP60, three points (12 in three years for lost licence)

34. **Victoria, Aus.** $215, three demerit points (12 in three years for full licence holders to lose licence, five in one year for others)

35. **Germany** (18 in a five-year period to lose licence)

36. **Ireland** (12 in three years to lose licence).

What happens to the revenue generated?

37. Revenues generated from red-light enforcement tend to be substantial, sometimes making a one-year return on investment, with funding available for ongoing maintenance and operation in the longer term. This differentiates it from other safety interventions which tend to require ongoing investment in order to maintain their benefits. However, this can also result in unintended incentives in terms of revenue raising, further reinforced by common measures of effectiveness such as tickets issued/revenue generated as opposed to crash reduction. From 1999 to 2007, red light and speed cameras in the UK were operated by Safety Camera Partnerships which were attached to local government. These partnerships were funded by claiming back fines revenue. This may have created an incentive whereby partnerships would benefit most from maximising revenue. The Department for Transport now provides a fixed amount to local authorities which then decide whether or not this will be re-invested in the Safety Camera Partnership.

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APPENDIX 1

Information from IIHS (Insurance Institute for Highway Safety) showing use of red light and speed cameras by US state.

State	Statewide or only specified locations?	Violations	Citation issued to whom?	Who is liable?	What image is taken?	Traditional enforcement penalties	Auto enforcement penalties/record
Alabama	no state law						
Alaska	no state law						
Arizona	statewide	red light	not addressed	not addressed	not addressed	$250 fine/2 points	$165; no points
	statewide	speed	not addressed	not addressed	not addressed	$250 fine/2 points	$165; no points
Arkansas	use of photo radar by county or state government prohibited except at school zones and railroad crossings; officer must be present and citation must be issued at time of offense						
California	statewide	red light	registered owner	driver	tag and driver	$100 fine/1 point	same as for traditional citation
	statewide	rail crossing	registered owner	driver	tag and driver	$100 fine/1 point	same as for traditional citation
Colorado	Colorado law grants the authority to use automated enforcement to capture any traffic violation						
	statewide	red light	registered owner	driver	tag and driver	$110 fine (including surcharge)/4 points	$75; no points or record
	restricted to construction and school zones, residential areas, or adjacent to a municipal park	speed	registered owner	driver	tag and driver	$39 fine (including surcharge)/4 points	$40 maximum fine ($80 in school zones); no points or record; warning only for first photo radar offense if speed within 10 mph of limit
Connecticut	no state law						
Delaware	statewide	red light	registered owner	owner	2 or more images of the vehicle	$75-$230 fine	$50 maximum fine; not a record or conviction offense; not to be used by insurers
District of Columbia	DC grants jurisdiction-wide authority to use automated enforcement to capture all moving infractions						
	entire jurisdiction	red light	registered owner	owner	not addressed	$75 fine/2 points	$75 fine; no points
	entire jurisdiction	speed	registered owner	owner	not addressed	$75 fine/2 points	$75 fine; no points
Florida	no state law						
Georgia	statewide	red light	registered owner	owner	license tag, intersection, and light	$1,000 maximum fine/3 points	$70 maximum fine; not a conviction or record offense; no points; not a moving violation; not to be used by insurers
Hawaii	no state law						
Idaho	no state law						

	Illinois has several different automated enforcement laws						
Illinois	Cook, DuPage, Kane, Lake, Madison, McHenry, St. Clair, and Will counties; requires local ordinance	red light	registered owner	owner	2 or more images of vehicle and tag	$500 maximum fine/20 points	$100; not a moving violation or record offense
	statewide only in construction zones or Illinois Toll Authority roads	speed	registered owner	driver	tag and driver	mandatory $250 fine/20 points	$250 fine or 25 hours community service
	any county or municipality may use automated enforcement in cooperation with the Illinois DOT and ICC; ordinance required; pilot program is also authorized	rail crossing	registered owner	driver (owner if driver not identified by owner)	vehicle, driver, and tag	$250 maximum fine/20 points	$250 fine or 25 hours community service
	local authorities are prohibited from using speed cameras; state may use speed cameras, but only when a law enforcement officer is present and witnesses the event	speed	not addressed	not addressed	not addressed	not addressed	not addressed
Indiana	no state law						
Iowa	no state law						
Kansas	no state law						
Kentucky	no state law						
Louisiana	state law provides that convictions resulting from camera enforcement shall not be reported for inclusion in driver record; law is silent on other issues						
Maine	all photo enforcement prohibited (effective 90 days after legislature adjourns)						
Maryland	statewide	red light	registered owner	owner	2 or more images of rear of vehicle and tag in any medium	$500 maximum fine/2 points	$100 maximum civil penalty; no points or record; not a moving violation; may not be used by insurers
	until 10/1/09, Montgomery County school zones and residential districts; after 10/1/09, Montgomery County school zones and residential districts, statewide in school zones by local ordinance and work zones	speed	registered owner	owner	2 or more images of rear of vehicle and tag in any medium	maximum fine $500 in residential district, $1,000 in school zone; points depend on speed	$40 maximum fine; no points
	Montgomery County (effective 10/1/09) and Prince George's County	rail crossing	registered owner	owner	vehicle, driver and tag	$500 maximum fine/1 point	$100 maximum fine; no points
Massachusetts	no state law						
Michigan	no state law						

Minnesota	no state law						
Mississippi	all localities prohibited from using automated enforcement; all current programs prohibited effective 3/20/09						
Missouri	no state law						
Montana	all localities prohibited from using automated enforcement; railroad grade crossings excepted						
Nebraska	no state law						
Nevada	prohibits use of imaging equipment unless it is hand held by an officer, installed in a vehicle or facility of a law enforcement agency; traditional enforcement penalties: $1,000 maximum fine and 4 points						
New Hampshire	prohibited unless there is specific statutory authorization						
New Jersey	photo radar is prohibited						
	local jurisdictions must pass an ordinance and apply to Transportation Commissioner to participate in a pilot program	red light	registered owner	registered owner and driver are jointly liable	two or more images of vehicle and tag	$85	penalty same as for traditional citation; no points
New Mexico	no state law specifically authorizing automated enforcement; state law requires counties and municipalities using camera enforcement to post a warning sign and a warning beacon						
New York	cities of at least 1 million people, up to 150 intersections in each city; Effective 5/28/09: counties of Nassau and Suffolk, the cities of Rochester and Buffalo, by local ordinance, up to 50 intersections; Yonkers, by local ordinance, up to 25 intersections	red light	owner	owner	2 or more images of rear of vehicle and tag in any medium	$100 maximum fine/3 points	$50 fine; not a record or conviction offense; may not be used by insurers
North Carolina	where specified by statute (Albemarle, Charlotte, Chapel Hill, Cornelius, Durham, Fayetteville, Greensboro, Greenville, High Point, Huntersville, Lumberton, Matthews, Nags Head, Newton, Pineville, Rocky Mount, Spring Lake, and Wilmington)	red light	owner	owner	photo, video, electronic image	$100 maximum fine/3 points	$75 civil penalty; no points
North Dakota	no state law						
Ohio	no state law						
Oklahoma	no state law						
Oregon	cities statewide	red light	registered owner or driver, if identifiable	registered owner	photographs; digital images	$300 maximum fine	penalty same as for traditional citation
	Albany, Beaverton, Bend, Eugene, Medford, Portland, and Tigard (may not be used for more than four hours per day in any one location)	speed	registered owner or driver, if identifiable	registered owner	photographs; digital images	$300 maximum fine	penalty same as for traditional citation

Pennsylvania	Philadelphia	red light	registered owner	owner	photographs	$25 fine/3 points	$100 maximum; not on operating record
Rhode Island	statewide	red light	registered owner	driver	2 or more images of vehicle and tag in any medium	$75 fine	$75 fine; not a criminal or record offense; not a moving violation; not to be used by insurers until there is a final adjudication of the violation
	statewide	school bus safety violations	registered owner	registered owner	2 or more images of vehicle and tag in any medium	$500 fine	$500 fine; not a criminal or record offense; not a moving violation; not to be used by insurers
South Carolina	no state law						
South Dakota	no state law						
Tennessee	statewide except for interstate highways that are not work zones	traffic violation	registered owner	registered owner	not addressed	$50 fine/points	not reportable; no points may be assessed
Texas	a Texas municipality may not use an automated traffic control system to enforce speed						
	statewide; requires local ordinance	red light	registered owner	owner	2 or more photographic or digital images of tag	$200 maximum fine	$75; not a criminal or record offense
Utah	statewide only school zones or where limit is 30 mph or less; officer must be present; requires local ordinance	speed	not addressed	not addressed	photograph	$1,000 maximum fine/50 points	not reportable; no points may be assessed
Vermont	no state law						
Virginia	counties, cities, and towns may operate cameras at no more than 1 intersection for every 10,000 residents; requires local ordinance; the exception is the Washington, DC metropolitan area, it permits up to 10 camera sites or 1 site per 10,000 residents, whichever is greater	red light	registered owner	driver	2 photographs or other recorded images	$200 maximum fine/4 points	$50 maximum fine; no court costs; not a criminal offense; no points; may not be used by insurers

	cities and counties statewide where two arterial roads intersect	red light	registered owner	registered owner	vehicle, license tag	$250 maximum fine	fine up to the maximum for parking violations in the jurisdiction; no record; no points
Washington	school zone	speed	registered owner	registered owner	vehicle, license tag	$250 maximum fine	fine up to the maximum for parking violations in the jurisdiction; no record; no points
	cities and counties statewide	rail crossing	registered owner	registered owner	vehicle, license tag	$250 maximum fine	fine up to the maximum for parking violations in the jurisdiction; no record; no points
West Virginia	all photo enforcement prohibited						
Wisconsin	photo radar is prohibited						
Wyoming	no state law						