Engineering Countermeasures to Reduce Red-Light Running (RLR)

6 ISSUE BRIEFS

National Statistics

Crash data from the National Highway Traffic Safety Administration indicates that in 2002, there were 921 fatalities and 178,000 injuries resulting from 207,000 crashes attributable to motorists running red lights at signalized intersections. Crashes involving red-light running are much more likely to cause an injury or a fatality than other intersection crashes. The number of fatal motor vehicle crashes at traffic signals is rising faster than any other type of fatal crash nationwide:

- Red-light running (RLR) has become a national safety problem with a societal cost estimated at $14 billion per year;
- Motorists are more likely to be injured in crashes involving RLR than in other types of crashes. Occupant injuries occurred in 45 percent of the RLR crashes, compared to 30 percent for other crash types; and
- According to a survey conducted by the U.S. Department of Transportation and the American Trauma Society, 63 percent of Americans witness a RLR incident more than once a week. One in three Americans knows someone who has been injured or killed because of a red-light runner

When does RLR occur?

RLR occurs when a driver enters an intersection after the traffic signal has turned red. The reasons that motorists run red lights are varied and are both intentional—"in a hurry and didn't want to wait"—and unintentional—"my vision to the signal was blocked." According to survey research, drivers believe RLR is often an intentional act with few legal consequences. The traditional way of enforcing this violation is to station a patrol vehicle near an intersection. This method is dangerous for the officer, expensive to localities and drains valuable police resources.

Engineering Countermeasures to Reduce RLR

ITE and the Federal Highway Administration developed a publication entitled *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running: An Informational Report*. The principal objective of the publication is to identify the engineering design and whether operational features of an intersection should be upgraded as necessary to discourage RLR. The engineering countermeasures can be grouped into four distinct areas:

- Improving signal visibility/conspicuity;
- Increasing the likelihood of stopping;
- Addressing intentional violations; and
- Eliminating the need to stop.

U.S. Department of Transportation
Federal Highway Administration

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Table 1:
Summary of Engineering Countermeasures to Reduce Red-Light Running

Increase Signal Visibility/Conspicuity	Increase Likelihood of Stopping	Address Intentional Violations	Eliminate Need to Stop
Placement/Number of Signal Heads	Signal Ahead Signs	Signal Optimization	Unwarranted Signals
Size of Signal Display	Advance Warning Flashers	Signal-Cycle Length	Roundabout Intersection Design
Line of Sight: Programmable Lens Signals	Rumble Strips	Yellow-Change Interval	
Line of Sight: Visors/Louvers	Left-Turn Signal Sign	All-Red Clearance Interval	
LED Signal Lenses	Pavement Surface Condition	Dilemma Zone Protection	
Backplates			

Table 1 summarizes the countermeasures that can be considered under each of the countermeasure groupings identified above. A brief description of each countermeasure follows. In addition, Figure 1, *Sample Assessment Sheet*, on page 4, shows the types of information that an engineer or an engineering technician should evaluate in the field. A separate assessment sheet would be completed for intersection approach.

Descriptions of Summary Items

Increase Signal Visibility/Conspicuity

Placement and Number of Signal Heads. Overhead-signal displays help to overcome the three most significant obstacles posed by pole-mounted signal heads, which are: (1) they generally do not provide good conspicuity, (2) mounting locations may not provide a display with clear meaning and (3) motorists' line-of-sight blockage to the signal head due to other vehicles, particularly trucks, in the traffic stream. Studies have shown significant reduction in accidents attributed to replacement of pole-mounted signal heads with overhead-signal heads.

Signal for Each Approach Lane. Section 4D.15 of the *Manual on Uniform Traffic Control Devices* (MUTCD) only requires that "a minimum of two signal faces shall be provided for the major movement on the approach." Under this standard, it would be acceptable to have only two signals on an approach with three or more through lanes. When a signal is positioned such that it is over the middle of the lane, it is in the center of the motorist's cone of vision, thereby increasing its visibility. The additional signal head further increases the likelihood that a motorist will see the signal display for the approach.

Size of Signal Displays. 12-in. signal lenses should be considered for all signals, and especially those displaying red indications, to increase signal visibility.

Programmable Lens Signals. The optically programmed or visibility-limited signals limit the field of view of a signal. They allow greater definition and accuracy of the field of view. The MUTCD speaks of visibility-limited signals mostly with regard to left-turning traffic at an intersection. The MUTCD permits the use of visibility limited signal faces in situations where the road user could be misdirected, particularly at skewed or closely-spaced intersections when the road user sees the signal indications intended for other approaches before seeing the signal indications for their own approach.

Louvers. Louvers are used to avoid confusion on intersection approaches where approaching motorists may be able to see the signal indication for another approach, typically due to a skewed approach angle at the intersection. The purpose of a louver is to block the view of the signal from another approach.

LED Signal Lenses. LED units are used for three main reasons: they are very energy efficient, are brighter than incandescent bulbs and have a longer lif e increasing the replacement interval. LED signals may be noticeably brighter and more conspicuous than an adjacent signal with the incandescent bulb. LED traffic signal modules have service lives of 6 to 10 years as compared to incandescent bulbs that have a life expectancy of only 12 to 15 months. However, research regarding the impacts of LED signal lenses on crash rates has not been undertaken. There is a belief that LEDs are brighter and last longer, and therefore would provide safety benefits but this has not been quantified. Some studies have found that LED's tend to loose brightness over time instead of exhibiting an immediate failure.

Backplates. Backplates are used to improve the signal visibility by providing a black background around the signals, thereby enhancing the contrast. They are particularly useful for signals oriented in an east-west direction to counteract the glare effect of the rising and setting sun or areas of visually complex backgrounds. A retroreflective yellow border strip around the outside perimeter of signal backplates has been found to significantly reduce night-time crashes at signals and also helps drivers identify an intersection as signalized during a power failure.

Increase Likelihood of Stopping

Signal Ahead Signs. The MUTCD requires an advance traffic control warning sign when "the primary traffic-control device is not visible from a sufficient distance to permit the road user to respond to the device."

Advance Warning Flashers. The purpose of an advance-warning flasher (AWF) is to forewarn the driver when a traffic signal on his/her approach is about to change to the yellow and then the red phase.

Rumble Strips. Rumble strips are a series of intermittent, narrow, transverse areas of rough-textured, slightly raised, or depressed road surface. The rumble strips provide an audible and a vibro-tactile warning to the driver. When coupled with the SIGNAL AHEAD warning sign and also the pavement marking word message—SIGNAL AHEAD—the rumble strips can be effective in alerting drivers of a signal with limited sight distance.

Left-Turn Signal Sign. The LEFT TURN SIGNAL sign provides additional information not given in the actual signal indication to the driver by specifying the control device for different intersection movements. The MUTCD requires this sign to accompany a separate signal face controlling a "protected-only mode" left turn movement (turn only allowed on green arrow) when that signal face uses a red ball indication. If the signal face uses a red left-arrow indication, this sign is not to be used.

Pavement Surface Condition. As a vehicle approaches a signalized intersection and slows to stop for a red light, it may be unable to stop due to poor pavement friction and as a result, proceed into the intersection. Countermeasures to improve skid resistance include asphalt mixture (type and gradation of aggregate as well as asphalt content), pavement overlays and pavement grooving. Additionally, countermeasures such as the use of a SLIPPERY WHEN WET sign with a supplemental Advisory Speed Plate for a lower advisory speed can be considered.

Address Intentional Violations

Signal Optimization. Interconnected signal systems provide coordination between adjacent signals and are proven to reduce stops, reduce delays, decrease accidents, increase average travel speeds and decrease emissions. If drivers are given the best signal coordination practical, they may not be as compelled to beat or run a red signal.

Signal Cycle Length. Proper timing of signal-cycle lengths can reduce driver frustration that might result from unjustified short or long cycle lengths. Longer cycle lengths means fewer cycles per hour and therefore fewer yellow-change intervals per hour and thus can reduce the number of opportunities for traffic-signal violations. On the other hand, signal cycles that are excessively long can encourage RLR because drivers do not want to have to wait several minutes for the next green interval.

Yellow Change Interval. A properly timed yellow interval is *essential* to reduce signal violations. An improperly timed yellow interval may cause vehicles to violate the signal. If the yellow interval is not long enough for the conditions at the intersection, the motorist may violate the signal. Motorists have some expectancy of what the yellow interval should be and base their decisions to proceed or stop based on their past experiences. In order to reduce signal violations, the engineer should ensure that the yellow interval is adequate for the conditions at the intersection and the expectations of the motorists.

All-Red Clearance Interval. An all-red interval is that portion of a traffic signal cycle where all approaches have a red-signal display. If used, the all-red interval follows the yellow-change interval and precedes the next conflicting green interval. The purpose of the all-red interval is to allow time for vehicles that entered the intersection during the yellow-change interval to clear the intersection before the traffic-signal display for the conflicting approaches turns to green.

Dilemma Zone Protection. The "dilemma zone" has been defined recently to be the area in which it may be difficult for a driver to decide whether to stop or proceed through an intersection at the onset of the yellow-signal indication. It is also referred to as the "option zone" or the "zone of indecision" One potential countermeasure to reduce red-light running is to reduce the likelihood that a vehicle will be in the dilemma zone at the onset of the yellow interval. This can be accomplished by placing vehicle detectors at the dilemma zone. They detect if a car is at the dilemma zone immediately before the onset of the yellow interval. If a vehicle is there, the green interval can be extended so that the vehicle can travel through the dilemma zone and prevent the onset of the yellow while in the dilemma zone.

Eliminate Need to Stop

Unwarranted Signals. If there is a high incidence of RLR violations, this may be because the traffic signal is perceived as not being necessary and does not command the respect of the motoring public. Sometimes signals are installed for reasons that dissipate over time. For instance, traffic volume may decrease due to changing land-use patterns or the creation of alternative routes. The removal of a traffic signal should be based on an engineering study. Factors to be considered are included in ITE's *Traffic Control Devices Handbook*. If a signal is eliminated, the traffic engineer must continue to monitor the intersection for potential increases in crashes.

Roundabout Intersection Design. When a roundabout replaces a signalized intersection, the RLR problem is obviously eliminated. Readers should consult the Roundabout Safety Briefing Sheet for further information.

References

1. Institute of Transportation Engineers, Publication IR-115, 2003. *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running: An Informational Report* http://safety.fhwa.dot.gov/rlr/rlrreport/RLRbook.pdf

2. J. Bonneson, M. Brewer, and K. Zimmerman, *Engineering Countermeasures to Reduce Red-Light Running, FHWA –TX-03/4027-2 and, 04/4196-1 (Washington, DC: Federal Highway Administration, 2002)* http://tcd.tamu.edu/Documents/4196-1.pdf http://tcd.tamu.edu/Documents/4027-2.pdf

Sample Assessment Sheet:
Engineering Countermeasures to Reduce Red-Light Running

Intersection: ______________________________ with ____

Approach Name: __________________________ Direction Heading: Lanes at Intersection: ____________________

CHECK SIGNAL CONTROL PARAMETERS

Yellow Interval	Y = ___________seconds		Approach speed	V= ___________mph
All-red Interval	AR= ___________seconds		Cross street width	W= ___________feet
Grade (as decimal)	g = ___________(uphill is positive)		Cycle length	C= ___________seconds

Calculate the needed change period (CP) for this approach using agency practice or the following equation:

$$CP = 1.0 + \frac{1.47 * V}{(10 + 64.4g)} + \frac{W + 20}{1.47 * V}$$

Calculated yellow: _______________ Calculated all-red: _______________ Are yellow and all-red adequate? Y N

CHECK SIGNAL VISIBILITY

Type of signal mounting: ________ Mast Arm ______ Span Wire________ Pole ________

Can signal faces on other approaches be seen? Y N

Is anything blocking the view of the signals (e.g. utility lines or foliage)? ____

Measurement		Reference	Is Existing Adequate?
Distance upstream signal is visible on approach	feet	MUTCD Table 4-1	Y N
Distance from stop bar to signal	feet	MUTCD Figure 4D-2	Y N
Diameter of signal lenses	8 inch 12 inch		
Near side signal	Y N		
Number of signals		Per MUTCD, at least 2 signals for the major movement	Y N

CHECK SIGNAL CONSPICUITY

Is there visual clutter at the intersection that could detract from the signal? Y N At night? Y N

Are the signal indications confusing? ______________________________ Could glare affect signal? _________________

Is the left turn signal discernible from the through signal? ____

OPTIONS FOR CONSIDERATION

- ❑ Conduct signal warranting study
- ❑ Change yellow or red interval
- ❑ Provide dilemma-zone protection
- ❑ Modify cycle length
- ❑ Coordinate signal
- ❑ Remove/relocate sight obstruction
- ❑ Install double red signal
- ❑ Relocate signal
- ❑ Change signal mounting
- ❑ Install additional signals
- ❑ Install near-side signal
- ❑ Install Advance Warning Flashers
- ❑ Install larger signal lenses
- ❑ Use programmable lenses
- ❑ Illuminate intersection
- ❑ Install backplates
- ❑ Install LEDs
- ❑ Install rumble strips on approach
- ❑ Use visors or louvers
- ❑ Install LEFT TURN SIGNAL sign
- ❑ Install SIGNAL AHEAD sign