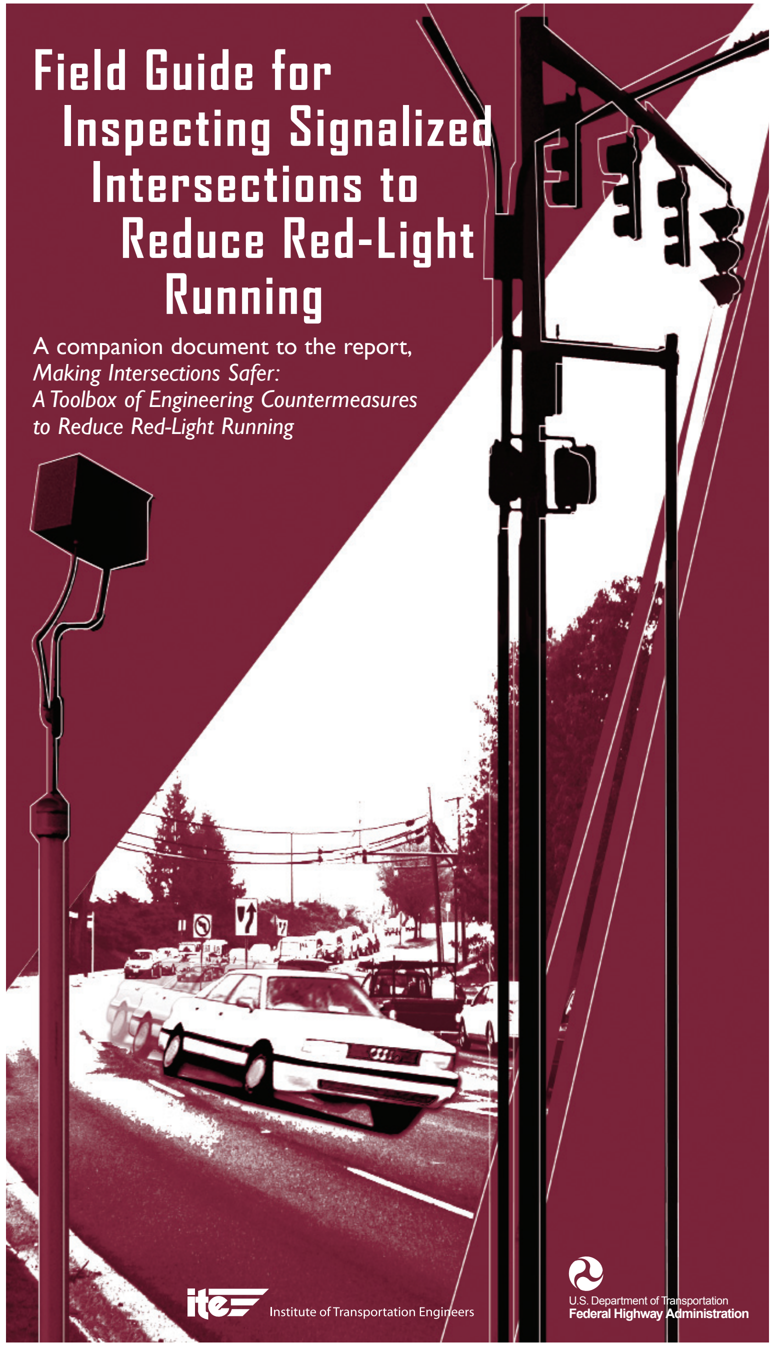
Field Guide for Inspecting Signalized Intersections to Reduce Red-Light Running

A companion document to the report,
Making Intersections Safer:
A Toolbox of Engineering Countermeasures to Reduce Red-Light Running



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Introduction

The Federal Highway Administration (FHWA) recognizes red-light running as a national safety problem, resulting in as many as 176,000 injuries and 1,000 fatalities annually, and an economic loss estimated at $14 billion per year. The solution to the problem involves education, enforcement and engineering measures. To publicize the engineering measures that can be taken, FHWA and the Institute of Transportation Engineers (ITE) prepared a report to provide information that could be used to proactively ensure that intersections can be engineered to discourage red-light running. The final product, *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running (1)*, addresses design and operational features that may need to be upgraded or modified to discourage red-light running. The report characterizes the red-light running safety problem, identifies and provides guidance on the application of numerous engineering measures that can be taken to reduce red light running, and provides a separate chapter describing a process for addressing the safety problem at a specific location.

To supplement this report and provide more details on how to conduct a site investigation, this field guide was prepared. The field guide suggests a procedure for conducting an investigation of a specific intersection that has been identified as a red-light running problem site. Presumably this identification has resulted from a review of red-light running violation and crash data. Having done so, the next step should be an investigation of the site to identify possible engineering deficiencies that could contribute to violations and crashes, and to form initial opinions as to the possible countermeasures. Final selection of appropriate countermeasures should be made based on further engineering analyses.

The field inspection guide is prepared in connection with the *Intersection Field Inspection Form* found at the end of the guide.

Field Site Review

Overall Objective

The purpose of the field site review is to identify any engineering design or operational deficiencies that may contribute to red-light running and the resulting crashes and to form initial opinions as to possible countermeasures. From an engineering perspective, red-light running may be reduced if, in general, any one of these actions is taken:

- ❖ Ensure that the traffic signals, and in particular, the red displays, are visible from a sufficient distance and capture the driver's attention;
- ❖ Increase the likelihood of drivers stopping for the red signal once seen;
- ❖ Address intentional violations; and
- ❖ Eliminate the need to stop.

It is paramount that the driver can see the traffic signal displays far enough in advance of the intersection so that he/she can stop safely upon viewing the yellow or red display. Then, upon viewing the yellow, and certainly the red indication, ensure that the signal operations and conditions do not entice the driver to intentionally or unintentionally enter on red. We must also ensure that a driver who tries to stop his/her vehicle can successfully do so before entering the intersection.

Recognizing that some drivers will intentionally violate the red signal at certain times and situations, those conditions that encourage this behavior must be minimized. Finally, engineers should examine whether or not the traffic signal is the most appropriate choice of control for the intersection. Consideration should be given to the possible replacement of the signal with another form of traffic control or design that eliminates the signal (e.g. a roundabout) and, therefore, the red-light running problem.

In view of this general goal, items to be considered in the review include:

- ❖ Visibility/conspicuity of signal indication;
- ❖ Signal timing and phasing;
- ❖ Traffic operations; and
- ❖ Geometric design and pavement condition.

Materials and Personnel Needed

The materials required for conducting the field site review include the following:

- ❖ Field guide;
- ❖ Field Inspection Form with clipboard;
- ❖ Measuring device, preferably a measuring wheel;
- ❖ Camera, preferably digital—a video camera is optional;
- ❖ Stopwatch—to time the traffic signal intervals; and
- ❖ Slope meter—to measure the grade on the approaches.

The inspection can be made by one person who has training and/or experience in traffic engineering principles. A second person is desirable to assist in the required measurements and to "get a second opinion" about deficiencies or possible countermeasures.

As with all field work, the inspectors should follow the agency's policies and procedures regarding personnel safety and traffic control.

Intersection Field Inspection Form

An *Intersection Field Inspection Form* has been prepared to assist in the inspection and is included at the end of the field guide. This form is also included full-size (8 1/2 x 11 inch) as a PDF at www.ite.org/library/redlight/FieldInspectionForm.pdf and at http://safety.fhwa.dot.gov/intersections/redl_reports.htm. It can be downloaded from these sites and multiple copies can be made. Alterations to the form may be necessary to meet the needs of your organization. How to use the form will be explained in the remainder of this guide.

Location Information

The first entries are to record the name of the intersection and the specific approach. **An inspection form is needed for each approach that is to be inspected.** It is recommended that an inspection be conducted for all approaches even if one or more legs or approaches has not been identified as a problem—upon inspection one or more deficiencies could be detected on the "non-problem" approaches.

The entries are as follows:

- ❖ **Intersection Identification:** Enter the names and/or route numbers or any other intersection identifier used by your agency.
- ❖ **Approach Name:** Enter the name and/or route number of the approach.
- ❖ **Direction Heading:** Enter the cardinal direction (for example, northbound) for the approach being investigated.

Part 1. Check Signal Visibility

The first item to check is the signal visibility available to drivers as they approach the signal. Here, you need to confirm whether or not there are unobstructed sight lines to the signal heads from a sufficient distance upstream. The entries to be made are as follows:

Type of Signal Mounting: Traffic signal heads can be placed on 1) span wire, 2) mast arm, 3) a pole, or 4) a structure. For any given approach, there may be any combination of the above. Also, signal heads can be placed near-side (just at or before the physical intersection), within the intersection boundaries, or far-side (just beyond the cross road). On the field sheet, indicate the type of signal mounting. If more than one mounting is used, then indicate this. You might want to take photographs of the signal displays for each approach, both from a distance and then close to the intersection.

Mast Arm Mounting

Span Wire Mounting

Pole Mounting

Sight Distance to the Signal (Section 4.D.15): The *Manual on Uniform Traffic Control Devices* (MUTCD), (2) stipulates if two signal faces cannot be seen within the minimum distances shown in Table 1, then a sign shall be installed to warn approaching traffic of the traffic signal. If any approach is on a curve and/or grade that restricts visibility/sight distance, measure the distance from the nearest signal head for the through movement to the point on the approach where the signal is first in view. Compare the distance to the values in Table 1 for the appropriate speed. If the 85th percentile speed is not known, choose a speed that is at least 10 mph higher than the posted speed limit. Measuring the sight distance is not necessary if the signal is clearly visible from a considerable distance upstream.

85th-Percentile Speed (mph)	Minimum Sight Distance (feet)
20	175
25	215
30	270
35	325
40	390
45	460
50	540
55	625
60	715

Table 1: Minimum Sight Distance

Requires Advance Warning Sign?: If the sight distance is less than required by the values in Table 1, indicate by circling **yes**, otherwise circle **no**.

Advance Signal Warning Sign Present?: Indicate if there is an advance signal warning sign. Take a photograph of the sign if you have a camera.

Is anything blocking the view of the signals?: Even though the minimum sight distance is met, continuous view to all or a portion of the signal face may be blocked by either utility lines, tree branches, or other objects. Drive towards the signals from a sufficient distance upstream in each approach lane and take note if this situation exists. Note the nature of the blockage and take a photograph of it (consider summertime if the inspection is being made during the non-foliage seasons). If the opportunity presents itself, drive behind any box-type trucks to see if they block the view.

Signal Blockage

Can signal faces on other approaches be seen?: Intersections with more than four approach legs and those with approaches at non-90 degree angles frequently experience a situation where the signal displays for other approaches can be seen from the approach being investigated. If not properly shielded with visors, this can cause driver confusion and some drivers may misinterpret the signal display for the appropriate approach. Indicate if this situation exists and if yes, mark whether visors, shields, or programmable lenses are being used. Check each lane on the approach.

Conflicting Signal Displays

Part 2. Check Signal Conspicuity

Could visual clutter detract from signal detection?: While the signals may be visible from the required distances, they may not be conspicuous to the driver. In terms of traffic control devices, such as a traffic signal, conspicuity means the ability for the specific device to be seen among other highway and non-highway features that compete for motorists' attention. There are many roads and streets that have dense commercial development with many signs and other forms of advertising that cause visual clutter and make it more difficult for the motorist, especially one who is unfamiliar with the road, to detect and react to traffic signals. Where this occurs it may be necessary to augment the signal display with additional signals and/or a double red signal section.

To check this possibility, it is recommended that the investigator drive through the intersection and note on each approach whether or not there is visual clutter. In doing so, the inspector should try to imagine how a driver unfamiliar with the area would view the scene. The inspection can be done during the day, and then, if there is reason to believe that nighttime would be more severe, a night inspection should be made as well. If it is believed that the visual clutter could detract from clearly seeing the signal, circle **yes**.

Confusing Signal Displays

Are Signal Indications Confusing?: The next check is to determine if the signal indications may be confusing. Sometimes signal head placement can be confusing or mistakenly identified to a driver approaching the intersection. For example, signals for left-turn traffic can be confused with those for through traffic, especially if there is a NO LEFT TURN (R3-2) sign. Also, if there is another signalized intersection a short distance downstream, and depending upon the approach grades, the signal for the second intersection can be confused for being the control for the first intersection. This could be particularly troublesome if the first signal displays red while the second signal displays green. Make note if any confusing condition exists.

Are backplates present? Are backplates necessary?: Answer **yes** or **no**.
Glare from the sun can make it difficult to see one or more signals as the driver approaches the intersection. Backplates enhance visibility and conspicuity of the signal indication by making it stand out. When you are in the field notice whether or not there are backplates on the signal.

Even if there are backplates, if the approach is on direct east or west bearing, then an inspection should be made during the critical period when the rising or setting of the sun will have the worst effect on signal visibility. If the inspection indicates that the sun glare is a problem and backplates are needed, circle **yes** to that question. Also, indicate whether or not other glare-reducing steps are needed. Re-positioning one or more of the signals may be necessary in this case.

Signal Lens Type: Note if the red signal lenses have either incandescent bulbs or LEDs. Signals with LED lenses are typically brighter than incandescent bulbs.

Signal Lens Size Adequate?: The next entries determine if the size of the red-signal lens as determined by its diameter is adequate.

- **Red Signal Lens Size:** Note the size of the red signal lenses; they are usually either 8 or 12 inches in diameter (measuring is usually not needed as the two sizes are distinguishable to a trained signal technician). If all red signal lenses are 12 inches, then they can be considered adequate. If there are any 8-inch signal lenses, then complete the next two entries.
- **Distance from stop line to signal:** **Enter** in feet.
- **Near-side signal present?:** Enter **yes** or **no**.
- **Is Existing Size Adequate?:** If any red signal lens is 8 inches, then circle **no** if any of the following conditions exist:
  - Both traffic control and lane-use control signal heads are in view simultaneously;
  - If the nearest signal face is between 120 and 150 ft. beyond the stop line, unless a supplemental near-side signal face is provided;
  - If the signal faces are more than 150 ft. from the stop line;
  - If the sight distance to the signals is less than required by Table 1;
  - If the signal is using an arrow;
  - The 85th-percentile approach speed exceeds 40 mph;
  - The traffic signal is unexpected;
  - Only post-mounted signal heads are used; or
  - It is known that there is significant percentage of elderly drivers.

These are all conditions that would indicate the need for 12-inch signal lenses.

Number of Signal Heads Adequate?: The MUTCD requires that there be at least two signal heads for the major movement (usually the thru movement, but may be for a turning movement). It is desirable to have one for each lane. To check for the adequacy of signal heads, enter the following:

- **Number of signals heads for major movement:** Note the total number of signal heads for the major movement.
- **Number of through lanes:** Note the number of lanes for the major movement.
- **Is existing number adequate?:** If there are less signal heads for the through movement than the number of through lanes, circle **N** in the last column.

Placement of Signal Heads: Note the placement of the signal heads in relation to the marked lanes. If the signal heads are not centered over the marked lanes, circle **N**.

Part 3. Check Signal Control Parameters

An inappropriately short or long yellow-change interval and the lack of an all-red clearance interval are two features that can contribute to red-light running and the resulting crashes. The yellow-change interval is simply the first interval following the green interval during which the yellow signal indication is displayed. The all-red clearance interval is an optional interval that follows a yellow-change interval and precedes the next conflicting green interval. It is frequently referred to as the all-red interval, because all approaches have a red signal display during this interval. The use of an all-red interval will not likely reduce red-light running violations, but it will help to avoid crashes if red-light running occurs in the first few seconds of the red indication. The two intervals are usually considered together as the change period and can be calculated using the following formula found in the most recent edition of ITE's *Traffic Engineering Handbook* (3):

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

Where:

CP = change period of yellow plus all-red

V = speed of approaching vehicle, expressed in miles per hour.

W = width of intersection in ft.

g = grade on the intersection approach, in percent divided by 100 (downhill is negative)

The equation above has been altered to include the assumed values of t, a and L, and a factor for converting miles per hour into feet per second.[1] If your agency uses different values, then you will need to modify the equation accordingly.

The first two terms of the equation are typically used for the yellow-change interval and the last term is for the all-red interval. To evaluate these features, determine the following:

- ❖ **Grade:** If the approach is not level or reasonably so, enter the grade, which can be determined using a slope meter. Enter the grade as a decimal, for example, a 5 percent downgrade is entered as -.05.
- ❖ **Approach Speed:** Enter the approach speed in miles per hour (mph). If available, the 85th percentile speed should be used. If not, then speeds up to 10 mph higher than the speed limit can be used.
- ❖ **Cross Street Width:** At a point closest to the intersection, measure the distance between the curbs, if any, or if none, the edge of the outside travel lanes of the crossroad. Enter the distance in feet.

[1] The original formula includes the following parameters:

t = perception-reaction time of the motorist

a = comfortable deceleration rate of the vehicle

L = length of vehicle

The original equation can be found in the *Traffic Engineering Handbook*. Washington DC: Institute of Transportation Engineers, 1999.

Then, enter the following for the phase that serves the through movement on this subject approach:

- ❖ **Yellow interval in seconds, and**
- ❖ **All-red interval in seconds.**

These two times should be available from the controller unit; if not, then it will be necessary to determine these times in the field using a stopwatch.

Next, enter the following:

- ❖ **Calculated Yellow:** Calculate the yellow interval, which is the first two parts of the equation and enter the calculated yellow-change interval on the form.
- ❖ **Yellow-Change Interval Adequate?:** Compare the calculated yellow-change interval to the actual yellow interval and note if it is adequate.
- ❖ **Calculated All-Red:** Using the last part of the equation with values for cross street width (W) and approach speed (V), calculate the all-red interval and enter it on the form.
- ❖ **Red-Change Interval Adequate?:** Compare the calculated red-change interval to the actual interval and note if it is adequate.

Part 4. Check Other Factors

Horizontal Location of Signal Faces: With respect to red-light running, traffic signals not properly located at the intersection (see Part 2 *"Placement of Signal Heads"*) may induce red-light running. Referring to Figure 1, if the signal is placed too close to the stop line, the driver already stopped at the line, may not be able to see the signal and may enter the intersection prematurely. Also, if the signal is placed further away from the stop line than prescribed in Figure 1, then the motorist may not associate the signal with the stop line and inadvertently enter the intersection on red. On the form, enter the distance from the stop line to the first far-side signal for the through movement.

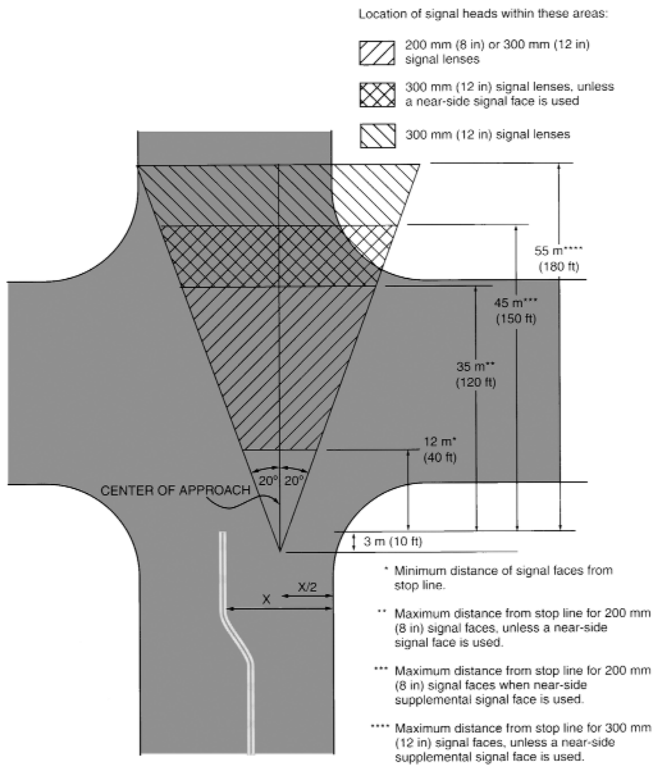

Figure 1: Horizontal Location of Signal Faces
Source: MUTCD 2003

Pavement Condition: If the pavement surface along the approach near the stop line appears to be slippery because of a smooth, polished condition or is severely rutted, motorists may be reluctant to decelerate to a stop when the yellow appears and may subsequently run a red light. Observe the condition of the pavement along the approach for either of these conditions and circle the most applicable condition on the form.

Reconsider Signal Installation: It is possible that traffic signal control is no longer warranted and could be replaced with a lower order control. A more detailed study is required to determine if the traffic signal should be removed. However, if it is observed during the inspection that the traffic volume levels on both the major and minor street are light (even during the peak traffic periods), then this should be noted.

Part 5. Identify Promising Countermeasures

Having completed the inspection and observed one or more deficiencies, then potential countermeasures to address the deficiency should be considered. On the form check off if any of the deficiency types are identified and countermeasures that you feel may be appropriate. The potential countermeasures for each category of deficiency are listed below.

Visibility Deficiency

1) Install additional signals on the near side of the intersection
2) Change signal mounting (to center over each marked lane)
3) Remove/relocate sight obstructing object
4) Install shields and visors
5) Install programmable lenses
6) Install SIGNAL AHEAD sign
7) Install advance warning flashers

Conspicuity Deficiency

- ❖ Add additional signal head to achieve one signal per lane (centered over each marked lane)
- ❖ Install LED signal head
- ❖ Install 12-inch signal head
- ❖ Install double red signal
- ❖ Install backplates; larger or enhanced backplates
- ❖ Install transverse rumble strips

Signal Timing Operation Deficiency

- ❖ Change yellow-change time (to correspond to ITE policy)
- ❖ Add/change all-red clearance time
- ❖ Coordinate signal operation with adjacent signals

Other Measures to Consider

- ❖ Provide dilemma-zone protection
- ❖ Determine if signal is still warranted
- ❖ Consider roundabout or other innovative design
- ❖ Improve pavement condition

The selection of the final countermeasure(s) should be made by the responsible engineer. The full report *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running* should be reviewed for this activity.

To download a one-page form, visit:

www.ite.org/library/redlight/FieldInspectionForm.pdf
http://safety.fhwa.dot.gov/intersections/redl_reports.htm

Intersection Field Inspection Form

LOCATION INFORMATION

Intersection Identification: ______________________________
with____

Approach Name: ______________________________________

Direction Heading:____________________________________

PART 1. CHECK SIGNAL VISIBILITY

Type of Signal Mounting:	Span Wire	Mast Arm
	Pole	Structure

Sight Distance to the Signal: ________feet

Requires Advance Warning Sign? Y N

Advance Signal Warning Sign Present: Y N

Is anything blocking the view of the signals? Y N
If yes, describe____________________________________
____

Can signal faces on other approaches be seen? Y N
If yes, do these signals have visors,
shields, or programmable lenses? Y N

PART 2. CHECK SIGNAL CONSPICUITY

Could visual clutter detract from the signal? Y N

Are the signal indications confusing? Y N
If yes, explain:______________________________________
____

Are backplates present? Y N

Are backplates necessary? Y N

Are other glare-reducing steps needed? Y N

Signal lens type: Incandescent LEDs

Signal Lens Size Adequate?:

Red signal lens size: 8 inch 12 inch

Distance from stop line to signal: ________feet

Near side signal? Y N

Is existing size adequate? Y N

Number of Signal Heads Adequate?:

Total number of signal heads for major movement: ______

Total number of lanes for major movement: ___________

Is existing number adequate? Y N

Signal Heads Placement Adequate?: Y N

PART 3. CHECK SIGNAL CONTROL PARAMETERS

Grade (as decimal) g =________(uphill is positive)

Approach speed V =_____________mph

Cross street width W =_____________feet

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

$$CP = 1.0 + \overbrace{\frac{1.47*V}{(20 + 64.4g)}}^{\text{Yellow}} + \overbrace{\frac{W + 20}{1.47*V}}^{\text{All-red}}$$

	Actual Value	Calculated Value	Is Existing Adequate?
Yellow interval	_____________	_____________	Y N
All-red interval	_____________	_____________	Y N

PART 4. CHECK OTHER FACTORS

Is horizontal location adequate? Y N

Enter the distance from the stop line to the first far side signal for the through movement.

Pavement condition on approach:
___Adequate ___Polished ___Severely Rutted

Should signal warranting study be conducted? Y N

Other concerns:____________________________________
____

PART 5. IDENTIFY PROMISING COUNTERMEASURES

Visibility Deficiency

- ____ Install additional signals on near side
- ____ Change signal mounting
- ____ Install SIGNAL AHEAD sign
- ____ Install advance warning flashers
- ____ Remove/relocate sight obstruction
- ____ Install programmable lenses
- ____ Install shields and visors

Signal Timing Operation Deficiency

- ____ Change yellow interval
- ____ Add/change all-red inter-

Conspicuity Deficiency

- ____ Add signals to achieve one per lane
- ____ Replace with LED lens type
- ____ Replace with 12" signal head
- ____ Install double red signal
- ____ Install/enhance backplates
- ____ Install rumble strips on approach
- ____ Install near side signal

Other Measures

- ____ Determine if signal is warranted
- ____ Consider roundabout or innovative design
- ____ Improve pavement condition

Other____

____

*A form should be completed for each intersection approach.

Inspection by: ______________________________________

Date: _______________

REFERENCES:

1. Institute of Transportation Engineers/Federal Highway Administration. *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running*. Washington, DC: ITE, 2003.

2. Federal Highway Administration. *Manual on Uniform Traffic Control Devices for Streets and Highways*, Washington, DC: Federal Highway Administration, 2003.

3. Institute of Transportation Engineers. *Traffic Engineering Handbook*. Washington DC: Institute of Transportation Engineers, 1999.

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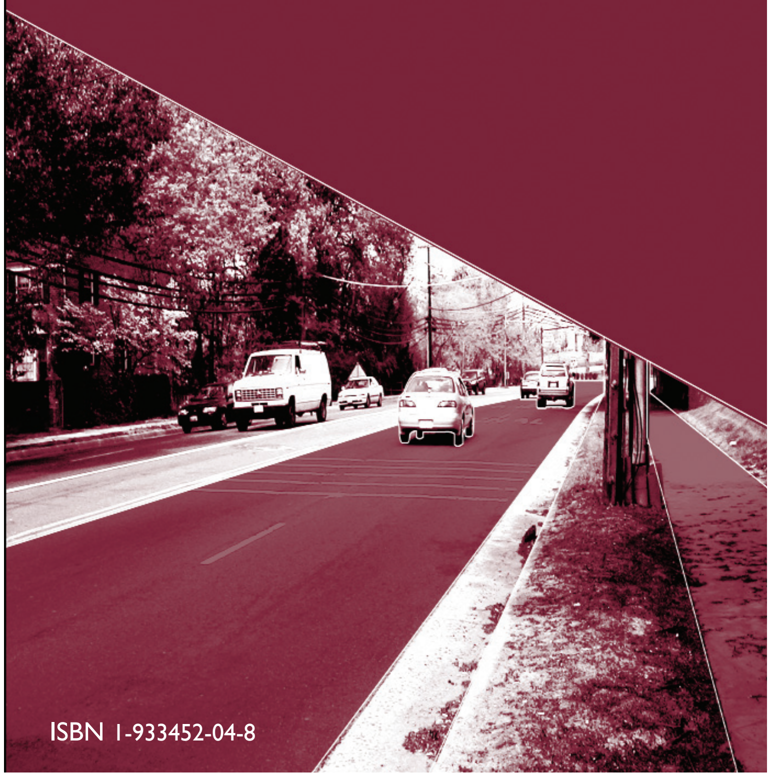

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