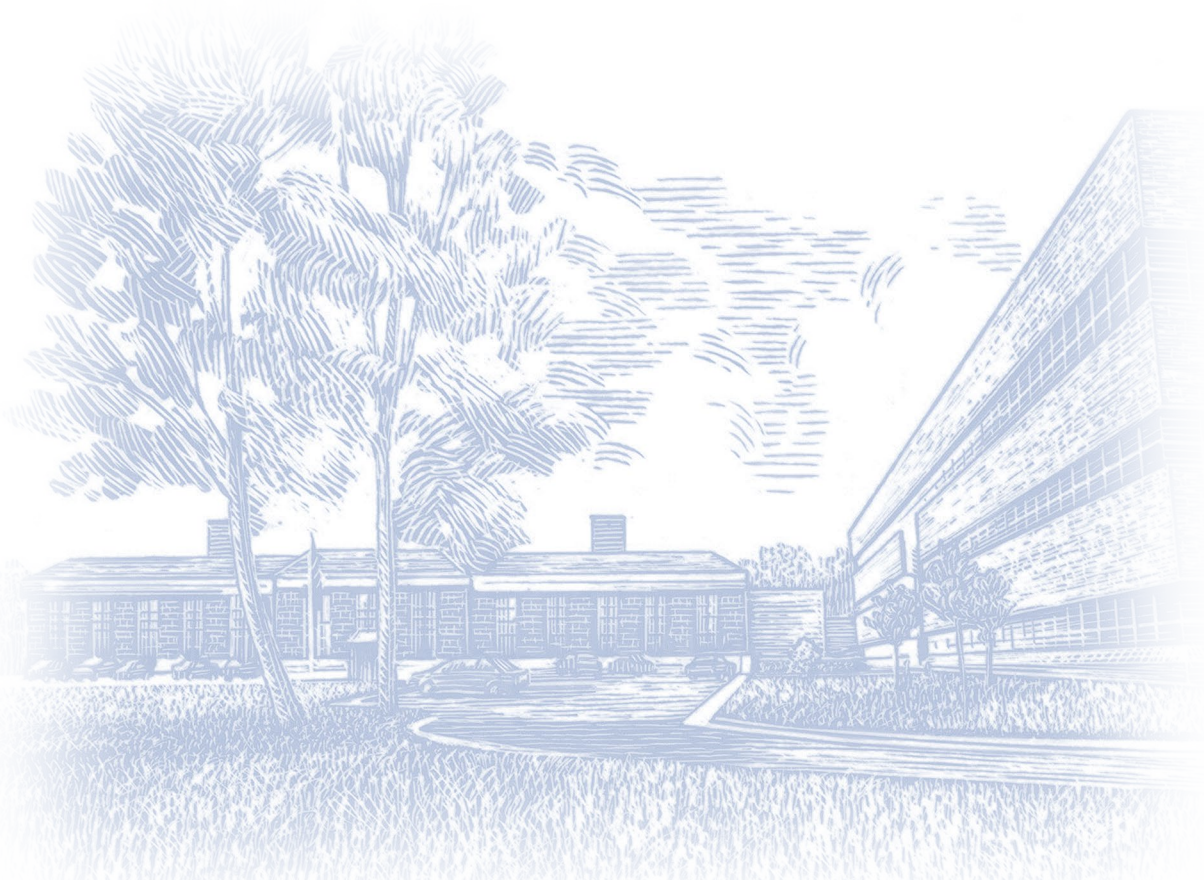


# A Review of the Signalized Intersections: Informational Guide

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## Introduction

In 2002, 21 percent of crashes and 24 percent of all fatalities and injury collisions occurred at signalized intersections. Because traffic signals play an important role in improving safety at intersections, the Federal Highway Administration (FHWA) has produced a comprehensive guide titled *Signalized Intersections: Informational Guide*, which provides methods for evaluating the safety and operations of signalized intersections and tools to remedy deficiencies.

The information contained in this guide is based on the latest research available. The guide's information and tools will help practitioners make insightful intersection assessments and understand the tradeoffs of potential improvement measures. Additional resources and references are highlighted for those who wish to learn more about a particular subject.

The guide includes examples of novel treatments and best practices in use by jurisdictions across the United States. These treatments include low-cost measures such as improvements to signal timing and signs, and high-cost measures such as intersection reconstruction or grade separation. Although some treatments apply only to high-volume intersections, information in the guide applies to signalized intersections of all volume levels.

This publication is not intended to replicate or replace traditional traffic engineering documents such as the *Manual on Uniform Traffic Control Devices*, the *Highway Capacity Manual*, and the American Association of State Highway and Transportation Officials' *A Policy on Geometric Design of Highways and Streets*, nor is the guide intended to serve as a standard or policy document.

## Overview

The guide takes a holistic approach to address signalized intersections and considers the safety and operational implications of a particular treatment on all system users (including motorists, pedestrians, bicyclists, and transit riders). It is organized into three parts:

- I. Fundamentals.
- II. Project Process and Analysis Methods.
- III. Treatments.

## I. Fundamentals

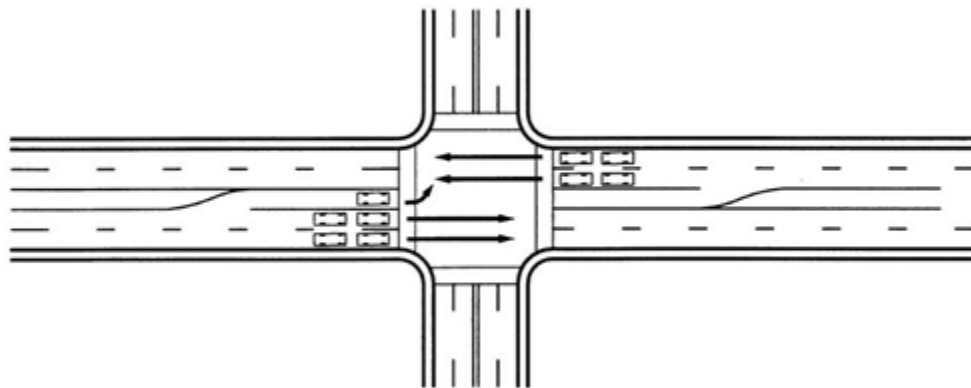
**Chapter 1. Introduction.** This section of the guide introduces practitioners to three topic areas, each in its own chapter: road user needs, geometric design, and traffic design and illumination.

**Chapter 2. User Needs.** This chapter begins with an overview of human factors research and describes the different needs of motorists, pedestrians, and bicyclists. The chapter concludes by discussing how to apply human factors principles to planning, designing, and operating high-volume signalized intersections. *For an example of one of these concepts, see [figure 1](#).*



*Figure 1. Many people who use crosswalks are traveling at different speeds. Pedestrian walking speeds generally range between 0.8 to 1.8 meters/second (2.5 to 6.0 feet/second).*

**Chapter 3. Geometric Design.** The next chapter presents guidelines for signalized intersections based on a review of technical literature and current design policy in the United States. This chapter addresses principles of channelization; number of intersection approaches; intersection angle; horizontal and vertical alignment; corner radius and curb ramp design; detectable warnings; access control; sight distance; and pedestrian and bicycle facilities. *For an example of one of these concepts, see [figure 2](#).*



*Figure 2. A dedicated left-turn lane reduces potential collisions between vehicles that are turning left and those that are moving through the intersection, which increases the capacity of the approach for both types of traffic.*

**Chapter 4. Traffic Design and Illumination.** This chapter highlights the fundamental principles of traffic design and illumination as they apply to signalized intersections. It includes a discussion of traffic signal hardware and software (the infrastructure that assigns vehicular and pedestrian rights-of-way at locations where conflicts or hazardous conditions exist). Properly applying and designing traffic signals are key components in improving an intersection's safety and efficiency. *For an example of one of these concepts, see [figure 3](#).*

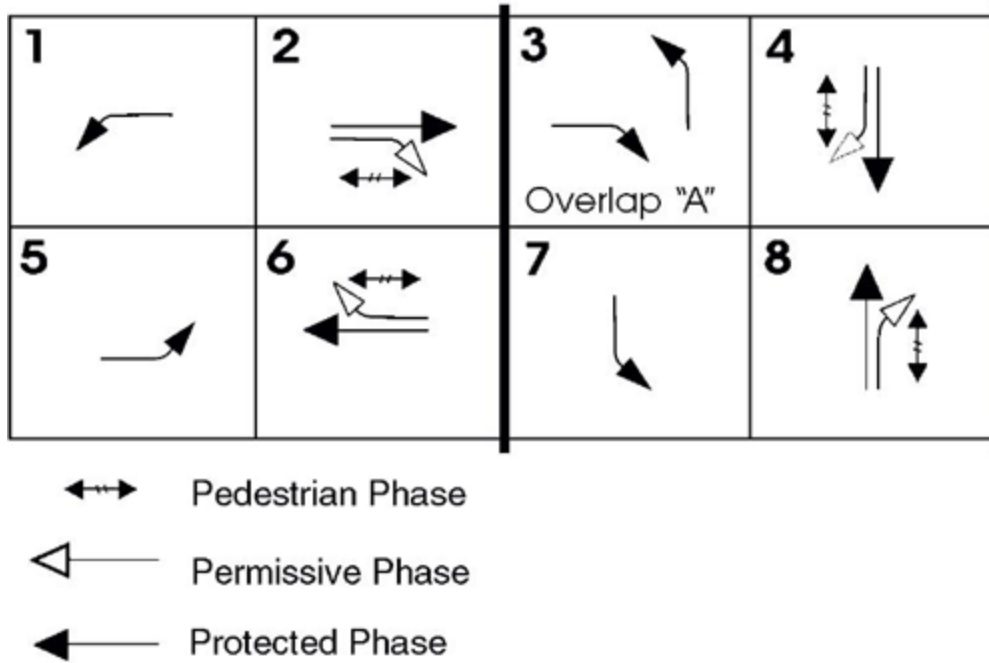


Figure 3. Typical phasing diagram illustrating a right-turn overlap.

## **Common Stakeholder Concerns**

### **Motorists**

- Cycle failure
- Long delays
- Queue spillback
- Poor progression
- Inefficient signal timing
- Numerous crashes
- High crash severity
- Poor sight distance
- High vehicle speeds
- Confusing signs

### **Pedestrians**

- Inadequate facilities
- Long wait times
- Wide crossing distance
- Fast vehicles
- Poorly located ramps/push buttons
- Numerous conflicts with other users
- Confusion regarding when to begin crossing

### **Transit Riders**

- Bus stop inaccessible/ poorly located
- Bus stop impedes vehicle movement
- Traffic stream merge is difficult

### **Bicyclists**

- Inadequate facilities
- Low clearance interval
- Ineffective lane striping

## II. Project Process And Analysis Methods

This section of the guide discusses project process, safety analysis methods, and operational analysis methods.

**Chapter 5. Project Process.** The section begins by describing a standard process for conducting an intersection design/re-design project. First, project managers should identify stakeholders, determine the scope of analysis, collect data, and identify key issues of concern. From this information, the team can develop a problem statement and identify potential countermeasures or treatments, then evaluate potential treatments for feasibility and effectiveness. After practitioners choose a treatment, the improvement is implemented and monitored over time. This chapter includes issues to consider and questions to ask during the design process. *For a list of common stakeholder concerns, see text box at right.*

**Chapter 6. Safety Analysis Methods.** Practitioners must carefully consider safety, mobility, cost, and available resources when designing, operating, managing, and rehabilitating roadways. The chapter on safety analysis methods discusses explicit safety considerations and the development of quantifiable safety information to enhance the flexible design process. It also describes a set of tools that professionals can use to assess the safety performance at a signalized intersection. *For an example of one of these concepts, see figure 4.*

- Unsafe/numerous conflicts with vehicles

### Facility Managers

- Local/Statewide policy not met
- Noncompliance with corridor plan, transportation system plan, comprehensive plan, etc.
- Construction effects and traffic maintenance
- Fiscal, land use, and right-of-way constraints

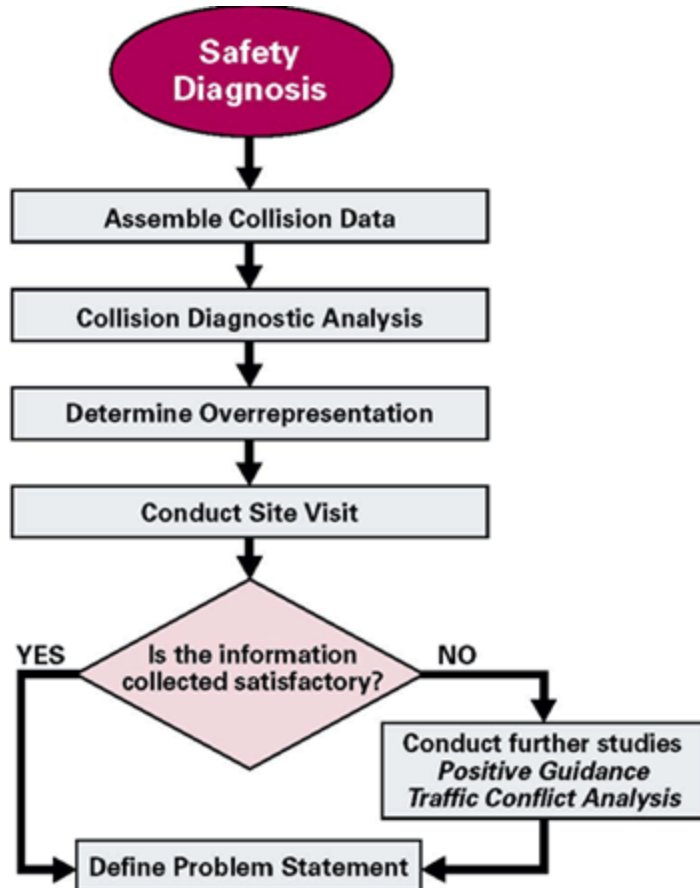


Figure 4. Steps to identify potential problems.

**Chapter 7. Operational Analysis Methods.** The ability to measure, evaluate, and forecast traffic operations is a fundamental element of effectively diagnosing problems and selecting appropriate treatments for signalized intersections. A traffic operations analysis should describe how well an intersection accommodates demand for all user groups. The operational analysis methods chapter describes key elements of signalized intersection operations and provides guidance for evaluating results. Practitioners can use traffic operations analyses at a high level to size a facility and at a refined level to develop signal timing plans. *For an example of one of these concepts, see figure 5.*



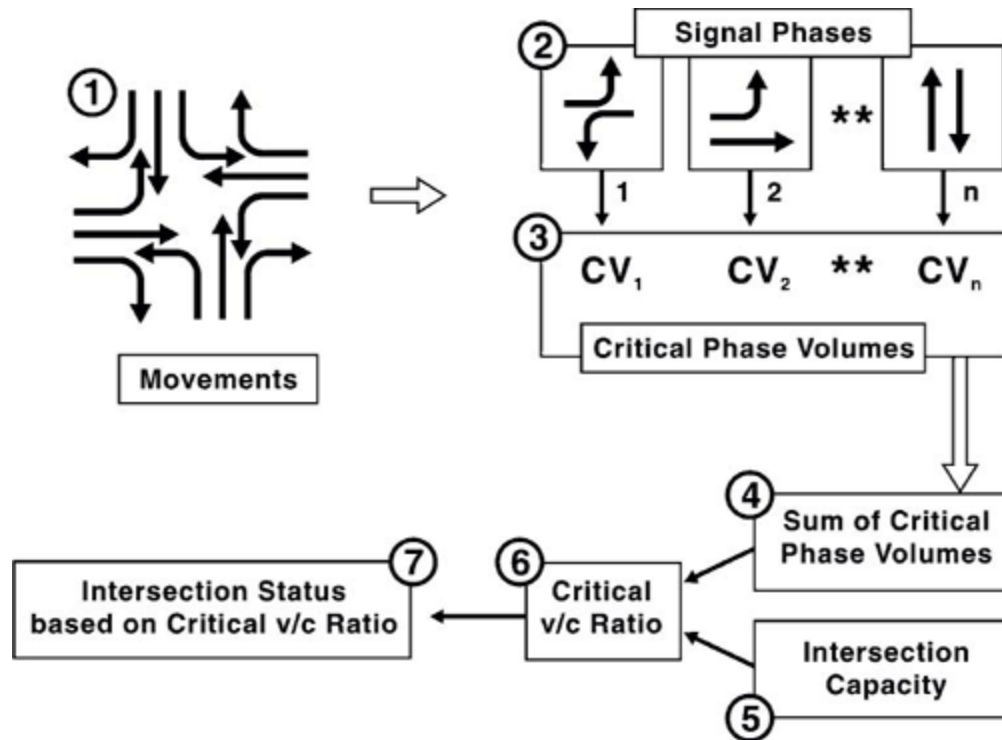


Figure 5. Graphical and tabular summary of the Quick Estimation Method.

### III. Treatments

The guide's final section describes five types of treatments.

**Chapter 8. System-Wide Treatments.** These apply to roadway segments located within the influence of signalized intersections and to intersections affected by traffic flow along a corridor. These treatments primarily address safety concerns associated with rear-end collisions, turbulence related to vehicles turning midblock from driveways or nonsignalized intersections, and coordination deficiencies associated with how traffic progresses from one location to another. *For an example of one of these concepts, see figure 6.*

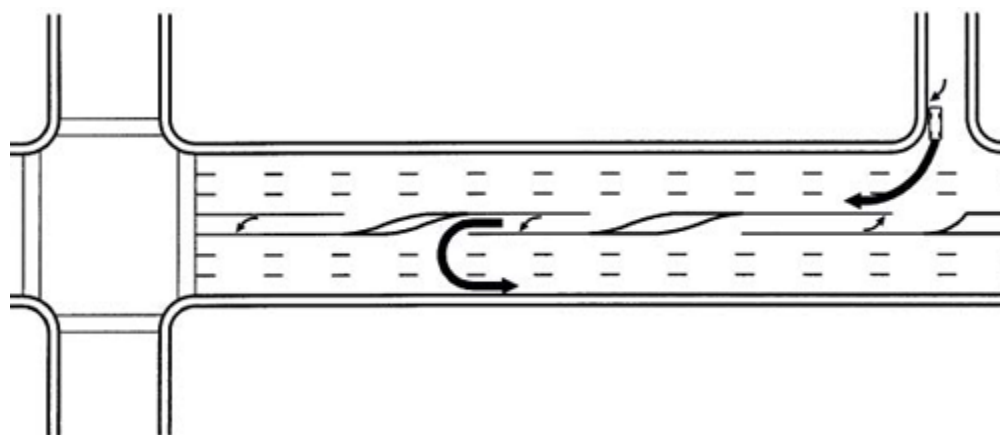
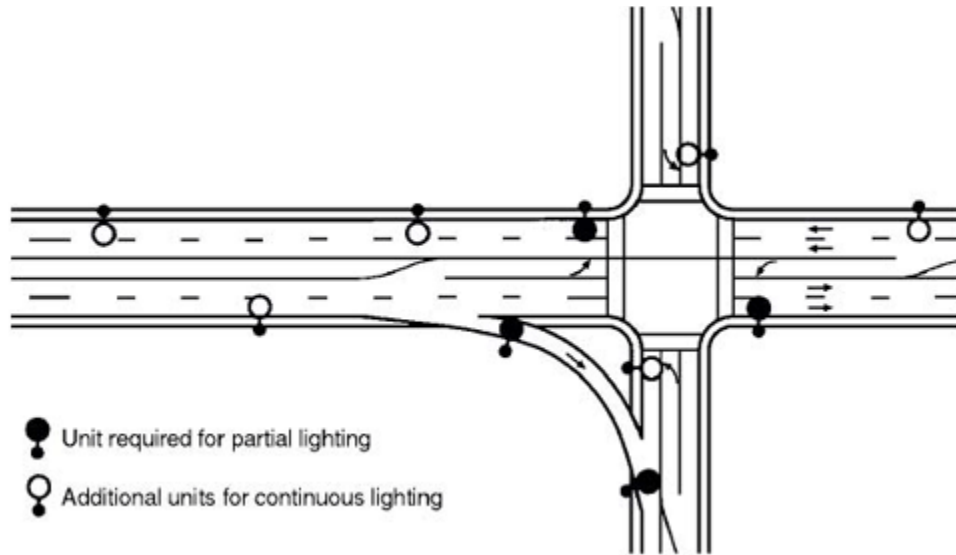


Figure 6. Access management requiring U-turns at an unsignalized, directional median opening.

**Chapter 9. Intersection-Wide Treatments.** This chapter discusses treatments that address non-auto modes, traffic control/signal timing, and illumination. There are five types of intersection-wide treatments: pedestrian, bicycle, transit, traffic control, and illumination. *For an example of one of these concepts, see figure 7.*



*Figure 7. Typical lighting layouts.*

**Chapter 10. Alternative Intersection Treatments.** This chapter describes three categories of alternative intersection treatments: intersection reconfiguration, at-grade indirect movements, and grade separation. Many of these treatments are commonplace, while others have seen limited or regional use, but all of them aim to reduce conflict points at the intersection. This enhances safety and operations by reducing the number of phases and conflicting volume at a single location. These reconstruction treatments are often necessary when relatively low-cost treatments such as improving signal timing and signing or adding an auxiliary lane will not solve the existing problem. *For an example of one of these concepts, see figure 8.*

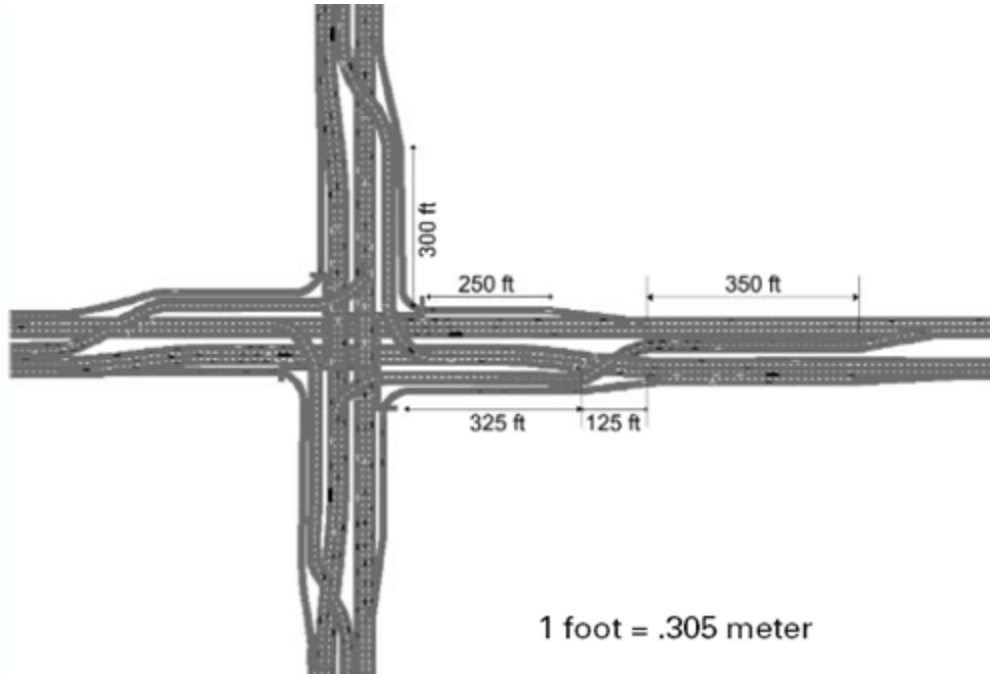


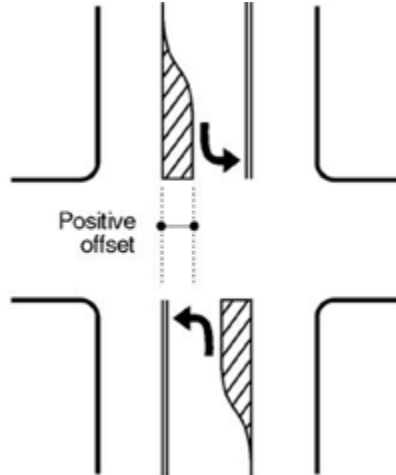
Figure 8. Diagram of a continuous flow intersection.

**Chapter 11. Approach Treatments.** These treatments ensure that approaching motorists, bicyclists, or pedestrians can see that an intersection is ahead, and that a traffic signal is controlling the traffic flow. Adequate signs and pavement markings help drivers choose an appropriate lane and travel direction. The pavement on the approaches gives drivers a smooth, skid-resistant surface, with adequate drainage. Intersection approaches ideally should meet at right angles, be at-grade, and free of unnecessary clutter and obstacles. Sight distance for all approaches should be adequate for drivers proceeding through the intersection, particularly those making a left turn. *For an example of one of these concepts, see figure 9.*



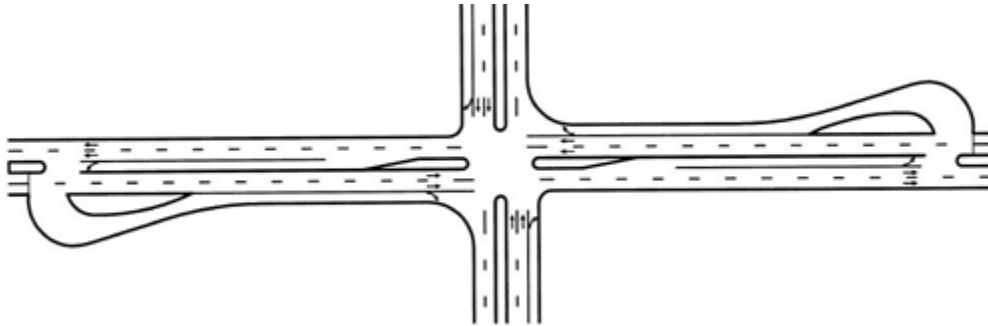
Figure 9. Photo of signal head using a double red signal indication.

**Chapter 12. Individual Movement Treatments.** These treatments influence how vehicles travel through signalized intersections and how they make left-, right-, and U-turns at these intersections. These treatments also affect variable lane use. Individual movement treatments help reduce rear-end collisions under congested conditions; collisions involving left-turning vehicles; bicycle and pedestrian crashes; and traffic delays. For an example of one of these concepts, see figure 10.



*Figure 10. Example of positive offset.*

#### Various Types of Alternative Treatments



*Figure 11. Diagram of a median U-turn crossover from the main line with a narrow median.*

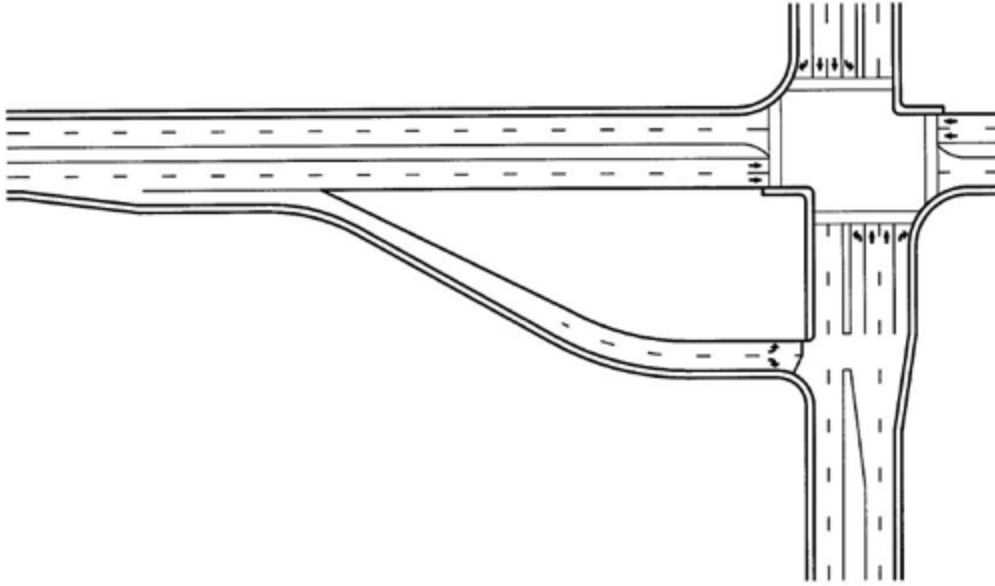


Figure 12. Diagram of a jughandle intersections

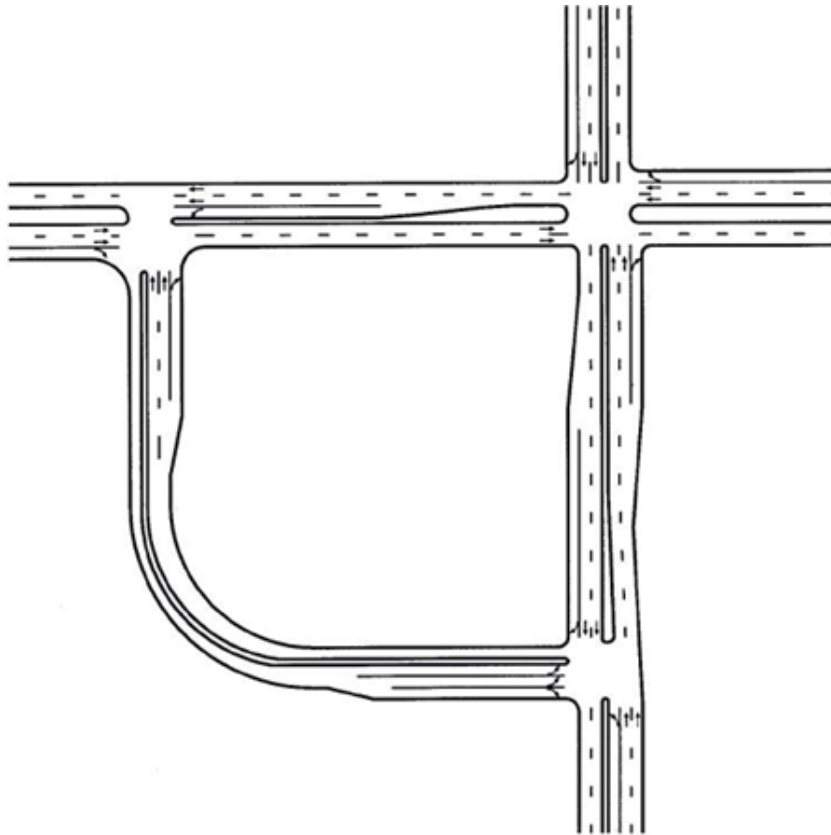


Figure 13. Diagram of a quadrant roadway intersection.

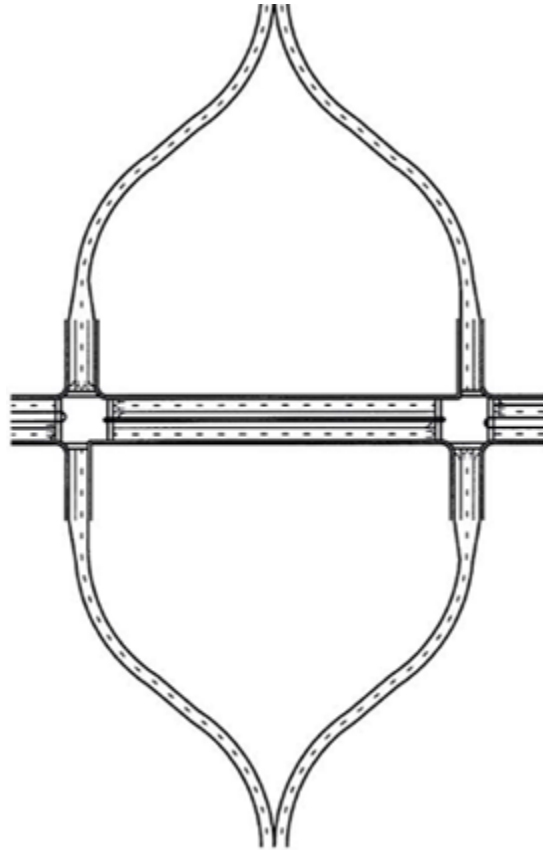


Figure 14. Illustration of a split intersection.

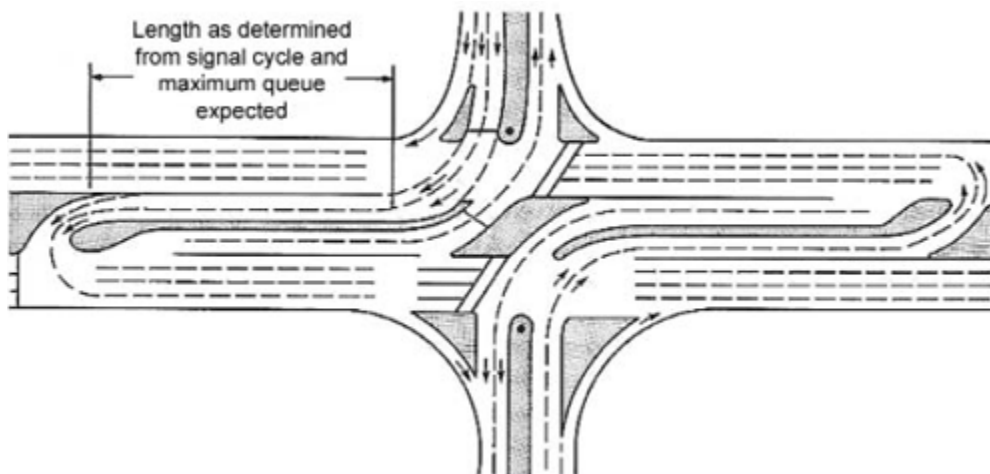


Figure 15. Illustration of super-street median crossover.

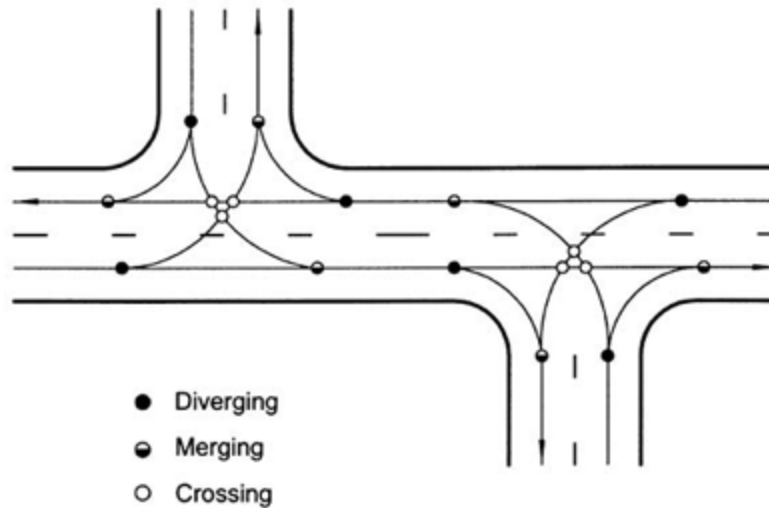


Figure 16. Conflict point diagram for two closely spaced T-intersections.

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**Key Words**—Signalized intersections, high volume intersections, unconventional treatments.

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