TDOT
Department of Transportation

TDOT 20 FLAGS INTERSECTION EVALUATION GUIDE

AUGUST 2025

Preface

The 20 Flags Intersection Evaluation Guide supports the Tennessee Department of Transportation (TDOT) Project Delivery Network (PDN) by enhancing pedestrian and bicycle intersection assessments during alternatives evaluation and the design process. The method is based on *NCHRP Research Report 948: Guide for Pedestrian and Bicyclists Safety at Alternative and Other Intersections and Interchanges* and refined for broader applications including conventional intersections.

The 20 Flags Intersection Evaluation Guide was developed by TDOT with assistance from the transportation engineering consulting firm of Kittelson & Associates, Inc. The TDOT guide development workshop participants consisted of:

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Introduction

This document describes an approach for considering pedestrian and bicyclist safety throughout the intersection design and project development process for Tennessee Department of Transportation (TDOT). The design factors that impact pedestrian and bicyclist intersection safety can often be subtle or seemingly disconnected from non-motorized facility elements, such as curb radii or signal clearance time. As a result, design decisions influencing pedestrian and bicyclist safety are made throughout the design process and outside the TDOT Project Delivery Network[1] (PDN) stages designated for Active Transportation review. In the past, there has not been a thorough and cost-effective tool to systematically consider these roadway elements critical to pedestrian and bicyclist safety at every stage of the design process.

In the TDOT Project Scoping Guide[2] (PSG), the principles of a Safe System Approach are highlighted, founded on "the principles that humans make mistakes and that human bodies have limited ability to tolerate crash impacts"[3]. The PSG includes five elements of a Safe System Approach shown in Figure 1.

Figure 1. Five Elements of a Safe System Approach (FHWA)

[1] The PDN is TDOT's process for scoping and delivering projects: https://www.tn.gov/tdot/pm/pdn.html
[2] The PSG is a primary resource for planning and design guidance and criteria: https://www.tn.gov/tdot/state-engineering-technical-training/production-support/project-scoping-guide.html
[3] FHWA. "Zero Deaths and Safe System." https://highways.dot.gov/safety/zero-deaths (as of May 20, 2024).

Following a Safe System approach is particularly important for people walking or bicycling, as these vulnerable road users lack the protections and safety technologies typically built into motorized vehicles. As such, a specific assessment of the safety of these road users is paramount to enhancing the overall safety of the transportation system.

The 20 Flags methodology is intended to streamline pedestrian and bicyclist safety evaluations so that they can be scored alongside other criteria, such as crash history or truck turning radii. The evaluation is intended to be conducted during existing conditions assessment, alternatives evaluation, and throughout the design process to document and inform comprehensive design decision-making at intersections. The 20 Flags methodology integrates Safe System design principles, by procedurally evaluating vehicle speeds and conflict points for people walking and bicycling at intersections.

The basis of the 20 Flags methodology is NCHRP Research Report 948: Guide for Pedestrian and Bicyclists Safety at Alternative and Other Intersections and Interchanges (NCHRP 948). The Guide provides project teams with guidance on how to evaluate and improve pedestrian and bicyclist safety at intersections and interchanges. The twenty design flags serve as a proxy for quantitative performance measures (crashes), which can go unreported and which cannot be assessed for new design concepts. Other predictive safety methods like crash modification factors (CMF) and safety performance functions (SPF) are not readily available for pedestrian and bicyclists at this time.

While the NCHRP 948 guide was originally motivated by enhancing pedestrian and bicyclist safety for alternative intersections and interchanges, the principles underpinning the methodology are applicable to conventional intersection forms. In fact, the project was specifically focused on creating a method that allows comparisons across any intersection or interchange designs. This was achieved by focusing on the design elements and their performance attributes (e.g. vehicle speed at crossing), as opposed to the overall form of the intersection or interchange. Extensive application of the methodology to conventional intersections has confirmed this goal was achieved. Subsequent testing and implementation of the method[4] further identified several modifications to make the methodology more effective, user-friendly, and widely applicable. These modifications have been integrated into this document

Given these modifications, the guidance in this document supersedes the 20 Flags methodology as presented in NCHRP Report 948. The NCHRP report remains a valuable resource for additional information, motivation behind the development of the flags, general insights on pedestrian and bicyclist safety, as well as specific considerations for alternative intersections and interchanges. However, the flag details and thresholds have been updated and revised in this document, consistent with follow-up research and implementation experience. All guidance and recommendations in this document were reviewed and vetted by original authors of NCHRP Report 948.

[4] NCHRP 20-44(35) - Implementation for NCHRP Research Report 948. apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=5046

Overview of Methodology

PURPOSE AND OBJECTIVES

The objectives and scope for NCHRP 948 and for this guide were generally two-fold:

I. Discuss the benefits and tradeoffs of pedestrian and bicycle design and operational treatments with consideration of delay and safety for pedestrians and bicyclists.

II. Develop a performance-based process for project teams to evaluate pedestrian and bicycle design elements in an intersection control evaluation, or ICE, process (referred to at TDOT as an Intersection and Interchange Evaluation [IIE]).

In developing the 20 Flags methodology, research sources included literature reviews, focus groups with users, online surveys, expert panels, and practitioner experience. From these sources, the 20 Flags were developed as a quantitative method to assess pedestrian and bicyclist safety. Through the research, it was determined that 3 design flags apply to pedestrians only, 7 design flags apply to bicyclists only, and 10 design flags apply to both pedestrians and bicyclists. Pedestrian design flags are evaluated for each of the four pedestrian paths crossing each leg of a conventional four-legged intersection, resulting in a total of 52 pedestrian flags to evaluate an intersection (13 pedestrian flags multiplied by 4 crossings). Bicyclist design flags are evaluated for each of the 12 bicyclist turning movements (left, through, and right on each approach), resulting in a total of 204 bicyclist design flags to evaluate at a conventional four-legged intersection (17 bicycle flags multiplied by 12 movements). This is illustrated in Figure 2.

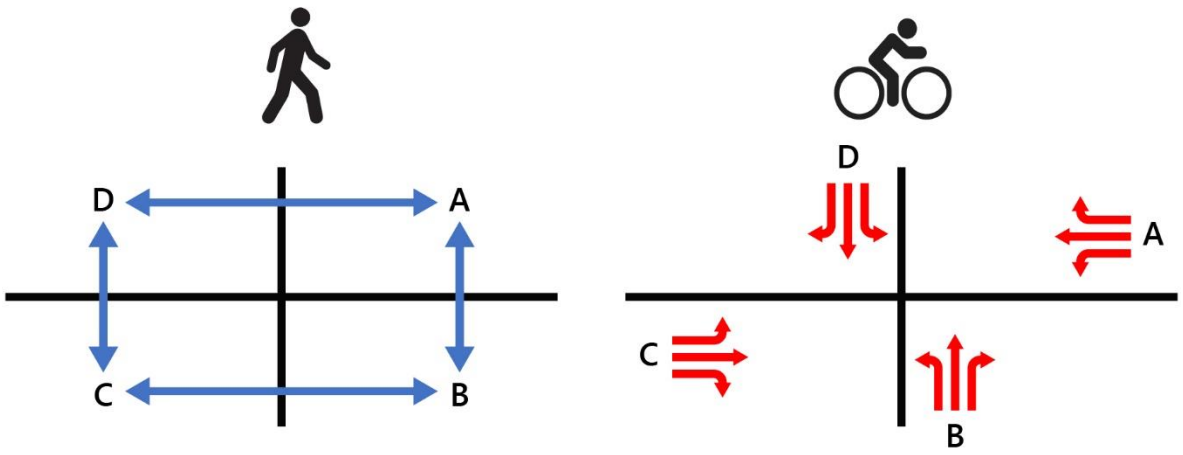


Figure 2. Application of 20 Flags to Pedestrian and Bicyclist Travel Paths

Intersections with three legs and/or one-way streets will generally have fewer total flags while five-legged intersections and those with exclusive pedestrian phases may have more possible flags.

While the bicycle flags are designed for application with in-street bicycle lanes, most are applicable to roadways without exclusive bicycle facilities, where bicyclists travel in a shared lane. Bicyclists traveling in a shared-use path or using the sidewalk should be evaluated using the pedestrian flags.

Design flags raised by this methodology represent a potential risk factor for people walking and bicycling, which should then be explicitly considered and discussed in the design process. Depending on the purpose and need of the project, the goal may or may not be to eliminate all flags, but that decision should be weighed carefully given intersection context and expected users. Through iteration in the design process, flags can be removed or mitigated while considering other design goals and constraints.

While pedestrians and bicyclists are the explicit focus of this methodology, it can assess conditions for users of other non-vehicle modes, such as personal conveyance devices, motorized scooters, and other micromobility devices, as many of the same factors are applicable as they traverse intersections via crosswalk or travel lane. Additionally, the methodology can respond to additional focus on certain user types, such as young or aged pedestrians, by emphasizing relevant flags and considering alternate routing. For example, grade change is a more significant barrier to wheelchair users and tight walking environment is a particular concern for adults caring for children. However, this 20 Flags method may not capture all factors important to the wide variety of non-vehicle devices and roadway users.

The 20 Flags Methodology is intended to be used to compare alternatives and identify where design iterations are possible when developing an intersection improvement. Project teams can use the iterative review process to evaluate design decisions made throughout the design lifecycle, continuing to align with priorities identified at the start of the project.

The primary benefit of the 20 Flags methodology is that it provides a quantitative and comprehensive design check that is straightforward to apply in the design process. Compared to other quantitative methodologies, like Pedestrian or Bicycle Level of Service, the 20 Flags methodology requires fewer data inputs and analysis and is more directly tied to design decisions. At the same time, it is more detailed and sensitive to actual design decisions than a level of traffic stress (LTS) analysis.

INTRODUCING THE 20 FLAGS

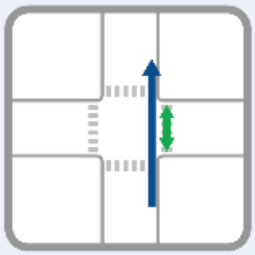
The 20 Flags developed for NCHRP 948 have been refined and reordered based on a national implementation effort, and the research team's experience in testing the process and further adapting the flags to be applicable to all intersections.

While the flags were originally grouped by applicable mode in NCHRP 948, they have been restructured into groupings by conflict area or type. Each grouping allows the project team to step through the intersection in a logical progression. The groupings are:

- Flags applying to mainline crossings,
- Flags applying to conflicts with turning traffic,

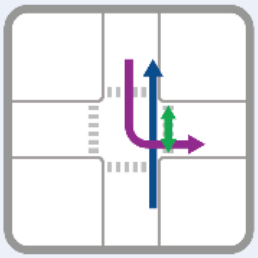
- Flags specific to bicycle maneuvers through an intersection, and
- Flags related to navigation and wayfinding tasks.

The flags and groups are summarized in Figure 3. The figure indicates the applicable mode(s) for each flag, and further highlights primary flags are in **bold.** The distinction of primary and secondary flags is discussed in more detail in the next section**.** Appendix A provides further documentation of revisions from the original NCHRP 948 procedure. Appendix B provides details for each of the flags in the form on one-page fact sheets.



Main Crossings (Flags A-E)

- **Flag A: Undefined Crossings at Intersections**
- **Flag B: Multilane Crossing**
- Flag C: Long Red Times
- Flag D: Bicycle Clearance Times
- Flag E: Sight Distance for Gap Acceptance Movements

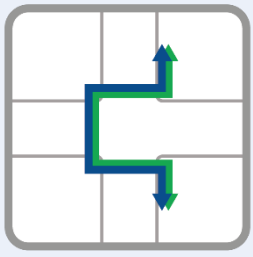


Turning Vehicles and Crossing Conflicts (Flags F-J)

- **Flag F: Motor Vehicle Right Turns**
- **Flag G: Motor Vehicle Left Turns**
- **Flag H: Turning Motor Vehicles Crossing Bike Path**
- Flag I: Intersecting Driveways and Side Streets
- **Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths**

Bicycle Maneuvers (Flags K-N)

- **Flag K: Lane Change Across Motor Vehicle Travel Lanes**
- **Flag L: Channelized Lanes**
- **Flag M: Riding in Shared Lanes**
- **Flag N: Riding Between Lanes**



Navigation and Wayfinding (Flags O-T)

- Flag O: Uncomfortable/Tight Walking Environment
- Flag P: Indirect Paths
- Flag Q: Grade Change
- Flag R: Nonintuitive Motor Vehicle Movements
- Flag S: Executing Unusual Movements
- Flag T: Off-Tracking in Turns and Curves

Figure 3. Overview and Grouping of 20 Flags (Primary Flags shown in bold text)

USING THE FLAGS IN THE DESIGN PROCESS

Design flags are often interconnected such that mitigating one flag may result in raising a different flag. The design process using the 20 Flags is intended to be both performance-based and iterative.

- **Performance-based** means that the design can be evaluated with quantitative performance measures (i.e. the flags), and that these performance measures are tied to design attributes and decisions (e.g. the turning radius of a right turn);
- **Iterative** means that while an initial design may have certain flags raised, these can be addressed through subsequent design modifications, or with the introduction of treatments or traffic control devices to enhance safety as illustrated in Figure 4.

Two systems are used to assist project teams in prioritizing flags for mitigation. First, the flags are prioritized by their degree of impact on pedestrian and bicyclist safety into 10 primary flags and 10 secondary flags. In applying the method, addressing a primary flag in design iterations may warrant higher priority than secondary flags. Similarly, it may not be advised to address a secondary flag at the expense of creating a primary flag.

Second, within most of the 20 flags, two thresholds exist, yellow and red, that summarize the level of exposure and risk of injury. Red flags represent risks likely to result in more severe injury than yellow flags due to factors such as speed and volume of adjacent or conflicting vehicles.

Flags are not necessarily a predictor of crashes, but an indicator of general conditions that may increase risk and discomfort for vulnerable road users. Actual crash risk of a specific facility design is based on many factors beyond the scale of this assessment, including vehicle speed, user volume and behavior, intersection context, compatibility with adjacent facilities and transportation networks, and other characteristics. The Highway Safety Manual presently does not have robust crash prediction methods (i.e. safety performance functions) for pedestrian and bicyclist crashes, much less ones that are sensitive to nuanced design decisions. The 20 Flags method fills this gap by providing a quantitative assessment of surrogate safety measures.

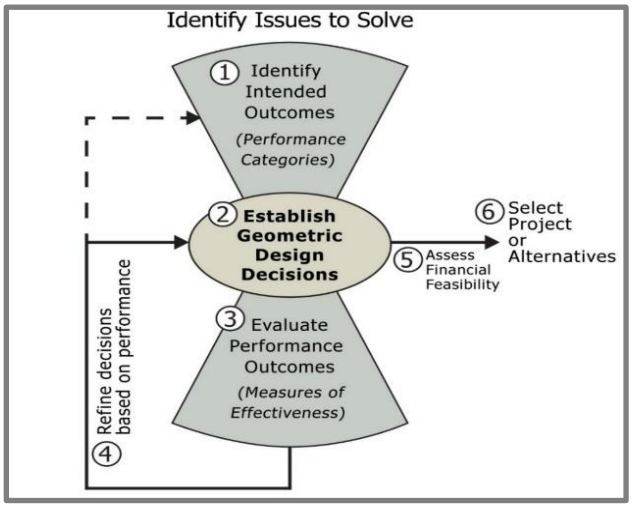


Figure 4: Iterative Design Process from NCHRP Report 785

Guidance of the 20 Flags Methodology in the Project Development Process

The Project Delivery Network (PDN) informs specific stages of the project development process for Tennessee DOT (TDOT) and provides guidance for development of project deliverables and documentation. TDOT's Project Scoping Guide (PSG) integrates a performance- and context-based planning and design approach, which is divided into multiple stages. This section discusses the applicability of the 20 Flags method within the PDN framework.

Since the 20 Flags method is fundamentally based on geometric design characteristics or decisions, it has more complete applicability in later stages of PDN, as design concepts and alternatives are further developed. That said, the method can be applied to existing conditions and can be useful for screening alternatives even in earlier stages as discussed below. In fact, the 20 Flags method can have the biggest impact on project decision making in the early stages of alternatives assessment, when intersection control options and design decisions are most amenable to modification. For example, the 20 Flags method can inform preferred locations of pedestrian crosswalks or the need for exclusive bicycle facilities at a time when there is still flexibility in the design to implement those changes. Moving a crosswalk (relative to drainage system) or adding exclusive bicycle facilities can be challenging at late stages of the PDN.

APPLICATION DURING PDN STAGE 1

As part of the Stage 1 process in TDOT's Project Delivery Network, this 20 Flags methodology can be applied to identify issues with the existing configuration and/or assess proposed intersection configurations and compare design alternatives.

PDN Stage 1 Concept Activities includes the IIE process with two stages, I and II:

- IIE Stage I: Scoping acts as an initial screening to filter alternatives. Current IIE Multimodal evaluation is the question: "Is the option likely to improve or maintain multimodal access?"
- IIE Stage II: Preferred Option Selection includes a more detailed screening based on preliminary engineering. Current IIE Multimodal Considerations is a qualitative assessment[5].

The 20 Flags method is ideally suited for IIE Stage II to evaluate multimodal alternatives, which is also consistent with national guidance in the NCHRP Guide for Intersection Control Evaluation[6]. The application of the 20 Flags method will have some limitations in IIE Stage I, as the necessary

[5] TDOT, HSAM Volume 2: Intersection & Interchange Evaluation, 2021
[6] NCHRP Research Report 1087: Guide for Intersection Control Evaluation. National Academy of Sciences. 2024

design details for applying the method have not been established (e.g. curve radii, number of lanes, control type, etc.).

Even at IIE Stage II, some of the information needed for the 20 Flags method may not be complete, but the method should still be applied and refined as the information becomes available. This is true for Design Flags C (Long Red Times), E (Sight Distance for Gap Acceptance Movements), and Q (Grade Change). The signal timing details, and three-dimensional geometry may not be determined at Stage 1 of the PDN and IIE Stage II. However, the general principles of how factors such as intersection crossing width, sight distance, and approach grades impact the safety of people walking or bicycling can still be considered in the design even if the corresponding flags cannot be fully assessed. The majority of flags can be fully applied and considered one a basic geometric design of the intersection is available.

The 20 Flags method can be completed as part of the IIE Stage II and PDN Stage 1 *Concept Activities* to inform the *Active Transportation Review* when project teams develop conceptual layouts and capture observations during site visits and provide documentation in the *Concept Report*.

The 20 Flags methodology results can be applied during PDN Stage 1 as a design check and deliverable in the development of the Scope of Work Document and the Project-Specific Design Criteria Document. The methodology can go beyond design guidance and criteria to assess design decisions and inform tradeoffs as the initial cross section and horizontal and vertical alignments are set. For example:

- Flag M: Riding in Shared Lanes can assess bicycle facility needs,
- Flag O: Uncomfortable/Tight Walking Environment can evaluate pedestrian sidewalk and buffer width,
- Flag F: Motor Vehicle Right Turns can inform curve radii, and
- Flag Q: Grade Change can help to develop sidewalk grades.

At each stage, it is recommended that project teams evaluate all applicable flags with available information, even if preliminary. Project teams should document reasonable assumptions and apply them consistently across design alternatives. The completed 20 Flags assessment can and should be updated as designs evolve and to check design decisions even at later stages in the project development process. The spreadsheet tool accompanying this guide can be used to readily store completed assessments and update them at later PDN stages.

APPLICATION DURING PDN STAGES 2 AND 3

The 20 Flags methodology can also be used as a design check later in the project development process. These checks may occur during Stage 2 of TDOT's PDN, while the design footprint is being established. Project teams should evaluate flags for mitigation, placing greatest weight on mitigating primary red and yellow flags.

As with PDN Stage 1, the 20 Flags methodology can be applied during PDN Stage 2 as a design check and deliverable in the development of the Functional Design Plans. During PDN Stage 3, the methodology can be completed to assess and document pedestrian and bicyclist

performance of the design as part of the Plans-in-Hand development. Ideally, the assessment started in PDN Stage 1 is just carried forward and augmented as needed in these later stages.

There may still be some limitations to information, depending on the level of engineering that has been performed at Stage 2. If signal timings and three-dimensional geometry are not determined until Stage 3, it would be beneficial to perform checks for Design Flags C (Long Red Times), E (Sight Distance for Gap Acceptance Movements), and Q (Grade Change) documenting reasonable assumptions. The results of these checks will help identify if further plan refinements would be beneficial.

OTHER METHODOLGY APPLICATIONS

The 20 Flags Method has versatile applications beyond the formal PDN process, such as:

- Existing conditions assessment: 20 Flags can be used as a part of any safety or operational assessment of a built intersection to identity potential areas for improvement and compare pedestrian and bicycle conditions across intersections. This includes intersection evaluations conducted as part of traffic impact analyses.
- Planning level screening tool: key flags can be disaggregated to be used for network-level screening to identify systemic needs and mitigation. For example, the principles from Flag D: Bicycle Clearance Times can be used to locate intersections where signal timing checks or changes may be beneficial.
- Quick Build: 20 Flags principles can identify the locations, needs, and mitigations for quick build projects, as well as the assessment of proposed treatments. This process can be abbreviated to primary flags.
- Resurfacing, Restoration, and Rehabilitation (3R) projects: While their scope is limited, 3R projects still provide opportunities to improve pedestrian and bicycle facilities through striping. As such, flags such as Flag A: Undefined Crossings at Intersections and Flags F and G for motor vehicle right and left turns, can still be mitigated within the 3R limitations.
- Travel route assessment: The method can be applied to linear routes across several intersections (instead of all movements at a single intersection) to assess the safety of the route and identify mitigations. Applications include evaluating bikeway routing, path feasibility, and Safe Routes to School.

FLAG PRIORITIZATION AND DESIGN TRADEOFFS

While it would be ideal for a selected design to have no flags raised, that is often not feasible to accomplish. Therefore, it is important to consider design tradeoffs, and which flags are more critical to the design given the context for the intersections and expected users. An initial categorization of flag priority, primary or secondary, is provided on each Flag Factsheet in Appendix B. These priority levels, along with the yellow and red thresholds, are provided to give project teams direction on which flags are the most important to mitigate.

However, project teams should also be empowered to set their own priorities based on project needs and goals in consultation with the TDOT Active Transportation Office. For instance, an isolated rural intersection may be unlikely to have regular pedestrian usage, but may be on a bicycling route and will frequently serve road bicyclists. Thus, bicycle flags should be emphasized. Alternatively, roadways with high-quality multiuse paths may expect most bicyclists to not be in the roadway and thus the pedestrian flags can carry more weight. Urban intersections are likely to serve both modes and both flag groupings should be considered. As with the overall PSG process, roadway context becomes a critical consideration in the application of the 20 Flags method.

Once the project team has identified which flags are most important, using the mitigations toolbox included in each Flag Factsheet will help with design iteration and refinement. The mitigations toolbox for each design flag provides several alternatives to eliminate flags or reduce red flags to yellow flags. However, some mitigations may increase or trigger other flags so tradeoffs should be considered using the flag priority established for the project, as well as pedestrian and bicycle facility design best practices.

Incorporating flag mitigations during Stage 2 or earlier of TDOT's PDN will help to develop intersection designs that are appropriate for pedestrians and bicyclists. Further guidance on pedestrian and bicycle facility types is presented in Chapter 4 of the *Project Scoping Guide (PSG)*. PSG Chapter 5 includes information on intersection design elements, tradeoffs, and decision making.

Steps for Applying the 20 Flags Methodology

At each Stage where the 20 Flags methodology is to be applied, it is recommended to complete the five steps outlined below. If the assessment is conducted across multiple alternatives, all five steps should be completed for each alternative, applying consistent assumptions to each.

1. *Identify Flag Prioritization*
2. *Obtain Concept Drawing and Data*
3. *Assign Pedestrian Paths and Bicycle Movements*
4. *Assess Each Flag along Each Movement or Path*
5. *Revise Design to Mitigate Flag and Iterate*

1. IDENTIFY FLAG PRIORITIZATION

Identify the prioritization of flags using the priority levels defined in in the Flag Factsheets or a custom prioritization based on the project-specific goals and context in consultation with Active Transportation Office. The default priority of flags for comparison is shown Table 1 with priority given to Primary red flags, then Secondary red flags. The prioritization of flags should be defined in advance of conducting the 20 Flags assessment.

Table 1. Priority of Flag Application

Flag Type	Primary	Secondary
Red	1st	2nd
Yellow	3rd	4th

Table 1 provides a general prioritization for a high-level assessment of alternatives, such as for IIE Stage II. However, not all flag results will have the same impact on overall risk due to activity levels and risk severity. Additional factors to consider when weighing specific movement-level flags include:

- Vehicle speed at conflict point
- Risk exposure based on expected pedestrian, bicycle, and vehicle volumes at conflict point
    - Emphasis on high-demand movements such as multi-use path crossings and free-flowing interchange ramps
- Multi-use path crossings may include a wide range of users, including children, micromobility users, and bicyclists crossing as pedestrians.
- Local experience with driver yielding behavior at the proposed crossing treatments

The goal of this first step is to consider the project context, expected pedestrian and bicyclist usage patterns, and the resulting priorities for the 20 Flag assessment at the beginning of the project. For example, a project with complementary land uses on opposite sides of the street (e.g. apartment complex on one side, grocery store on the other) would likely have a high emphasis on flags pertaining to that crossing. Similarly, an intersection with a multi-use path traversing through it would likely have a high priority placed on movements along and to/from the path.

2. OBTAIN CONCEPT DRAWING AND DATA

For a proposed intersection alternative under consideration, obtain a design drawing in the form of an intersection concept drawing or design plans such as Line and Grade plans. Aerial photography and/or as-built plans will be sufficient for an existing facility. The locations of pedestrian and bicycle facilities and crossings should be included along with the roadway cross sections and configuration and traffic control of the intersection. Gather the necessary input information for each flag as documented in Table 2 or document a reasonable assumption.

Table 2. Data Needs and Sources for Flag Application

Information Needed	Flag(s)	Data Source
Crossing and Path Markings	A	Design Drawing/Aerial Mapping
Number of Lanes without Refuge	B	Design Drawing/Aerial Mapping
Pedestrian and Bicycle Delay	C	Signal Timing*
Vehicle Speed and Clearance Zone Length	D	Posted Speed and Design Drawing/Aerial Mapping
Sight Distance	E	Design Drawing/Aerial Mapping/Field Measurements
Vehicle Turning Speed & Vehicle Volume	F, G	Design Drawing/Aerial Mapping, Traffic Counts
Motor Vehicle Lane Configuration	H	Design Drawing/Aerial Mapping

Information Needed	Flag(s)	Data Source
Number of Access Points in Area of Influence	I	Design Drawing/Aerial Mapping
Vehicle Speed & Vehicle Volume	J, K, M	Posted Speed, Traffic Counts
Vehicle Speed & Channelization Length	L	Design Drawing/Aerial Mapping
Motor Vehicle Lane Configuration	N, R	Design Drawing/Aerial Mapping
Walkway Width	O	Design Drawing/Aerial Mapping
Out of Direction Travel Distance	P	Design Drawing/Aerial Mapping
Percent Grade	Q	Design Drawing/Aerial Mapping
Compliance with Local Expectation	S	Design Drawing/Aerial Mapping
Turn Angle	T	Design Drawing/Aerial Mapping

** Factsheets provide planning-level guidance to approximate delay for early IIE process evaluations.*

3. ASSIGN PEDESTRIAN PATHS AND BICYCLE MOVEMENTS

Assign pedestrian paths and bicyclist movements for each intersection and/or alternative:

- **Pedestrian Paths:** One pedestrian path should be assigned between each adjacent quadrant, as illustrated in Figure 5. Typically, one path should be provided across each leg of an intersection. All legal pedestrian paths should be assigned – lack of a designed pedestrian facility is not grounds for leaving a pedestrian path unassessed (but may require non-direct paths to complete). Paths will look different for three-legged or five-legged intersections, as well as for intersections with pedestrian scramble phases allowing diagonal crossings. The general guidance for the assessment of pedestrian paths is to conduct the evaluation "as designed" for the given intersection.

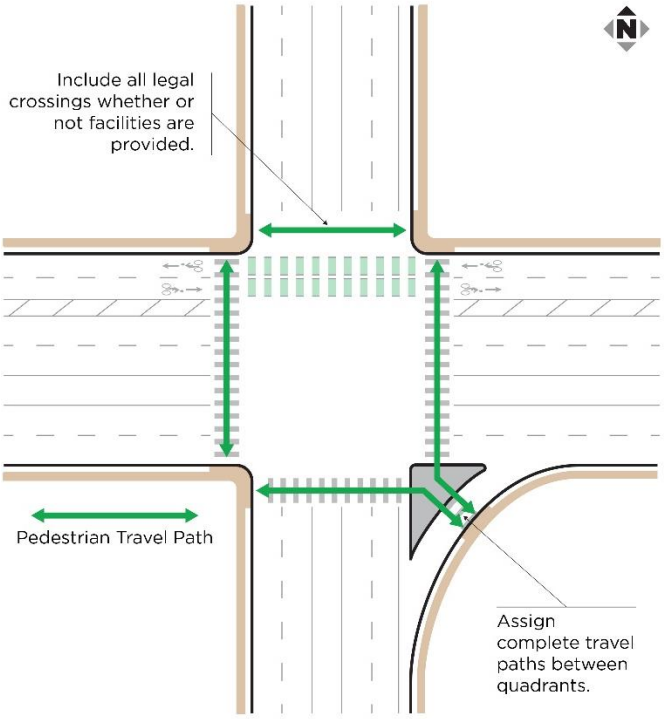


Figure 5. Pedestrian Path Assignment Example

- **Bicycle Movements:** Bicycle movements should be assigned for each pair of legal approach and departure legs at the intersection. At a four-legged intersection, each approach leg should have three bicycle movements assigned (left, through, and right), and 12 bicycle movements total. All legal bicycle movements should be assigned – lack of a designed bicycle facility is not grounds for leaving a path unassessed.

  Bicycle movements should explicitly identify where a bicyclist will be positioned. For example, will bicyclists use a shared vehicle lane or the sidewalk? Will a left-turning bicyclist shift into the left turn bay at the opening of the bay, further downstream, or use a two-stage left turn? Bicycle movements exclusively using shared use paths or sidewalks should instead be evaluated using the pedestrian paths and associated pedestrian flags.

Figure 6 illustrates the assignment of bicycle movements at a four-legged intersection with a two-way protected cycle track in the east-west direction and an on-street bike lane in only the northbound direction. Bicycle movements should be assigned to the most desirable facility (e.g. use a bike lane if present) and evaluate the facility "as currently designed" (e.g. if no bike lane present, ride in the road, not on the sidewalk).

The assignment of bicycle movements may change the resulting flags; and a mitigation may alter the movement path, as well as the flag. For example, a direct bicycle permissive left turn at an intersection (e.g. south-to-west left turn in Figure 6-a) may be mitigated with a two-stage left turn using a bicycle turn box (e.g. east-to-south left turn in Figure 6-b).

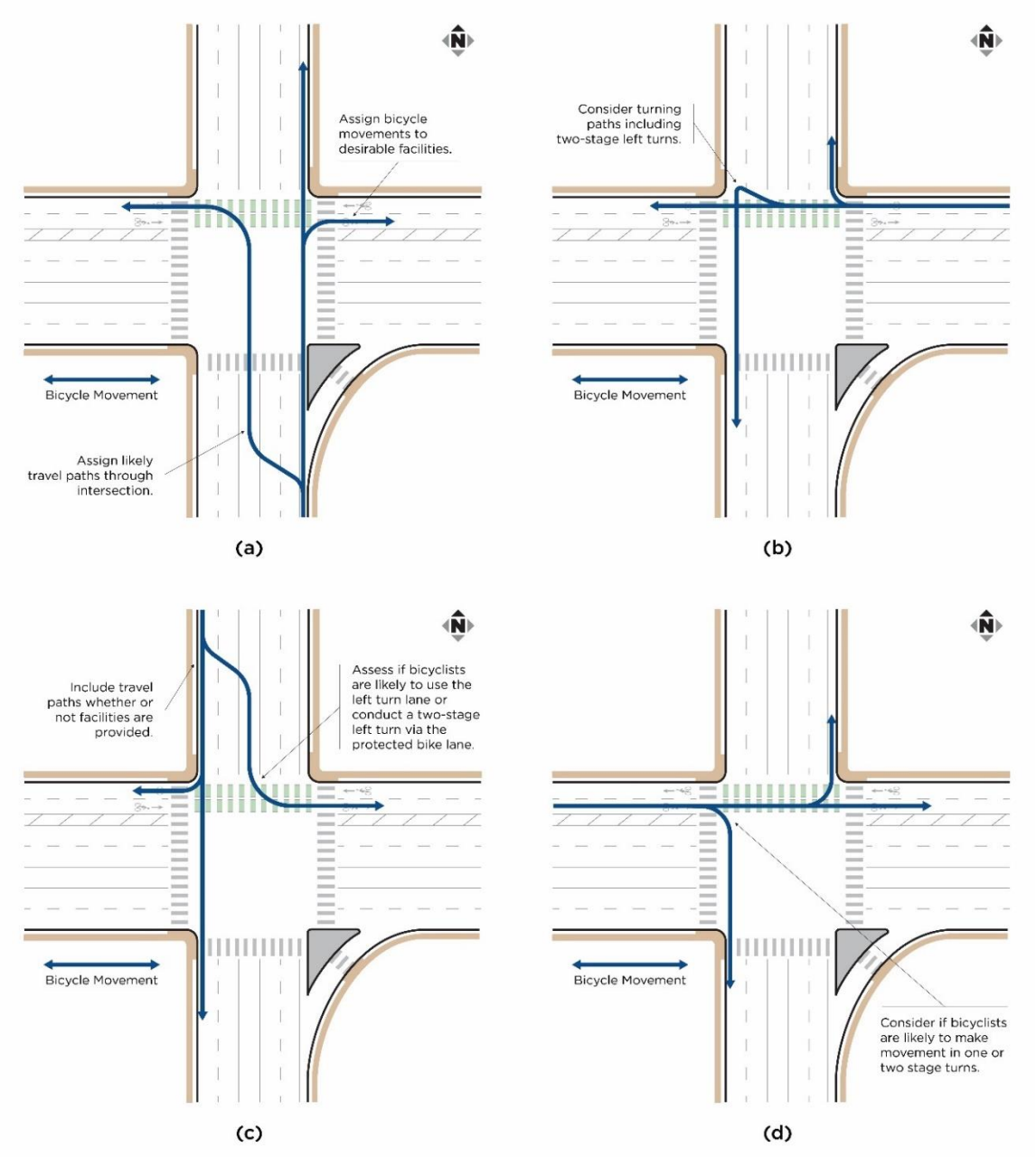


Figure 6. Bicycle Movement Assignment Example

4. ASSESS EACH FLAG ALONG EACH PATH OR MOVEMENT

Assess each flag for each pedestrian path and/or bicycle movement using the accompanying spreadsheet tool. Enter in vehicle volumes and speeds at the top of the spreadsheet then work through each flag by movement, following the entry prompts. The Flags Factsheets in Appendix B and the pedestrian paths and bicycle movements drawn in Step 3 will be useful references.

When checking for flags, it is recommended to investigate one flag at a time for each of the defined movements or paths. The assessment generally follows two steps:

1. Where is a flag applicable along the path or movement?
2. What is the severity of the flag in the locations identified?

Each flag for each path/movement will have four possible results:

- No Flag: the flag is applicable and was evaluated, but did not meet the yellow or red flag thresholds
- Yellow Flag: the flag is applicable and was evaluated and meets yellow flag threshold but not the red flag threshold
- Red Flag the flag is applicable and was evaluated and meets the red flag threshold
- Not Applicable (N/A): the flag cannot be applied due to factors including specific flag guidance for the study configuration, no applicable path/movement (e.g., a three-legged intersection), and bicycle flags when bicycles have been deemed to use a multiuse path.

In assessing each movement, it is possible that a flag applies multiple times. For example, a pedestrian crossing path may encounter multiple yield-controlled vehicular movements. In this case, each location is evaluated and the most severe flag applied to the overall movement. If mitigating the more severe location, the flag may still apply due to other occurrences along the movement.

Example: Flag A Assessment

Applying Flag A: Undefined Crossing at Intersections to the signalized intersection shown in Figures 5 and 6 yields the following results:

		Pedestrian Assessment				Bicycle Assessment											
Flag	Flag	West	East	North	South	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
A	Undefined Crossing at Intersections	No Flag	No Flag	Yellow	No Flag	N/A	Yellow	N/A	N/A	N/A	N/A	N/A	No Flag	N/A	N/A	No Flag	N/A

- Pedestrian Flags:
  - The West, East, and South legs have marked crosswalks and pedestrian signal heads so do not meet the yellow or red flag thresholds, so are assessed “No Flag”.
  - The North leg does not have a marked crosswalk, but is signal controlled with a pedestrian head, so meets the yellow flag threshold.
- Bicycle Flags

- Flag A does not apply to right- and left-turning bicyclists, so the turning movements are assessed "N/A"
- The Northbound through movement includes a bike lane, but no markings through the intersection, so meets the yellow flag threshold.
- The Southbound through movement does not have an on-street bicycle facility, so Flag A does not apply and Flag M: Riding in Shared Lanes would be considered instead.
- The Eastbound and Westbound through movements have bike lane markings through the intersection, so do not meet the yellow or red flags and are assessed "No Flag".

Results Interpretation

The spreadsheet tool will sum the total number of yellow and red flags for primary and secondary prioritization and report them as a percentage of total possible flags, as shown in Figure 7. These findings should be interpreted based on the prioritization and considerations specific to the intersection, as developed in Step 1.

	TOTAL			PRIMARY FLAGS			SECONDARY FLAGS		
	All	Pedestrian	Bicycle	All	Pedestrian	Bicycle	All	Pedestrian	Bicycle
Total Yellow Flags:	36	8	28	28	5	23	8	3	5
Total Red Flags:	13	4	9	1	1	0	12	3	9
Total No Flags:	160	44	116	72	14	58	88	30	58
Total N/A:	111	24	87	59	20	39	52	4	48
Total Possible:	209	56	153	160	40	120	49	16	33
Percent Yellow:	17%	14%	18%	18%	13%	19%	16%	19%	15%
Percent Red:	6%	7%	6%	1%	3%	0%	24%	19%	27%
Percent Not Flagged:	77%	79%	76%	82%	85%	81%	59%	63%	58%

Figure 7. 20 Flags Spreadsheet Tool Summary Example

In the example, the subject intersection only has one primary red flag for pedestrians, and none for the bicycle movement. There are several yellow primary flags, as well as secondary flags that are red and yellow. The specific flags should now be assessed against the project goals and the specific intersection context defined in Step 1.

Both the total number of flags and the percent should be considered, as some intersection types, such as roundabouts, preclude the applicability of some flags. However, while roundabouts have fewer possible flags that apply due to lacking signal control and left turns, Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths is likely to dominate the walking and bicycling experience at a roundabout and should be evaluated and considered closely.

For applications evaluating intersection design alternatives, such as IIE Stage II, the flag total and percentage tables are a starting point for comparing the pedestrian and bicyclist safety risk of the alternatives. An alternative with fewer primary red flags is generally preferable to one with

more flags, as an absolute number or as a percentage. However further investigation is recommended to assess the severity of which flags were triggered and the feasibility of mitigating high priority flags through the design process.

For applications assessing a chosen intersection design, possible mitigations and design tradeoffs should be considered based on established prioritization, as well as factors such as flag interactions, flag score relative to the threshold, and mitigation feasibility. Design modifications to mitigate flags and gauge flag interactions can be explored by iterating the inputs to the spreadsheet tool, as described in Step 5.

5. REVISE DESIGN TO MITIGATE FLAGS AND ITERATE

Compare results of alternatives (PDN Stage 1 Assessment) or use findings to inform the intersection design (PDN Stage 2 Assessment and beyond). Work to mitigate flags, placing greatest weight on higher priority red flags. Use the mitigations provided by the

- Flag Factsheets,
- NCHRP 948 Chapters 2, 3, and 5,
- PSG Chapter 4 and 5, and/or
- Consult with TDOT Active Transportation Office staff.

Following mitigation and design revisions, the 20 Flags method should be re-applied to evaluate if the changes addressed the flags in question. Care should be taken that no other flags were introduced in the mitigation process. The analyst should iterate this process until an acceptable outcome is achieved that meets the project performance objectives under consideration of context.

Example: Flag A Mitigation

- Pedestrian Flags:
  - The North leg yellow flag can be mitigated by marking a crosswalk across the leg with an accompanying pedestrian signal head.
- Bicycle Flags
  - The Northbound through yellow flag can be mitigated by striping white dash lines through the intersection. This treatment can be enhanced by green paint and/or bicycle symbols with chevrons.
  - The Southbound through movement did not meet the criteria for Flag A, but providing a designated bicycle lane with intersection markings would avoid flags for both Flag A and Flag M.
  - Though not specifically identified through the Flag A assessment, the bicycle movement exercise illustrated in Figure 6 indicates that the Southbound, Northbound, and Westbound left turns and the Eastbound

right turn movements may benefit from a two-stage turn box to allow bicyclists to wait out of the traveled way to use the crossing signal phase to make a turning movement across vehicle travel lanes.

The mitigated intersection shown in Figure 8 results in no yellow or red flags from the Flag A criteria.

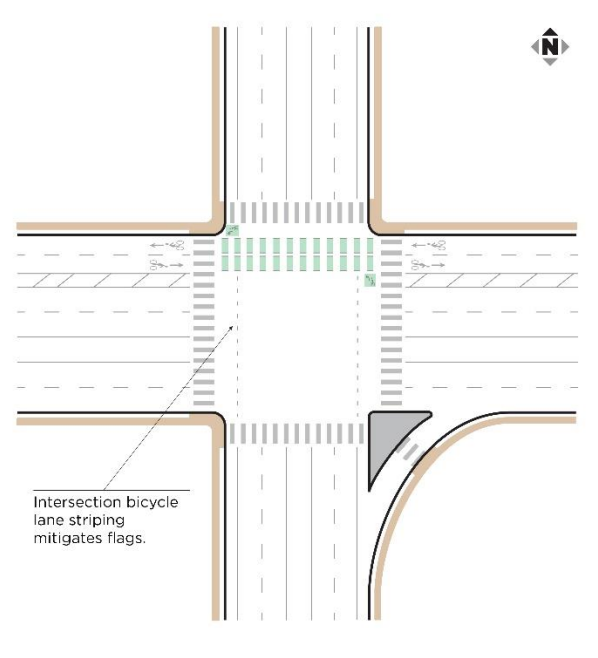


Figure 8. Flag A Mitigations

		Pedestrian Assessment				Bicycle Assessment											
Flag	Flag	West	East	North	South	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
A	Undefined Crossing at Intersections	No Flag	No Flag	No Flag	No Flag	N/A	No Flag	N/A	N/A	No Flag	N/A	N/A	No Flag	N/A	N/A	No Flag	N/A

How To Use This Guidebook

The Flag Factsheets in Appendix B provide guidance for each of the 20 individual flags. These Flag Factsheets include the flag name, description, priority, graphic depicting the flag, yellow and red flag thresholds, a mitigations toolbox, flag evaluation references, and considerations when evaluating the flag. An example Flag Factsheet with callouts is shown below.

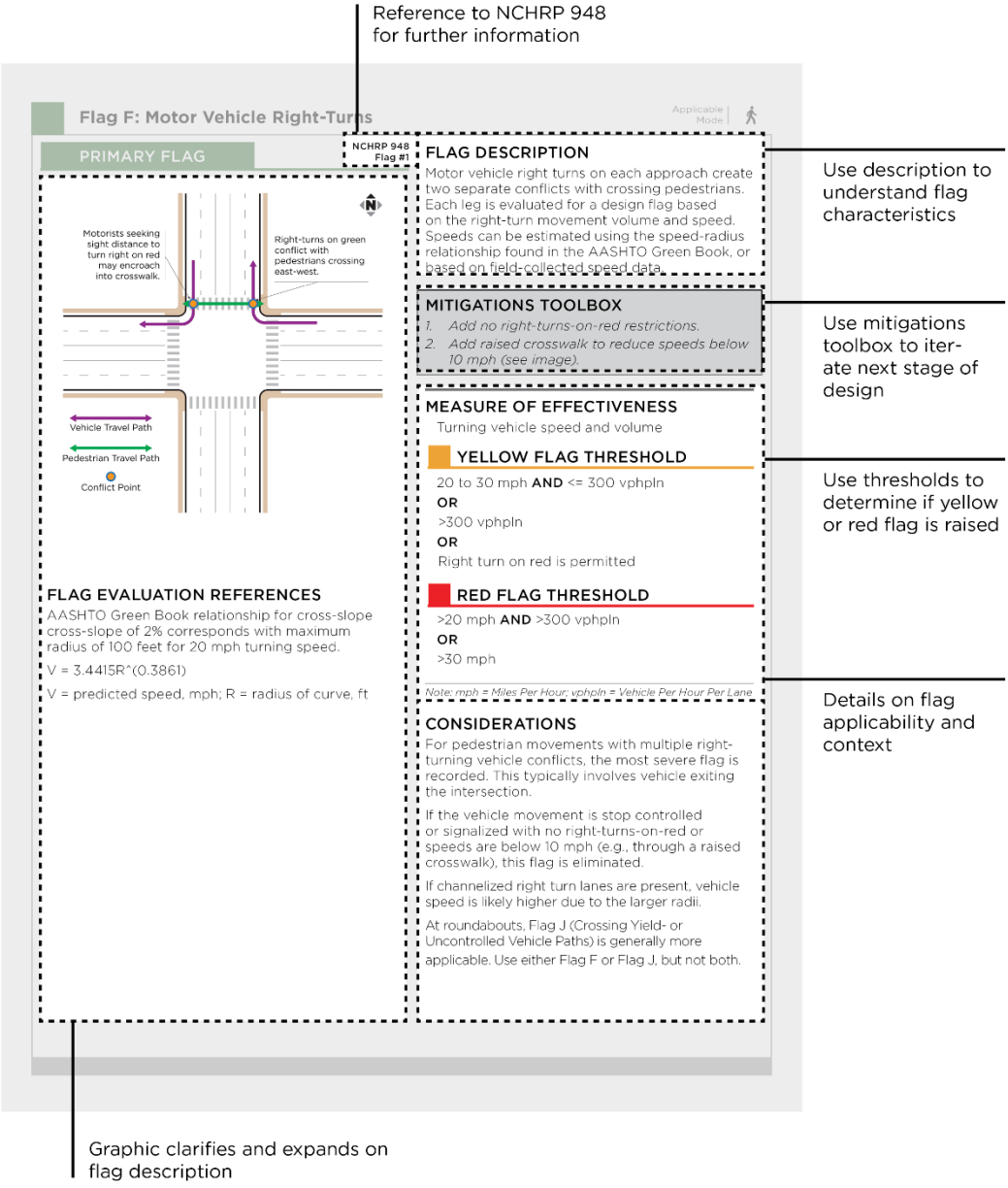


Figure 9. Flag Factsheet Example

This manual is accompanied by an Excel-based spreadsheet tool to calculate flags, document data inputs and flag findings, and summarize flags by priority and color across alternatives. The worksheets include a line-by-line accounting of applicable flags for each design flag by pedestrian and/or bicycle movement for each alternative. The worksheets also include boxes at the bottom to add the yellow and red flags to calculate the percent of yellow flags, red flags, and all flags.

NCHRP Research Report 948 remains a useful resource for further guidance on each flag, as well as their application to alternative intersections. As noted, several refinements were made to the NCHRP 948 methodology for this manual to reflect training and application experience and to improve the methodology's applicability to conventional intersections. These modifications are documented in Appendix A. When there is a conflict, the guidance in this document supersedes NCHRP 948.

Detailed Use Case Guidance

This section provides additional design considerations and details on how certain flags interact with various intersection elements and traffic control devices. The section is intended to serve as a guide to project teams to assess designs and help anticipate some of the frequently asked questions and considerations for specific designs. Detailed use case guidance is provided for the following intersection forms or design elements:

- Right Turn Lanes
- Channelized Right Turns
- Roundabouts
- Signalized Intersections
- All-Way Stop Controlled Intersections
- Two-Way Stop Controlled Intersections
- Skewed Intersections
- Multi-Use Path Crossings
- Three-Legged and One-Way Intersections
- Interchanges

For some projects, multiple guidance cases may be applicable; for instance, application to channelized right turn lanes at an interchange has relevant discussion in sections on channelized right turns, as well as interchanges.

This guidance supplements the information provided under "Considerations" on each Flag Factsheet. Note that all flags should be considered for all analyses until determined to be not applicable. Some flags listed as less common may still be relevant to specific or unusual configurations. Flags not explicitly listed in the sections below, such as Flag I: Intersecting Driveways and Side Streets, remain important to all intersection configurations.

RIGHT TURN LANES

Modal Conflicts

Right-turning vehicles conflict with bicyclists in on-street bike facilities at intersections or at the start of exclusive right turn lanes where vehicles turn across bicycle lanes. Careful treatment of this conflict is essential for bicyclists to cross the intersection safely and comfortably.

For pedestrians, right-turning vehicles often conflict with crossings of the intersection, especially when vehicle movements are otherwise not controlled (e.g. right turns on green or major street turns at two-way stop-controlled intersections). Right turn lanes may clarify this conflict by separating right-turning vehicles from through vehicles, but may be paired with channelized turn lanes or other features that may increase turning speeds or otherwise increase conflict risk.

Pedestrian and Bicyclist Routing

Bicyclist routing should consider conflict and weave points related to right turn lanes. Pedestrians traverse the intersection in the conventional manner.

Critical Design Elements

- Curve radius and vehicle turning speed
- Presence of a channelizing island
- Configuration of exclusive of shared right turn lane with regard to crossing, weaving, or merging with bicyclists
- Traffic control for right-turning vehicles

Emphasis Flags

The following flags are more common or more severe with right turn lanes:

- Flag F: Motor Vehicle Right Turns
- Flag H: Turning Motor Vehicles Crossing Bike Path
- Flag L: Channelized Lanes
- Flag N: Riding Between Lanes
    - Do not apply Flag N when using Flag H to avoid double counting

Less Common Flags

Most other flags apply to different types of intersection elements and therefore do not typically apply to right turn lanes.

Common Mitigations

- Mitigate vehicle turning speeds

- Clearly designate weaving, crossing, and merging points between bicycle lane and right-turning vehicle path.
- Restrict right turning vehicle movements
- Implement exclusive bicycle signal phase

Additional guidance for safely designing for bicyclists at right turns is available in the National Association of City Transportation Officials (NACTO) *Urban Bikeway Design Guide*.

CHANNELIZED RIGHT TURNS

Modal Conflicts

Channelized right turns can shorten pedestrian crossings, separate conflicts, and distinguish vehicle paths. However, channelized turn lanes, especially when paired with add lanes, can lead to higher vehicle speeds and more complex crosswalk interactions. For right-turning bicyclists, channelized right turns create conflicts with right-turning vehicles, especially for long channelized lanes and those designed for higher vehicle speeds.

Pedestrian and Bicyclist Routing

Complete pedestrian paths through the channelized island to the outside curb. Right-turning bicyclists are routed through the channelized lane, unless a multi-use path exists at the intersection.

Critical Design Elements

- Curve radius and vehicle turning speed
- Length of channelized lane
- Travel path width
- Crosswalk location
- Traffic control measures

Emphasis Flags

The following flags are more common or more severe with channelized right turn lanes:

- Flag E: Sight Distance for Gap Acceptance Movements
- Flag F: Motor Vehicle Right Turns
- Flag H: Turning Motor Vehicles Crossing Bike Path
- Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths
- Flag L: Channelized Lanes

Less Common Flags

Most other flags apply to different intersection elements and therefore do not typically apply to channelized right turns.

Common Mitigations

- Mitigate vehicle turning speeds
- Install signal or raised crosswalk to control channelized movement
- Locate crosswalks to separate the crossing conflict point from the vehicle merging conflict point and enhance visibility

ROUNDABOUTS

Modal Conflicts

Roundabouts contain unique interactions between bicyclists, pedestrians, and vehicles. Crosswalk typically placed one car-length from the entry and exit points to separate decision points for drivers (first interact with crosswalk, then screen for gaps to enter circle). Crosswalk users typically cross one direction of vehicles at a time.

Pedestrian and Bicyclist Routing

Bicyclists can often traverse the roundabout as a vehicle or via the circulating pathway and crosswalks. Assess which route is more likely due to local conditions. If both are likely to be used, conduct the 20 Flags assessment on both routing options. Pedestrians traverse the roundabouts on the provided sidewalks and crossings.

Critical Design Elements

- Entry, circulating, and exit speeds
- Number of lanes at crosswalk locations
- Crosswalk locations and traffic control measures
- Sight distance of approaching traffic, especially at exit lanes

Emphasis Flags

The following flags are more common or more severe in roundabouts than other intersection types:

- Flag B: Multilane Crossing
- Flag E: Sight Distance for Gap Acceptance Movements
- Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths
- Flag M: Riding in Shared Lanes
- Flag N: Riding Between Lanes
- Flag P: Indirect Paths

Less Common Flags

The following flags do not typically apply to roundabouts due to crosswalk configuration, lack of signalization, left turn prohibitions, and other common design elements:

- Flag C: Long Red Times
- Flag D: Bicycle Clearance Times
- Flag F: Motor Vehicle Right Turns
- Flag G: Motor Vehicle Left Turns
- Flag H: Turning Motor Vehicles Crossing Bike Path
- Flag R: Nonintuitive Motor Vehicle Movements
- Flag S: Executing Unusual Movements

Common Mitigations

- Reduce circulating, entry, and/or exit speeds
- Provide path crossings on all legs
- Assess crossing traffic control needs (*NCHRP Research Report 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities: A Guidebook* and *NCHRP Research Report 1043, Guide for Roundabouts in Section A.6*).

More information on the 20 Flags method at roundabouts is available in *NCHRP Research Report 1043, Guide for Roundabouts* in Sections 9.8.1 and A.5.

SIGNALIZED INTERSECTIONS

Modal Conflicts

Signalized intersection control may include permissive left turns and/or channelized yield-controlled or uncontrolled right turn maneuvers that introduce conflict between crossing pedestrians and turning vehicles not controlled by the signal. Right turn on red creates conflict with pedestrians crossing in front of turning vehicles, particularly from the right as drivers look left to assess gaps. Bicyclists in the travel lanes may experience challenges due to signal clearance time or risk exposure due to long crossing times and distances.

Pedestrian and Bicyclist Routing

Pedestrians and bicyclists traverse the intersection in the conventional manner.

Critical Design Elements

- Signal clearance time
- Right turn traffic control
- Left turn signal phasing

- Number of lanes
- Curb radii affecting vehicle turning speed
- Channelized right turns (see separate discussion above)

Emphasis Flags

The following flags are of a particular focus at signalized intersections, especially involving major street vehicles:

- Flag B: Multilane Crossings
- Flag C: Long Red Times
- Flag D: Bicycle Clearance Times
- Flag F: Motor Vehicle Right Turns
- Flag G: Motor Vehicle Left Turns

See discussion above for additional emphasis flags for right turn or channelized lane presence as applicable.

Less Common Flags

The following flags do not typically apply to signalized intersections due to lack of the commonality of the configuration:

- Flag R: Nonintuitive Motor Vehicle Movements
- Flag S: Executing Unusual Movements

Common Mitigations

- Provide bicycle clearance time
- Implement protected-only left turns
- Reduce vehicle turning speed
- Prohibit right turn on red

See discussion above for additional mitigation strategies for right turn or channelized lane presence as applicable.

ALL-WAY STOP CONTROLLED INTERSECTIONS

Modal Conflicts

All-way stop-controlled intersections are generally among the most comfortable and safe for bicyclists and pedestrians to travel through due to low vehicle speeds and high crosswalk compliance.

Pedestrian and Bicyclist Routing

Pedestrians and bicyclists traverse the intersection in the conventional manner.

Critical Design Elements

- Number of lanes

Emphasis Flags

The following flags are of a particular focus at all-way stop controlled intersections:

- Flag A: Undefined Crossings at Intersections
- Flag B: Multilane Crossings

Less Common Flags

The following flags do not typically apply to all-way stop controlled intersections due to lack of signalization and stop control for all vehicles:

- Flag B: Multilane Crossings
- Flag C: Long Red Times
- Flag D: Bicycle Clearance Times
- Flag F: Motor Vehicle Right Turns
- Flag G: Motor Vehicle Left Turns
- Flag H: Turning Motor Vehicles Crossing Bike Path
- Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths
- Flag L: Bicyclist Crossing Motor Vehicle Travel Lane
- Flag R: Nonintuitive Motor Vehicle Movements
- Flag S: Executing Unusual Movements

Common Mitigations

- Reduce number of approach lanes
- Provide appropriate crossing treatments across all legs

TWO-WAY STOP CONTROLLED INTERSECTIONS

Modal Conflicts

At two-way stop controlled intersections, the evaluation focus should be on the potential difficulty for pedestrians and bicyclists to cross the uncontrolled approaches. Vehicle drivers may have less awareness that they are crossing through an intersection compared to other types of intersection control and thus not expect crossing pedestrians or bicyclists. Other potentially severe conflicts include vehicles turning on and off the major street.

Pedestrian and Bicyclist Routing

Pedestrians and bicyclists traverse the intersection in the conventional manner. Pedestrian crossing paths may need to utilize unmarked crosswalks for major street crossings.

Critical Design Elements

- Vehicle travel speed
- Crossing traffic control devices
- Number of major road lanes to cross

Emphasis Flags

The following flags are of a particular focus at two-way stop-controlled intersections, especially involving major street vehicles:

- Flag A: Undefined Crossings at Intersections
- Flag B: Multilane Crossings
- Flag E: Sight Distance for Gap Acceptance Movements
- Flag F: Motor Vehicle Right Turns
- Flag G: Motor Vehicle Left Turns

Less Common Flags

The following flags do not typically apply to two-way stop-controlled intersections due to lack of signalization:

- Flag C: Long Red Times
- Flag D: Bicycle Clearance Times
- Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths
- Flag R: Nonintuitive Motor Vehicle Movements
- Flag S: Executing Unusual Movements

Common Mitigations

- Manage main road vehicle speed
- Reduce vehicle turning speeds
- Provide appropriate crossing treatments across all legs
- Ensure appropriate sight distance
- Reduce travel lanes at crossings or provide refuges

SKEWED INTERSECTIONS

Modal Conflicts

Skewed, non-perpendicular intersections may have sight distance constraints and typically include two corners smaller than right angles and two with larger angles. These configurations can lead to inconsistent vehicle operations that may defy pedestrian and bicyclist expectations. Pedestrian crossing paths may cross travel lanes at an angle, leading to a longer crossing distance and a larger intersection area than the number of lanes may imply. Channelized turn islands and/or slip lanes are common.

Pedestrian and Bicyclist Routing

Pedestrians and bicyclists traverse the intersection in the conventional manner per the intersection traffic control.

Critical Design Elements

- Free and yield-controlled vehicle turns with channelized islands
- Crosswalk distance when at angles other than perpendicular
- Sight distance and drivers looking back at steep angles
- Vehicle turning speed, especially for corners with angles greater than 90 degrees

Emphasis Flags

The following flags are more common or more severe at skewed intersections:

- Flag B: Multilane Crossing (with consideration of crossing width in feet, not number of lanes)
- Flag C: Long Red Times
- Flag D: Bicycle Clearance Times
- Flag E: Sight Distance for Gap Acceptance Movements
- Flag F: Motor Vehicle Right Turns
- Flag G: Motor Vehicle Left Turns
- Flag H: Turning Motor Vehicles Crossing Bike Path
- Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths

- Flag P: Indirect Paths
- Flag T: Off-Tracking in Turns and Curves

Less Common Flags

Intersection skew does not generally preclude flags from being applicable.

Common Mitigations

- Reduce intersection skew angle
- Reconstruct skewed intersection as two separate intersections
- Reduce vehicle turning speeds
- Install signal or raised crosswalk to control free- and yield-controlled movements
- Make crossings direct, short, and with appropriate traffic control devices. Balance shortening crossing by making them more perpendicular with out of direction travel, pedestrian compliance, and driver expectation.

MULTI-USE PATH CROSSINGS

Modal Conflicts

Multi-use paths crossings may have higher crossing volumes than typical sidewalks. These paths are more likely to carry large numbers of bicyclists, e-bike and motorized scooter riders, etc. These wheeled conveyances are likely to lead to higher speed conflicts at roadway crossings. Paths on one side of the road or one leg of the intersection may lead to contraflow travel (e.g., southbound cyclists on the east side of a north/south street) that may defy expectations and lead to conflicts with turning vehicles.

Pedestrian and Bicyclist Routing

Pedestrians traverse the intersection in the conventional manner.

Bicyclists traveling through an intersection solely on multi-use paths should be assessed via the pedestrian flags, but considering that bicyclists travel faster and take more time to stop than pedestrians.

Bicyclists accessing or departing a path via the roadway should be considered bicyclists. Bicyclists may take unconventional routes to access a multi-use path, particularly for contraflow travel and/or when paths are not present on all intersection legs.

While many bicyclists may choose to ride on the multi-use path, some experienced and capable cyclists may prefer to travel in the roadway. Therefore, the bicycle flags could be considered for both path and roadway users.

Critical Design Elements

- Multi-use path width to accommodate a variety of users
- Clear right-of-way indication and crossing signage and markings
- Comfortable routes to access the multi-use path from all directions
- Appropriate traffic control treatments

Emphasis Flags

The following flags are more common or more severe with multi-use paths:

- Flag E: Sight Distance for Gap Acceptance Movements
- Flag I: Intersecting Driveways and Side Streets (note two-way bicycle flag threshold)
- Flag K: Lane Change Across Motor Vehicle Travel Lanes
- Flag O: Uncomfortable/Tight Walking Environment
- Flap P: Indirect Paths

Less Common Flags

Multi-use paths do not generally preclude flags from being applicable.

Common Mitigations

- Install beacon and/or raised crosswalk to improve yielding compliance
- Make crossings direct, short, and with appropriate traffic control devices
- Provide wayfinding for unconventional crossing routing

THREE-LEGGED AND ONE-WAY INTERSECTIONS

Modal Conflicts

Three legged intersections remove pedestrian crossings and bicycle approaches and movements, reducing the number of total flags possible. Pedestrians crossing the through street on the left side of the terminated street at a three-legged intersection may conflict with heavy left turn volumes, potentially requiring an exclusive pedestrian phase (in the absence of a side-street through phase). Specific configurations may have further challenges, such as the Continuous Green T intersection, which have some vehicle movements that are not controlled by a signal or stop sign.

One-way intersections similarly eliminate possible movements and conflicts for bicyclists, without additional dedicated bicycle infrastructure. One-way roadways can have shorter crosswalks and simpler crossing conflicts than two-way streets. Configurations of one-way roadways can lead to unconventional situations, such as where vehicles are approaching from the opposite direction than expected by the pedestrian (i.e. from their right, not their left).

Pedestrian and Bicyclist Routing

Pedestrian paths should be made for each adjacent crossing. Some flags, such as Flag I: Intersecting Driveways and Side Streets can apply even if the paths don't cross an intersection leg.

All bicyclist movements with feasible/legal routing should be considered. Special consideration should be taken for facilities such as two-way separated bicycle lanes and sidewalks that allow for contraflow bicycle travel.

Critical Design Elements

- Crosswalk distance
- Vehicle turning speed

Emphasis Flags

The following flag is more common or more severe with three-legged or one-way intersections:

- Flag R: Nonintuitive Motor Vehicle Movement

Less Common Flags

Three legged or one-way intersections do not generally preclude flags from being applicable.

Common Mitigations

- Reduce vehicle turning and through speeds
- Make crossings direct, short, and with appropriate traffic control devices

INTERCHANGES

Modal Conflicts

Interchanges typically include large turning vehicle demand, heavy truck volumes, and bridge structures that constrain both sight distance and pedestrian and bicycle paths. Free-flowing ramps can present a challenge to crossing pedestrians. Interchanges also often include varied and atypical configurations such as frontage roads, loop ramps, and indirect pedestrian paths that increase travel time. Heavy turning volumes pose a challenge for bicyclists crossing the interchange on the surface street.

Pedestrian and Bicyclist Routing

Assign routes through the interchange where pedestrian and bicyclist travel is permitted. Bicycle movements need not be assessed for freeway ramps unless joined by a frontage road or other

roadway where bicycles are allowed. Pedestrian paths across the surface street should be assessed, particularly if no other crossings of the surface street are closely located.

Critical Design Elements

- Interchange configuration
- Free and yield-controlled vehicle turns
- Pedestrian and bicycle wayfinding
- Sight distance with grade and structure obstacles
- Vehicle turning speed

Emphasis Flags

The following flags are more common or more severe at intersections:

- Flag A: Undefined Crossings at Intersections
- Flag C: Long Red Times
- Flag E: Sight Distance for Gap Acceptance Movements
- Flag F: Motor Vehicle Right Turns
- Flag G: Motor Vehicle Left Turns
- Flag H: Turning Motor Vehicles Crossing Bike Path
- Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths
- Flag L: Channelized Lanes
- Flag N: Riding Between Lanes
- Flag O: Uncomfortable/Tight Walking Environment
- Flag P: Indirect Paths
- Flag Q: Grade Change
- Flag R: Nonintuitive Motor Vehicle Movements
- Flag S: Executing Unusual Movements

Less Common Flags

The following flags do not typically apply to interchanges due to lack of bicyclist turns onto or off the freeway ramps:

- Flag K: Lane Change Across Motor Vehicle Travel Lanes

Common Mitigations

- Reduce vehicle turning speeds
- Install signal or raised crosswalk to control free- and yield-controlled movements
- Make crossings direct, short, and with appropriate traffic control devices
- Provide wayfinding for unconventional crossing routing
- Provide off-street bicycle facility for travel along surface street

Appendix A: Modifications to NCHRP 948 Methodology

This appendix documents changes made in consultation with the NCHRP 948 team as a result of their experience conducting national implementation training, as well as extensive real-world project experience applying the 20 Flags methodology to conventional intersections. These modifications include:

- The yellow flag definition is no longer related to user comfort. Instead, the yellow and red flags both reflect a safety issue, with the yellow flag involving less exposure and crash severity risk than the related red flag.
- The flags were assembled into primary and secondary flags based on correlation to known crash problems and expected severity of injury in the event of a crash.
- The flags were reordered into more logical groups based on context and required data. Flags were alphabetized to reduce confusion with NCHRP 948 flag reference numbers.
    - Mainline Crossings (Flags A-E)
    - Turning Vehicles and Crossing Conflicts (Flags F-J)
    - Bicycle Maneuvers (Flags K-N)
    - Navigation and Wayfinding (Flags O-T)
- The flag thresholds for turning vehicle conflict Flags F, G, J were modified to create a distinction between the yellow and red flag categories. With the new thresholds, the red flag is triggered in fewer circumstances, and there are increased circumstances under which no flag is triggered.

Flag level modifications are shown in Table A1.

Table A3. NCHRP 948 Flag Modifications

Flag	TDOT Ref	NCHRP 948 Ref #	Primary Flag?	Change
Undefined Crossings at Intersections	A	9	Yes	Expanded threshold descriptions to differentiate conditions for pedestrians and bicycles
Multilane Crossing	B	7	Yes	Expanded threshold descriptions to differentiate conditions for pedestrians and bicycles and for crossing traffic control
Long Red Times	C	8		
Bicycle Clearance Times	D	15		
Sight Distance for Gap Acceptance Movements	E	12		
Motor Vehicle Right Turns	F	1	Yes	Revised threshold to clarify range of conditions and acknowledge impact of right turn on red; added guidance for roundabout application
Motor Vehicle Left Turns	G	10	Yes	Revised threshold to clarify range of conditions and acknowledge impact of protected left turn criteria; added guidance for roundabout application
Turning Motor Vehicles Crossing Bike Path	H	18	Yes	
Intersecting Driveways and Side Streets	I	11		
Crossing Yield-Controlled or Uncontrolled Vehicle Paths	J	4	Yes	Revised threshold; added guidance for roundabout application
Lane Change Across Motor Vehicle Travel Lanes	K	16	Yes	
Channelized Lanes	L	17	Yes	Revised threshold to clarify over range of conditions
Riding in Shared Lanes	M	14	Yes	Revised name, revised threshold to clarify over range of conditions
Riding Between Travel Lanes, Lane Additions, or Lane Merges	N	19	Yes	Revised name
Uncomfortable/Tight Walking Environment	O	2		
Indirect Paths	P	5		
Grade Change	Q	13		

Flag	TDOT Ref	NCHRP 948 Ref #	Primary Flag?	Change
Nonintuitive Motor Vehicle Movements	R	3		
Executing Unusual Movements	S	6		
Off-Tracking in Turns and Curves	T	20		Revised name, revised criteria to assess vehicle encroachment onto unprotected bicycle lanes

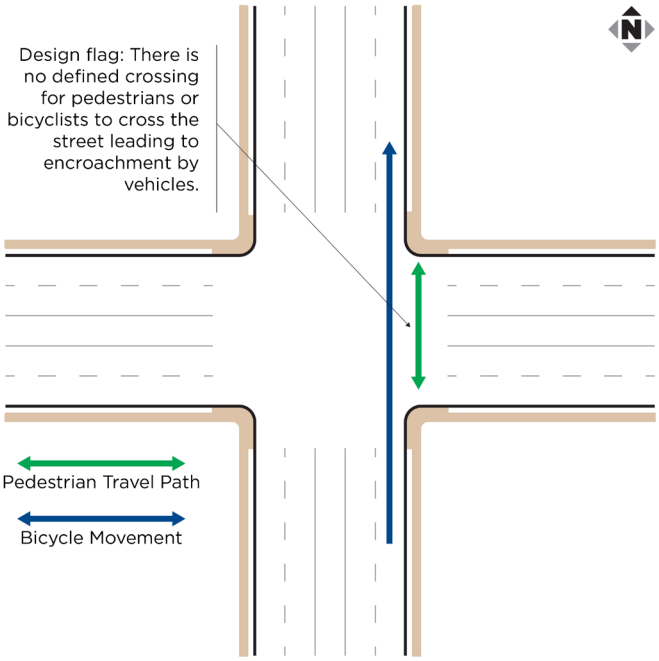
Appendix B: 20 Flags Factsheets

Flag A: Undefined Crossing at Intersections

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #9



FLAG DESCRIPTION

Unmarked crossings at an intersection can lower the level of comfort when walking or biking. Right-turning drivers are more likely to encroach on pedestrian and bicyclist paths when clear pavement demarcation is absent. Additionally, turning vehicles may not expect pedestrians of bicyclists at the downstream crossing point. This flag applies to both pedestrian and bicyclist movements.

MITIGATIONS TOOLBOX

1. *Striping biking pathways through an intersection to identify where drivers are entering the designated path of bike travel.*
2. *Installing marked crosswalks.*
3. *Continuing bicycle lanes through intersections.*
4. *Installing pedestrian signal head with actuation.*
5. *Where off-street bicycle facilities are provided, placing the bike crossing and the pedestrian crossing next to one another to reduce undefined space.*
6. *Designing two-stage left-turn queue boxes with queuing space for multiple bicyclists.*

MEASURE OF EFFECTIVENESS

Path markings and signal equipment

YELLOW FLAG THRESHOLD

Unmarked crosswalk at stop-controlled or signalized movement (pedestrian)

No bicycle lane markings through intersection (bicycle)

RED FLAG THRESHOLD

Unmarked crosswalk across movement not controlled by a stop sign, beacon or, signal

OR

Signalized movements without pedestrian signal head (pedestrians)

Bicycle lane ends at intersection (bicycle)

CONSIDERATIONS

Bicycle lane markings that are present on both sides of the intersection but do not extend through the intersection are subject to a yellow flag.

Right-turn and left-turn bicycle movements are exempt from this flag.

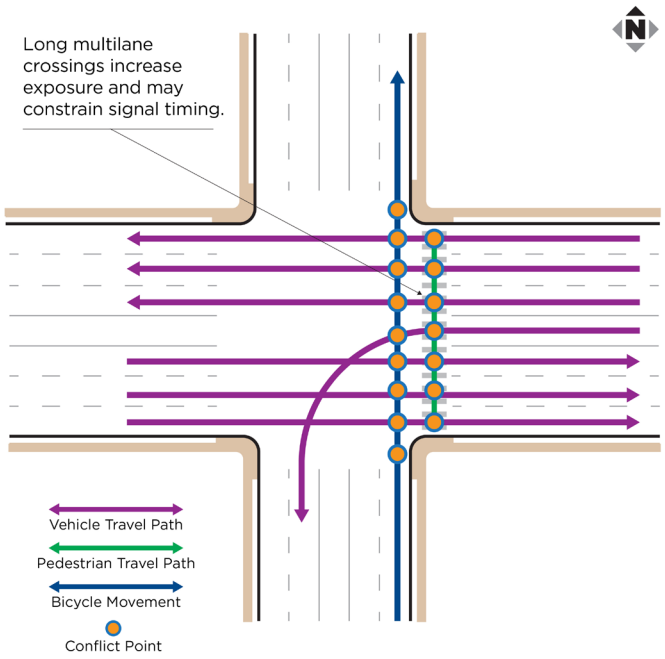
This flag applies to roadways with bicycle facilities. If no on-street bicycle facilities exist, Flag M applies instead.

Flag B: Multilane Crossing

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #7



FLAG DESCRIPTION

Long crossings, particularly with multiple lanes in both directions, are a source of stress and risk at intersections. Shorter crossings with median refuges, for crossing one direction of travel at a time, and for having raised separation between opposing directions of traffic are preferred for comfortable travel.

MITIGATIONS TOOLBOX

1. *Reducing the number of travel lanes.*
2. *Providing refuge islands and two-stage crossings to reduce the number of lanes and travel directions crossed at one time.*
3. *Providing signalized or stop-controlled crossings.*
4. *Installing raised crosswalks to reduce vehicle speed.*

MEASURE OF EFFECTIVENESS

Number of lanes crossed without refuge

		Crossing Traffic Control		
		Signalized	**Beacon**	**Unsignalized**
Pedestrian	Yellow	4 lanes	3-4 lanes	3 lanes
	Red	5+ lanes	5+ lanes	4+ lanes
Bicycle	Yellow	4-5 lanes	4-5 lanes	3-4 lanes
	Red	6+ lanes	6+ lanes	5+ lanes

CONSIDERATIONS

The number of lanes is irrespective of the direction of travel. Lane count is the maximum number of lanes of any direction, crossed between refuge areas

Bicycle lanes and parking lanes are not counted in this assessment.

This flag applies to roadways with and without bicycle facilities.

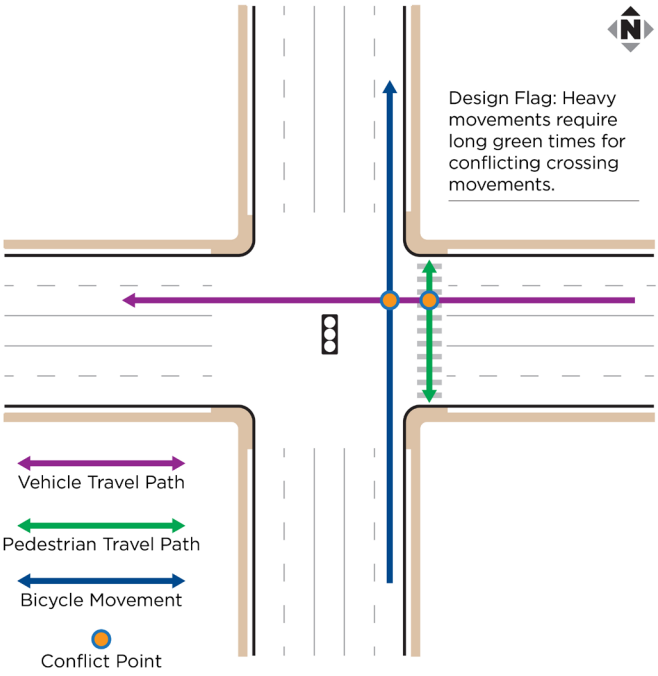
Lane counts for left-turning bicyclist includes the number of lanes crossed on the adjacent approach plus the number of lanes crossed on the opposing approach.

Flag C: Long Red Times

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #8



FLAG DESCRIPTION

Long cycle lengths and phases can lead to extended delays for pedestrians and bicyclists. Multiple stage crossings, such as at median refuge islands or left-turning bicyclists via a bike box, are particularly susceptible to long red times.

A planning level estimation of delay can be made using the equation below and reference table below can be used to estimate red time.

MITIGATIONS TOOLBOX

1. *Reducing the overall cycle length.*
2. *Modifying the phase sequence to reduce the total crossing time. This applies for priority movements in particular because improvements in travel time for one movement may result in longer crossing times for other movements.*

MEASURE OF EFFECTIVENESS

Pedestrian and bicyclist delay

YELLOW FLAG THRESHOLD

30 seconds

RED FLAG THRESHOLD

45 seconds

EQUATION FOR PLANNING LEVEL ESTIMATE OF DELAY

$$Delay = \frac{r^2}{2C}$$

Where:

r = movement time (seconds)
C = cycle length (seconds)

# Critical Phases	% Red Time of Cycle Length	
	Crossing with Major Vehicle Movement	Crossing with Minor Vehicle Movement
2	30%	70%
3	50%	75%
4	60%	85%

CONSIDERATIONS

For bicyclists, the delay is assessed for each turning movement.

Only signal delay, not extra distance traveled delay, should be included in the calculation of red time.

Total time is combined across all stages for pedestrians crossing an approach which requires multiple stages (e.g. due to a short flashing don't walk indication and a median refuge) and for bicycle movements redirected to multi-stage movements (e.g. through a bike box).

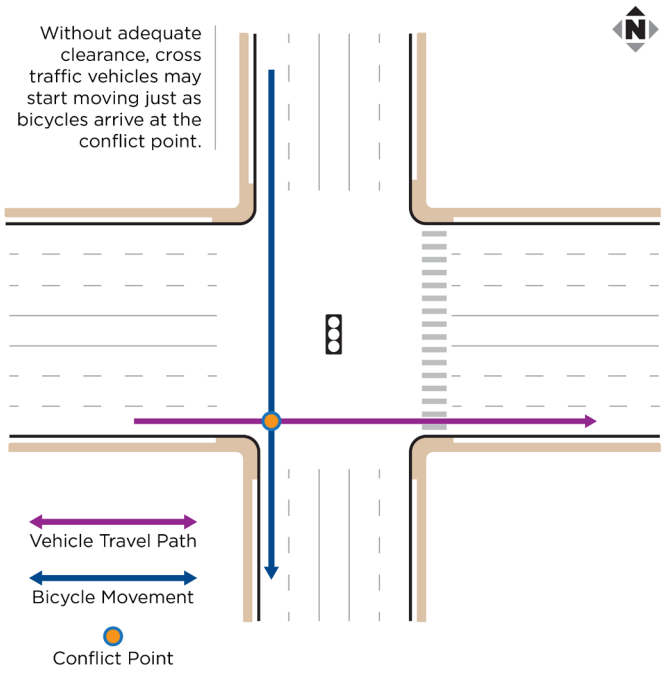
This flag applies to roadways with and without bicycle facilities.

Flag D: Bicycle Clearance Times

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #15



FLAG DESCRIPTION

The clearance times calculated for motorists are likely insufficient for bicyclists to travel through the intersection during the yellow and red indications, exposing bicyclists to conflicting vehicles entering the intersection on a subsequent green indication. This clearance time difference is greater with higher vehicle speeds and at larger intersections.

MITIGATIONS TOOLBOX

1. *Reducing the number of lanes to cross.*
2. *Reducing lane widths.*
3. *Reducing median widths.*
4. *Providing refuge for bicyclists.*
5. *Installing bicycle dilemma zone detection to extend the transition of signal phases when necessary.*
6. *Providing a separate bicycle signal with a dedicated indication of required clearance time.*

MEASURE OF EFFECTIVENESS

Vehicle speed and clearance zone length

YELLOW FLAG THRESHOLD

<35 mph and 36 - 72 feet
OR >35 mph and 24 - 60 feet

RED FLAG THRESHOLD

<35 mph and >72 feet
OR >35 mph and >60 feet

Note: mph = Miles Per Hour

CONSIDERATIONS

Clearance zone length should include the full distance from the upstream stop bar through the furthest downstream conflicting movement.

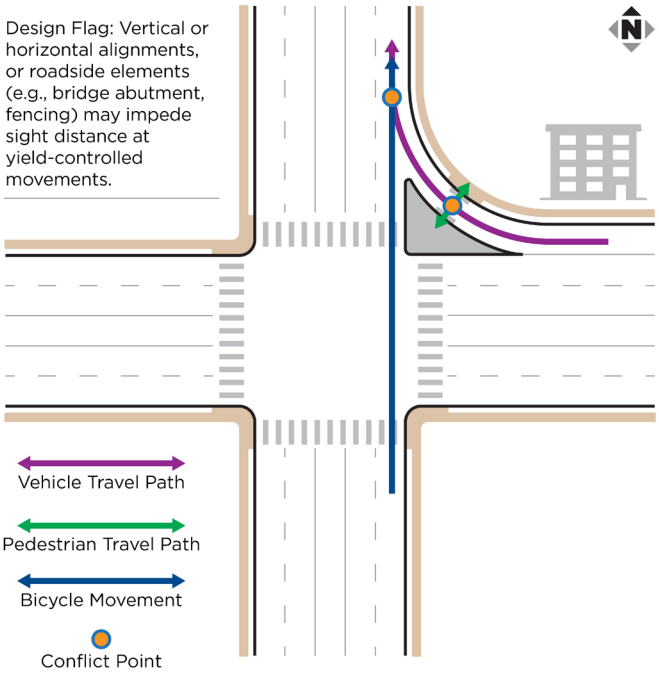
This flag applies to roadways with and without bicycle facilities.

Flag E: Sight Distance for Gap Acceptance Movements

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #12



FLAG DESCRIPTION

Sight distance must be provided in all aspects of an intersection design. Sight distance includes stopping sight distance, intersection sight distance, decision sight distance, and view angles.

MITIGATIONS TOOLBOX

1. *Designing vertical obstructions, such as bridge abutments, tall landscaping, buildings, fences, and signal cabinets to be positioned outside of necessary sight triangles.*
2. *Establishing horizontal and vertical alignments that provide the necessary sight distance.*
3. *Reducing operational speed to suit available sight distance.*

MEASURE OF EFFECTIVENESS

Sight distance

RED FLAG THRESHOLD

Less than required for vehicle speed

FLAG EVALUATION REFERENCES

Sight distance requirements by vehicle speeds can be found in the AASHTO Green Book and NCHRP Report 834 for pedestrians.

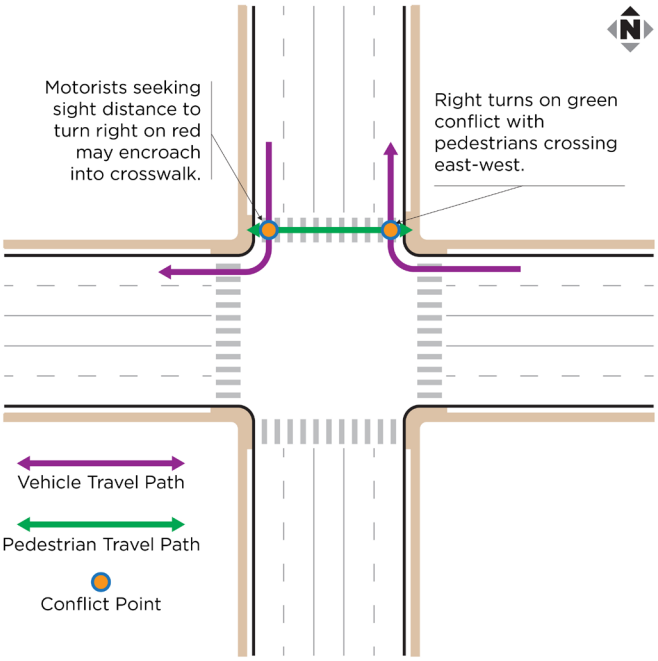
This flag applies to roadways with and without bicycle facilities.

Flag F: Motor Vehicle Right Turns

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #1



FLAG DESCRIPTION

Motor vehicle right turns on each approach create two separate conflicts with crossing pedestrians. Each leg is evaluated for a design flag based on the right-turn movement volume and speed. Speeds can be estimated using the speed-radius relationship found in the AASHTO Green Book, or based on field-collected speed data.

MITIGATIONS TOOLBOX

1. *Add no right-turns-on-red restrictions.*
2. *Add raised crosswalk to reduce speeds below 10 mph (see image).*

MEASURE OF EFFECTIVENESS

Turning vehicle speed and volume

YELLOW FLAG THRESHOLD

20 to 30 mph **AND** <= 300 vphpln

OR

>300 vphpln

OR

Right turn on red is permitted

RED FLAG THRESHOLD

>20 mph **AND** >300 vphpln

OR

>30 mph

Note: mph = Miles Per Hour; vphpln = Vehicle Per Hour Per Lane

FLAG EVALUATION REFERENCES

AASHTO Green Book relationship for cross-slope cross-slope of 2% corresponds with maximum radius of 100 feet for 20 mph turning speed.

V = 3.4415R^(0.3861)

V = predicted speed, mph; R = radius of curve, ft

CONSIDERATIONS

For pedestrian movements with multiple right-turning vehicle conflicts, the most severe flag is recorded. This typically involves vehicle exiting the intersection.

If the vehicle movement is stop controlled or signalized with no right-turns-on-red or speeds are below 10 mph (e.g., through a raised crosswalk), this flag is eliminated.

If channelized right turn lanes are present, vehicle speed is likely higher due to the larger radii.

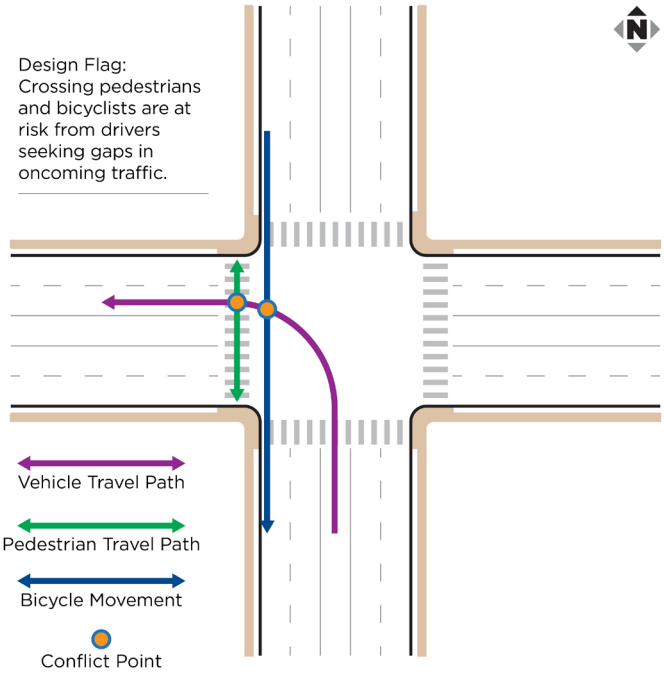
At roundabouts, Flag J (Crossing Yield- or Uncontrolled Vehicle Paths) is generally more applicable. Use either Flag F or Flag J, but not both.

Flag G: Motor Vehicle Left Turns

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #10



FLAG EVALUATION REFERENCES

AASHTO Green Book relationship for cross-slope of 2% corresponds with maximum radius of 100 feet for 20 mph turning speed and 275 feet for 30 mph.

V = 3.4415R^(0.3861)

V = predicted speed, mph; R = radius of curve, ft

FLAG DESCRIPTION

Both permissive and protected motor vehicle left-turns can affect the safety and comfort of pedestrians and bicyclists. Drivers making permissive left-turns are often focused on finding a gap in oncoming traffic and may not be watching for nonmotorized road users crossing the side street. Pedestrians may not realize the conflicting leading protected left-turn has been given the green indication but the walk interval has not yet started.

MITIGATIONS TOOLBOX

1. *Converting permissive left-turn movements into protected left-turn movements with a dedicated signal phase.*
2. *Implementing leading pedestrian interval.*
3. *Adding centerline hardening*

MEASURE OF EFFECTIVENESS

Turning vehicle speed and volume for permissive left turns

YELLOW FLAG THRESHOLD

PERMISSIVE LEFT TURNS

20 to 30 mph **AND** <= 300 vphpln

OR

>300 vphpln (permissive left turns)

PROTECTED LEFT TURNS

Leading left (any volume/speed)

RED FLAG THRESHOLD

PERMISSIVE LEFT TURNS

>20 mph **AND** >300 vphpln

OR

>30 mph (permissive left turns)

Note: mph = Miles Per Hour; vphpln = Vehicle Per Hour Per Lane

CONSIDERATIONS

This flag does not apply to roundabouts or to crossings with vehicle speed below 10 mph, such as at raised crosswalks.

Movements with protected-only left turn phasing can only have a yellow flag.

This flag considers movements with protected and permissive phasing as permissive.

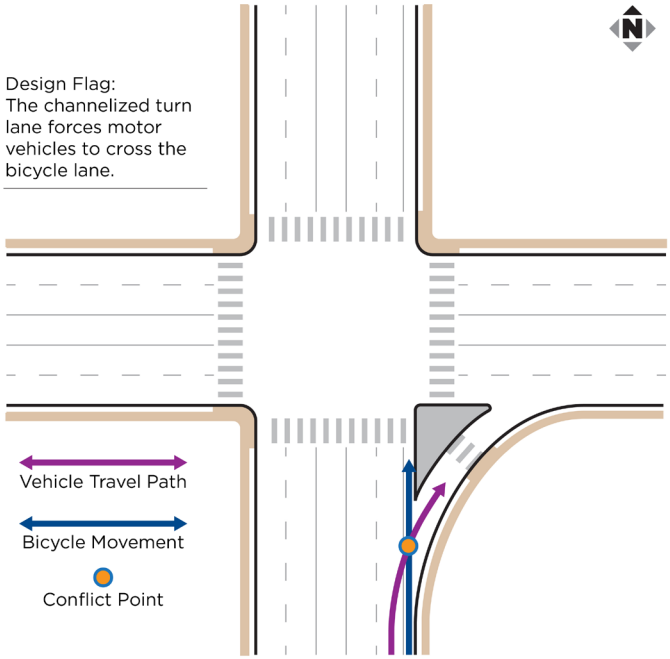
This flag applies to roadways with dedicated bicycle lanes or without exclusive bicycle facilities where bicyclists use the sidewalk or shared use path.

Flag H: Turning Motorists Crossing Bike Path

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #18



FLAG DESCRIPTION

Motor vehicle lane changes across bicyclists' paths is fraught with complex conflicting maneuvers conducted at speed. This movement is subject to bicyclists being in a driver's blind spot and "right hook" crashes across the bicycle lane. Exclusive turn lanes provide more space to navigate this crossing conflict than shared through/right turn lanes.

MITIGATIONS TOOLBOX

1. *Providing design treatments for vehicle storage between the pedestrian crossing and vehicle merge.*
2. *Installing a signal to control the channelized movement.*
3. *Designing channelization to manage vehicular speeds through the use of compound curves.*
4. *Implementing raised crossings at the location within the channelized turn where motorists speeds are lowest.*
5. *Removing channelization.*

MEASURE OF EFFECTIVENESS

Motor vehicle lane configuration

YELLOW FLAG THRESHOLD

Exclusive turn lane

RED FLAG THRESHOLD

Shared through & turn lane

CONSIDERATIONS

This flag should not be double counted with Flag N.

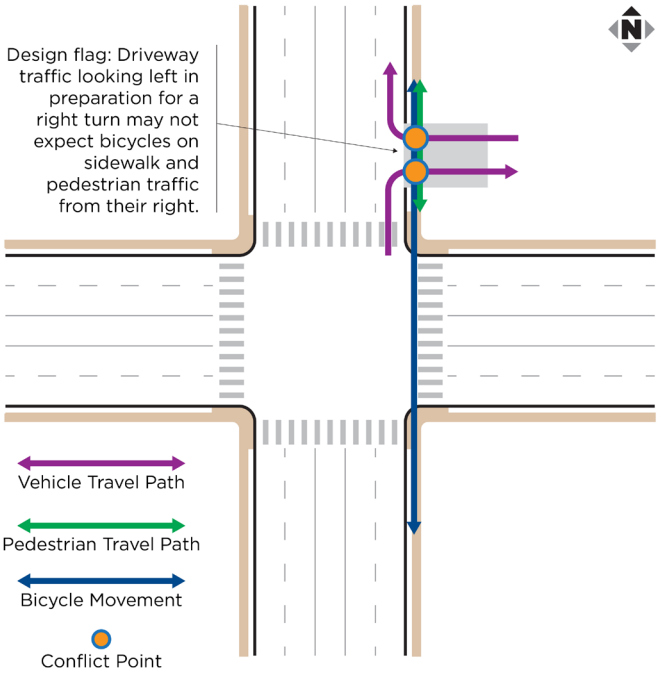
This flag is applicable at both channelized and non-channelized locations.

Flag I: Intersecting Driveways and Side Streets

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #11



FLAG DESCRIPTION

Conflicting movements at driveways and side streets can result in an increased cognitive load and distractions for all users. Turning drivers may be more focused on seeking gaps in multiple traffic streams than monitoring crossing users in the immediate vicinity.

MITIGATIONS TOOLBOX

1. *Reducing the number of driveways through access management.*
2. *Controlling vehicle speeds at driveways through curvature, tight curb radii, or vertical elements.*
3. *Providing signalized or stop-controlled crossings at driveways.*
4. *Daylighting driveways adjacent to on-street bike lanes*

MEASURE OF EFFECTIVENESS

Number of access points in area of influence

YELLOW FLAG THRESHOLD

1 - 2 (pedestrians)
1 - 2 (one-way bIcycles)

RED FLAG THRESHOLD

>2 (pedestrians)
>2 (one-way bicycles)
>0 (two-way bicycles)

CONSIDERATIONS

An intersection's influence area is 250 feet in all directions from the center of the intersection

Given the increased concern of vehicle/bicycle conflicts on two-way bicycle facilities, any access points within the area of influence should be classified as a red flag.

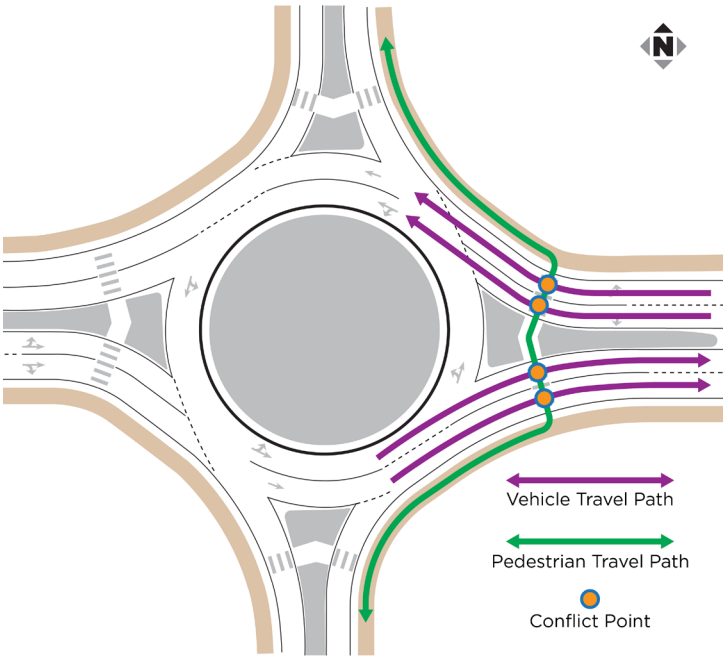
This flag applies to roadways with and without bicycle facilities.

Flag J: Crossing Yield-Controlled or Uncontrolled Vehicle Paths

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #4



FLAG DESCRIPTION

Yield-controlled and uncontrolled crossings lead to uncomfortable and potentially unsafe conflicts between bicyclists, pedestrians, and vehicles. Even if a crosswalk is marked, drivers may not perceive pedestrians and may fail to yield to them. This flag applies to both pedestrian and bicycle paths. Speeds can be estimated using the speed-radius relationship found in the AASHTO Green Book, or based on field-collected speed data.

MITIGATIONS TOOLBOX

1. *Providing signalized crossing.*
2. *Providing stop-controlled crossing.*
3. *Reducing vehicle speed through curvatures.*
4. *Installing raised crosswalks to reduce vehicle speed.*

MEASURE OF EFFECTIVENESS

Turning vehicle speed and volume

YELLOW FLAG THRESHOLD

20 to 30 mph **AND** <= 300 vphpln

OR

>300 vphpln

RED FLAG THRESHOLD

>20 mph **AND** >300 vphpln

OR

>30 mph

Note: mph = Miles Per Hour; vphpln = Vehicle Per Hour Per Lane

CONSIDERATIONS

For pedestrian and bicycle movements crossing multiple vehicle flows, the most severe flag is recorded.

Flag J can be used at roundabouts and is preferred over Flag F.

This flag applies to roadways with dedicated bicycle lanes or without exclusive bicycle facilities where bicyclists use the sidewalk or shared use path.

FLAG EVALUATION REFERENCES

AASHTO Green Book relationship for cross-slope of 2% corresponds with maximum radius of 100 feet for 20 mph turning speed.

V = 3.4415R^(0.3861)

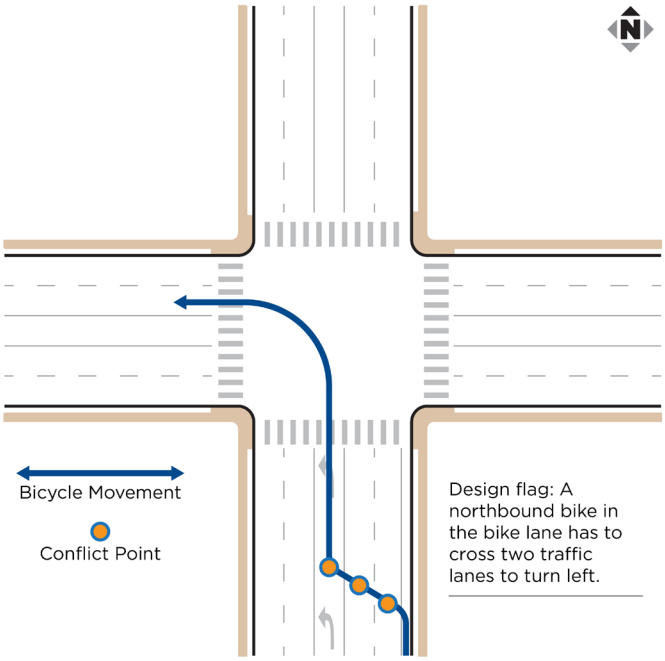
V = predicted speed, mph; R = radius of curve, ft

Flag K: Lane Change Across Motor Vehicle Travel Lanes

Applicable Mode

PRIMARY FLAG

NCHRP 948 Flag #16



FLAG DESCRIPTION

Bicycle movements that require lane changes or weaving over motor vehicle travel lanes are both a safety and comfort concern. Bicyclists have to look over their shoulders to assess available gaps for lane changes while maintaining their trajectory approaching the intersection.

MITIGATIONS TOOLBOX

1. *Designing for bicyclists to use ramps to sidewalks or shared-use paths and cross in a crosswalk.*
2. *Designing for bicyclists to use a two-stage bicycle left-turn queue box.*
3. *Clearly marking the entry to the crossover area.*
4. *Design for motorist speeds below 20 MPH through a crossover area by reducing radii or implementing speed-reducing treatments.*

MEASURE OF EFFECTIVENESS

Vehicle speed and vehicle volume

YELLOW FLAG THRESHOLD

25 - 35 mph

OR

3,000 - 7,000 vpd

RED FLAG THRESHOLD

>35 mph

OR

>7,000 vpd

Note: mph = Miles Per Hour; vpd = Vehicles Per Day

CONSIDERATIONS

This flag should not be confused with those where motor vehicles cross bicycle lanes, such as Flag H.

In absence of operating speed data, design speed and engineering judgement can be used.

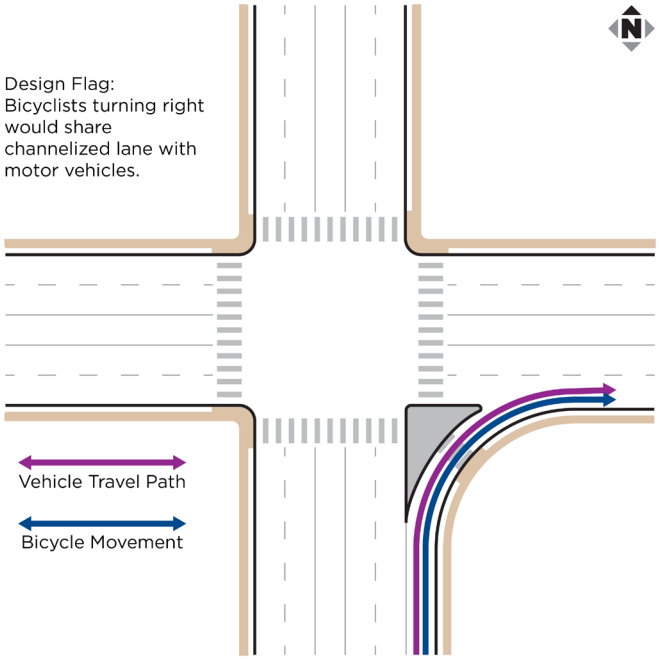
This flag applies to roadways with and without bicycle facilities.

Flag L: Channelized Lanes

Applicable Mode

PRIMARY FLAG

NCHRP 948 Flag #17



FLAG DESCRIPTION

For bicyclists, sharing a channelized lane with motorized traffic is both a safety and comfort concern. This flag applies to single-lane channelized lanes (narrow shared space between curbs) and multilane facilities.

MITIGATIONS TOOLBOX

1. *Designing for bicyclists to use ramps to sidewalks or shared-use paths and cross in a crosswalk.*
2. *Clearly marking the entry to the crossover area.*
3. *Design for motorist speeds below 20 MPH through a crossover area by reducing radii or implementing speed-reducing treatments.*

MEASURE OF EFFECTIVENESS

Vehicle speed and channelization length

YELLOW FLAG THRESHOLD

25 - 35 mph **AND** <= 50 feet

RED FLAG THRESHOLD

>35 mph

OR

>50 feet

Note: mph = Miles Per Hour

FLAG EVALUATION REFERENCES

AASHTO Green Book relationship for cross-slope cross-slope of 2% corresponds with maximum radius of 100 feet for 20 mph turning speed.

V = 3.4415R^(0.3861)

V = predicted speed, mph; R = radius of curve, ft

CONSIDERATIONS

Channelization length is defined a length of curbs on both side.

For multilane facilities, Flag N could be applied. It should not be double-counted.

Does not apply to location where bicycle lane is between two lanes in a multilane channelized area or when channelization is provided by striping only.

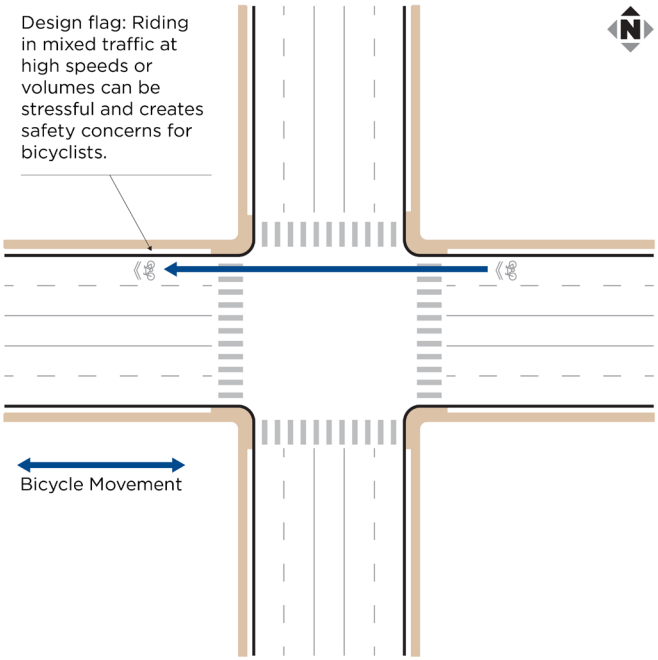
This flag applies to roadways with and without bicycle facilities.

Flag M: Riding in Shared Lanes

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #14



FLAG DESCRIPTION

Bicyclists sharing a lane with heavy volumes of higher speed vehicles can create a high level of stress for bicyclists and an increased likelihood of severe injury or death if a bicyclist-motorist collision occurs.

MITIGATIONS TOOLBOX

1. *Separating bicyclists from motor vehicles through dedicated protected lanes.*
2. *Designing for lower motor vehicle speeds where bicyclists and motorists interact.*

MEASURE OF EFFECTIVENESS

Vehicle speed and vehicle volume

YELLOW FLAG THRESHOLD

25 - 35 mph **AND** 3,000 - 7,000 vpd

RED FLAG THRESHOLD

>35 mph

OR

> 7,000 vpd

Note: mph = Miles Per Hour; vpd = Vehicles Per Day

CONSIDERATIONS

In absence of operating speed data, design speed and engineering judgement can be used.

Buffered bicycle lanes are exempt from the yellow flag but subject to the red flag.

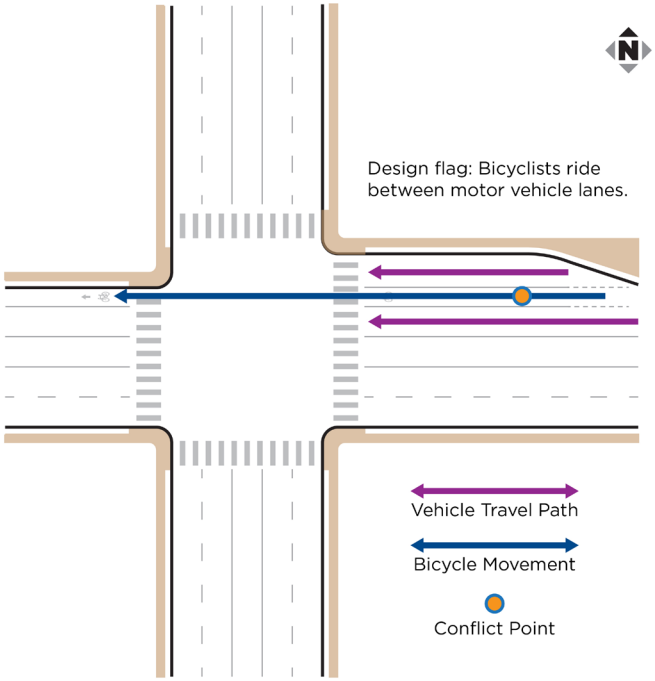
Separated and off-street bicycle facilities are exempt from both the yellow and red flags.

Flag N: Riding Between Travel Lanes, Lane Additions, or Lane Merges

Applicable Mode

PRIMARY FLAG

NCHRP 948
Flag #19



FLAG DESCRIPTION

Bicyclists are often intended to travel between vehicle travel lanes, with traffic on both sides of the bicyclists. Two common occurrences that warrant this flag are 1) upstream of intersections, with a bicycle lane between the vehicle right-turn-lane and through lane(s) and 2) downstream of intersections, with a bike lane between a vehicle merge or acceleration lane and through lane(s).

MITIGATIONS TOOLBOX

1. *Replacing merge areas with stop-or yield-controlled movements.*
2. *Constructing separate protected bicycle lanes or shared use paths.*
3. *Reducing vehicle speeds in conflict areas.*

MEASURE OF EFFECTIVENESS

Motor vehicle lane configuration

YELLOW FLAG THRESHOLD

Motor vehicle lanes remain parallel or diverge

RED FLAG THRESHOLD

Motor vehicle lanes merge

CONSIDERATIONS

Less common flag.

Do not double count with Flag H. Where both apply, use only Flag H as the crossing movement has more severe risk. Exceptions include where the configuration is long (>300 feet) or otherwise significant, in which case both Flag H and N may be used.

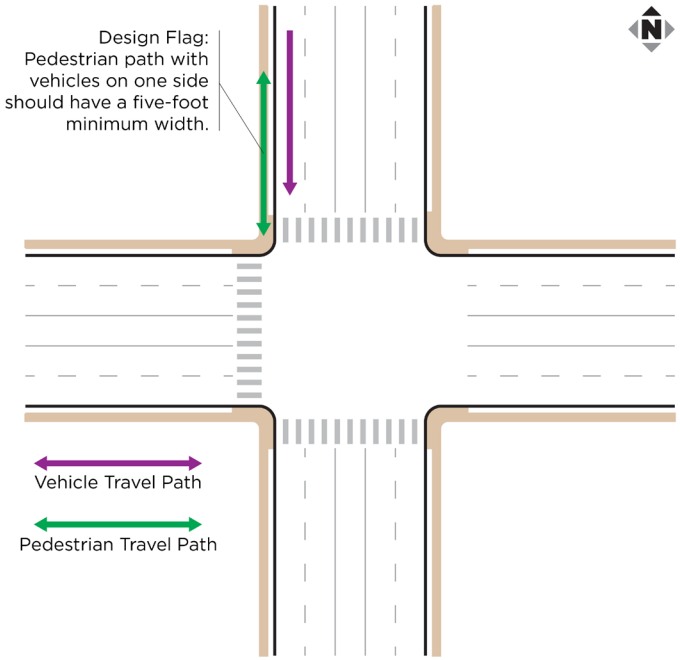
This flag exists even if there is not a bicycle lane, such as if a bicycle lane is dropped before an intersection, but bicyclists are continuing straight.

Flag O: Uncomfortable/Tight Walking Environment

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #2



FLAG DESCRIPTION

Most sidewalks are used for two-way pedestrian traffic, so sufficient width for passing must be provided. Pedestrians avoid walking immediately next to other modes of traffic or buildings, reducing the usable width of the sidewalk.

MITIGATIONS TOOLBOX

1. *Widening the sidewalk.*
2. *Illuminating the walking environment.*
3. *Increasing the size of channelization islands and corner areas.*
4. *Providing vertical separation between pedestrian and vehicles.*
5. *Providing horizontal separation (buffers) between pedestrians and vehicles.*

MEASURE OF EFFECTIVENESS

Effective walkway width plus buffer space

YELLOW FLAG THRESHOLD

<5 feet if traffic present on one side
<10 feet if traffic present on two sides

CONSIDERATIONS

This design flag can only be yellow and primarily applies to pedestrians, but can be applied to bicyclists on shared use paths.

Channelizing islands is an example of an environment with traffic present on more than one side.

ADA requirements must still be met.

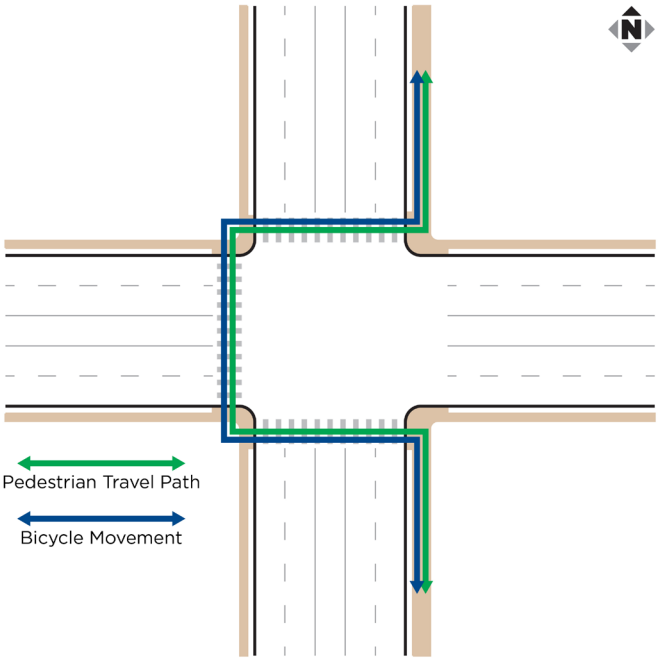
If used for a shared-use path next to a vertical object, the effective width of the path is reduced by two feet to account for the shy distance.

Flag P: Indirect Paths

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #5



FLAG DESCRIPTION

Indirect, or out-of-direction, paths lead to inconvenience, delay, and exposure to more crossing risk for pedestrians and bicyclists. Paths that are inefficient may encourage pedestrians or bicyclists into risk taking behavior to use a more convenient path.

MITIGATIONS TOOLBOX

1. *Direct crossing opportunities with a dedicated pedestrian phase.*
2. *Midblock crossing before the intersection to address an otherwise indirect path.*
3. *Grade-separated pedestrian and bicycle facilities, depending on the context and the O-D patterns for pedestrians and bicyclists.*

MEASURE OF EFFECTIVENESS

Out-of-direction travel distance

YELLOW FLAG THRESHOLD

90 feet (pedestrian)
450 feet (bicycle)

RED FLAG THRESHOLD

135 feet (pedestrian)
675 feet (bicycle)

CONSIDERATIONS

For approaches with more than four legs, it may be appropriate to consider desire lines across multiple approaches rather than only desires lines between adjacent approaches.

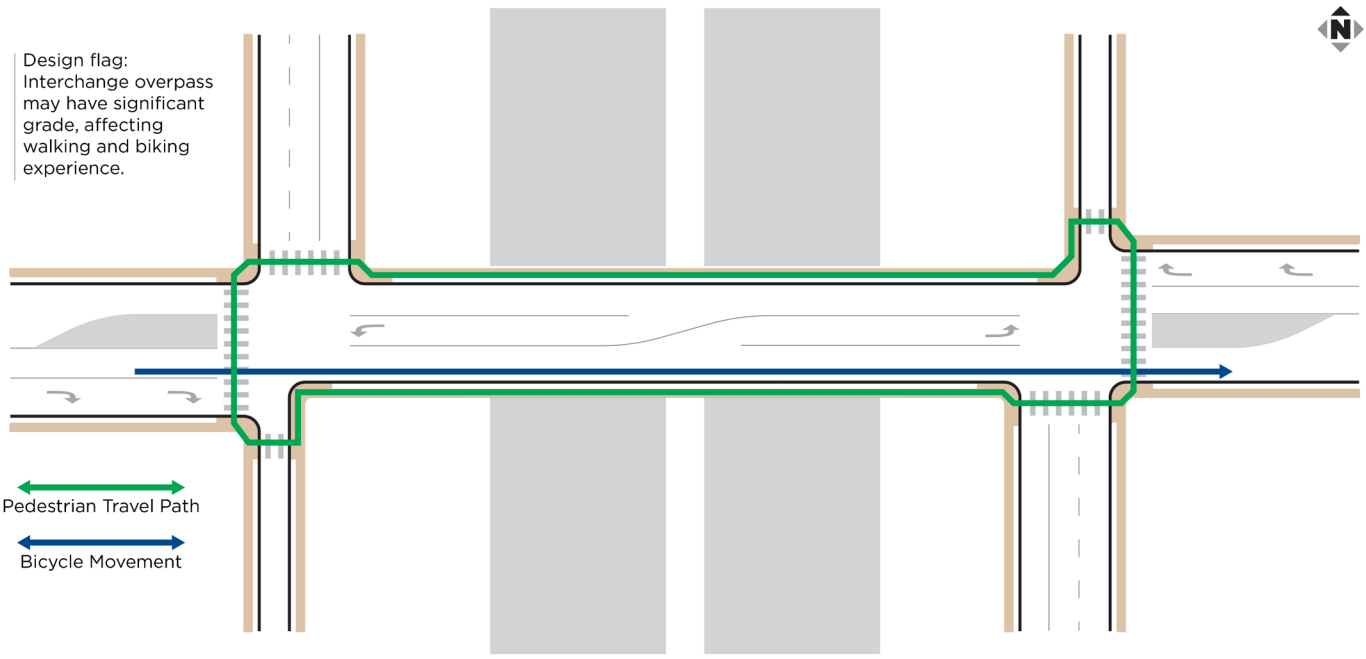
This flag applies to roadways with and without bicycle facilities.

Flag Q: Grade Change

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #13



FLAG DESCRIPTION

Grade changes within or immediately next to an intersection can created challenges for pedestrians and bicyclists. For example, initiating a movement uphill can be challenging for stopped bicyclists. Pedestrians may move slower when walking up hill.

MITIGATIONS TOOLBOX

1. *Constructing a dedicated protected bike lane on grade sections.*
2. *Constructing a shared use path on grade sections.*
3. *Reducing vehicular speeds.*

MEASURE OF EFFECTIVENESS

Percent grade

YELLOW FLAG THRESHOLD

+3% to +5%

OR

-3% to -5%

RED FLAG THRESHOLD

<-5%

OR

>+5%

CONSIDERATIONS

The slope of curb ramps should not be considered in determining the steepest grade but should still conform to ADA requirements.

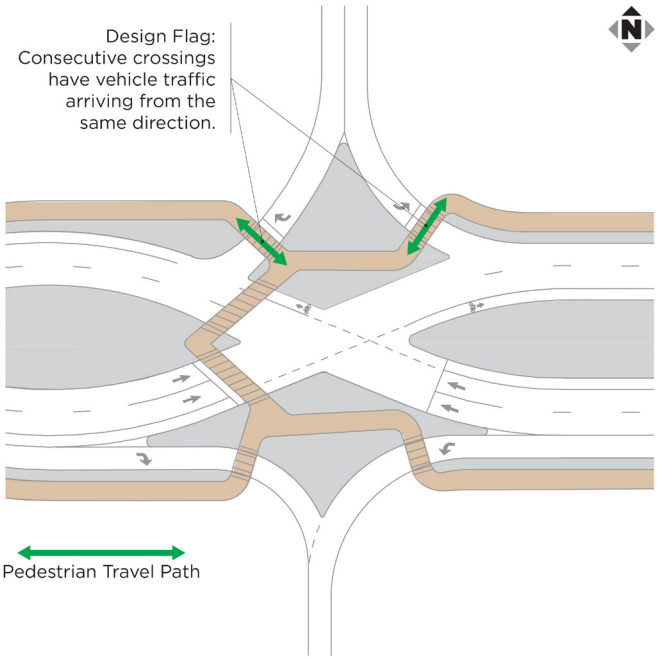
This flag applies to roadways with and without bicycle facilities.

Flag R: Nonintuitive Motor Vehicle Movements

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #3



FLAG DESCRIPTION

When a pedestrian begins crossing the street, the normal expectation is that the first conflicting motor vehicle traffic approaches from the left followed by conflicts from the right. This flag identifies nonintuitive configurations that violate this expectation.

MITIGATIONS TOOLBOX

1. *Designing the approaching path to face the initial direction of opposing traffic.*
2. *Providing wayfinding that is understandable to intended users, as well as appropriate speech messages for audible information devices.*
3. *Providing pavement marking at the entrance to the crossing indicating which direction a pedestrian or bicyclist should look.*
4. *Choosing different geometric features of the design to minimize movements from unexpected directions.*

MEASURE OF EFFECTIVENESS

Vehicle acceleration profile at crossing location

YELLOW FLAG THRESHOLD

Vehicle decelerating

RED FLAG THRESHOLD

Vehicle accelerating or free-flowing

CONSIDERATIONS

Less common flag.

Nonintuitive vehicle movements are common at interchanges.

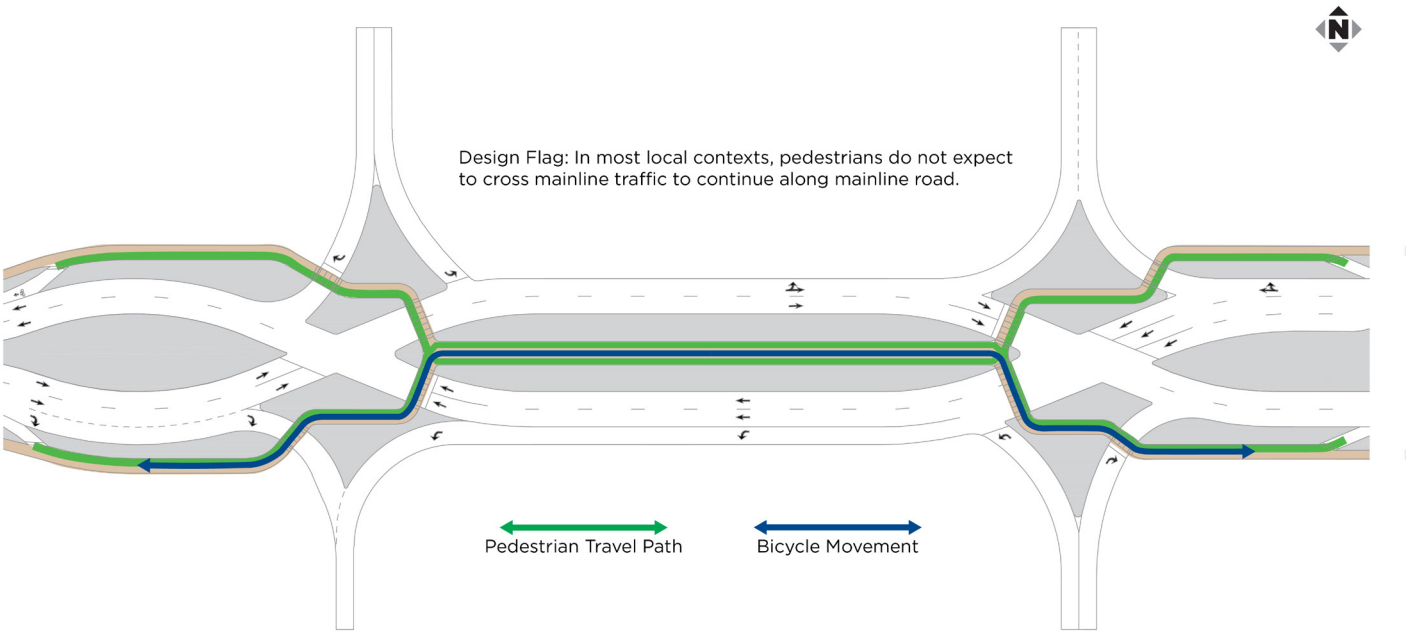
This flag does not apply to stop-controlled crossings.

Flag S: Executing Unusual Movements

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #6



FLAG DESCRIPTION

Roadway users have expectations for their travel paths and vehicle movements at intersections. This flag captures confusion or uncertainty users may experience when being unsure of how to continue on the desired path. This flag is most commonly seen at interchanges, one way streets, alternative intersections, intersections with channelized turns and multiple crossing stages.

MITIGATIONS TOOLBOX

1. *Re-aligning pedestrian/bicycle movement to make them more intuitive.*
2. *Constructing dedicated pedestrian or bicycle facilities*
3. *Following the design process to meet expectation for pedestrians and bicyclists.*

MEASURE OF EFFECTIVENESS

Compliance with local expectation

YELLOW FLAG THRESHOLD

This path does not match the expectation

CONSIDERATIONS

Less common flag.

This design flag can only be yellow.

Determining if a movement is unusual likely relies on local context. It is not intended to cover common but undesirable movements.

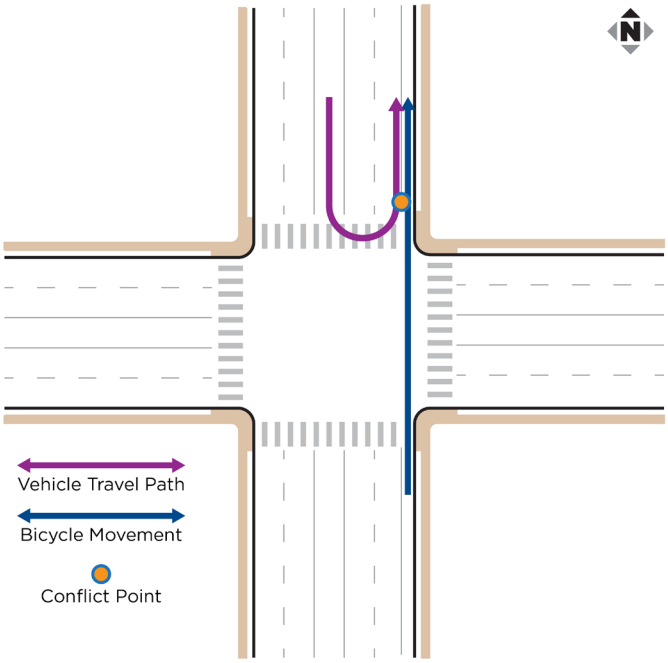
A first-of-its-kind design in an area may qualify as an unusual movement until familiarity with the design becomes common.

Flag T: Off-Tracking in Turns and Curves

Applicable Mode

SECONDARY FLAG

NCHRP 948
Flag #20



FLAG DESCRIPTION

Depending on curvature and lane widths, vehicles may off-track into adjacent lanes during u-turn or other turning maneuvers, resulting in a comfort and safety concern for cyclists. This situation is common for heavy trucks, intersections with u-turns or multiple left or right turn lanes, and for unprotected bicycle lanes on the inside of a curve.

MITIGATIONS TOOLBOX

1. *Constructing separate protected bicycle lanes or shared use paths.*
2. *Using striped vane islands to separate vehicle lanes.*

MEASURE OF EFFECTIVENESS

Design vehicle encroachment into bicycle lane

YELLOW FLAG THRESHOLD

Design vehicle can make turn without encroaching on bicycle lane

RED FLAG THRESHOLD

Design vehicle cannot make turn without encroaching on bicycle lane

CONSIDERATIONS

Less common flag.

Applicable only at locations where vehicle off-tracking may encroach into bicycle paths, particularly at conventional bicycle lanes without vertical barriers.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