12-5-3 Intersection Conflict Warning Systems — August 2021

BACKGROUND

Intelligent Transportation System (ITS) technologies can be used to provide enhanced warning information to drivers approaching intersections compared to static signing and marking applications. One type of ITS installation that *may* reduce crashes at intersections is an Intersection Conflict Warning System (ICWS). An ICWS is an actuated system which provides advance warning of a condition that may require a vehicle to stop but the condition is not always present. These systems have a broad spectrum of types and applications but are all categorized as ICWSs. An ICWS is a countermeasure intended to address locations that are experiencing crash issues, have unusual geometry, or restricted sight distances. An ICWS *should* only be used where other countermeasures have failed or *may* not be feasible.

GUIDELINES

Three criteria are to be considered when reviewing a location for an ICWS. These criteria are as follows:

1. Demonstrated crash issue
2. Visibility restrictions
3. Unusual geometrics

Due to the long-term maintenance of these systems, other countermeasures *should* be considered first to address safety concerns prior to the installation of an ICWS. These include:

- Improving sight distance (clearing vegetation, obstructions, or brush)
- Installing an advance intersection warning sign (W2 series)
- Increasing sign sizes
- Double-marking signs
- Installing advanced crossroad name signs (D series), if applicable. See TEOpS 2-4-50.
- Installing permanent flags on signs
- Electrical countermeasures (beacons, etc.)

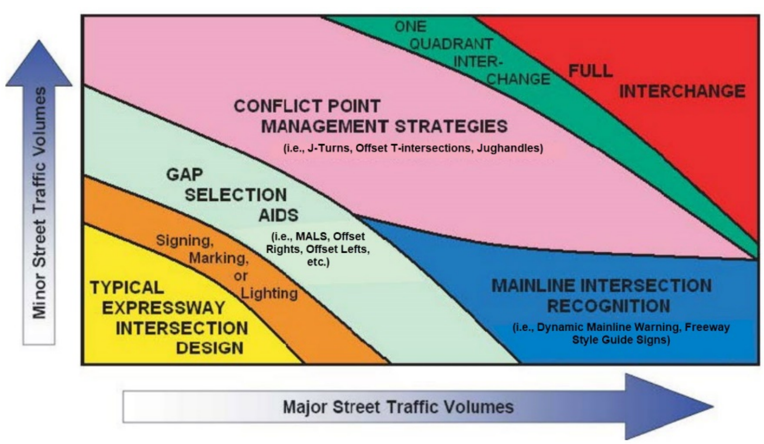
THROUGH ROUTE ACTIVATED WARNING SYSTEMS

<u>Introduction</u>

The frequency of crashes at two-way stop-controlled (TWSC) intersections is typically lower than at signalized intersections; however, the crashes are often more severe. The most common crash type at TWSC intersections is a multi-vehicle angle crash where a vehicle stopped on the minor road enters the intersection without an acceptable gap, resulting in a collision with a through vehicle on the major road. On higher speed roadways, these crashes are often severe because of the nature of the impact. In many cases, a primary factor in these crashes is misjudgment of approaching traffic on the major road by the minor road vehicle, not failure to stop at the minor road approach.

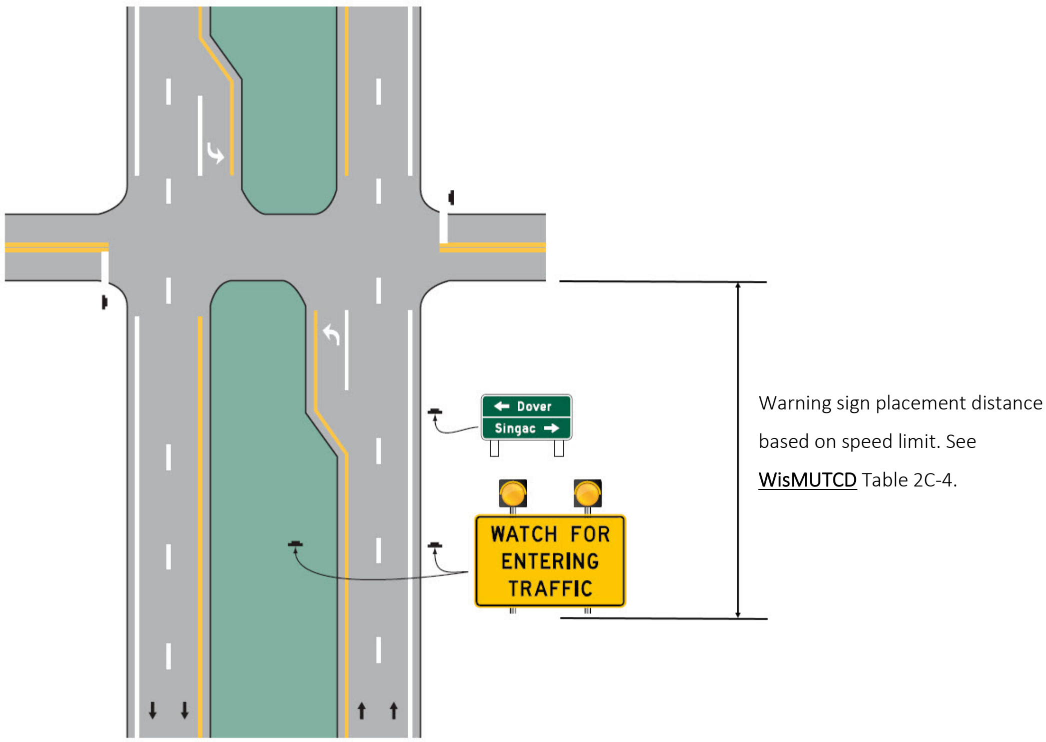
Several countermeasures are available to mitigate these angle crashes with varying costs and effectiveness. Figure 1 shows several categories of countermeasures for reducing crashes at TWSC intersections. Some countermeasures are more appropriate for divided highways and some are more appropriate for undivided highways. The most appropriate countermeasure *should* be based on the crash trends and contributing factors of those crashes at the intersection in question.

Figure 1. TWSC Rural Expressway Intersection Countermeasure Categories



One type of ICWS which has been implemented in several states is a Through Route Activated Warning System (TRAWS). A TRAWS detects vehicles on the minor road of a TWSC intersection to warn traffic on the major road. Detected vehicles activate flashing beacons that are attached to static warning signs. The flashing beacons are activated to warn major road traffic that vehicles on the minor road *may* enter the intersection. An evaluation by FHWA showed that a TRAWS has the ability to reduce right angle crashes at TWSC intersections. Figure 2 shows a conceptual layout of a TRAWS.

Figure 2. Typical Installation of a TRAWS on a multi-lane highway



Policy

This policy contains provisions for proper site selection, application, design, and installation of a TRAWS on the State Trunk Highway (STH) system.

Site Selection Criteria

A TRAWS *should* be considered at an existing TWSC intersection if it meets all the following conditions:

1. Enhanced signing and marking treatments have failed to mitigate crashes
2. Conflict point management strategies such as Restricted Crossing U-Turn (RCUT) intersections or other access restrictions are not appropriate or are too costly to implement
3. Improving sight distance is too costly to implement, if applicable
4. The intersection experienced three or more angle crashes in the previous five years or since the most recent safety improvement, if one was installed, within the previous five years
5. The posted speed limit for the through route is greater than 45 mph

As traffic volumes on the side road increase, the amount of time the beacons are activated increases respectively. The total activation time per vehicle is dependent on several factors. Minor road Average Annual Daily Traffic (AADT) volumes of more than 3,000 vehicles per day *may* cause near continuous activation of the system which can lead to drivers ignoring the dynamic warning and diminish the effectiveness of the system. Average activation times **shall** be considered based on the site conditions and engineering judgement used to confirm the system will activate dynamically for drivers on the major road. To optimize the effectiveness of a TRAWS, the following maximum AADT volumes *should* be considered:

- Major Road AADT typically does not exceed 12,000
- Minor Road AADT typically does not exceed 3,000

Design and Installation

The following provisions pertain to the design and installation of the signing components for a TRAWS on the STH system:

1. Installations **shall** be in compliance with the requirements established in the Wisconsin MUTCD (WisMUTCD)

2. The sign legend **shall** follow WisDOT sign plate W8-75. Sign size varies by facility type. For sizing information, see TEOpS 2-1-35.
3. Number of signs, beacon details and sign installation
    a. The sign and beacon assembly **shall** be ground mounted in the lateral and vertical location as specified in the WisMUTCD
        i. The sign **shall** be located in accordance to WisMUTCD Table 2C-4
        ii. See WisDOT sign plate A4-4 for information on roadway offsets, number of posts and post spacing required
        iii. Warning beacons **shall** be mounted on the same support as the warning sign. See WisMUTCD 4L.01 and 4L.03 for information. The beacon **shall** be mounted, at minimum, one foot above the sign with a maximum of two feet.
    b. The number of signs depends on the facility type and site condition. See Figure 2 for an illustration of a typical installation on a divided, multi-lane highway.
        i. For two-lane undivided highways, one sign **shall** be installed for each direction of travel
        ii. For four-lane divided highways, one sign **shall** be installed on each side of the highway for each direction of travel
    c. Two flashing beacons **shall** be used on all signs. When activated, the beacons **shall** operate with an alternating flashing, “wig-wag”, signal indication.

The following provisions pertain to the design and installation of the detection and electrical service for a TRAWS on the STH system:

1. Detection
    a. All stop approaches *should* have advance and stop bar detection. The type of detection *should* be controlled through radar detection. The equipment **shall** be furnished by the Department.
    b. Detection of a vehicle on the stop approaches **shall** be transmitted through a hard-wired connection from a detector to activate the beacons on the system
    c. Any poles needed for mounting detection equipment **shall** be in conformance with the standards in FDM 11-15-1
    d. System timing *should* be based on the operating speeds on the major and minor roads, major road sign placement, major road vehicle perception-reaction time, intersection geometrics, traffic volumes, vehicle mix and type of detection at each site
    e. The need to detect vehicles in the median who are making two-stage crossing maneuvers **shall** be evaluated during design

2. Electrical service
    a. Service **shall** be installed underground. The conduit **shall** run up and be attached to the control cabinet. The control cabinet **shall** be mounted on the pole at least three feet from the ground.
    b. Solar-powered installations **shall** not be allowed on the STH system

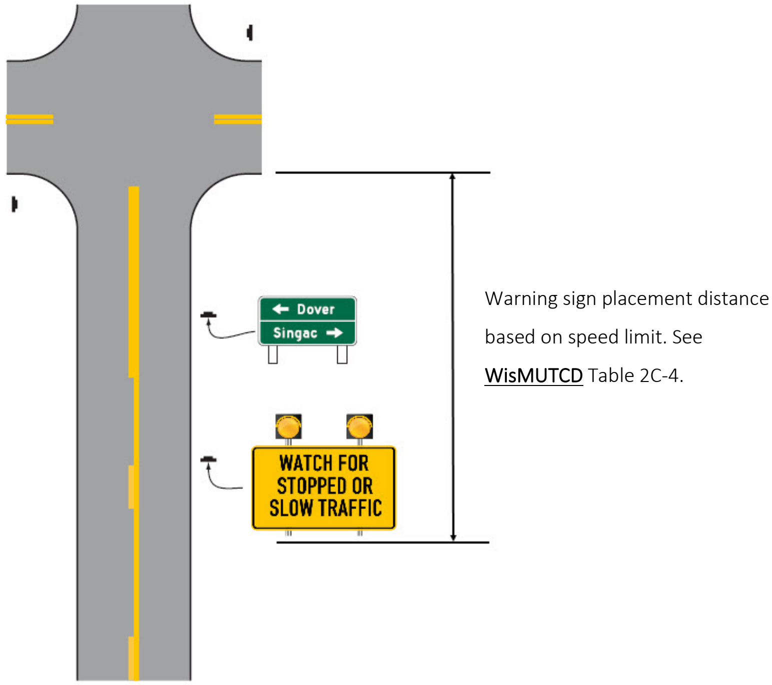
STOPPED OR SLOW TRAFFIC AHEAD WARNING SYSTEM

Introduction

A common crash type at a TWSC intersection where a separated left turn lane doesn’t exist is when a vehicle on the mainline slows to perform a turn or is stopped within a queue of vehicles due to turning traffic and is rear-ended by another vehicle. Several factors that could contribute to these types of crashes are restricted sight distance, unusual geometry, and roadway curvature.

A Stopped or Slow Traffic Ahead Warning System is a type of ICWS that detects vehicles on the major road to warn subsequent vehicles of a stopped/slowed vehicle ahead. A vehicle that is slowing prior to the intersection to perform a turn activates flashing beacons that are attached to a static warning sign. Figure 3 displays a typical installation on a two-lane undivided facility.

Figure 3. Typical Installation of a Stopped or Slow Traffic Ahead Warning System on a two-lane highway



Policy

This policy contains provisions for proper site selection, application, design, and installation of a Stopped or Slow Traffic Ahead Warning System on the STH system.

Site Selection Criteria

A Stopped or Slow Traffic Ahead Warning System *should* be considered at an existing TWSC intersection if it meets all the following conditions:

1. Enhanced signing and marking treatments have failed to mitigate crashes
2. The Stopping Sight Distance (SSD) does not meet minimum standards for a category 1 sight distance requirement or the intersection experienced three or more correctable crashes (mainline rear-ends relating to left-turning movements) in the previous five years or since the most recent safety improvement, if one was installed, within the previous five years. See FDM 11-10-5.1.1 for SSD requirements.
3. Installing geometric alternatives (turn lanes, bypass lanes, paved shoulders) is not feasible due to unusual geometrics, existing roadway features, or other factors
4. The posted speed limit for the through route is greater than 45 mph

Design and Installation

The following provisions pertain to the design and installation of the signing components for a Stopped or Slow Traffic Ahead Warning System on the STH system:

1. Installations **shall** be in compliance with the requirements established in the Wisconsin MUTCD (WisMUTCD)
2. The sign legend **shall** follow WisDOT sign plate W8-77. Sign size varies by facility type. For sizing information, see TEOpS 2-1-35.
3. Number of signs, beacon details and sign installation
    a. The sign and beacon assembly **shall** be ground mounted in the lateral and vertical location as specified in the WisMUTCD
        i. The sign **shall** be located in accordance to WisMUTCD Table 2C-4
        ii. See WisDOT sign plate A4-4 for information on roadway offsets, number of posts and post spacing required
        iii. Warning beacons **shall** be mounted on the same support as the warning sign. See WisMUTCD 4L.01 and 4L.03 for information. The beacon **shall** be mounted, at minimum, one foot above the sign with a maximum of two feet.
    b. This system *should* only be used for two-lane undivided highways. One sign **shall** be installed for each direction of travel
    c. Two flashing beacons **shall** be used on all signs. When activated, the beacons **shall** operate with an alternating flashing, “wig-wag”, signal indication.

The following provisions pertain to the design and installation of the detection and electrical service for a Stopped or Slow Traffic Ahead Warning System on the STH system:

1. Detection
    a. Detection *should* be camera-based in order to detect mainline vehicles slowing to perform a turn. The type of detection *should* be evaluated at each location. The equipment **shall** be furnished by the Department.
    b. Detection of a vehicle **shall** be transmitted through a hard-wired connection from a detector to activate the beacons on the system
    c. Any poles needed for mounting detection equipment **shall** be in conformance with the standards in FDM 11-15-1
    d. Considerations for system timing and system delays *should* be based on conditions at the site such as traffic volumes, vehicle type, vehicle speeds, major road vehicle perception-reaction time, intersection geometrics, and major road sign placement.

2. Electrical service
    a. Service **shall** be installed underground. The conduit **shall** run up and be attached to the control cabinet. The control cabinet **shall** be mounted on the pole at least three feet from the ground.
    b. Solar-powered installations **shall** not be allowed on the STH system

PERMITTING OF INTERSECTION CONFLICT WARNING SYSTEMS

See TEOpS 4-5-1 for provisions on permitting ICWSs.

MAINTENANCE AND RELIABILITY OF INTERSECTION CONFLICT WARNING SYSTEMS

Reliability of an ICWS is critical for public acceptance and successful crash mitigation. The provisions described in this policy have been developed to provide a high level of system reliability commensurate with other ITS devices deployed by the Department. Design of the detection system, electrical service and data transmission, and sign messaging all play a role in how drivers perceive and react to an ICWS during normal and fail-safe conditions. Once a system has been installed, the Region operations section **shall** be the primary caretaker of the system to provide any needed maintenance and repairs that keep the system functional on the STH system. Coordination with local maintenance forces, law enforcement and local stakeholders is needed to identify any system malfunctions so the appropriate personnel can promptly respond to any issues.

REFERENCES

1. Amjadi, R. (2015). TechBrief: Safety Evaluation of Intersection Conflict Warning Systems (ICWS). *Report No. FHWA-HRT-15-076.* Federal Highway Administration, Washington, D.C.
2. Bryer, T. (2011). Stop-Controlled Intersection Safety: Through Route Activated Warning Systems. *Report No. FHWA-SA-11-015*. Federal Highway Administration, Washington, D.C.
3. Crowson, G., & Jackels, J. (2011). Design and Evaluation Guidance for Intersection Conflict Warning Systems (ICWS). *Report No. ENT-2011-1.* ENTERPRISE Transportation Pooled Fund Study TPF-5 (231).
4. Himes, S., Gross, F., Eccles, K., Persaud, B. (2016). Safety Evaluation of Intersection Conflict Warning Systems*. Report No. FHWA- HRT-16-035*. Federal Highway Administration, Washington, D.C.
5. “Planning Guidance for Intelligent Transportation Systems (ITS) Devices. Version 3.1” (2015). ENTERPRISE Transportation Pooled Fund Study TPF-5 (231).
6. Vaughan, I., & Jackson, S. (2016). Intersection Conflict Warning Systems Human Factors: Final Report*. Report No. FHWA-HRT-16-061*. Federal Highway Administration, Washington, D.C.

12-5-4 Friction Surface Treatment — August 2021

BACKGROUND

Maintaining pavement friction is a critical component of vehicles safely navigating a roadway. Almost 20% of all traffic fatalities result from lane departure crashes, while they only account for less than 5% of all traffic crashes. A “lane departure” crash is a “non-intersection crash which occurs after a vehicle crosses an edge line or a center line, or otherwise leaves the travel way.”

One of the primary causes for lane departure crashes is related to poor weather conditions, particularly snow/ice and wet weather conditions.

One method to address lane departure crashes is to provide friction enhancements to the pavement. Wisconsin has several types of surface treatments that are considered friction enhancements to existing roadway or bridge surfaces.

High Friction Surface Treatments (HFST) use a calcined bauxite aggregate with resin binder, which is an aggregate that maintains frictional resistance over time by resisting polishing and wear. A resin binder is applied to the roadway or bridge surface prior to the aggregate application. HFSTs are a proven low-cost countermeasure to reduce lane departure crashes in areas that have an observed crash history related to poor, especially wet, weather conditions.

Enhanced Friction Surface Treatments (EFST) include all other types of friction enhancements to roadway and bridge surfaces.

GUIDANCE

Areas that have vehicles changing lanes or braking excessively *may* experience pavement surfaces becoming prematurely polished which reduces pavement friction. These locations commonly are located on interchange ramps and horizontal or vertical curves. Locations that experience a high number of lane departure crashes that can be considered for friction treatment installation include:

- Interchange Ramps
- Horizontal or vertical curves
- Structures
- Roundabouts

A HFST **shall** be the preferred friction enhancement to mitigate lane departure crashes. Friction surface treatments **shall** be installed as spot treatments or on short segments to mitigate crashes related to pavement friction deficiencies. These treatments are not intended to be applied as a corridor treatment and *should* only be considered when warranted.

<u>Placement and application</u>

Crashes are likely to occur in the area where a driver recognizes an upcoming change of condition and applies the brakes to navigate the roadway feature. These crashes *may* be prevented by providing a HFST prior to the change of condition. Placement of a HFST *should* be based on the characteristics of the roadway and other indications that are specific to each site. These factors *may* include:

- Crash locations
- Presence of skid marks
- Damaged roadside barriers or other objects
- Presence and condition of previous low-cost countermeasures
- Superelevation
- Driver speeds
- Advisory speeds
- Driver behavior
- Point of curvature and point of tangent
- Horizontal and vertical sight distances
- Intersections near or within a curve
- Heavy vehicle use
- Speed differentials
- Presence of horizontal curves, vertical curves, or weaving areas
- Friction levels (if existing pavement will remain)

When applying a HFST to the roadway surface it **shall** be installed in a single layer unless it is being applied to a bridge deck. When applying either a Thin Polymer Overlay (TPO) or a HFST to the bridge deck it **shall** require a two-layer application for deck preservation against chloride infiltration. Additionally, the standard two-layer application provides protection against snowplow and snowmobile operations.

For bridge applications, the standard two-layer TPO consists of a two-component system of epoxy polymer and aggregates for a ¼-inch minimum total thickness. This TPO system does not require use of calcined bauxite aggregates and is considered an EFST. When a HFST is warranted, a two-layer TPO with calcined bauxite aggregates **shall** be applied. The bridge deck (driving lanes and shoulders) *should* be the only feature that receives the treatment. Other considerations *should* be evaluated to determine if the approach slabs or travel lanes prior to the bridge deck need to be treated such as the presence of a curve or areas where heavy weaving may occur. Use of a HFST on bridge decks will require additional coordination and prior approval from the Bureau of Structures. For additional information on friction treatments for bridge decks, refer to the thin polymer overlay section in Chapter 40 of the WisDOT Bridge Manual.

For applications prior to vertical curves and roundabouts, the above factors *should* be taken into consideration at each situation due to the unique properties of the site.

For horizontal curves, the braking distance can be used to provide an approximate location of where to begin placement of a HFST. Table 1 provides general placement guidance for horizontal curves prior to the point of curvature (PC).

Table 1. Recommended HFST placement distances prior to the point of curvature (PC)

Approach Speed (mph)	Curve Advisory Speed (mph)											
	15	20	25	30	35	40	45	50	55	60	65	70
25	100	75	50	-	-	-	-	-	-	-	-	-
30	125	125	100	50	-	-	-	-	-	-	-	-
35	175	150	125	100	50	-	-	-	-	-	-	-
40	200	200	175	150	100	50	-	-	-	-	-	-
45	250	225	225	175	150	100	50	-	-	-	-	-
50	300	300	275	225	200	150	125	50	-	-	-	-
55	375	350	325	300	250	225	175	125	50	-	-	-
60	425	400	375	350	325	275	225	175	125	50	-	-
65	500	475	450	425	375	350	300	250	200	125	50	-
70	575	550	525	500	450	425	375	325	275	200	125	50
75	650	625	600	575	525	500	450	400	350	275	225	150

Note: Recommended values are based on the braking distance with a conservative deceleration rate of 10 ft/s^2. All values include an added 50 feet and are rounded to the nearest 25 feet.

REFERENCES

1. "Frequently Asked Questions – High Friction Surface Treatments (HFST) – 2017" (2018, February). Federal Highway Administration, Washington, D.C. Retrieved from https://safety.fhwa.dot.gov/roadway_dept/pavement_friction/faqs_links_other/hfst_faqs/. Accessed August 9, 2021.
2. "High Friction Surface Treatments" (2018, February). Federal Highway Administration, Washington, D.C. Retrieved from https://www.fhwa.dot.gov/innovation/everydaycounts/edc-2/hfst.cfm. Accessed August 9, 2021.
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4. "Wisconsin Strategic Highway Safety Plan 2017-2020" (2017, November). Wisconsin Department of Transportation, Madison, WI. Retrieved from https://wisconsindot.gov/Documents/safety/education/frms-pubs/strategichwy-17-20.pdf. Accessed August 9, 2021.

WISDOT SPECIAL PROVISIONS AND REFERENCES

1. Wisconsin Resin Binder High Friction Surface Treatment
2. WisDOT Bridge Manual: Chapter 40 – Bridge Rehabilitation, 40.5.1.1 Thin Polymer Overlay