1-5-1 Subject Numbering System — June 2005

DEFINITIONS

Chapter: A main divisional unit of this manual, addressing one of the major functions of traffic engineering or supporting functions.

Section: A grouping of related subjects within a chapter.

Subject: A specific guideline, policy or procedure.

SUBJECT NUMBERING

The manual is divided into topical chapters with each chapter having one or more sections that are divided into specific treatments of material, called subjects.

Chapters, sections and subjects are all numbered.

Chapter numbers are numbered consecutively, generally without gaps. Sections and subjects are numbered consecutively or sometimes with gaps--5, 10, 15, 20--to allow for future insertions of material at the most appropriate locations within the chapter or to follow the MUTCD numbering system.

Chapters 2 through 10 are allotted to subjects related to traffic control devices covered in the corresponding Parts 2 through 10 of the MUTCD.

1-5-5 Table of Contents — August 2023

3-15-15 Dynamic Envelope Marking **November 2015**

PURPOSE

The MUTCD Section 8B.29 defines dynamic envelope pavement markings as a 4-inch solid white line, placed parallel to and 6 feet away from the nearest rail of an at-grade crossing. The MUTCD further defines a supplemental marking consisting of 12-inch solid white lines, placed at a 45-degree angle and 5 foot spacing between the 4-inch solid lines. This policy will clarify dynamic envelope pavement marking installation on state maintained roadways.

POLICY AND GUIDELINES

Between the 4-inch parallel lines, dynamic envelope markings fully cover 20 percent of the driving surface. This broad coverage area presents a potential safety hazard to bicycles and motorcyclists, as pavement marking material offers significantly less surface friction than unmarked pavement. In addition, this large amount of marking creates a maintenance issue for the department. For these reasons, dynamic envelope markings **shall not** be utilized on state maintained roadways.

Certain grade-crossing locations on state maintained roadways *may* present operational issues. In lieu of dynamic envelope markings, the following signing countermeasures *may* be implemented:

1. The R8-8 “DO NOT STOP ON TRACKS” sign *may* be used at grade crossings where drivers tend to stop on the tracks.
2. The R10-6 “STOP HERE ON RED” sign *may* be used at grade crossings with signals downstream of the crossing.
3. The W10-11-A “XX FEET BETWEEN TRACKS & HIGHWAY” sign *may* be mounted in advance of a grade crossing where limited storage space exists between the tracks and a downstream intersection.
4. The W10-11-B “XX FEET BETWEEN HIGHWAY & TRACKS BEHIND YOU” sign *may* be used downstream of a grade crossing where limited storage space exists between the tracks and a downstream controlled intersection. If used, this sign *should* be mounted either below the STOP or YIELD sign, or just prior to the signalized intersection.

4-2-1 Restricted Locations — June 2004

GENERAL

When justified by a traffic engineering study, traffic control signals provide benefits to intersection traffic operations and *may* provide some types of safety improvements as well. While certain benefits can be realized, there *may* be potential trade-offs caused by the installation of traffic control signals including increased delay and reduced mobility on the major approaches, as well as an increase of rear-end type crashes at an intersection.

POLICY

Traffic control signals at isolated, single-source, private access points **shall not** be allowed on the STH system for the following reasons:

1. Signals at isolated, private access points disregard the public interest and investment in STH highway facilities.
2. Private access points are limited to a width of 35 feet (per Trans 231). This width *may* not be great enough to accommodate the geometry required for adequate signalized intersection operations.
3. Signal infrastructure (i.e. detection, signal bases, pull boxes, conduit) *may* need to be installed outside of the public right-of-way.

In lieu of installing traffic signals on the STH system at private access points, other alternatives *may* include:

1. Development of adjacent local street systems to concentrate traffic from other generators and/or direct traffic to intersections that are already controlled by traffic signals or roundabouts
2. Implementation of access restrictions (i.e. right-in/right-out or median modifications), or
3. Use of standard side-street stop control.

Private access point intersections that are aligned with public street connections are not the focus of this policy and are generally not considered to be in conflict with the points made above. However in these cases, it is desirable to locate signal infrastructure within public right-of-way.

The limited number of traffic control signals installed at private access points on the STH system prior to the adoption of this policy will continue to be operated by WisDOT until they are removed, replaced by other forms of intersection traffic control, or jurisdictionally transferred to local government agencies.

SUPPORT

In addition to a traffic engineering study that is performed to justify signal installations at a specific location, other factors *should* be considered. System and access issues also need to be considered when deciding whether signals are appropriate. Examples of these issues are indicated below:

1. Type of facility being proposed for signalization (i.e. it is generally not desirable to signalize expressways or high-speed bypasses around communities)
2. Signal spacing for progressive traffic flow along a corridor
3. Treatment of consolidated access points
4. Connectivity of the access point to the local roads network
5. Relative safety implications
6. Signal maintenance and operation implications.

Other guidance in this topic area *may* be found in the Traffic Impact Analysis (TIA) Guidelines Manual, Highway Access Management Reference Guide, Administrative Rules Trans 233 and Trans 231, State Highway Maintenance Manual Chapter 91, Facilities Development Manual Chapters 7 and 11, TRB Access Management Manual, and NCHRP Report 348 Access management Guidelines for Activity Centers.

If signals are to be installed at public street connections that are aligned with private access points, from a systems perspective, it *may* be desirable to have a portion or all of the private drive dedicated as a public street. There are several reasons for this:

- Provides system consistency for connectivity to local network
- Allows for access control on the subject approach, near the signalized intersection
- Signal infrastructure placement and signal maintenance considerations
- Will allow for greater control of features that *may* reduce sight distance (such as on-premise signing or landscaping)
- *May* provide greater design flexibility for intersection capacity.

When driveways are dedicated as public streets to meet the objectives of effective access and signal systems management, local agreements that are designed to cover or share the additional operations and maintenance costs for the additional infrastructure, *should* be considered.

4-2-4 Flashing Operations May 2011

GENERAL

Reference is made to the MUTCD, Secitons 4D.28, 4D.29, 4D.30, and 4D.31, and Wisconsin State Statute 346.37, 346.39, and 346.40.

There are four types of flashing operations for traffic control signals: start-up flash, emergency flash, program flash, and manual override flash. Each of these conditions are described briefly below:

1. New signal start-up flash operation is used to acclimate motorists to the revised form of intersection traffic control at a given location prior to initiating steady stop-and-go mode operation.
2. Emergency flash operation *may* be caused by controller malfunction, utility service disruption, or physical damage to the installation (such as a pole knock-down).
3. Program (time-of-day) flash operation is generally limited to use at pre-timed signal installations where no actuation exists to detect vehicles and provide variable green time based on actual approach demand. This type of flash operation is used during off-peak hours (for example, from 10 PM to 6 AM) to reduce intersection delay at pre-timed signals.
4. Manual override flash operation *may* be used by law enforcement officers that assume intersection traffic control associated with special events or incidents.

In addition to flash operation, two flash modes are used: red-red or yellow-red flash.

POLICY

New Signal Installation Start-Up Flash Operation

At newly installed signals that have just become operational, consideration *should* be given to using flash-mode operations if the intersection was open to traffic during construction. This is used to acclimate motorists to the revised form of intersection traffic control at a given location prior to initiating steady stop-and-go mode operation.

Engineering judgment **shall** be used to determine the need for and duration of flash-mode operations. Consideration *should* also be given to the location of the signal and type of motorists that use the route. For example, along a commuter route, new signals *may* be flashed for a length of time between Monday and Friday. Similarly, new signals along a tourist route can be flashed during a weekend period.

Start-up flash for new signals *should* reflect the prior intersection traffic control condition. That is, if a signal is installed to replace a two-way STOP condition, a yellow-red flash mode *may* be used. If a signal is installed to replace an all-way STOP condition, a red-red flash mode *may* be used.

Program (Time-of-Day) Flash Operation

Pre-timed signals on the STH system *may* use program (time-of-day) flash operations but *should* be scheduled for upgrade to semi-actuation, at a minimum. Traffic signals on the STH system that are fully or semi-actuated **shall not** use program (time-of-day) flash operations. Actuated signals can detect and respond to actual demand on conflicting approaches; efficiencies gained by this type of operation at a pre-timed signal do not necessarily exist at an actuated signal. In addition, the transition out of flash operation to steady stop-and-go operations *may* be a time of potential confusion to motorists.

Traffic signals on the STH system that are interconnected with rail-grade crossing systems **shall not** use program (time-of-day) flash operations.

Emergency Flash Operation & Manual Override Flash Operation

Regardless of whether program flash operation is used at a particular installation, the flash mode must be determined for emergency and manual override situations. The bullet points below discuss these two modes:

1. Red-red (R-R) flash mode is prescribed for most signalized intersections, as this mode tends to reflect motorist expectancy. On multilane highways, this type of operation will benefit motorists on the side road since clearance distances can be large.
2. Yellow-red (Y-R) flash mode *may* be appropriate at signals where overall intersection volumes are relatively light and the proportions of mainline volumes significantly exceed those on the side road. This rule of thumb reflects a consideration for intersection delay and maintaining priority based on route significance. However, driver expectancy may be violated causing drivers to unnecessarily stop on yellow, thereby creating a potential safety hazard for other drivers and negating the potential delay reduction.

Even if an isolated intersection meets the broad volume criteria above for yellow-red flash mode, other signalized intersections along a corridor *may* dictate the type of flash mode that *should* be used. For example, if adjacent signalized intersections use a red-red flash mode, driver expectancy *may* determine that any additional signals in the immediate area operate in the same manner; regardless of this generalized volume criteria.

SUPPORT

Whether a signal is operating in steady stop-and-go mode, R-R or Y-R flashing mode, or non-operable (dark) mode, driver expectancy *should* be considered. Careful engineering judgment *should* be used to balance the needs of safety, efficiency and motorist expectancy.

4-2-5 Vehicle Clearance Intervals — May 2006

GENERAL

Reference is made to the MUTCD Section 4D.10.

According to State Statute 346.37(1)(b), "When shown with or following the green, traffic facing a yellow signal **shall** stop before entering the intersection unless so close to it that a stop *may not* be made in safety."

The purpose of the YELLOW vehicle clearance interval is to inform drivers of an impending change in right-of-way assignment. Yellow clearance intervals are normally three to six seconds in duration.

The purpose of the ALL-RED clearance interval is to allow vehicles to travel through an intersection that have lawfully entered during the yellow clearance interval. It *may* also provide a brief period of separation time between opposing movements. All-red clearance intervals normally do not exceed three seconds in duration.

POLICY

By the WisMUTCD, all traffic signal installations **shall** display a yellow indication following every green interval. In addition, by this policy, state-owned signal installations **shall** operate with an all-red clearance interval for mainline and side street intersection through-vehicle movements. All-red clearance intervals *may* be used for other intersection movements, such as protected left turns.

Fundamentally, there are three ways that yellow and all-red clearance intervals are developed: timing derived by kinematic principles, uniform timing, and rule of thumb. As a statewide organization, WisDOT routinely operates signals adjacent to various jurisdictions that *may* have differing perspectives about signal timing methodology. In the interest of providing uniform conditions to the extent possible, all methods are considered acceptable but *may* have greater applicability in certain situations or within specific areas of the state.

Kinematic Method

Develops a clearance interval duration based on driver behavior and physical principles. Clearance interval timing based on this method can be calculated for each intersection movement by using the following formula:

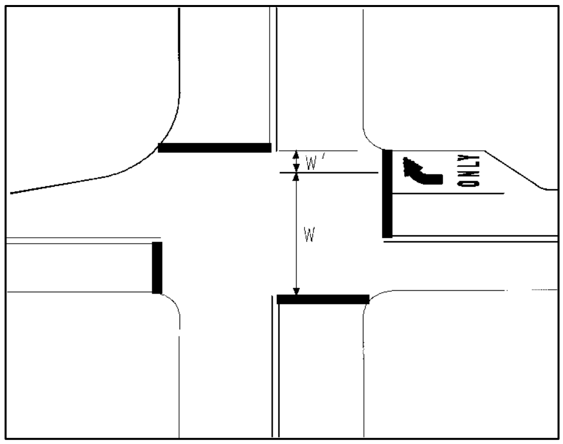
$$CT = prt + \frac{v}{2a+2Gg} + \frac{L+w}{v}$$

$$= \underbrace{prt + \frac{v}{2a+2Gg}}_{\text{yellow portion}} + \underbrace{\frac{L+w}{v}}_{\text{all-red portion}}$$

Where:

CT	=	clearance time (*may* be rounded up to nearest 0.5 second)
prt	=	driver perception-reaction time (usually 1.0 second)
v	=	vehicle approach speed (feet per second, vehicle approach speed *should* be based on the posted speed, or the 85-percentile speed if data is available)
a	=	average vehicle deceleration rate (usually 10 to 15 feet per second^2, 10 to 12 fps^2 recommended)
g	=	acceleration due to gravity (32 fps^2)
G	=	approach grade (expressed as decimal)
L	=	vehicle length (usually 20 feet)
w	=	intersection width (measured in feet from the near-side stop bar, see “w” diagram below)

Figure 1. Recommended Intersection Width (“w”) Determination



Intersection width measured from approach stop bar to center of conflicting vehicle lane on the far side of the intersection. Width *may* also include distance from center of far lane to the outside edge of the traveled way ($w + w^{l}$).

When used, variables within the formula above *may* need to be adjusted for various applications and for different intersection movements. For example, in the case of left-turns, driver perception-reaction times *may* be shorter and/or vehicle approach speeds lower.

As stated above, the upper limit of the yellow and all-red clearance intervals are typically 6 and 3 seconds, respectively. Longer clearance interval times *may* breed driver noncompliance that can actually degrade intersection safety benefits. Excessively long clearance interval times will also reduce the efficiency of signal operations. The lower limit of the yellow clearance interval is typically 3 seconds.

For isolated state-owned signals that can be considered outside the influence of established timing practices of adjacent jurisdictions (for purposes of driver expectancy), it is desirable to use the kinematic method of determining vehicle clearance intervals.

For given approach speeds and gradients, the table below indicates YELLOW CLEARANCE INTERVALS calculated by the equation above (considering a lower deceleration rate of 10 fps^2).

Table 1. Yellow Clearance Intervals at Deceleration Rate of 10 fps^2

Approach	Approach Grade								
Speed (mph)	+4%	+3%	+2%	+1%	0%	-1%	-2%	-3%	-4%
25	2.6	2.7	2.7	2.8	2.8	2.9	3.0	3.0	3.1
30	3.0	3.0	3.1	3.1	3.2	3.3	3.4	3.4	3.5
35	3.3	3.3	3.4	3.5	3.6	3.7	3.7	3.8	4.0
40	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.3	4.4
45	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.7	4.8
50	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.1	5.2
55	4.6	4.7	4.8	4.9	5.0	5.2	5.3	5.5	5.6
60	4.9	5.0	5.1	5.3	5.4	5.6	5.7	5.9	6.1
65	5.2	5.4	5.5	5.6	5.8	5.9	6.1	6.3	6.5

Gray-shaded values fall outside typical time intervals indicated. Use only as needed and at the direction of the regional traffic engineer.

For given approach speeds and gradients, the table below indicates YELLOW CLEARANCE INTERVALS calculated by the equation above (considering a higher deceleration rate of 15 fps^2)

Table 2. Yellow Clearance Intervals at Deceleration Rate of 15 fps^2

Approach	Approach Grade								
Speed (mph)	+4%	+3%	+2%	+1%	0%	-1%	-2%	-3%	-4%
25	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3
30	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.6	2.6
35	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	2.9
40	2.8	2.8	2.9	2.9	3.0	3.0	3.0	3.1	3.1
45	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.4
50	3.3	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7
55	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9
60	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.2
65	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5

Grey-shaded values fall outside typical time intervals indicated. Use only as needed and at the direction of the regional traffic engineer.

For given intersection widths and approach speeds, the table below indicates ALL-RED CLEARANCE INTERVALS calculated by the equation above.

Table 3. All-Red Clearance Intervals

Approach	Intersection Width (ft)								
Speed (mph)	24	36	48	60	72	84	96	108	120
25	1.2	1.5	1.9	2.2	2.5	2.8	3.2	3.5	3.8
30	1.0	1.3	1.5	1.8	2.1	2.4	2.6	2.9	3.2
35	0.9	1.1	1.3	1.6	1.8	2.0	2.3	2.5	2.7
40	0.7	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
45	0.7	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.1
50	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.7	1.9
55	0.5	0.7	0.8	1.0	1.1	1.3	1.4	1.6	1.7
60	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6
65	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.5

Gray-shaded values fall outside typical time intervals indicated. Use only as needed and at the discretion of the region traffic engineer.

Uniform Timing

Assigns a standardized duration for the clearance interval regardless of location. In this case, times *may* be based on the type of movement being made. For example, based on higher vehicle speeds, a through movement on a mainline approach *may* have a longer yellow clearance time then for a side street through movement or for a protected left-turn.

This method *may* be used when a state-owned signal is located in close proximity to signals operated in this manner by another jurisdiction. The purpose being, to address driver expectancy issues. However, assigning a single clearance interval value for all intersections and intersection movements is not recommended.

Rule of Thumb

Assigns a standardized duration for the clearance interval based on vehicle approach speed, the type of movement being made, or roadway classification. For example, mainline and side street movements *may* have the following yellow clearance interval durations:

Approach speed <30 mph = 3 seconds
Approach speed between 30-50 mph = 4 seconds
Approach speed >50 mph = 5 seconds
Protected left turns = 3 seconds

The interval times are for demonstrative purposes only. Similarly, though, all-red clearance times *may* be categorized.

This method *should* typically be used when a state-owned signal is located in close proximity to signals operated by another jurisdiction using this method to address driver expectancy issues.

SUPPORT

Even nationally, there is no clear consensus on appropriate methodology for determining vehicle clearance times ("Determining Vehicle Signal Change and Clearance Intervals", ITE, August 1994). According to ITE, "Divergent and strongly held positions are common when vehicle signal change interval lengths are discussed. Some believe that a common interval length is best, while others believe that uniform yellow change interval lengths are wrong….". This finding was verified more recently in an ITE document titled *Signal Timing Practices and Procedures – State of Practice* dated March 2004.

The kinematic methodology is typically the most desirable unless driver expectancy would be better served through the use of the other principals described above.

As stated above, since WisDOT signals routinely operate near locally owned installations, the intent *should* be uniformity across an appropriate area or along a specific corridor. As such, proper coordination with other jurisdictions *should* take place. If a crash or red light running problem exists, vehicle clearance intervals *should* be verified and, if needed, reasonably extended.

4-2-8 Battery Backup Systems May 2006

GENERAL

The recent application of LED traffic signal indications, which consume less power than conventional incandescent lamps, has made battery-powered energy backup systems feasible. However, it is recognized that, because of the cost of such systems, that gradual deployment at strategic signalized intersection locations is appropriate.

Factors that *may* influence the placement of battery backup systems are: proximity of other transportation systems, intersection geometry, traffic volumes, corridor (i.e. progressive movement) considerations, or safety considerations.

POLICY

<u>Location Criteria</u>

Signalized intersection locations that meet the criteria below **shall** be equipped with a battery backup system capable of maintaining signal operation, as defined and prioritized below:

1. RR interconnected installations, or
2. Single point urban interchanges, or
3. Intersections with triple-left turn lanes.

Signalized operations *should not* need to be modified in order to reduce energy requirements or extend service time. Rather than introducing modified signal operations or displays, signals that function with battery backup systems with low power reserves *may* go into flashing operation.

Intersections and roadway lighting **shall not** be connected to battery backup systems.

SUPPORT

Battery backup systems are expected to maintain safe and efficient traffic operations at critical signalized intersections during power outages. Of particular concern are intersections that are near railroad grade crossings (for preemption) and geometrically complex intersections.

Besides providing potential benefits to traffic safety and operations, the use of battery backup systems *may* allow increased response times by electrical personnel, which could provide an advantage in light of increased signal infrastructure and associated maintenance demands.

4-2-20 Emergency Vehicle Preemption February 2013

GENERAL

The following applies to the installation and operation of emergency vehicle preemption (EVP) systems involving traffic control signals owned and operated by the department.

POLICY

Statutory Provisions

347.255 Auxiliary lamps on emergency vehicles used to actiate traffic control signal preemption devices. (1) An authorized emergency vehicle described in ss.340.01 (3)(a), (c), (g) or (I) *may* be equipped and operated with lamps designed and used solely to activate official traffic control signal pre-emption devices. (2) The lamps authorized for use under this section *may* be any color and *may* be flashing, oscillating, rotating or pulsating. (3) No operator of an authorized emergency vehicle *may* use such lamps except when responding to an emergency call, when pursuing an actual or suspected violator of the law or when responding to, but not when returning from, a fire alarm.

The above does not preclude actuation by means of devices other than lamps.

Eligibility

Any local government unit, agency, or organization having responsibility for providing emergency services is eligible to request an EVP system.

Request Procedure

The local unit **shall** make the request in writing to the department. The following information *should* be included in the request:

1. Location of proposed EVP systems
2. Location of emergency facilities (fire station, police station, etc.) where vehicles will be departing from and description of the route to be provided with a preemption system
3. Listing or estimate of number of vehicles to be outfitted
4. Brand/model of equipment being requested.

Approval

1. The department **shall** review each request and respond in writing to the local unit as to the approval or denial of the request.
2. The department *may* deny any request that it deems would have an overall negative impact on the traveling public.
3. If the local agency is requesting a brand/model of EVP other than the department standard, the request must include a discussion about compatibility with neighboring agencies along the same corridor.
4. For approved requests, an official EVP System Agreement **shall** be prepared and approved by the department and the local unit. Template is included at the end of this policy. This policy **shall** be included as a supplement to the agreement. Any special terms or conditions beyond the scope of this policy **shall** be included as a supplement to the agreement. Any special terms or conditions beyond the scope of this policy **shall** be stipulated in the agreement.
5. The department *may* allow an indicator light that is intended to confirm o the driver of an emergency vehicle that the preemption signal has been received. The use of this device does not preclude the need of the vehicle operator to rely on the signal indications for assigned intersection right-of-way. Requests for EVP confirmation lights *should* be reviewed on a case-by-case basis, and are subject to the following conditions:
    a. The department *may* deny any request for confirmation lights that it deems would have an overall negative impact on traffic safety or operations.
    b. EVP confirmation lights **shall** only be installed at signalized intersections where:
        i. Signal(s) on the STH system are embedded in a locally-owned system that is also equipped with confirmation lights. This implies consideration for route continuity.
        ii. Or, multiple emergency vehicles have the potential to respond on conflicting

approaches to and from different points of origin. These conditions will typically exist in large urban areas where there are multiple precincts in the same municipality.

6. EVP equipment that has the ability to discriminate between individual responding vehicles **shall not** be used.
7. In the event that it comes to the attention of the department that the preemption is being misused, such as by unauthorized vehicles, or that the municipality is not using or intends to abandon the system, the department *may* notify the municipality of the situation. If the matter is not resolved and corrected, the department reserves the right to set about removing the equipment. The scheduled date of removal of the equipment is indicated in item 5 below.

Installation & Maintenance

1. Department forces **shall** perform the installation, maintenance, modification, or removal of the EVP system equipment that is located at the traffic signal. Generally, this equipment would include the receiving device (mounted on the mast arm or signal head), the phase selector (in the control cabinet), confirmation light, and any miscellaneous cables and wiring needed to operate and power the portion of the EVP system located at the signal.
2. The local unit will be responsible for the installation of the emitting devices in authorized vehicles.
3. The department **shall** maintain a reasonable inventory of spare parts for the department's selected standard equipment in order to service the EVP system equipment located t the traffic signal. If the local agency is requesting equipment other than the standard equipment, the local agency **shall** be responsible for maintaining and providing a reasonable inventory. Specify which in the agreement.
4. When notified, department forces will respond to correct suspected failures or breakdowns, or perform requested modifications in the EVP system equipment at the traffic signal.
5. Upon the department's request, the local unit will be responsible for verifying the working status of the EVP system by performing a field test using an emergency vehicle equipped with an EVP emitter device. The local unit is responsible for periodically checking the EVP equipment.
6. If used, the syle and type of confirmation lights on state- and locally-owned signals within each municipality **shall** be standardized. Confirmation lights **shall** be a LED 120 VAC white directional light that fits into a PAR 38 socket.
7. In the event of a construction project, EVP service **shall** be maintained at any intersection with permanent EVP agreements. In addition, EVP equipment may be installed, if requested by a local unit, at any additional signals within the construction project itself, or on a designated detour route in the event of a road closure.

Operation/Phase Timing

1. The department **shall** determine the phasing and timing of the preemption sequencing with input from the local unit. There are three key features that must be considered when determining how the preemption will operate:
    a. Left turn phasing (protected, protected/permissive, or permissive only)
    b. Signal head configuration for left-turning movement (shared vs. exclusive head)
        i. Shared heads: include both circular indications and arrow indications (used by through and turning vehicles)
        ii. Exclusive heads: arrow indications only (used solely by turning vehicles)
    c. Style of preemption sequencing (common greens vs. exclusive greens)
        i. Common greens: indicates opposing through phases both have a green ball. The corresponding left turn phases are permissive only.
        ii. Exclusive greens: indicates only one through movement and its corresponding left turn phase have the green ball/arrow.
2. The department offers the following operational guidance based upon the combination of those three key features identified above:
    a. Protected only left turns

            i. Exclusive head **shall** operate with exclusive greens for the safety and ease of turning of the preempting vehicle

    b. Permissive only left turns

        i. Shared head

            1. Common greens *may* be used

            2. Exclusive greens *may* be used if an all-red period is introduced or a W25-2 sign is installed.

        ii. Exclusive head:

            1. **Shall** operate with common greens since a green left turn arrow is not available for use with exclusive greens

    c. Protective/permissive left turns

        i. Shared head

            1. Common greens: *may* be used

            2. Exclusive greens *may* be used if an all-red period is introduced or a W25-2 sign is installed

        ii. Exclusive head

            1. Common greens *may* be used

            2. Exclusive greens *may* be used

3. Any exceptions to the guidance in item 2 above **shall** be included as part of the special terms or conditions of the agreement.

4. If used, the operation of confirmation lights on state- and locally-owned signals **shall** be standardized such that the approach being preempted has a steady indication. Approaches with secondary calls **shall** flash. The flash rate **shall not** be between 5 and 30 flashes per second to avoid frequencies that might cause seizures.

Driver Training

1. The local unit **shall** be responsible for training the emergency services personnel on the proper operation of the system.

2. This training *should* provide clear understanding of these items:

    a. The definition of an authorized emergency vehicle at the beginning of this policy

    b. The conditions when preemption *may* be used

    c. The use of preemption does not remove the responsibility of the vehicle operator from determining whether or not it is safe to enter the intersection

    d. The operator cannot assume that the preemption has gone into effect; the operator must rely on the traffic signal indication

    e. The proper operation of the activating device located on the vehicle.

Cost

1. The most common source of funding for a complete EVP system has been local funds or federal urban funds. However, EVP equipment at the traffic signal and installation may also be funded as part of an improvement project, provided it is incidental to the improvement. Please see Program Management Manual 3-25-5 to determine the most appropriate source of funding.

2. The local municipality **shall** be responsible for all costs associated with the emitting devices for is authorized vehicles.

3. The department **shall** be responsible for all material, equipment, labor, training, and incidental costs associated with maintaining, operating, modifying, or removing the EVP system at the traffic signal unless nonstandard EVP system equipment is used. When nonstandard equipment is installed, the local unit **shall** be responsible for maintaining and supplying spare inventory to the department.

4. Any cost associated with the continuance of service of an EVP system on temporary signals or aon a temporary route during a construction project **shall** be borne by the project.

WISCONSIN DEPARTMENT OF TRANSPORTATION

Emergency Vehicle Pre-emption (EVP) System Agreement

This is a binding agreement between the Wisconsin Department of Transportation and the

____

This agreement stipulates the terms and conditions for use of Emergency Vehicle Pre-Emption (EVP) systems at the state-owned traffic control signal located at the intersection of

____

in the ______________________ of ______________________

Description of route: ______________________________

____

Listing of estimated number of vehicles to be outfitted: ______________

____

Inventory of spare EVP equipment shall be provided by WisDOT/Local Agency.

The Department's Policy for *Use of Emergency Vehicle Pre-emption (EVP) Systems at State-Owned Traffic Control Signals is hereby* made a part of this agreement (copy attached). The following special terms or conditions also apply to this agreement:

ACCEPTED FOR THE ______________________________
Local Government

BY ______________________ DATE ______________________

TITLE ______________________

APPROVED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION

BY ______________________ DATE ______________________

TITLE ______________________

4-2-34 Signal Sequencing During Railroad Preemption — August 2023

GENERAL

Reference is made to the MUTCD, Section 4D.27 and 8C.09.

Modern signal controllers are capable of providing alternate phasing/timing plans based on train operations. Once it has been determined that a highway-rail grade crossing flashing light signal system will be interconnected with adjacent traffic signals, the traffic signal controller *should* be programmed to run an alternate sequence during railroad preemption.

Highway-rail grade crossings can be occupied by trains for extended periods of time depending on a number of operating conditions including: reduced train speeds, train length, and/or switching movements. During the time a train is located within the approach circuit and the traffic signals remain under preempted control, any non-conflicting vehicular traffic *should* be served using specialized phasing (a.k.a. railroad preemption sequencing or railroad hold sequencing) to reduce vehicular delay.

POLICY

Even if trains are not expected to occupy crossings for long periods, signal controllers *should* be programmed to run two preemption sequences. The first preemption sequence **shall** initiate a phase to clear the tracks before the train reaches the crossing. This advanced preemption places a call in the traffic signal controller to transfer right-of-way from the current phase to the track clearance phase(s) or hold if already in those phases, prior to activating the railroad warning devices.

The second preemption sequence *should* begin once the controller receives the gate down call from the railroad bungalow, a set time after the gate down notification, or after the track clearance green interval plus the additional time to prevent turning the signal red prior to gate down. At the onset of the second preemption, or if the crossing enters failsafe mode, a constant call **shall** be placed in the signal controller, causing the signal to remain preempted. At that time, the signal controller *should* be programmed to operate a sub-routine to serve traffic that does not move toward the tracks. Either blank-out signs or a red signal indication *should* prohibit vehicles from moving toward the tracks.

According to MUTCD Section 4D.27, during the transition into preempted control, the preemption sequence **shall not** shorten or omit the yellow change interval and any red clearance interval that follows. Minimum vehicular green times at actuated signals *should* be at least five seconds to allow drivers to react to the change in right-of-way and enter into the intersection.

According to MUTCD Section 4D.27, pedestrian WALK and/or pedestrian change intervals *may* be shortened or omitted in order to begin the track clearance interval earlier. This practice is not preferred since drivers might yield to crossing pedestrians, thereby preventing subsequent vehicles from clearing the tracks.

Shortened or omitted pedestrian clearance intervals are typically found in legacy systems where providing the full pedestrian change interval required a substantial increase in cost for the railroad track circuit.

For new signal designs, pedestrian clearance intervals *should not* be shortened or omitted unless all other methods to reduce the length of advance preemption time have been considered. Calculated pedestrian clearance time *may* include the yellow change interval and the red clearance interval to help satisfy the advance preemption requirements.

It is important to recognize the preemption capabilities of different signal controllers and firmware because they vary from one model or manufacturer to another. Some controllers allow minimum green times and pedestrian clearance times to be shortened during railroad preemption sequencing and others do not.

When a train no longer occupies the highway-rail grade crossing, the signal *should* serve the preempted approach immediately following preempted control before serving the mainline left-turn movements or mainline through movements if there are no left-turn phases. Additionally, the controller *should* be programmed to place calls on all initiated NEM phases upon exiting preemption.

According to MUTCD Section 4D.27, during the transition out of preempted control, the preemption sequence **shall not** shorten or omit the yellow change interval and any red clearance interval that follows.

Eliminating the Left Turn Trap

When a protected/permitted phasing sequence is used for the track clearance phase, special consideration *should* be taken to eliminate the possibility of the left-turn trap at the onset of railroad preemption.

For example, if the preempted approach is already green when the preemption call is received (beset case scenario), the signal *should* finish servicing the minimum green time and yellow change interval before going into an all=red sequence. After the all-red sequence the track clearance phase(s) *should* display a left-turn green arrow and a green ball indication. This will allow the track clearance phase to serve a protected left-turn movement and eliminate a left-turn trap condition.

Inspection of Signal Sequencing During Railroad Preemption

State-maintained traffic signals with railroad preemption sequencing **shall** be inspected on an annual basis. Regional traffic engineers are responsible for ensuring that each state-maintained traffic signal is inspected.

At a minimum, the preemption inspection team *should* consist of an individual representing the traffic signal operating agency and an individual representing the railroad authority. This cooperative approach is critical to the success of the inspection because the operation of railroad preemption systems is dependent on both the railroad and highway equipment.

A copy of the completed inspection **shall** be forwarded to the grade crossing safety engineer at the WisDOT Railroads & Harbors Section (RHS) in the Bureau of Transit & Local Roads (BTLR). The annual Highway-Railroad Preemption Inspection Form is provided below.

Second Train Re-Service Considerations

Where a railroad crossing has more than one through track, special consideration must be given to operation of the warning devices and traffic signal when a second train follows the first train.

The point at which preemption is released from the railroad active warning devices to the traffic control signals is critical to the proper operation of preemption re-service. In order for the traffic signal controller to recognize the second train, the preempt call for first train must be released. The railroad active warning devices must release the preempt call just as the gates begin to raise, otherwise traffic *may* drive under the ascending gates and this traffic must be cleared in the event of a second train.

SUPPORT

According to MUTCD Section 4D.27, "Traffic control signals operating under preemption control or under priority control *should* be operated in a manner designed to keep traffic moving."

Figure 1. WisDOT Railroad Preemption Inspection Form

WisDOT RAILROAD PREEMPTION INSPECTION FORM

1. REVIEW TEAM

TRAFFIC SIGNAL INSPECTION COMPLETED BY:		INSPECTION DATE:	
RAILROAD INSPECTION COMPLETED BY:		DATE OF LAST INSPECTION:	

2. LOCATION DATA

HIGHWAY INTERSECTION:		MUNICIPALITY:	COUNTY:
TRAFFIC SIGNAL OPERATING AGENCY:	SIGNAL ID: (ex. S1056)	SIGNAL CONTACT:	SIGNAL CONTACT PHONE:
RAILROAD OPERATING COMPANY:	RR CROSSING ID: (ex. 391768X)	RR CONTACT:	RR CONTACT PHONE:
TRAFFIC SIGNAL EMERGENCY CONTACT NUMBER:		RAILROAD EMERGENCY CONTACT NUMBER:	

3. RAILROAD DATA

ACTIVE WARNING DEVICES: ☐ 3 or 4-Quadrant Gates ☐ 2-Quadrant Gates ☐ Flashers	
MAXIMUM TRAIN SPEED (MPH):	SPEED RANGE OVER XING (MPH):
NUMBER OF TRAINS PER DAY:	NUMBER OF TRACKS:
AVAILABLE CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	
USED CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	
CIRCUIT NOTES: APPT = Advanced Pedestrian Preemption APT = Advance Preemption GD = Gate Down HC = Health Circuit Sup = Supervisor	XR = Island Circuit

4. TRAFFIC SIGNAL DATA

CABINET TYPE: ☐ TS1 ☐ TS2	CONTROLLER MAKE & MODEL:
TYPE OF SIGNAL PREEMPTION: ☐ Advanced ☐ Simultaneous	BLANKOUT SIGNS PRESENT? ☐ Yes ☐ No
OTHER TYPES OF PREEMPTION: ☐ Emergency Vehicle ☐ Bus/Transit	DOES RR PREEMPT HAVE PRIORITY? ☐ Yes ☐ No
BATTERY BACKUP PRESENT? ☐ Yes ☐ No	BATTERY BACKUP COMMUNICATION? ☐ Yes ☐ No
AVAILABLE CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	
USED CIRCUITS: ☐ APPT ☐ APT ☐ GD ☐ HC ☐ Sup ☐ XR	
VEHICULAR PHASES PRESENT: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8	
PEDESTRIAN PHASES PRESENT: ☐ 2 ☐ 4 ☐ 6 ☐ 8	OTHER PHASES PRESENT:

5. RAILROAD EQUIPMENT TIMERS

RAILROAD SETTINGS	DESIGNED	MEASURED	NOTES
Equipment Reaction Time (ERT):	sec.		
Advanced Pedestrian Preemption Time (APPT):	sec.	sec.	
Advanced Preemption Time (APT):	sec.	sec.	
Minimum Warning Time (MWT):	sec.		
Additional Clearance Time (CT): (overspeed tolerance, wide/angled crossings)	sec.		
Buffer Time (BT):	sec.		
Total Warning Time (MWT + CT + BT):	sec.		

6. DESIGN RAILROAD PREEMPTION PHASING SEQUENCE

WORST CASE CONFLICTING PHASES				TRACK CLEARANCE PHASE(S)	PREEMPT DWELL PHASES	PREEMPT CYCLE PHASES
Vehicle:		Pedestrian:				

7. TRAFFIC SIGNAL TIMINGS				
CONTROLLER SETTINGS	DESIGNED	PROGRAMMED	MEASURED	NOTES
Preempt Delay:	sec.	sec.		
Entrance Min Green:	sec.	sec.	sec.	
Entrance Walk + Ped Clear:	sec.	sec.	sec.	
Entrance Yellow + Entrance Red:	sec.	sec.	sec.	
Maximum RWTT (Delay + Min G + Y + R or Delay + Walk + Ped Clear + Y + R):	sec.	sec.		
Track Clear Min Green:	sec.	sec.	sec.	
Track Clear Ext Green:	sec.	sec.	sec.	
Track Clear Max Green:		sec.		
Min Dwell:		sec.	sec.	
Dwell Preemption Ext:		sec.	sec.	

8. FIELD TESTING AND INSPECTION		
		NOTES
DO THE RAILROAD FLASHERS OPERATE AS EXPECTED?	☐ Yes ☐ No	
DO THE RAILROAD GATES OPERATE AS EXPECTED?	☐ Yes ☐ No	
ARE THE BLANK OUT SIGNS WORKING PROPERLY?	☐ Yes ☐ No ☐ NA	
DOES A PREEMPT CALL TRIGGER RIGHT OF WAY TRANSFER?	☐ Yes ☐ No	
DOES A PROTECTED ARROW COME UP FOR TRACK CLEARANCE?	☐ Yes ☐ No	
DOES GATE DOWN RELEASE TRACK CLEAR PHASE?	☐ Yes ☐ No ☐ NA	
PROPER DWELL/CYCLE PHASES OPERATE?	☐ Yes ☐ No ☐ NA	
IS THE PREEMPT CALL RELEASED AT BEGINNING OF GATE ASCENT?	☐ Yes ☐ No	
DOES THE SIGNAL EXIT TO THE PROPER PHASE UPON RELEASE OF PREEMPT?	☐ Yes ☐ No	
DOES PREEMPT RESERVICE ACTIVATE?	☐ Yes ☐ No	
ARE EXEMPT SIGNS POSTED AT THE CROSSING?	☐ Yes ☐ No	
ARE EMERGENCY CONTACT STICKERS IN SIGNAL CABINET AND BUNGALOW?	☐ Yes ☐ No	

9. OTHER INFORMATION / NOTES

- Railroad Preemption Inspection form
- WisDOT Railroad Preemption Inspection form

6-6-20 One-Lane Bridges **June 2004**

PURPOSE

The purpose of this subject is to provide some general guidelines for the selection of traffic signal control vs. stop sign controls at long-term (non-flagging) one-lane bridge construction sites. Since each one-lane bridge site is unique, a site-specific investigation of the factors affecting the selection *should* be done. A number of variables can influence the selection, so a definitive breakpoint between the two options cannot be defined. This subject will provide a discussion of the variables which *should* be analyzed and provide some general guidelines on the selection process.

FACTORS INFLUENCING THE CONTROL SELECTION

The following factors *should* be considered when evaluating the type of control at one-lane bridge sites.

1. Average Daily Traffic (ADT). This is a good general indicator in the selection process. Below 1,000 ADT or 100 vehicles per hour, a STOP sign control can usually be used without experiencing operational problems. Above 3,000 ADT, a traffic signal is usually a better choice for more efficient operation. These ADT values are not absolute and the other factors must be considered in the selection process.
2. Peak-Hour Traffic. If the bridge site is located near a larger city or on a recreational travel route or carries special event traffic, the peak-hour traffic will be a greater factor than the ADT. The bridge control must be able to accommodate the peak-hour traffic within a reasonable amount of time delay.
3. Directional Traffic Distribution. This again will be a factor if the bridge site is located just outside a large city on a route which is a major radial commuting route, or is a major recreational route.
4. Width Restriction. The width *may* influence the speed of traffic, increasing the clearance time necessary for a single vehicle to cross the bridge. The additional clearance time will reduce the capacity of both a stop-control and signal-control bridge site.
5. Time Duration of Project. For shorter projects (1-2 weeks), it *may* be acceptable to tolerate slightly oversaturated stop-control conditions, rather than implement a signal-control scheme.
6. Distance between Stoplines. This will greatly affect the one-lane capacity because it will dictate the clearance time necessary for a vehicle to cross the bridge. The stoplines *should* be kept as close as possible to the ends of the bridge allowing for necessary storage of construction equipment and placement of traffic control devices. Typically, each stopline *should* be placed about 150-250 feet from the end of the bridge. This allows workspace (usually less than 100 feet) for the contractor off the end of the bridge and a taper for the single-lane transition. With this constraint, the typical stopline-to-stopline distance is 300-500 feet, plus the length of the bridge. See SDD 15D33 (Traffic Control, One Lane Road with Temporary Signals) and 15D32 (Traffic Control, One Lane Road Stop Condition) for more details on dimensions and traffic control layout.

   On projects which involve bridge approach resurfacing of several hundred feet, the bridge work involving the one-lane controls *should* be staged first, thus allowing the closest stopline-to-stopline distance possible. Then, after the bridgework is completed, the one-lane bridge controls can be removed. The approach resurfacing can be completed by using a flagging operation. Further discussion is found under Special Cases.
7. Sight Distance between Stoplines. This factor in itself could dictate the control type. If adequate sight distance is not available (if bridge is an overpass on a sharp crest, or construction equipment or temporary concrete barrier is expected to block site), then traffic signal control must be used to assign right-of-way across the one-lane bridge. The stop-control situation, which is self-regulating, would fail without adequate sight distance, because it relies on motorists to see each other in order to determine which vehicle has the right-of-way.

GENERAL

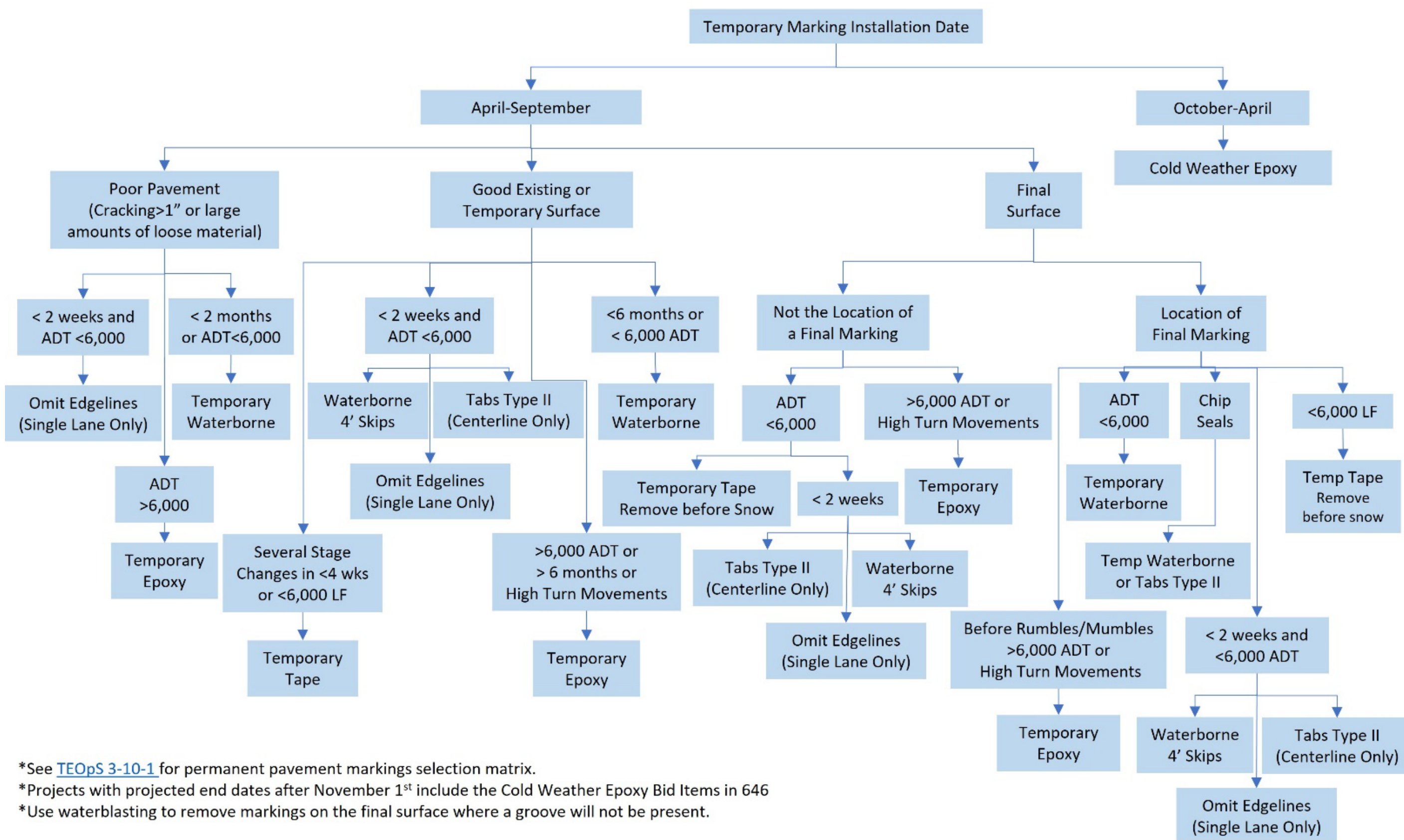
Temporary Pavement Markings help delineate the roadway during a construction project.

POLICY

Temporary Pavement Markings **shall** resemble the width and color of the permanent pavement markings. Temporary Pavement Markings can be one of the markings listed below:

1. Transition Areas, Lane Shifts, and Crossovers *may* use the following marking for emphasis:
    - Contrast lane lines (removable tape)
    - Type I temporary raised pavement markers
    - Solid lines (any product)
2. Same Day Marking
    - When the final marking needs to be placed quickly because the roadway is open to traffic.

Temporary Marking Selection



*See TEOpS 3-10-1 for permanent pavement markings selection matrix.
*Projects with projected end dates after November 1st include the Cold Weather Epoxy Bid Items in 646
*Use waterblasting to remove markings on the final surface where a groove will not be present.

12-2-1 Wisconsin Strategic Highway Safety Plan — August 2023

Wisconsin's Strategic Highway Safety Plan (SHSP) is a statewide, comprehensive, and data-driven plan that implements the framework for supporting the safety goals. This plan identifies and examines a variety of issue areas and provides tasks with the most potential to reduce roadway crashes. By working with community partners such as law enforcement, emergency responders, health care providers, and local County Traffic Safety Commissions, WisDOT is committed to keep travelers safe on our roads. The SHSP examines a variety of factors that affect highway safety in Wisconsin. Goals of the SHSP include:

- Improve Safety Culture, Safety Data, and Safety Technology
- Reduce Driver Distraction/Improve Driver Alertness
- Reduce Alcohol and Drug-Impaired Driving
- Reduce the Incidence and Severity of Motorcycle Crashes
- Improve Driver Performance (Teens, Older and Competent)
- Improve Non-Motorist Safety
- Improve Safety of Intersections
- Increase Occupant Protection
- Curb Aggressive Driving/Reduce Speed-Related Crashes
- Reduce Lane Departure Crashes
- Improve Work Zone Safety

The SHSP provides direction for future safety programs and strategies that are implemented in Wisconsin. This document is a requirement by the Federal Highway Administration. Each plan is developed in a cooperative process with Local, State, Federal, Tribal, and other public and private sector stakeholders.

12-2-2 Zero in Wisconsin — April 2023

In pursuit of the goals identified in Wisconsin's SHSP, WisDOT has advocated for *Zero in Wisconsin*, a program that advocates for safe driving practices and strives to eliminate all preventable traffic-related deaths on Wisconsin roadways. WisDOT does not tacitly accept deaths and injuries; its citizens and state policy makers work together towards achieving zero fatalities and serious injuries on our roadways.

The program provides information and resources about occupant protection, impaired driving, distracted driving, speeding, and aggressive driving, as well as pedestrian and bicycle safety.

Transportation safety involves a multifaceted approach to improve safety. Community Maps was developed to help support and enhance traffic safety planning, resource allocation, and decision support at the local level. This provides the public and local agencies a statewide map of all law enforcement reported motor vehicle crashes.

12-2-3 Safe System Approach — April 2023

The Safe System Approach aims to eliminate fatal and serious injuries for all roadway users. This is accomplished by minimizing the risks involved in using transportation systems. It is a holistic approach that accounts for human mistakes and human vulnerability with redundancies in place to protect users. The Safe System Approach is comprised of the following principles:

- Death and serious injury are unacceptable
- Humans make mistakes
- Humans are vulnerable
- Shared responsibility
- Safety must be proactive
- Redundancy is crucial

The Safe System Approach aims to design and operate our vehicles and infrastructure to anticipate human error to minimize the risk of fatal and serious injuries. This is accomplished by utilizing roadway design or having redundancies in place so that if a crash takes place the impact energy on the human body occurs at a tolerable level. It also seeks to expand the availability of vehicle systems and features that prevent and minimize the impact of crashes. The Safe System Approach also aims to enhance the survivability of crashes with prompt emergency medical care, while also facilitating a safe work environment for first responders via effective incident management practices.

There are five elements to the Safe System Approach that build on one another to create layers of protection for all road users. These are: safe road users, safe vehicles, safe speeds, safe roads, and post-crash care. With each of these elements in place, it creates a holistic approach to minimize fatal and serious injuries.

Figure 1: The Safe System Approach Principals and Elements

Safe Roads Measures: Systematic, Systemic and Spot Infrastructure Improvements, Design, Education, Training, Awareness, Technology, Legislation, Data

Safe Road Users Measures: Education, Training, Awareness, Enforcement, Technology, Data, Legislation

Safe Vehicles Measures: Technology, Legislation, Education

Safe Speeds Measures: Design/Target Speed, Education, Training, Awareness, Enforcement, Infrastructure Improvements, Technology, Data, Legislation

Post-Crash Care Measures: Quick Crash Scene Clearance, Quick Emergency Response, Crash Analysis, Education