4-2-1 Capacity Analysis — April 2025

INTERSECTION CAPACITY ANALYSIS

In cases where the Signal Investigation Study indicates a traffic signal is warranted, the maintaining authority or its agents **shall** compute the capacity and level of service for the future signalized intersection during the peak hour periods for construction, as well as design or horizon year volumes. If no projection information is readily available, reasonable assumptions *should* be made to extrapolate turning movement volumes to the design/horizon year levels. It is typically assumed that traffic growth increases at a rate of 2 percent per year.

Capacity analysis *should* be based on actual turning movement volume counts and projected turning movement volumes. Only turning movement counts conducted within the previous three years *should* be used for capacity analysis. Refer to FDM 11-5-2 for information related to requesting traffic volume forecasts.

The purpose of the analysis is to determine proper intersection geometric design, and to begin to develop appropriate signal phasing and timing plans. If the signal is to be located on the STH system, an electronic version of the intersection capacity analysis **shall** be shared with the Regional Traffic Signal staff for review.

The analysis of the unsignalized vs. signalized intersection provides additional information for the review of the study, the design of the signal, and the need for possible geometric improvements. Signals that are a part of, or adjacent to, a coordinated system **shall** be studied as part of a systems analysis. In these cases, a traffic simulation model *may* also need to be developed, particularly when developing signal timing plans.

Computer software **shall** be used to determine the intersection capacity and using current versions of software as identified by FDM 11-05-03, section 3.7.

Capacity analyses that are performed for state-maintained signals **shall** be supplemented with a technical memorandum summarizing analysis results using existing and/or proposed geometrics and recommending preferred phasing and timing alternatives. The technical memorandum and capacity analysis **shall** be provided to Regional Traffic Signal Engineers in electronic and hard copy form.

BASIC PARAMETERS FOR CAPACITY ANALYSIS

GENERAL SIGNAL TIMING ANALYSIS PARAMETERS

Note: The Signal Timing Analysis Parameters below are recommended guidelines for general analysis of state-owned signals at typical at-grade intersections. For analysis that is conducted to determine actual design parameters (such as turn bay lengths) or for analysis of complex signals (such as at an interchange), contact the appropriate Region to check for additional regional guidance prior to submitting the analysis.

Minimum Green Values:

Mainline Through Phases (2 & 6) – 10 to 15 secs

Side Street Through Phases (4 & 8) – 7 to 10 secs

Mainline & Side Street Left Turn Phases (1,3,5,7) – 5 or 6 secs for single lanes, 8 secs for dual lanes.

Maximum Green Values:

Mainline Through Phases (2 & 6) – 35 to 70 secs

Side Street Through Phases (4 & 8) – 25 to 40 sec.

Note: At intersection of two STHs, on the lower volume STH a lower max time may be used.

Mainline & Side Street Left Turn Phases (1,3,5,7) – 15 to 35 sec.

Clearance Intervals:

Use ITE's kinematic formula for determining clearance intervals for signal installations on the STH system. Refer to TEOpS 4-7-5, Clearance Intervals.

Pedestrian Phase Times:

Walk Time – 7 sec.

Ped Clearance Time – [(Distance from curb to curb)/(3.5 ft/sec)].

Note: If it is known that Children or Elderly use the intersection, a walking speed of less than 3.5 ft/sec may be considered.

Ped Check – Walk Time + Ped Clearance Time ≥ the amount of time it takes for a person walking 3 ft/sec to cross from the pedestrian detector to the far side of the traveled way being crossed. Any additional time that is required to satisfy this condition *should* be added to the Walk Time.

Isolated Signal Cycle Lengths:

Typically Range from 60 secs – 120 sec.

Coordinated Signal Cycle Lengths:

Typically Range from 80 secs – 130 sec.

Interchanges:

Typically Range from 100 – 130 sec.

GENERAL SIGNAL ANALYSIS REVIEW PARAMETERS

1. PHF – Verify that the correct PHF is used.
2. % Heavy Vehicles – Verify that correct % Heavy Vehicles are used.
3. RTOR – Refer to TEOps 16-15-5.
4. Ideal Saturation Flow Rate – Ideal Saturation Flow Rate used for left-turn and through movements **shall** be 1900. If any other Ideal Saturation Flow Rate is used it must be supported by a study performed in a comparable location, with similar characteristics, and same geographical area.
5. Phasing –Verify that sequence of operation (phasing) is correct for existing conditions and that changes to existing phasing for future conditions are reasonable and *should* consider any necessary geometric changes. Split phasing on the mainline **shall** only be considered as last resort in extreme cases.
6. Geometric Design – Verify dimensions of turn bay lengths and that the existing/proposed lane configuration is appropriate and corresponds between field conditions, signal plan information and sequence of operations sheets.
7. Turning movement Volumes – Verify that the input volumes used in the analyses are correct.
9. Left Turn Requirements – Verify that under existing or future conditions that left turn movements are accounted for by signal phasing. A protected/permissive or protected only left turn phase **shall** be considered in accordance with the Left-turn Conflict Analysis.
10. Coordinated Signal System Analysis – When signals are in a coordinated system and pedestrian phases are present, verify that minimum green time given to through phase is enough time to cross pedestrians curb to curb unless pedestrian actuation is used.

4-2-2 Intersection Geometrics April 2025

BASIC GUIDELINES FOR INTERSECTION DESIGN

The following is a set of guidelines used by Regional Traffic Engineers for the review process of intersection geometrics submitted by Project Development and Consultants. These standards **shall** be followed when designing an intersection that *may* be signalized in the next 5 to 10 years or revising an existing signalized intersection. The guidelines contained in this chapter are a supplement to those found in the FDM 11-25.

The Regional Traffic Engineer *should* review the recommended queue length storage for left and right turns based on the capacity analysis. Intersection design *should not* be based solely on capacity analysis but also based on operation requirements. Additional considerations are listed below.

- When designing an intersection keep in mind that even if traffic signals are not an immediate design criteria, signals *may* be needed in the future.
- It is very important to include Traffic Operations personnel early in the scoping of a project. Volumes, storage, geometric, and R/W needs *should* be addressed. It can then be determined if further involvement of Traffic Operations is needed.
- Verify that the intersection design meets these criteria before R/W becomes an issue or is purchased.
- For proposed or reconstructed intersections, use desirable design criteria, not minimum. R/W restrictions are taken into consideration on modifications to existing intersections.
- Intersections *should* not be located on curves (horizontal or vertical). Experience has shown that motorists don't handle these situations well even if adequate sight distance is provided.
- Design of any signalized intersection **shall** consider applicability of heavy vehicles. All right turns and both opposing left turn movements *may* need to accommodate WB-67 vehicles. This includes two WB-67 vehicles making opposing left turns at the same time. Higher consideration for Oversized/Overweight vehicle turning movements *should* be given at locations within five miles along long-truck routes. Refer to FDM 11-25-2, Intersections at Grade – Design Criteria & Guidelines.
- Intersection geometrics **shall** be designed using turning templates. The intersection plan with turning template overlay **shall** be submitted to the Regional Traffic Unit for review.

Refer to FDM 11-25-1, *Intersections At Grade – General*

- Selection of Intersection Criteria
- Rural Intersections
- Urban Intersections

RIGHT-OF-WAY

Public right-of-way at STH intersections needs to accommodate design geometrics (for existing & future conditions), operations-related infrastructure, and adequate sight distance. All WisDOT maintained signal & electrical equipment **shall** be located within the public right-of-way. Such signal equipment typically includes cabinet bases, signal/lighting bases, vehicle detection, associated conductor runs, and *may* also include temporary signal support guy lines.

As a last resort when equipment cannot be located within the public right-of-way (i.e., far loops in mall entrances), it **shall** be necessary to have an established permitted limited easement (PLE) to access private lands before electrical staff can perform associated maintenance activities. Note: This could be problematic if it is necessary to install additional equipment or if repairs are time sensitive.

Consideration *should* also be given to future capacity expansion. Examples of this *may* include right- & left-turn lanes, widened medians, sidewalk, bike lanes, roundabouts or interchanges. Because of these issues, Regional Traffic Engineering staff **shall** be involved in identifying required right-of-way at signalized intersections early in the design process.

CORRIDOR CONSIDERATIONS

The design of an individual intersection will not only need to provide a safe environment with adequate capacity but will also need to reflect the needs of adjacent intersections and the corridor. As such, isolated intersection designs *may* need to include features not dictated by capacity alone. These features *should* be coherent with the overall facility, examples of which *may* include turn lanes, separation of turn lanes from adjacent through lanes, raised medians, islands, and separated bicycle facilities. Right-of-way *may* also need to be preserved for future corridor-based improvements.

The proximity of adjacent intersections to locations that are or *may* be signalized *should* be maintained at a minimum of 1200-ft. The distance to adjacent private driveways also need to be considered, especially as to how traffic along the corridor and at various access points interact.

Refer to FDM 11-30-1, Interchange – Design Elements regarding ramp terminal spacing and FDM 11-5-5, Access Control – Attachment 5.1 for access spacing guidelines.

DESIGN VEHICLE AND TRUCK TURNING

The design vehicle used to determine intersection geometrics at locations that *may* be signalized **shall** be at least a WB-62. If the area being designed is known to have WB-65 or WB-67s, that design vehicle *should* be used. Using the appropriate sized design vehicle has significant impacts on intersection operation and signal efficiency.

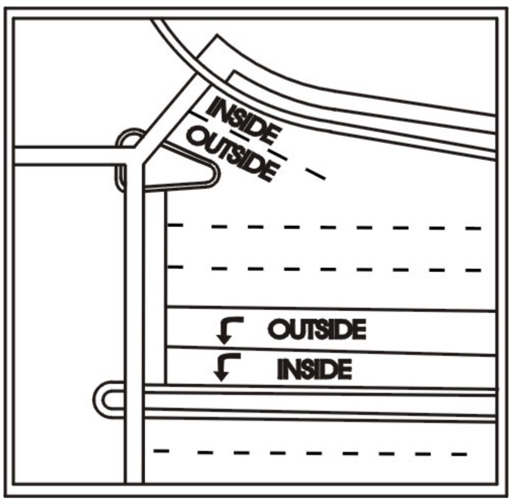
Movements *should* allow for the appropriate design vehicle~~s~~ to turn with a smooth continuous radius. Opposing left turns require a minimum of 3' clearance at the center of the intersection as they pass the opposing vehicle.

Dual lefts are typically designed for the truck (WB-62) using the outside lane a single unit using the lane. There *should* be a minimum of 3' between the vehicles as they turn with each other. Refer to Figure 2.1 for clarification on outside and inside lane terminology for dual left turn lanes.

Dual rights are designed for the truck (WB-62) using the outside lane and a single unit using the inside lane. There *should* be a minimum of 3' between the vehicles as they turn with each other.

Refer to FDM 11-25-2, *Intersections at Grade – Design Criteria & Guidelines*.

Figure 2.1. Outside and Inside Lanes for Left and Right dual turn lanes.

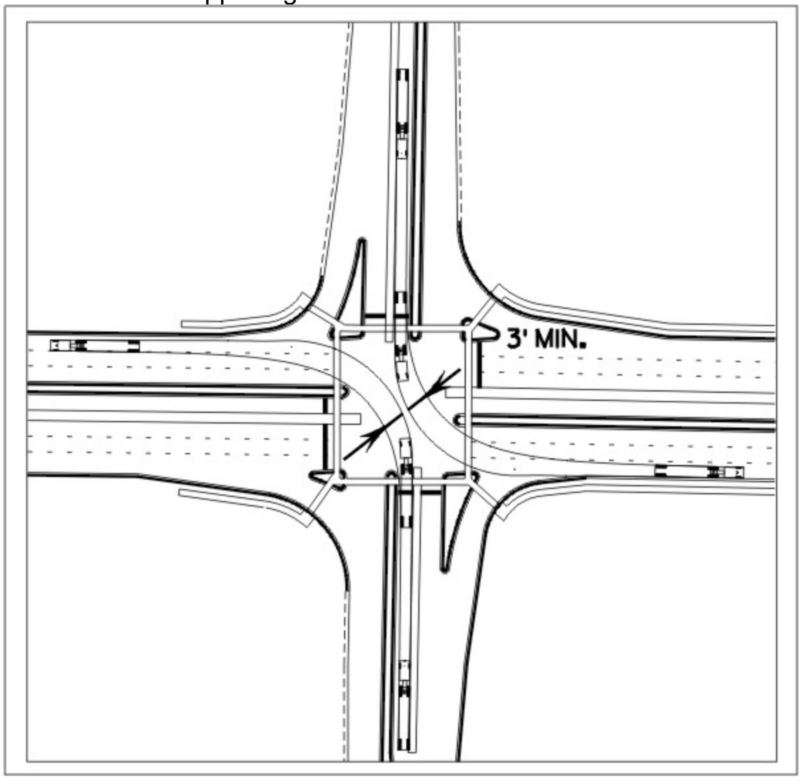


Left turning trucks *should not* encroach on the left turn lane for the approach that they are entering when making their left turn. Trucks need not be restricted to the nearest lane when making a turn. Trucks *may* encroach into other lanes on multiple lane roadways (not across the centerline for trucks making a right turn movement, in this case the stop line *may* be pulled back). Parking *may* need to be restricted at intersections to aid in truck turning movements.

Specific routes along the state-system have been established to accommodate either Over-sized/Over-weight (OSOW) and/or Over-height (OH) vehicles. Check with the Region Traffic Engineer to determine appropriate design requirements that *may* be needed for specific locations.

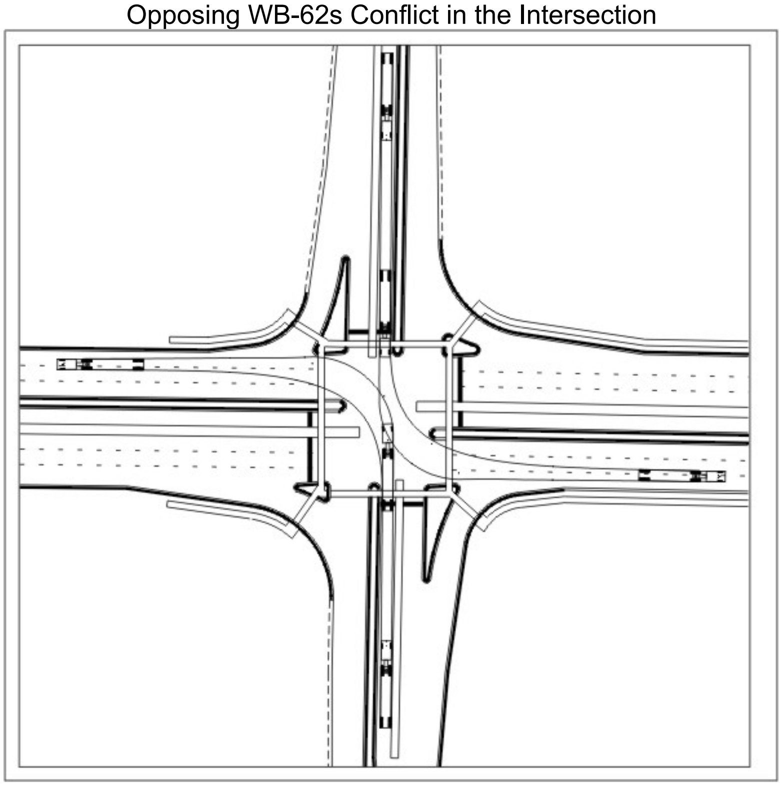
CORRECT

Opposing WB-62's Clear Each Other

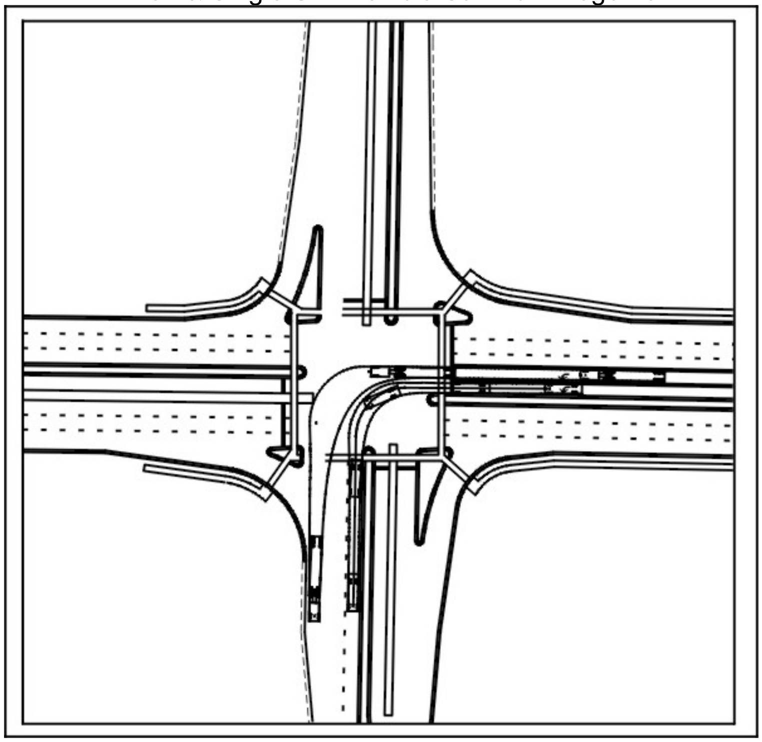


INCORRECT

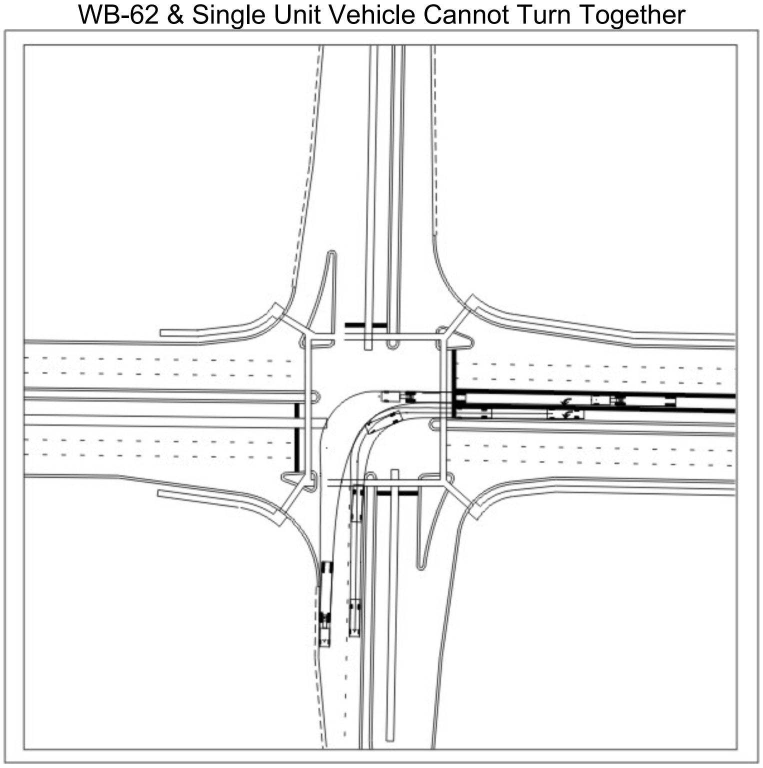
Opposing WB-62s Conflict in the Intersection



CORRECT
WB-62 & Single Unit Vehicle Can Turn Together



INCORRECT
WB-62 & Single Unit Vehicle Cannot Turn Together



LEFT TURN LANES

Refer to [FDM 11-25-5, Intersections at Grade – Left Turn Lanes]

The width of a left turn lane *should* desirably be the same as the width of the through lane. A left turn lane width of 12 feet *should* be used on rural and suburban arterial highways.

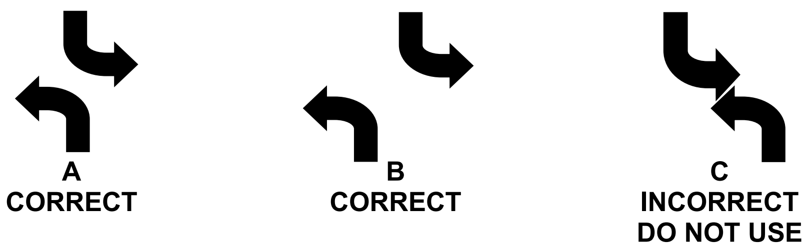
With the general exception of interchange ramp terminals, it is desirable to separate left turn lanes from the adjacent through movement at intersections on the STH system. Separation *may* be accomplished by the following different ways:

- Raised median including slotted left turn lanes
- Pavement Marking
- Corrugated median (generally not desirable)

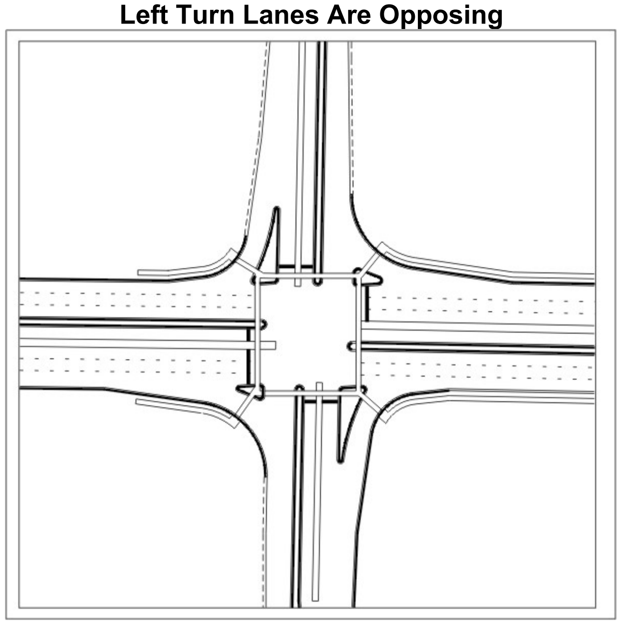
The Regional Traffic Engineer **shall** be consulted when selecting proper channelization methods.

The ideal alignment of left turn lanes is to have opposing left turns directly opposite (head-to-head) of each other (A) or to positively offset them as shown in (B). For visibility and safety reasons, the alignment shown in (C) *should not* be used.

- Alignment of left turn lanes is critical to enable turning vehicles to see past opposing left turners and view opposing through vehicles to allow them to pick an adequate gap to complete their maneuver.
- If there is poor alignment, Traffic Operations *may* be faced with prematurely adding protected left turn arrows for low volume left turn movements due to crashes that occur due to poor visibility. This will increase the delay at the intersection. See the Incorrect and Correct left turn design figures.
- It is sometimes advantageous to "hook" the ends of the left turn lane, which enables better sight around left turners in a "tight" intersection.



CORRECT
Left Turn Lanes Are Opposing



When designing dual left turn lanes, it is extremely important that opposing left turns complete their movements simultaneously. Dual left turn lanes do not need to be designed to accommodate two WB-62 vehicles, or larger, turning side by side since the chance of this occurring is quite remote, but rather a single unit vehicle in the inside turn lane and a truck (WB-62) in the outside turn lane.

1. Left turn lanes *should* be provided at signalized intersections wherever the turns are permitted.

2. Shared left turn lanes are not desirable and *should* only be allowed along minor low-speed streets or where it is physically impossible to develop protected lanes. If allowed, their crash history *should* be monitored, especially along principal roads.

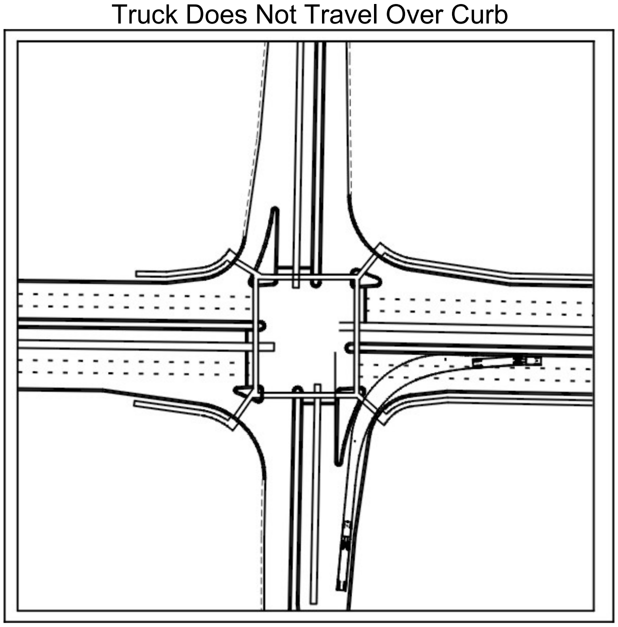
3. Dual left turn lanes are desirable and *should* be considered where left turn volumes exceed 300 vph (depends on opposing volumes). These lanes require sufficient width on the receiving roadway to accommodate design vehicles running side-by-side. The receiving roadway **shall** carry two through lanes a sufficient distance to allow both lanes to be utilized effectively (typically 1000 feet minimum).

RIGHT TURN LANES

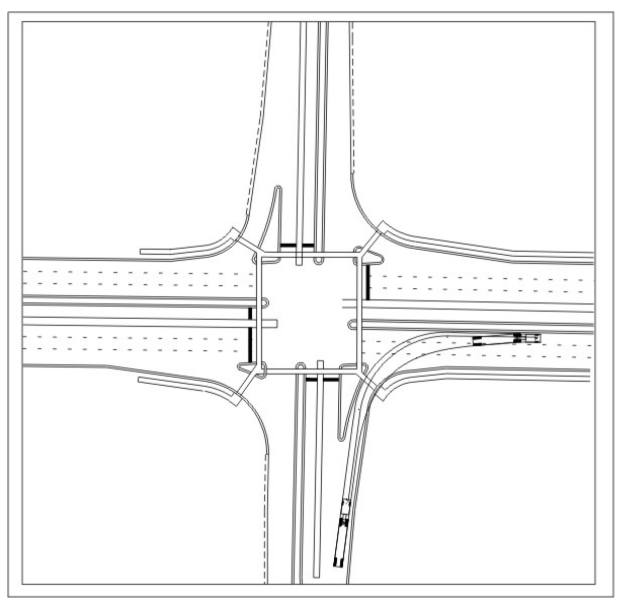
Refer to FDM 11-25-10, Intersection at Grade, Right Turn Lanes and FDM 11-25-15, Intersection at Grade, Turning Roadways (Channelized Right)

- Exclusive right turn lanes *should* always be considered on all approaches.
  - A right turn lane provides refuge for safe deceleration outside a high speed through lane and provides storage for right-turning vehicles to assist in optimizing traffic signal phasing.
- When the design of the radius is quite flat (i.e., > 70'), this creates a traffic signal design problem when locating the near right traffic signal. The preferred solution is to design a small pork chop island (minimum of 150 square feet) to place the traffic signal and lighting bases, pull box, pedestrian pushbuttons, pedestrian walkways, and to facilitate channelization of the right turn movement.
- Improperly designed right turn radii most likely will result in traffic signal knockdowns.
- For speeds more than 40 mph, the island *should* be offset 8-10 feet from the adjacent through lane.
- Consideration *should* be given for the type of controls to use for channelized right turns. Typically, it is preferred to use a least restrictive method and increase the degree of control as volumes, safety, and geometric conditions dictate.
- Channelized right turns *should* be brought in as near as perpendicular as possible for vision to the left.
- Adequate R/W width *should* be provided for future right turn lane expansion.

CORRECT
Truck Does Not Travel Over Curb



INCORRECT



MEDIANS AND ISLANDS

The desired minimum width for a median at a signalized intersection is 8 feet face to face, the absolute minimum width is 6 feet face to face. This width is required for signal and sign/structure placement, and pedestrian refuge. In addition, this minimum is wider than the wheelbase of a typical passenger vehicle and therefore if in an accident a vehicle traverses the median it *may* knock down the traffic signal standard but will not damage the bolts in the concrete base.

Right turn pork chop islands are typically needed for delineation, pedestrian refuge, and traffic signal placement at intersections with flat radii. This island *should* be no smaller than 150 square feet in area. It is inevitable revisions at a signalized intersection will need to be made at some point in the future. Therefore, the construction of islands is very important. Islands constructed as in Figure 2.2 are not desired because to install a pull box or base would require removal of 12”, + of concrete. The detail shown in Figure 2.3 is the preferred construction. Pork chop islands *should* be skewed to improve visibility for approaching vehicles.

Slotted left-turn islands *should* be set back for clarity of turning movement as shown in Figure 2.4.

Figure 2.2. Non-desirable island design

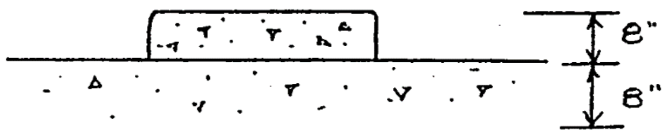
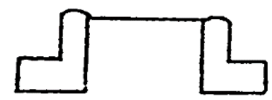


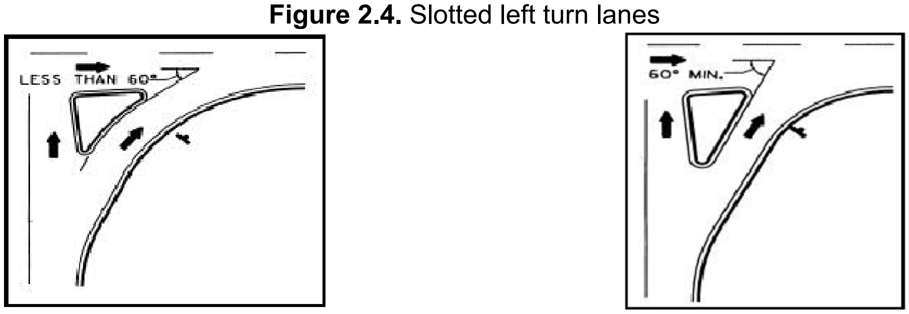
Figure 2.3. Desirable island design



Plowable noses *may* be an issue with pedestrian crossings. A cut-through *may* be necessary for pushbuttons to be pedestrian accessible. Coordination with design staff *should* take place to ensure proper placement of pedestrian crossing and signal bases.

Designers *should* be aware of the hazards that develop when right turn lanes separated by islands having intersecting angles less than 60 degrees with the cross street. These layouts require the driver to look back over their left shoulder to view oncoming traffic; this is particularly difficult for older drivers. Designers are encouraged to design all right turn islands in urban/suburban areas with the right-turn lane at an angle of 60 degrees or greater. 10:1 tapers on the approach to the right-turn lane *should* be used to allow the driver adequate time to decide and maneuver their vehicle in the direction of choice.

Figure 2.4. Slotted left turn lanes



Not Recommended | Recommended

PEDESTRIANS

Intersections *should* be designed to accommodate pedestrian traffic whenever required. The surrounding area *should* be surveyed for schools, development which *may* lend towards pedestrian traffic, elderly housing, group homes, etc. to determine if pedestrian indications *should* be included. Pedestrian provisions need to include signal infrastructure design requirements and pushbutton placement that are ADA compliant. For more information on accessible design requirements refer to FDM 11-46-10, Curb Ramps or go to www.access-board.gov.

Traffic signal standards/poles *should* be located to accommodate the addition of pedestrian signals and pushbuttons in the future. To accomplish this the standards/poles must be located within 2 feet of the sidewalk and or crosswalk. Be sure the button is placed on the correct side of the pole.

It is recommended to place a pedestrian crossing on the right side of a T-intersection to prevent left turning vehicles from queuing due to pedestrians in the crosswalk. Refer to Figure 2.5 for typical layouts of crosswalks at a signalized intersection.

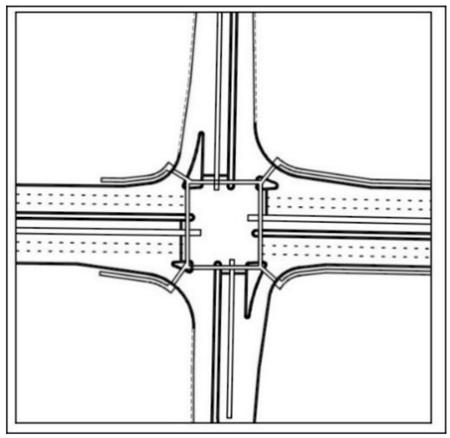
If there is no channelized right turn, the preferred design incorporates Type 2 curb ramps. These are particularly desirable in locations where visually impaired pedestrians *may* use the intersection. A Type 2 curb ramp will properly align pedestrians with the correct crosswalks whereas a Type 1 curb ramp will orient the pedestrian into the middle of the intersection.

If there is a channelized right turn, the preferred curb ramp design incorporates a Type 1 curb ramp that will direct pedestrians to the channelizing island (porkchop). Pedestrians *should* then be directed to cross the mainline or side street accordingly. This method implies that the channelizing island (porkchop) is large enough (150 ft^2 minimum) to accommodate space for pedestrians/bicycle cut-throughs, pull boxes, signal bases, and curb ramps.

Crossing pedestrians to a channelizing island, as described above has several advantages:

1. It reduces pedestrian crossing time,
2. It reduces the number of conflicting traffic turning maneuvers that pedestrians will need to negotiate,
3. This design will typically accommodate larger design vehicles and heavy turning movements with less intersection delay.

Figure 2.5. Typical crosswalk placement at a signalized intersection



ADJACENT ACCESS/INTERSECTIONS

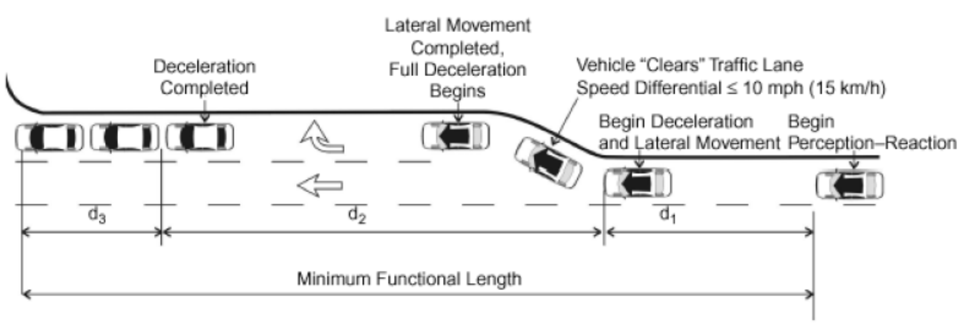
Access points located immediately near any intersection are generally problematic. Typically, vehicle turning movements at the intersection and the adjacent access further complicates driver decision making. This effect *may* cause safety problems. At a minimum, close access will affect operations.

Consideration *should* be given to the impacts of access points located immediately near signalized intersections. It *may* be necessary to close, move or restrict driveways so overall safety and operations can be effectively maintained at acceptable levels. The functional area of the intersection, as described below, *should* be considered relative to adjacent access. Typically, this functional area *should* include areas that experience routine queuing. Median openings in the intersection functional area *should* be avoided. According to FHWA's "Signalized Intersections: Informational Guide," (2nd Ed, 2013), the functional area has four parameters for which it is defined:

- Distance *d1*: Distance traveled during perception-reaction time as a driver approaches the intersection, assuming 1.5 seconds for urban and suburban conditions and 2.5 seconds for rural conditions.
- Distance *d2*: Deceleration distance while the driver maneuvers to a stop upstream of the intersection.
- Distance *d3*: Queue storage at the intersection.
- Distance immediately downstream of the intersection so that a driver can completely clear the intersection before needing to react to something downstream (stopping sight distance is often used for this).

Figure 3.6 illustrates the functional area distances. Refer to FDM 11-25-1, Intersections At Grade for additional information for determining the intersection distances for WisDOT projects.

Figure 2.6. Elements of upstream functional intersection area



The Regional Access Management Coordinator *should* be consulted prior to making changes to access points. Guidance regarding access management concepts *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, *FDM* Chapters 7 and 11, TRB *Access Management Manua*l, and NCHRP Report 348 *Access Management Guidelines for Activity Centers*.

Detection for signalized intersections *should* be placed such that vehicles entering or exiting adjacent driveways do not activate loops and subsequently interfere with signal operations.

FUTURE TRAFFIC SIGNALS

The Regional Traffic Unit needs to be involved during the scoping of a project. The installation of traffic signals as part of an improvement project can have an impact on the amount of right-of-way needed to accommodate signal equipment. Geometric configurations *may* be driven by the need for lane requirements, medians, islands, etc.

All intersections within project limits **shall** be evaluated to determine if traffic signals are warranted and *should* be included with the project.

If traffic signals are not currently warranted, it *may* be feasible to install conduit and pull boxes for future use. Factors that *may* or *may not* support installation of underground features are the timeline for future geometric changes, how close the intersection is to meeting warrants, and known future developments.

The installation of underground conduit systems *should* be considered when:

- It is apparent that signals will someday be located prior to the next project on a roadway.
- Project timing and location is appropriate.
- Post improvement project installation will not readily accommodate future installation (i.e., breaker run roadway base, conduit crossing structures, etc.).
- Impacts to adjacent land use and/or underground utilities necessitate the early placement of an underground system.

RIGHT TURN CONTROL

Right turn control at signalized intersections *should* be studied very thoroughly considering such factors as the volume of right turning vehicles, queue length, number of pedestrians, turn radii, cross street geometrics, channelizing islands, vehicular speeds, etc. Typically, it is preferred to use a less restrictive method and increase the degree of control as volumes, safety, number of pedestrians, and geometric conditions dictate.

FREE FLOW (No control)

- Right turn lane **shall** be channelized. The higher the right turn speed, the larger the channelizing island.
- The receiving approach **shall** have a designated traffic lane (acceleration lane) to be used exclusively for the right turning vehicles. It is recommended to extend the channelizing island to separate the right turn acceleration lane from the adjacent through lanes.
- Use only when no to very low volume of pedestrians crossing the right turn movement.
- Requires larger amount of right of way and is typically used in rural areas where continuous flow is preferred.

YIELD CONTROL

- Right turn lane **shall** be channelized.
- Channelized right turns *should* be brought in as near as perpendicular as possible for vision to the left.
- Recommended when no to very low volume of pedestrians crossing the right turn movement.
- Typically, is the preferred control type, unless more control is required.

STOP CONTROL

- Right turn lane **shall** be channelized.
- Channelized right turns **shall** be brought in as near as perpendicular as possible for vision to the left.
- Periodic enforcement *may* be needed to ensure drivers are obeying the stop sign.

SIGNAL CONTROL

Unchannelized right turn only lanes

- No channelizing island (porkchop). This layout is not the most desirable if there is a significant volume of conflicting pedestrians.
- Generally, a 3-section head (red, yellow and green ball) *should* be used.
- A 5-section head (red, yellow and green ball, yellow right arrow and green right arrow) configuration for the near and far right indications *may* be used, if considering the use of overlaps.
- The right turn arrow **shall not** be displayed at the same time as a conflicting pedestrian interval.
- Right turn FYA *may* be used with engineering judgement.

Channelized right turn lanes

- Per the WMUTCD, two signal faces **shall** be installed.
- A 3-section head configuration (red ball, yellow right arrow, and green right arrow) *should* be used when there is an opposing protected left turn.
- A 5-section head (yellow right arrow and green right arrow) *may* be used when there is an opposing permissive left turn.
- For control of dual right-turn movements, refer to State Statute 346.37(1)(c)3 regarding right turn on red from left most right-turn lane.
- In cases of multiple right turn lanes, “NO TURN ON RED” signing *may* be required at the discretion of the Regional Traffic Engineer. Red right arrows *may* only be used in conjunction with the “NO TURN ON RED” sign.
- Pedestrian crossings *should* be designed to direct the pedestrians from the radius to the channelizing islands (porkchops) and not to the median. This will allow for the possibility of utilizing a right turn overlap situation.

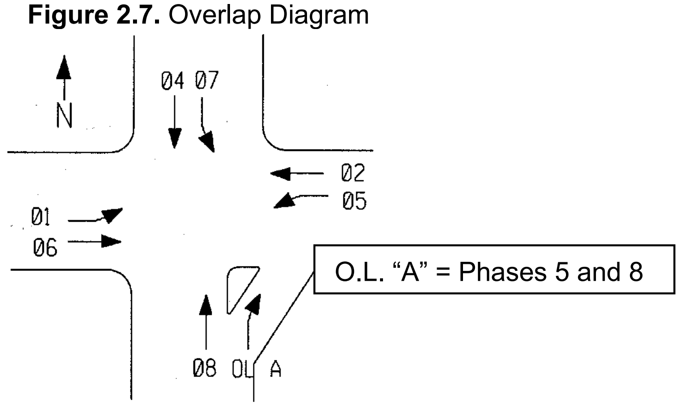
For geometric guidance for right turn lanes, refer to FDM 11-25-10, Right Turn Lanes.

VEHICLE OVERLAPS

An overlap is a vehicle movement that operates with more than one parent phase. Overlap movements will display a green when the phase to which the overlap is initially assigned within the cycle is green. Clearance (yellow and red) timings for the overlap signal indications are determined by the last parent phase of the overlap within the cycle. For example, if an overlap is assigned to phases 2 and 3, its green will begin timing with phase 2. The overlap will continue and then terminate with phase 3 yellow and all-red clearance intervals.

To distinguish from the basic vehicle and pedestrian phases, overlaps are designated alphabetically by letters (i.e., A, B, C, etc.). The overlap chart is located on the Sequence of Operations Sheet. The overlap *should* only be shown if it contains two (2) or more phases. The chart *should* indicate which phases the overlap times concurrently.

Figure 2.7. Overlap Diagram



In the example above, overlap “A” is a right-turn movement operating in conjunction with the complementary left turn movement (Phase 5) and will also operate with the adjacent through movement (Phase 8). Under this scenario, time given to the right turn overlap is governed by the associated left turn demand or the adjacent through movement depending on which phase is operating, not the right turn demand.

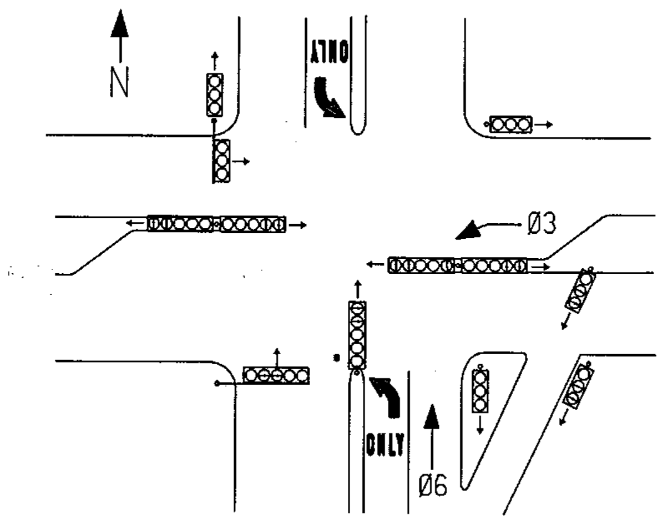
Figure 2.8. Overlap Chart

O.L. “A” =	O.L. “E” =
O.L. “B” =	O.L. “F” =
O.L. “C” =	O.L. “G” =
O.L. “D” =	O.L. “H” =

Geometrics

Right turn overlaps are best utilized at locations where there is an exclusive right turn lane, a complementary left turn lane and a left turn phase on the crossing street. Refer to figures 2.9 and 2.10 below for examples of typical signal head layouts with overlaps.

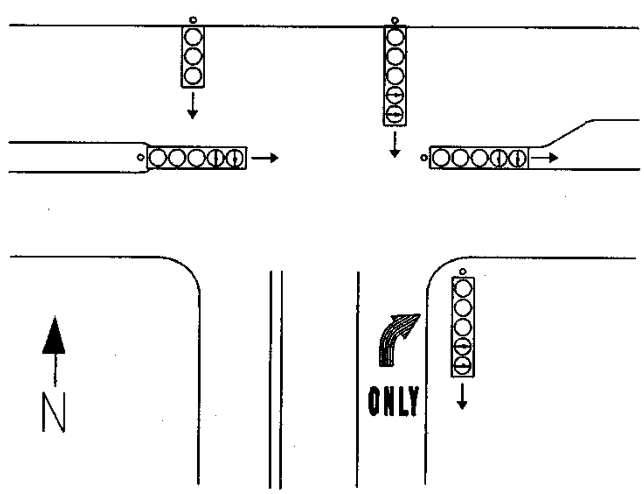
Figure 2.9. Right Turn Overlap with 3-Section Heads



NOTE: Signal heads only shown for EB/WB/SB left-turns and NB right-turn indications.
5-section heads are normally not recommended on right-turn bypasses, and may be dependent on opposing left-turn volumes. See Regional Traffic Engineer for guidance.
•If no median, then the signal head should be placed in far-left channelizing island.

The use of a protected only versus a permissive left turn for the southbound left turn movement (Phase 5) is dependent on receiving approach geometrics and intersection turning movement volumes. The Regional Traffic Signal Engineer **shall** be consulted.

Figure 2.10. Right Turn Overlap at T-intersection



NOTE: Signal heads only shown for EB/WB left-turns and NB right-turn indications

For information about flashing yellow arrow overlaps, see TEOpS 4-7-1.

Interchanges

At interchanges, overlaps are commonly used in conjunction with the ramp phases and the through phases between the ramps when one controller is used.

Figure 2.11. Single Controller – Dual Ring

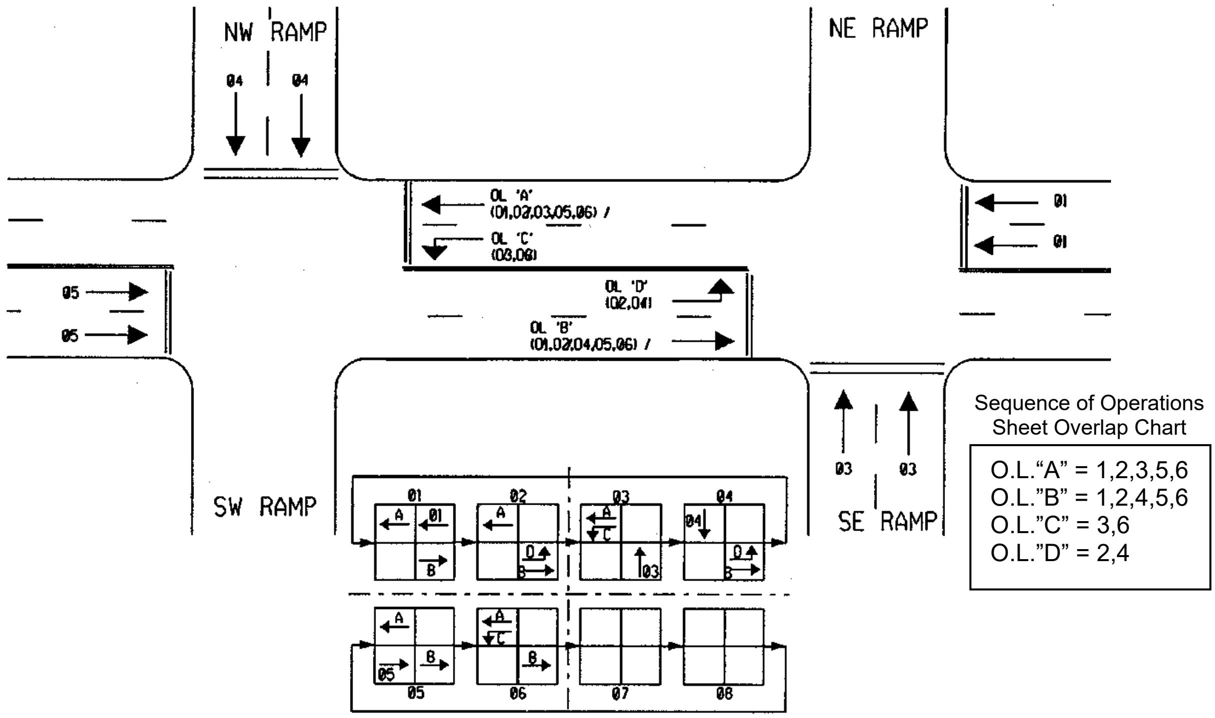
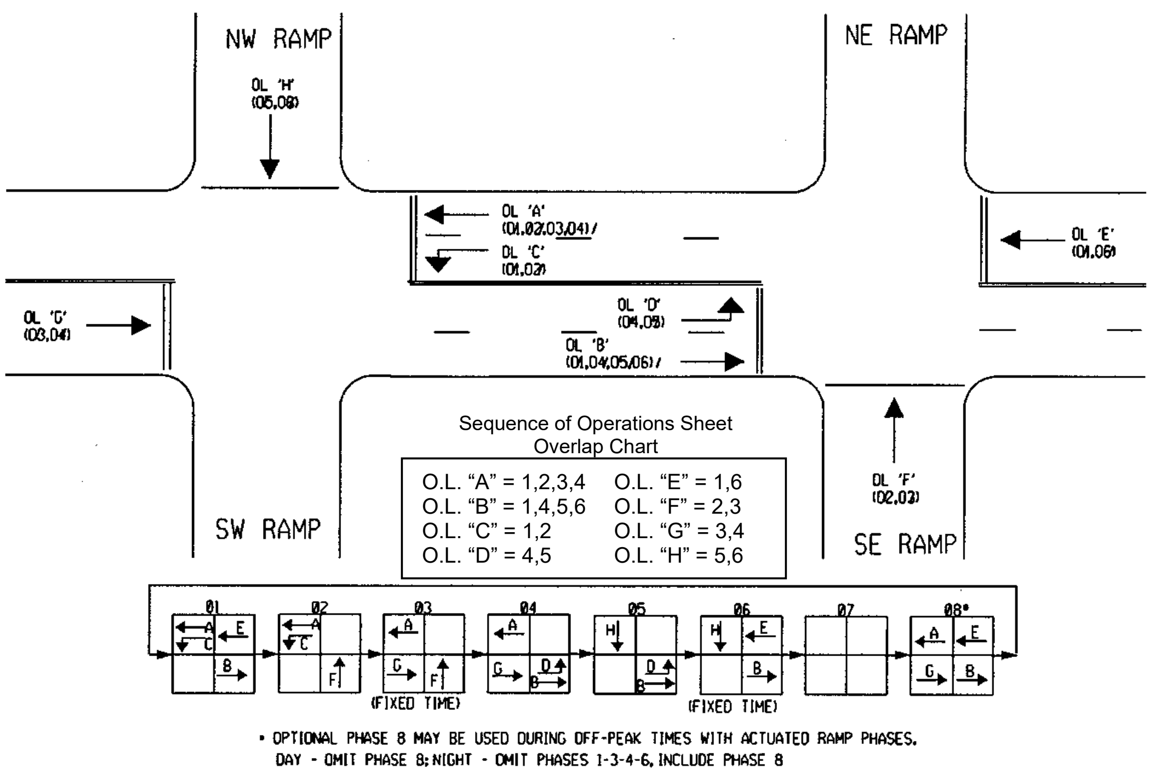


Figure 2.12. TTI Lead – Sequential Interchange



Pedestrian Considerations

In areas where pedestrian demands are high, particularly in central business districts, school crossings, or locations associated with special events, the use of right turn overlaps *should* be carefully evaluated with respect to pedestrian safety.

RESTRICTED LOCATIONS

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 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 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-premises 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.

TEMPORARY SIGNALS

Temporary traffic signals are typically installed for traffic control, when an existing signalized intersection is partially or totally reconstructed, as part of construction staging, detours, diversions or as part of a bridge rehabilitation project. Consult with the regional traffic section as to the type of temporary signal installation (partial or full) that *may* be needed for the project. The Regional Traffic Unit **shall** make the final decision regarding the installation, design, and operation of temporary traffic control signals.

The type of temporary signal installation is based on how much of the project work impacts the signalized intersection. The temporary signal could be as minor as overhead cable drops to the existing signal poles or standards or a complete overhead span wire signal head installation. When the signal heads are span wire mounted, the road work *may* require the signal heads to be moved on the plans for the different stages. If the scope of the project includes several stages, the temporary signal plan **shall** show the placement of the span wire signal heads for the various construction stages including temporary pavement markings, temporary signing, and placement of any work zone traffic control devices.

Before the temporary signal plan is developed, a field site review *should* be conducted to determine constructability. Additionally, all utilities *should* be located by contacting Diggers Hotline. Any utilities that are not on Diggers **shall** require a call directly to that utility to get their facilities located.

- Conduct a site review after all the utilities have been located.
- Check for any overhead facilities such as fiber optic, telephone, cable TV, and electrical lines both primary and secondary voltages that could conflict with any signal poles, light poles, and temporary wood poles for the temporary traffic signal.
- Maintain span length less than 200 feet. If length exceeds 200 feet, an additional median wood pole is required.
- Consult the utility for their clear zone working clearances when working around their utilities.
- Place temporary signal wood poles free of overhead utility conflicts and free from any new utility installations that *may* be installed as part of the project. The proposed signal equipment **shall** also be taken into consideration so that temporary head remain visible throughout construction. Sufficient right-of-way (or temporary limited easements) must be available to install down guys, Temporary wood poles *should* be located away from the vehicular traffic or adequately protected from vehicle traffic.
- Determine the cabinet location during the site visit if the installation will be installed and maintained by WisDOT. Factors to consider for the cabinet location are the accessibility of the electrical service, good sight vision of the intersection from the cabinet, avoid low areas where the cabinet could be flooded, and located in an area to avoid being struck by vehicles.
- Provide for temporary lighting.
- Determine if coordinated signal operations need to be developed or maintained with adjacent signals. Typically, time-based coordination is used.

Temporary left turn phasing during construction needs to be considered and approved by the Regional Traffic Signal Unit prior to the project. Sight limitations and limited turning movements *may* require the use of split phasing or the use of protected left turn phases in place of a protected/permissive phase. Provide adequate turn lane storage and channelization during the project to avoid vehicles queuing into the adjacent thru lanes for turning movements. If appropriate turning accommodations cannot be made, consider restricting the turning movement at the intersection.

Temporary signals operated in the pretimed mode *should* consider time of day plans for efficient operations. Temporary signals *may* use non-intrusive vehicle detectors as staging allows. Typically providing detection for vehicles, pedestrians and emergency vehicles is constrained during construction. Detection can be accommodated and **shall** be discussed with the Regional Traffic Unit. Requirements *may* include:

- Show the type/placement of vehicular detection on the plan (temporary detection (video, microwave, radar)
- Provide adequate refuge for pedestrian storage.
- Provide unrestricted access to pedestrian push button detectors.
- Show the placement of the EVP detector heads on the temporary signal plan.
- Show the EVP operation on the temporary signal sequence sheet.
- Refer to WMUTCD 6L.01, Temporary Traffic Control Signals.

The temporary signal plan set will include construction staging plan, temporary pavement marking and signing plan, temporary timing plan, placement of work zone traffic control devices (barrel or wands), a temporary signal plan, and a sequence of operation sheet for the temporary signal.

Section 661 of the *State of Wisconsin Standard Specifications for Highway and Structure Construction* and SDD 9g1 sheets a through g (Span Wire Temporary Traffic Signal) provide additional information about temporary traffic signal installations. These specifications define:

- Equipment to be furnished for temporary signals,
- Electrical service requirements, and
- Required working clearance is 17 to 19 feet for the signal heads and lower tether wire above the roadway.

The Regional Traffic Signal Unit **shall** determine the need for signal controller cabinets of full or partial temporary signal.

- Full temporary signals typically require the use of a separate (contractor furnished) traffic signal cabinet and/or controller, remote communications and non-intrusive detection during the construction project. The use of a temporary control cabinet allows for a safe transition from the temporary signal operation to the permanent signal operation.
- Partial temporary signals *may* use existing controller cabinets if state maintained during construction.

Responsibility for developing temporary signal timing plans *should* be clearly established. For temporary signals within WisDOT jurisdiction, the Regional Traffic Unit will develop temporary signal timing plans. If the timing plan is consultant developed, the Regional Traffic Signal Unit **shall** review and accept the plan.

INTERCHANGES

Selection of interchange signal operations

A common question relating to the design of signals at diamond interchange ramp terminals is whether to use one or two controllers. There *may* be advantages or disadvantages to either alternative. This subject presents typical applications and some of the differences between these alternatives.

When deciding how many controllers and what type of phasing *should* be used, consider the following general factors: required flexibility in signal operation/timing plan, physical interchange size, nature/volume of ramp traffic, mainline coordination with adjacent signals, vehicle storage requirements, and motorist expectancy. In any case, the Regional Traffic Engineer **shall** make the final determination regarding the type of operation at signalized interchanges.

Table 2.1 indicates some of the advantages and disadvantages of various interchange operations discussed below.

SINGLE CONTROLLER INTERCHANGE APPLICATIONS

Single controllers are typically used at interchanges with tightly spaced ramp terminals (less than 500 ft) where vehicle storage *may* be an issue. Signals at interchange ramps that use a single controller will generally use the following types of phasing options:

- TTI phasing is commonly used at interchanges with relatively consistent, heavy ramp volumes. When this type of phasing is used, right-of-way is assigned to a single mainline approach which is followed up with the ramp on the same side of the interchange. Next, right-of-way is assigned to the opposing mainline approach which is then followed up with the ramp movement on that side of the interchange. Put differently, the mainline approaches (followed up by their "complimentary" ramp movement) are alternated.

Vehicles will store on the outside of the ramp terminals; this will eliminate queuing on the roadway between the ramps. Phasing is appropriate for tightly spaced interchanges. It is advantageous because mainline movements will only be stopped once in the interchange area, due to leading protected left turn phasing on the mainline approach of the interchange.

- <u>Dual Ring with Overlaps</u> phasing *may* be preferred over TTI Phasing particularly if ramp volumes are more variable or unbalanced. External mainline movements are assigned to phases 1 and 5. Ramp movements are assigned to phases 3 and 4. Internal mainline through and left turn movements are assigned to overlaps within phases 1 through 6. Like a standard four-legged intersection, any non-conflicting phases that have demand can be serviced simultaneously. Also, within these phases multiple movements that have been assigned to overlaps can be serviced.

  Ramp spacing *should* be great enough to accommodate queuing between ramp terminals. As such, a queue analysis *should* be performed.

- <u>Simultaneous Ramp Release</u> *may* be either leading or lagging relative to the mainline through movements. With this type of phasing, traffic on opposing ramps are released at the same time and stored within the interchange. Next opposing interior through and left turn movements are released. This interval is followed by opposing exterior mainline through movements. Exterior mainline through vehicles that want to access the freeway by turning left at the opposite ramp terminal will also need to store within the interchange while the opposing through movement times out concurrently. This *may* necessitate multiple stops within the same interchange.

  This phasing requires that ramp spacing be great enough to accommodate queuing of the ramp traffic between terminals. As such, this phasing will not typically be appropriate for interchanges with tightly spaced ramp terminals and moderate to heavy ramp traffic. Even locations with relatively light ramp volumes would need to be analyzed carefully. As with the Dual Ring phasing alternative above, a queue analysis *should* be performed.

Splice Cabinets at Single Controller Interchanges

When a single controller is used to operate both terminals, a splice cabinet *may* be located on the opposite side of the interchange at the discretion of the Regional Traffic Engineer. A splice cabinet is a controller cabinet shell that houses the consolidated signal cable conductors from the separate indications for each phase. Once wiring splices have been made in the splicing cabinet, then a multi-conductor signal cable is run back to the controller cabinet on the opposite side of the interchange. Otherwise, a single conductor per indication type and per phase is required to run back to the controller cabinet for each of these phases. Installing a splice cabinet allows electrical personnel to pull only one cable instead of many.

The splice cabinet *should* be placed in a location where electrical service is accessible. This will allow for placement of a full signal control cabinet in the future, if necessary.

<u>TWO CONTROLLER INTERCHANGE APPLICATIONS</u>

In some situations, it *may* be more appropriate to use a controller for each interchange ramp terminal. This type of arrangement will typically be applied at interchanges with ramp spacing greater than 500 ft. In large part, this is due to the long distances to far detection that *may* be on the opposite side of the interchange from the signal cabinet and the ability for those devices to function effectively.

The use of two controllers will likely necessitate the need for coordination. One advantage of dual controller interchange operation is that a conduit crossing the interchange *may* not be necessary unless interconnected coordination is desired.

In some cases, two controller arrangements have flexibility for interchange signal operations due to the opportunity to program offsets. However, they are more labor intensive, in terms of coordination, maintenance, and cost when compared to single controller arrangements.

It is essential that two controller interchanges are accurate and remain in step with each other for coordination purposes.

These concepts will apply to standard diamond interchanges or modified interchange configurations, such as Diverging Diamond Interchanges (DDI's).

Table 2.1. General Signalized Interchange Alternative Considerations

Operation or Phasing	Key Factors	Advantages	Disadvantages
Single Controller Applications (ramp terminal spacing < 500 ft)			
TTI	Heavy, consistent volumes at isolated location or where there is a relatively high percentage of left turning movements.	▪ Eliminates queuing within the interchange ▪ Works well in areas of high-demand ▪ Relatively straight-forward, consistent operation -- one movement occupies the interchange at any time ▪ *May* require only one stop within the interchange	▪ *May* not provide ideal conditions for coordination with adjacent signals ▪ *May* impose higher delay on users during periods of low use ▪ Forces queue outside of interchange ramps ▪ Basically, a pre-timed operation
Dual Ring w/Overlaps	Desire to provide progression on the mainline with more variable/unbalanced ramp volumes.	▪ Can provide improved conditions for coordination with adjacent signals ▪ Ability to provide leading-lagging left-turn phasing ▪ Omits phases 2 & 6 and recalls phases 3 & 4 ▪ Efficient	▪ Inconsistent operation, (penalized ramps (phase 3) must stop)
Simultaneous Release	Desire to provide high throughput on the mainline. Lower left-turning ramp volumes.	▪ Provides improved conditions for coordination with adjacent signals	▪ Requires storage of left-turning ramp traffic within the interchange ▪ Left-turns off the mainline *may* be delayed due to phasing sequence
Single Point	High volume interchanges in a tight, urban environment	▪ Improved operation and safety due to fewer conflict points ▪ Controlled by a single signal	▪ Higher cost due to needing a larger bridge ▪ Large areas of pavement needed ▪ Not pedestrian friendly ▪ Difficult to clear snow
Two Controller Applications (ramp terminal spacing > 500 ft)			
Coordinated Ramps	Desire to provide progression on the mainline & need to provide maximum flexibility for future operational alternatives.	▪ Provides improved conditions for coordination with adjacent signals ▪ Can be made to mimic the phasing alternatives above. ▪ Provides greatest opportunity for operational flexibility	▪ Identifying & implementing maximized operational/timing plan using multiple controllers is more complex than using a single controller ▪ Both controllers must be coordinated ▪ Increased maintenance & capital ▪ *May* require additional detection

VEHICLE DETECTION

In the cases where a single controller is used, large ramp spacing can impact the effectiveness of inductance loops used for vehicle detectors.

To operate properly, the differential between the inductance of the loop *should* exceed that of the lead-in cable by a factor of 2:1. There are two ways to compensate for the increased spacing.

The first method is to decrease the physical distance between the detection amplifiers that reside in the controller cabinet and the far loops. At diamond interchanges, the preferred location for the controller cabinet is inside the interchange footprint and adjacent to either off-ramp. Placement adjacent to either off-ramp is acceptable if sight-distance from the controlled approach is not impeded.

The second method is to increase inductance within the loop relative to the lead-in cable. This is done by using a larger number of turns within the loop or increasing the loop size. In general, the maximum number of turns a loop can contain is six.

RAMP METERING CONSIDERATIONS

In highly urbanized locations, future or pending ramp metering capabilities *may* need to be considered. Additional capacity treatments *may* include extension of right- and left-turn lanes used to access metered on-ramps, and additional lanes (at appropriate length) on the ramp itself to store vehicles.

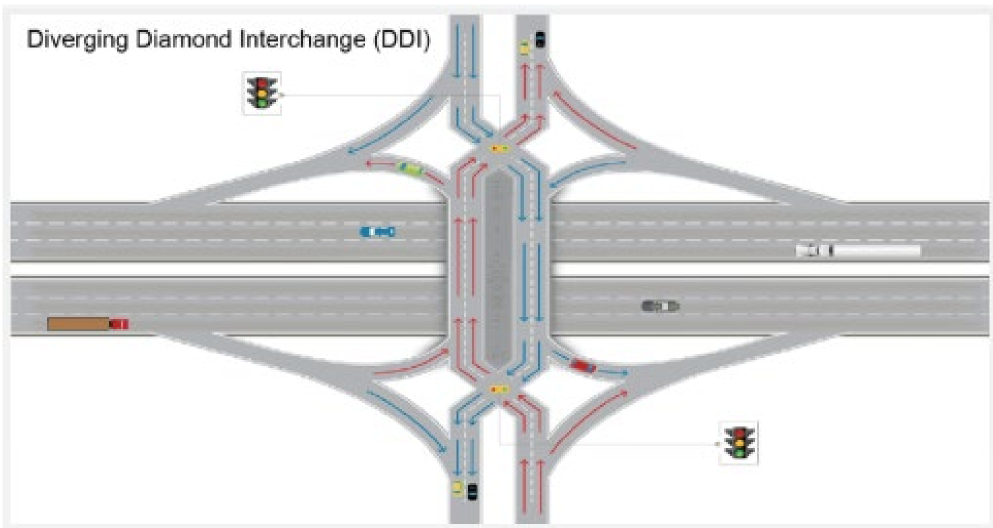
OTHER ELECTRICAL FACILITIES

Other facilities such as continuous roadway lighting or ITS elements (such as ramp meters and DMS), **shall** be contained within their own systems for maintenance and operational reasons.

ALTERNATIVE INTERCHANGE DESIGNS

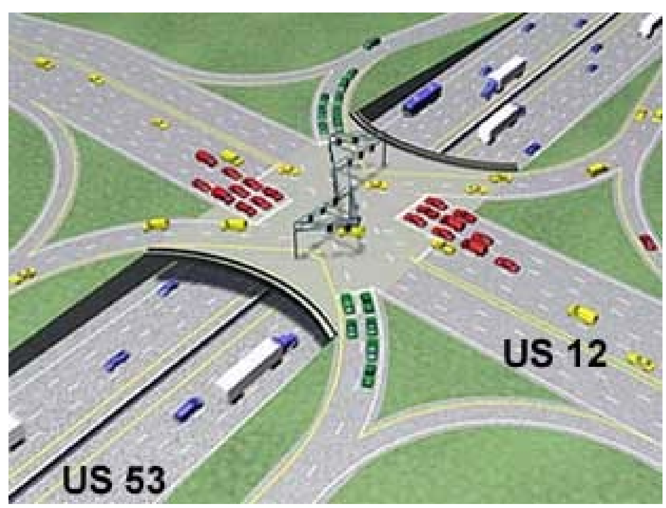
Diverging Diamond Interchanges (DDI's) are a modified version of the standard diamond where vehicles entering the interchange, cross over to the opposite roadway through the interchange area. The advantage of this configuration is that ramp volumes are less impeded, similar to right-turn movements at standard intersections. Whether a DDI or stand diamond, the concepts discussed above regarding single- or dual controller operations, still apply. DDI's will typically use 2-phase operation.

Figure 2.13. Diverging Diamond Interchange



Single Point Interchanges (SPI's) consist of a distinct geometric design, such that all interchange movements converge at a single point within the interchange and left-turns phases are eliminated. SPI's are also a proper application for single controllers and will typically use 3-phase operation.

Figure 2.14. Single Point Interchanges



In the illustration on the right, vehicular movements served by individual phases are distinguished by color.

PEDESTRIAN APPLICATIONS/WARRANTS

Reference is made to the WMUTCD Sections 4C.05, 4C.06, 4D.03, and 4I.

The design and operation of traffic control signals **shall** take into consideration the needs of pedestrian as well as vehicular traffic. The decision to signalize pedestrian movements *should* be a collaborative decision between the regional signal engineer and the regional bicycle/pedestrian safety coordinator and *should* be based upon the warrants and other criteria provided hereafter.

POLICY

Sidewalk and curb ramps **shall** be provided at locations where pedestrian signal heads are to be installed.

Per WMUTCD 4I.01:

"Pedestrian signal heads **shall** be used in conjunction with vehicular traffic control signals under any of the following conditions:

A. If a traffic control signal is justified by an engineering study and meets either Warrant 4, Pedestrian Volume or Warrant 5, School Crossing (see WMUTCD 4C.05 and 4C.06);

B. If an exclusive signal phase is provided or made available for pedestrian movements in one or more directions, with all conflicting vehicular movements being stopped;

C. At an established school crossing at any signalized location; or

D. Where engineering judgment determines that multi-phase signal indications (as with split-phase timing) would tend to confuse or cause conflicts with pedestrians using a crosswalk guided only by vehicular signal indications."

"Pedestrian signal heads *should* be used in conjunction with vehicular traffic control signals under any of the following conditions:

A. If it is necessary to assist pedestrians in deciding when to begin crossing the roadway in the chosen direction or if engineering judgment determines that pedestrian signal heads are justified to minimize vehicle-pedestrian conflicts;

B. If pedestrians are permitted to cross a portion of a street, such as to or from a median of sufficient width for pedestrians to wait, during an interval but are not permitted to cross the remainder of the street during any part of the same interval; and/or

C. If no vehicular signal indications are visible to pedestrians, or if the vehicular signal indications that are visible to pedestrians starting a crossing provide insufficient guidance for them to decide when to begin crossing the roadway in the chosen direction, such as on one-way streets, at T-intersections, or at multi-phase signal operations."

In addition to the guidance provided above, there are a few other items to consider when deciding whether to install pedestrian signal indications:

1. Is a pedestrian with a visual disability requesting the accommodation? (It is WisDOT's policy to accommodate pedestrians with visual disabilities by installing pedestrian heads and APS devices, so long as the pedestrians with visual disabilities are the ones requesting it).
2. What is the land use adjacent to the intersection? Does the intersection serve as a connection between businesses? To a school? To a parking lot? To a transit/bus stop?

At locations where, pedestrian heads and push buttons are not initially installed, the designer *should* locate all signal poles with future pedestrian accommodations in mind. This way the intersection can be easily retrofitted with pedestrian heads and push buttons once the sidewalk and curb ramps have been installed.

SUPPORT

In Wisconsin, pedestrians can legally cross a roadway at a traffic signal even if that traffic signal does not have pedestrian signal heads.

Wisconsin State Statute 346.37 (1)(a)2: "Pedestrians, and persons who are riding bicycles or electric personal assistive mobility devices in a manner which is consistent with the safe use of the crosswalk by pedestrians, facing the (green) signal *may* proceed across the roadway within any marked or unmarked crosswalk."

Wisconsin State Statute 346.37 (1)(c)2: "No pedestrian, bicyclist, or rider of an electric personal assistive mobility device facing such signal (red) **shall** enter the roadway unless he or she can do so safely and without interfering with any vehicular traffic.

Also, Wisconsin State Statute 346.23 addresses motorists' responsibility at intersections relative to pedestrians:

(1) At an intersection or crosswalk where traffic is controlled by traffic control signals or by a traffic officer, the operator of a vehicle **shall** yield the right-of-way to a pedestrian, or to a person who is riding a bicycle or electric personal assistive mobility device in a manner which is consistent with the safe use of the crosswalk by pedestrians, who has started to cross the highway on a green or "Walk" signal and in all other cases pedestrians, bicyclists, and riders of electric personal assistive mobility devices **shall** yield the right-of-way to vehicles lawfully proceeding directly ahead on a green signal. No operator of a vehicle proceeding ahead on a green signal *may* begin a turn at a controlled intersection or crosswalk when a pedestrian, bicyclist, or rider of an electric personal assistive mobility device crossing in the crosswalk on a green or "Walk" signal would be endangered or interfered with in any way. The rules stated in this subsection are modified t intersections or crosswalks on divided highways or highways provided with safety zones in the manner and to the extent stated in sub. (2).

(2) At intersections or crosswalks on divided highways or highways provided with safety zones where traffic is controlled by traffic control signals or by a traffic officer, the operator of a vehicle **shall** yield the right-of-way to a pedestrian, bicyclist, or rider of an electric personal assistive mobility device who has started to cross the roadway either from the near curb or shoulder or from the center dividing strip or a safety zone with the green or "Walk" signal in the favor of the pedestrian, bicyclist, or rider of an electric personal assistive mobility device.

CONTROL FOR EMERGENCY VEHICLE ACCESS

Reference is made to the WMUTCD, Section 4F, and Wisconsin State Statute 346.455

POLICY

The following conditions describe various forms of traffic control associated with emergency vehicle access as well as general installation, design, and operational criteria.

Condition 1: Warning Device with No Traffic Control

Prescribed practice is to use the warning sign W11-8, Fire Station Truck, with or without a flashing beacon used to supplement the sign. Use of this type of warning is intended for use only at locations with restricted sight distances. If used with a flashing beacon, the beacon *should* be activated by a control in the firehouse for a preset period for the emergency vehicle to enter the highway.

An alternate method is to use a W11-8 at the emergency vehicle access with a yellow flashing beacon, and install an advance warning sign, W54-60, Fire Trucks (Emergency Vehicles) Enter when Signal Flashes.

On the state trunk highway system, signing will be furnished, installed, and maintained by the department. The municipality *may* have an option to install a flashing beacon subject to obtaining a permit from the regional office and accepting responsibility for operating and maintaining the beacon in accordance with the permit.

Condition 2: Emergency Vehicle Hybrid Beacons and Mid-Block Access

Under this condition, the emergency vehicle access is at mid-block and controlled by a hybrid beacon.

Application

Emergency vehicle hybrid beacons **shall not** be installed mid-block on two-lane roadways. In addition to guidance provided in the WMUTCD 4F, emergency vehicle hybrid beacons *may* be considered on multilane highways when the following volume criteria is met:

1. Traffic volume on the adjacent roadway exceeds 18,000 vehicles per day, or
2. Traffic volume on the adjacent roadway exceeds 1,800 vehicles during the peak hour of the day.

In addition to the volume criteria above, a specialized study **shall** be conducted by the agency requesting the beacons to demonstrate the need for control at emergency vehicle access points. Minimally, k=the study will consider adjacent roadway geometry (to include sight distance criteria), traffic volumes and characteristics, relative emergency vehicle exposure, and related vehicular conflicts (to include crash history). The study *should* also include a traffic capacity analysis to evaluate the effects of such an installation on the adjacent roadway. Such an installation *may* be denied if the study determines that a substantial, negative impact will be created by the installation of an emergency vehicle hybrid beacon.

Design and Operation

All design and operation requirements for an emergency vehicle hybrid beacon can be found in WMUTCD 4F.

Maintenance and Funding

Since emergency vehicle hybrid beacons are installed to serve a defined community, it is reasonable to assign maintenance responsibilities to the community being served. However, for installations outside connecting highway limits, communities *may not* have resources available to manage such systems. As such, this function will likely need to be fulfilled by WisDOT. In that case, an agreement with the community *may* be developed that will establish a means to reimburse WisDOT for any time and materials spent maintaining these installations. This agreement *may* address costs to install traffic control hybrid beacons as well.

Other Traffic Control Methods for Emergency Vehicle Access

Devices used to control traffic on the STH system, including connecting highways, at locations of emergency vehicle access are subject to Wisconsin State Statute 346.455, the WMUTCD, and this policy. Forms of traffic control outside of these standards are not permitted. Examples of this include using red flashing beacons with signs indicating “WHEN FLASHING – STOP FOR FIRE TRUCKS” or similar messages.

SUPPORT

Regardless of the reason traffic control devices are installed, they need to convey a purposeful, clear, and consistent message to motorists.

In addition to providing these types of devices on the STH system to promote safety, drivers of emergency vehicles *should* be properly trained regarding the proper operation of emergency vehicle hybrid beacons, and the concept that use of emergency vehicle hybrid beacons does not remove the responsibility of the vehicle operator from determining whether it is safe to enter the highway.

The local municipality **shall** be responsible for such training programs.

4-2-3 Other Considerations — April 2025

LOCAL COORDINATION

Coordination with Local Municipalities

When evaluating a location for traffic signal control, consideration *should* be given to the proximity of other types of intersection traffic control, including those in other jurisdictions. Despite ownership of traffic control devices, route continuity, intersection spacing, and traffic volumes *may* dictate the need to place signals in coordination if adjacent to other signals.

In the case of multi-jurisdictional coordinated systems, timing plans need to be developed collaboratively. Consideration *should* also be given to agreements that define roles of responsibility relative to maintenance of the system (i.e. interconnect demarcation for locates or repairs), and/or use of equipment that keeps signal controllers in step (i.e. GPS clocks).

More complex multi-jurisdictional systems, such as Traffic Responsive or Adaptive signal control, require central control of individual intersections. In this case, a Memorandum of Agreement (MOA) is strongly suggested to address jurisdictional authority, financial responsibilities (i.e. ongoing utility costs, sharing of software maintenance contracts), as well as operational and maintenance roles. In these cases, the Region Traffic Signal Engineer **shall** be contacted.

State-owned Equipment Located on Private Property

State-owned signal equipment **shall** be placed in public right-of-way. In the unusual case that equipment needs to be located on private property, a Permanent Limited Easement (PLE) is required to allow state personnel to routinely access this portion of the property for signal maintenance purposes and to install detection and other equipment. To establish a PLE, the Regional Real Estate Unit **shall** be contacted.

Specialty Equipment – Locally owned/maintained signals

Local municipalities/agencies *may* request decorative or ornamental signal equipment for poles, standards or mast arms. Cost of decorative or ornamental signal hardware **shall** be borne by the jurisdiction requesting the specialty items and is subject to standard project cost-sharing practices.

Specialty Equipment – State owned/maintained signals

Local municipalities/agencies *may* request standard signal equipment (i.e. poles, standards or mast arms) that have been manufacturer painted (or anodized) black. Requests **shall** be made in writing and submitted to the appropriate Region. The Region maintains discretion over the approval of such requests. If approved, the local municipality/agency **shall** sign an agreement with the state.

The specifics of this agreement are also at the discretion of the region and will cover items such as inventory management, delivery of spare equipment, and the billing of additional costs incurred outside of regular maintenance work back to the local municipality/agency. In addition, initial installation cost of black painted signal equipment **shall** be borne by the jurisdiction requesting the specialty items and is subject to standard project cost-sharing practices.

JURSIDICTIONAL TRANSFER CONSIDERATIONS

Signals and signal systems need to be considered when highways are transferred between agencies. The ownership of traffic signal installations *may* be jurisdictionally transferred several reasons:

- Jurisdictional transfer of a segment of highway due to a change to the route (i.e. bypass of a community),
- Establishing or changing the limits of connecting highway segment, or
- Reallocation to a specific agency for traffic management or operational benefits (i.e. establishing alternate routes during construction projects and/or coordinated systems).

Since many of the jurisdictional transfers/connecting highway changes take effect upon completion of a state let construction project which *may* include installation of new signals or rehab of existing signals, the transfer of any existing or new signal(s) *should* be a part of the highway jurisdictional process initiated by Regional Planning staff.

Regional Traffic and Planning staff, as well as the local municipality, *should* be involved in discussions relating to the details associated with the signal transfer. There are many key signal operation and maintenance issues to consider <u>early</u> in the highway jurisdictional process.

Ideally, the transfer of traffic signal installations will be addressed via the jurisdictional transfer agreement for the subject roadway. In some cases, the transfer agreements have been approved and signed by both agencies, however the actual transfer of the signal has been detained for several years after the transfer of the roadway due to various issues ranging from warranties to interconnect.

For any signal transfer it is important to remember that the utility costs *should* be transferred on the date the signal transfer is effective.

The lists of items below *should* be considered when jurisdictionally transferring signal installations between agencies. Items include, but are not limited to, the following:

<u>PROPOSED SIGNALS THAT WILL BE TRANSFERRED UPON COMPLETION OF INSTALLATION</u>

- Who is designing the signal (e.g. local municipality, consultant or DOT)?
- Will the signal be designed to DOT standards or to municipal standards?
- If designed to DOT standards, who will provide the signal equipment?
- Who will do the final electrical inspection and turn on the signal (i.e. DOT electricians, contractor or local municipality's electricians or contractor)?
- What conditions are to be met prior to the transfer to take place? Ideally, the signal will become jurisdiction of the local municipality upon signal turn on as opposed to completion and acceptance of the associated roadwork, which *may* occur several months after signal turn on.
- What agency (DOT, local municipality or consultant) will be responsible for initial signal timing required at turn on?
- Is signal in coordination with other state maintained or locally maintained signals? (If yes, see EXISTING OR PROPOSED COORDINATED SIGNALS)
- A key situation to address early, is if the signal(s) to be transferred operates in coordination with another agency's signal(s). In this case the following needs to be addressed, mutually agreed upon, and spelled out in the transfer agreement*:*
    - Type of coordination (TBC, closed loop, fiber, etc.)?
    - If multiple agencies will be involved, who will locate and maintain the interconnect conduit? Specific maintenance limits **shall** be defined in the agreement.
    - Who will review, update and pay for changes to timing to maintain or improve coordination?
    - Who will pay to change controllers in the future for compatibility reasons?
    - Who will respond to communication/network issues?

EXISTING SIGNALS THAT WILL BE TRANSFERRED

If an existing signal is being transferred, then the following issues need to be addressed, mutually agreed upon, and spelled out in the transfer agreement:

- Is the signal being transferred in “AS IS” condition, i.e. the signal equipment is in proper working condition or will upgrades be required?
- Condition/age of the existing controller?
- Coordination with other state maintained or locally maintained signals? (If yes, see EXISTING COORDINATED SIGNALS, above)
- What conditions *should* be met for the transfer to take place (e.g. inspection by local municipality)?
- Warranties **shall not** be used.
- A key situation to address early is the signal coordination status. The following issues *should* be addressed, mutually agreed upon and spelled out in the transfer agreement:
- Specify the signals in a coordinated system that are maintained by individual agencies.
    - Type of coordination (TBC, closed loop, fiber, etc.)?
    - Multiple Agencies:
    - Who will maintain the interconnect conduit? Specific maintenance limits **shall** be defined in the agreement.
    - Who will review, update and pay for changes to timings to maintain or improve coordination?
    - Who will pay to change controllers in the future for compatibility reasons?
    - Who will respond to communication/network issues?

SIGNAL TRANSFER CHECKLIST

When transferring an existing state owned/maintained traffic signal to another agency there are several associated issues to remember to take care of approximately two weeks prior to transfer:

- ❑ Request inspection of signal by WisDOT electricians, i.e., check loop functionality, lamp outages, etc.
- ❑ Notify electric utility of impending change in ownership.
- ❑ Remove WisDOT decals or other identification from control cabinet
- ❑ Send letter to receiving municipality to remind of pending transfer.

The text of the letter *should* include transfer date and a reminder to establish account with electrical utility (See sample letter). Copies of the following *should* be included with the letter:

- ❑ Latest timing
- ❑ Latest signal plan and sequence sheet
- ❑ Signed documentation for signal transfer
- ❑ Notify impacted law enforcement agencies including state patrol.
- ❑ Notify pertinent regional staff including:
    - ❑ Other pertinent regional staff who are responsible for the operation of the signals, paying the electrical service bill, and maintaining pavement marking and signing, if applicable.
    - ❑ Electricians
    - ❑ Planning staff who are responsible for manual traffic counts and updating STN log
    - ❑ Digger’s Hotline
    - ❑ Roadway Maintenance
    - ❑ Pertinent Bureau of Traffic Operations staff who are responsible for maintaining asset management tools and signal cabinet wiring diagrams.

SIGNAL TRANSFER SAMPLE LETTER

June 20, 2005

City Engineer

City XYZ

1234 Drive

City XYZ, Wisconsin 53200

Dear :

SUBJECT: STH XX & CTH XX

XX County

This letter is a reminder, that effective June 30, 2005, the subject traffic signal will become the maintenance and operational responsibility of the City of XYZ per the enclosed agreement.

We have informed the utility company of the pending transfer. They request that you contact them to provide the applicable billing information.

For your use you will find copies of the existing signal plan, sequence of operations sheet and timing.

If you have any questions, please feel free to contact me (XXX) XXX-XXXX.

Sincerely,

Regional Traffic Signal Engineer

UTILITIES, CULTURAL AND ENVIRONMENTAL ISSUES

Early in the design process, existing above- and below-ground utilities must be identified to determine if there is a potential conflict that will affect the placement of signal equipment and particularly for monotube signal bases that *may* require wing walls.

Underground facilities *should* be located and marked in the field prior to a field investigation. Examples of such facilities include:

- electric
- utility vaults
- high pressure gas lines
- fiber optic packages
- telecommunication
- cable
- water
- sewer lines
- municipal communication duct packages, etc.

Overhead electrical facilities *may* have proximity requirements regarding signal monotube and/or mast arm clearances.

Guidelines for historical boundaries and cemeteries are found in FDM Chapter 26, Cultural Resource Preservation.

Guidelines regarding required Environmental processes and documentation are found in FDM Chapter 20, Environmental Documents, Reports and Permits.

COMMUNITY SENSITIVE DESIGN (CSD)

According to FDM 11-3-1, Community Sensitive Design, CSD is a collaborative interdisciplinary approach that includes early involvement of all stakeholders to ensure that transportation projects not only provide safety and mobility, but are also in harmony with communities and the natural, social, economic, and cultural environments.

When requests are made for non-standard WisDOT signal equipment (i.e., decorative hardware), consideration *should* be given to establishing connecting highway limits so local jurisdictions can own and maintain signals that incorporate special equipment.

When decorative pavement is used near state owned and maintained intersections, the location of signal equipment *should* be considered. Decorative pavement *should not* be used near signal bases, pull boxes or in-pavement detection for maintenance and replacement reasons.