



2-1-8 LEDs (Blinker Signs)

June 2014

PURPOSE

The WisMUTCD section [2A.07](#) provides standards and options for the usage of Light Emitting Diode (LED) units within the face of a sign and in the border of a sign to improve conspicuity and increase the legibility of sign legends and borders. This policy provides requirements and guidance on the proper use of the LED (commonly referred to as blinker) signs on state-maintained highways. Per the [WisMUTCD](#), these blinker signs *may* be used on STOP signs, Warning signs and other regulatory signs such as speed limit sign or school signs. This policy provides guidance and requirements for usage on state-maintained highways. [Refer to TEOpS 4-5-1 for warning sign flasher enhancement device options for pedestrians.](#)

BACKGROUND

The [WisMUTCD](#) includes language in [2A.07](#) which provides guidelines for the proper use of these devices. They are considered similar to flashing beacons in WisMUTCD Section [4L](#).

- Guideline 1: Demonstrated crash problem
- Guideline 2: Visibility restrictions
- Guideline 3: Unusual geometrics
- Guideline 4: Poor conspicuity—sign blending in with the environment

These four guidelines apply to all public highways and streets, including those not under state jurisdiction. The policy statements below pertain specifically to state-maintained highways.

DEFINITIONS AND WISMUTCD REQUIREMENTS (IF LEDS USED)

1. LEDs **shall** have a maximum diameter of ¼ inch and **shall** be the following colors based on the type of sign:
 - a. White or red, if used with STOP or YIELD signs.
 - b. White, if used with regulatory signs other than STOP or YIELD signs.
 - c. White or yellow, if used with warning signs.
2. If flashed, the LED units **shall** flash simultaneously at a rate of more than 50 and less than 60 times per minute.
3. The uniformity of the sign design **shall** be maintained without any decrease in visibility, legibility, or driver comprehension during either daytime or nighttime conditions.
4. A module of multiple LED units used as a closely-spaced, single light source **shall** only be used within the sign face for legends or symbols.

POLICY

The usage of any illumination methods for traffic signs, including LEDs, is strictly limited to situations with documented safety concerns.

1. Local authorities **shall not** be allowed to installed units on state-maintained highways.
2. Blinker signs **shall** only be considered at existing locations. A conversion from a two to four-way stop is also considered an existing location. New locations **shall not** be considered until a minimum of one-year crash data, volume data and other traffic data is available for a traffic safety evaluation which **shall** be submitted to the State Safety Engineer for review.
3. For blinker STOP and STOP AHEAD signs, at a minimum, consider at intersections that meet both of the following criteria:
 - a. Crashes due to failure to stop (i.e. running the stop sign), not failure to yield the right of way (i.e. stopping and then proceeding)
 - b. At least two documented failures (crash reports) to stop in the most recent 12-month period, or

three documented failures to stop within the past five years.

4. Other countermeasures *should* be considered first, prior to installation of blinker STOP and STOP AHEAD signs, to address safety concerns, such as:
 - a. Clearing vegetation
 - b. Double-marking STOP or STOP AHEAD signs
 - c. Flags on signs
 - d. Rumble strips
 - e. Increasing sign sizes
 - f. Flashing beacons
 - g. Others.
5. Side-by-side ramps are common at partial cloverleaf interchanges where entrance and exit ramps operate directly adjacent to one another at the interchange ramp terminal. Geometric design techniques to discourage wrong way maneuvers *should* be considered at side-by-side ramps. Where design constraints exist, blinker WRONG WAY signs *may* be utilized at side-by-side interchange ramps, provided there are documented wrong way movements noted by law enforcement or the Department. Blinker WRONG WAY signs **shall not** be used at locations other than side-by-side interchange ramps. WRONG WAY blinker signs shall only be used downstream of the ramp termini.
6. To maximize the effectiveness of the blinker WRONG WAY signs, vehicle actuated and time-of-day usage **shall** be considered by the Region. Some examples of time-of day usage would include:
 - a. Operation during periods when wrong way drivers are prevalent.
 - b. Operation during periods of low visibility or darkness, which may include a photocell operation.
7. ~~To avoid a proliferation of b~~ Blinker signs, ~~now they~~ **shall** only be used for STOP, STOP AHEAD, and WRONG WAY signs (at side-by-side ramps). These are considered the more important of the regulatory and warning sign series. Enhancements or blinkers to warning signs are allowed on pedestrian and school crossing warning signs, refer to TEOpS 4-5-1. There is the longstanding concern that overuse of the blinker signs will diminish their effectiveness.

~~*There have been requests to utilize different types of blinker signs. To address these requests, the Bureau of Traffic Operations is in the process of coordinating the evaluation of different types of blinker signs, and the evaluation results will determine the potential expansion of use per statewide policy. Presently, blinker signs are currently being evaluated on chevron signs in the SE and SW Regions, where there is a dynamic (vehicle actuated) system.~~

Any requests for additional blinker sign evaluations **shall** be approved by the Bureau of Traffic Operations.

8. Blinker STOP AHEAD signs **shall** be furnished and installed by WisDOT on state highways based on the criteria noted above.
9. Do not install blinker STOP signs and STOP AHEAD signs on the same approach. If used where there is a curve or hill approaching a STOP sign, use blinker on STOP AHEAD sign rather than STOP sign.
10. Do not mix beacons and blinker signs with STOP and STOP AHEAD signs on the same approach.

A cost comparison analysis *should* be done to determine where beacons or blinker sign is more appropriate. Studies have not been performed to determine if one device is more appropriate than the other.



2-1-41 Jurisdictional Boundary Signs

June 2018

GENERAL

Communities *may* request informational signing to either identify their municipal boundaries or to promote/advertise their community. These types of signs are considered to be Jurisdictional Boundary signs and *may* take the form of three different types of signs:

- Welcome signs (also referred to as municipal welcome signs)
- Enhanced political boundary signs
- Community population signs.

The community population signs and enhanced political boundary signs are considered a traffic sign and are allowed on the highway right-of-way. Per Wis. Stat. s. 86.19 (1n), municipal welcome signs are not traffic control devices and are not subject to the provisions of the WisMUTCD. A municipality *may* erect and maintain within the right-of-way of any highway, a municipal welcome sign as defined in s.84.30(2)(hm), within the boundaries of the municipality. This policy provides guidance for working with these types of signing requests.

AUTHORITY

[Wis. Stat. s. 86.19](#) prohibits signs within the limits of any highway except as are necessary for the guidance or warning of traffic and certain other exceptions as provided in that section (i.e., municipal welcome signs s. 84.30). This statute also requires the Department to prescribe regulations with respect to erection of signs on public highways.

The MUTCD Section [1A.01](#) states that advertising messages **shall not** appear on traffic control devices and Section [1A.10](#) states that the design, application and placement of traffic control devices, other than those adopted in the MUTCD are prohibited.

Therefore, the 2009 MUTCD and Wis. Stat. s. 86.19 have specific standards regarding the design and installation of such signing.

POLICY FOR MUNICIPAL WELCOME SIGNS

Welcome signs are defined as an official sign that is erected and maintained by or for a local government within the boundaries of the municipality boundary to inform motorists of the territorial boundaries of the municipality.

The Highway Maintenance Manual (HMM 09-20-30)^[d1] contains the formal detailed policy governing the permitting of Municipal Welcome Signs.

In summary, HMM 09-20-30 states:

1. Welcome signs along state highways *may* be permitted when located on or off the highway right-of-way. When off the right-of-way, the sign is considered an outdoor advertising sign and a permit is required under [s. 84.30](#) and [Trans 201.05](#).
2. Unpermitted municipal welcome signs **should** be removed if conditions warrant that the sign cannot be permitted as is. Prior to removal, the Department will work with the community to determine if the sign may be moved to a different location, rebuilt with yielding features/materials, shielded, etc. to allow issuance of a DT1812 permit.
3. Welcome signs installed within the highway right-of-way shall require a work on right-of-way permit ([DT 1812](#) form).
4. Welcome signs that are within the clear zone or clear recovery area on the right-of-way **should** be constructed with breakaway or yielding features/materials. If not, then WisDOT approved shielding **shall** be provided for the sign.
5. No welcome sign will be allowed to remain if it is a safety hazard. The permittee **shall** be responsible for any costs incurred by the Department to correct or eliminate hazards related to the welcome sign.
6. Municipal welcome signs **shall not** have auxiliary plaques, as these are considered advertising, and not allowed per s. 86.19.
7. Municipal welcome signs are not allowed to be placed within the right-of-way of a highway designated

as part of the national system of interstate and defense highways.

8. Municipal welcome signs are not owned or installed by the Department.
9. Municipal Welcome signs **shall not** be installed where vision corners may be blocked, such as at intersections or median breaks.
10. Care shall be taken to ensure that vision of existing or planned traffic signs is not blocked.

POLICY FOR ENHANCED POLITICAL BOUNDARY SIGNS

Enhanced political boundary signs are more of an informational sign as they do not directly provide a guidance function for the motorist. These signs are traffic signs that are installed on conventional highways, in the highway right-of-way, at the municipal limits by permit. The signs serve the functions of conveying the municipal limits of a community and *may* tie into the theme of the community by utilizing different colors and/or a pictograph on the sign.

GENERAL POLICY CRITERIA

1. If location efforts fail for a welcome sign, then a community could apply for a permit to install and maintain an “enhanced political boundary sign.” Enhanced political boundary signs **shall not** be allowed if there is an off-right-of-way welcome sign in place.
2. If an enhanced political boundary sign is installed, then WisDOT would remove the standard population sign.
3. Enhanced political boundary signs *should* be ground-mounted on the right side of the roadway. Ground-mounted median signs *may* be installed if right-side installation opportunities are not available. No overhead sign installations are allowed.
4. Supplemental signs (tree city USA, 1979 baseball champs, Lions clubs, etc.) **shall not** be allowed on the enhanced political boundary signs or supports.
5. Enhanced political boundary signs **shall** only be allowed on conventional highways for incorporated cities and villages, located at the municipality border. Enhanced political boundary signs **shall not** be allowed for townships or unincorporated communities.
6. All enhanced political boundary sign requests, including CSS projects, **shall** be approved by the Region Traffic Engineer. Requestor **shall** furnish proposed locations, sign and pictograph design and type of supports used.
7. The community population number *may* be included on the enhanced political boundary sign.
8. The community **shall** be responsible for all costs associated with the manufacture, installation and maintenance of the permitted enhanced political boundary signs.

SIGN DESIGN STANDARDS

1. Destinations, arrows or specific traffic generators **shall not** be allowed on the signs.
2. The pictograph (logo) height **shall not** exceed two times the height of the uppercase letters and **shall** be located at the top or left side of the sign. The pictograph **shall** be the official designation adopted by the jurisdiction. The pictograph *may* contain wording, provided it is not a commercial advertising message. Only one pictograph is allowed per sign.
3. Enhanced political boundary signs **shall not** be lighted or contain any animated or moving parts, flashing lights or disks.
4. At minimum, enhanced political boundary signs **shall** utilize Type H—High Intensity sheeting.
5. Minimum letter size **shall** be 4 ½” lowercase, 6: uppercase letters. Maximum sign size **shall** be 72: width by 48: height.
6. Sign base material **shall** be in accordance with [Section 637 of the WisDOT Standard Construction Specifications](#).
7. The sign shape **shall** be rectangular. Aluminum signs **shall** have rounded corners.
8. Border is required on the signs and **shall** be retroreflective, and of the same color as the text.

9. Colors **shall** meet the standards for highway colors specified by the Federal Highway Administration.

Two color combinations *may* be used which are:

- White or yellow on blue, green or brown
- Blue, green, black or brown on white
- Red or orange on white, but not the reverse
- The background colors of orange, red, yellow, purple, or the fluorescent versions thereof, fluorescent yellow green and fluorescent pink **shall not** be allowed. One background color only allowed. Lettering and border (if used) **shall** be of the same color.

SIGN INSTALLATION STANDARDS

1. The standard WisDOT posts (4" x 6" wood or 2" x 2" tube steel) *may* be used. The community also *may* be allowed to utilize other types of sign posts. Non-standard sign posts **shall** conform to [TEOpS 2-15-52](#).
2. Sign installation and placement **shall** be per WisDOT standards.
3. Sign mounting height **shall** be five feet to bottom of sign.
4. Sign locations **shall** be approved by WisDOT. Signs **shall** be located outside of the influence area of an intersection (typically 200' minimum distance from the intersection).
5. WisDOT **shall** approve any proposed landscaping plans. Any landscaping items **shall** meet breakaway standards or be shielded with FHWA approved shielding. For example, there is a 20" high decorative curb that meets FHWA standards.

POLICY FOR COMMUNITY POPULATION SIGNS

1. City or village limit signs *may* be installed on freeways or expressways at or near where the highway enters the municipality, unless the city or village is identified on the primary guide signs or a supplemental guide sign.
2. City or village population signs **shall** be installed on conventional highways at or near where the highway enters the municipal limits. WisDOT will install and maintain the standard signs with the official current decennial census figures. No other signs **shall** share the supports.
3. If the city or village requests a population update, the Regional Traffic Engineer *may* authorize the municipality to modify the numbers with a white on green Type H adhesive overlay, using the same size and font as the original sign.
4. Signing for unincorporated communities is covered in [TEOpS 2-4-48](#).

APPLICATION AND PERMIT

1. Permit **shall** be approved by the WisDOT Regional Traffic Engineer.
2. The application from the requesting community **shall** contain a plan showing the sign locations) and sign fabrication detail (including colors and heights of letters and pictograph).



2-3-51 Pedestrian Crossing Warning Signs

February 2018

PURPOSE

The MUTCD provides general guidance for the installation of pedestrian related warning signs. These signs ~~are considered to be~~ the W11-2 (pedestrian crossing sign), W11-9 (wheelchair crossing sign) and the S1-1 (school crossing sign assembly).

There are some standards and guidance contained in the ~~May 25, 2011 Wis~~MUTCD. However, there are several undocumented state practices involving the application of these types of signs. There is a need to encompass the guidance and standards from ~~all of these~~these resources into a single document that will be able to assist the practitioner and provide for a consistent statewide application.

POLICY

Pedestrian Crossing Signs

1. Pedestrian crossing signs *should* be used where there are higher volumes of pedestrian activity and at mid-block crossings where crossings are unexpected or the visibility distance, as defined in MUTCD section [2C.46](#) is deficient. Pedestrian crossings signs *may* be used at unsignalized and non-stop controlled intersections.
2. The Pedestrian Crossing Sign with AHEAD plaque (W16-9P) *may* be used in sight deficient areas where pedestrians walk along the edge of the roadway.
3. ~~A Pedestrian Crossing Sign may be installed in locations without a crosswalk. For crosswalk markings, refer to TEOpS 3-2-3. Crosswalk Locations~~
 - ~~a. A Pedestrian Crossing Sign may be installed in locations without a crosswalk.~~
 - ~~b. On state highways, crosswalks are maintained by the local unit of government by permit (DT 2136 form).~~
 - ~~c. A crosswalk may be installed without a pedestrian crossing sign for roadways with posted speeds of 40 mph or less.~~
 - ~~d. For roadways with posted speeds of 45 mph or higher, new marked crosswalks alone, without other measures to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways (see WisMUTCD, Section 3B.198, paragraph 09).~~^[d1]
4. Pedestrian Crossing Signs located on WisDOT maintained roadways, **shall** be installed and maintained by WisDOT.
5. Pedestrian Crossing Signs **shall not** be utilized at a signalized or stop controlled intersection. The Wheelchair Crossing Sign *may* be used at a signalized or stop controlled intersection.
6. Pedestrian Crossing Signs *may* be used at an unsignalized right turn bypass. Another option at an unsignalized right turn bypass is to utilize the Yield Here to Pedestrians (R1-5 sign) at the crosswalk location.
7. The Pedestrian Crossing Sign (W11-2) and arrow plaque (W16-7L/R) **shall** be placed at the point of crossing.
8. For roadways with posted speeds of 45 mph or greater, the Pedestrian Crossing Sign (W11-2) with ahead plaque (W16-9P) **shall** be installed in advance of the crossing.
9. For multiple pedestrian crossings that are close together on roadways with posted speeds that are lower than 45 mph, the Pedestrian Crossing Sign (W11-2) with ahead plaque (W16-9P) *may* be used in lieu of signs at the point of crossing.
10. The W11-15 or W11-15a, Recreational Trail Crossing sign **shall** follow the parameters listed above ~~similar to~~like the W11-2 Pedestrian Crossing Sign.
11. The W11-9 Wheelchair Crossing Sign **shall** follow the parameters listed above similar to the W11-2 Pedestrian Crossing Sign, with the exception that it *may* be used at signalized and stop controlled intersections.

School Crossing Signs

1. School Crossing Signs *may* be used at signalized controlled intersections.

2. Regardless of posted speed, the School Crossing Assembly (S1-1 sign with S16-7L/R plaque) **shall** be installed at every crossing. If two crossings are at one intersection (far side and near side), both crossings do not need to be signed.
3. For multiple School Crossings, the advance warning sign is not required in advance of every crossing.
4. Engineering Judgment should be utilized to determine if the advance sign is required in advance of each crossing in a series.
5. For placement of School Crossing signs, refer to [TEOpS 2-3-54](#).

[Refer to TEOpS 4-5-1 for pedestrian actuated warning device options.](#)

2-3-54 School Area Signing

February 2018

PURPOSE

The MUTCD has expanded the usage of signing for school areas. This policy will summarize the standards and guidance contained in [Part 7](#) of the MUTCD and will address three specific applications of School Area signing on the state highway system. This policy pertains to signing on conventional highways and expressways.

BACKGROUND

[Part 7](#) of the MUTCD and [Wisconsin State Statute 118.08](#) provide support for the guidelines listed in this policy.

POLICY FOR SCHOOL AREA SIGNING

The installation of School Area signing on the State Highway System can be addressed with three different types of applications:

1. School Zone Signing. School Zones are school areas that would include buildings and/or grounds that border the roadway, but would have no specific crossing. The grounds may or may not have fencing. "School grounds" refers to public and private schools and their surrounding grounds where any of grades K through 12 are regularly taught during the normal school year.
 - a. The S1-1 School Warning sign **shall** be installed in advance of the school grounds at the prescribed warning sign distance outlined in MUTCD Table [2C-4](#).
 - b. The supplemental S16-9P AHEAD plaque **shall** be installed under the S1-1 School Warning sign.
 - c. The R2-6P FINES HIGHER plaque **shall** be installed under the School Zone assembly (S1-1 Sign with S16-9P plaque).
 - d. The END SCHOOL ZONE (S5-2 Sign) **shall** be installed at the end of all school zones and areas. If there is a regulatory speed limit at the end of the school zone or area, the END SCHOOL ZONE (S5-2) sign should be mounted under the R2-1 sign. The mounting height of the END SCHOOL ZONE sign mounted under a speed limit sign should be 4' to the bottom of the secondary sign or 5' to the bottom of the lowest plaque in urban areas where there are pedestrians or parked cars.
2. School Advance Crossing Signing. The School Advance Crossing Signing is used to warn motorists that they are approaching a crossing where school children are present. The crossing may be in the same roadway where the school is located or may be on a neighboring roadway, based on the school's master plan of the school routes.
 - a. The S1-1 School Warning sign **shall** be installed in advance of the school grounds at the prescribed warning sign distance outlined in MUTCD Table [2C-4](#).
 - b. The supplemental S16-9P AHEAD plaque **shall** be installed under the S1-1 School Warning sign.
 - c. The R2-6P FINES HIGHER plaque **shall** be installed under the School Zone assembly (S1-1 Sign with S16-9P plaque). The mounting height should be 4' to the bottom of the lowest plaque or 5' to the bottom of the lowest plaque in urban areas where there are pedestrians or parked cars.
 - d. If the school crossing is located on a cross street in close proximity to the turning motorist, the S16-6P Advance Direction Arrow should be used in lieu of the S16-9P AHEAD plaque.
3. School Crossing Signing. The School Crossing signing is used at the location where the school children

cross the roadway. Crosswalk marking is required whenever school crossing signs are used per the MUTCD. Crossing locations are established based on the school's route master plan as shown in the MUTCD, Section [7A.02](#).

- a. The S1-1 School Warning sign **shall** be installed at the crossing location.
- b. The S16-7L/R Diagonal down arrow warning sign **shall** be installed under the S1-1 School Warning sign.

If the school crossing is located on the same roadway as the school property, then the school advance assembly can function in a dual purpose as the advanced sign for the school bordering the roadway and the advance sign for the school crossing. The school advanced sign does not need to be duplicated for this situation (See Figures 2 and 3).

POLICY FOR ADDITIONAL SIGNING FOR SCHOOL AREAS

Listed below are other signs covered in the MUTCD, [Part 7](#), that are installed on the state highway system.

1. School Bus Stop Ahead (S3-1) Sign
 - a. The word message SCHOOL BUS STOP AHEAD (S3-1 signs) shall no longer be used. The new sign is a School Bus / Children symbol that is fluorescent yellow green in color and is still the S3-1 sign code. The existing SCHOOL BUS STOP AHEAD word message signs in the field shall be replaced with the new symbol signs by no later than December 31, 2015.
 - b. In order to determine if a School Bus Stop *qualifies* for a sign, the Minimum Visibility Distance table in MUTCD Section [2C.36](#) *should* be used.
 - c. If a School Bus Stop qualifies for a sign (based on the Minimum Visibility Distance outlined above), MUTCD Table [2C-4](#) **shall** be used to determine field placement of the sign(s).
2. Reduced School Speed Limit Ahead (S4-5 Sign).
 - a. A Reduced School Speed Limit Ahead Sign (S4-5) **shall** be installed for reductions of 15 mph or more.
 - b. The distance table in [TEOpS 2-3-30](#) should be used in determining the placement distance of the Reduced School Speed Limit Ahead Sign (S4-5) from the School Speed Limit (S4-51 Sign).
3. School Speed Limit (S4-51 Sign).
 - a. [Wisconsin State Statute 346.57](#) places a Statutory Fixed Speed Limit of 15 mph on school crossings when children are present and the crossing is properly signed. Wisconsin State Statute 349.11 allows the Department of Local units of government the authority to modify this speed restriction on their respective maintained roadways. WisDOT recommends that the school speed limit be 10 mph less than the speed limit of the roadway. The School Speed Limit (S4-51 Sign) **shall** be installed at all school areas and crossings where the speed restriction is modified.
 - b. For school areas and crossings, the School Speed Limit (S4-51 Sign) should be installed in areas that are urban or have school children walking/crossing within the right-of-way.
 - c. For school areas and crossings in fringe or rural areas, the School Speed Limit (S4-51 Sign) *may* be installed. However, the signs are generally not installed in these areas, unless school children are walking or crossing within the right-of-way. If the signs are installed in these areas, they should be 10 mph less than the posted speed limit of the roadway.
4. Flashing Beacons.
 - a. The local unit of government *may* be allowed by permit to install a flashing beacon on one of the school area signs in each direction of roadway travel. RRFB's (Rectangular rapid flash beacons) *may* be allowed by permit on the school crossing sign assembly (S1-1 and S16-7L/R) only, since this would be the location of the physical crossing. Policy criteria for flashing beacon usage is covered in [TEOpS 4-5-1](#) and the application/permit form ([refer to Conditions on DT 1877 form](#)).

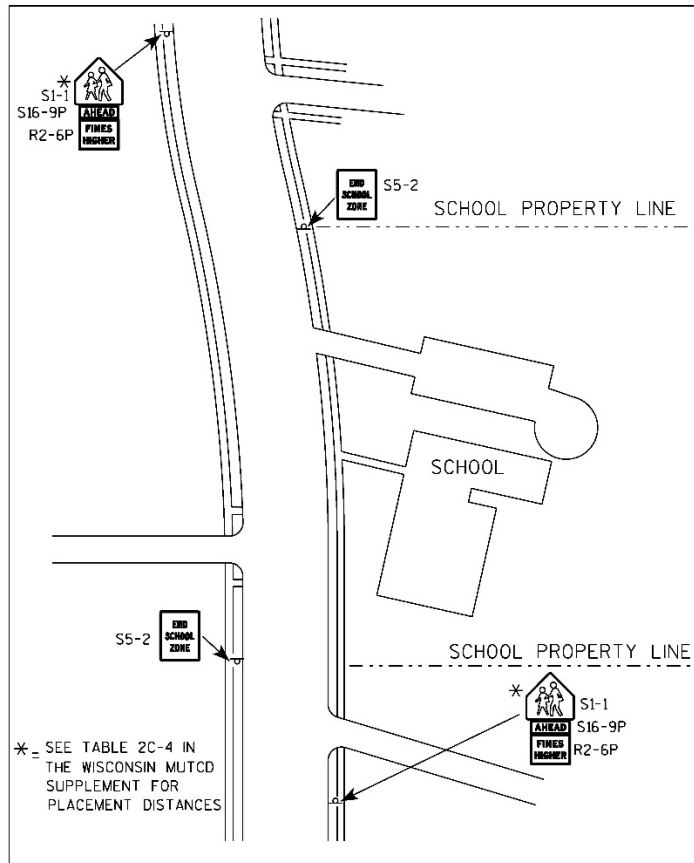


FIG. 1 RURAL SCHOOL WITHOUT CROSSING

NOTE: SIGNING IS SHOWN AS TYPICAL SIGN PLACEMENT.
 FIELD CONDITIONS MAY DICTATE CHANGES IN
 SIGN PLACEMENT.

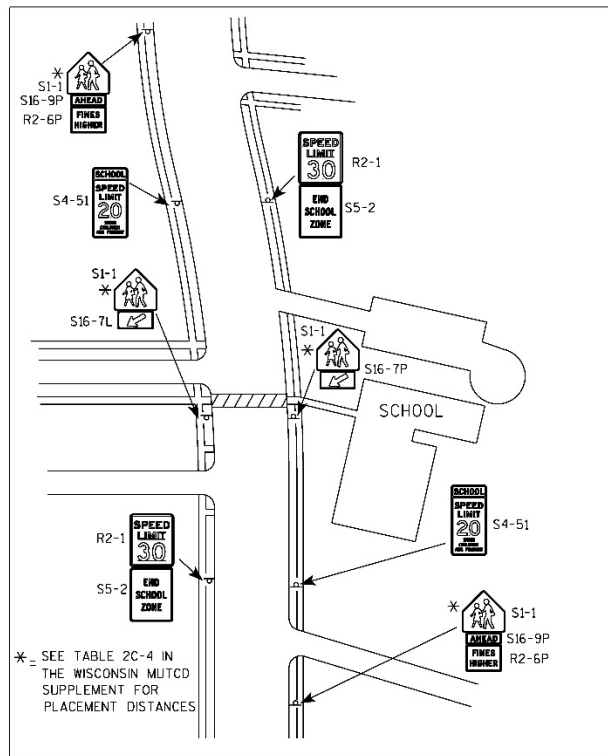


FIG. 2 URBAN SCHOOL CROSSING (WITHOUT REDUCED SCHOOL SPEED ZONE SIGNS)

NOTE: SIGNING IS SHOWN AS TYPICAL SIGN PLACEMENT. FIELD CONDITIONS MAY DICTATE CHANGES IN SIGN PLACEMENT.

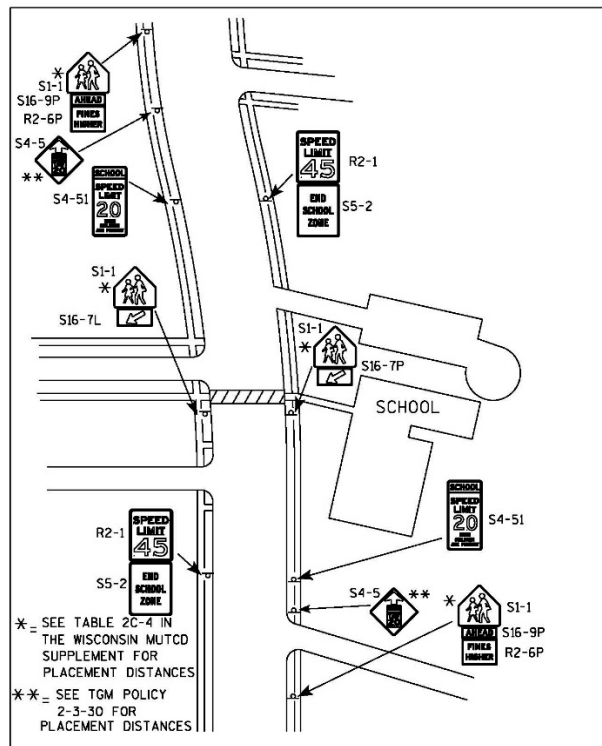


FIG. 3 URBAN SCHOOL CROSSING (WITH REDUCED SCHOOL SPEED ZONE SIGNS)

NOTE: SIGNING IS SHOWN AS TYPICAL SIGN PLACEMENT. FIELD CONDITIONS MAY DICTATE CHANGES IN SIGN PLACEMENT.



3-2-1 Longline Marking

November 2016

GENERAL

The purpose of this policy is to provide specific guidance for the uniform application of long line markings on State Highways under DOT jurisdiction. The MUTCD Section [3B](#) contains further guidance on longline markings.

Centerline Markings

Centerline markings **shall** be a 4" wide yellow line. Dashed lines **shall** be 12.5' long with a 37.5' gap.

Centerlines markings **shall** be marked on:

- All highways under DOT jurisdiction
- Through all intersections with local roads on two-lane state highways.
- On undivided multilane highway with a double yellow line

Centerline markings **shall not** be marked through:

- Intersections where the state highway is more than two lanes
- Intersections where Interstate, US, or State Highways intersect
- Signalized intersections
- All way stop
- Intersections with opposing left turn lanes.
- Stop lines or marked crosswalks.

Further information on centerline markings are located in Section [3B.01](#) of the MUTCD.

Edge line Markings

The MUTCD Section [3B.06](#), describes edge line markings in more detail. Edge line markings **shall** be a 4" white line on the edge of the roadway except the left most edge line on a divided highway **shall** be yellow.

Edge line markings **shall**:

- Continue through all driveways (commercial or private) except major commercial driveways (big box stores, etc.)
- Be used on freeways and expressways
- Be used on rural arterial roads with a traveling width of at least 20 feet and an ADT > 6,000 vehicles per day
- Urban areas with a travel lane of 16 ft. or greater.

Edge line markings **shall not** continue through:

- Intersections with more than two lane
- Intersections where Interstate, US, or State Highways intersect
- Intersections with opposing left turn lanes
- Signalized intersections
- Stop controlled intersections
- Commercial driveways meeting intersection design standards with full width paved turn lanes.

Edge lines *should* be used in urban areas or semi urban areas that do not have curb and gutter as required in MUTCD Section [3B.07](#).

Edge Lines Adjacent To Urban Curb & Gutter Sections

POSTED SPEED	IS THERE CONTINUOUS LIGHTING?	
	YES	NO
≤ 30 mph	No	Optional
35 mph or 40 mph	Optional	Recommended
≥ 45 mph	Recommended	Required

Lane Line Markings

Lane lines **shall** be marked to delineate traffic traveling in the same direction. Lane lines **shall** be a 4" wide white line that is 12.5 foot long with a 37.5 foot gap between lines. Lane lines **shall** be marked on all state highways

under DOT jurisdiction. Lane lines **shall** be marked through minor intersections and major T-intersections on the state highways, see [SDD 15C8 sheets b and c](#).

Dotted Lane Lines

According to the MUTCD Section [3B.04](#), adotted line (3' line, 9' gap) *maybe* used as a substitute lane line. This line **shall** be 4" wide and **shall** be used to separate a through lane that continues beyond an intersection or interchange from an adjacent lane under the following conditions:

- A deceleration or acceleration lane
- A through lane that becomes a mandatory turn or exit lane ([SDD 15C8-sheet e](#), [SDD 15C28](#))
- Auxiliary lane
- Tapered Exit Ramps ([SDD 15C31 sheets a, b, and d](#))
- Parallel Exit (Deceleration) Ramps ([SDD 15C 31 sheet c](#))

Dotted Extension Lines

Dotted extensions **shall** be added to provide guidance past exits or *may* be added through intersections on curves where the edge of the traveled lane is unclear. A dotted extension line *may* be continued through an uncontrolled movement of a state highway intersection with another highway. If these lines are used through an intersection they **shall** be 2' lines with a 6' gap and the same width as the line that is being extended see in [SDD 15C8-17 sheet e](#).

Channelizing Lines

Channelizing lines **shall** be white and 8" in width. Channelizing lines **shall** be used in the following locations:

- In advance of an exit ramps or intersections to distinguish a lane. (3 foot line with a 9 foot gap) [SDD 15C8-17 sheet e](#)
- In advance of freeway route splits with dedicated lanes.
- To separate a through lane that continues beyond an intersection from an adjacent auxiliary lane between two intersections [SDD 15C8-17b](#)
- Exit gore markings **shall** extend fifty feet past the unpaved neutral area and 300 feet to begin the gore line, as shown on [SDD 15C 8-13g](#) and [SDD 15C31 sheet b](#).
- Entrance gore marking **shall** follow [SDD 15C31-1a](#)

Channelizing markings **shall not** be marked through:

- Signalized intersections.
- Intersections at a 4 way stop.
- Stop lines or marked crosswalks.

Bike Lane

If bike lanes are marked it **shall** be at least 5 ft. wide. Refer to [SDD 15C29](#) in the FDM. The words "BIKE LANE" or the bike symbol *maybe* used to delineate the bike lane. Signing *may* also be used to supplement the marking. The DT2500 form **shall** be completed to permit locals to install/maintain bike lanes and the DT2137 form **shall** be completed to permit the locals to install/maintain Shared Lane Markings.

The usage of green pavement marking for bike lanes or bike boxes **shall not** be allowed on state maintained roadways.

3-2-2 No-Passing Zone Standards

February 2017

GENERAL

No-passing zones are marked and signed on state maintained highways to indicate where a driver cannot safely complete a passing maneuver under normal light and weather conditions. In addition to the zones required by inadequate sight distance, certain other conditions warrant short zones or no-passing zone extensions which are marked by no-passing barrier lines. Although sufficient sight distance *may* be present at these locations, the passing operation is not appropriate under state law or for safety reasons as documented in an engineering study.

Unmarked zones (where passing is allowed) allow the driver to make a decision based on rules of the road and circumstances, such as oncoming traffic, reduced visibility due to fog, low light, rain or smoke, turning traffic, or

vehicles entering from side roads or driveways. **No-passing zones *should not* be marked to eliminate all possible conflicts.**

[Wisconsin Statute 346.10](#) allows passing another vehicle in a rural (non-business regional, non-residential regional) intersection, unless the intersection is designated by signals, stop signs, yield signs, or warning signs. Routinely marking zones through minor intersections and/or driveways would significantly reduce legal passing areas available to the driver, increasing non-compliance and unsafe passing in less favorable locations where adequate sight distance *may not* be available.

NO-PASSING ZONE CRITERIA

No-passing zones **shall** be marked at all locations on the State Highway system that have insufficient sight distance for a vehicle to safely complete a passing maneuver under normal light and weather conditions. **The establishment of these zones shall be based exclusively on the sight distance required for the posted speed and the highway characteristics.**

The following criteria **shall** be used to mark no-passing zones:

SIGHT DISTANCE

Each Region has either a No-Passing Zone Sight Distance Map or spreadsheet listing the sight distance criteria on The State Trunk Highways. Either is available from your Regional Traffic Section. Typical sight distances are shown in the following table, but other criteria such as ADT or geometrics *may* change or alter those requirements.

Posted Speed Limit (MPH)	No-Passing Zone Sight Distance		Minimum Distance Between Zones	
	(mile)	(feet)	(mile)	(feet)
25-30	0.10	528	0.10	528
35-40	0.13	686	0.10	528
45-50	0.16	845	0.13	686
55	0.21*	1,110*	0.15	792

* When authorized by the designated Regional Signing/Marking Engineer, the 55 MPH No-Passing Zone, sight distance **may be increased from 0.21 to 0.26 miles** on certain higher volume highway segments, due to higher frequency of crashes and/or a demonstrated history of excessive speeding above the posted limit.

The specific characteristics and factors leading to the increase or decrease of the No-Passing Zone sight distance from the DOT 55 MPH standard of 0.21 mile, *should* be documented in the Region.

For 55 mph posted speed roadways, during the project design process, the designer **shall** contact the Region Signing/Marking Engineer to determine the correct No Passing Zone Sight Distance to be used. STSP 648-005 **shall** be inserted into the Special Provisions with the correct No Passing Zone Sight Distance for 55 mph posted speed roadways.

REQUIRED EQUIPMENT

1. Use two vehicles that provide a target on the lead vehicle 42 inches above the roadway. The observer's eye in the trailing vehicle **shall** be 42 inches above the roadway. Whatever type of target is used, it **shall** have a sharp cutoff when it disappears and appears.
2. A Distance Measuring Instrument (DMI) **shall** be used and **shall** have an accuracy of at least 10 feet per mile. The DMI **shall** decrease the measured distance when the vehicle backs up.
3. Two-Way communication equipment is required for the two vehicles.
4. At a minimum, a full-width flashing yellow light bar with 360 degree visibility **shall** be used. Additional signs and flashing lights on the vehicles are recommended.

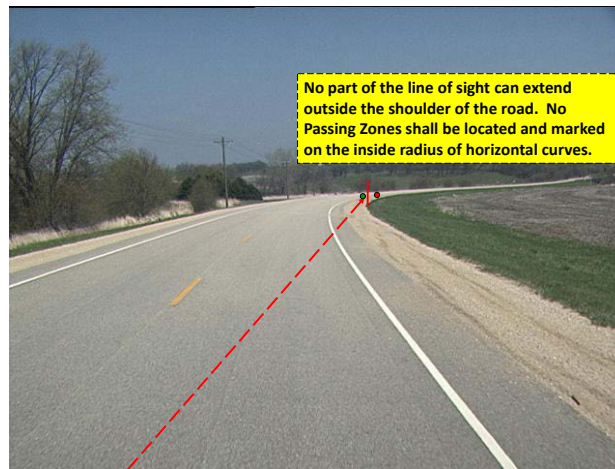
PROCEDURE FOR LOCATING AND MARKING NO PASSING ZONES

1. LOCATING NO PASSING ZONES

- Prior to beginning work on locating no passing zones, the project engineer or Region Signing/Marking Engineer **shall** be contacted to determine if there are any special no-passing zones to mark under the contract.
- The No Passing Zone sight distance shown in the table in part B **shall** be followed.
- The termini of no-passing zones **shall** be established to an accuracy of +/- 50 feet (0.01 mile).
- When the distance between two successive no-passing zones is less than the minimum distance shown in the table in part B, the two zones **shall** be connected.

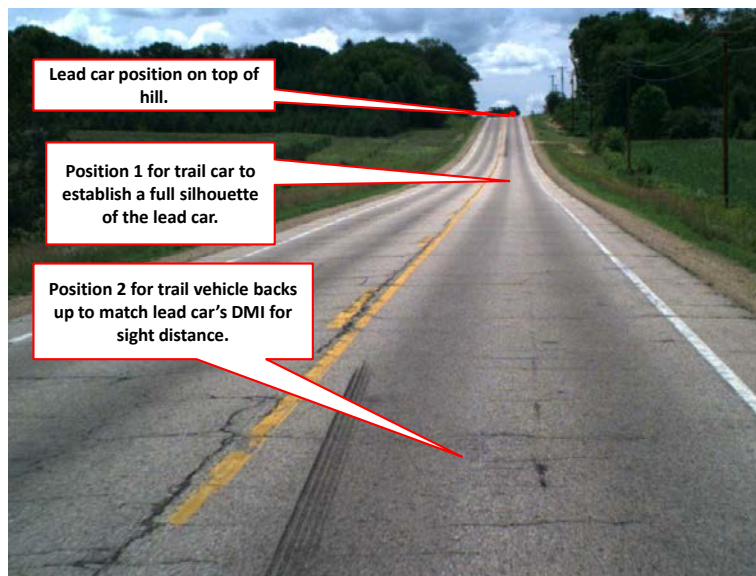
- For roadways with speed limit changes, the proper no-passing zone sight distance in the table in part B **shall** be maintained. For locations where the posted speed limit is increasing, when the lead vehicle reaches the increased speed sign, the trail vehicle would back up until the appropriate no-passing zone sight distance is achieved. For locations where the posted speed limit is decreasing, once the trail vehicle reaches the first decreased speed regulatory sign, the lead vehicle would back up until the appropriate no-passing zone sight distance is achieved.
- On horizontal curves, no part of the line of sight **shall** extend outside the shoulder (see Figure 1). No passing zones **shall** be located and marked on the inside radius of horizontal curves. If the horizontal curve requires a No Passing Zone, the starts and ends of the zones **shall** be recorded in the cardinal direction.

Figure 1. Horizontal Curve



- On vertical curves, whenever the target light disappears from sight, the crew **shall** check for blind spots. For a crest vertical curve, if the target light on the lead vehicle goes out of sight, the trail vehicle parks at the base of the hill. The lead vehicle **shall** back up to reveal a full silhouette of the rear of the car (from the bottom of the bumper up). Once the trail vehicle sees the full silhouette of the lead vehicle, the trail vehicle **shall** back up to establish the sight distance between the 2 vehicles before marking the roadway (see Figure 2).

Figure 2. Crest Vertical Curve



- For sag vertical curves, if the target on the lead vehicle goes out, the lead vehicle **shall** stop at the base of the hill or in the sag. The trail vehicle **shall** pull forward until they see a full silhouette of the lead vehicle. Once the trail vehicle sees the full silhouette of the lead vehicle, the lead vehicle **shall** pull forward to establish the sight distance between the 2 vehicles before marking the roadway (see Figure 3).

Figure 3. Sag Vertical Curve



- If the no passing zone is less than 500 feet in length, the zone **shall** be extended to 500 feet by lengthening the zone at its beginning in each traffic direction.
- The correctness of no-passing zones leading into and out of the project limits **shall** be checked. Ensure that the minimum distance between zones and the sight distance are checked.

MARKING MATERIAL

- The beginning and end of all no-passing zones **shall** be marked on the roadway by the marking of T's and dots with white spray paint (for asphalt) and black spray paint (for concrete).
- T's **shall** be 12" X 12" and 2" stroke. Dots **shall** be 3" - 4" in diameter.
- The paint material used to mark the road **shall** be durable enough to be readily visible for one year after application.

RECORDING OF NO PASSING ZONES

The WisDOT Standard No Passing Zone Log (form [DT2124](#)) **shall** be used to record the No Passing Zones (see Figure 4). Include the following data on the No Passing Zone Log Sheets:

- Date of survey on each sheet.
- County and Route on each sheet.
- The cardinal direction of travel (for east west roads, record in the easterly direction, for north south roads, record in the northerly direction).
- All starts and ends are logged in miles to the nearest 1/100th of a mile.
- The beginning and ending of each no-passing zone line in both directions.
- The sight distance and speed criteria for each zone.
- The location of landmarks (intersecting U.S., State and County trunk highways, bypass lanes, truck climbing lanes, passing lanes, county boundary lines, railroad crossings, starts and ends of bridges and regional boundaries).

NO-PASSING BARRIER LINE CRITERIA

1. No-passing barrier lines, 500 feet in length, **shall** be marked on an undivided STH approach in the following intersection situations:
 - The STH traffic is controlled by a stop sign.
 - The intersection with the STH is controlled by a signal.
 - The intersection with the STH is controlled by a roundabout.
 - At a T-intersection with a standard bypass lane that allows vehicles proceeding straight to pass to the right of a left turning vehicle without leaving the paved portion of the highway as per [SDD 15C8-b](#), a 500-foot barrier line **shall** be installed prior to the start of the bypass taper.
2. A no-passing barrier line **shall** be marked in the following non-intersection situations:
 - In advance of a divided highway. The marking configuration **shall** extend a barrier line 500 feet in advance of the island or median nose so passing is prohibited entering into the divided highway. This is

illustrated on the Standard Detail Drawing titled "Signing and Marking For Two Lane to Four Lane Divided Transitions", located in the Facilities Development Manual. ([SDD 15C21](#))

- In advance of a painted median island. The marking configuration **shall** extend a barrier line 500 feet in advance of the separation of the double yellow center line. This is illustrated on the Standard Detail Drawing titled "Median Island Marking", located in the Facilities Development Manual. ([SDD 15C18](#))
- Bridges having a width less than 24 feet. The marking **shall** include a 500 foot barrier in advance of the actual structure as shown on the Standard Detail Drawing titled "Traffic Control Devices for Two-Lane Bridges", located in the Facilities Development Manual. ([SDD 15C6](#))
- Railroad grade crossings. The barrier line **shall** be placed 500 feet prior to each approach (unless markings are not required, as provided in the MUTCD). The configuration of the marking is shown on the Standard Detail Drawing titled "Pavement Marking Details for Railroad-Highway Grade Crossings" and located in the Facilities Development Manual. ([SDD 15C9](#))
- Passing Lanes. The pavement marking configuration **shall** extend a barrier line 500 feet in advance of the beginning of the taper. This is illustrated on the [SDD 15C8-c](#) and [SDD 15C8-d](#), "Pavement Marking (Climbing Lane & Passing Lane)", located in the Facilities Development Manual. A bypass lane for an intersection is **not** considered a passing lane under this guideline.
- Truck Climbing Lanes. The pavement marking configuration **shall** extend a barrier line 500 feet in advance of the beginning of the taper. This is illustrated on the [SDD 15C8-c](#) and [SDD 15C8-d](#), "Pavement Marking (Climbing Lane & Passing Lane)", located in the Facilities Development Manual.
- Undivided 4 lane roadways. Any stretch of roadway with this configuration **shall** have the opposing lanes designated by a barrier line for its entire length and **shall** have barrier lines of 500 feet in length on the approaches to this section.

SPECIAL NO PASSING BARRIER LINES

No-passing barrier lines **shall** be marked with the approval of the designated Regional Signing/Marking Engineer in the following situations. When marked, they *should* be documented in the Region.

- At any intersection when justified by an engineering study. Appropriate reasons include a crash history related to passing maneuvers or demonstrated operational problems. The 500-foot barrier line would end at the near edge line of intersecting road and *may* be placed in only one direction based on operational need. This is illustrated on the [SDD 15C8-13b](#), "Pavement Marking (Intersections)", located in the Facilities Development Manual.
- In low speed urban areas, double yellow barrier lines *may* be placed when justified by an engineering study. Criteria for the engineering study include curb and gutter, reduced speed, parking allowed, poor stopping sight distance, closely spaced driveways or intersections, and high pedestrian volumes. The double yellow lines *should* be installed from the start of the curb and gutter to the end of curb and gutter through the urban area. When urban double yellow lines are used, 500-foot barrier lines **shall** be placed on the approaches to this special layout, unless a longer no-passing zone takes precedence.
- At a T-intersection with roadway pavement that allows vehicles proceeding ahead to legally pass to the right of a left turning vehicle without leaving the paved portion of the roadway, a 500-foot barrier line prior to the start of the bypass taper will be optional based on engineering judgment.

MARKING NO-PASSING BARRIER LINES

Barrier lines, as designated above, **shall** have a minimum length of 500 feet.

On State Trunk Highway approaches with stop or signal control, the barrier line would end at the stop line, theoretical stopping point or marked crosswalk. Each approach on the State Trunk Highway *should* be considered separately.

Barrier lines **shall** be connected into adjacent no-passing zones when there is less than minimum distance between zones, as described in the NO-PASSING ZONE CRITERIA section of this policy.

Where allowable barrier lines are justified, the traffic engineer **shall** give the crew locating no-passing zones specific directions as to where barrier lines are to be placed.

SIGNING

A No-Passing Zone pennant sign (W14-3) **shall** be installed as required in [TEOpS 2-3-38](#), supplementing zones established under this guideline. This sign **shall** be placed no more than 50 feet from the start of the no-passing barrier line unless it's impossible due to location on a bridge deck or other exception.

Sign quantities for moving the existing W14-3 sign **shall** be paid for separately and listed in the Permanent Signing Miscellaneous Quantities Sheet in the plan. If moved, the sign location **shall** be based on placement of the beginning of the revised no passing zone.

3-2-3 Special Marking

April 2017

GENERAL

Special pavement markings consist of arrows, symbols, words, stop lines, crosswalks, diagonals, and aerial/vascar enforcement markings. These markings *may* be used to supplement signing. When used, they **shall** conform to the requirements in Section [3B](#) of the MUTCD, and the following guidelines.

POLICY

All special markings **shall** be white and reflective.

Arrows

In general, arrows are used to supplement signing. There are 3 main types of arrows that WisDOT uses:

1. *Lane Control Arrows*
 - To supplement signing for complicated lane assignments and turn lanes. For mandatory turn lanes, the installation of arrows are required, per [SDD 15C8-17b](#)
2. *Wrong Way Arrows (Type 4)*
 - On any freeway off-ramp with high crash rates or unusual or poor geometrics.
 - Intersections or ramps with demonstrated problems of wrong way driving.
3. *Lane Drop Arrows (Type 5)*
 - On any lane drop with high crash rates.

Use [SDD 15C7 sheet c and d](#) for the size and shapes of these markings.

Words

Words currently allowed by WisDOT can be found in [SDD 15C7.12b](#) and [SDD 15C29 sheet e and f](#) for the size and shape of these words. All words *should* be used at a site with a documented safety problem and discussed with the regional traffic engineer.

- The word, "ONLY", *may* only be used with singular Type 1 or Type 2 lane use arrows. The word, "ONLY", **shall not** be used in a two-way left turn lane.
- The word, "SCHOOL", either single or dual lane marking, **shall** only be used when one of the following criteria applies:
 - In advance of a marked crosswalk, which is typically monitored by a school crossing guard.
 - At a mid-block or uncontrolled intersection. The requestor **shall** be responsible for maintenance of the "SCHOOL" marking in combination with the crosswalk marking. This **shall** be documented on the application/permit form, DT2136 and the crosswalks policy under the "Type of Crosswalk Marking, Other". The required detail **shall** comply with [SDD 15C7](#).
- "BIKE LANE" **shall** only be used with a signed bike lane.
- "YIELD" **shall** only be used at roundabouts.
- The word, "OK", **shall not** be used on any state maintained highways.

Symbols

Symbols **shall** conform to the [SDD15C7 sheet a](#) and **shall** only be used when the following criteria applies:

- At a site with a documented safety problem.

- Supplement to regulatory signage.
- At the discretion of the regional traffic engineer.

Chevron/Diagonal Markings

Chevron/Diagonal markings provide added emphasis to the neutral area of the gore. Chevron markings *may* be applied at gores. Refer to the FDM [SDD 15C8-13g, h, and i](#).

Stop Lines

Stop lines indicate where vehicles are required to stop at intersections. Stop lines are not required at all intersections, but *may* be desired if:

- An approach to a signalized intersection where detection is installed and stopping at a certain point *may* enhance the operation.
- Intersection approaches with unusual geometrics such as large skew angles or non-symmetric approaches.
- Complex multilane approaches.
- An approach to an intersection with the STOP sign installed well in advance of the desired stopping point because of curb radii.
- In advance of a marked or unmarked crosswalk with significant pedestrian volumes.

For placement of stop lines refer to [SDD 15C33](#). If the stop lines are required by the department, the Department will maintain the markings. All other stop lines and crosswalks *may* be marked by contract at the request of the municipality with the understanding that the local agency assumes responsibility for the maintenance.

Crosswalks

Crosswalks mark the path at which pedestrians *should* cross the roadway by delineating paths on approaches to and within signalized intersections, and on approaches to other intersections where traffic stops. As a secondary purpose, crosswalk markings *may* also serve to alert drivers of a pedestrian crossing point without signal or stop control. At non-intersection locations, crosswalk markings legally establish the crosswalk.

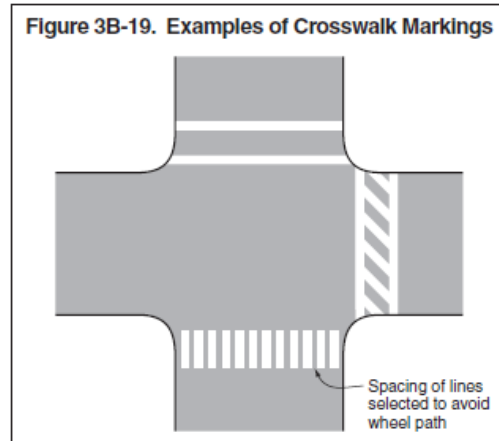
The Department policy for installation of crosswalks is as follows:

- Crosswalk markings *should* be installed at signalized intersections where pedestrian signal indications are present and at locations where there is a signed school crossing.
- Crosswalk markings *should not* be installed at non-intersection, mid-block locations or urban locations where posted speed limits are 45 MPH or more, unless traffic controls (all-way stop, signal, roundabout) or crossing enhancements (curb bump outs, median divider island, etc.) are present.
- Non intersection crosswalk markings **shall not** be permitted at rural locations with a posted speed limit of 45 MPH or more. Exceptions *may* include trail crossings where advance warning signs are present.
- A permit for crosswalk markings *should not* be approved if a sidewalk or trail approach and/or ADA-compliant curb ramps (where there is curb) do not currently exist or are planned outside the roadway limits on both sides of the crosswalk approach. Per approval of the Region Traffic Engineer, the local government *may* be permitted to maintain existing crosswalk markings without sidewalk and/or ADA-compliant curb ramps as long as the local unit of government agrees to become compliant with the next highway project (regardless of sidewalk or curb work) or local sidewalk project.
- A permit for crosswalk markings **shall not** be approved unless parking is prohibited within 15 feet of the near limits of the crosswalk, as referenced in Wisconsin State Statute 346.53(5).

Crosswalk Type Selection

There are 2 types of crosswalks that WisDOT allows as shown in Figure 3B-19 of the MUTCD

- Two 2 - 6" Transverse Lines (all intersections, excluding roundabouts) and roundabouts)
- 24" Ladder Pattern (Only for midblock crossings)
- Roundabouts
 - Two 6" Transverse Lines for single and multi-lane roundabouts.
 - The 24" Ladder Pattern may be utilized for multi-lane roundabouts where there is a presence of pedestrians during peak hours. Consult the Region Traffic Engineer and Bike/Ped Coordinator for concurrence.



Crosswalk markings *should* be placed as nearly perpendicular as possible to the direction of travel on the roadway. The following form needs to be completed to permit a municipality to install and maintain a crosswalk DT2136. A signed copy of the permit **shall** be sent to the local unit of government and a copy **shall** be filed in the Region office.

Special Marking Treatments for Crosswalks

FHWA has published an official MUTCD Ruling, dated August 15, 2013 that allows subdued-colored aesthetic pavement treatments between legally marked transverse crosswalk lines. However, the following criteria **shall** apply:

- The colored pavement treatment **shall not** be made of retroreflective material.
- Transverse crosswalk lines **shall** delineate the edges of the crosswalk and **shall** be 2-6" white transverse lines.
- Examples of acceptable aesthetic pavement treatments include brick lattice patterns, paving bricks, paving stones, cobbles or other types of paving. All treatments cannot impede wheelchair pedestrians.
- Examples of acceptable colors for aesthetic pavement treatments are red, rust, brown, burgundy, clay, tan or similar earth tone equivalents.

Aerial Enforcement and Vascar Enforcement Bars

Aerial and Vascar Enforcement Bars are transverse markings placed on the roadway to assist law enforcement agencies in the enforcement of speed regulations. These markings are a series of two to five bars with a center-to-center spacing of 660 ft. and **shall** conform to the [SDD15C14](#).

- Aerial –These lines are utilized by airplane to determine vehicle speeds from the air.
- VASCAR (Visual Average Speed Computer and Recorder) – These lines are utilized at ground locations for speed monitoring and verification of distance traveled.

Wisconsin State Patrol is the authority on these markings in cooperation with the Division of Transportation System Development to determine the quantity and locations of these markings for the use on state trunk system. Wisconsin State Patrol **will notify** the Regional traffic office for new locations that are needed or those that need to be remarked. Actual marking of the lines will be done by the Special Marking Contractor as the work schedule permits. A representative of State Patrol **shall** mark the locations of the lines with a small paint stripe prior to placing markings. A car can be provided by State Patrol for Traffic Control during the marking process, if the project engineer deems it necessary.

PURPOSE

This policy explains the concept of how islands **shall** be marked consistent with MUTCD Section [3B.23](#)

POLICY

Channelizing lines **shall** be placed upstream and adjacent to islands. The color of the pavement marking adjacent to the island **shall** be indicative of the function of the island.

- If an island separates traffic flowing in the same direction, such as a right or left turn island, the pavement markings along the island **shall** be white.
- If an island separates opposing traffic, such as a median island, the pavement markings **shall** be yellow.

Channelizing lines *may* be extended to address a demonstrated problem.

Refer to [SDD 15C8 \(c\)](#) for details on how to mark a Turn Lane Island, Median, and Corrugated Median

3-2-11 Raised Pavement Markers**March 2017****PURPOSE**

Raised pavement markers are used to either supplement or substitute longitudinal pavement markings. These retroreflective units are either placed on top of or embedded into the pavement. Section [3B.11 to 3B.14](#) of the MUTCD covers the installation of raised pavement markers, and Section [6F.79](#) covers temporary raised pavement markers. This policy will clarify application of raised pavement markers on WisDOT maintained roadways.

POLICY

The color of the raised pavement markers **shall** match the color of the line that they supplement or substitute.

Plowable raised pavement markers **shall not** be used on state-maintained roadways. Existing plowable raised pavement markers **shall not** be covered over during a resurface project and **shall** be removed, prior to resurfacing the roadway.

Temporary Raised Pavement Markers, Type I

Temporary Raised Pavement Markers Type I *may* be used in construction zones to supplement pavement marking through shifting tapers. If used in shifting tapers within construction zones, temporary raised pavement markers **shall** remain in place until the traffic staging changes. They **shall** be placed every 50 feet.

Temporary Raised Pavement Markers, Type II

Temporary Raised Pavement Markers Type II **shall** be used to substitute pavement markings which are completely covered. Permanent markings **shall** be installed within 14 days of the marking being obliterated.

On undivided roadways, W8-12 "NO CENTER LINE" signs **shall** be used to warn motorists of a roadway without any centerline until temporary or permanent markings are installed. These signs **shall** be placed at the beginning of the project, at two-mile intervals throughout the project, and at locations where traffic enters the project area from intersections with state trunk and county trunk highways.

On undivided roadways, prior to the existing marking being obliterated, the locations of the existing pavement markings, including no passing zones, **shall** be documented. In addition, prior to the existing marking being obliterated, the R4-1 DO NOT PASS sign **shall** be installed at the beginning of the no passing zones. Additional R4-1 DO NOT PASS signs **shall** be installed within any no-passing zone that continues beyond an intersection with a state or county trunk highway or that exceeds one mile in length. The R4-2 PASS WITH CARE sign **shall** be installed at the downstream end of the no passing zones. Once the permanent pavement marking has been re-established, the R4-1 and R4-2 signs **shall** be removed.

If the above signs are in place for less than seven continuous days and nights, rollup signs and stands *may* be used in lieu of post mounted signs.

Same-day pavement marking *may* be used in lieu of using Temporary Raised Pavement Markers, Type II.

The standard application of Temporary Raised Pavement Markers, Type II **shall** be installed as shown on Standard Detail Drawing [15C34-3](#).

Same Day Pavement Marking or if Roadway is Detoured During Construction

If temporary same-day pavement marking is being installed or if the roadway is detoured during construction, a

reduced amount of temporary raised pavement markers *may* be used to locate the centerline and channelizing lines. At a minimum, the following spacing requirements **shall** be used for Temporary Raised Pavement Markers, Type II for same-day pavement marking operations:

- Centerline, Lane Line, and Edge Line Marking: Place temporary pavement markers at 100' spacing.
- Place temporary pavement markers at beginning and ends of barrier lines.
- Beginning of 8" channel line: Place two temporary pavement markers side by side.
- Dotted 8" Line: Place 1 temporary raised pavement marker at the beginning of the segment of dotted line.
- If the roadway is detoured during construction, the R4-1 DO NOT PASS, R4-2 PASS WITH CARE and W8-12 NO CENTER LINE signs *may* be omitted, provided a liquid marking is installed before the roadway is reopened to traffic.



GENERAL

Reference is made to the WisMUTCD Chapter [4L](#).

Flashing beacons (a.k.a. flashers, warning flashers, beacons) are a special type of signal indication used to supplement standard regulatory and warning signs. According to the WisMUTCD, flashing beacons have the following applications:

1. Intersection control beacon
2. Stop beacon
3. Speed limit sign beacon
4. Warning beacon (includes Rectangular Rapid Flashing Beacons)

Warning beacon includes Rectangular Rapid Flashing Beacons (RRFB). Flashing beacons are part of a sign, as it pertains to the provisions for allowing the installation of the beacons on highway right-of-way. Statutes [84.02 \(4\)\(c\)](#) and [86.19 \(3\)](#) convey exclusive authority for signs and warning devices on the state trunk system to the department.

This policy contains provisions for proper application, design, and permitting of flashing beacons on the STH system.

POLICY

General

The following general criteria apply to all flashing beacon installations on the STH system:

1. There are two types of flashing beacons:
 - a. Red—only to be used with STOP signs
 - b. Yellow—to be used with any yellow warning (W-series) signs, speed limit, speed limit reduction, pedestrian warning and school speed limit signs

Flashing beacons **shall** only be associated with the sign installations referred to above.

2. Flashing beacons are supplementary to signs. When used, they **shall** be mounted on the same support as the sign which the beacon supplements in accordance with WisMUTCD [4L.03](#).
3. Activated flashing beacons **shall not** be approved on the STH system for use in conjunction with train crossings.
4. Emergency vehicle entrances *may* have activated flashing beacons, which will cancel after a pre-timed period of flash.
5. State-owned and permitted installations
 - a. The department *may* determine that flashing beacons are needed and *may* install and maintain them at specific sites. In this case, the regional traffic engineer **shall** make a final determination regarding the use of these devices on behalf of the department.
 - b. At locations where local authorities determine that the use of flashing beacons is desirable, a permit *may* be issued for the installation and maintenance of flashing beacons. Permitted installations are subject to the approval of the department and the conditions of this policy. Additionally, permits are revocable at the discretion of the department.

Application of Flashing Beacons

The following sections highlight policy items for flashing beacons that *may* be different from those represented in WisMUTCD Chapter [4L](#).

Intersection Control Beacon: Used at intersections where traffic or physical conditions do not justify conventional traffic control signals but crash rates indicate the possibility of a special need, generally located over the center of an intersection. Refer to WisMUTCD Section [4L.02](#).

Stop Beacon: Refer to WisMUTCD Section [4L.05](#).

Speed Limit Sign Beacon: Refer to WisMUTCD Section [4L.04](#). The department rarely, if ever, would install and maintain flashing beacons with speed limit signs or school speed limit signs. Local authorities **shall** follow the permit requirements stated below.

Warning Beacon: Refer to WisMUTCD Section [4L.03](#).

Flashing Beacon Design & Installation

The following provisions pertain to the installation, operation, and maintenance of flashing beacons other than rectangular rapid flashing beacons (RRFBs) on the state trunk highway system.

1. Location
 - a. Ground mount: Flashing beacons *may* be ground mounted, where they will be approximately one foot above the sign they supplement. The sign *should* be in the lateral and vertical location as specified in the WisMUTCD Part 2 (no change). Illustrations of typical ground-mount installations are in Figure 1 below.
 - b. Overhead mount: A flashing beacon *may* be mounted on one or both sides of an overhead sign. It *may* be mounted above the sign if the entire assembly including the sign has a minimum clearance of 17 feet.
2. For state-maintained installations, the standard size of flashing beacons is 12 inches in diameter. At the discretion of the regional traffic engineer, permitted (not state-maintained) installations that are in areas with a posted speed less than 30mph *may* use 8-inch diameter beacons.
3. Ground-mounted supports **shall** be the same as are normally used to support the sign, and of the same cross-section as normally used. These **shall** be 4 x 4 or cross-drilled 4 x 6 posts, or in urban areas signal posts on concrete footings, or light poles or wood poles where speeds are low. Usage of any kind of pole **shall** be in conformance with the offsets specified in highway lighting permit policy, [FDM 11-15-1](#).
4. The installation of two posts, one for the sign and the other for the flashing beacon, is not permissible within the clear zone because of the unpredictable behavior of the combination of two posts when struck.
5. Service poles must be offset to the right-of-way line or in conformance with offsets in [FDM 11-15-1](#).
6. Service *may* drop to the top of the support, which would be extended to maintain an 18-foot minimum wire-to-ground clearance as per Wisconsin electrical code. Service *should* preferably be installed underground. In the latter case, the conduit **shall** be run up and attached to the post or pole. The control box *may* be mounted on the post or pole.
7. At the discretion of the regional traffic engineer, solar-powered flashing beacon installations *may* be allowed on the STH system provided the installation meets applicable electrical and crash standards.
8. According to [TEOpS 2-1-8](#), flashing beacons and STOP or STOP AHEAD signs that incorporate flashing displays (e.g. blinker signs) **shall not** be used at the same intersection approach.

Warning Beacon (i.e., RRFBs) Design & Installation

Yellow flashers are to be used with any yellow warning (W-series) signs and school speed limit signs. Actuated blinker signs are supplementary to warning signs. When used, they **shall** be mounted on the same support as the sign which the beacon supplements in accordance with WisMUTCD 4L.03.

At locations where it is determined that the use of warning sign enhancements signs is desirable, a permit *may* be issued for the installation and maintenance of these blinker-type signs. Permitted installations are subject to the approval of the Department and the conditions of this policy. Additionally, permits are revocable at the discretion of the Department.

It is recognized that the use of warning sign enhancements *may* affect STH traffic operations by increasing delay and reducing mobility, especially if used near existing signalized or stop controlled intersections. The following location criteria should be met prior to approval:

1. The location is an uncontrolled pedestrian crossing.
2. A minimum volume of 20 or more pedestrians during a single hour (any four consecutive 15-minute periods) of an average day *should* be met. Young (<12), elderly (>85) and disable pedestrians count 2 times toward volume thresholds. Additionally, seasonal day volumes can be used in place of average day volumes if the crossing is in a known tourist area.

3. A minimum vehicular volume of 1,500 vehicles per day.
4. Maximum of four lanes crossed, unless there is a raised median, in which case it can be six lanes.
5. There exists a minimum of 300 feet between the subject crossing and the nearest controlled pedestrian crossing or intersection traffic control device on the state trunk highway system. Consideration *should* be given to extending this distance beyond 300 feet if the proposed crosswalk location falls within an auxiliary turn lane for the nearby intersection or if the standing queue from the intersection extends over the proposed crosswalk location.
6. Adequate stopping sight distance exists based on FDM 11-10-5 or greater than 8 times the posted speed limit.
7. RRFBs **shall** use a much faster flash rate and **shall** provide 75 flashing sequences per minute (except for existing RRFBs that follow FHWA IA-11). According to IA-21, the left and right RRFB indications **shall** operate using the following sequence:

RRFB Flash Pattern												
Beacon	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec	0.50 sec
Left	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
Right	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF

The use of warning sign enhancements *may not* be appropriate at locations where there is a combination of both high traffic volumes and high pedestrian volumes. In these situations, there *may* be an increase in crashes and/or delay that make the use of the actuated blinker signs inappropriate. Instead a traffic signal or Pedestrian Hybrid Beacon (PHB) *should* be considered, if feasible.

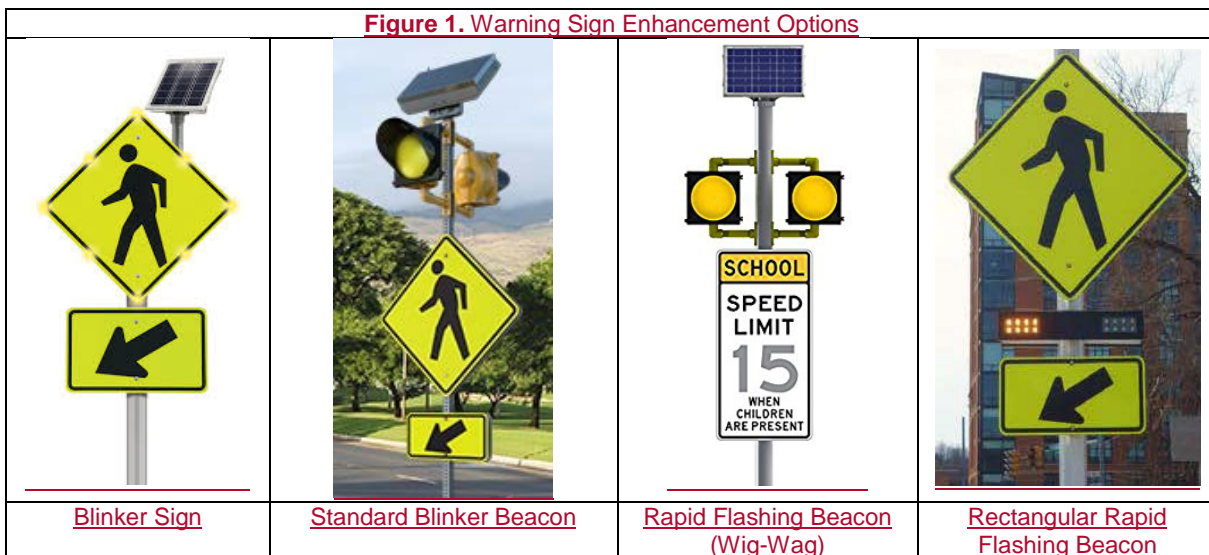
Consideration *should* also be given to spacing between pedestrian crossings – both uncontrolled as well as those supplemented with warning sign enhancements. These blinker-type signs are highly visible and therefore can be confusing or distracting to drivers if there are too many within their field of vision at one time. Historically, 1,200 feet has been a rule of thumb for minimum spacing.

Warning beacon types

There are four options that *may* be used to enhance pedestrian and school warning signs:

1. Blinker Sign. Refer to TEOpS 2-1-8 for application criteria.
2. Standard Blinker Beacon. Refer to TEOpS 4-5-1 for application criteria.
3. Rapid Flashing Beacon (Wig-Wag).
4. Rectangular Rapid Flashing Beacon (RRFB). RRFBs can only be pedestrian actuated.

These devices can be pedestrian actuated and/or time-of-day programmed.



As of March 20, 2018, FHWA has granted interim approval (IA-21) for the optional use of the RRFB as a pedestrian-actuated conspicuity enhancement to supplement standard pedestrian crossing or school crossing signs at uncontrolled marked crosswalks to any jurisdiction that submits a written request to FHWA. WisDOT received statewide approval from FHWA to allow all jurisdictions to install an RRFB. The jurisdiction must agree

to furnish a list of locations where RRFBs are installed, acknowledge that FHWA has the right to rescind the interim approval at any time and acknowledge that the interim approval does not guarantee that the provisions will be adopted into the WisMUTCD.

Any existing rectangular rapid flashing beacon that was installed or in plans prior to the rescinding of IA-11 on December 21, 2017, may remain in place until it reaches the end of its useful service life

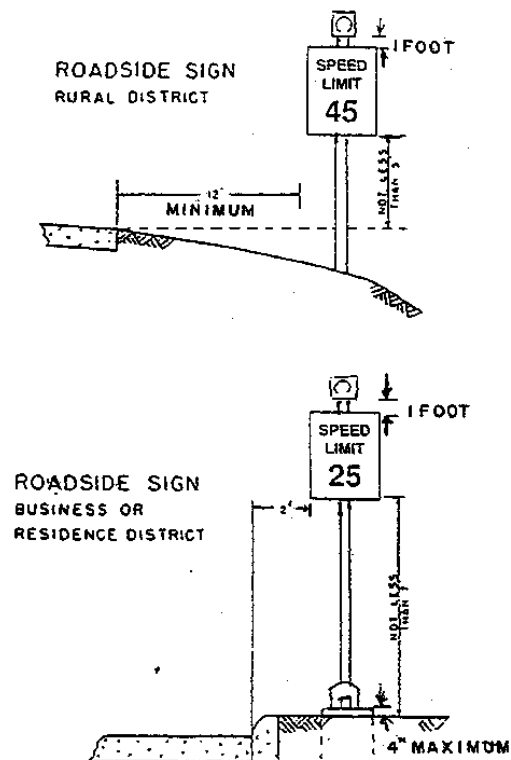
PERMITTING OF FLASHING BEACONS

Any improperly installed electrical equipment *may* pose a hazard to the public. As such, the department spells out general and specific conditions, which are part of the permit agreement. These conditions are incorporated into the permit form, [DT1877](#), a copy of which is appended to this policy. The WisMUTCD Chapter [4L](#) and specific conditions stated above **shall** also be followed for flashing beacons installed on all state trunk highways. Flashing beacons installed on connecting highways **shall not** require a WisDOT permit.

The following information provides conditions and processes related to the issuance of permits:

1. Permit applications **shall** be received, and permits issued, by the appropriate regional office.
2. Permits for flashing beacons *may* only be issued to municipalities, not to private individuals at agencies, or to power companies. This *should* result in working with the most responsible and objective agency associated with the safety problem being addressed.
3. The region *may* rightfully deny the issuance of the permit. Reasons for denial *may* include: lack of need, conflict with other traffic control devices, vulnerable location, lack of confidence in the maintaining ability of the subject agency, or knowledge that the request is due to reaction rather than long term need of commitment.
4. The region *may* revoke the permit for any of the reasons above, especially regarding lack of maintenance, as well as for reasons cited on the permit itself.
5. For permitted flashing beacons installed on signal standards, Standard Detail Drawings [9C2](#), [9C3](#), and [9E7](#) *should* be made part of the permit. SDDs [9C5](#) and [9D3](#) for control cabinet installations *may* also apply.
6. In the event of the reconstruction of the highway, reasonable notice *should* be given to the municipality to allow their removal of the equipment and arranging for disconnecting the electrical service.

Figure 1. Standard Flashing Beacon Installations for Rural & Urban Districts



4-5-2 Rectangular Rapid Flashing Beacons**January 2018****INTRODUCTION/GENERAL**

~~Rectangular Rapid Flashing Beacons (RRFBs) are a special type of beacon used to supplement pedestrian crossing signs at marked crosswalks. FHWA has rescinded FHWA Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11) for all new installations of RRFB devices effective December 21, 2017.~~

~~This policy contains provisions for proper application, design, and permitting of RRFBs on the STH system.~~

POLICY**General**

~~As of December 21, 2017, the installation of any new or replacement RRFBs by any highway agency, including those agencies who received the FHWA's approval to use RRFBs under IA-11, **shall** be prohibited.~~



Traffic Engineering, Operations & Safety Manual

Chapter 16 Traffic Analysis and Modeling

Section 1 Traffic Modeling Process

16-1-1 Overview

January 2018

1.1 Originator

The Traffic Analysis and Safety Unit (TASU) within the Bureau of Traffic Operations (BTO) is the originator of this chapter. Submit all questions and comments concerning this chapter to the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox.

1.2 General

This chapter addresses the methodologies and tools for conducting traffic operations analyses for the evaluation and design of WisDOT facilities. Traffic operations analyses provide an assessment of how traffic demands for all modes of travel and the capacity of the facility affect the overall performance of the transportation system. The results of traffic operations analyses assist WisDOT in determining the best way to meet the department's goal of providing a safe, reliable and efficient multimodal transportation system.

There are multiple tools and methodologies for completing traffic operations analysis, each having their own set of capabilities and limitations. Selecting the appropriate analysis procedure and tool is not always intuitive and can prove challenging. The primary goal of this chapter is to address this challenge by providing guidance on the uniform and consistent application of the various traffic operations analysis tools, methodologies and procedures. The policy within this chapter does not cover the travel demand models (TDMs) used to generate traffic forecasts. Refer to the [Transportation Planning Manual \(TPM\), Chapter 9](#) for additional details regarding traffic forecasting protocols.

1.3 Content

[Attachment 1.1](#) provides an illustration (flow chart) outlining the process for the development and review of traffic models used to conduct traffic operations analyses. For cost-effective traffic analyses, project managers *should* refer to [Attachment 1.1](#) as they develop the project schedules, budgets and management plans.

This chapter defines WisDOT's policy pertaining to traffic analysis tools and methodologies. Use the policy within this chapter in conjunction with WisDOT's Facilities Development Manual (FDM), specifically [FDM 11-5-3.7](#). In the event the two documents provide conflicting information, contact BTO-TASU via the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox to confirm the controlling methodology.

1.4 Acronyms/Terminology

The key terms and acronyms used within this chapter include:

AADT – Average Annual Daily Traffic

BPED – Bureau of Planning and Economic Development

BSHP – Bureau of State Highway Programs

BTO – Bureau of Traffic Operations

CDR – Concept Definition Report

Department – Wisconsin Department of Transportation

DOT – Department of Transportation

DHV – Design Hour Volume

DTIM – Division of Transportation Investment Management

DTSD – Division of Transportation System Development

FDM – Facilities Development Manual

FHWA – Federal Highway Administration

GoF – Goodness of Fit

HCM – Highway Capacity Manual

HCM6 – Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis

LOS – Level of Service

Microsimulation – Microscopic traffic simulation. Tools using this methodology analyze the movement of individual vehicles as they travel through a simulated network on a second-by-second or sub-second basis.

MOEs – Measures of Effectiveness

O-D Matrix – Origin-Destination Matrix

PDAS – Program Development and Analysis Section (part of BSHP)

PMP – Project Management Plan

RFP – Request for Proposal

RTOR – Right-Turn on Red

TASU – Traffic Analysis and Safety Unit (part of BTO)

TAT III –Traffic Analysis Tool Box Volume III, published by FHWA

TAT IV - Traffic Analysis Tool Box Volume IV, published by FHWA

TDM – Travel demand models used to generate traffic forecasts

TEOpS – Traffic Engineering, Operations and Safety Manual

TFS – Traffic Forecasting Section (part of BPED)

TOPS Lab – University of Wisconsin, Madison Traffic Operations and Safety Laboratory

Traffic Models – the computer models used to carry out traffic operations analysis. These include both the HCM-based traffic analyses and microsimulation analyses. This does not include TDMs.

TSDM – Traffic Signal Design Manual

V-SPOC – WisTransPortal Volume, Speed and Occupancy Application Suite

WisDOT – Wisconsin Department of Transportation

LIST OF ATTACHMENTS

[Attachment 1.1](#) Traffic Model Development & Review Process

16-1-2 Basic Principles

January 2018

2.1 Establish Project Purpose and Needs and Goals

The traffic analysis requirements for a project are highly dependent on the project goals. If the project goal is to provide a preliminary or planning level assessment of the traffic operations, then a higher-level analysis may suffice. If the goal of the project is to define project-specific design requirements, then a detailed analysis is often necessary.

Every project is unique, with its own set of assumptions and applicable methodologies. A clear understanding of the purpose, needs and goals of the project is critical in determining the necessary level of traffic analysis. When developing the project schedule and budget, consider the traffic analysis and modeling needs, including the associated peer review requirements. Ideally, the traffic analysis and modeling needs *should* dictate the schedule as opposed to having the project schedule dictate the level of traffic analysis conducted for the project. This ensures the appropriate level of traffic analysis is conducted at the most appropriate stage of the project life cycle, reducing the need for any rework. Defining the project schedule without consideration of the traffic analysis needs may compromise the integrity of the traffic models, which in turn may affect the selection of the project alternative.

The process defined within this chapter will be used to clarify the intent and intended outcome of the project and the associated traffic analysis needs while preparing the concept definition report (CDR), project management plan (PMP), request for proposal (RFP) and other project scoping documents. The key internal stakeholders, including the project team, regional traffic engineers and other pertinent staff, *should* hold a project kick-off meeting to reach internal agreement on key project goals and to define the traffic analysis needs early in the

process.

2.2 Defining the Traffic Analysis Scope/Level of Effort

To provide clear guidance for the project and to ensure that the project goals and objectives are satisfied, the project team *should* address the following questions during the initial project kick-off meeting:

- What agencies/divisions/bureaus need to be involved in the project as it pertains to the traffic analysis (i.e., who are the intended stakeholders)? What will be their intended level of involvement (project resource, project review, traffic analysis, etc.)?
- In general, what is the purpose of the project, specifically as it pertains to the traffic analysis (i.e., what questions does the traffic analysis need to answer)?
- What type of process will the project address (planning, design, construction, etc.)?
- What type of study area will the project consider (corridor, intersection/interchange, highway segment, etc.)?
- What transportation components will the project address (travel modes, traffic control, facility type, etc.)?
- What types of outputs are important for the decision-making process? What are the intended deliverables? Is the purpose of the evaluation detailed technical assessment, visual animation or both?
- What transportation alternatives does the project need to consider? What evaluation criteria will the project apply?
- Are there any known/key issues about the study area? If so, how will the project address them?
- What are the schedule and budget constraints (including agency review needs) associated with this effort?
- What is the critical path for the project? Does the traffic analysis fall within the critical path? When will changes in the project scope/ purpose significantly affect the project schedule?

The facilitator of the kick-off meeting *should* use [DT2290](#) to guide the discussion of the key aspects of the project, specifically as they pertain to the traffic analysis needs. Circulate the completed [DT2290](#) form to the internal stakeholders immediately after the completion of the kick-off meeting and update the form as necessary as the project progresses. Although the [DT2290](#) form *should* remain a fluid document, be cautious of unnecessary changes to the scope of the project and/or traffic model (i.e., watch out for scope creep).

2.3 Identify Need for Consultant Team

After defining the project goals, objectives and traffic analysis needs, the internal WisDOT project team *should* coordinate closely with the regional traffic operations staff to assess whether the region has the knowledge, time and resources available to conduct the anticipated level of traffic analysis required for the project. Oftentimes, the regional traffic operations staff can perform the simpler traffic analyses (such as the deterministic-HCM analyses) in-house while the more complex and/or demanding traffic analyses (such as the microscopic traffic simulation analyses) typically requires that the work be outsourced to one or more consultant firms.

If in need of consultant services, the internal WisDOT project team *should* follow the process outlined in [FDM 8-5](#) to select and procure the consultant team(s) to perform the necessary traffic analyses for the project. Historically, BTO has maintained master contracts for general traffic engineering services (BTO01) and traffic modeling and analysis services (BTO03). Coordinate with BTO regarding the potential use of either of these master contracts.

After procuring the consultant team(s), the internal WisDOT stakeholders *should* meet with the selected consultant firm(s) to define/clarify their roles, tasks and tentative schedule. WisDOT *should* procure the consultant team(s) and host the traffic analysis kick-off meeting early on during the project process to allow the consultant(s) to provide input on the traffic analysis methodologies, including the identification of the appropriate traffic analysis tool(s). Refer to [FDM 11-5-3.7](#) for details on defining the most appropriate traffic analysis tool(s).

2.4 Initiate Traffic Analyses

Follow the process illustrated in Attachment 1.1 to conduct the necessary traffic analyses. Refer to [FDM 11-5-3.7](#) for details on defining the most appropriate traffic analysis tool(s) and analysis methodologies, [TEOpS 16-20](#) for guidance on conducting microsimulation analyses and [TEOpS 16-25](#) for details pertaining to conducting peer

reviews. Details on other aspects of the traffic-model development process shown in [Attachment 1.1](#) are forthcoming.

Coordinate with WisDOT regional traffic staff and/or BTO-TASU as necessary to address any questions/concerns regarding the traffic analyses tool(s), methodologies and/or results.



16-15-1 Basic Principles

January 2018

The Highway Capacity Manual (HCM) provides several analytical or deterministic tools that can estimate roadway or intersection capacity, delay, density, and other performance measures for various elements of the street and highway system. The HCM also includes procedures for evaluating bicycle, pedestrian, and transit facilities. In most cases, the HCM is the standard for traffic analysis in the US; its methods are generally reliable and have been well-tested through significant validation efforts. The Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis (HCM6) (1) is the most current version of the HCM.

The HCM6 consists of the following four volumes:

- Volume 1: Concepts
- Volume 2: Uninterrupted Flow
- Volume 3: Interrupted Flow
- [Volume 4: Applications Guide](#) (a web-based document, requires a user account)

Each chapter within Volume 2 and Volume 3 of HCM6 has six or more sections covering the following topics: introduction, concepts, methodology, extensions to the methodology, applications and references. The methodology section (typically Section 3) highlights the scope, strengths and limitations of the applicable HCM methodology, and as such, serves as a good reference when determining whether use of the HCM methodology is appropriate. Additional guidance as to when an alternative (non-HCM based) analysis methodology may be appropriate is provided in HCM6, Volume 1, Chapter 7.

The HCM procedures are good for analyzing the performance of isolated and non-congested facilities, but do have limitations. For example, the HCM models cannot account for interactions between network elements (e.g., they cannot reflect the effect of a queue backup at a ramp terminal on the adjacent freeway operations) and they may under-predict the extent of congestion in oversaturated conditions. Consider the strengths and limitations of the HCM methods when selecting the methodology to apply to a particular analysis or study. (See Section 3 of the applicable HCM chapter to identify the strengths and weaknesses of the HCM methodology.) Document the rationale for choosing the selected traffic analysis methodology (HCM-based, microsimulation, etc.) in the Traffic Analysis Tool Selection memoranda and submit to the WisDOT regional traffic staff for approval.

[FDM 11-5-3.7](#) provides a brief description of when and how to apply the HCM methodologies and identifies the WisDOT-supported programs that implement the HCM methodology.

16-15-5 Signalized Intersections

January-June 2018

5.1 Introduction

Refer to [FDM 11-5-3.7](#) for general guidance on conducting deterministic analysis at signalized intersections. When conducting capacity analysis for signalized intersections, apply the basic signal parameters as outlined in the following section in conjunction with the analysis methodologies outlined in [FDM 11-5-3.7](#).

5.2 Basic Parameters for Capacity Analysis

[TSDM 3-2-2](#) provides recommended parameters to use for the general analysis of state-owned signals; including minimum and maximum green times, pedestrian phase times and cycle lengths. The following provides updated direction for the use of right-turn on red (RTOR) and saturation flow rate. Unless noted otherwise, the policy within this section supersedes the guidance provided in [TSDM 3-2-2](#). If it is unclear which guidance to follow, contact BTO-TASU via the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox for clarification.

5.2.1 Right-Turn on Red (RTOR)

5.2.1.1 Background

Right-turns made while facing a red traffic signal indication, permitted under Wisconsin statute 346.37(1)(c)3, can have a beneficial effect on traffic flow and intersection capacity as they reduce the number of vehicles serviced during the green phase. The following section describes how to apply RTOR when conducting capacity analysis for signalized intersections.

5.2.1.2 Dedicated Right-Turn Lanes

Since vehicles making other movements (through or left-turns) *may* block right-turn access at shared left-through-right (LTR) or shared through-right lanes, WisDOT has only investigated RTOR volumes at locations with dedicated right-turn lanes. For the purposes of RTOR inclusion in capacity analyses, a dedicated right-turn lane is any lane that satisfies at least one of the following criteria:

- Pavement markings and/or signage clearly show the lane is dedicated for a right-turn only movement
- Field observations indicate that the lane functions as a de-facto right-turn only lane (requires approval from WisDOT regional traffic staff)
- Subject approach flares out at the intersection such that a right-turning vehicle can safely fit beside a through vehicle within the same lane and field observations show vehicles using the approach flare to make right turns (requires approval from WisDOT regional traffic staff)

Additionally, for RTOR inclusion to be applicable for capacity analysis, the following must exist:

- Right-turns on red are permissible (i.e., field signage does not prohibit this maneuver during the analysis period)
- Vehicle queuing from the adjacent lane does not prevent vehicles wishing to make a right-turn from accessing the dedicated (or de-facto) right-turn lane

For additional clarification, as to what constitutes a right-turn lane for purposes of capacity analysis at signalized intersections, contact the WisDOT regional traffic engineer and or BTO-TASU.

5.2.1.3 RTOR Estimation

An estimate of the proportion of vehicles making RTOR from a dedicated right-turn lane is most accurate when derived from field counts taken at the intersection in question. As it is not always practical to gather this information, WisDOT developed the following recommendations regarding RTOR volumes (V_{RTOR}) in relation to total right-turn demand (V_{RT}):

- Single Right-Turn Lanes at Intersections: $V_{RTOR} = 0.38V_{RT}$ [Equation 5.1]
- Single Right-Turn Lanes at Interchange Off Ramps: $V_{RTOR} = 0.66V_{RT}$ [Equation 5.2]
- Dual Right-Turn Lanes (Intersections and Interchanges): $V_{RTOR} = 0.30V_{RT}$ [Equation 5.3]

Field studies conducted throughout Wisconsin in 2009 (2) and 2015 (3) guided the development of these recommendations. WisDOT has not studied RTOR at any other intersection configuration, such as shared lanes or triple right-turn lanes, thus unless intersection-specific field data is available to indicate otherwise, the analyst *should* assume that vehicles do not make RTOR movements at these locations. Obtain approval from WisDOT regional traffic staff prior to including RTOR volumes for triple right-turn lanes or shared lanes within the capacity analysis.

Equation 5.2, is only applicable for single right-turn lanes exiting the off ramp at an interchange. For single right-turn lanes turning onto an on-ramp at an interchange, utilize Equation 5.1.

Equation 5.2, for Single Right Turn Lanes at Interchanges, shall only be applied to single right turn lanes on an off-ramp. It is not intended for use for single right turn lanes onto an on-ramp – in that situation, use Equation 5.1.

The analyst **shall not** use RTOR volumes in the analysis when field signage prohibits this maneuver during the analysis period.

5.2.1.4 RTOR Application

Highway Capacity Software (HCS) and Synchro are the two WisDOT-supported HCM-based software programs for both traffic signal analysis and signal optimization (see [FDM 11-5-3.7](#)). HCS uses the same module for both HCM-compliant analysis and for signal optimization. Synchro, however, uses two distinct modules – one which provides HCM-compliant analysis and another which provides signal optimization as well as non-HCM-compliant analysis. The later module uses a proprietary methodology to calculate intersection delay and other values. Changes made in one module do not necessarily transfer to the other module. Therefore, there are nuances in how to conduct HCM-compliant analysis and signal optimization in Synchro which are not present in HCS.

Figure 5.1 provides an overview of the various methodologies available for affecting RTOR in the two modules of Synchro. A subset of the methodologies, those which adjust demand, affect both Synchro modules. As noted in the figure, the “growth factor” method is the preferred methodology when the analyst is using Synchro to conduct HCM-compliant analysis and signal optimization. This methodology involves applying a growth factor of less than

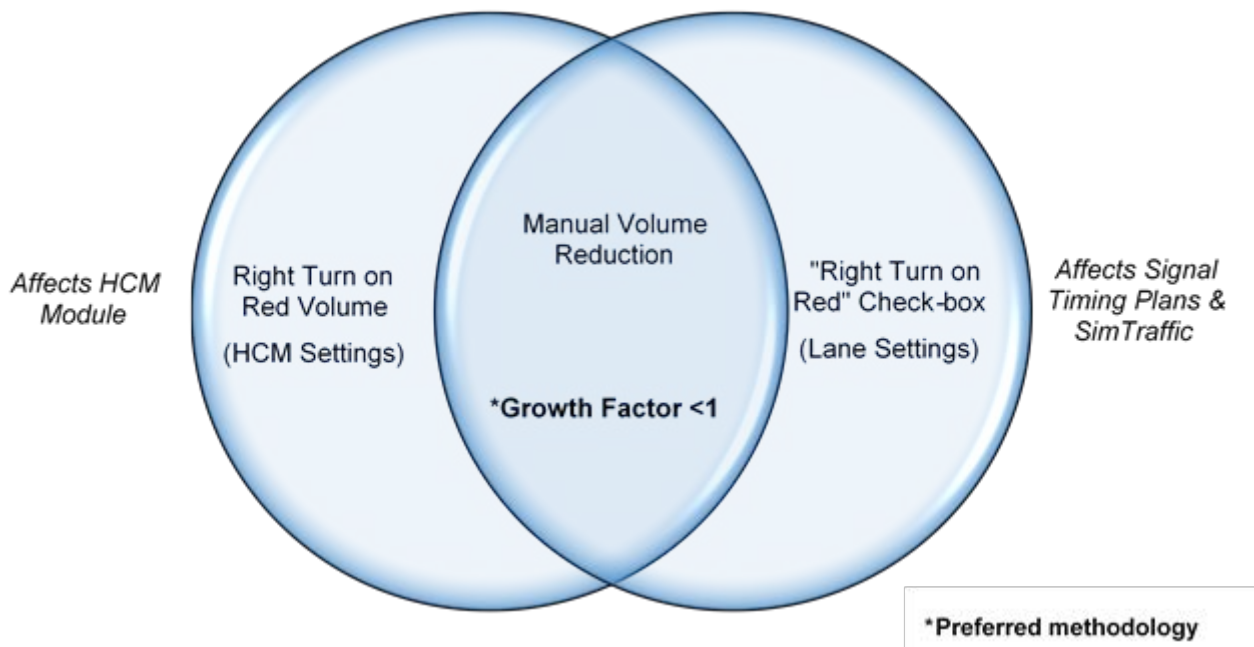
one to the right turn movements. Apply the following growth factors, derived from Equations [5.1-5.35.1](#) and [5.3](#), unless field data is available and supports otherwise:

- 0.62 for Single Right-Turn Lanes at Intersections
- ~~0.34 for Single Right-Turn Lanes at Interchanges~~
- 0.70 for Dual Right-Turn Lanes (Intersections and Interchanges)

~~Note that the above rates do not include a growth rate for Single Right-Turn Lanes at Interchange Off Ramps. Applying Equation 5.2 would yield a growth factor of 0.34 for this scenario; however, Synchro currently sets a floor of 0.5 for growth rates preventing the use of the 0.34. Note that a growth factor is not provided for Single Right-Turn Lanes at Interchanges. The growth factor would be 0.34, but a floor of 0.5 is currently set by Synchro for growth rates preventing use of the 0.34 factor in this situation.~~ [When dealing with Single Right-Turn Lanes at Interchanges, use the manual reduction method detailed below.](#)

The other methodology to affect both modules in Synchro is to manually reduce the right-turn volumes by the V_{RTOR} . This is less transparent when conducting a peer review and is more prone to typographical error. Therefore, WisDOT prefers the use of the growth factor method [in all situations where possible.](#)

Figure 5.1 Synchro RTOR Adjustments Venn Diagram



5.2.1.4.1 HCM-Compliant Analysis

WisDOT provides the following guidance on incorporating RTOR volumes when conducting HCM-compliant analysis. The RTOR volumes used may be based on field-collected values or the equations above (see Equations 5.1 – 5.3).

- **HCS:** Enter the V_{RTOR} , rounded to the nearest whole vehicle per hour (veh/h), into the “RTOR, veh/h” field for the relevant approaches. This field is at the bottom of the “Primary Input Data” within the HCS “Streets” module, which includes traffic signal analysis.
- **Synchro:** Use the growth factor method outlined above. Checking the “Right Turn on Red” box in the “Lane Settings” area **does not** affect the HCM-compliant analysis.

Entering the V_{RTOR} value associated with the approach into the “Right Turn on Red Volume” field in the Synchro HCM module is also acceptable, though WisDOT does not prefer this method as it only affects the HCM module. The analyst **shall not** enter a volume other than the default of 0 into the “Right Turn on Red Volume” field in combination with the growth factor method, as it will lead to incorrect results.

5.2.1.4.2 Signal Optimization

In Synchro, changes to the “Right Turn on Red Volume” field in the HCM module do not affect the signal timings or optimization calculations. If the analyst checks a box to allow RTOR within the “Lane Settings” module

(automatically checked by default), Synchro uses an algorithm to determine a “Saturated Flow Rate (RTOR)”. Synchro uses the “Saturated Flow Rate (RTOR)” value within the signal optimization function. The RTOR checkbox does not affect the HCM results. Synchro’s proprietary RTOR methodology, enabled via the RTOR checkbox, is not straightforward and is thus not a preferred methodology for developing signal timing plans. When optimizing signals, the analyst *should* uncheck the RTOR box checkbox for all approaches.

WisDOT prefers the use of the growth factor method for conducting signal optimization in Synchro.

5.2.1.4.3 Microsimulation Analysis

WisDOT also currently supports three microsimulation software programs for traffic signal analysis: SimTraffic (associated with Synchro, affected by demand reductions but not by changes within the HCM module), Paramics, and Vissim although, effective January 1, 2018, WisDOT will no longer support for Paramics for new microsimulation analyses (see [FDM 11-5-3.7.1.4](#)). The analyst *should not* dictate RTOR volumes within microsimulation programs, as the models *should* determine when these turns happen based on how the right-turning vehicles interact with other vehicles in the system. Where right-turns at signals are critical movements, a good check for reasonableness could be comparing modeled RTOR volumes to field-collected ones. The analyst *should* direct any questions regarding how to model RTOR within a specific microsimulation software program to BTO-TASU via the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox.

5.2.2 Saturation Flow Rate

5.2.2.1 Background

One of the many variables that influence the performance of traffic signals is saturation flow (sat. flow) rate. The base saturation flow rate for a lane is the theoretical number of vehicles that could travel through the intersection during one hour of green time under ideal conditions. The saturation headway, or the average time between the front bumper of one vehicle and the front bumper of the vehicle behind it under ideal conditions, determines the saturation flow rate. The HCM6 default values for base saturation flow rate are:

- 1900 passenger cars per hour per lane (pc/h/ln) in metropolitan areas with population >250,000
- 1750 pc/h/ln otherwise

The HCM provides several factors to adjust these base saturation flow rates to account for prevailing conditions at the approach, including heavy vehicle percentages, grade, lane width, etc. More information on flow rate concepts is available in HCM6, Chapters 4 and Chapters 19.

Through movements at signalized intersections typically have high volumes relative to other movements, and therefore have an oversized role in determining the overall timing and phasing, as well as level of service (LOS). Therefore, this policy focuses on the saturation flow rate for through lanes. Additional guidance on the saturation flow rate for left and right turn lanes is forthcoming.

5.2.2.2 Saturation Flow Rate Methodology

A field saturation flow study at an intersection will provide the most accurate measure of experienced flow rates on its approaches. Given the expense, it *may* not be practical to conduct these studies, especially at locations that are operating significantly under capacity.

Since it is impractical to conduct field studies for every intersection and in an effort to gain a better understanding of the range of saturation flow rates, WisDOT funded a study in 2015 to evaluate saturation flow rates at various signalized intersections across the state (3). The study aimed to identify the variables, beyond those already accounted for by the HCM, which influenced the field saturation flow rates. The study followed the methodology laid out in the HCM and only collected data on the saturation flow rate for through lanes.

The 2015 WisDOT sat. flow study (3) found that the following three factors affect the base saturation flow rate of a through lane at a signalized intersection: the urbanized area or cluster population, the total number of approach lanes (left, through and right), and the posted speed limit of the approach. Accordingly, the base saturation flow rate *may* differ from one approach to the next at a given signalized intersection. The field conditions or traffic signal design dictate the total number of approach lanes and the posted speed limit of the approach. The urbanized area or cluster population information is available from either the table or map provided by the [2010 Census Bureau](#).

WisDOT used the results of this study to develop a methodology to estimate the base saturation flow rate for through lanes at signalized intersections in Wisconsin. Since the methodology accounts for more variables and reflects Wisconsin-specific data, analyst *should* use the WisDOT sat. flow methodology as described below to estimate the base saturation flow rate for through lanes at signalized intersections in Wisconsin. If the WisDOT

estimation methodology results in a sat. flow rate less than the relevant HCM default value, specifically if it is less than 1750 pc/h/ln, the analyst *should* consider completing a field study or using the HCM6 default values.

Coordinate with WisDOT regional traffic staff to determine the most appropriate methodology for calculating the base saturation flow rate for through lanes. Unless instructed otherwise, use the HCM default values for the base saturation flow rate for left and right turn lanes.

5.2.2.3 Saturation Flow Rate Estimation

Use the [WisDOT sat. flow spreadsheet](#) (a Microsoft Excel based spreadsheet) or the adjustment factors shown in [Table 5.1](#) to implement the WisDOT sat. flow methodology. The WisDOT sat. flow spreadsheet implements equations to apply the various site-specific adjustments in the same general form as HCM6 and calculates the base sat. flow rate by approach.

In lieu of the WisDOT sat. flow spreadsheet, the analyst *may* use the adjustment factors shown in [Table 5.1](#) in conjunction with a starting saturation flow rate value of 1980 pc/h/ln (derived from the 2015 WisDOT sat. flow study (3)) and the following equation:

$$s_0 = 1980 \times f_{Pop} \times f_N \times f_{SL} \quad \text{[Equation 5.4]}$$

Where:

s_0 = Base saturation flow rate

f_{Pop} = Adjustment factor for population

f_N = Adjustment factor for number of approach lanes

f_{SL} = Adjustment factor for speed limit of approach

As with the WisDOT sat. flow spreadsheet, apply the adjustment factors at the approach level. Note that due to rounding, use of the adjustment factors from Table 5.1 will result in a slightly different sat. flow rate than that calculated through use of the WisDOT sat. flow spreadsheet. The WisDOT sat. flow spreadsheet uses formulas to calculate the adjustment factors and does not round until after it computes the sat. flow rate, where the adjustment factor methodology utilizes rounded values from Table 5.1 to compute the sat. flow rate.

An example of how to apply the adjustment factors for saturation flow rate follows:

A signalized intersection is in a city with a population of 29,000 ($f_{Pop} = 0.95$). Looking at an approach with a left-turn lane, two through lanes, and two right-turn lanes (five total approach lanes, so $f_N = 0.97$) and a posted speed limit of 40 MPH ($f_{SL} = 1.00$), the resulting base saturation flow rate would be:

$$s_0 = 1980 \times 0.95 \times 0.97 \times 1.00 \quad s_0 = 1825 \text{ pc/h/ln}$$

Use the resulting S_0 , or base saturation flow rate (1825 pc/h/ln), for operational analysis of the two through lanes on this approach. Unless instructed otherwise, use the HCM default values for the left and right turn lanes. Calculate the base saturation flow rate for the other approaches in a similar manner.

Table 5.1 WisDOT Saturation Flow Adjustment Factors

Population Adjustment Factor		Lane Adjustment Factor		Speed Adjustment Factor	
Urbanized Area/ Cluster Population	Adjustment Factor	Total # Approach Lanes	Adjustment Factor	Posted Speed Limit of Approach (mph)	Adjustment Factor
< 2,000	0.91	1	0.88	25	0.94
2,000 - 4,499	0.92	2	0.94	30	0.96
4,500 - 8,999	0.93	3	0.96	35	0.98
9,000 - 18,999	0.94	4	0.97	40	1.00
19,000 - 39,999	0.95	5	0.97	45	1.02
40,000 - 82,999	0.96	6	0.98	50	1.04
83,000 - 170,499	0.97	≥7	0.98	55	1.07
170,500 - 347,499	0.98				
347,500 - 704,499	0.99				

$\geq 704,500$	1.00
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Since the WisDOT sat. flow methodology calculates a Wisconsin, site-specific base saturation flow rate; the analyst *should* apply all other HCM adjustment factors, including the Central Business District (CBD) adjustment factor, as appropriate to calculate the final adjusted sat. flow rate. It is important to note that the WisDOT sat. flow estimation methodology applies only to exclusive through lanes and shared through-right lanes, as these two types of through lanes were the only ones included in the 2015 study.

5.2.2.4 Saturation Flow Rate Application

5.2.2.4.1 HCM-Compliant Analysis and Signal Timing Plan Development

As detailed in [FDM 11-5-3.7.3.1](#), WisDOT currently supports two HCM-based software programs for traffic signal analysis, HCS and Synchro. WisDOT provides the following guidance on entering base saturation flow rates generated from the WisDOT sat. flow methodology.

- **HCS:** Enter the base saturation flow rate, rounded to the nearest 5 pc/h/ln, into the “Saturation, pc/h/ln” field for the relevant approaches. This field is in the “Traffic” section within the HCS “Streets” module, which includes traffic signal analysis.
- **Synchro:** In the HCM module, used to generate fully HCM-compliant results, enter the base saturation flow rate, rounded to the nearest 5 vehicles per hour per lane (vphpl), into the “Ideal Satd. Flow (vphpl)” field for the relevant approaches. Alternately, edit this field through the “Lane Settings” module – changes made there carry through to the HCM module.

5.2.2.4.2 Microsimulation Analysis

Capacity is not typically an explicit input within microsimulation programs, as it will vary based on vehicle interactions and various parameters. Since headway dictates saturation flow rate and because each microsimulation program has one or more adjustable parameters characterizing the concept of headway, adjustments to these settings will increase or decrease potential and realized capacities. The analyst *should* calibrate each signalized intersection, ensuring that applicable validation thresholds are met and that field behavior is replicated adequately. Direct any questions regarding how to apply saturation flow rate within a specific microsimulation software program to BTO-TASU via the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox.

16-15-70 References

January 2018

1. **Transportation Research Board.** *Highway Capacity Manual, 6th Edition: A Guide For Multimodal Mobility Analysis.* Washington, D.C. : National Academy of Sciences, 2016. ISBN 978-0-309-36997-8.
2. **R.A. Smith National.** *Right Turn on Red Methodology Evaluation.* 2009.
3. **TranSmart Technologies, Inc.** *Signalized Intersection Capacity Data Collection: A Statewide Evaluation of Saturation Flow Rate and Right Turn on Red.* 2015.



1.1 Introduction

Microscopic traffic simulation, or microsimulation, refers to traffic analysis tools that analyze the movement of individual vehicles as they travel through a network. As the simulation progresses, it updates factors such as the vehicle's position and its need to increase/decrease speed or change lanes several times a second. Accordingly, these tools are suitable for evaluating the interaction of different components of the transportation network, such as queues from an intersection that cause lane blockages upstream or complex weaving and merging behaviors. Additionally, the visual animation of traffic flows can make microsimulation traffic models useful for public outreach and stakeholder presentations. Typical situations where microsimulation traffic analysis *may* be appropriate include scenarios that macroscopic tools cannot or do not address well, such as:

- Complex weaving along freeways and/or arterials
- Arterial and freeway interaction (e.g., spill-back from an arterial onto the freeway at an exit ramp)
- Non-traditional or alternative interchange/intersection analysis (e.g., diverging diamond interchanges and continuous flow intersections)
- Turn-lane spillover
- Oversaturated conditions
- Signal and roundabout interaction
- Vehicle/transit/pedestrian interaction

The primary purpose of traffic modeling is to simulate the transportation system under various volume and geometric conditions to assess what (if any) improvements are necessary. Most often, the models represent projected (or future) traffic conditions. Although analysts typically use traffic models to assess the impact of potential capacity/expansion improvements, they can also use microsimulation models to assess non-expansion improvements such as managed lanes, channelization optimizations (e.g., removing shared lane movements), and additional transit service.

WisDOT supports the use of microsimulation traffic models; however, it is important to match the analysis methods with the scale, complexity and technical requirements of the project. Microsimulation modeling work typically requires significantly more time, data and effort than other traffic analysis tools. Thus, prior to selecting microsimulation as the analysis tool, the project team *should* assess whether less resource-intensive traffic analysis tools can sufficiently meet the needs of the project. The project team *should* also consider the project schedule and budget to ensure that they can adequately accommodate the development and review of the microsimulation traffic models. [FDM 11-5-3.7](#) provides additional information and guidance on selecting the most appropriate traffic analysis tool(s).

1.2 Calibration vs. Validation

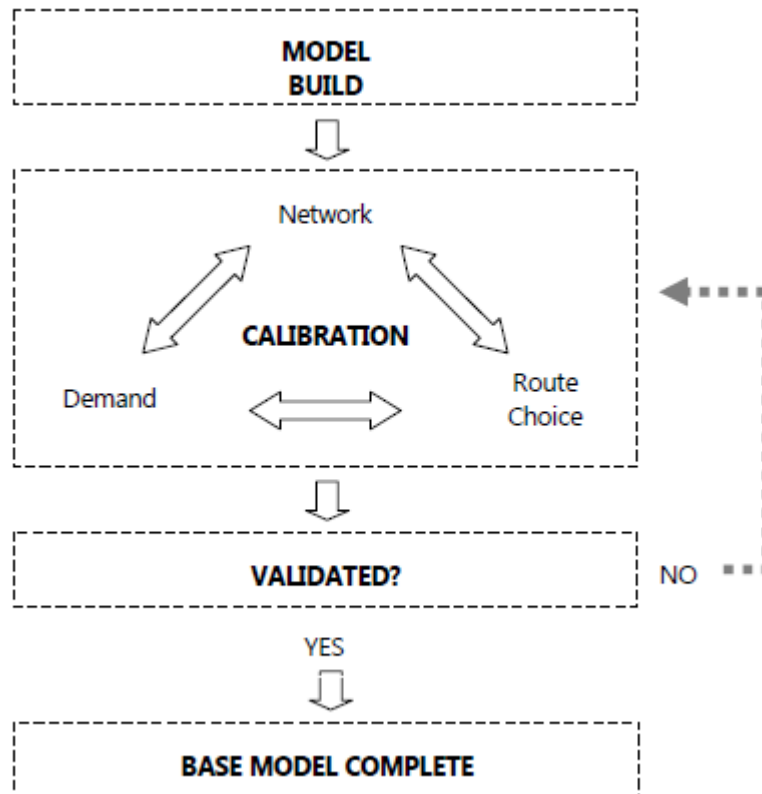
Microsimulation models contain multiple parameters that the analyst can modify to reflect varying degrees of driver behavior, vehicle characteristics and roadway conditions. Developing a traffic model with a reasonably accurate representation of real-world local traffic conditions requires calibration and validation of the model where, for purposes of WisDOT policy, calibration and validation have the following definitions.

Calibration: The process where the analyst adjusts selected input parameters within the traffic model (typically driver behavior elements such as headway and reaction times, driver aggressiveness, etc. and roadway elements such as sign posting) such that the traffic model represents field conditions. See [TEOpS 16-20-5](#) for additional details on the calibration process.

Validation: The independent process where the analyst checks the traffic model outputs against field measured data including, but not limited to, traffic volumes, travel speeds, travel times, intersection queuing and trip-making patterns (e.g., weaving volumes). See [TEOpS 16-20-8](#) for additional details on the validation process.

Calibration and validation are part of an iterative cycle. If, after the initial round of calibration, the model results do not satisfy the validation thresholds, the analyst must conduct additional model calibration and recheck the updated model results against the validation targets. This process continues until the model results meet the validation targets and the traffic model has reached a level of fidelity that is acceptable. Figure 1.1, taken from the New South Wales (NSW) Government Transport Roads & Maritime Services (RMS) 2013 *Traffic Modelling Guidelines* (1), illustrates the iterative relationship between model calibration and validation.

Figure 1.1 Traffic Model Calibration and Validation Process



Source: NSW Transport Roads & Maritime Services 2013 *Traffic Modelling Guidelines*, Figure 11.3 (1)

1.3 Purpose of Calibration & Validation

The process of developing a microsimulation model starts with an existing conditions model and then transitions into the development of various scenarios representing future-year alternatives. The only way to determine that a traffic model reasonably represents real-world traffic conditions is to compare the existing conditions traffic model to traffic conditions observed in the field. If the existing conditions traffic model cannot reproduce the existing traffic conditions with a reasonable degree of accuracy, then analyses of other scenarios will be highly suspect. Therefore, prior to using the model outputs for project or study decisions, especially any related to critical aspects of the design, the analyst **shall** calibrate and validate the microsimulation traffic model in accordance with [TEOpS 16-20-5](#) and [TEOpS 16-20-8](#), respectively. Additionally, the traffic model *should* undergo the peer review process in accordance with [TEOpS 16-25](#), prior to the commencement of work on any other traffic model scenarios or alternatives (e.g., design year no-build traffic model). Conducting the peer review process at the proper time will limit the potential of needing to modify multiple models to address reviewer comments.

After completion of the calibration, validation and peer review processes, the analyst can use the existing conditions model as the starting point for future-year alternative models. Most of the parameters calibrated in the existing conditions model *should* be transferable to the future-year models; however, the analyst *may* need to modify some parameters to account for changes in roadway geometry and/or associated driver behavior. The calibration, validation and peer review processes ([TEOpS 16-20-5](#), [TEOpS 16-20-8](#) and [TEOpS 16-25](#), respectively) are applicable for all future-year model alternatives and the analyst *should* apply them as appropriate.

2.1 Traffic Model Boundaries

Confusion about the purpose, objectives or physical boundaries of the traffic model can cause delays and other potential problems such as:

- Misunderstandings or ambiguities regarding the purpose/objectives of the traffic modeling effort
- Mission creep or unplanned expansion of the traffic model that could delay the delivery of results, such as unexpected enlargement of the geographical boundaries
- Misapplication of the traffic model (e.g., attempting to use the traffic model at a level of detail for which it was never intended)
- Inappropriate sequencing of activities (e.g., starting to develop the build scenarios before the existing conditions traffic model has been properly calibrated and validated)

Although the above problems can apply to all types of traffic analyses, the complexities associated with microsimulation traffic models only exacerbate the issues. To ensure that there is a clear understanding of the traffic analysis requirements, the project team **shall** work with WisDOT regional traffic staff to define the preliminary traffic model boundaries. After coordinating with WisDOT regional traffic staff, the project team *should* organize a meeting with other key stakeholders to finalize the traffic model boundaries and review/update the [DT2290](#) Traffic Model Scope form as appropriate. In addition to the meeting, it *may* be beneficial to conduct an organized visit to the site to familiarize the team with the current traffic conditions/issues.

Typically, the traffic analysis kick-off meeting will include only those internal stakeholders, and applicable consultant team representatives, who will be involved in the development and/or review of the traffic model. It *may* be beneficial to promote early involvement with the Bureau of Traffic Operations – Traffic Analysis and Safety Unit (BTO-TASU) and the Federal Highway Administration (FHWA), as appropriate, by inviting them to this initial meeting. This is especially true for mega projects, high profile projects and FHWA Projects of Division Interest (PoDI). At a minimum, the project team **shall** invite the FHWA Wisconsin Division Operations Program Manager to the initial kick-off meeting for any interstate project that has a scope of work greater than pavement replacement. Refer to the FHWA/WisDOT “Risk-Based Project Stewardship and Oversight Agreement”, provided in [FDM 11-5-2-1](#), for details on FHWA and WisDOT stewardship and oversight of federal-aid projects.

Refer to [TEOpS 16-25-2](#) for additional guidance on determining who *should* participate in the review of the traffic model. In general, BTO-TASU **shall** be involved with the review of all models where FHWA participation is desired or required. It is also advisable to include BTO-TASU when dealing with new, unique or complex modeling concepts or analysis tools, especially if the region does not have the necessary knowledge and/or resources. Direct any questions regarding the need to involve BTO-TASU to the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

After the traffic-analysis kick-off meeting and any site visits, key stakeholders, including the consultant team as applicable, *should* have a good grasp on the following:

- Purpose and objective of the traffic model(s)
- Traffic issues/concerns for the study area
- Applicable traffic analysis method(s) and tool(s)
- Temporal and spatial boundaries of the traffic model(s)
- Analysis scenarios (e.g., existing, no-build, build, etc.)
- Potential data needs and sources

If, after the meeting, there are still components of the ~~DT2290~~[DT2290](#) form that are unknown, the project team *should* coordinate further discussions between WisDOT regional traffic staff, the traffic analyst (i.e., consultant team) and BTO-TASU as appropriate. The following provides additional details on how to define the model limits (spatial and temporal) and analysis scenarios.

2.1.1 Traffic Model Spatial Limits

The limits of the microsimulation traffic model *should* encompass not only the limits of the specific transportation project under study, but it *should* also include all parts of the surrounding transportation network (or zone of influence) that may significantly influence the operations of the study area. When setting the limits of the traffic model, the analyst *should* consider the potential impact of planned/proposed roadway improvement projects and/or strategies, especially if the future improvement may result in a shift in travel patterns. Other adjacent and/or nearby improvement projects may have a significant impact on the spatial limits of the traffic model, especially if the projects are proceeding concurrently (e.g., the traffic model *may* need to be extended to incorporate the adjacent projects or portions of the traffic model may overlap with the model of an adjacent project, etc.). Thus, it is critical to have early coordination with any adjacent and/or nearby projects.

Where practically feasible, the spatial boundaries of the traffic model *should* capture all congestion, existing and future, in the area. Where it is not possible to capture the congestion spatially, evaluate whether extending the temporal limits of the model will allow the traffic model to reflect the traffic congestion (see [TEOpS 16-25-2.1.2](#)). In situations where resource or other constraints prevent the traffic model from being extended (spatially or temporally) to allow for the capture of all congestion, coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to set the traffic model limits. Include discussion on the potential risk of not being able to identify the full extent of congestion for future/alternative scenarios until after completion of the existing conditions model. All key stakeholders *should* agree on the approach to use to compensate for any congestion that occurs outside the established model limits. Initial discussions on the spatial limits of the traffic model *should* occur during project scoping.

The analyst *should* take care not to extend the model limits out further than necessary, as the larger the model, the more complex and time-consuming it will be to calibrate and validate. One-way to measure the complexity of the traffic model is to consider the size of its origin-destination (O-D) matrix, which represents each location (or zone) where vehicles can enter or exit the model. The O-D matrix increases with the square of the number of traffic zones included in a model: a 25-zone model has 625 O-D pairs ($25 \times 25 = 625$) while a 50-zone model has 2,500 O-D pairs ($50 \times 50 = 2,500$). Every O-D pair added to the traffic model adds additional time to the network coding, calibration and validation process. Therefore, depending on the size of the study area, it *may* make more sense to break the traffic model into two or more smaller models rather than to develop one large model. (Coordinate with WisDOT regional traffic staff and/or BTO-TASU to assess whether to break one large model into smaller models.) All boundaries of the traffic model *should* occur at logical break points in the roadway network (e.g., locations where the traffic volumes naturally drop-off or locations where traffic attributes such as travel speeds normalize or return to free-flow speeds). Avoid breaking the model at critical study area locations (e.g., avoid breaking the model in the middle of a complex weaving segment between two large interchanges).

Depending on the operational characteristics, it is possible for the limits of the traffic model to extend beyond the end of the project termini. Additionally, microsimulation analysis *may* only be necessary for a portion of the project study area such that the limits of the microsimulation model are smaller than the project limits. For example, if a project study area encompasses three interchanges (interchange A, B and C), of which only one (interchange A) involves complex weaving maneuvers and requires microsimulation analyses, the limits of the microsimulation model would only need to extend far enough to capture the weaving traffic behavior at interchange A. The analyst could then use an HCM-based analysis tool to evaluate the traffic conditions at interchanges B and C. Due to this variability, there is no standard set of guidance for determining the spatial limits of a traffic model. Rather, the geographical boundaries for a microsimulation traffic model needs to be determined on a project-by-project basis. FHWA's [Traffic Analysis Toolbox Volume III \(TAT III\) \(2\)](#) provides some general guidance on determining the spatial limits for a microsimulation model.

The analyst *should not* finalize the spatial limits of the traffic model until field observations document the extent of congestion and length of vehicle queues within the study area. Provide a brief discussion of the geographical traffic model boundaries within [DT2290DT2290](#). Document all assumptions and methods regarding the geographical limits for the traffic model within the modeling methodology report and/or other project memoranda as appropriate.

2.1.2 Temporal Model Limits

The temporal limits of the traffic model are dependent on the location of the project and the experienced levels of congestion, and therefore, must be determined on a project-by-project basis. Some general guidance on defining the temporal model limits follows.

2.1.2.1 Temporal Analysis Periods

Depending on the purpose and objectives of the project, the microsimulation traffic model *may* need to address two or more temporal analysis periods (TAPs) where each TAP could encompass anywhere from one to six or

more consecutive hours. Typical TAPs addressed with microsimulation models include, but are not limited to the following:

<u>AM Peak Period (AM):</u>	This typically comprises of one or two hours of each weekday between 6 a.m. and 9 a.m., although in severely congested areas it could comprise of four or more hours.
<u>Midday Peak Period (MD):</u>	This period is relevant in areas where traffic patterns peak in the non-traditional commuting hours such as a school or restaurant district. If applicable, it typically is one hour between 11 a.m. and 3 p.m.
<u>PM Peak Period (PM):</u>	This typically comprises of two or three hours of each weekday between 4 p.m. and 7 p.m., although in severely congested areas it could comprise of six or more hours.
<u>Friday Peak Period (Fri):</u>	This period is relevant in areas that experience higher traffic patterns during the Friday peak period versus the typical weekday commute, typically due to the combination of both commuter and recreational traffic.
<u>Sunday Peak Period (Sun):</u>	This period is relevant in areas where there is higher traffic than the typical weekday commute on a Sunday afternoon/early evening as travelers return home from a recreational weekend trip.
<u>Seasonal/Special Event (SP):</u>	This period is relevant in areas that experience unusual traffic patterns due to holidays, tourism and/or special events. This <i>may</i> coincide with the Friday and/or Sunday peak period.

The length of the TAP is dependent on extent of congestion in the study area. Although the TAP will vary depending on local field conditions, FHWA's [TAT III \(2\)](#) and [TAT IV \(3\)](#) provide general guidance for determining the appropriate TAPs for a traffic model.

When selecting the TAPs, consider existing field data for traffic volumes, speeds and queues, along with anticipated future traffic volumes and levels of congestion. Where practically feasible, the TAP *should* encompass the entire extent of the congestion (existing and future). If it is not feasible to extend the TAP to capture all congestion, coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to set the TAPs. Include discussion on the potential risk of not being able to identify the full extent of congestion for future/alternative scenarios until after completion of the existing conditions model. All key stakeholders *should* agree on the approach to use to compensate for any congestion that occurs outside the established TAPs.

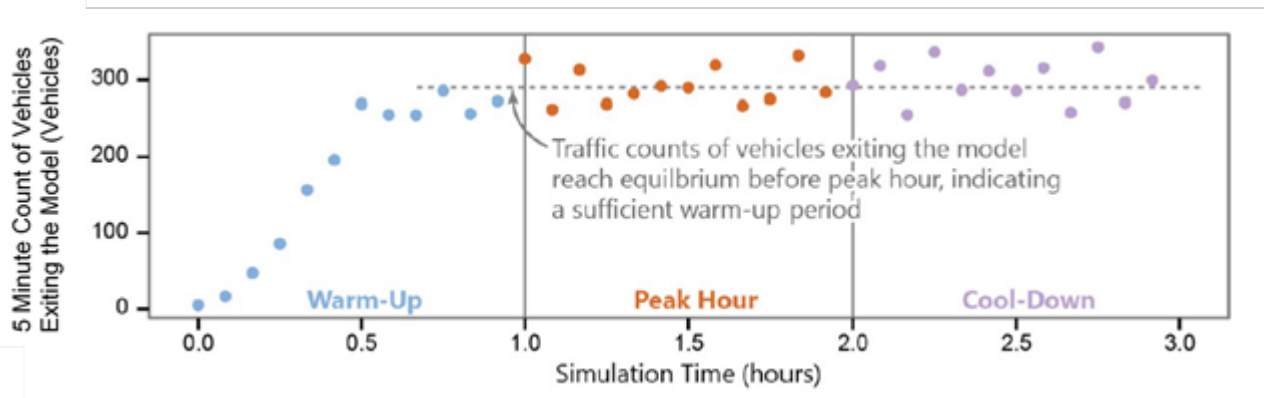
Provide a brief discussion of the TAPs within ~~DT2290~~DT2290. Document all assumptions and methods regarding the TAPs for the traffic model within the modeling methodology report and/or other project memoranda as appropriate.

2.1.2.2 Warm-Up/Cool-Down Periods

In addition to the analysis period, the microsimulation models **shall** also include a warm-up period and *should* include a cool-down period to allow for the build-up and dissipation of congestion. The warm-up period is essential because the roadway network within the traffic model is initially empty and requires some time for the network to reach conditions that reflect the start of the analysis period. Essentially, the first vehicles to enter the study area are driving under free flow conditions. Without a warm-up period, data from the beginning of the analysis period would have a strong bias toward smaller delays (lower congestion) and *may not* reflect real-world conditions. The exact length of the warm-up period will vary from project-to-project; however, as referenced in FHWA's TAT III (2), a good way to approximate the minimum warm-up period, for at least the initial model runs, is to double the free-flow travel time from one end of the network to the other. After completing one or more model runs, verify the adequacy of the warm-up period and extend as appropriate.

The warm-up period is adequate when conditions at the end of the warm-up period reflect the field conditions at the start of the analysis period. One way to assess adequacy of the warm-up period is to review the number of vehicles present at any one time on the network to determine whether the model has reached equilibrium. Once the number of vehicles present on the network stays constant or increases by an amount consistent with the applicable profile, the model has reached equilibrium and signifies the conclusion of the warm-up period. Figure 2.1 provides an illustration of how to verify that the warm-up period is adequate by reviewing the number of vehicles exiting the model.

Figure 2. 1 Warm-Up Duration Verification Example



The cool-down period allows time for the dissipation of queues created during the analysis period which is typically necessary for the traffic model to replicate real-world conditions. Like the warm-up period, the cool-down period will vary depending on local field conditions, but is typically in the range of 15 to 60 minutes. After completing one or more model runs, verify the adequacy of the cool-down period and extend as appropriate.

FHWA's [TAT IV \(3\)](#) provides additional guidance for determining the appropriate warm-up and cool-down periods for a traffic model. Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to confirm the warm-up and cool-down periods. Provide a brief discussion of the warm-up and cool-down periods within [DT2290DT2290](#). Document all assumptions, methods and exemptions regarding the warm-up and cool-down periods for the traffic model within the modeling methodology report and/or other project memoranda as appropriate.

2.2 Analysis Scenarios

It is generally advantageous to identify the anticipated analysis scenarios/alternatives prior to beginning development of the traffic models. Early identification of the analysis scenarios/alternatives aids in determining the level of effort requirements, resource needs and budget implications. Additionally, by knowing the potential analysis scenarios in advance, the analyst can assess whether the spatial and temporal model limits adequately address all analysis scenarios up front, minimizing the chances of rework and model inconsistencies. When assessing the scenarios/alternatives to model, consider the potential impacts of any adjacent planned or pending projects, especially if the adjacent projects will influence the traffic demand in the study area. The analyst *should* coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the analysis scenarios/alternatives.

Although the specific details of the analysis scenarios are project dependent, there are four basic analysis categories: 1) Existing (EX) Model, 2) Design Year, No-Build (FEC) Model, 3) Design Year with Minor Improvements (FEC+) Model and 4) Design Year, Build Model. A brief description of each of these analysis scenario categories follows.

Existing (EX):

The existing (or base) year traffic model replicates existing field conditions. Existing year traffic conditions *should* reflect the year that is as close to the original start of the traffic analysis as possible. Whenever possible, traffic data *should* be no more than three years old and ideally, all traffic data *should* be from the same year. Ongoing construction or other special circumstances may dictate the need to use older data or data from multiple years.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to select the existing year. Identify the existing year on the [DT2290DT2290](#) form and document the rationale for selecting the existing conditions within the modeling methodology report and/or other project memoranda as appropriate. The analyst **shall** obtain approval of the existing year from the WisDOT regional traffic engineer prior to initiating development of the traffic model.

Design Year, No-Build (FEC):

The design year, no-build traffic model reflects design year conditions absent of the proposed project. It will reflect design year traffic volumes and existing geometry or existing geometry with other planned and enumerated (or committed) improvement projects and may include signal timing modifications. As such, another name for this scenario is the future with existing plus committed (FEC)

scenario. The planned improvement projects need to occur after the existing year but prior to the proposed project's design year in order to be included in the FEC model. Note that the FEC conditions for a specific project may not match the no-build conditions reflected in a travel demand model (TDM) used in forecasting traffic. Therefore, coordination with the WisDOT traffic forecasting section (TFS) is essential to verify that the traffic forecasts reflect the FEC scenario assumed in the microsimulation model.

The roadway geometry of the FEC model often limits (or constrains) the volume of traffic entering, traveling through or exiting the model. The FEC model, is thus a "constrained" model, and may not reflect the true demand on all segments within the model. Depending on the purpose and objectives of the project, full analysis of a true no-build or "constrained" traffic model *may not* be necessary.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the need for developing a design year, no-build model and to clarify the need to assess "constrained" conditions. Document the rationale for including or not including the design year, no-build (FEC) model and/or "constrained" conditions within the modeling methodology report and/or other project memoranda as appropriate. The analyst **shall** obtain approval from the WisDOT regional traffic engineer on how to address the design year, no-build (FEC) conditions prior to initiating development of the traffic model.

Design Year, FEC+:

For the traffic model to function with the design year traffic volumes, it *may* be necessary to include minor geometric improvements (e.g., the extension of an existing right or left turn lane or channelization optimizations such as the removal of shared lane movements within the FEC right-of-way, etc.) beyond the committed projects. In these cases, the traffic model actually represents future with existing plus committed plus minor improvements (FEC+) conditions. The project team *should* clearly document these minor improvements within the modeling methodology report and/or other project memoranda as appropriate.

The inclusion of a design year with minor improvements (or FEC+) model is often driven by the need to eliminate the geometric constraints within or adjacent to the traffic model in order to reflect the true demand on all segments within the model. Thus, the FEC+ model is generally (but not always) representative of an "unconstrained" model. The analyst *may* elect to apply other methodologies (such as removing traffic volumes that exit the roadway network prior to the study area) in addition to or instead of including minimum geometric improvements, to develop a design year "unconstrained" traffic model.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the need for developing a FEC+ model and to clarify the need to assess "unconstrained" conditions. Document the rationale for including or not including the FEC+ model and/or "unconstrained" conditions within the modeling methodology report and/or other project memoranda as appropriate. The analyst **shall** obtain approval from the WisDOT regional traffic engineer on how to address the FEC+ conditions prior to initiating development of the traffic model.

Design Year, Build (ALT):

The design year, build traffic models capture design year conditions with the proposed project improvements. The build traffic models may reflect "constrained" or "unconstrained" conditions. Typically, the analyst will need to develop a traffic model for more than one project alternative.

Due to the complexity and level of effort and resources required to develop microsimulation models, conduct a high-level review of potential alternatives using an HCM-based deterministic analysis tools to narrow down the number alternatives prior to developing the design year, build traffic model alternative using microsimulation.

Coordinate with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate to identify the design year, build model alternatives and to clarify the need to assess "constrained" conditions,

“unconstrained” conditions or both. Document the rationale for including or not including the “constrained” and/or “unconstrained” conditions within the modeling methodology report and/or other project memoranda as appropriate. The analyst **shall** obtain approval from the WisDOT regional traffic engineer on the design year build alternatives prior to initiating development of the traffic model.

Depending on the specifics of the project, it *may* be beneficial and/or necessary to develop a model that represents the conditions that will exist in the year the proposed project improvements are first opened to traffic (i.e., opening year conditions model). This scenario reflects the opening year traffic volumes and opening year geometry, which includes the existing geometry with the proposed project improvements and any other completed improvement projects. Discuss the need to develop and opening year model with WisDOT regional traffic staff and other key stakeholders (BTO-TASU, FHWA, etc.) as appropriate.

To ensure consistency, avoid confusion and aid in the model reviews, use the [file naming convention spreadsheet](#). For example, a PM peak model of existing conditions for a project referred to as “WIS 1194” submitted on June 15, 2018 would be “WIS 1194_EX_2017_PM_061518”. A future, unconstrained model for Alternative 3 looking at the PM peak in year 2045 and submitted on September 29, 2018 would be “WIS 1194_ALT-3_UCD_2045_PM_092918”.

2.3 Traffic Model Tree

Prior to development of the microsimulation traffic model, the analyst *should* coordinate with the project team, WisDOT regional traffic staff and BTO-TASU as appropriate to develop the traffic model tree. The purpose of the model development tree is to show all the scenarios to include in the analysis, along with their relationships to one another and the existing conditions model. It formally illustrates the way the model will evolve as the work progresses, and establishes the sequence of work activities. Developing the traffic model tree prior to development of the existing conditions model helps avoid unnecessary work. Whenever possible, the analyst *should* use the same transportation network structure for all temporal analysis periods (AM peak, PM peak, Friday peak, Sunday peak, etc.) within the same year. The fewer the number of model variations, the easier it is to maintain consistency between the different analysis scenarios. Figure 2.2 provides an illustration of a basic traffic model tree.

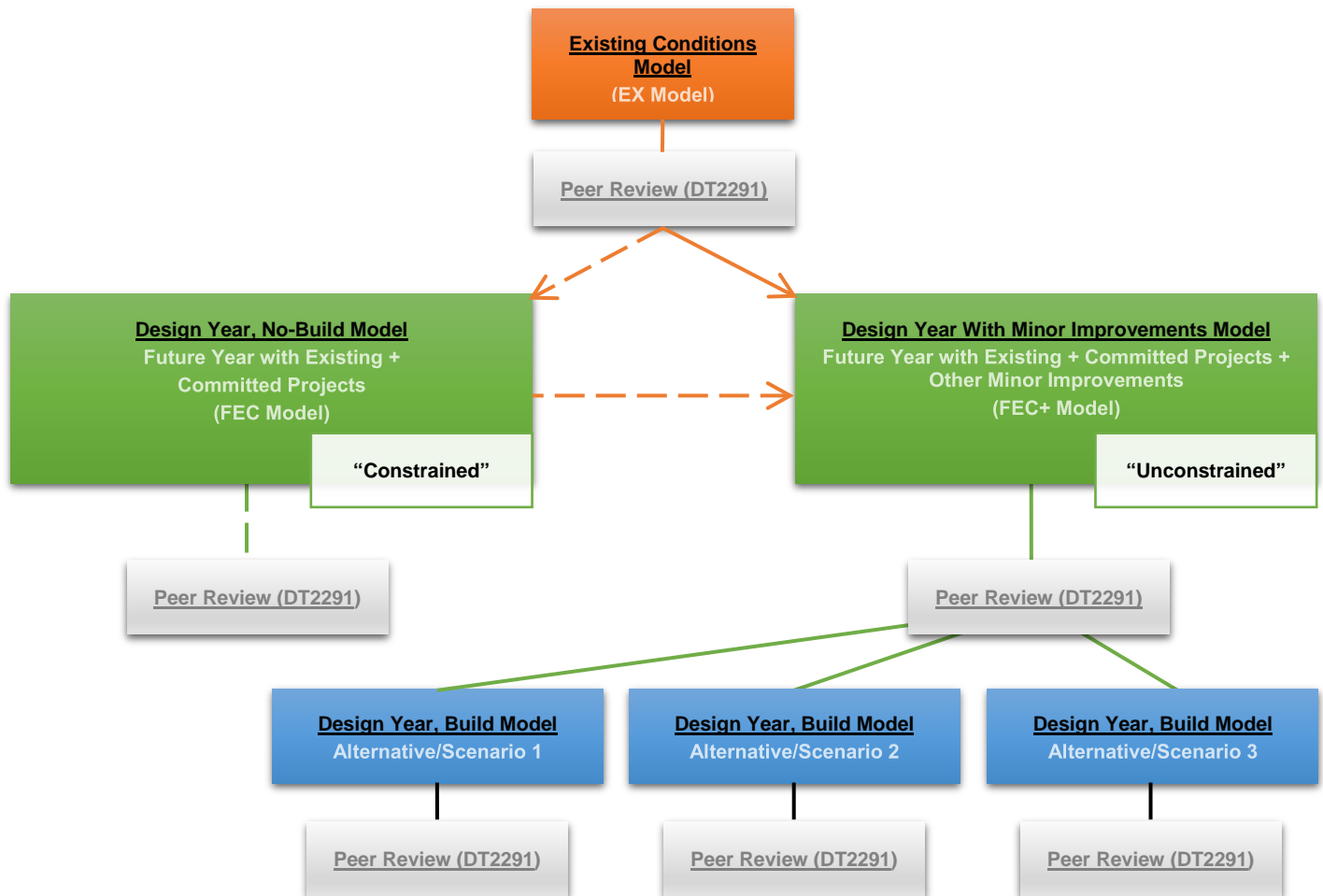
As illustrated in Figure 2.2, each version of the traffic model *should* undergo the peer review process prior to the development of the model for a new scenario. Refer to [TEOpS 16-25](#) for additional details on the peer review process. When the project has a compressed schedule, there may be a temptation to begin development of the design year models prior to completion of the peer review process of the existing conditions model. This is often counterproductive, as the analyst needs to address any comments from the peer review of the existing conditions model in not only the existing (parent) model but also in any of the design year (child) models under development.

2.4 Constructing the Traffic Model

Construct and code the traffic model in accordance with the recommendations of the user guides/manuals for the applicable microsimulation software platform. When developing the model, the analyst *should* consider the following best practices:

- Use aerials and/or design plans as background images to aid in the review
- Minimize the amount of non-link space (dead space in Paramics, connectors in Vissim) where practical
- Label major roadway segments
- Avoid the use of link-specific adjustment factors as much as possible. When their use is necessary, associate link-specific adjustment factors with roadway geometry and/or software limitations. This will make it easier to assess whether the adjustment factor is applicable for other modeling scenarios.

Figure 2.1 Example of a Typical Traffic Model Tree



2.5 Deliverables

It is generally advantageous to establish a list of deliverables prior to beginning development of the traffic models. This list will identify all the documents, videos, computer files and other items that the project team will need to produce. Early identification of the list of deliverables can clarify project expectations and assist with defining resource needs. Typical deliverables include, but are not limited to, the following:

- Traffic Forecasting Methodology Report, typically will include the following attachments
 - Forecasting and O-D Development Methodology
 - Traffic Forecasts
 - Traffic Volume Balancing Methodology
- Traffic Analysis Tool Selection Memoranda
- Modeling Methodology Reports for each model, typically will include the following attachments
 - Existing Traffic Data (e.g., traffic volumes, speeds, queuing, etc.)
 - Exhibit Illustrating the Project Design Plans/Improvements
 - Tables Showing Validation Checks
- Microsimulation Software Files (provide for all temporal analysis periods and analysis scenarios/alternatives)
- [DT2290](#)~~DT2290~~

- DT2291 for each model

For sample formats or questions on any of the above deliverables, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

16-20-3 Measures of Effectiveness (MOEs)

January 2018

3.1 Types of MOEs for Validation

The project's purpose, need and objectives typically dictate which MOEs the analyst *should* use for reporting the performance measures of the traffic model. The MOEs chosen for validation of the traffic model; however, are dependent on several factors including, but not limited to, the availability and quality of data, the size of a model, the capability of the microsimulation software, the purpose of the model, and the project scope. The following focuses on the MOEs chosen for validation of the traffic model.

3.1.1 Traffic Volumes

It is critical to validate traffic volumes on the roadway link level and/or the turning-movement level for every microsimulation model, regardless of size or complexity. There are several data sources for traffic volumes with varying levels of availability and/or data quality. Some of these resources include manual counts and various detection methods (e.g., loop, microwave, radar, video, etc.). Sources available in Wisconsin include, but are not limited to, the following:

- WisDOT interactive count map: [WisDOT Roadrunner link](#)
- Wisconsin Hourly Traffic Data: [WisTransPortal, Wisconsin Hourly Traffic Data Web Access Portal](#)
- V-SPOC detector database: [WisTransPortal, V-SPOC: Volume, Speed and Occupancy Application Suite](#)

The [BTO-TASU Data Hub](#) provides a list of additional data sources with a brief description of types of data available through each source, a hyperlink to the primary data source, and notes to consider when choosing to use or not use a particular data source. Prior to conducting specialized counts, contact WisDOT regional traffic staff to determine whether there are other data sources available for the project study area. Review, verify and document the validity of the volume data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

3.1.2 Traffic Speeds

Validation tests for traffic speeds *may* be representative of spot speeds and/or segment speeds. Common sources for spot speed data include, but are not limited to, loop detectors, radar detection or other resources. Common sources for segment speed data include, but are not limited to, Bluetooth detectors, probe data or floating car studies. Document the methodology used to collect and calculate the spot and/or segment speeds. Review, verify and document the validity of the traffic speed data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

Larger-scale traffic models *may* rely on a combination of spot speed and segment speed validation, while models that are smaller in length *may* rely more on spot speed validation. Where possible, collect and report out spot or segment speed in 15-minute intervals.

Discuss the type of speed data required for model validation with WisDOT regional traffic staff and/or BTO-TASU during the scoping stage of a project.

3.1.3 Travel Times

Travel time validation is a common MOE used for freeway models and arterial corridors. The availability and quality of travel time data has become better in recent years due to advancement in probe data and Bluetooth technologies. Common sources for travel time data include Bluetooth detectors, probe data or floating car studies. Where possible, collect and report out travel times in 15-minute intervals. Review, verify and document the validity of the travel time data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

If using both segment speeds and travel times for model validation, the roadway limits used for these comparisons *should* be of different lengths. It is desirable to have the travel time comparisons use longer lengths than the segment speed comparisons. The intent of the travel time validation test is to capture vehicle behavior at a larger scale while the intent of the speed validation test, whether spot or segment, is to capture the behavior at a more local level.

Discuss the limits, segmentation and type of travel time data required for model validation with the regional traffic engineer and/or BTO-TASU during the scoping stage of a project.

3.1.4 Intersection Queue Lengths

Intersection queue length is a common MOE used for arterial corridors or smaller freeway/interchange models where collection of other MOEs may not be possible or fiscally feasible. If there is significant congestion at an intersection in the existing conditions, the queue lengths may vary significantly day-to-day or even 15-minute period to 15-minute period. Video detection, loop detection, and field observations are common ways to collect intersection queue data. The methodology for the collection of intersection queues involves some subjectivity and requires sound judgment of vehicle speeds and the number of vehicles to include in the queue (e.g., *should* the vehicle queue include slow moving vehicles or just stopped vehicles?). Review, verify and document the validity of the queue data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

If queues are used for validation, the project team *should* consider the following questions prior to data collection and when performing comparisons to modeled data.

- If analyzing an interchange, do the exit ramp queues extend back to or close to the mainline?
- Do intersection queues spill back into the adjacent intersection(s)?
- Does data collection capture the average, 95th percentile, and/or maximum queue lengths? Is the desired type of queue length for model validation easily extractable from the selected microsimulation software?
- For multiple lanes, such as a triple left-turn lane, do the queue measurements and comparisons reflect the lane-by-lane queues or the worst-case lane queue?
- How, and at what frequency (every cycle, every 15 minutes, etc.), *should* queues be measured in the field?

Discuss the locations of intersection queues required for model validation with WisDOT regional traffic staff and/or BTO-TASU during the scoping stage of a project.

3.1.5 Lane Utilization

Lane utilization, or the volume/percentage of vehicles using a given lane relative to the other lanes in the same direction, is a common MOE used for freeway corridors or arterial corridors with complex intersection interaction. In Wisconsin, it may be possible to approximate lane utilization from lane-by-lane volume data available through the WisTransPortal, V-SPOC detector database ran by the Wisconsin Traffic Operations and Safety (TOPS) Lab ([WisTransPortal, V-SPOC](#)). The V-SPOC database has the most robust coverage in the Madison and Milwaukee metropolitan areas, with more sporadic coverage for other parts of the state. Other methods to collect lane utilization data include manual counts, time-lapse aerial photography or video detection. Review, verify and document the validity of the lane utilization data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

The analyst *may* use lane utilization as a validation metric for the traffic model; however, they *should* first carefully evaluate and document the quality and availability of the existing data. If used as a validation metric, perform lane utilization comparisons at critical locations within the corridor. Discuss the need for and locations of lane utilization comparisons with WisDOT regional traffic staff and/or BTO-TASU during the scoping stage of a project.

3.1.6 Lane Density

Observed density is a less common metric used for model validation. Video detection or time-lapse aerial photography may allow for the collection of lane density information. Coordinate with WisDOT regional traffic staff and/or BTO-TASU prior to using lane density as a validation metric.

3.1.7 Bottleneck Locations

Bottlenecks signify where recurring congestion occurs within a network. They have a direct relationship to travel times, traffic speeds, and/or intersection queue lengths. Validation of bottlenecks in a traffic model typically occurs through conducting visual observations and/or by creating spatiotemporal graphics displaying observed versus modeled MOEs. If observations indicate the presence of recurring congestion, or a bottleneck, in the existing conditions, the analyst *should* use this MOE as a validation metric.

3.1.8 Throughput

Throughput is a less common metric related to flow rates through an intersection or freeway segment. Possible ways to observe throughput include manual counts, video detection or other methods. WisDOT *should* approve throughput as an acceptable MOE for model validation prior to its use.

3.1.9 Visual Observation

Visual observation is a good preliminary or secondary check for validating the model results to field data, specifically for bottlenecks or queues, however, visual observations **shall not** be the sole MOE used for model validation. Instead, see the MOE descriptions for bottleneck or intersection queue validation.

3.1.10 Weaving Volumes

If existing O-D data is available, the analyst *should* evaluate weaving volumes. Common sources of O-D data included Bluetooth detection, video detection, time-lapse aerial photography and field observations. In absence of field data, it may be possible to conduct a high-level evaluation of weaving percentages using data from travel demand models. Comparisons of weaving volumes are typically applicable to freeway weaving; however, it could also apply to arterials with complex intersection interactions.

If field data is the basis of the weaving volumes/patterns used for validation, the project team *should* document the conditions during field data collection. This may include construction activities, atypical congestion, weather, if school is in session, or other pertinent information.

If a travel demand model is the source of the weaving volumes/patterns used for validation, the project team *should* document general inputs and calibration notes about the travel demand model. These may include the version, socioeconomic data, base year, horizon year, anticipated developments in the project area, or other pertinent information.

If used as a validation metric, perform weaving volume comparisons at critical locations within the corridor. Discuss the need for and locations of weaving volume comparisons with WisDOT regional traffic staff and/or BTO-TASU during the scoping stage of a project. Review, verify and document the validity of the weaving volume data prior to developing the traffic model. Coordinate with WisDOT regional traffic staff as appropriate.

3.1.11 Intersection Delay

Intersection delay dictates the intersection level of service (LOS), noting that if the volume-to-capacity ratio (v/c) exceeds 1.0 the LOS is F regardless of the delay value. Due to the difficulty of the data collection and the variance in day-to-day and minute-to-minute delays at congested intersections, it is not very common to obtain field data on intersection delay. Delay is typically more challenging to quantify than queue lengths, which also provide insight as to how the intersection operates at the approach level. WisDOT *should* approve intersection delay as an acceptable MOE for model validation prior to its use.

3.1.12 Capacity

Similar to throughput, capacity is a less common metric related to how much traffic an intersection, arterial segment or freeway segment can handle. It may be possible to gather field capacity data during oversaturated conditions using manual counts, video detection or other methods. Oftentimes, the analyst will indirectly adjust the capacity as part of the calibration process, therefore capacity may not be a suitable validation MOE. WisDOT *should* approve capacity as an acceptable MOE for model validation prior to its use.

3.1.13 Routing

Vehicle routing checks may be a qualitative exercise based on a project team's familiarity with a corridor, more of a quantitative exercise supported by O-D or demand modeling data, or a combination of both. Although a critical component of model calibration, vehicle routing checks *should not* be the primary model validation MOE.

3.2 Number of MOEs for Validation

3.2.1 Primary vs. Secondary MOEs

The project team *should* discuss, in detail, the type and number of MOEs to use for model validation with WisDOT regional traffic staff during the scoping of a project as they may have a significant effect on the project budget, schedule and resource needs. Involve BTO-TASU, and other key stakeholders, in these discussions as appropriate.

The factors that influence the number of MOEs required for microsimulation model validation may include data availability and quality as well as project type, geometric conditions, traffic patterns, and levels of existing and anticipated congestion. The capabilities of the applicable microsimulation software may have implications on the MOEs. For example, SimTraffic has fewer capabilities when it comes to reporting weaving volumes and routing metrics than Vissim, thus these MOEs may not be appropriate for a SimTraffic model.

To assist in formulating recommendations on the type and number of MOEs to use for model validation from the least to most complex models, each MOE (see [TEOpS 16-20-3.1](#)) has either a "primary" or "secondary" designation. The validation checks for all models, regardless of the model complexity, **shall** always include a

comparison of traffic volumes. Thus, traffic volumes do not have an associated primary or secondary designation.

The primary MOEs include spot speeds, segment speeds, travel times and intersection queue lengths. The secondary MOEs include intersection queue lengths, lane utilization, weaving, and any other MOE that a project team *may* request for approval (such as intersection delay, throughput, etc.) based on available data. Depending on the purpose and objectives of a project, intersection queue lengths may be either a primary or a secondary MOE. Table 3.1 shows the primary and secondary MOE designations.

Table 3.1 Summary of MOEs for Model Validation

Metric (MOE)	MOE Designation	<p>Summary of MOEs for Model Validation</p> <ul style="list-style-type: none"> • 3 to 4 Primary • 2 to 3 Secondary • 6+ Upon WisDOT Approval
Link and/or Turning Movement Volumes	Required for all projects	
Segment Speeds	Primary	
Spot Speeds	Primary	
Travel Times	Primary	
Intersection Queues	Primary or Secondary	
Lane Utilization	Secondary	
Weaving Volumes	Secondary	
Density	Secondary Upon Approval	
Intersection Delay	Secondary Upon Approval	
Bottleneck Locations	Secondary Upon Approval	
Throughput	Secondary Upon Approval	
Capacity	Secondary Upon Approval	
Routing	Secondary Upon Approval	
Others?	Secondary Upon Approval	

3.2.2 Scoring System

The number of MOEs required for validation will vary depending on the complexity of the traffic model, which is dependent on the project type, project scope, corridor type, traffic control, roadway congestion level and type of microsimulation tool used for analysis. To quantify the complexity of the traffic model (specifically a microsimulation traffic model), the department worked with a consultant to establish a scoring system. The same scoring system is applicable for determining the number of MOEs required for validation and defining the level of peer review required. Refer to [TEOpS 16-25-2](#) for details on the model complexity scoring system.

Figure 3.1 provides an illustration of the traffic model level of complexity scoring system. Use Figure 3.1 in conjunction with the Traffic-Model Complexity Scoring Template (a Microsoft Office Excel based worksheet) provided in [Attachment 3.1](#) to develop the overall complexity score for the traffic model. The project team's traffic lead or project manager, in coordination with WisDOT regional traffic staff, *should* complete the scoring template.

The overall traffic model complexity score defines the minimum number of MOEs required for model validation for the project. Depending on data availability, and the project objectives, it might be appropriate to use more than the minimum required MOEs for model validation. Ultimately, it is up to WisDOT regional traffic staff to define the type and number of MOEs to use for model validation. Refer to Table 3.2 for the complexity score associated with each MOE requirement level.

When assessing the complexity of the traffic model and number of MOEs needed for model validation, keep in mind that, due to modified roadway geometry, increased traffic volumes, reduced levels of congestion, etc., it is possible for the model complexity score to be different under future alternative scenarios than it is under existing conditions. Therefore, it is critical to consider both existing conditions and potential future alternatives (including levels of service) when defining the traffic model complexity score and the associated number of MOEs. The highest traffic model-complexity-score across all of the scenarios (existing and future alternatives) dictates the number of primary and/or secondary MOEs required for base model validation.

Figure 3.1 Traffic Model Complexity Scoring Diagram

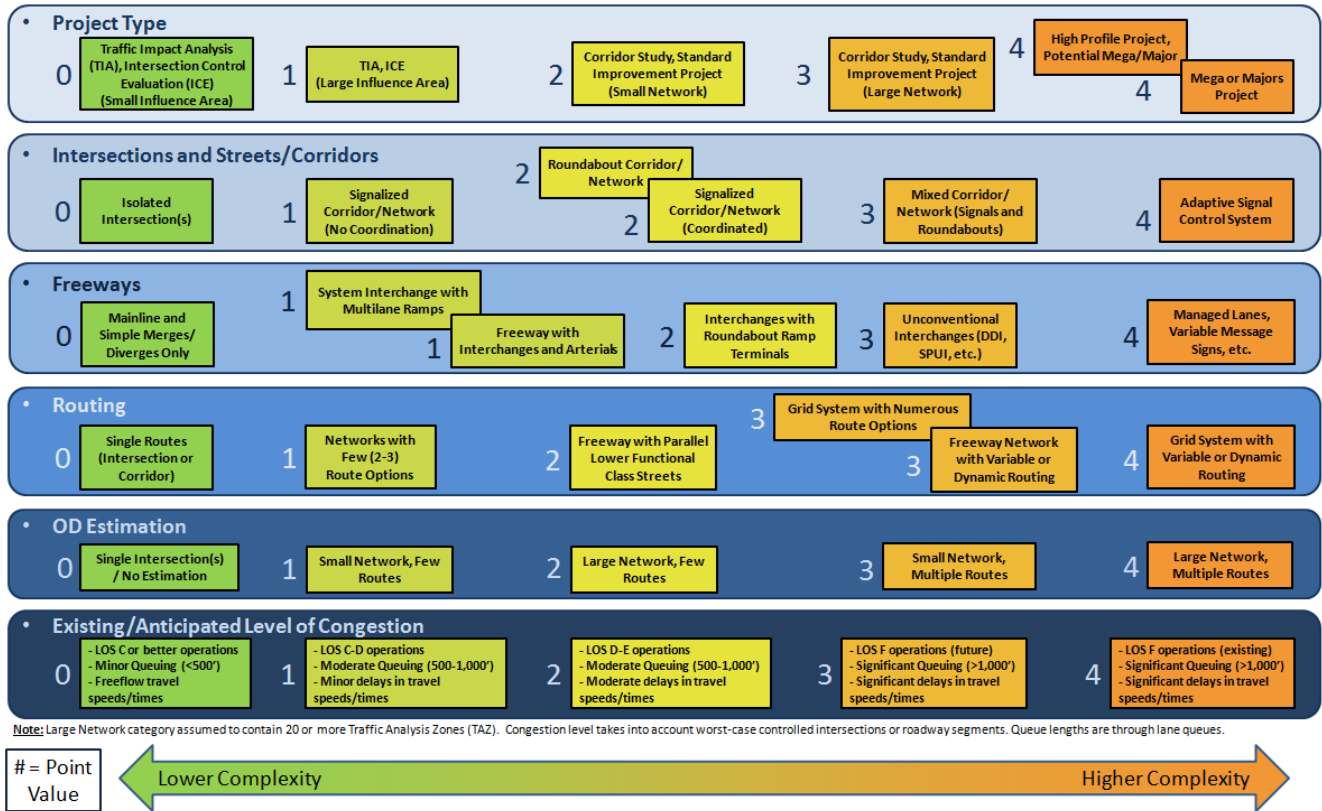


Table 3.2 Number of MOEs Required for Model Validation

Model Complexity Score (a)	Minimum # of MOEs Required for Model Validation (b)
0 – 3	1 to 2 Primary MOEs
4 – 7	1 to 2 Primary MOEs 1 Secondary MOE
8 – 10	2 to 3 Primary MOEs 1 Secondary MOE
11+	2 to 3 Primary MOEs 1 to 2 Secondary MOEs

(a) Model complexity score from the Traffic Model Complexity Scoring Template, [Attachment 3.1](#)
 (b) Minimum MOEs are those in addition to link and/or turning movement traffic volumes

Use the scores and recommendations shown in Table 3.2 as a guide only. Professional judgment and coordination with WisDOT staff needs to factor into the decisions on the number and type of MOEs to use for validation of the traffic microsimulation model. Document all assumptions and decisions regarding the number and type of MOEs to use for model validation within the modeling methodology report and/or other project memoranda as appropriate.

LIST OF ATTACHMENTS

[Attachment 3.1](#) Traffic Model Complexity Scoring Template

16-20-4 Microsimulation Analysis Software

4.1 WisDOT Supported Software

WisDOT currently supports the use of the following programs for microsimulation traffic analysis:

- SimTraffic Version 10, Trafficware
- Quadstone Paramics Version 6, Pitney Bowes (effective January 1, 2018, WisDOT will no longer support)
- Vissim Version 10, PTV Group

Use the most current build number for the software listed above (e.g., SimTraffic 10.1.2.20, Paramics 6.9.3, Vissim 10.03). However, please contact BTO-TASU for consideration of the use of different versions of the software (e.g., SimTraffic 9 vs. SimTraffic 10, Vissim 9 vs. Vissim 10). Do not switch from one software platform to another without first consulting with BTO-TASU. [TEOpS 16-20-11](#) provides additional information on when to consider upgrading the software for a microsimulation model that has either already been completed or is in the process of being developed.

4.2 SimTraffic Overview

Trafficware, a company based out of Sugar Land, Texas, is the developer for both SimTraffic and its companion software Synchro. SimTraffic is the microsimulation platform and Synchro is the macroscopic (or deterministic) platform. Trafficware typically releases major updates to the Synchro/SimTraffic Studio every two to three years.

The Synchro platform is the primary mechanism for drawing the roadway network and coding in several of the parameters for roadway geometry and traffic control. The SimTraffic platform is where the analyst can code in various driver behavior and vehicle characteristics. Both SimTraffic and Synchro use a link-node structure. SimTraffic tracks every vehicle in the traffic system on a 0.1-second interval. Typical MOEs available through SimTraffic include travel time, vehicle queues and intersection delay.

WisDOT only accepts SimTraffic for arterial analysis and this software is best suited for signalized corridors. Often times, the analyst will use SimTraffic to observe driver behavior and conduct a “reality check” on the Synchro outputs. SimTraffic may also be beneficial for reporting the vehicle queues, especially when vehicles spill-out of the turn lane and block through traffic. If the primary purpose of the SimTraffic model is to conduct “reality checks”, calibration and validation of the traffic model may not be necessary. However, prior to using the model outputs from SimTraffic (or any other microsimulation analysis tool) for project or study decisions, especially any related to critical aspects of the design, the analyst **shall** calibrate and validate the model in accordance with [TEOpS 16-20-5](#) and [TEOpS 16-20-8](#), respectively.

4.3 Quadstone Paramics Overview

Pitney Bowes Software provides support for the microsimulation software Quadstone Paramics from their international office out of Oxfordshire, England. The last update for Paramics occurred in 2012, and it is unclear whether Pitney Bowes Software has plans to release any future updates.

Paramics uses a link-node structure. It is best suited to freeway modeling, and is distinguished by its relatively quick and easy model coding, though this is counterbalanced (and ultimately outweighed) by its lack of detail for simulating complex arterials and its aging usability. Typical MOEs available through Paramics include travel time, speed, vehicle queues, intersection delay, and density. MOE extraction typically happens through the Analyser module.

Effective January 1, 2018, WisDOT will no longer support the use of Paramics on any new projects. Projects that initiated the microsimulation traffic analysis using Paramics prior to January 1, 2018 *may* continue to use Paramics for the duration of the project. However, if the traffic mode requires major revisions (e.g., the analyst has to update the traffic model to reflect different existing conditions), or if the traffic model is more than three years old, the analyst *should* consider switching the traffic models over to Vissim. Consult with the WisDOT regional traffic contact and/or BTO-TASU to determine whether it is appropriate to switch software platforms.

4.4 Vissim Overview

The PTV Group, a company based out of Karlsruhe, Germany (with U.S. offices in Oregon and Virginia), is the developer for the microsimulation software Vissim. The PTV Group typically releases major updates to the Vissim software once a year.

Vissim uses a link-connector structure. Vissim can model any facility, though it is especially known for being able to accurately represent complex arterial corridors. It provides great flexibility, but can be time-consuming to use for modeling due to the many aspects of the software that enable that flexibility. Vissim has many parameters to

adjust and ways to replicate real-world driver behaviors, leading to its applicability in almost any situation where deterministic tools and SimTraffic are not sufficient. Typical MOEs available through Vissim include travel time, speed, vehicle queues, intersection delay, and density, though Vissim provides ways to get data from the simulated vehicles at any granularity.

4.4 Other Microsimulation Software

Microsimulation analysis requiring the support, review and/or input from BTO **shall** use one of the WisDOT supported microsimulation software packages. BTO-TASU conducts periodic reviews/evaluations of the microsimulation tools to assess the need to add and/or remove microsimulation tools to/from WisDOT's traffic analysis toolbox. Please contact BTO-TASU, via the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox to request consideration of additional microsimulation software tools.

4.5 Selecting a Microsimulation Software

Consider the needs of the project along with the strengths and limitations of the software when selecting the most appropriate tool to use for developing the microsimulation model. In general, if you already have a Synchro model and/or you are looking at a relatively small scale/simple arterial network, consider the use of SimTraffic. All other scenarios, specifically freeway models, will generally require the use of Vissim for microsimulation analyses. Effective January 1, 2018, do not initiate any new microsimulation analyses using Paramics.

Document the rationale for choosing the selected microsimulation software tool in the Traffic Analysis Tool Selection memoranda and submit to the WisDOT regional traffic staff for approval.

16-20-5 Microsimulation Model Calibration

January 2018

5.1 Introduction

Calibrating a traffic model requires the analyst to review and possibly adjust various model parameters (e.g., global and local headway and reaction times, driver aggressiveness, etc.) to get the traffic model to reproduce conditions observed in the field. Failure to calibrate a microsimulation model properly can produce unrealistic or misleading results. Therefore, prior to using the microsimulation model outputs for critical design decisions, the analyst **shall** calibrate the traffic model.

5.2 Calibration Process

The model calibration process is often very complex, labor intensive and resource intensive and may take more time to complete than the initial development of the traffic model. Modifications to the input parameters in one component of the traffic model may have unexpected impacts in other areas of the traffic model. Skipping the model calibration process is not permissible and there is no shortcut to completing model calibration. However, applying the following principles will provide structure and efficiency to the calibration process.

By definition, a model is a simplified representation of reality and no model can reproduce reality perfectly. When developing the model, the analyst *should* strive to balance model perfection with practicality. To help achieve this balance, BTO-TASU developed both quantitative and qualitative validation thresholds for microsimulation models that are dependent on the purpose and need of the traffic model. See [TEOpS 16-20-8](#) for additional details on the WisDOT microsimulation validation thresholds.

5.2.1 Global, Categorical and Local Calibration Factors

The analyst can apply and modify the input parameters within a microsimulation model on a global, categorical or localized level. For the purposes of WisDOT policy, global, categorical and localized calibration factors have the following definitions:

- Global Factors: Global factors are those factors/parameters that affect the entire model.
- Categorical Factors: Categorical factors are those factors/parameters that affect a category of the links within the model (e.g., every off-ramp, all weaving segments, major street signalized intersection approaches, etc.).
- Localized Factors: Localized (or link-specific) factors are those factors/parameters that only influence vehicles while they are driving on a link, a short series of connected links, or through a specific intersection within the model.

When calibrating a traffic model, the analyst *should* adjust the global and categorical, parameters first, and *should* use localized/link-specific factors sparingly and only for the final fine-tuning of the model. Document and justify the

use of any localized/link-specific factors by associating them to limitations of the microsimulation software or specific geometric conditions that may influence driving behavior (e.g., a short weaving segment). Relating the localized adjustment factors to geometric conditions or software limitations makes it easier to assess whether to carry the adjustments forward from existing year to alternative scenarios.

5.2.2 Unreleased, Blocked, Stuck/Stalled Vehicles

For purposes of WisDOT policy, unreleased, blocked and/or stuck/stalled vehicles have the following definitions:

Unreleased Vehicles: Unreleased vehicles represent those vehicles that were able to enter the network but were unsuccessful in traveling through the model and were thus not able to exit the network. Typically, the presence of unreleased vehicles results in a downstream traffic volume undercount and gives the false impression that downstream operations are better than they actually are.

Blocked Vehicles: Blocked vehicles are those vehicles that are unable to enter the network at their desired time due to downstream vehicle queues. When vehicle blockage occurs, the traffic model will not be able to capture the true demand on the system and will thus not be able to accurately report out MOEs such as delay and vehicle queues. If the vehicle blockage in the model matches field conditions, it may be necessary to extend the link and/or temporal limits of the model in order to accommodate the entire queue (i.e., congestion). See [TEOpS 16-20-2](#) for additional details on the spatial and temporal model limits.

Stuck/Stalled Vehicles: Stuck or stalled vehicles are vehicles that unexpectedly slow or stop partway through their route. They can cause backups that do not exist in the field.

The presence of unreleased, blocked and/or stuck/stalled vehicles within the traffic model is an indicator of congestion within the model, but may also be a sign of a serious model calibration problem. When calibrating the traffic model, the analyst *should* consider the magnitude and location of the blocking that occurs. If the blocking occurring in the traffic model does not reflect field conditions, or does not meet expectations, reevaluate the spatial and temporal model boundaries, warm-up/cool-down factors and demand profiles (see [TEOpS 16-20-2.1](#)) as they may have a direct effect on issues related to blocked vehicles. It may not be necessary, or realistic, to prevent blocking of all vehicles, specifically for the design year, no-build or FEC constrained scenario.

Paramics and Vissim both contain features that allow the analyst to specify a maximum allowable time a vehicle can remain in the same position before removing the stuck/stalled vehicle from the model as if it never existed. The terminology is “blockage removal” for Paramics and “diffusion” for Vissim. Using these features leads to undercounting vehicles and is not realistic. The use of these features in the pre-calibration model building can be helpful, but it is not acceptable for a final calibrated model.

5.2.3 O-D Matrix Estimation

Oftentimes the analyst *may* use a separate O-D matrix estimating software (e.g., Cube by CITILABS, TransCAD by Caliper, Visum by PTV Group, etc.) to develop the O-D matrices for the microsimulation models. Use of a O-D matrix estimating software that is separate from the microsimulation model may be useful, as it will allow the O-D matrix to reflect true demand without influence from network coding problems. However, intersection or other network coding errors within the microsimulation model may affect throughput such that the microsimulation model outputs may not reflect the same volumes as those developed by the O-D matrix estimation tool. Therefore, for preparing the model validation checks, the analyst **shall** run the volumes through the network using the primary modeling software. It is not acceptable to prepare the model validation checks using statistics from the O-D matrix estimation software.

5.3 Traffic Volume Balancing

Usually the available traffic data for a microsimulation study area is unbalanced. For example, starting at an Automatic Traffic Recorder (ATR) station on a freeway mainline and proceeding in the direction of travel, adding the raw on-ramp volumes and subtracting the raw off-ramp volumes, the result will almost never match the volume measured at the next downstream ATR. This happens for three main reasons:

- Often, due to limited resources, it may be necessary to collect intersection and/or ramp traffic counts for multiple locations along the corridor at different times and/or on different days.
- There are inherent imperfections in the data collection process. For example, if a vehicle is changing lanes as it drives over a detection loop, the detector loop could count the vehicle twice (or not count it at all) or, with respect to microwave detectors, a larger vehicle could occlude a smaller vehicle making the smaller vehicle undetectable.

- Data collected manually (such as intersection turning counts) is subject to human error.

Microsimulation models cannot account for these imperfections, so the analyst *should* balance the data to create a mathematically consistent volume set. In general, the analyst *should* use balanced volumes as the traffic volume targets for the existing conditions model. The use of balanced volumes usually removes statistical outliers from the target volume set, making it easier to achieve validation targets.

On arterials and other corridors that are not access controlled, to account for traffic generated by developments located between intersections, it may be necessary to include side or “dummy” zones in the model.

The analyst *should* use a “soft” balancing process to make sure that the development along the corridor can account for any variation in traffic volumes between intersections. Soft balancing means that the volume entering each intersection is comparable to the sum of the volumes leaving the intersections that feed it. Hard balancing, on the other hand, requires the entering volume to equal (exactly) the sum of the relevant upstream volumes (as is the case for an access-controlled facility). Soft balancing is generally acceptable for SimTraffic; however, Vissim and Paramics require the use of hard balancing.

5.4 Vehicle Characteristics and Classification

When coding and calibrating the traffic model, it is important to verify that the vehicle composition (vehicle type, classification, operating characteristics, etc.) included in the model accurately represents that which is present in the project study area.

When available, the analyst *should* use field data to determine the appropriate vehicle mix or classifications, specifically as it pertains to the volume or percentage of heavy vehicles, buses, high-occupancy vehicles (HOVs), pedestrians/bicycles and other vehicle types included in the analysis. Oftentimes the microsimulation model will use separate demand profiles and/or O-D matrices for heavy trucks and passenger vehicles. However, depending on the project purpose, it may be necessary to have additional demand profiles and/or O-D matrices for other travel modes as well.

The format for entering in the specifics on vehicle characteristics and classifications varies depending on the microsimulation software package. However, most software packages have predefined default values that specify various vehicle characteristics including, but not limited to, vehicle length, vehicle acceleration/deceleration rates and vehicle occupancy. The default values are a good starting point; however, the analyst *should* adjust the default values as appropriate to reflect local conditions.

For SimTraffic, the default values are automatically included as part of the initial model set-up. Paramics and Vissim, however, require the analyst to load in the vehicle characteristics files. For Vissim, the analyst *should* use the North American Fleet default values for the initial input values and adjust them as appropriate. For Paramics, use the Wisconsin-specific vehicle fleet file housed by BTO-TASU as the initial starting point. Please contact BTO-TASU via the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox to request a copy of the Wisconsin-specific vehicle fleet file for Paramics.

5.5 Route Assignment

The analyst *should* develop the route assignment in coordination with WisDOT regional traffic staff, BTO-TASU and other key stakeholders as appropriate.

16-20-6 Calibration Parameters and Simulation Settings

January 2018

6.1 Overview

Microsimulation models contain many adjustable parameters, and the relevant adjustments vary for each software package. If a model fails to satisfy the validation thresholds, it is essential for the analyst to adjust the appropriate parameters to correct the situation. For example, adjusting driver aggressiveness or link cost factors will not successfully compensate for a flawed O-D matrix. The user manuals and technical support service for each software product provide some guidance on calibration parameters, but these sources may not be privy to the local or specific characteristics for the project study area. Local peer/user groups such as the ITE Simulation and Capacity (SimCap) user group or other independent experts with experience in the relevant software may also provide valuable insight with respect to which model calibration parameters to adjust during the calibration process.

The following text provides details on the key parameters of the traffic model that the analyst *should* consider during the model calibration process. The guidance below is specific for SimTraffic, Paramics and Vissim; however, the general principles are applicable for all microsimulation software packages. This list is not all-inclusive and *should* only serve as a guide to the project team.

6.1.1 Network Coding

Network coding establishes the horizontal and vertical geometry of the roadway network, including intersection spacing and roadway curvature. Network coding also includes appropriate use of settings such as link free-flow speed and turning speeds.

6.1.2 Intersection Traffic Control and Ramp Metering

Intersection controls are devices that regulate traffic flow at intersections (e.g., signals, roundabouts, stop control and ramp meters). Elements of the signals/ramp meters may include the controller type, detector placement, signal heads, signal groups, coordination between signals, signal phasing and/or signal/ramp meter-timing plans.

6.1.3 Closures, Restrictions and Incidents

Closures represent temporary or permanent roadway segment, link, or lane closures (i.e., traffic is restricted from using that particular roadway segment, link, or lane). Restrictions represent links or lanes where travel is restricted, either temporarily or permanently, to specific vehicle types (e.g., lanes designated for HOV or lanes restricting truck use). Incidents include simulated vehicle breakdowns, crashes, etc.

6.1.4 Entrance Ramps

Entrance ramps or freeway merge areas typically require careful coding in microsimulation. This section generally refers to parallel freeway entrance ramps, although there are instances where this feature is appropriate for arterials as well. The reviewer *should* review the lane utilization upstream of the entrance ramp, the aggressiveness of the merging vehicles (e.g., minimum time on entrance ramp, driver headway factors), and the length of the acceleration lane and/or taper parallel to the entrance ramp.

6.1.5 Lane Use Parameters

Lane use parameters control the amount and/or destination of the traffic using each lane. A typical application of these parameters is to pre-position vehicles in advance of a fork in the road.

6.1.6 Zone Structure/Vehicle Inputs

Zone structure and vehicle inputs define where and how traffic is loaded into the network.

6.1.7 O-D Matrices, Demand Profiles & Time Periods

O-D matrices contain the network demand patterns (number of trips traveling between each pair of zones). Time periods and demand profiles control the timing for the release of vehicles into the network (e.g., are the vehicles released at a steady rate or at a gradually increasing/decreasing rate). In some cases, it is necessary to use multiple O-D matrices and/or demand profiles (e.g., there may be one matrix for cars and a second matrix for trucks).

6.1.8 Core Simulation Parameters

Core simulation parameters affect fundamental aspects of vehicle behavior in the network, such as driver aggressiveness and the willingness to merge into small gaps. Default values are acceptable for some parameters, but other parameters require project- or area-specific values.

6.1.9 Routing Parameters/Vehicle Routes

Routing parameters influence the way vehicles travel through the network. If coded improperly, these controls can cause unrealistic or erratic routing.

6.1.10 Vehicle Types and Proportions

The proportion and types of vehicles (such as trucks, buses and HOVs) influences the overall performance of each part of the network.

6.1.11 Stuck/Stalled Vehicles

Stuck or stalled vehicles are vehicles that unexpectedly slow or stop partway through their route. They can cause backups that do not exist in the field.

6.1.12 Special Features

Special features include site or study-specific items such as the use of detectors, car parks, variable message signs, special purpose lanes, speed harmonization, public transit routes, toll lanes, toll plazas, pedestrian modeling, special graphics, plugins or scripts, among others.

6.2 SimTraffic Calibration Parameters

6.2.1 Interval Settings

A critical component of performing a SimTraffic simulation is to set up appropriate simulation intervals. The default settings for the simulation interval include a 3-minute seeding period and a 10-minute analysis period. To be more compliant with HCM analysis methodologies and common microsimulation practices, the modeler *should* extend the seeding period and analysis period beyond these default values. WisDOT recommends using the interval settings setup shown in Table 6.1 for SimTraffic simulation models if SimTraffic is one of the project's official traffic analysis tools (i.e., the project will rely on SimTraffic volume and operation reports to make critical decisions).

The interval setting shown in Table 6.1 are not necessary for applications such as conducting reality checks on Synchro outputs, creating videos for public involvement or performing a high-level screening of an alternative. For high-level applications, a seeding period and one 15-minute analysis interval may be appropriate.

Table 6.1 Recommended Interval Settings for SimTraffic

Interval	Seeding	Recording	Recording	Recording (Peak)*	Recording
Duration	7 mins**	15 mins	15 mins	15 mins	15 mins
PHF Adjust	No	No	No	Yes	No
Anti-PHF Adjust	No	Yes	Yes	No	Yes
Random Seed	Non-zero for repeatable results; Zero for random seeding				
*Peak 15-minute interval is recommended to be the 2nd or 3rd interval in the simulation.					
**Seeding interval <i>should</i> be long enough for one vehicle to travel through the network or longer than the maximum cycle length in the network, whichever is greater					

6.2.2 Parameter Discussion

[Attachment 6.1](#) provides a list of the parameters, along with recommended ranges, that the modeler will typically adjust while calibrating a SimTraffic model. This list provides a good starting point for the parameter value adjustment. ~~A complete list of the adjustable parameters for SimTraffic is available on the BTO, Traffic Analysis, Modeling and Data Management webpage.~~ Unless field data supports doing otherwise, modify only those parameters recommended as settings to adjust. Obtain WisDOT staff approval prior to modifying non-recommended adjustment parameters.

Refer to the *Synchro Studio 10 User Guide* (4), for some tips on calibrating a SimTraffic model. Departing from the Synchro/SimTraffic defaults may not be necessary to validate modeled traffic volumes at moderately congested locations. However, at highly congested locations, it may be necessary to modify the Synchro/SimTraffic defaults to calibrate and validate the traffic model. If validating to intersection queue data, the analyst may need to make minor adjustments to settings such as turning speeds (based on geometry of the intersection) or local headway factors (change in small increments only to improve the locations with long queues).

6.2.3 Common Errors and Warnings

Chapter 23 of the *Synchro Studio 10 User Guide* (4) provides a list of common errors and warning messages along with potential causes and tips for resolving the issues. This list of common errors and warnings may serve as a beneficial resource during the calibration process.

6.3 Paramics Calibration Parameters

WisDOT is currently phasing out the use of Paramics. As noted in [TEOpS 16-20-4.3](#), effective January 1, 2018, WisDOT will no longer support the use of Paramics on any new projects. However, projects that initiated the microsimulation traffic analysis using Paramics prior to January 1, 2018 *may* continue to use Paramics for the duration of the project (although the analyst should consider switching the traffic models over to Vissim if major revisions to the traffic model is necessary or if the model is more than three years old). As such, it is possible that Paramics will still be in use in Wisconsin for several more years necessitating the need to provide some guidance on calibrating Paramics models, specifically for the alternative model development.

[Attachment 6.2](#) provides a list of the parameters, along with recommended ranges, that the modeler will typically adjust while calibrating a Paramics model. This list provides a good starting point for the parameter value adjustment. ~~A complete list of the adjustable parameters for Paramics is available on the BTO, Traffic Analysis, Modeling and Data Management webpage.~~ Unless field data supports doing otherwise, modify only those parameters recommended as settings to adjust. Obtain WisDOT staff approval prior to modifying non-

recommended adjustment parameters.

The following typically-used parameters all have direct impacts on model performance. Since different methods with multiple parameter combinations may exist to calibrate a specific modeling condition in Paramics, the analyst *should* first adjust the global parameters and then, only if necessary, adjust the local parameters. As noted in [Attachment 6.2](#), the analyst *should* adjust several of the global and local parameters, such as the dynamic feedback routing factors, in small increments. Apply local adjustment factors (e.g., link-specific headway and reaction time factors) sparingly.

6.3.1 Introduction

This section contains suggested calibration parameter settings based on Wisconsin experience with Paramics. The use of these suggestions may help achieve a well-functioning model more quickly, but do not guarantee success.

6.3.2 Mean Target Headway

Headway is the time between two successive vehicles as they pass a point on the roadway, measured from the same common feature of both vehicles (for example, the front axle or the front bumper). As vehicles drive closer together, the headway decreases and the throughput of the roadway increases. A related concept is the gap, which is the time or distance from the back bumper of the first vehicle to the front bumper of the second vehicle.

Several vehicle behaviors depend on the minimum headway vehicles are willing to accept. An example is the smallest gap that a vehicle will accept when it merges or changes lanes. In Paramics, the MEAN TARGET HEADWAY coefficient strongly influences this behavior.

In effect, reducing the MEAN TARGET HEADWAY coefficient makes vehicles drive more aggressively and increases capacity. Therefore, base any adjustments to this coefficient on the prevalent driving style in the study area. People tend to drive more aggressively in big, congested cities than they do in uncongested rural areas or small towns. As such, use the following as the initial starting point for the MEAN TARGET HEADWAY

- Urban areas: 0.85 to 0.90
- Small Cities: 0.90 to 0.95
- Rural areas: 0.95 to 1.00

Provide documentation and justification for any deviations in these settings in the modeling methodology report.

6.3.3 Generalized Cost Coefficients

Many Paramics networks have situations where vehicles can use more than one route between a given origin and destination. The generalized cost coefficients have a strong influence on the route choice algorithm in the model. These coefficients determine how much weight to assign to time, distance and toll price.

By default, Paramics assumes that such decisions are made 100% based on time, but the coefficients can (and *should*) be adjusted to take distance and tolls into consideration.

For routes without tolls, use the following coefficients:

- 0.667 Time
- 0.333 Distance

Wisconsin does not currently have any toll roads; as such, the toll price cost coefficient is generally not applicable.

6.3.4 Ramp Calibration

Several global and localized parameters affect ramp performance. The following offers some general principles to consider when calibrating the Paramics model to ensure realistic ramp operations.

- Driver gap acceptance is a controlling parameter concerning the operation of ramps. As such, the model timestep settings may affect the ramp performance.
- Increasing ramp length and decreasing minimum ramp time have about the same effect.
- When calibrating the ramps, first adjust ramp aware distance and minimum ramp time leaving any adjustments to local ramp headway factors to the end of the process.
- Generally, leave the local ramp headway factor set to 1.00.
- Unless field conditions indicate otherwise, implement the same settings for all other ramps in the network.

6.3.5 Truck-Related Coefficients

WisDOT recommends using “HEAVIES USE ALL LANES” for Wisconsin Paramics models to spread trucks out into all mainline lanes. Wisconsin does not require trucks to stay in the right lane.

6.3.6 Vehicle Fleet

Use the Wisconsin-specific vehicle fleet file housed by BTO-TASU as the initial starting point for the vehicle fleet and adjust as appropriate to reflect the project-specific conditions. Please contact BTO-TASU via the DOT Traffic Analysis & Modeling(DOTTrafficAnalysisModeling@dot.wi.gov) mailbox to request a copy of the Wisconsin-specific vehicle fleet file for Paramics.

6.4 Vissim Calibration Parameters

Given the complex and iterative nature of model calibration and the large number of calibration parameters provided in Vissim, it is a good practice to start calibration using parameters that a modeler is certain about based on field data or experience. If additional calibration is still necessary, the analyst *may* move to parameters that they are less certain about but willing to experiment with different values. [Attachment 6.3](#) provides a list of the parameters, along with recommended ranges, that the modeler will typically adjust while calibrating the Vissim model. This list provides a good starting point for the parameter value adjustment.

The following typically-used parameters all have direct impacts on model performances. Since different methods with multiple parameter combinations may exist to calibrate a specific modeling condition in Vissim, the analyst *should* first adjust the global parameters and then, only if necessary, adjust the local parameters.

6.4.1 Vehicle Fleet

Use the “North American” vehicle compositions from PTV Group for the initial input values. Based on local project conditions and road types included in the model, it may be necessary to refine or adjust the vehicle classifications (e.g., it may be best to remove the AASHTO WB67D/WB65 tractor and trailer from the fleet when simulating downtown or small neighborhood streets). Direct any specific questions on adjusting the vehicle fleet in Vissim to BTO-TASU via the DOT Traffic Analysis & Modeling(DOTTrafficAnalysisModeling@dot.wi.gov) mailbox.

6.4.2 Simulation Step

In most cases, use 10 seconds per simulation second.

6.4.3 Car Following Model for Freeways

For freeway segments, apply the Wiedmann 99 car following model. Standstill distances (CC0), headway time (CC1) and following variation (CC2) have significant impacts on the car following behaviors. Higher values represent more cautious driving behaviors and lower roadway capacity.

6.4.4 Car Following Model for Urban Arterials

For urban arterials, apply the Wiedmann 74 car following model. Higher values of average standstill distance, additive part of safety distance and multiplicative part of safety distance means more distance between vehicles and therefore lower roadway capacity.

6.4.5 Lane Change Parameters

Lane change parameters are the same for both freeway and arterial segments and the analyst *should* adjust them to match field conditions, especially at merging, diverging and weaving areas.

6.4.6 Local Car Following and Lane Change Parameters

Additional car following and lane change parameter sets can be defined separately as global settings and then only applied for local links and connectors where driving behaviors are different from global definitions.

6.4.7 Connector Lane Change Distance

The default lane change distance for all connectors is 656 feet and is typically representative of arterials. The analyst can, and *should* adjust the default lane change distance higher or lower as needed, especially for freeways and closely-spaced intersections. Additionally, there is an option to have this lane change distance increase for each lane that a vehicle must cross to travel via the connector. The analyst *should* adjust the lane change distance parameters to avoid unrealistic repositioning and last-minute lane-changing behavior that may arise.

6.4.8 Other Adjustable Parameters

A complete list of the adjustable parameters for Vissim is available on the [BTO, Traffic Analysis, Modeling and Data Management webpage](#). Unless field data supports doing otherwise, modify only those parameters recommended as settings to adjust. Obtain WisDOT staff approval, prior to modifying non-recommended adjustment parameters.

LIST OF ATTACHMENTS

Attachment 6.1	SimTraffic Calibration Parameters
Attachment 6.2	Paramics Calibration Parameters
Attachment 6.3	Vissim Calibration Parameters

16-20-7 Simulation Runs

January 2018

7.1 Need for Multiple Simulation Runs

Real-world traffic varies considerably from day to day, and even from minute to minute. Microsimulation models attempt to mimic this effect by using stochastic (randomized) variables to account for variations in driver behavior and departure time. The source of this stochasticity is an algorithm within the microsimulation software package known as a pseudo-random number generator. Since purely random generation of numbers is mathematically problematic, pseudo-random number generators require a seed that initiates the underlying algorithm. This algorithm then generates a stream of millions or more apparently random numbers, which determine the release pattern of vehicles (i.e., how many and when) and the distribution of driver characteristics such as speed, among others, for each microsimulation model run. If the microsimulation software is functioning correctly, two model runs with the same seed will produce identical results.

If the analyst were to conduct only one run of the simulation model, there would be no way to assess whether the model was a good representation of reality as, depending on the seed value and the validity of the model, the results could represent a typical day, an abnormal day or they could misrepresent reality altogether. Running multiple runs of the model with different seed values allows the analyst to get a better sense as to whether the model results accurately reflects the range of traffic conditions encountered in the real world. Thus, during the calibration and validation process, the analyst **shall** complete multiple simulation runs.

7.2 Simulation Seeds

Microsimulation software packages use many different types of pseudo-random number generating algorithms, potentially including multiple options within each package, but due to their pseudo-random nature, every type of algorithm will eventually begin to repeat if left running continuously. At the point of repetition, the algorithm will start generating the same stream of numbers in the same order. With certain types of pseudo-random number generators, the seed type can dictate the length of the resulting stream of numbers; zero and even numbers can cause some algorithms to repeat quickly or have other undesirable effects. Out of an abundance of caution, WisDOT has historically and will continue to require the use of prime numbers as seeds.

The purpose of this policy is to assure the uniform use of prime numbers as seeds, provide transparency and allow for the reproducibility of results. It has long been good modeling practice to record the seed number associated with each model run, but this has never been a formal requirement. With adoption of the formal peer review policy (see [TEOpS 16-25](#)), it has become necessary to document how the results recorded can be replicated. To ease this process and ensure consistency statewide, WisDOT is specifying the use of the seed values listed in [Table 7.1](#) for all traffic model scenarios. Typically, a calibrated model will not require more than 30 simulation runs. If there is a desire to conduct additional runs, the analyst *should* carefully weigh the potential benefits of conducting additional runs against the additional resource requirements. If, warranted, contact BTO-TASU via the DOT Traffic Analysis & Modeling (DOTTrafficAnalysisModeling@dot.wi.gov) mailbox to receive seed values for additional runs.

Table 7.1 Seed Values

Run Number	Seed Value	Run Number	Seed Value	Run Number	Seed Value
1	199	11	7	21	23
2	409	12	157	22	29
3	619	13	307	23	13
4	829	14	457	24	103
5	1039	15	607	25	193
6	1249	16	757	26	283
7	1459	17	907	27	373
8	1669	18	5	28	463
9	1879	19	11	29	28657
10	2089	20	17	30	514229

Notes:

- To simplify the process of running the models using the specified seed numbers (especially for Vissim), the seed numbers above represent prime numbers. The first ten runs are prime numbers that have an increment of 210 between each seed value. (To run the first ten runs in Vissim, enter the first seed (199) in the "Random Seed" box under Simulation>Parameters. Set the "Number of runs" to the desired number (up to 10), and then enter 210 as the "Random seed increment". This allows Vissim to complete runs 1-10 with the seed values shown above.
- The SimTraffic simulation engine generates sequential seeds for multiple runs, the seed values shown above are **not** applicable

7.3 Number of Simulation Runs - Background

The purpose of this policy is to provide transparency and consistency with the determination of the number of simulation runs. Multiple forms of federal guidance exist on the number of simulation runs. FHWA's [TAT III \(2\)](#), Appendix B, outlines a method for determining the number of model runs using the standard deviation of the model results, confidence level (typically 95 percent), confidence interval (suggested to be a multiple or fraction of the model standard deviation) and corresponding t-statistic (see Equation 13 in [TAT III \(2\)](#), Appendix B). The use of the t-statistic reflects the deviation from the normal distribution when there are a limited number of trial runs, typically less than 30. If the initial estimate of the minimum number of runs exceeds the number of runs completed, the analyst must conduct additional model runs and then update the number of runs equation in an iterative fashion until the number of runs completed is equal to or greater than the number of runs required.

The *Highway Capacity Manual 2010* (HCM2010) (5) provides a slightly different method for determining the number of required repetitions for stochastic simulation analyses. The HCM2010 (5) methodology identifies three factors that have an influence on the number of required repetitions: the amount of error allowed in the model results, the confidence level for the model results, and the model variability. This is a more explicit restatement of the methodology outlined in [TAT III \(2\)](#), and the final equation (see HCM2010 (5) Page 7-27, Equation 7-2) to determine the required number of runs is the same with the exception that the HCM2010 (5) methodology uses the z-score instead of the t-statistic. The *Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis* (HCM6) (6) maintains this methodology (see HCM6 (6), Page 7-29, Equation 7-2).

The most recent national guidance on the minimum required number of runs is included as part of the [Guidance on the Level of Effort Required to Conduct Traffic Analysis Using Microsimulation](#) (7), published by FHWA in March 2014. The methodology outlined in this document uses field data to calculate the error tolerance. After completing several (5-10) initial model runs, the analyst can evaluate the number of required runs, and then, if necessary continue conducting additional model runs until the required number of runs is satisfied.

After reviewing the national guidance describe above, BTO-TASU chose to use the methodology outlined in the [FHWA 2014 Guidance](#) (7) as the basis for WisDOT's policy on determining the number of simulation runs. The following details WisDOT's policy regarding the number of simulation runs.

7.4 Number of Simulation Runs - Process

7.4.1 Selecting Test Location Sites

To complete the required number of runs calculations, the analyst **shall** select at least one representative location within the model study area for each peak period of analysis. A location is representative if it meets all of the following criteria:

- Lies within the area of interest associated with the purpose of the model
- Is on a facility of the highest or second-highest functional class being modeled
- Experiences higher-than-average traffic demand during the peak period being modeled

Given the data requirements spelled out below, the location(s) selected *should* have enough field data available to complete the required number of runs calculations.

The analyst *may* use the same location for more than one peak period provided it is representative of the peak period conditions. A location may be directional – that is, the location may reflect only the eastbound direction of a two-way facility. In fact, directional locations that match up with the peak traffic flows may be more representative than a location that reflects both directions of travel.

Although the minimum number of locations is one per peak period, for larger models, the analyst *should* include more than one location. A general rule would be to have one location per five miles of freeway or other principal arterial included in the model, with a practical upper limit of four locations per peak period.

7.4.2 Selecting the MOEs to Test

Volume, has historically been, the MOE used for calculating the required number of simulation runs. The national publications providing guidance on determining the number of runs cited in the simulation background ([TEOpS 16-20-7-3](#)) use volume in their examples. This may be because volume, in the past, has been the most data-rich MOE. Given advances in technology and data collection methodologies, WisDOT has other MOEs (such as travel time and speed) with sufficient field data that may be available for calculating the number of runs. Refer to [TEOpS 16-20-3](#) for details on other potential MOEs.

In general, the analyst has latitude in selecting the MOE to use for determining the number of runs. The analyst *should* use the same MOE for every location and peak period included in the number of runs evaluation. Volume remains a good starting point, though data availability, the nature of the facility, and the model purpose *should* play a role in the MOE selection.

7.4.3 Use of Field Data

Rather than determining *a priori* what level of error is acceptable when calculating the required number of runs, the analyst *should* compute the error tolerance based on the variability observed in field data. To assist with determining the error tolerance using field data and calculating the number of required runs, BTO-TASU developed a [Microsoft Excel based workbook](#).

The [number of runs workbook](#) requires the use of between 3 and 365 field data points, which the analyst would enter into the “Variability Analysis of Field Data” area of the workbook. To preserve the integrity of the test, the data entered **shall** be representative of the operating conditions that align with the purpose of the modeling effort. This permits filtering out data points with atypical conditions such as incidents or inclement weather when normal operating conditions are being modeled, while also requiring that only comparable situations be used where a special condition, such as an event at a stadium, is being analyzed. Selecting field data for entry in such a way as to unduly influence the resulting calculations, is not permissible.

The field data generates a margin of error, from which the spreadsheet then computes an error tolerance percentage. The workbook then uses this tolerance in combination with the initial model run results to calculate a required number of runs. Through thorough testing of the workbook, to account for the stochasticity inherent in the modeling processing, BTO-TASU set a minimum tolerance of one percent, even if the calculated tolerance from field data is lower. There is no upper limit to the tolerance.

7.4.4 Initial Simulation Runs

After entering the field data into the [number of runs worksheet](#), the analyst must perform a series of initial model runs to allow for comparisons between the field data and model result variability. Historically, seven runs have proven to be a sufficient number of runs to capture the variation observed in the field. It provides enough samples to run summary statistics on, and falls within the 5 to 10 initial runs recommended in the most recent national guidance. Accordingly, the analyst **shall** complete seven initial model runs.

To facilitate the consistent use of prime seeds, discussed above in [TEOpS 16-20-7.2](#), the “Initial Runs” portion of the [number of runs workbook](#) contains the seeds to use for each simulation run. Using prime number seeds in arithmetic sequence, or primes that are evenly spaced, substantially simplifies the process of running the models using the specified seed numbers, at least in Vissim. To run the initial seven runs in Vissim, enter the first seed, 199, in the “Random Seed” box under Simulation>Parameters. Set the “Number of runs” to 7, and then enter 210 as the “Random seed increment.” This allows Vissim to complete seven successive runs with the appropriate seed values.

After the model runs are complete, enter the results from the first location for the selected MOE for the peak hour of the first peak period into the [number of runs workbook](#). The workbook will automatically eliminate any statistical outliers (at the 95% confidence level), and will update the number of valid (non-outlier) runs accordingly. For additional information on how to address outliers, see [TEOpS 16-20-7.4.7](#).

Using the tolerance from the field data, the [workbook](#) will compute an estimated number of runs. If the number of valid runs is less than or equal to the estimated number of runs, the test is completed for that location. Continue for other locations and/or other peak periods. If the number of valid runs is less than the estimated number of runs, more runs will be necessary (see the following section).

7.4.5 Additional Simulation Runs

If additional runs are required, enter the additional results data in the “Additional Runs” part of the [number of runs workbook](#). The results from the first seven runs will automatically transfer over. The workbook will update the required number of runs calculations as appropriate to reflect the additional run data. The analyst *should* continue with additional runs, adding one at a time, until either the number of runs completed exceeds the number of runs required, or they have completed 30 runs. If the analysis indicates a need for more than 30 runs, contact BTO-TASU via the DOT Traffic Analysis & Modeling(DOTTrafficAnalysisModeling@dot.wi.gov) mailbox.

7.4.6 Number of Runs to Use for Reporting Results

It is likely that the number of runs will vary for each location and/or peak period of analysis; it may be higher than the seven initial runs for one or more locations and lower for others. The analyst *should* use the highest required number of runs value from any location for reporting model results. This will ensure that the required number of runs is met (and often exceeded) everywhere. If the highest required number of runs is less than seven, use the seeds for the initial seven runs to report results.

Typically, a calibrated model will not require more than 30 simulation runs. However, if the number of runs calculations find that more than 30 runs are necessary, coordinate with WisDOT regional traffic staff and/or BTO-TASU as appropriate to assess whether or not to conduct additional model runs, as it may be necessary to perform additional model calibration. If additional model runs are warranted, contact BTO-TASU via the DOT Traffic Analysis & Modeling(DOTTrafficAnalysisModeling@dot.wi.gov) mailbox to receive the seed values to use.

Unless the results of the model run are determined to be a statistical outlier (see [TEOpS 16-20-7.4.5](#)), the analyst **shall** use the results for the appropriate number of runs for the corresponding seed number shown in [Table 7.1](#). See the following section ([TEOpS 16-20-7.4.7](#)) for additional information on how to address outliers, in both the number of runs calculations and runs used to report model results.

7.4.7 Model Run Outliers

In a non-technical sense, a model run is a statistical outlier if its value is significantly higher or lower than expected given the other model runs. For the purposes of WisDOT microsimulation analyses, WisDOT defines an outlier as anything outside of the 95% confidence interval, or more than 1.96 standard deviations away from the average value assuming a two-tailed normal distribution. Normally, a t-statistic-based test would be most appropriate data sets with less than 30 samples; however, this would add complexity to the process. More importantly, assuming a normal distribution is consistent with the [FHWA 2014 Guidance](#) (7) which serves as the basis for the number of run calculations ([TEOpS 16-20-7.3](#)).

Model run outliers are identified in both the initial seven runs and in any additional runs that are required. It is possible for there to be more than one outlier, though this is highly unlikely in the initial seven runs given the significant effect of the outliers themselves on the standard deviation of the sample.

The analyst **shall** remove the statistical outliers from calculations related to the number of runs required, as they overstate the dispersion of results observed in the model and would unnecessarily require a higher number of runs. Identifying outliers in an objective manner eliminates questions surrounding the analyst manually selecting runs to eliminate and will introduce greater consistency across projects.

7.4.8 Model Runs for Future Year Scenarios

The above policy applies to the existing conditions models, as they are the only scenarios with field data. For future scenarios, or for those without any applicable field data, use the same seed numbers associated with the required number of runs from the existing conditions (see [Table 7.1](#) for the seed numbers to use). This includes using the highest required number of runs when reporting results for all other scenarios.

7.4.9 Recommended Process with Limited Field Data

When insufficient field data is available for representative locations, the analyst **shall** use the methodology laid out in Chapter 7 of HCM6 (6). Use volume as the MOE and seven initial runs. For the E_T , the maximum tolerable error, BTO-TASU recommends the use of 2 percent of the average volume at the representative location. If using an alternate maximum tolerable error, document the rationale for using the selected percent tolerable error within the modeling methodology report. Complete this calculation at each location for each peak period. Comply with the “Number of Runs to Use for Reporting Results” section above ([TEOpS 16-20-7.4.6](#)).

7.5 Software Considerations

The above policy is applicable for all Vissim and Paramics models, noting that WisDOT will cease support for the use of Paramics on new projects effective January 1, 2018 (see [TEOpS 16-20-4](#)). For SimTraffic models, conduct a minimum of seven runs. The SimTraffic simulation engine generates sequential seeds for multiple runs, the seed values shown in [Table 7.1](#) is not applicable. To ensure the use of the same seed values for all model scenarios, make sure to start the multiple run recording with the same value.

16-20-8 Model Validation

January 2018

8.1 Introduction

This section describes the validation metrics and acceptance thresholds required for the MOEs discussed in [TEOpS 16-20-3](#). This policy addresses the validation process for microsimulation traffic models and replaces the 2014 WisDOT Draft Microsimulation Guidelines previously housed on the www.wisdot.info website. **The policy provided within this document will become final and take effect on January 1, 2018.**

After January 1, 2018, use of the 2014 WisDOT Draft Microsimulation Guidelines will continue to be acceptable only for those projects that satisfy all the following conditions:

- The existing conditions traffic model is complete
- The existing conditions traffic model has undergone the peer review process
- The WisDOT regional traffic engineer and/or BTO-TASU determined that the model was adequately calibrated and validated
- No major revisions to the existing conditions model are necessary

If the project satisfies all the above conditions, the 2014 WisDOT Draft Microsimulation Guidelines may be applicable for all traffic modeling scenarios. However, WisDOT strongly encourages the analyst to assess whether the traffic model would satisfy the new validation thresholds as outlined below. Please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov) to request a copy of the 2014 WisDOT Draft Microsimulation Guidelines.

8.2 Validation Process

To validate that the traffic model reflects real world conditions, the analyst **shall** conduct both quantitative and qualitative checks on the model outputs for the analysis period. The analyst **shall** conduct validation checks of the existing conditions model using field-measured data, including but not limited to, traffic volumes, travel speeds, travel times, intersection queuing and trip-making patterns (e.g., weaving volumes). The analyst shall conduct the validation checks of the alternative models using traffic forecast and other data that is available for the alternative scenario. See [TEOpS 16-20-8.3](#), [16-20-8.4](#) and [16-20-8.5](#) for details on the quantitative and qualitative validation thresholds.

During validation, it is also important to confirm that the model meets the purpose and need of the project (e.g., if the purpose of the project is to assess the feasibility of managed lanes, during validation it is important to confirm that the model can capture managed lane alternatives, etc.).

If the model outputs satisfy the validation thresholds (see [TEOpS 16-20-8.3](#), [16-20-8.4](#) and [16-20-8.5](#)), and the model meets the purpose and need of the project the analyst can consider the model to be valid and can use the

model to assess various performance measures and/or MOEs. If the model outputs fail to satisfy the validation thresholds and/or the model does not meet the purpose and need of the project, additional calibration of the model will be necessary.

8.2.1 Historical Validation Process (pre January 1, 2018)

The 2014 WisDOT Draft Microsimulation Guidelines validation process consisted of three realism tests, where realism test 1 looked at traffic volumes, realism test 2 assessed travel times and speeds and realism test 3 considered travel patterns. Realism tests 1 and 2 were quantitative/mathematical tests that used GEH (Geoffrey E. Haver's volume tolerance formula) and absolute and/or percent differences to assess the differences between observed (field) and modeled data. Realism test 3 was a qualitative test that relied on professional judgement to determine if the modeled travel patterns were a good representation of field conditions. The 2014 WisDOT Draft Microsimulation Guidelines required the traffic model to satisfy all criteria in all three realism tests.

Although the realism tests generally provided a good assessment as to whether a traffic model accurately represented real world conditions, there were some concerns with the methodology. Specifically, WisDOT had the following concerns with the 2014 realism tests:

- The acceptance targets for GEH were initially developed for travel demand models, and thus may not be appropriate for microsimulation models.
- Since the original intent of the GEH formula was to evaluate daily or hourly volumes, was it appropriate to apply the GEH formula to 15-minute volumes?
- Depending on whether the modeled value was higher or lower than the target value, the same incremental difference could result in different GEH values. For example, if the target value was 250, a modeled volume of 325 (75 higher than the target) would yield a GEH of 4 while a modeled volume of 175 (75 lower than the target) would yield a GEH of 5. In this example, it appears that a modeled volume that is 75 vehicles higher than the target volume is a closer match to reality than a modeled volume that is 75 vehicles lower than the target volume. Does this make sense?
- Did it make sense to apply travel time realism tests to short routes, especially if performing travel speed realism tests on the same segment?
- How could BTO-TASU ensure that travel times are not blended in with travel speeds (i.e., travel speeds were calculated as the inverse of travel time)?
- How *should* project teams handle situations where there is no data available for a MOE included in one of the realism tests? Data is not always available for both travel time and travel speeds, making it impossible to conduct all three realism tests.
- Was it appropriate to apply the same validation tests for all types of microsimulation models?

In light of the concerns WisDOT had with the 2014 realism tests, BTO-TASU worked with a consultant team to assess whether there were other Goodness of Fit (GoF) metrics and/or validation thresholds that would be better suited for assessing whether a traffic model provided a good representation of reality. As part of the assessment, BTO-TASU and the consultant team conducted literature reviews, surveys of other state DOT practices and evaluation testing. To evaluate the GoF metrics, the consultant team used output from previously developed models, most of which had previously been calibrated and validated in accordance with the 2014 realism tests. The evaluation included models from the three WisDOT supported software tools (SimTraffic, Paramics and Vissim). The SimTraffic models were the only models that did not previously go through the calibration and validation process.

Since most of the models used in the evaluation testing had already undergone the calibration and validation process, the consultant team performed sensitivity testing by modifying model output to broaden the sample size of the data sets. After completing the sensitivity testing, the consultant team assigned a ranking system (with 1 being the best and 7 being the worst) for each MOE to determine the quality of validation for each model. This ranking system helped evaluate both the feasibility and acceptance levels for each of the GoF validation tests.

Through the literature reviews, surveys and evaluation testing; WisDOT determined that an overhaul of the 2014 realism tests were necessary. Although the new validation tests use different GoF metrics, models previously calibrated and validated using the 2014 realism tests *should* still be able to pass the new validation process. The following sections describe the new validation thresholds.

8.2.2 Tiered Validation Process (post January 1, 2018)

Effective January 1, 2018, WisDOT will require the use of a tiered validation approach. In this tiered approach, the Tier 1 test would be a global validation test for a metric and the Tier 2 test would be a local test for that same metric. If a model passes the Tier 1 (global) test, the modeling team would not need to perform the Tier 2 (local) test and a detailed summary of the Tier 2 test would not be necessary. BTO-TASU established the validation acceptance criteria to allow only well calibrated and validated models to pass the Tier 1 (global) test.

[Table 8.1](#) summarizes the tiered validation tests. Refer to [TEOpS 16-20-3](#) to identify the number and type of MOEs on which to perform validation tests, noting that the volume validation tests are required for all traffic models. The analyst *should* satisfy the validation thresholds shown in [Table 8.1](#) for the selected MOEs to the best extent that is practically feasible. If the model is unable to satisfy the validation thresholds outlined in [Table 8.1](#), the analyst **shall** consult with WisDOT regional traffic staff and BTO-TASU prior to finalizing the modeling methodology report and/or proceeding with the development of additional modeling scenarios.

8.3 Tier 1 (Global) Validation Tests

The Root Mean Squared Percent Error (RMSPE) is the primary validation metric for the global tests. This metric was based on the results of literature reviews, surveys of other state DOT practices with respect to GoF metrics to apply to microsimulation models and evaluation testing. The equation for RMSPE is as follows:

$$\text{RMSPE} = \sqrt{\frac{1}{N} \sum_{i=1}^N \left(\frac{M_i - O_i}{O_i} \right)^2}$$

Where:

M = Modeled Data

O = Observed Data

N = Number of Data Points

i = Observation Point

The Tier 1 (global) validation tests are applicable for link/segment volumes, travel times and travel speeds. [Table 8.2](#) summarizes the Tier 1 (global) validation tests. Refer to [TEOpS 16-20-3](#) to identify the number and type of MOEs on which to perform the Tier 1 (global) validation tests, noting that the Tier 1 volume validation tests are required for all microsimulation traffic models.

Table 8. 1 Validation Tests

MOE	Criteria	Validation Acceptance Threshold	
Volume ^(a)	All Links > 100 vph (Mainline and Critical ^(b) Arterials)	Tier 1:	RMSPE <5.0%
		Tier 2:	RNSE <3.0% for >85% of links
	All Turns	Tier 1:	Not Applicable
		Tier 2:	RNSE <3.0% for >75% of turns
Speeds	All Segments or Spot-Speed Locations	Tier 1:	RMSPE <10.0%
		Tier 2:	Within \pm (Mainline Posted Speed X 20%) for >85% of locations
Travel Times	All Routes > 1.5 Miles	Tier 1:	RMSPE <10.0%
		Tier 2:	Within \pm 15% for >85% of routes
Queues	All Critical ^(b) Queue Locations	Tier 1:	Not Applicable
		Tier 2:	\pm 150 feet for queues 300 to 750 long, Within \pm 20% for queues >750 feet long
Lane Use	All Critical ^(b) Lane Utilization Locations	Tier 1:	Not Applicable
		Tier 2:	RNSE <3.0% for >85% of locations Consistent with field conditions
<p>(a) Volume validation (Tier 1) tests are required for all traffic models</p> <p>(b) Critical locations are those locations likely to have an impact on operations to the project study area (e.g., locations with higher traffic volumes, existing or projected level of service is at or approaching unstable flow, queues block or impede travel, weaving areas, merge/diverge locations, etc.)</p> <p>vph = vehicles per hour</p> <p>RMSPE = Root Mean Squared Percent Error, See TEOpS 16-20-8.4 for equation</p> <p>RNSE = Root Normalized Squared Error, See TEOpS 16-20-8-5.1 for equation</p>			

Table 8.2 Tier 1 (Global) Validation Tests

MOE	Criteria	Validation Acceptance Threshold	
Volume ^(a)	All Links > 100 vph (Mainline and Critical ^(b) Arterials)	Tier 1:	RMSPE <5.0%
Speeds	All Segments or Spot-Speed Locations	Tier 1:	RMSPE <10.0%
Travel Times	All Routes > 1.5 Miles	Tier 1:	RMSPE <10.0%
<p>(a) Volume validation (Tier 1) tests are required for all traffic models</p> <p>(b) Critical locations are those locations likely to have an impact on operations to the project study area (e.g., locations with higher traffic volumes, existing or projected level of service is at or approaching unstable flow, queues block or impede travel, weaving areas, merge/diverge locations, etc.)</p> <p>vph = vehicles per hour</p> <p>RMSPE = Root Mean Squared Percent Error, See TEOpS 16-20-8.4 for equation</p>			

8.3.1 Traffic Volumes

The Tier 1 volume validation test is required for all microsimulation traffic models, see [Table 8.2](#). This test requires a global evaluation of the modeled versus observed (field) traffic volumes for all roadway links/segments for which traffic volume data is available. The volume validation tests evaluate the volumes during the peak period analysis times (does not include the warm-up or cool-down periods) included in the model (see [TEOpS 16-20-2.1.2](#) for additional direction on determining the temporal analysis periods).

The traffic model will often be broken into smaller links than what exists in the field, so use the roadway segmentation that exists or is planned to exist in the field to identify locations where volume data comparisons are justified. Focus on the mainline segment and other critical arterials and ramps included in the study area, where critical locations are those locations likely to have an impact on traffic operations.

A benefit of the RMSPE is that it considers relative error, so the results will be the same whether the modeled volume is higher or lower than the observed volume. Sensitivity testing, however, found that the RMSPE was somewhat unstable when volumes were less than 100 vehicles per hour (vph). Thus, the Tier 1 volume validation threshold is only applicable for those roadway links with a minimum volume of 100 vph during the analysis period. Values that may be under 100 vph likely include ramps or arterial roadways that have minimal to no effect on the operations of the facility under study.

The acceptance criteria for the global link volume test is a RMSPE of 5 percent (i.e., to pass the Tier 1 volume validation test, the RMSPE for all links must be less than 5 percent). This acceptance criterion was based on the results of the evaluation testing on previously developed, calibrated and validated models. Only well validated models will pass the 5 percent acceptance criteria. If the model does not pass the 5 percent acceptance criteria, the analyst **shall** proceed onto the Tier 2 volume validation to pinpoint where any issues in the model may exist.

Conduct the Tier 1 volume validation tests by direction for every model run. The analyst should conduct the volume validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the volume validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the volume validation test at the sub-hourly level.

Summarize and document the results of the volume validation tests. Include a copy of the volume validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the volume validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.3.2 Travel Speeds

See [TEOpS 16-20-3](#) to identify whether to apply the Tier 1 travel speed validation test. As shown in [Table 8.2](#), the Tier 1 travel speed validation test requires a global evaluation of the modeled versus observed (field) travel speeds during the analysis period (does not include the warm-up or cool-down period) for all segments where travel speeds are available (either average segment travel speeds or spot speeds). To ensure that the travel speed validation test is independent from the travel time validation test, take care not to use the inverse of travel times to derive the segment travel speeds for the travel speed validation.

The acceptance criteria for the global travel speed test is a RMSPE of 10 percent (i.e., to pass the Tier 1 travel speed test, the RMSPE for all segment/spot speed locations must be less than 10 percent). This acceptance criterion was based on the results of the evaluation testing on previously developed, calibrated and validated models. Only well validated models will pass the 10 percent acceptance criteria. If the model does not pass the 10 percent acceptance criteria, the analyst **shall** proceed onto the Tier 2 travel speed validation to pinpoint where any issues in the model may exist.

Conduct the Tier 1 travel speed validation tests by direction for every model run. The analyst should conduct the speed validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the speed validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the speed validation test at the sub-hourly level.

Summarize and document the results of the travel speed validation tests. Include a copy of the travel speed validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel speed validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling

mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.3.3 Travel Times

See TEOpS 16-20-3 to identify whether to apply the Tier 1 travel time validation test. As shown in [Table 8.2](#), the Tier 1 travel time validation test requires a global evaluation of the modeled versus observed (field) travel times during the analysis period (does not include the warm-up or cool-down period) for all study routes greater than 1.5 miles in length. To ensure that the travel time validation test is independent from the travel speed validation test, take care not to use the inverse of the segment travel speeds to derive the travel times for the travel time validation.

It is easier for drivers to relate travel time to longer routes versus shorter routes (i.e., a driver may say they drove ½ mile at an average of 60 miles per hour but typically will not say they took 30 seconds to drive the ½ mile). Further, on shorter segments, travel times and travel speeds tend to blend together (i.e., the travel time is often taken as the inverse of travel speed). WisDOT experience with previous projects has shown that it is easiest to make a distinction between travel time and travel speeds when the travel route is at least 1.5 miles long. For these reasons, the Tier 1 validation test for travel times is only applicable to travel routes greater than 1.5 miles long. Unless the use of shorter segments is logical, the analyst *should* combine short travel time segments (those less than 1.5 miles) together to make one longer travel time segment to use for the Tier 1 travel time validation test. If unsure whether to combine segments for the travel time validation test, please contact WisDOT regional traffic staff and/or BTO-TASU. Document the rationale for using the shorter travel time routes or combining routes into one longer segment in the modeling methodology report.

The acceptance criteria for the global travel time test is a RMSPE of 10 percent (i.e., to pass the Tier 1 travel time test, the RMSPE for all routes greater than 1.5 miles must be less than 10 percent). This acceptance criterion was based on the results of the evaluation testing on previously developed, calibrated and validated models. Only well validated models will pass the 10 percent acceptance criteria. If the model does not pass the 10 percent acceptance criteria, the analyst **shall** proceed onto the Tier 2 travel time validation to pinpoint where any issues in the model may exist.

Conduct the Tier 1 travel time validation tests by direction for every model run. The analyst should conduct the travel time validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the travel time validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the travel time validation test at the sub-hourly level.

Summarize and document the results of the travel time validation tests. Include a copy of the travel time validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel time validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4 Tier 2 (Local) Validation Tests

If the model fails to pass the Tier 1 (global) validation tests, the analyst **shall** perform the Tier 2 (local) test for the applicable MOEs. The purpose of the Tier 2 validation test is to pinpoint where potential problems in the model may exist. Since the Tier 2 validation test is a localized test, the GoF metric varies depending on the MOE. The Tier 2 (local) validation tests are applicable for link/segment volumes, turning movement volumes, travel speeds, travel times, queues and lane use. [Table 8.3](#) summarizes the Tier 2 (local) validation tests. Refer to [TEOpS 16-20-3](#) to identify the number and type of MOEs on which to perform validation tests, noting that if a model passes the Tier 1 (global) tests for a specific MOE, it is not necessary to perform the Tier 2 (local) tests for that same MOE. Document the rationale for excluding the Tier 2 validation tests (e.g., the MOE in question successfully passed the Tier 1 validation test) in the modeling methodology report. The analyst, however, *should* always perform the Tier 2 turning movement volume test for projects that include intersections.

Table 8.3 Tier 2 (Local) Validation Tests

MOE	Criteria	Validation Acceptance Threshold	
Volume ^(a)	All Links > 100 vph (Mainline and Critical ^(b) Arterials)	Tier 2:	RNSE <3.0% for >85% of links
	All Turns	Tier 2:	RNSE <3.0% for >75% of turns
Speeds	All Segments or Spot-Speed Locations	Tier 2:	Within ± (Mainline Posted Speed X 20%) for >85% of locations
Travel Times	All Routes > 1.5 Miles	Tier 2:	Within ± 15% for >85% of routes
Queues	All Critical ^(b) Queue Locations	Tier 2:	± 150 feet for queues 300 to 750 long, Within ±20% for queues >750 feet long
Lane Use	All Critical ^(b) Lane Utilization Locations	Tier 2:	RNSE <3.0% for >85% of locations Consistent with field conditions

(a) Link/Segment Volume Tier 2 validation tests are required for all traffic models that do not pass the Tier (1) validation test and Turning Volume Tier 2 validation tests are required for all traffic models that include intersections

(b) Critical locations are those locations likely to have an impact on operations to the project study area (e.g., locations with higher traffic volumes, existing or projected level of service is at or approaching unstable flow, queues block or impede travel, weaving areas, merge/diverge locations, etc.)

vph = vehicles per hour

RNSE = Root Normalized Squared Error, See [TEOpS 16-20-8-5.1](#) for equation

8.4.1 Traffic Volumes

The volume validation test is required for all microsimulation traffic models, however, the Tier 2 volume validation test for links/segments is only required if the model fails to pass the Tier 1 volume validation test. The analyst, however, *should* always perform the Tier 2 turning movement volume test for projects that include intersections. A metric named root normalized squared error (RNSE), which is a variation of the GEH (Geoffrey E. Havers) tolerance formula is the validation metric for local volume tests. The RNSE removes the modeled volume from the basis of normalizing error. The RNSE metric was developed based on literature reviews and evaluation testing. . The equations for GEH and RNSE are shown below.

$$GEH = \sqrt{2 \frac{(M-O)^2}{(M+O)}} \quad RNSE = \sqrt{\frac{(M-O)^2}{O}}$$

Where:

M = Modeled Data

O = Observed Data

The RNSE shares the same general form as the global RMSPE test that is the basis for the global volume test. Additionally, RNSE provides a consistent value above and below a target volume, whereas GEH does not, eliminating some of the concerns BTO-TASU has with the GEH.

Sensitivity testing found that volumes less than 100 vph may erroneously influence the statistics by potentially reducing the impact of critical links with higher volumes not meeting the threshold. Thus, the Tier 2 (local) volume validation threshold is only applicable for those roadway links with a minimum volume of 100 vph during the analysis period. Values that may be under 100 vph likely include ramps or arterial roadways that have minimal to no effect on the operations of the facility under study. The RNSE, however, is applicable to all turning movements (i.e., there is no minimum volume threshold for turning movements).

For the local link volume test, a RNSE of less than 3.0 is required for greater than 85 percent of links over 100 vehicles per hour. For the local turning movement volume test a RNSE of less than 3.0 is required for greater than 75 percent of turns. These acceptance criteria are based on the results of the evaluation testing on previously

developed, calibrated and validated models. Though the RNSE test value is more robust than the WisDOT 2014 local volume criteria (realism test 1.1, 1.2 and 1.3), its use did not result in well-validated models becoming invalid. Other agencies including the Washington Department of Transportation and London Department for Transport use a similarly strict criterion (GEH criteria of 3.0).

Conduct the Tier 2 volume validation tests by direction for every model run. The analyst should conduct the volume validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the volume validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the volume validation test at the sub-hourly level.

Summarize and document the results of the volume validation tests. Include a copy of the volume validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the volume validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.2 Travel Speeds

See [TEOpS 16-20-3](#) to identify whether to apply the Tier 2 travel speed validation test (note Tier 2 is only required if the model fails to pass the Tier 1 validation test). A combination of absolute error and percent error related to the posted speed limit of a roadway segment is the validation metric for local travel speeds (see [Table 8.3](#)). These validation metrics are based on the results of literature reviews, surveys of other state DOT practices and evaluation testing. The range of acceptance for this test is determined by using a threshold of plus or minus 20 percent of the posted speed limit (i.e., a posted speed of 40 mph would have a range of acceptance of plus or minus 8 mph). For the validation testing, the analyst would apply this range of acceptance (plus or minus 20 percent of the posted speed limit) to the observed speed. For example, an observed speed of 31 mph would have a range of acceptance between 23 and 39 mph (31 +/- 8 MPH) if the posted speed were 40 mph.

Since the 2014 realism tests had an acceptance criterion of plus or minus 10 mph regardless of the speed, it was possible for models to pass the realism test even if portions of the study corridor had modeled speeds that were 50% or more higher or lower than the observed speeds. This was most noticeable on arterials. The new local speed test tightens up the travel speed criteria for arterials and provides more flexibility for freeways experiencing congestion as compared to the 2014 realism tests.

Conduct the Tier 2 travel speed validation tests by direction for every model run. The analyst should conduct the travel speed validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the travel speed validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the travel speed validation test at the sub-hourly level.

Summarize and document the results of the travel speed validation tests. Include a copy of the travel speed validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel speed validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.3 Travel Times

See [TEOpS 16-20-3](#) to identify whether to apply the Tier 2 travel time validation test (note Tier 2 is only required if the model fails to pass the Tier 1 validation test). The 2014 realism test for travel times had separate acceptance thresholds for routes less than seven minutes and routes equal to or greater than seven minutes, where routes less than seven minutes had an acceptance criterion of plus or minus one minute. The one-minute acceptance criterion for short routes was very easy to meet, especially if considering routes with observed travel times of less than one minute. For this reason, BTO-TASU and the consultant team considered several local testing options for travel times to develop a validation threshold that would address the issues the 2014 realism test had concerning short segments.

Percent error is the metric the local travel time validation test. This metric was developed based on the results of literature reviews, surveys of other state DOT practices and evaluation testing. The selected travel time criterion requires modeled travel times to be within plus or minus 15 percent of observed travel times (see [Table 8.3](#)). WisDOT experience with previous projects has shown that it is easiest to make a distinction between travel time and travel speeds when the travel route is at least 1.5 miles long. Further, a driver is more likely to start noticing

slight changes in travel times on routes 1.5 miles long or longer (e.g., at 45 mph, the driver would take 2 minutes to travel 1.5 miles, any changes in travel time less than 2 minutes will likely be unnoticeable). For these reasons, the local travel time test is only applicable for routes over 1.5 miles in length. Unless the use of shorter segments is logical, the analyst *should* combine short travel time segments (those less than 1.5 miles) together to make one longer travel time segment to use for the Tier 2 travel time validation test. If unsure whether to combine segments for the travel time validation test, please contact WisDOT regional traffic staff and/or BTO-TASU. Document the rationale for using the shorter travel time routes or combining routes into one longer segment in the modeling methodology report.

Conduct the Tier 2 travel time validation tests by direction for every model run. The analyst should conduct the travel time validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the travel time validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the travel time validation test at the sub-hourly level.

Summarize and document the results of the travel time validation tests. Include a copy of the travel time validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the travel time validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.4 Queue Lengths

Refer to [TEOpS 16-20-3](#) to identify whether or not to apply the Tier 2 (local) queue validation test, noting that queues can be either a primary or a secondary validation MOE. Typically, if intersection queuing is critical to the design decisions (e.g., the project is assessing the storage length requirements for a left turn lane), queue lengths will be one of the primary validation MOEs for the arterials. Intersection queue lengths are often the primary MOE for validation of a SimTraffic model. The quantitative metrics for queues shown in [Table 8.3](#) are applicable for all models where queue lengths are a primary validation MOE (typically applicable for arterial segments). The qualitative measures discussed in [TEOpS 16-20-8.5](#) are applicable for models that use queue length as a secondary validation MOE (typically applicable for freeway segments).

Upon conducting, BTO-TASU decided to use The validation metric for intersection queue length is a combination of absolute error and percent error. This validation metric was developed based on the results literature reviews, surveys of other state DOT practices and evaluation testing. The acceptance criterion for the intersection queue validation test is an absolute error of plus or minus 150 feet for all observed queues between 300 and 750 feet and a percent error of plus or minus 20 percent for all observed queues greater than or equal to 750 feet. Similar to other tests, 85 percent of locations compared are required to pass the intersection queue validation criteria.

Although the analyst *should* perform the queue length validation test for all models where queue lengths are a primary validation MOE, BTO-TASU realizes there are potential issues with using queue length as a validation metric including, but not limited to:

- Queue lengths are generally unstable and can fluctuate significantly from one moment to the next, thus the queues observed in the field may not reflect the queues that were present during the time of the turning movement count.
- There is no standard procedure for measuring the length of queue. Queues could include only stopped vehicles or they could include stopped and slow moving (less than 5 mph) vehicles.
- Each microsimulation analysis tool has its own proprietary methodology for reporting on queue lengths, so there is a lack of consistency.

As such, the Tier 2 (local) queue validation test is non-binding, in that failure to meet the queue validation thresholds alone will not necessarily require further calibration and validation of the model. If the model is unable to satisfy the queue validation thresholds outlined in [Table 8.3](#), the analyst **shall** consult with WisDOT regional traffic staff and BTO-TASU to assess the need for further model calibration. This coordination **shall** occur prior to finalizing the modeling methodology report and/or proceeding with the development of additional modeling scenarios

Conduct the Tier 2 queue validation tests by direction for every model run. The analyst should conduct the queue validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the queue validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-

hourly data, strive to satisfy the queue validation test at the sub-hourly level.

Summarize and document the results of the queue validation tests. Include a copy of the queue validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the queue validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.5 Lane Utilization

Refer to [TEOpS 16-20-3](#) to identify whether to apply the Tier 2 (local) lane utilization validation test. Other agencies (such as Oregon DOT, Minnesota DOT and Washington DOT) use their traffic volume validation criteria and a comparison of modeled and observed lane utilization percentages. Comparable to the criteria used by Oregon DOT, Minnesota DOT and Washington DOT, the acceptance criterion for lane utilization is a RNSE of less than 3.0 for greater than 85 percent of data points (see [Table 8.3](#)). The data points chosen for the lane utilization validation *should* represent those locations where lane usage is critical for the operations of the facility (e.g., weaving areas, upstream of lane drops, etc.).

Although the analyst is encouraged to perform the quantitative lane utilization validation test for areas where lane usage has a significant influence on operations, BTO-TASU acknowledges that data may not always be available to conduct mathematical checks on lane utilization. As such, it may be acceptable to do more of a qualitative assessment to assess that the model reasonably reflects the lane utilization observed in the field. Justify and document the use of any qualitative assessments in the modeling methodology report.

Conduct the lane utilization validation tests by direction for every model run. The analyst should conduct the lane utilization validation for the finest resolution that is feasible, with practical bounds from 15 minutes up to one hour. BTO-TASU realizes that using sub-hourly time periods for validation may not be practical (e.g., data is unavailable at the sub-hourly level, the additional value does not justify the added level of effort required, etc.). Consider the lane utilization validation test satisfied if the model passes the tests at the hourly level. Ideally, however, if using sub-hourly data, strive to satisfy the lane utilization validation test at the sub-hourly level.

Summarize and document the results of the lane utilization validation tests. Include a copy of the lane utilization validation tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the lane utilization validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.6 Density

Acceptance of quantitative validation testing for density may be acceptable. To use density as a validation check for microsimulation models; the analyst **shall** obtain approval from WisDOT regional traffic staff and/or BTO-TASU.

8.5 Qualitative Validation Tests

The goal of the model validation process is to assure that the model is a good representation of the actual traffic conditions. This means that the model must not only meet the mathematical targets related to traffic volumes, speeds and travel times, but must also be reasonable in terms of overall traffic patterns such as lane choice and routing. [Table 8.4](#) provides a summary of the qualitative validation checks. The analyst **shall** perform the qualitative validation tests for all models, even those that pass the Tier 1 (global) mathematical validation thresholds. Document and justify the decisions made as they pertain to the qualitative validation tests and summarize the findings of the tests in the modeling methodology report.

Table 8.4 Qualitative Validation Tests

MOE	Criteria	Validation Acceptance Threshold
Queues	All Critical Queue Locations	Visually realistic for intersection queues. Quantitative checks required if queues are a primary validation MOE.
Bottlenecks	Replication of Real-World Bottlenecks	Visually realistic for intersection queues and freeway bottlenecks
Routing	All Routes	Represents field conditions and driver behavior. Acceptance of quantitative results require WisDOT approval.
Lane Use	All Critical Lane Utilization Locations	Visually realistic. Quantitative checks encouraged for areas where lane usage has a significant influence on operations.
Freeway Merging	All Merge Locations	Visually realistic
Vehicle Types and Truck Percentages	All Locations	Represents field conditions.

16-20-9 Design Year Analysis**January 2018****9.1 Recommended Process**

Only after calibrating and validating the existing conditions and only after completing the peer review process of the existing conditions model, *should* the analyst proceed with the development of other modeling scenarios. If the analyst chooses to develop the alternatives model prior to calibrating and validating the existing conditions model and/or prior to having the model go through the peer review process, they take the risk that they must go back and revise not only the alternatives model but the existing conditions model as well. This can lead to potential inconsistencies in the modeling scenarios and could result in the need for additional time to calibrate and perform the peer review(s) of the alternatives model. Although it may be tempting, especially when the project has a compressed schedule, to skip or delay the calibration, validation and/or peer review process of the existing conditions model, it may end up being counterproductive and is strongly discouraged.

Refer to [TEOpS 16-20-2](#) for additional details on the model development process, analysis scenarios and traffic model tree.

9.1.1 Carrying Parameters Forward into Model Scenarios

Unless changes to roadway geometry or traffic conditions are expected to alter the driving behavior, the analyst *should* carry the parameters from the calibrated existing conditions model forward, without any changes, to each subsequent scenario. For example, if it is necessary to use a headway of 0.85 to reproduce the level of congestion in the existing real-world network during the AM peak hour, then the analyst *should* use the same 0.85 headway value for the AM peak hour model in the design year.

Document and justify the rationale for modifying any of the existing conditions parameters. Where possible, associate any modification to the existing conditions parameters to changes in geometric conditions that may influence driving behavior (e.g., the design year build alternative lengthens the weaving area resulting in the need for drivers to be less aggressive thus increasing the headway).

9.1.2 Validation of Design Year Models

The only mathematical validation test that is applicable for design year models is the volume validation (both Tier 1 and Tier 2) tests. When conducting the volume validation tests (see [Table 8.1](#)) for the design year models, the analyst *should* compare the modeled volumes (i.e., output from the microsimulation model) to the appropriate design year traffic forecasts. Due to future congestion, the microsimulation model may not be able to sufficiently capture the true design year traffic demand within the analysis period, specifically for the no-build or FEC conditions. Under this scenario, the analyst *should* run the model with only the traffic demand for the analysis period (e.g., do not include the demand from the warm-up or cool-down periods) until all vehicles have exited the network, thereby capturing the full demand reflected in the design year traffic forecasts. Apply the volume validation tests (typically for each one-hour period) to both the seed matrix (full demand, no warm-up or cool-down) and analysis period matrix (includes warm-up, analysis period, and cool-down periods) runs. Running the model with the seed matrix allows the analyst to validate that the peak period demand matrix, when isolated, is sound.

Given the context within which quantitative checks on MOEs (specifically travel speeds, travel times, queue lengths and lane utilization) are conducted for the design year models, the validation tests for the MOEs for design year models consist of a visual check of the traffic model for reasonableness. Additionally, the analyst *should* perform the qualitative validation tests as summarized in [Table 8.4](#) as appropriate.

In addition to the visual and qualitative tests, the analyst *should* compare the travel times, travel speeds and queue results from the design year model to existing conditions data to assess whether the relative increase/decrease in each MOE between the scenarios is reasonable.

Conduct the quantitative volume validation tests and qualitative/visual checks by direction for each 15-minute analysis period for every model run. Summarize and document the results of the quantitative volume validation tests and qualitative/visual checks for the average of all (valid) runs. Include a copy the volume validations tests as an attachment to the modeling methodology report and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate. For sample formats or questions on the design year volume validation test, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

9.2 Traffic Volume Development

Work with the WisDOT regional traffic staff and WisDOT-TFS to develop the forecasts for the design year. Chapter 9 of the WisDOT [Transportation Planning Manual](#) provides details on the process for obtaining and developing traffic forecasts.

The forecasts developed by the WisDOT-TFS typically provide forecasts for the average annual daily traffic (AADT) and peak-hour intersection turning movement volumes (if requested). The microsimulation models, however, often require the use O-D matrix tables in addition to or instead of turning movement volumes and generally need to capture 15-minute profiles for the warm-up, analysis and cool-down periods. Further, microsimulation models require the use of a balanced volume data set, and oftentimes the traffic forecasts will reflect unbalanced volumes. Thus, in most cases, it will not be possible to enter the forecasts into the microsimulation model directly as provided by the WisDOT-TFS.

Document the methodology used to develop and modify the forecasts for use in the microsimulation models in the Traffic Forecasting Methodology Report and submit to the regional office and WisDOT-TFS for approval. The WisDOT-TFS will typically provide any comments on their review of the forecasting methodology report in [DT2340](#). The regional office will involve BTO-TASU in the review as appropriate.

9.2.1 Design Hour Volumes for Microsimulation Models

The analyst shall coordinate with WisDOT regional traffic staff, WisDOT-TFS and BTO-TASU as appropriate to develop design-hour volumes (DHV) for microsimulation models.

9.2.2 Origin-Destination Matrix Development for Microsimulation Models

The analyst shall coordinate with WisDOT regional traffic staff, WisDOT-TFS and BTO-TASU as appropriate to develop the O-D matrices for microsimulation models.

16-20-10 Documentation/Reporting/Presentation of Results

January 2018

10.1 Modeling Methodology Report

Prior to submitting the traffic model to the WisDOT regional office and other members of the peer review team (see [TEOpS 16-25](#)), document the methodology and assumptions used to develop, calibrate and validate the traffic model. Prepare a separate modeling methodology report for each model scenario. The exact format of the modeling methodology report will vary depending on the specifics of the project; however, the content of the report *should* always include the following:

- Project background – What is the goal/purpose of the project and why is microsimulation being used?
- Methodology/assumptions – Identify the methodology used to develop the model, being sure to note any assumptions.
- Calibration parameters – Identify and describe any user-defined parameters (i.e., note where changes to default parameters were made). Provide justification for the use of any localized (link-specific) calibration parameters.
- Validation summary – Summarize the findings of the validation tests. Provide the detailed validation testing results as an attachment to the report. Additionally, submit an electronic copy (preferably in Excel format) of the validation tests to the peer review team members.

Reference other reports such as the Traffic Analysis Tool Selection memo or Traffic Forecasting Methodology Report as appropriate, being sure to provide copies of any referenced documents as an attachment to the modeling methodology report.

For sample formats or questions on what to include in the modeling methodology report, please contact BTO-TASU via the DOT Traffic Analysis & Modeling mailbox (DOTTrafficAnalysisModeling@dot.wi.gov).

10.2 Presentation or Results

It is critical to format the presentation of microsimulation results to the audience because the expectation is that managers, technical staff, public officials and the traveling public will each have different levels of comprehension. For example, the average transportation user may understand the impacts on roadway performance through travel times, delay or congestion levels. If the average commute on a particular corridor increases from 20 minutes in a current year to 40 minutes in the future, the average user may understand how this is going to affect them. Whereas this same audience may have a much more difficult time understanding how future traffic conditions are going to affect them if density increases by 100%.

Generally, most audiences can understand pictures, graphical presentations, simulation videos or screen shots that describe the results. Presentations at public meetings *should* begin by orienting the audience around the modeled scenario. Point out the basic elements of the simulation display and identify traffic conditions that will help to gain the audience's confidence in the model. Animation videos or screen shots are very powerful to display a traffic flow concept that is difficult to grasp using numerical output. For example, depending on the type of data, it may be difficult to identify the start of a freeway bottleneck using numerical output alone. It may be obvious to the analyst where the bottleneck begins but a 30-second video or series of screen shots can convey this message clearly to an audience that is unfamiliar with the model.

10.2.1 Animation Output

Use animation videos or static screen shots exclusively for qualitative assessment. The analyst *should* review the simulation model and focus on the key points of a particular scenario. Before showing the animation videos to an audience outside of the modeling development and/or review team, verify that the driver behavior is realistic. Most microsimulation tools now provide the option to show a 3D visualization of the model, complete with roadway infrastructure and other architectural features. While these features may help to orient the audience to the project study area, take care not to let the presentation graphics overshadow the fundamental engineering objectives of the model. Discuss the requirements for the needs and emphasis of animation output of the traffic model with the WisDOT project team during the project scoping process.

Choosing an appropriate segment of the model to display during presentations requires professional judgment and an understanding of the project's objectives. Typically, the analyst *should* consider the average condition unless the worst case is realistic and the result causes system failure.

Recording animation output minimizes the chance for software and technology issues during presentations. It is generally best to keep the recorded animation videos relatively short (a run time of 2 to 3 minutes). Overlay text on the simulation videos as appropriate to orient the audience and provide information on the model outputs.

10.2.2 Graphical and Numerical Output

A seemingly endless amount of data can be output from most microsimulation models. The importance of such outputs is dependent upon the purpose of the project, operational analysis and microsimulation model. The objective of the analyst is to focus on a few key performance measures that tell the story of how the transportation facility is operating. The analyst *should* carefully choose numerical output that best addresses the objectives of the simulation model and ultimately the overall project.

Understanding the strengths of microsimulation software and knowing how different performance measures are calculated are important aspects of the analysis process. The methods and effectiveness of each software to measure performance may require analysts to use multiple tools to provide a comprehensive analysis of the traffic operations.

Display graphical or tabular data in a clear and concise format so the intended audience can draw conclusions without becoming overwhelmed with the amount of data. Analysts *should* consider supplementary visual cues to draw the audience's attention to the most important pieces of data. Bolding, indenting or highlighting text with different colors can help to increase discrimination between the different levels of data. Colored shading typically represents the following conditions.

Color	Performance Level
Green / Blue	Good
Yellow	Acceptable
Orange	Poor
Red	Failing or Severe

Analysts *should* be cognizant of common vision deficiencies when presenting results with different colors. Consider using redundant visual cues instead of relying on color alone (e.g., use colors along with letters or shapes).

16-20-11 Upgrading Simulation Models

January 2018

Keeping a model relevant and useful often requires upgrading it to the latest release of the simulation software. As noted in [TEOpS 16-20-4](#), the PTV Group typically releases major updates to the Vissim software once a year and Trafficware typically releases major updates to the Synchro/SimTraffic Studio software every two to three years. The software vendor may release minor updates, to address software bugs/errors, as often as once a month. As a note, there have not been any updates to Paramics since 2012.

These releases may or may not affect a specific simulation model but it is important to understand that no matter how small a change, any change could influence the results and validity of a model. This section will go over the questions to ask and the steps to follow when upgrading a model. The purpose of these steps is to give the modeler the information they need to assess the potential impact of upgrading the traffic model and to identify the additional work that may be necessary to re-calibrate and re-validate the traffic model. Before upgrading to a new model version, the analyst **shall** consult with the WisDOT project team, WisDOT regional traffic engineering staff and/or BTO-TASU as appropriate. When determining whether to upgrade, be cognizant of the version of the software that the peer review team has available to them to review the models (it may not be possible to open/use one version of the software in another version).

11.1 Software Upgrades

The general goals of large-scale projects involving microsimulation models usually involve multiple project stages/phases and may take 12 months or longer to complete. During this extended timeline, a software package may go through one or more updates. These updates usually occur for one or more of the following reasons:

- Software bug or error fix
- Feature addition
- Major version release

These updates can play an important role in the application of the software to a project and may require the need to update the model. For example, if the software vendor discovers a bug within the latest version of the software, they may release an update to address/fix the bug. Generally, the analyst *should* update the model to apply the bug fix as soon as possible. If the software update includes new or enhanced features, the modeling team may decide that the new features would benefit the project. If the benefit of adding the additional feature outweighs any potential implications (e.g., additional time/resources needed to revise the model), updating the model to apply the new features may be justified. Since major version releases of the software typically involve larger changes to the analysis methodologies, upgrading the traffic model to a new version may introduce new problems and the analyst is encouraged to hold off on upgrading the model to a later date.

11.2 When to Upgrade

In most cases, when establishing the project scope and budget, the project team assumes/expects that the traffic modeling will be done using a specific version of the software. Thus, the project scope and budget may not be able to absorb the additional time/costs needed to upgrade the traffic model to a new release of the software.

The stage/phase of the model is the most important thing to consider when evaluating whether it is the correct time to upgrade the model. The best time to upgrade a model is usually between major stages of a project. The following list highlights scenarios when the analyst and project team *may* want to consider upgrading a model:

- A new project is using an older model
- There is a major break in a project schedule
- The latest update feature(s) to the software addresses a geometric element or other concern of the project that the older version of the model could not accurately capture

- The latest version update to the software addresses/fixes major bugs/errors

The following list highlights scenarios when upgrading a model might introduce new problems and the analyst and project team *may* decide to upgrade the model later or not at all:

- Current project is almost finished
- Current model is still currently being used to test scenarios
- Model is very large and complex
- Newer version if not available to the peer review team

Ultimately, before upgrading to a new model version, the analyst **shall** consult with the WisDOT project team, WisDOT regional traffic engineering staff and/or BTO-TASU as appropriate.

11.3 Verify Model Calibration and Validation

If the WisDOT project team, WisDOT regional traffic engineering staff and BTO-TASU all agree that there is enough reason to convert the model to a new release/version of the software, it is often advisable for the analyst to compare the outputs/results of the key MOEs from the upgraded model to those of the original calibrated/validated model. This check *should* give the modeler an idea of how much work will be required to get the model to the same level of validity as the previous model. A model that does not require an extensive amount of modifications following an upgrade *should* be able to provide results that are similar and close to the original model.

Depending on the software package and the extent of the software modifications, upgrading the traffic model to the newest software version/release may cause a previously calibrated/validated model to fall out of validation. Therefore, the analyst *should* verify that the model still meets the validation thresholds. The modeler *should* first conduct a high-level, qualitative, assessment of the model, focusing on the components most significantly impacted by the software upgrade, to identify where revisions to the model may be necessary. Upon completing any necessary revisions to the model, the analyst *should* verify the validity of the model by performing the quantitative and qualitative validation tests summarized in [TEOpS 16-20-8](#).

Document the results of the validation tests, either as part of the modeling methodology report or as a separate addendum, and submit to the regional office for review and comment. The regional office will involve BTO-TASU in the review as appropriate.

16-20-12 References

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2. **Federal Highway Administration.** *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software*. 2004. FHWA-HRT-04-040.
3. **Federal Highway Administration.** *Traffic Analysis Toolbox Volume IV: Guidelines for Applying CORSIM Microsimulation Modeling Software*. 2007. FHWA-HOP-07-079.
4. **Trafficware, LLC.** *Synchro Studio 10 User Guide*. 2017. Published July 13, 2017.
5. **Transportation Research Board.** *Highway Capacity Manual 2010*. Washington DC : National Academy of Sciences, 2010. ISBN 978-0-309-16077-3.
6. **Transportation Research Board.** *Highway Capacity Manual, 6th Edition: A Guide For Multimodal Mobility Analysis*. Washington, D.C. : National Academy of Sciences, 2016. ISBN 978-0-309-36997-8.
7. **Federal Highway Administration.** *Guidance on the Level of Effort Required to Conduct Traffic Analysis Using Microsimulation*. McLean, VA : Research, Development, and Technology Turner-Fairbank Highway Research Center, 2014. FHWA-HRT-13-026.

VISSIM Calibration Settings

Last Updated: 5-31-18
Source: PTV Vissim 10 User Manual

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Vissim v. 9.00-04)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description	
GLOBAL	Simulation Settings	Simulation resolution; Time steps (seconds)/Simulation second	10.00	5 to 10	Yes	The simulation resolution has an impact on the behavior of vehicles, pedestrians, and the way they interact. A higher simulation resolution allows vehicles to make decisions based on the car following and lane change logic at a higher frequency.	
		Simulation Speed, Simulation second/second	10	Value 1.0: the simulation is run in real-time Value 2.0: The simulation is run at double real-time speed, etc. Maximum option: Runs the simulation at the maximum speed	No	Corresponds to a time lapse factor. It indicates simulation seconds per real-time second. The simulation speed does not affect the simulation results. The simulation speed can be changed during the simulation run.	
	Traffic Settings	Vehicle Composition (Veh Type; DesSpeedDistr; RelFlow)		Adjust to represent field conditions	Yes	Adjust relative flows to represent field conditions	
		Pedestrian Composition (Ped Type; DesSpeedDistr; RelFlow)		Adjust to represent field conditions	Yes	Adjust relative flows to represent field conditions	
	Base Settings	Vehicle Fleet		Use "North American" as default	Yes	Adjust to represent field conditions	
		Vehicle/Pedestrian Types	Car, HGV, Bus, Tram, Man, Woman	Adjust to represent field conditions	Yes	Vehicle/pedestrian type allows you to form a group of vehicles/pedestrians with the same technical driving/walking characteristics (e.g., SUV, Crossover, Sedan, Pickup Truck, Sedan, etc.)	
		Vehicle/Pedestrian Classes		Typically separate into passenger cars and heavy trucks, but may use any of the FHWA 13 vehicle classes	Yes	By default, the data for all vehicle and pedestrian classes is entered together, but you can show the data for certain vehicle classes and/or pedestrian classes separately in the evaluation.	
		Functions (Maximum and Desired Acceleration/Deceleration)	-	Typically use defaults per vehicle type/class	No	Impacts how fast or slow a vehicle will accelerate/decelerate. Generally more critical on steeper grades.	
		Distributions (vehicle characteristics, function and distribution)		2D/3D Model - Use "North American" as default, adjust to match field conditions as appropriate	Yes	Allows you to define the specific vehicles (Volkswagen Golf, Audi A4, etc.) that are included in the vehicle fleet.	
		Vehicle Characteristics function and distribution		Speed Distribution: left turn 12.4 to 18.6 mph; right-turn 7.5 to 15.5 mph		Adjust to represent field conditions	
LOCAL	Car Following	Look ahead distance min. (feet)	0.00	Typically not modified	No	Minimum distance that a vehicle can see forward in order to react to other vehicles either in front or to the side of it (within the same link). The minimum look-ahead distance is important when modeling lateral vehicle behavior. If several vehicle can overtake within a lane, this value needs to be greater than 0.00. If several vehicles can overtake within a lane, you can enter a greater look ahead distance to prevent any vehicle from running a red light (when doing so, do not change the number or Observed vehicles as this can lead to unrealistic simulation).	
		Look ahead distance max. (feet)	820.21	Typically not modified	No	Maximum distance that a vehicle can see forward in order to react to other vehicles either in front or to the side of it (within the same link). May want to extend if modeling rail traffic with block signals.	
		Look ahead distance. Observed vehicles	Arterial: 4 Freeway: 2	4	Yes	The number of observed vehicles or number of certain network objects affects how well vehicles in the link can predict other vehicles' movements and react accordingly. Higher value means vehicles can better react to multiple network objects in the network	
		Look back distance min. (feet)	0.00	Typically not modified	No	Defines the minimum distance that a vehicle can see backwards in order to react to other vehicles behind (within the same link). The minimum look-back distance is important when modeling lateral vehicle behavior. If several vehicles can overtake with a lane, this value needs to be greater than 0.00. This way you make sure the cars drive in an orderly fashion when two or more vehicles, than specified in the Observed vehicles attribute, on the same route want to position themselves at a stop line. This applies in particular to bicycles.	
		Look back distance max. (feet)	492.13	Typically not modified	No	Defines the maximum distance that a vehicle can see backwards in order to react to other vehicles behind (within the same link). You can reduce the maximum look-back distance in close-meshed networks (e.g., many connectors over a short distance). This may positively affect the simulation speed.	
		Temporary lack of attention duration (s)	0.00	0.00 to 1.00	No	The period of time when vehicles may not react to a preceding vehicle (they do react, however, to emergency braking). With increasing values, the capacity of the affected links decreases.	
		Temporary lack of attention probability	0%	0 to 5%	No	Frequency of the lack of attention. With increasing values, the capacity of the affected links decreases.	
		Smooth closeup behavior	Selected	Typically not modified	No	If this option is checked, vehicles slow down more evenly when approaching a stationary obstacle. If this option is not selected, the following vehicle uses the normal following behavior until the speed of the preceding vehicle drops to less than 3.28 feet/second and it comes almost to a halt. The later approach behavior can include a temporary acceleration.	
		Standstill distance for static obstacles	Not Selected, 1.64 ft if selected	Typically not modified	No	Standstill distance upstream of static obstacles such as signal heads, stop signs PT stops, priority rules, conflict areas. Not valid for stop signs in parking lots. The attribute Smooth closeup behavior must be selected. If this option is not selected, the vehicles use a normally distributed random value [0.5;0.15]. If this option is selected, the vehicles will use the given value.	
		Wiedemann 74 Car following model (applicable for arterials)	Wiedemann 74-Average standstill distance (feet)	6.56 ft	3.28 to 9.84 ft.	Yes	Defines the average desired distance between two cars. Higher value means larger standstill distance and lower capacity
			Wiedemann 74-Additive part of safety distance	2.00	1 to 3.75 ft	Yes	Value used for the computation of the desired safety distance. Higher value means larger standstill distance and lower capacity
			Wiedemann 74-Multiplic. Part of safety distance	3.00	2 to 4.75 ft	Yes	Value used for the computation of the desired safety distance. Greater value equals greater distribution (standard deviation) of safety distance. Higher value means larger standstill distance and lower capacity

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Source: PTV Vissim 10 User Manual

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Vissim v. 9.00-04)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description
Car Following (Cont)	Wiedemann 99 Car following model (applicable for freeway/highway)	Wiedemann 99-CC0 (Standstill Distance) (feet)	4.92 ft	Basic segment: 4.0 to 5.5 Weaving/Merge/Diverge: >4.92	Yes	The average desired standstill distance between two vehicles, it has no variation. Higher value means larger standstill distance and lower capacity
		Wiedemann 99-CC1 (Headway Time) (s)	0.90	Basic segment: 0.7 to 3.0 Weaving/Merge/Diverge: 0.9 to 3.0	Yes	Time distribution of speed-dependent part of desired safety distance. Higher value means more cautious driver and lower capacity
		Wiedemann 99-CC2 ('Following' Variation) (feet)	13.12 ft	Basic segment: 6.56 to 22.97 Weaving/Merge/Diverge: 13.12 to 39.37	Yes	Restricts the distance difference (longitudinal oscillation) or how much more distance than the desired safety distance a driver allows before he intentionally moves closer to the car in front. Higher value means more cautious driver and lower capacity
		Wiedemann 99-CC3 (Threshold for Entering 'Following')	-8.00	Typically not modified	No	It controls the start of the deceleration process (i.e., the number of seconds before reaching the safety distance.) At this stage the driver recognizes a preceding slower vehicle.
		Wiedemann 99-CC4 (Negative 'Following' Threshold)	-0.35	Typically not modified	No	Defines negative speed difference during the following process. Low values result in a more sensitive driver reaction to the acceleration or deceleration of the preceding vehicle.
		Wiedemann 99-CC5 (Positive 'Following' Threshold)	0.35	Typically not modified	No	Defines positive speed difference during the following process. Low values result in a more sensitive driver reaction to the acceleration or deceleration of the preceding vehicle.
		Wiedemann 99-CC6 (Speed dependency of Oscillation)	11.44	Typically not modified	No	Influence of distance on speed oscillation while in the following process. If the value is 0, the speed oscillation is independent of the distance. Larger values lead to a greater speed oscillation with increasing distance.
		Wiedemann 99-CC7 (Oscillation Acceleration) (ft/s ²)	0.82 ft/s ²	Typically not modified	No	Oscillation during acceleration
		Wiedemann 99-CC8 (Standstill Acceleration) (ft/s ²)	11.48 ft/s ²	Typically not modified	No	Desired acceleration when starting from standstill (limited by maximum acceleration defined within the acceleration curves).
		Wiedemann 99-CC9 (Acceleration with 50 mph) (ft/s ²)	4.92 ft/s ²	Typically not modified	No	Desired acceleration when starting at 80 km/h, approximately 50 mph, (limited by maximum acceleration defined within the acceleration curves).
LOCAL (CONT)	Lane Change	General behavior	Free lane selection	Free lane selection or Slow lane rule	No	Free lane selection: vehicles may overtake on each lane Slow lane rule: allows overtaking on freeways or similar links according to the rules in road traffic Regardless of option selected, you can model the general behavior more realistically using the settings under Cooperative lane change
		Maximum deceleration - Own (ft/s ²)	-13.12 ft/s ²	-15 to -12	Yes	Upper bound of deceleration for own vehicle. Higher absolute value means more aggressive lane changing behaviors
		-1 ft/s ² per distance - Own (feet)	Arterial: 100 Freeway: 200	100 to 250	No	This reduces the Maximum deceleration with increasing distance from the emergency stop distance linearly by this value down to the Accepted deceleration .
		Accepted deceleration - Own (ft/s ²)	-3.28	-2.5 to -4	No	Lower bound of deceleration for own vehicle for a lane change
		Maximum deceleration - Trailing (ft/s ²)	-9.84 ft/s ²	-12 to -8	No	Upper bound of deceleration for trailing vehicle. Higher absolute value means more aggressive lane changing behaviors
		-1 ft/s ² per distance - Trailing (feet)	Arterial: 100 Freeway: 200	50 to 250	No	This reduces the Maximum deceleration with increasing distance from the emergency stop distance linearly by this value down to the Accepted deceleration .
		Accepted deceleration -Trailing (ft/s ²)	Arterial: -3.28 Freeway: -1.64	-1.5 to -2.5	No	Lower bound of deceleration for trailing vehicle for a lane change
		Waiting time before diffusion (s)	60.00	99999	Yes	The maximum amount of time a vehicle can wait at the emergency stop distance for a necessary change of lanes. When this time is reached, the vehicle is removed from the network. Higher value means more tolerance on vehicles waiting at the emergency stop distance for necessary lane changes.
		Min. headway (front/rear), (ft)	1.64	1.5 to 6	No	The minimum distance between two vehicles that must be available after a lane change, so that the change can take place. A lane change during normal traffic flow might require a greater minimum distance between vehicles in order to maintain the speed-dependent safety distance.
		To slower lane if collision time is above (s)	11.00	0 to 0.5	No	Defines the minimum distance to a vehicle in front, in seconds, which must be present on the slower lane, so that an overtaking vehicle switches to the slower lane. Only applicable for Slow lane rule or Fast lane rule .
		Safety distance reduction factor	0.60	0.1 to 1.0	No	This factor is taken into account for each lane change. During the lane change, Vissim reduces the safety distance to the value that results from the following multiplication: Original safety distance * safety distance reduction factor . The default value of 0.6 reduces the safety distance by 40%. Once a lane change is completed, the original safety distance is taken into account again.
		Maximum deceleration for cooperative braking (ft/s ²)	-9.84	-32.3 to -3	No	Specifies to what extent the trailing vehicle is braking cooperatively, so as to allow a preceding vehicle to change lanes into the same lane they are traveling in. The higher the value, the stronger the braking and the greater the probability of changing lanes.
		Overtake reduced speed areas	Not Selected	Typically not modified	No	If this option is selected, vehicles immediately upstream of a reduced speed area may perform a free lane change. The vehicle will acknowledge any reduced speed area of the lane they changed into and adjust their speed accordingly. If the option is not selected (default), vehicles never start a free lane change directly upstream of a reduced speed area and they completely ignore the reduced speed areas on the new lane.
		Advanced merging	Selected	Adjust to match field conditions	Yes	If this option is selected, more vehicles can change lanes earlier, therefore capacity increases
Vehicle routing decisions look ahead	Selected	Typically not modified	No	If this option is selected, vehicles leaving the route identify new routing decisions on the same link in advance and take them into account when choosing the lane. For routing decisions further downstream that vehicles should identify in advance, the option Combine static routing decisions (under "Attributes of static vehicle routing decisions") must be selected.		

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Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Vissim v. 9.00-04)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description	
LOCAL (CONT)	Lane Change (Cont)	Cooperative lane change	Not Selected	Adjust to match field conditions	Yes	If this option is selected, trailing vehicles will make necessary lane change to facilitate the lane change of a leading vehicle	
		> Maximum speed difference (mph)	6.71	Typically not modified	No	Applicable only if Cooperative lane change has been selected. Identifies the maximum possible speed difference.	
		> Maximum collision time (s)	10.00	Typically not modified	No	Applicable only if Cooperative lane change has been selected. Identifies the maximum collision time (time a vehicle can travel before reaching a preceding vehicle or network object that has an impact on its desired speed)	
		Rear correction of lateral position	Not Selected	Typically not modified	No	This causes the vehicle to be aligned to the middle of the lane at the end of the lane change, instead of at an angle in the original lane. This can affect the capacity. Only performed if the Keep lateral distance to vehicles on next lane(s) option is selected under "Lateral" behavior.	
		> Maximum speed (mph)	1.86	Typically not modified	No	Speed up to which the correction of the rear end position should take place. Lateral correction of the rear end position is not performed for faster vehicles.	
		> Active during time period from "x sec" until "x sec" after lane change start	1.00 until 10.00	Typically not modified	No	Time after the start of the lane change at which the lateral movement of the rear end position should start until time after the start of the lane change at which the lateral movement of the rear end position should end.	
	Lateral	Desired position at free flow	Middle of lane	Typically not modified	No	Lateral orientation of a vehicle within its lane while it is in free traffic flow	
		Keep lateral distance to vehicles on next lane(s)	Not Selected	Typically not modified	No	If this option is selected, the vehicles consider the position and therefore the lateral orientation of vehicles on adjacent lanes and keep the Lateral min. distance . For this purpose, vehicles even adjust their lateral orientation on their own lane and swerve out of the way. If this option is not selected, vehicles on adjacent lanes are ignored even if they are wider than their lanes, except when they perform a lane change. Note: using this option can reduce the simulation speed significantly.	
		Diamond shaped queuing	Not Selected	Typically not modified	No	If this option is selected, queues take into account a realistic shape of vehicles with vehicles positioned offset, such as bikes. Vehicles are internally represented not as a rectangle, but as a rhombus.	
		Consider next turning direction	Not Selected	Typically not modified	No	Enables more intelligent lateral behavior in case of non-lane-bound traffic. If the option has been selected, a vehicle with this driving behavior does not pass another vehicle on the same lane if this might cause a collision at the next turning connector. To achieve this, attributes that enable passing on the same lane must be selected. Note the option Consider next turning direction has precedence over option Desired position at free flow .	
		Collision time gain (s):	2.00	Typically not modified	No	Minimum value of the collision time gain for the next vehicle or signal head, which must be reached so that a change of the lateral position on the lane is worthwhile and will be performed. Calculated based on the desired speed of the vehicle. Smaller values lead to a livelier lateral behavior, since vehicles also have to dodge sideways for minor improvements.	
		Minimum longitudinal speed (mph):	2.24	Typically not modified	No	Minimum longitudinal speed which still allows for lateral movements. The default value (2.24 mph) ensures that vehicles can also move laterally if they have almost come to a halt already.	
		Time between direction changes (s):	0.00	Typically not modified	No	Defines the minimum simulation time which must pass between the start of a lateral movement in one direction and the start of a lateral movement in the reverse direction. The higher this value, the smaller the lateral movements of vehicles. These lateral movements only take place if overtaking on the same lane is permitted. (Does not affect the lateral movement for a lane change.)	
		Default behavior when overtaking vehicles on the same lane or on adjacent lanes	Overtake on same lane	Overtake left (default) - Not Selected Overtake right (default) - Not Selected	Typically not modified	No	When modeling traffic that is not lane-bound, you can allow vehicles to overtake within a lane. Left: vehicles are allowed to overtake on a lane to the left; Right: vehicles are allowed to overtake on a lane to the right.
			Minimum lateral distance (ft)	Distance standing at 0 mph: 0.66 ft Distance driving at 30 mph: 3.28 ft	Typically not modified	No	Minimum distance between vehicles when overtaking within the lane and keeping the distance to vehicles in the adjacent lanes. Distance Standing at 0 mph is the lateral distance of the passing vehicle; Distance driving at 30 mph is the lateral distance of the passing vehicles.
		Exceptions for overtaking vehicles of the following vehicle classes	No exceptions listed	Typically not modified	No	Behavior for specific vehicle classes that deviates from the default behavior when overtaking vehicles on the same lane. When modeling traffic that is not lane-bound, you can select vehicle classes which may be overtaken within a lane by vehicles of the defined driving behavior set.	
	Signal Control	Reaction after end of green	Behavior at amber signal	Continuous Check	Not typically modified	No	Defines the behavior of vehicles when they approach an amber light. Continuous check: driver of vehicle continuously decides whether to continue driving or whether to stop. Vehicles assume that the amber light will only be visible for another two seconds. They then decide continuously, with each time step, whether they will continue to drive or stop. A vehicle will not brake, if its maximum deceleration does not allow it to stop at the stop line, or if it would have to brake for more than 15 ft/s ² . The vehicle will brake, if at its current speed, it cannot drive past the signal head with two seconds. Both braking and stopping are possible for cases that lie in between these two scenarios. One decision: The decision made is maintained until the vehicle crosses the stop line. Calculated using the probability factors.
			Probability Factors	Alpha: 1.59 Beta 1: -0.26 Beta 2: 0.27	Only applicable is One decision model is selected, Not typically modified	No	Used to calculate the probability (i.e., whether a driver stops at an amber light or not). $p = \frac{1}{1 + e^{-\alpha - \beta_1 v - \beta_2 a}}$ The following settings make a vehicle continue driving for longer when there is an amber light and occasionally even make it run a red light: The One decision option is selected, Alpha is greater than the default value 1.59; Beta1 is greater than the default value 0.27; and Beta2 is greater than the default -0.26 but less than 0.00.
		Reaction after end of red	Behavior at red/amber signal	Go (same as green)	Not typically modified	No	Used to define country-specific or regional behavior at red/amber signal. Options are Stop (same as red) or Go (same as green) ; where Stop (same as red) means the Go signal is green (the response time is effective from the time step the signal changes to green) and the Go (same as green) means the Go signal is red-amber (the response time is effective from the time step the signal changes to red-amber).
			Reaction time distribution	Blank	Typically not modified	No	Reaction time of a vehicle to the Go signal. It causes a time delay between the time step when the signal switches to Go and the time step when the first vehicle upstream of the corresponding stop line starts to move. If no time distribution is selected, the default time is 0 seconds.
		Reduced safety distance close to a stop line	Factor	0.60	0.60	Yes	Higher value reduces the safety distance between vehicles close to the signal stop bar
			Start upstream of stop line (ft)	328.08	Not typically modified	No	Distance upstream of the signal head
	End downstream of stop line (ft)		328.08	Not typically modified	No	Distance downstream of the signal head	

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LOCAL (CONT)	<i>Connector-level</i>	Emergency Stop (feet)	16.4 ft per lane	Adjust to match field conditions	Yes	Distance before the downstream connector where vehicles can make last chance lane changes
		Lane change (feet)	656.20	>656.20	Yes	Distance before the downstream connector where vehicles begin to make lane changes
		Lane change per lane	Not Selected	Adjust to match field conditions	Yes	If this option is selected, the entered lane change attribute value is multiplied by the number of lane changes which a vehicle requires to reach the connector
	<i>Point-level</i>	Speed distributions (mph)	Linear distributions	Adjust to represent the field conditions	Yes	The distribution function of desired speeds is a particularly important parameter, as it has an impact on link capacity and achievable travel times. If not hindered by other vehicles or network objects (e.g., signal controls), a driver will travel at his desired speed. Desired speed distributions are defined independently of vehicle or pedestrian type.
		Time distributions (mph)	Linear distributions	Not typically modified	No	You can use dwell time distributions for: 1) standstill time on parking lots 2) waiting times at toll counters through stop signs or 3) for PT stops to allow adequate time for passengers to board and alight the bus/transit vehicle.