Traffic Engineering, Operations & Safety Manual

Chapter 16 Traffic Analysis and Modeling

Section 1 Traffic Modeling Process

16-1-1 Overview September 2019

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) for additional details regarding traffic forecasting protocols.

1.3 Content

Attachment 1.1 outlines the process for the development and review of traffic models. 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).In the event the two documents provide conflicting information, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) to confirm the controlling methodology.

1.4 Acronyms/Terminology

The key terms and acronyms used within this chapter include:

AADT – Annual Average 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

DTA – Dynamic Traffic Assignment

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

Macroscopic simulation – Macroscopic traffic simulation models (a.k.a. travel demand models)

Mesoscopic simulation – Mesoscopic traffic simulation models (a.k.a. DTA)

Microsimulation – Microscopic traffic simulation models

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

TSDM – Traffic Signal Design Manual

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

WisDOT – Wisconsin Department of Transportation

1.5 Terminology

The key terms used within this chapter include:

DTA – Dynamic Traffic Assignment. DTA is a modeling approach that captures the relationship between dynamic route choice behaviors (path and start time) and transportation network characteristics (travel speeds, signal timings, level of congestion, etc.) It is possible to incorporate DTA into any level of simulation models (macroscopic, mesoscopic, microscopic); however, the most common application of DTA is for mesoscopic simulation models. Therefore; this policy assumes all DTA models are mesoscopic models.

Macroscopic simulation – Tools using this methodology assess the operation/capacity of a facility or network utilizing the deterministic relationships of the flow, speed, and density of the traffic stream. The simulation analyzes the movement of vehicles on a section-by-section basis. Travel demand models (TDMs) are an example of a macroscopic model. This policy does not cover the use of macroscopic simulation models.

Mesoscopic simulation – Tools using this methodology analyze the movement of individual vehicles or vehicle cells as they travel through a simulated network using predefined capacity and speed-density relationships. Mesoscopic models incorporate a level of network and operational detail comparable to microsimulation models with the route choice flexibility of macroscopic simulation models (TDMs). Most mesoscopic simulation models incorporate DTA, thus, this policy utilizes the term DTA model throughout to represent mesoscopic simulation models.

Microsimulation – Microscopic traffic simulation. Tools using this methodology analyze the movement of individual vehicles as they travel through a simulated 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.

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.

LIST OF ATTACHMENTS

Attachment 1.1	Traffic Model Development & Review Process

16-1-2 Basic Principles September 2019

2.1 Establish Project Purpose, 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. 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.

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 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 regional office 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 demanding traffic analyses (such as the microscopic traffic simulation analyses) typically require outsourcing the work to one or more consultant firms.

If in need of consultant services, the internal WisDOT project team *should* follow the process 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 TEOpS 16-10 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 TEOpS 16-10 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 on conducting peer reviews.

Coordinate with WisDOT regional traffic staff as necessary to address any questions/concerns regarding the traffic analyses tool(s), methodologies, or results. If desired, the WisDOT regional traffic engineer may request additional support or guidance from BTO-TASU.

Attachment 1.1 Traffic Model Development & Review Process

Last Updated: January 2018

List of Abbreviations

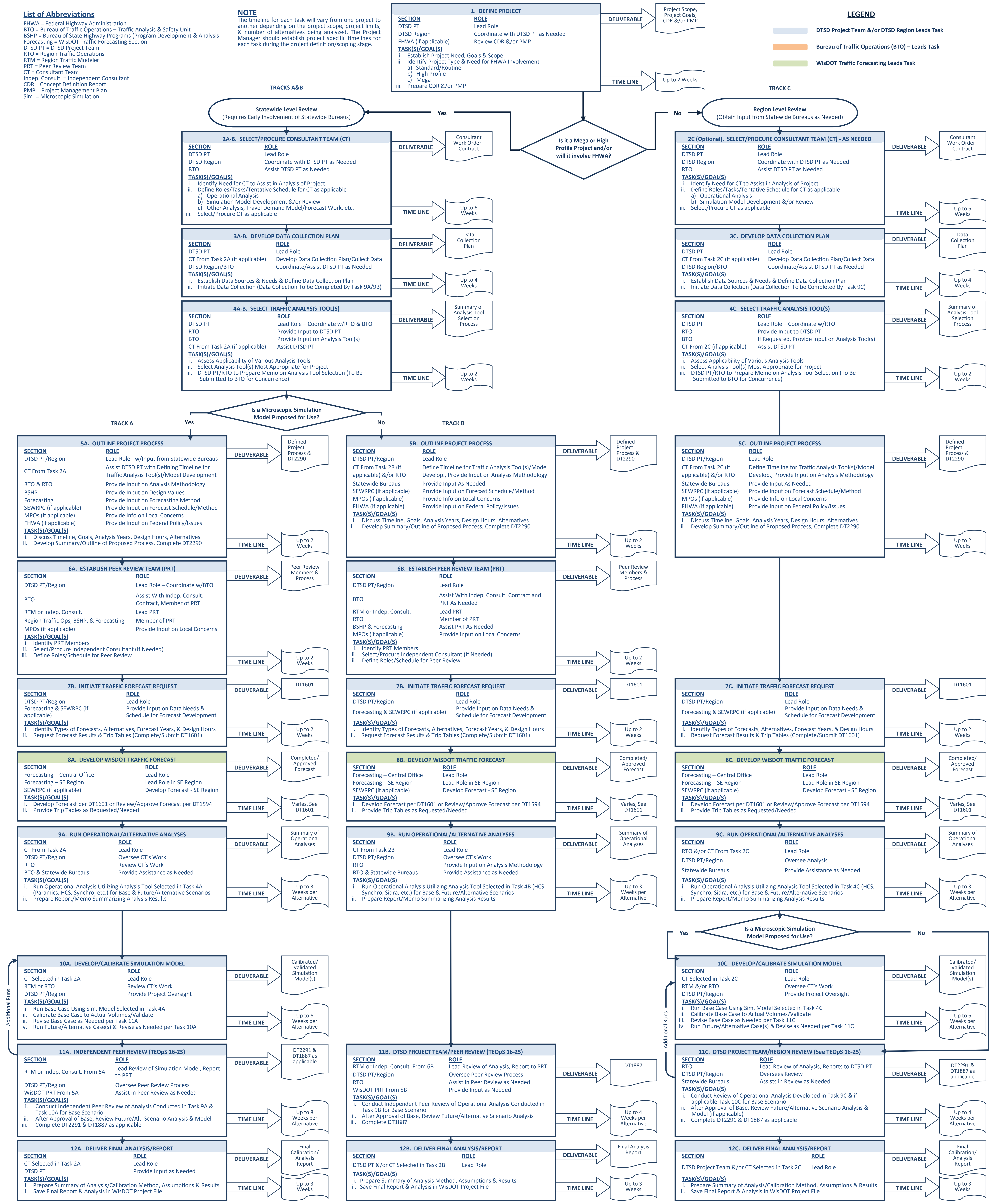
FHWA = Federal Highway Administration
BTO = Bureau of Traffic Operations – Traffic Analysis & Safety Unit
BSHP = Bureau of State Highway Programs (Program Development & Analysis
Forecasting = WisDOT Traffic Forecasting Section
DTSD PT = DTSD Project Team
RTO = Region Traffic Operations
RTM = Region Traffic Modeler
PRT = Peer Review Team
CT = Consultant Team
Indep. Consult. = Independent Consultant
CDR = Concept Definition Report
PMP = Project Management Plan
Sim. = Microscopic Simulation

NOTE

The timeline for each task will vary from one project to another depending on the project scope, project limits, & number of alternatives being analyzed. The Project Manager should establish project specific timelines for each task during the project definition/scoping stage.

LEGEND

🟦 DTSD Project Team &/or DTSD Region Leads Task
🟧 Bureau of Traffic Operations (BTO) – Leads Task
🟩 WisDOT Traffic Forecasting Leads Task



1. DEFINE PROJECT

SECTION	ROLE
DTSD PT	Lead Role
DTSD Region	Coordinate with DTSD PT as Needed
FHWA (if applicable)	Review CDR &/or PMP

TASK(S)/GOAL(S)
i. Establish Project Need, Goals & Scope
ii. Identify Project Type & Need for FHWA Involvement
  a) Standard/Routine
  b) High Profile
  c) Mega
iii. Prepare CDR &/or PMP

DELIVERABLE: Project Scope, Project Goals, CDR &/or PMP
TIME LINE: Up to 2 Weeks

Is it a Mega or High Profile Project and/or will it involve FHWA?
Yes → TRACKS A&B
No → TRACK C

TRACKS A&B

Statewide Level Review
(Requires Early Involvement of Statewide Bureaus)

2A-B. SELECT/PROCURE CONSULTANT TEAM (CT)

SECTION	ROLE
DTSD PT	Lead Role
DTSD Region	Coordinate with DTSD PT as Needed
BTO	Assist DTSD PT as Needed

TASK(S)/GOAL(S)
i. Identify Need for CT to Assist in Analysis of Project
ii. Define Roles/Tasks/Tentative Schedule for CT as applicable
  a) Operational Analysis
  b) Simulation Model Development &/or Review
  c) Other Analysis, Travel Demand Model/Forecast Work, etc.
iii. Select/Procure CT as applicable

DELIVERABLE: Consultant Work Order - Contract
TIME LINE: Up to 6 Weeks

3A-B. DEVELOP DATA COLLECTION PLAN

SECTION	ROLE
DTSD PT	Lead Role
CT From Task 2A (if applicable)	Develop Data Collection Plan/Collect Data
DTSD Region/BTO	Coordinate/Assist DTSD PT as Needed

TASK(S)/GOAL(S)
i. Establish Data Sources & Needs & Define Data Collection Plan
ii. Initiate Data Collection (Data Collection To be Completed By Task 9A/9B)

DELIVERABLE: Data Collection Plan
TIME LINE: Up to 4 Weeks

4A-B. SELECT TRAFFIC ANALYSIS TOOL(S)

SECTION	ROLE
DTSD PT	Lead Role – Coordinate w/RTO & BTO
RTO	Provide Input to DTSD PT
BTO	Provide Input on Analysis Tool(s)
CT From Task 2A (if applicable)	Assist DTSD PT

TASK(S)/GOAL(S)
i. Assess Applicability of Various Analysis Tools
ii. Select Analysis Tool(s) Most Appropriate for Project
iii. DTSD PT/RTO to Prepare Memo on Analysis Tool Selection (To Be Submitted to BTO for Concurrence)

DELIVERABLE: Summary of Analysis Tool Selection Process
TIME LINE: Up to 2 Weeks

Is a Microscopic Simulation Model Proposed for Use?
Yes → TRACK A
No → TRACK B

TRACK A

5A. OUTLINE PROJECT PROCESS

SECTION	ROLE
DTSD PT/Region	Lead Role - w/Input from Statewide Bureaus
CT From Task 2A	Assist DTSD PT with Defining Timeline for Traffic Analysis Tool(s)/Model Development
BTO & RTO	Provide Input on Analysis Methodology
BSHP	Provide Input on Design Values
Forecasting	Provide Input on Forecasting Method
SEWRPC (if applicable)	Provide Input on Forecast Schedule/Method
MPOs (if applicable)	Provide Info on Local Concerns
FHWA (if applicable)	Provide Input on Federal Policy/Issues

TASK(S)/GOAL(S)
i. Discuss Timeline, Goals, Analysis Years, Design Hours, Alternatives
ii. Develop Summary/Outline of Proposed Process, Complete DT2290

DELIVERABLE: Defined Project Process & DT2290
TIME LINE: Up to 2 Weeks

6A. ESTABLISH PEER REVIEW TEAM (PRT)

SECTION	ROLE
DTSD PT/Region	Lead Role – Coordinate w/BTO
BTO	Assist With Indep. Consult. Contract, Member of PRT
RTM or Indep. Consult.	Lead PRT
Region Traffic Ops, BSHP, & Forecasting	Member of PRT
MPOs (if applicable)	Provide Input on Local Concerns

TASK(S)/GOAL(S)
i. Identify PRT Members
ii. Select/Procure Independent Consultant (If Needed)
iii. Define Roles/Schedule for Peer Review

DELIVERABLE: Peer Review Members & Process
TIME LINE: Up to 2 Weeks

7B. INITIATE TRAFFIC FORECAST REQUEST

SECTION	ROLE
DTSD PT/Region	Lead Role
Forecasting & SEWRPC (if applicable)	Provide Input on Data Needs & Schedule for Forecast Development

TASK(S)/GOAL(S)
i. Identify Types of Forecasts, Alternatives, Forecast Years, & Design Hours
ii. Request Forecast Results & Trip Tables (Complete/Submit DT1601)

DELIVERABLE: DT1601
TIME LINE: Up to 2 Weeks

8A. DEVELOP WISDOT TRAFFIC FORECAST

SECTION	ROLE
Forecasting – Central Office	Lead Role
Forecasting – SE Region	Lead Role in SE Region
SEWRPC (if applicable)	Develop Forecast - SE Region

TASK(S)/GOAL(S)
i. Develop Forecast per DT1601 or Review/Approve Forecast per DT1594
ii. Provide Trip Tables as Requested/Needed

DELIVERABLE: Completed/ Approved Forecast
TIME LINE: Varies, See DT1601

9A. RUN OPERATIONAL/ALTERNATIVE ANALYSES

SECTION	ROLE
CT From Task 2A	Lead Role
DTSD PT/Region	Oversee CT's Work
RTO	Review CT's Work
BTO & Statewide Bureaus	Provide Assistance as Needed

TASK(S)/GOAL(S)
i. Run Operational Analysis Utilizing Analysis Tool Selected in Task 4A (Paramics, HCS, Synchro, etc.) for Base & Future/Alternative Scenarios
ii. Prepare Report/Memo Summarizing Analysis Results

DELIVERABLE: Summary of Operational Analyses
TIME LINE: Up to 3 Weeks per Alternative

10A. DEVELOP/CALIBRATE SIMULATION MODEL

SECTION	ROLE
CT Selected in Task 2A	Lead Role
RTM or RTO	Review CT's Work
DTSD PT/Region	Provide Project Oversight

TASK(S)/GOAL(S)
i. Run Base Case Using Sim. Model Selected in Task 4A
ii. Calibrate Base Case to Actual Volumes/Validate
iii. Revise Base Case as Needed per Task 11A
iv. Run Future/Alternative Case(s) & Revise as Needed per Task 10A

DELIVERABLE: Calibrated/ Validated Simulation Model(s)
TIME LINE: Up to 6 Weeks per Alternative

Additional Runs

11A. INDEPENDENT PEER REVIEW (TEOpS 16-25)

SECTION	ROLE
RTM or Indep. Consult. From 6A	Lead Review of Simulation Model, Report to PRT
DTSD PT/Region	Oversee Peer Review Process
WisDOT PRT From 5A	Assist in Peer Review as Needed

TASK(S)/GOAL(S)
i. Conduct Independent Peer Review of Analysis Conducted in Task 9A & Task 10A for Base Scenario
ii. After Approval of Base, Review Future/Alt. Scenario Analysis & Model
iii. Complete DT2291 & DT1887 as applicable

DELIVERABLE: DT2291 & DT1887 as applicable
TIME LINE: Up to 8 Weeks per Alternative

12A. DELIVER FINAL ANALYSIS/REPORT

SECTION	ROLE
CT Selected in Task 2A	Lead Role
DTSD PT	Provide Input as Needed

TASK(S)/GOAL(S)
i. Prepare Summary of Analysis/Calibration Method, Assumptions & Results
ii. Save Final Report & Analysis in WisDOT Project File

DELIVERABLE: Final Calibration/ Analysis Report
TIME LINE: Up to 3 Weeks

TRACK B

5B. OUTLINE PROJECT PROCESS

SECTION	ROLE
DTSD PT/Region	Lead Role
CT From Task 2B (if applicable) &/or RTO	Define Timeline for Traffic Analysis Tool(s)/Model Develop., Provide Input on Analysis Methodology
Statewide Bureaus	Provide Input As Needed
SEWRPC (if applicable)	Provide Input on Forecast Schedule/Method
MPOs (if applicable)	Provide Info on Local Concerns
FHWA (if applicable)	Provide Input on Federal Policy/Issues

TASK(S)/GOAL(S)
i. Discuss Timeline, Goals, Analysis Years, Design Hours, Alternatives
ii. Develop Summary/Outline of Proposed Process, Complete DT2290

DELIVERABLE: Defined Project Process & DT2290
TIME LINE: Up to 2 Weeks

6B. ESTABLISH PEER REVIEW TEAM (PRT)

SECTION	ROLE
DTSD PT/Region	Lead Role
BTO	Assist With Indep. Consult. Contract and PRT As Needed
RTM or Indep. Consult.	Lead PRT
RTO	Member of PRT
BSHP & Forecasting	Assist PRT As Needed
MPOs (if applicable)	Provide Input on Local Concerns

TASK(S)/GOAL(S)
i. Identify PRT Members
ii. Select/Procure Independent Consultant (If Needed)
iii. Define Roles/Schedule for Peer Review

DELIVERABLE: Peer Review Members & Process
TIME LINE: Up to 2 Weeks

7B. INITIATE TRAFFIC FORECAST REQUEST

SECTION	ROLE
DTSD PT/Region	Lead Role
Forecasting & SEWRPC (if applicable)	Provide Input on Data Needs & Schedule for Forecast Development

TASK(S)/GOAL(S)
i. Identify Types of Forecasts, Alternatives, Forecast Years, & Design Hours
ii. Request Forecast Results & Trip Tables (Complete/Submit DT1601)

DELIVERABLE: DT1601
TIME LINE: Up to 2 Weeks

8B. DEVELOP WISDOT TRAFFIC FORECAST

SECTION	ROLE
Forecasting – Central Office	Lead Role
Forecasting – SE Region	Lead Role in SE Region
SEWRPC (if applicable)	Develop Forecast - SE Region

TASK(S)/GOAL(S)
i. Develop Forecast per DT1601 or Review/Approve Forecast per DT1594
ii. Provide Trip Tables as Requested/Needed

DELIVERABLE: Completed/ Approved Forecast
TIME LINE: Varies, See DT1601

9B. RUN OPERATIONAL/ALTERNATIVE ANALYSES

SECTION	ROLE
CT From Task 2B	Lead Role
DTSD PT/Region	Oversee CT's Work
RTO	Provide Input on Analysis Methodology
BTO & Statewide Bureaus	Provide Assistance as Needed

TASK(S)/GOAL(S)
i. Run Operational Analysis Utilizing Analysis Tool Selected in Task 4B (HCS, Synchro, Sidra, etc.) for Base & Future/Alternative Scenarios
ii. Prepare Report/Memo Summarizing Analysis Results

DELIVERABLE: Summary of Operational Analyses
TIME LINE: Up to 3 Weeks per Alternative

11B. DTSD PROJECT TEAM/PEER REVIEW (TEOpS 16-25)

SECTION	ROLE
RTM or Indep. Consult. From 6B	Lead Review of Analysis, Report to PRT
DTSD PT/Region	Oversee Peer Review Process
RTO	Assist in Peer Review as Needed
WisDOT PRT From 5B	Provide Input as Needed

TASK(S)/GOAL(S)
i. Conduct Independent Peer Review of Operational Analysis Conducted in Task 9B for Base Scenario
ii. After Approval of Base, Review Future/Alternative Scenario Analysis
iii. Complete DT1887

DELIVERABLE: DT1887
TIME LINE: Up to 4 Weeks per Alternative

12B. DELIVER FINAL ANALYSIS/REPORT

SECTION	ROLE
DTSD PT &/or CT Selected in Task 2B	Lead Role

TASK(S)/GOAL(S)
i. Prepare Summary of Analysis Method, Assumptions & Results
ii. Save Final Report & Analysis in WisDOT Project File

DELIVERABLE: Final Analysis Report
TIME LINE: Up to 3 Weeks

TRACK C

Region Level Review
(Obtain Input from Statewide Bureaus as Needed)

2C (Optional). SELECT/PROCURE CONSULTANT TEAM (CT) - AS NEEDED

SECTION	ROLE
DTSD PT	Lead Role
DTSD Region	Coordinate with DTSD PT as Needed
RTO	Assist DTSD PT as Needed

TASK(S)/GOAL(S)
i. Identify Need for CT to Assist in Analysis of Project
ii. Define Roles/Tasks/Tentative Schedule for CT as applicable
  a) Operational Analysis
  b) Simulation Model Development &/or Review
iii. Select/Procure CT as applicable

DELIVERABLE: Consultant Work Order - Contract
TIME LINE: Up to 6 Weeks

3C. DEVELOP DATA COLLECTION PLAN

SECTION	ROLE
DTSD PT	Lead Role
CT From Task 2C (if applicable)	Develop Data Collection Plan/Collect Data
DTSD Region/BTO	Coordinate/Assist DTSD PT as Needed

TASK(S)/GOAL(S)
i. Establish Data Sources & Needs & Define Data Collection Plan
ii. Initiate Data Collection (Data Collection To be Completed By Task 9C)

DELIVERABLE: Data Collection Plan
TIME LINE: Up to 4 Weeks

4C. SELECT TRAFFIC ANALYSIS TOOL(S)

SECTION	ROLE
DTSD PT	Lead Role – Coordinate w/RTO
RTO	Provide Input to DTSD PT
BTO	If Requested, Provide Input on Analysis Tool(s)
CT From 2C (if applicable)	Assist DTSD PT

TASK(S)/GOAL(S)
i. Assess Applicability of Various Analysis Tools
ii. Select Analysis Tool(s) Most Appropriate for Project
iii. DTSD PT/RTO to Prepare Memo on Analysis Tool Selection (To Be Submitted to BTO for Concurrence)

DELIVERABLE: Summary of Analysis Tool Selection Process
TIME LINE: Up to 2 Weeks

5C. OUTLINE PROJECT PROCESS

SECTION	ROLE
DTSD PT/Region	Lead Role
CT From Task 2C (if applicable) &/or RTO	Define Timeline for Traffic Analysis Tool(s)/Model Develop., Provide Input on Analysis Methodology
Statewide Bureaus	Provide Input As Needed
SEWRPC (if applicable)	Provide Input on Forecast Schedule/Method
MPOs (if applicable)	Provide Info on Local Concerns
FHWA (if applicable)	Provide Input on Federal Policy/Issues

TASK(S)/GOAL(S)
i. Discuss Timeline, Goals, Analysis Years, Design Hours, Alternatives
ii. Develop Summary/Outline of Proposed Process, Complete DT2290

DELIVERABLE: Defined Project Process & DT2290
TIME LINE: Up to 2 Weeks

7C. INITIATE TRAFFIC FORECAST REQUEST

SECTION	ROLE
DTSD PT/Region	Lead Role
Forecasting & SEWRPC (if applicable)	Provide Input on Data Needs & Schedule for Forecast Development

TASK(S)/GOAL(S)
i. Identify Types of Forecasts, Alternatives, Forecast Years, & Design Hours
ii. Request Forecast Results & Trip Tables (Complete/Submit DT1601)

DELIVERABLE: DT1601
TIME LINE: Up to 2 Weeks

8C. DEVELOP WISDOT TRAFFIC FORECAST

SECTION	ROLE
Forecasting – Central Office	Lead Role
Forecasting – SE Region	Lead Role in SE Region
SEWRPC (if applicable)	Develop Forecast - SE Region

TASK(S)/GOAL(S)
i. Develop Forecast per DT1601 or Review/Approve Forecast per DT1594
ii. Provide Trip Tables as Requested/Needed

DELIVERABLE: Completed/ Approved Forecast
TIME LINE: Varies, See DT1601

9C. RUN OPERATIONAL/ALTERNATIVE ANALYSES

SECTION	ROLE
RTO &/or CT From Task 2C	Lead Role
DTSD PT/Region	Oversee Analysis
Statewide Bureaus	Provide Assistance as Needed

TASK(S)/GOAL(S)
i. Run Operational Analysis Utilizing Analysis Tool Selected in Task 4C (HCS, Synchro, Sidra, etc.) for Base & Future/Alternative Scenarios
ii. Prepare Report/Memo Summarizing Analysis Results

DELIVERABLE: Summary of Operational Analyses
TIME LINE: Up to 3 Weeks per Alternative

Is a Microscopic Simulation Model Proposed for Use?
Yes → 10C
No → 11C

10C. DEVELOP/CALIBRATE SIMULATION MODEL

SECTION	ROLE
CT Selected in Task 2C	Lead Role
RTM &/or RTO	Oversee CT's Work
DTSD PT/Region	Provide Project Oversight

TASK(S)/GOAL(S)
i. Run Base Case Using Sim. Model Selected in Task 4C
ii. Calibrate Base Case to Actual Volumes/Validate
iii. Revise Base Case as Needed per Task 11C
iv. Run Future/Alternative Case(s) & Revise as Needed per Task 11C

DELIVERABLE: Calibrated/ Validated Simulation Model(s)
TIME LINE: Up to 6 Weeks per Alternative

Additional Runs

11C. DTSD PROJECT TEAM/REGION REVIEW (See TEOpS 16-25)

SECTION	ROLE
RTO	Lead Review of Analysis, Reports to DTSD PT
DTSD PT/Region	Oversees Review
Statewide Bureaus	Assists in Review as Needed

TASK(S)/GOAL(S)
i. Conduct Review of Operational Analysis Developed in Task 9C & if applicable Task 10C for Base Scenario
ii. After Approval of Base, Review Future/Alternative Scenario Analysis & Model (if applicable)
iii. Complete DT2291 & DT1887 as applicable

DELIVERABLE: DT2291 & DT1887 as applicable
TIME LINE: Up to 4 Weeks per Alternative

12C. DELIVER FINAL ANALYSIS/REPORT

SECTION	ROLE
DTSD Project Team &/or CT Selected in Task 2C	Lead Role

TASK(S)/GOAL(S)
i. Prepare Summary of Analysis/Calibration Method, Assumptions & Results
ii. Save Final Report & Analysis in WisDOT Project File

DELIVERABLE: Final Calibration/ Analysis Report
TIME LINE: Up to 3 Weeks

16-5-1 Data Assembly and Collection September 2019

1.1 Introduction

Transportation planning and engineering requires real-world data to understand system performance, identify emerging trends, and find solutions to issues. This section discusses data assembly, collection, and preparation for use in the development of traffic models and other general capacity analyses. Other specialized studies, such as safety, transit, parking, noise, or freight, would need data beyond the scope of this section. Data requirements are highly dependent on the individual project needs and goals and may necessitate additional data beyond that discussed within this policy. Prior to gathering any data, coordinate with the regional traffic engineer to discuss the data needs for the project, identify potential data sources, and develop a data assembly/collection plan.

1.2 Data Assembly/Collection Plan

This section describes the typical components of a data assembly/collection plan ("data plan"). The actual data plan will vary depending on the specific needs of the project. Regardless of the precise content, the data plan *should* provide clear guidance as to how, when, and where to obtain the required data. The data plan should also include details on the schedule and budget needs necessary to compile the data elements. Preparing the data plan should occur during project scoping to avoid project delays and to allow time for acquiring existing and any new time-sensitive data.

The following provides an example outline of a data assembly/collection plan.

1. **Introduction/Background**

   Provide a brief background on the project, including a description of the project's needs and purpose. Include a discussion on the traffic analysis tools, traffic models, and other analyses that require data for the project.

2. **Data Needs**

   Identify the data requirements necessary to develop, calibrate, and validate the traffic models and other analyses tools. See TEOpS 16-5-1.4 for guidance on selecting the appropriate data for analysis. When defining the data needs, consider not only the project objectives but also other potential uses and users of the data to optimize resources. Coordinate with WisDOT regional traffic staff to determine if there are current or upcoming projects that could also benefit from the required data.

3. **Data Locations**

   Illustrate the data needs on a list or map. Label what type of data to assemble at each location. As the data plan progresses, identify where existing data is available and its source, as well as where new data collection is necessary.

4. **Data Sources**

   List potential sources for obtaining the necessary data and identify the owner or responsible party for each data source. Data sources could include existing databases, previous studies, and new data collection efforts. The Bureau of Traffic Operations (BTO) - Traffic Analysis and Safety Unit (TASU) Data Hub provides a list of potential data sources. Coordinate with WisDOT regional traffic staff to verify other potential sources of data. Additional resources for identifying data sources include WisDOT Bureau of State Highway Programs (BSHP) and WisDOT Traffic Forecasting Section (TFS).

5. **Justification for New Data Collection**

   Identify any gaps, errors, obsolete, or other issues/concerns with existing data sources. Establish an approach for resolving the identified issues. Document and justify the need for new/additional field data collection. Follow the Transportation Planning Manual (TPM) and other available WisDOT guidelines for data collection as applicable.

6. **Methodology for Acquiring Data**

   For new data collection efforts, identify the approach for gathering the data. Include information on how to collect the data, when to collect the data (e.g., months of the year, days of the week, time periods, or time of day), who is responsible for the data collection, the duration of the counts (e.g., peak-hour, peak-period, one week, one month, etc.) and the time interval (e.g., 5 minutes, 15 minutes, 1 hour, etc.). Where appropriate, define how to determine the appropriate sample size. Refer to TEOpS 16-5-1.3 for additional guidance on the techniques for acquiring data.

7. **Data Preparation and Management Strategies**

   Establish procedures for conducting data quality assurance and control. Define protocols for archiving and storing the data files, noting that WisDOT will maintain ownership of all data collected for WisDOT projects. Refer to TEOpS 16-5-1.5 for additional information on data preparation.

8. **Schedule and Budget**

   Prepare a schedule and an itemized budget for the data assembly/collection efforts.

Submit the data plan to the WisDOT regional traffic engineer for review and approval prior to gathering any data. Involve WisDOT TFS and BTO-TASU in the review of the data plan as appropriate. Save the data plan with the project files.

1.3 Techniques for Acquiring Data

There are several resources available on data acquisition techniques, three of which include:

- *Manual of Transportation Engineering Studies, 2nd Edition* (1)
- *Highway Capacity Manual, 6th Edition* (HCM6) (2)
- *Traffic Monitoring Guide* (3)

As noted in the above documents, it is possible to acquire transportation data through office reviews, existing databases, and field data. Oftentimes, it is necessary to utilize a combination of all three approaches. See below for additional details on each of these data acquisition techniques.

1.3.1 Office Reviews

Office reviews include any means of gathering data from existing sources to determine physical system characteristics and asset locations. Example office reviews include inspecting aerial maps, as-built plans, and Photolog. Office reviews are appropriate for high-level data acquisition to become familiar with a project location, land use, and existing infrastructure. The age of existing sources can vary and may not reflect current conditions. Verify office reviews with field reviews as appropriate, especially when using the data for detailed study or design projects.

1.3.2 Existing Databases

WisDOT has access to or maintains existing databases of traffic count, speed, and other transportation data. Examples include: MetaManager, WisTransPortal, and WisDOT TCMap (Traffic Count Map), among others. Existing databases often contain data aggregated at a statewide level for facilities managed by WisDOT. Data for local municipalities or counties may or may not be available. Coordinate with WisDOT regional traffic staff to identify existing database sources.

Evaluate the spatial and temporal resolution of existing databases against project needs. Validate existing databases with field reviews as appropriate, especially for older or unmaintained databases.

1.3.3 Field Data

Field data collection refers to any manual or automatic method of obtaining data directly from the field. This may include taking video or pictures, jotting down field notes, or using portable microwave/radar or other equipment. Field data collection may require specialized equipment that entails mounting hardware to poles or locating equipment on private property. Contact WisDOT regional staff to approve data collection techniques with these requirements. It is advisable to contact property owners and local law enforcement to inform them of the data collection activities. Contact the WisDOT Traffic Data Unit (traffic.counts@dot.wi.gov) for specifications and guidance relating to the statewide count program traffic count data. Guidance for conducting turning movement counts is available on the BTO Traffic Analysis, Modeling and Data Management Program area webpage.

Complete office reviews and consult existing databases first before collecting field data. The age of existing data and effort to reconcile old and new data, however, can create challenges. For example, balancing old and new traffic volumes (see TEOpS 16-5-15 for additional details on volume balancing), or utilizing speed and count data from different days, can increase the traffic model calibration effort.

Prior to collecting new counts, coordinate with WisDOT regional traffic staff to verify there are no other sources of data available. Additional resources for identifying data sources include WisDOT BSHP and WisDOT TFS. Document and justify the need for any new traffic counts and save as part of the project files.

1.4 Selecting Appropriate Data for Analysis

Data needs (type, amount, etc.) vary by the facility type and study purpose. As the complexity and detail of the analyses increase, so does the need for more meticulous data. Table 1.1 shows potential data requirements for use in traffic modeling of typical weekday AM and PM peak period scenarios. Table 1.1 also identifies if the data type is a required capacity analysis input, or if the data, although not necessarily required, may have value for calibration or general deficiency analyses.

Analyses beyond the scope of Table 1.1 may require additional data. Such analyses include, but are not limited to:

- Analysis of special peak periods (e.g., weekends or special events)
- Travel time reliability analysis (See *HCM6* (2)*,* Chapters 11 and 17 for freeways and arterials, respectively)
- Project-specific needs
- Other specialized analyses (e.g., safety, transit, parking, noise, freight, etc.)

Table 1.1 Selecting Data for Traffic Analysis

Facility Type	Data Type	Notes and Potential Data Needs/Sources	Required for Capacity Analysis	Useful for Calibration or Deficiency Analysis	Additional Resources
Signalized Intersection	Intersection Geometry and Configuration	• Number of lanes on each approach, lane markings, and turn lane lengths • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		
	Turning Movement Counts	• 15-minute interval counts, for all turning movements, vehicle classes, and pedestrians/bikes • Weekday AM and PM peak period counts (typically 3 hours each) • Other peaks and times as necessary • Ensure counts reflect traffic demand and not discharge in oversaturation conditions. Supplement turning movement counts with additional counts upstream of queuing.	X		ITE (1)
	Saturation Flow	• Obtain if existing conditions operate at or over capacity • Use TEOpS 16-15-5.2.2.3 as estimates when field data is unavailable		X	TEOpS 16-15 ITE (1) HCM (2)
	Right-Turn on Red (RTOR)	• If applicable, observe RTOR operation in the field • Use TEOpS 16-15-5.2.1.3 as estimates when field data is unavailable		X	TEOpS 16-15
	Signal Timing	• Contact WisDOT regional staff for signal plans and timing	X		WisDOT regional staff

Facility Type	Data Type	Notes and Potential Data Needs/Sources	Required for Capacity Analysis	Useful for Calibration or Deficiency Analysis	Additional Resources
	Queue Length	• Record queue lengths on all approaches. Queue length is extremely sensitive to prevailing conditions and traffic volumes. Record queues and volumes simultaneously when possible.		X	ITE (1)
	Delay	• Perform travel time runs through the intersection during peak periods to determine actual versus free-flow travel time		X	ITE (1)
Unsignalized Intersection	Intersection Geometry and Configuration	• Number of lanes on each approach, lane markings, turn lane lengths, and control sign types (stop, yield) and locations • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		
	Turning Movement Counts	• 15-minute interval counts, for all turning movements, vehicle classes, and pedestrians/bikes • Weekday AM and PM peak period counts (typically 3 hours each) • 12 to 14 hour counts if analyzing traffic signal warrants • Ensure counts reflect traffic demand and not discharge in oversaturation conditions. May need to supplement turning movement counts with additional counts upstream of queuing.	X		ITE (1)
	Crash History	• Required if analyzing traffic signal warrants		X	WisTransPortal WisDOT regional staff
	Queue Length	• Record queue length for stop or yield controlled movements. Queue length is extremely sensitive to prevailing conditions and traffic volumes. Record queues and volumes simultaneously when possible.		X	ITE (1)
	Gap Acceptance	• Use Wisconsin calibrated gap parameters for roundabout analysis (FDM 11-26-20.4). • Can require intensive labor effort; only conduct gap studies if traffic modelling and engineering judgement fail to produce reasonable results		X	FDM 11-26-20.4 ITE (1)
	Sight Distance	• Verify sight distance in the field if considering geometric improvements		X	ITE (1)
Freeway	Highway Geometry and Configuration	• Speed limit, number of lanes, auxiliary lane lengths, and merge/diverge/weave locations • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		
	Statewide Count Program Data	• Use Automatic Traffic Recorder (ATR) counts where possible to obtain current and historical trends. • WisDOT short-term counts • Ensure counts are of sufficient duration to capture all congestion • 15-minute interval counts are preferable	X		WisDOT regional staff WisDOT Traffic Data Unit

Facility Type	Data Type	Notes and Potential Data Needs/Sources	Required for Capacity Analysis	Useful for Calibration or Deficiency Analysis	Additional Resources
	Ramp Counts	• WisDOT short-term counts • Volume, Speed and Occupancy (V-SPOC) data • Obtain new counts when WisDOT short-term counts are unavailable or no longer reflect existing conditions • 15-minute interval counts are preferable	X		WisDOT regional staff V-SPOC WisTransPortal
	Ramp Terminal Intersection Data	• Assemble signalized and unsignalized intersection data shown above at all interchanges • Data at the ramp terminals within the same interchange *should* reflect the same date/time	X		ITE (1)
	Capacity	• If existing conditions are over capacity, use 15-minute volume and speed data to estimate capacity		X	HCM (2)
	Spot Speeds	• V-SPOC, microwave, or radar data collection useful for determining free-flow and congested speeds		X	ITE (1) V-SPOC
	Travel Time	• FHWA NPMRDS or other 3rd party data providers • Use travel time runs to verify 3rd party data • Use GPS tracking to continuously record time/speed		X	ITE (1)
	Origin-Destination	• Bluetooth or other OD study method • 3rd party data provider • WisDOT Travel Demand Model (TDM)		X	TEOpS 16-5-20 Transportation Planning Manual (TPM)
Rural Corridor	Highway Geometry and Configuration	• Speed limit, number of lanes • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		
	Count Data	• Counts, covering a minimum of a 24-hour period, along the corridor wherever major changes in traffic occur (before and after major intersections, corridor termini). • 15-minute interval counts are preferable	X		ITE (1)
	Intersection Data	• Assemble signalized and unsignalized intersection data shown above at all intersections. • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		ITE (1)
	Driveway Locations	• Required for calculating access point density for two-lane highway HCM analysis • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		WisDOT regional staff
	Passing Lanes and No Passing Zones	• Required for two-lane highway HCM analysis • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		WisDOT regional staff
	Spot Speeds	• Requires microwave or radar data collection. Useful for speed limit analysis.		X	ITE (1)

Facility Type	Data Type	Notes and Potential Data Needs/Sources	Required for Capacity Analysis	Useful for Calibration or Deficiency Analysis	Additional Resources
	Travel Time	• Travel time runs for end-to-end through the corridor • Use GPS tracking to continuously record time/speed		X	ITE (1)
Urban Corridor	Highway Geometry and Configuration	• Speed limit, number of lanes • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		
	Intersection Data	• Assemble signalized and unsignalized intersection data shown above at all intersections. • Aerial maps/photography • Photolog/Google Streetview • Confirm with field reviews as appropriate	X		ITE (1)
	Count Data	• Supplement intersection counts with directional counts covering a minimum of a 24-hour period to determine daily traffic volumes.	X		ITE (1)
	Transit Routes, Stops, & Parking	• Note bus routes, bus stop frequency, and parking maneuvers for use in intersection traffic analysis	X		WisDOT regional staff
	Spot Speeds	• Requires microwave or radar data collection. Useful for speed limit analysis.		X	ITE (1)
	Travel Time	• Travel time runs for end-to-end through the corridor • Use GPS tracking to continuously record time/speed		X	ITE (1)
	Origin Destination	• Useful for complex corridors where traffic patterns affect operations such as closely spaced intersections			TEOpS 16-5-20
Additional Resources (1) Manual of Transportation Engineering Studies, 2nd Edition (2) Highway Capacity Manual, 6th Edition					

1.5 Data Preparation

After assembling data from existing or field sources, additional data preparation steps typically include data storage, cleaning, reduction, and presentation. The following sections discuss each of these steps in more detail.

1.5.1 Data Storage

Store data with file and folder names consistent with conventions established for the project. If integrating the project data into existing databases, check with WisDOT regional staff and BTO-TASU to ensure the project data is in a compatible format. Regardless of file and folder convention, ensure there is a traceable record of the data to facilitate ease of use and file transfers. Include a “readme” file, map, emails, or other documentation to accompany the data.

Before processing the data, save a backup of the original unmodified/raw data in case of computer failure. Unmodified data is also useful to keep because it allows comparisons between raw and processed data when investigating data quality issues discovered during later analyses.

1.5.2 Cleaning the Data

Inspect the data for missing values, outliers, duplicate records, misplaced locations, or counter-intuitive trends. Document and justify the need to collect additional data to address issues.

Use descriptive statistics (average, mean, standard deviation, etc.), graphs, and maps to help visualize and spot issues with the data. Avoid filling in, or imputing, missing data unless necessary for the specific analysis. When it is necessary to impute missing data, the documentation should note where and why it was necessary. The documentation should also provide a summary of the techniques used to fill in the data gaps.

1.5.3 Data Reduction

Data reduction, or analysis, aims to answer questions that vary in complexity and vary from project to project. Analysis involves translating raw data into meaningful information using summaries, graphs, maps, and tables. Regardless of the data type or complexity, the analysis should be reproduceable and understandable by others to facilitate decision making and to allow for error checking.

Most data reduction processes start by converting the raw data into a format suitable for analysis. Keep the converted data separate from the raw/unmodified data to prevent data loss. Data conversion could include combining multiple files into one file, reshaping the organization of tables, or projecting spatial data to a common coordinate system. Data conversion may also be part of the cleaning process (TEOpS 16-5-1.5.2). It may be necessary to filter the dataset to extract specific records or time periods of interest for further exploration and more detailed analysis.

Documenting the data reduction should scale with the complexity of the analysis. For example, collecting and analyzing intersection turning movement counts for import into a traffic model may be a linear process of documenting the field data, inputs, and outputs of the analysis in a traffic report. More complex data analyses may be iterative and require additional documentation of methodology and assumptions. The analyst may need to try multiple statistical tests (hypothesis testing, ANOVA, etc.), or create diverse types of tables and graphs before formulating conclusions. Creating documentation throughout complex analyses can help the analyst keep track of and support resulting conclusions in addition to keeping the project organized.

1.5.4 Presentation of Data

Mass amounts of data can be overwhelming. Thus, it is important to present the data in such a way as to accurately communicate what the data means in an easy to understand format. Take into consideration the target audience; public documents may require simplified explanations of the technical details. Data visualization techniques like tables, graphs, maps, infographics, pictures, and videos can enhance communication by providing a clear and concise message without overwhelming the audience. Highlight key information to focus the audience's attention on conclusions. Check with WisDOT regional staff for preferences and examples of data presentation methods, especially regarding public involvement.

16-5-15 Volume Balancing September 2019

15.1 Introduction

Traffic volume balancing is the act of reconciling discrepancies in traffic volumes between adjacent locations. Discrepancies or imbalances are often the result of having to utilize counts from various times, days, or years. Longer time differences between adjacent counts typically results in larger imbalances. Although utilizing counts from the same period may minimize these differences, limited data collection resources may preclude this as an option. Differences in data collection methods may also lead to an imbalance of traffic volumes. Depending on the calibration of the device and skill of the manual counter, manual traffic counts may be more error-prone than automatic data collection devices.

The purpose of balancing is to create a logical set of volumes that is representative of the current or forecasted year traffic demand. Balancing the traffic volumes is necessary when evaluating a “closed-system” corridor with no driveways or other access points between intersections/ramps. In a closed-system corridor, the amount of traffic leaving one location must equal the amount of traffic arriving at the next downstream junction. A balanced volume data set is typically more critical for intersection-focused analyses versus analyses that focus on the mainline, although project specific needs *may* necessitate volume balancing along a freeway-only corridor. Additionally, since microsimulation models track individual vehicle movements, most microsimulation software require a balanced volume data set. For those microsimulation models that do not require a balanced volume data set to function (e.g., SimTraffic), use of unbalanced volumes will result in vehicles randomly appearing/disappearing from the roadway network, potentially skewing the results of the analysis.

There is no single unique solution when balancing volumes. Balancing using traffic counts taken on one day would yield a different answer than counts taken on a different day. Likewise, one analyst's results from the volume balancing process will not necessarily match the results from another analyst. This policy addresses how to reconcile imbalanced traffic volumes to foster consistency in traffic analysis conducted within Wisconsin. The Bureau of Traffic Operations, Traffic Analysis and Safety Unit (BTO-TASU) has developed Excel spreadsheet tools to help perform volume balancing in a consistent manner. The volume balancing Excel tools, one-page user guides, and step-by-step job aids are available on the BTO Traffic Analysis, Modeling and Data Management Program area webpage. TEOpS 16-5-15.4.3 provides additional details on the BTO-TASU volume balancing tools.

Although an analyst *may* choose to develop their own templates for balancing volumes, BTO encourages the use of the BTO-TASU volume balancing tools. Obtain approval from the WisDOT regional traffic engineer on the volume balancing methodology prior to developing or utilizing a tool other than that provided by BTO-TASU.

15.2 Benefits of Volume Balancing

When implemented judiciously, volume balancing helps "clean" the traffic data. The balancing process can moderate the effects of the daily, monthly, and seasonal factors, lessen the impact of counting errors (such as counts affected by equipment problems), and temper the influence of outliers (such as counts collected on non-representative days). To a limited degree, volume balancing may also allow the analyst to fill in gaps of data with a preliminary count estimate (e.g., using last year's data as an approximation of the volume at a site where a detector has recently failed).

Volume balancing may also be beneficial for the development of origin-destination (O-D) matrices, the mechanism for providing traffic volume demand data for most microsimulation software. By avoiding oscillation between conflicting numerical targets that slows or prevents convergence, volume balancing reduces the matrix estimation effort. Refer to TEOpS 16-5-20 for additional details on the O-D matrix development process.

Volume balancing ensures that traffic demands reflect what the analyst intends to simulate (e.g., microsimulation). Balancing also helps the simulation to meet the microsimulation traffic volume validation requirements of TEOpS 16-20-8.3.1 and TEOpS 16-20-8.4.1.

15.3 When to Conduct Volume Balancing

Unless mitigating circumstances dictate otherwise, the analyst **shall** perform volume balancing for:

- Closed-system corridor analyses (i.e., there are no mid-block driveways or other access points for traffic to enter or exit the network) along arterials and freeways where a balanced volume data set is critical for the operational analyses (e.g., HCM freeway facility analyses) and
- Apart from SimTraffic analyses as defined below, all microsimulation analyses.

The analyst could choose to, but does not have to, perform volume balancing for:

- Analyses of an urban corridor with driveways, or
- SimTraffic analyses to evaluate signal timings and progression.

Scenarios that typically do not warrant volume balancing include:

- Analysis of a single isolated intersection or interchange, provided that the adjacent interchanges, intersections, or driveways will not impact traffic operations.
- HCM/deterministic or planning-level analysis of a long freeway corridor with isolated interchanges (e.g., K30 analysis on I-39/90).

Depending on the purpose and need of the project; the analyst *may* not include all driveways or intersections along the study corridor within the traffic model. In these instances, the analyst *should* confirm that the excluded driveway/intersection can appropriately account for any imbalance in the traffic volumes. If not, the analyst *should* consider including a "dummy" access to act as a sink/source to capture the representative imbalance and then balance the remaining volumes along the corridor.

Coordinate with the WisDOT Traffic Forecasting Section (TFS) (DOTTrafficForecasting@dot.wi.gov) to confirm whether to conduct volume balancing before or after completion of the traffic forecasts. If requesting WisDOT TFS to balance the traffic volumes, note this on the DT1601 – Project Level Traffic Forecast Request form.

If unsure about the need for volume balancing on a specific project, check with the WisDOT regional traffic engineer. If desired, the WisDOT regional traffic engineer *may* request additional support or guidance from BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

15.4 Volume Balancing Process

The typical volume balancing process includes the following primary steps:

1. **Assemble** traffic volume data (traffic counts and forecasts). See TEOpS 16-5-15.4.1.
2. **Select** the volume data to use as a starting point for balancing (referred to as the “raw” or initial volumes). See TEOpS 16-5-15.4.2.
3. **Balance** volumes by adjusting the raw/initial volumes up or down as needed to account for imbalances and driveways. Where and how the analyst makes these adjustments typically depends on the type of facility included in the traffic model (freeway-only, intersection-only, or mixed freeway-arterial corridors). See TEOpS 16-5-15.4.3.
4. **Review** the balanced volumes for reasonableness; adjust balanced volumes as necessary. See TEOpS 16-5-15.4.4.
5. **Document** the data sources and volume balancing methodology. See TEOpS 16-5-15.4.5.

The following sections detail each step of the volume balancing process. The BTO-TASU volume balancing tools provide a mechanism to help organize, document, and perform volume balancing. Refer to TEOpS 16-5-15.4.3 for additional details on the BTO-TASU volume balancing tools.

15.4.1 Assemble Traffic Volumes

Obtain existing or base year (if other than current year) and forecasted traffic count data for each intersection, ramp, mainline, and major driveway within the analysis limits. If available, the analyst *should* also gather historical count information which may be helpful in assessing data quality and identifying outliers.

There are several data sources for traffic volumes with varying levels of availability and 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: WisDOT, Wisconsin Traffic Operations and Safety (TOPS) Lab (WisTransPortal), and local municipalities. 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 selecting a particular data source. Contact WisDOT regional traffic staff to determine whether there are other data sources available for the project study area. Additional resources for identifying data sources include WisDOT Bureau of State Highway Programs (BSHP) and WisDOT TFS.

If the required data, such as turning movement counts, is not available from existing sources, project specific data-collection efforts *may* be necessary. Document and justify the need for new/additional field data collection. Follow the Transportation Planning Manual (TPM) and other available WisDOT guidelines for data collection as applicable.

Review, verify, and document the validity of the count data prior to balancing the volumes. Coordinate with WisDOT regional traffic staff as appropriate.

15.4.1.1 Forecasted Traffic Volumes

Refer to the TPM for guidance on when and how to obtain forecasts from WisDOT TFS. If there is a need to convert daily traffic forecasts into hourly volumes through use of K-factors or other means, document the conversion process and obtain approval of the hourly volumes from TFS and WisDOT regional traffic staff. If desired, the WisDOT regional traffic engineer *may* request additional support or guidance from BTO-TASU. Refer to the Traffic Forecasting webpage and Section 40.3 of the TPM for more information regarding the use of design-hourly volumes and K-factors.

15.4.1.2 Data Quality

Traffic count quality may vary by location, data collection device, and data collection method. The analyst must apply judgement based on historical data, adjacent counts, and location-specific knowledge to assess traffic count quality. Permanent automatic traffic recorder (ATR) stations typically produce high quality traffic counts and often have extensive historical data that can help in assessing data quality if located within the analysis limits.

The analyst **shall** document the rationale for any suspected errors and any manual error corrections in the BTO-TASU or other equivalent volume balancing worksheet. Report any suspected errors in counts, especially those from WisDOT data sources, back to the appropriate WisDOT contact.

If there are potential errors in the data, depending on the project-specific needs, obtaining new counts may be more effective compared to adjusting questionable counts before or during balancing. Prior to collecting new counts, coordinate with WisDOT regional traffic staff to verify there are no other sources of data available. Additional resources for identifying data sources include WisDOT BSHP and WisDOT TFS. Follow the TPM and other available WisDOT guidelines for data collection as applicable.

15.4.1.3 Volume Balancing Between Multiple Projects

Occasionally, the study limits of one project will intersect or overlap with the limits of another project. Theoretically, the same location in multiple projects *should* have the same volume for the same analysis period. However, differing study limits, facility types, and study-specific priorities (e.g., if one project prioritizes the freeway facility while the other project prioritizes the arterial corridor) may result in variations in volumes at the same location. The project study teams *should* seek to minimize differing volumes for the same location and analysis period. Document and identify reasons for and potential consequences of any volume differences. Obtain approval from WisDOT regional traffic staff prior to utilizing the resulting traffic volumes in any analysis.

Throughout the volume balancing process, the overlapping project teams *should* coordinate and share volume and forecast information with each other and the WisDOT regional traffic staff. This will ensure consistency and avoid duplicating efforts. Involve BTO-TASU and WisDOT TFS in these coordination efforts as appropriate.

15.4.2 Select Raw/Initial Volumes

To start the volume balancing process, the analyst must select a single traffic volume for each study location. If multiple existing or historical counts are available for the same location, choose the count that is representative of the scenario under investigation. Selected counts may or may not be the most recent count depending on data quality factors as described in TEOpS 16-5-15.4.1.2. Document, in the BTO-TASU or other equivalent volume balancing worksheet, the data source and count date and identify whether the raw/initial volume accounts for seasonal, daily, and axle factor adjustments (typically incorporated into mainline counts but not raw turning movement counts). If balancing forecasted volumes, use the forecasted hourly volumes as described in TEOpS 16-5-15.4.1.1 as a starting point for the balancing process. Record the details of any additional adjustments made to the raw/initial or forecasted volumes before starting the balancing process. Note any other unique information regarding the traffic volumes within the BTO-TASU or other equivalent volume balancing worksheet and save as part of the project files.

15.4.3 Balance Volumes

Traffic volume balancing can be a highly iterative, time consuming, and judgement-oriented process because there are an infinite number of solutions to achieve balanced volumes. The BTO-TASU volume balancing tools provide a mechanism to help organize, document, and perform volume balancing. There is one tool for balancing along freeway-only corridors and one tool available for balancing intersection volumes along an arterial corridor. These tools provide a template for manual balancing and provide automatic balancing methods to help the iterative process. The analyst **shall** review and, if necessary, adjust the results from the automated balancing methods to ensure the balanced volumes are logical.

Projects *may* need to develop their own templates for balancing volumes beyond the tools provided by BTO-TASU. Any volume balancing templates **shall** provide an organized means for reviewing:

- Raw/initial input volumes (existing, base-year or forecast volumes)
- Comparisons between raw/initial and balanced volumes
- Methodology for balancing volumes
- Notes regarding count errors, manual adjustments, and large discrepancies between raw/initial and balanced volumes.

Obtain approval from the WisDOT regional traffic engineer on the volume balancing methodology prior to developing or utilizing a tool other than that provided by BTO-TASU. Consult with WisDOT TFS as appropriate. If unsure about whether the tools available for volume balancing will work for a particular project, the WisDOT regional traffic engineer *may* contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance.

15.4.3.1 Volume Balancing Calculation Methods

Volume balancing *should* seek to minimize the difference between raw/initial and balanced volumes. Proportioning (pro-rata) methodologies and goal-seeking optimization routines are common calculation methodologies to obtain balanced volumes[1,2,3]. To account for any data quality concerns and to capture location-specific knowledge, the volume balancing process will also typically involve manual adjustments. The BTO-TASU volume balancing tools provide templates to help implement these methodologies.

The goals of the project and the type of facility in the traffic model (freeway-only, intersection-only, or mixed freeway-arterial corridors) *may* require the prioritization of critical locations over others during the volume balancing process. Prioritized locations *should* have minimal difference between the raw/initial and balanced volumes and *may* result in larger differences at lower priority locations. The following sections (TEOpS 16-5-15.4.3.2.2 – 4.3.2.5) discuss balancing priorities for different facility types.

15.4.3.2 Balancing Freeway-Only Corridors

Freeway analysis typically focuses on the freeway mainline, merge, diverge, and weaving traffic operations. Volume balancing for freeway-only corridors *should* prioritize mainline and ramp locations before any ramp-terminal intersection or arterials in the study limits.

Analysts will often use ATR locations on the freeway mainline as “anchor” points, meaning they consider the raw/initial volumes as fixed values. To eliminate any imbalance along the corridor, the analyst will adjust the ramp volumes between the anchor points and will hold the volumes at the anchors constant. The analyst *should* ensure that any location used as an anchor has high-quality volume data representative of the scenario under investigation. Even if anchor points are high quality, the analyst *may* consider allowing some flexibility (e.g., allow ± 20 vehicles/hour/lane difference between the raw/initial and balanced volumes) at the anchor location if it helps minimize differences between raw/initial and balanced volumes at other critical locations. Confirm the allowable flexibility at anchor points with WisDOT regional traffic staff. Involve WisDOT TFS as appropriate. If desired, the WisDOT regional traffic engineer *may* request additional support or guidance from BTO-TASU.

If the analyst suspects that the differences between the raw/initial and balanced volumes at ramp-terminal intersections may trigger operational issues affecting the mainline freeway, they *should*:

- If possible, manually adjust the balanced volumes at the ramp-terminal to reduce the differences between the raw/initial and balanced volume; or
- Conduct separate sensitivity analysis with higher demand intersection volumes to investigate operational concerns.

Coordinate the need for manual adjustments or sensitivity analysis with WisDOT regional traffic staff. Involve WisDOT TFS as appropriate. If desired, the WisDOT regional traffic engineer *may* request additional support or guidance from BTO-TASU. Document any manual adjustments or sensitivity analysis within the BTO-TASU or other equivalent volume balancing worksheet and save as part of the project files.

15.4.3.3 Balancing Intersection-Only Corridors

Intersection-focused analyses *should* prioritize high-volume capacity-critical intersections and allow more flexibility at lower-volume locations with reserve capacity. The purpose of the analysis may provide additional priorities for balancing. For example, a study focused on signal timing and coordination *may* allow more flexibility in changing mainline volumes that have fixed phase lengths to avoid overestimating side road timing needs.

The volume balancing process will typically resolve any imbalances between intersections by proportioning adjustments amongst all contributing turning movements, and not necessarily take into consideration any prioritization of which locations or turning movements are most important. Thus, if utilizing the BTO-TASU volume balancing tools or other automated balancing tool, the analyst *may* need to manually refine outputs to reflect any project-specific prioritization. Note any project-specific prioritization needs or other unique considerations within the BTO-TASU or other equivalent volume balancing worksheet and save as part of the project files.

The analyst *should* also consider driveways when balancing intersection corridors. Refer to TEOpS 16-5-15.4.3.2.5 for additional details on volume balancing at driveways.

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[1] Federal Highway Administration, *Traffic Monitoring Guide*. 2016 (3)

[2] Shaw, J. Automated Optimal Balancing of Traffic Volume Data for Large Access-Controlled Highway Networks and Freeway-to-Freeway Interchanges. Proceedings from the TRB 2014 Annual Meeting. (5)

[3] Ren, J. & Rahman, A, Automatically Balancing Intersection Volumes in a Highway Network. 12th TRB Transportation Planning Applications Conference. 2009. (6)

15.4.3.4 Balancing Mixed Freeway-Arterial Corridors

Traffic models that contain both freeway and arterial intersections are the most complex case for volume balancing, and require simultaneous consideration of freeway-only and intersection-only priorities (see TEOpS 16-5-15.4.3.2 and TEOpS 16-5-15.4.3.3, respectively). The analyst *should* prioritize capacity-critical freeway, mainline, and intersection locations first and allow more flexibility at lower-volume locations with reserve capacity. The analyst can accomplish this by utilizing the weighting factors to influence the automated balancing in the BTO-TASU freeway volume balancing tool or by manually adjusting outputs. Note any project-specific prioritization needs or other unique considerations within the BTO-TASU or other equivalent volume balancing worksheet and save as part of the project files.

Balancing the freeway and arterials simultaneously *may* or *may not* be feasible from a calculation standpoint. If not, balancing *may* require iterating between balancing the freeway and arterial separately and using the results of one iteration to inform the next.

15.4.3.5 Volume Balancing at Driveways

Driveways are any mid-block locations where traffic can enter or exit the network and are typically access points to businesses or intersections excluded from the traffic model. The analyst **shall** review any volume imbalance between intersections to ensure that the driveways could realistically capture the magnitude of the imbalance. Land use, development type, and directionality of the imbalance *may* help determine if the imbalance is reasonable.

- If a driveway imbalance appears unreasonably high, volume balancing *should* minimize the imbalance to a reasonable percentage. For example, the analyst *may* adjust the imbalance to be within 10% of the adjacent intersection volumes.
- If a driveway imbalance appears unreasonably low, the analyst *should* use caution when adjusting the imbalance, as it *may* be possible for the incoming and outgoing traffic at the driveway to yield no net change in volume. The analyst *should* also consider the directionality of the traffic (i.e., origin and destination) when assessing reasonableness.

Microsimulation *may* require special treatment of driveways depending on if the simulation is closed-system (such as Vissim) or open-system (such as SimTraffic).

Vissim uses a closed-system of roadway links where traffic can only enter or exit at the network edges, which assumes balanced input volumes. The analyst must account for driveways in the network by the following methods:

- Explicitly model all high-volume driveways which affect operations of adjacent junctures as separate intersections.
- Combine multiple low-volume driveways into one or more “dummy” intersections.
- Omit driveways with negligible effects on traffic operations from the traffic volume and eliminate all volume imbalances. This method is acceptable only if the balanced volumes and traffic operations at intersections near the omitted driveways are representative of field or benchmark conditions.

SimTraffic uses an open-system network where simulated vehicles instantly appear or disappear mid-block when there are imbalanced input volumes. Depending on the project-specific needs, this *may* or *may not* be acceptable. With an open-system network, it *may* be necessary to include major driveways as explicit intersections to replicate field or benchmark conditions.

The analyst *should* direct any questions regarding how to accommodate driveways to the WisDOT regional traffic engineer. If desired, the WisDOT regional traffic engineer *may* contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance. Note any project-specific needs or other unique considerations within the BTO-TASU or other equivalent volume balancing worksheet and save as part of the project files.

15.4.4 Review

To ensure that the results are logical and representative of the analysis scenario, it is critical to carefully review the results of the volume balancing process, especially if using automated balancing tools. Diagnostic checks to help the review *should* include:

- Comparison between raw/initial and balanced counts using the WisDOT root normalized squared error (RNSE)[4] metric (See TEOpS 16-20-8.4.1).
    - RNSE less than 3.0 are typically acceptable,
    - RNSE 3.0 to 4.9 *may* be acceptable,
    - RNSE 5.0 or greater require further investigation. Avoid RNSE values equal to or greater than 5.0, unless lowering the difference negatively affects higher priority locations. Document and explain the reason for high RNSE values.
- Review of any remaining imbalances in the balanced volumes to ensure they appropriately reflect driveways.

Diagnostic checks of balanced volumes sometimes reveal errors in the raw/initial traffic count data. If this occurs, the balancing process *may* restart using corrected raw/initial values as inputs or remain as-is if the balanced volumes are reasonable. In either case, document the error in the raw/initial count.

Final review of balanced volumes typically occurs during the modeling peer review process described in TEOpS 16-25 and Section 10 of the TPM. WisDOT regional traffic staff will typically lead the volume balancing review process, with assistance from WisDOT TFS, WisDOT BTO-TASU and an independent consultant as deemed appropriate. Refer to the Volume Balancing Checklist available on the BTO Traffic Analysis, Modeling and Data Management Program area webpage for criteria to consider while reviewing the balanced volumes. Document and save the results of the volume balancing review with the project files. Direct questions regarding review of volume balancing to BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

15.4.5 Document

Document the volume balancing methodology including a summary of the raw/initial and balanced traffic volumes, data sources, and count dates. Note any count errors and manual adjustments. Explain any large discrepancies between raw/initial and balanced volumes. Describe any sensitivity analysis and potential impacts to the operational analyses. Provide a summary of the volume balancing peer review. If utilizing the BTO-TASU volume balancing tools, it *may* be sufficient to provide this documentation within the Excel template. Use of alternate volume balancing methodologies or tools, or complex volume balancing scenarios *may* require a technical memorandum to properly document the process. Consult with the WisDOT regional traffic engineer to confirm the required level of documentation (i.e., confirm the need for a technical memorandum). Save the completed volume balancing tools and associated documentation with the project files.

Obtain approval from the WisDOT regional traffic engineer on the volume balancing methodology and documentation prior to proceeding with the traffic analysis. Involve WisDOT TFS and BTO-TASU in the review of the volume balancing documentation as appropriate, noting that volume balancing of forecasted traffic volumes for use in microsimulation models will require WisDOT TFS approval. Refer to TEOpS 16-25 and Section 10 of the TPM for additional details on when to involve WisDOT TFS and BTO-TASU in the review process.

16-5-20 Origin-Destination Matrix Development September 2019

20.1 Basic Principles

This policy focuses on the use of origin-destination (O-D) matrices in microsimulation models. Refer to the TPM for additional details on working with O-D matrices in travel demand models (TDMs).

An O-D matrix is a table that displays the number of trips (i.e., traffic demand) traveling from each origin (row) to each destination (column) in the study area. The O-D matrix provides a mechanism to illustrate the travel demand patterns across small and large transportation networks in a single table. An analyst will often use O-D matrices to load traffic demand data into a microsimulation model. Figure 20.1 provides an example of an O-D matrix.

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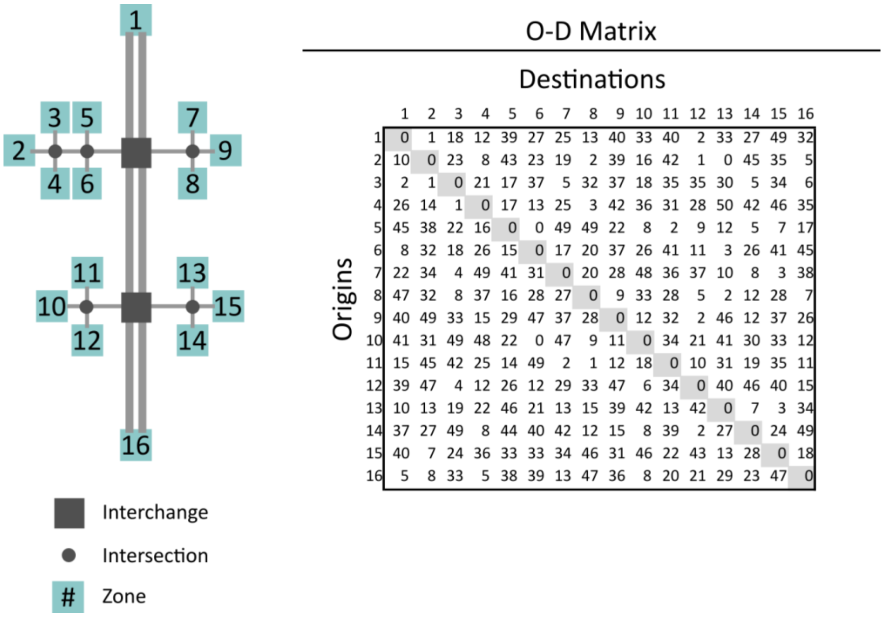
[4] $RNSE = \sqrt{\frac{(Vb-Vr)^2}{Vr}}$ Where Vb = Balanced Volume and Vr = Raw Volume

O-D matrices can be challenging to develop in terms of time and amount of data. The following provides information to help the analyst choose appropriate O-D estimation or data collection methods and data requirements when working with microsimulation models. Document the O-D development methodologies and assumptions, typically within the Traffic Forecasting Methodology Report, and submit to WisDOT regional traffic staff and WisDOT TFS for review and approval. WisDOT TFS will summarize their comments on the development of the O-D matrices within DT2340. Involve BTO-TASU in the review as appropriate (see TEOpS 16-25).

Figure 20.1 Example Zone Map and O-D Matrix



O-D Matrix

Destinations

Origins

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	1	18	12	39	27	25	13	40	33	40	2	33	27	49	32
2	10	0	23	8	43	23	19	2	39	16	42	1	0	45	35	5
3	2	1	0	21	17	37	5	32	37	18	35	35	30	5	34	6
4	26	14	1	0	17	13	25	3	42	36	31	28	50	42	46	35
5	45	38	22	16	0	0	49	49	22	8	2	9	12	5	7	17
6	8	32	18	26	15	0	17	20	37	26	41	11	3	26	41	45
7	22	34	4	49	41	31	0	20	28	48	36	37	10	8	3	38
8	47	32	8	37	16	28	27	0	9	33	28	5	2	12	28	7
9	40	49	33	15	29	47	37	28	0	12	32	2	46	12	37	26
10	41	31	49	48	22	0	47	9	11	0	34	21	41	30	33	12
11	15	45	42	25	14	49	2	1	12	18	0	10	31	19	35	11
12	39	47	4	12	26	12	29	33	47	6	34	0	40	46	40	15
13	10	13	19	22	46	21	13	15	39	42	13	42	0	7	3	34
14	37	27	49	8	44	40	42	12	15	8	39	2	27	0	24	49
15	40	7	24	36	33	33	34	46	31	46	22	43	13	28	0	18
16	5	8	33	5	38	39	13	47	36	8	20	21	29	23	47	0

20.2 Defining Zones

One of the first steps in building an O-D based microsimulation model is to establish a set of zones which represent the locations where traffic enters and exits the model. Zones can be origins or destinations of traffic. The schematic in Figure 20.1 illustrates an example zone map where the numbers represent the zones at the edges of the network.

Figure 20.1 also shows an example O-D matrix which corresponds to the zone map in the schematic. The values in each cell of the matrix represent the number of one-way trips between each O-D pair for a given time period. If a model is comprised entirely of two-way links, each zone will function as both an origin and a destination. In the O-D matrix, zeros reflect intrazonal trips (the shaded diagonal line in Figure 20.1), impossible trip pairs, or just the absence of trips between the zones. Depending on the zone structure, it *may* be possible for a trip to start and end at the same zone, specifically for U-turns or alternative intersection designs[5]. For the traffic model to properly capture these trips, it *may* be necessary to modify the zone structure by splitting zones into separate origin and destination zones or by adding “dummy” zones.

Consistent zone numbering helps organize O-D matrices. For example, an analyst might start with Zone 1 at one end of the model and continue numbering to the other end as shown in Figure 20.1. If the modeling objectives include analyzing the impacts of future development, it *may* be appropriate to reserve one or more “dummy” zone numbers to facilitate adding the development traffic to the design year model.

Prior to developing the O-D matrices, the analyst *should* meet with WisDOT regional traffic staff to confirm the proposed zone structure. It *may* be advantageous to involve WisDOT TFS and BTO-TASU in these meetings, especially if they will be involved in the review of the traffic model (see TEOpS 16-25).

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[5] Alternative intersections reroute one or more turning movements (typically left-turns) away from the center of the primary intersection to a secondary junction and then back through the primary intersection. Examples of alternative intersections include, but are not limited to, restricted crossing U-Turn (RCUT), median U-Turn (MUT) and displaced left turn (DLT).

20.3 Sources of O-D Data

There are multiple techniques, within two main classifications (field measurement or synthesis), available for collecting or estimating O-D data. The basis of the O-D data for the simulation modeling (not including the TDM) typically comes from three main sources:

- TDM data
- Field measured O-D data
- O-D synthesis using traffic count data

Depending on the level of detail and confidence required to accomplish the goal of the simulation analysis, the analyst *may* utilize one or more sources to develop the O-D matrix. Refer to TEOpS 16-5-20.4 for additional details on what O-D sources *may* be appropriate for modeling.

20.3.1 TDM O-D Data

In Wisconsin, the Metropolitan Planning Organizations (MPOs) and most Regional Planning Commissions (RPCs) coordinate with WisDOT TFS to develop and maintain TDMs which aid in the development of long-range transportation plans. WisDOT TFS also maintains a statewide TDM. Contact WisDOT TFS to determine the latest version of TDMs for project data. Complete the DT1599 (Agreement for and Restrictions on use of WisDOT Travel Demand Models) form and submit to WisDOT TFS (DOTTrafficForecasting@dot.wi.gov) to request a copy of the TDM or subarea model extraction and the associated O-D trip tables. Refer to the TPM for additional details on the TDMs in Wisconsin.

If there is an existing TDM that covers the area of interest, the associated O-D information from a subarea model extraction can be a good starting point for the O-D matrix for the microsimulation models. However, since the microsimulation models typically have more detail than TDMs, in terms of the transportation network and zones, and often require more discrete analysis periods, the conversion from the TDM is not without effort. The additional effort *may* be attributable to the following:

- To utilize the TDM subarea O-D data in the more detailed simulation models, the analyst must first make sure that they align the origin and destination data between the two models. This *may* require the analyst to group the zones within the more detailed model to reflect the TDM zone structure.
- Although peak hour or peak period data *may* be available from the TDM, in some of the TDMs, the output is only representative of 24-hour traffic flows. Further, the TDM output *may* only represent traffic patterns from the nearest decennial census year. Thus, to develop accurate peak hour or peak period O-D matrices from regional TDM data, the analyst *may* need to apply factors to the O-D data to represent the desired conditions (e.g., AM and PM peak hours of the existing conditions).
- TDM O-D data typically reflect regional travel patterns and *may not* be able to accurately capture turning movements at the intersection level. If the project goals require detailed intersection level analysis, prior to utilizing the TDM O-D data, it *may* be necessary to gather field counts to validate and modify the volume targets. Before collecting new field counts, coordinate with WisDOT regional traffic staff to verify there are no other sources of the necessary data available. Additional resources for identifying data sources include WisDOT BSHP and WisDOT TFS. Follow the TPM and other available WisDOT guidelines for data collection as applicable.

20.3.2 Field Measured O-D Data

O-D data collection methods have historically been labor and time intensive, but modern technologies and data sources have reduced the effort involved. The benefits of having additional data from the field (e.g., better understanding of travel patterns in the study area, a more legally defensible and accurate model), often out-weigh the additional time and effort spent collecting the O-D information necessary for development of microsimulation models. With that said, before conducting any new O-D field surveys, coordinate with WisDOT regional staff and WisDOT TFS to verify there are no existing sources of relevant O-D data available. Refer to Section 60 of the TPM for additional information on O-D travel surveys as they pertain to TDMs.

Historical techniques for collecting O-D data have included: roadside interviews, mail-back (postcard) surveys, telephone surveys, and license plate matching. These techniques often have limited sample sizes and can be invasive or disruptive to traffic. License plate matching using video data collection can still be a useful technique, but requires extensive data collection equipment, data reduction, and has privacy concerns because it *may* be possible to trace the license plates to a database of vehicle owners.

Modern techniques for collecting O-D data include:

- **Wireless Data Readers:** Analyst can utilize Bluetooth devices to determine vehicle O-D patterns. Bluetooth is a short-range wireless communication protocol for connecting consumer electronics such as headsets, mobile phones, laptop computers, global positioning systems (GPS), and car communication systems. Every device equipped with Bluetooth has a number called the Media Access Control (MAC) address. Bluetooth devices exchange MAC addresses to initiate communication with each other. Unless the user has manually disabled "discovery mode", the Bluetooth device transmits its MAC address periodically to search for new connections. For traffic monitoring purposes, it is not necessary to establish communication with the Bluetooth device—it is sufficient to monitor the signals from passing vehicles, record the MAC addresses they transmit, and re-identify the devices when they cross another zone boundary. In principle, this is like the license plate matching technique, but it avoids some of the privacy concerns since there is no master database of MAC addresses. The number of discoverable vehicles by Bluetooth, sometimes referred to as the "penetration rate," can vary depending on location and time of day, so it is necessary to scale up (i.e., post-process) the raw Bluetooth O-D matrix to reflect actual traffic volumes. With Bluetooth surveys, it is important to note that most, if not all, commercial trucks have GPS devices in discovery mode, while it is unknown if passenger vehicles have GPS, potentially leading to an overrepresentation of heavy vehicles. Additionally, the Bluetooth penetration rate is relatively low (typically less than 10%). The sample size *should* consider the penetration rate and potential overrepresentation of heavy vehicles to ensure that the Bluetooth O-D data sufficiently captures the travel patterns of those utilizing the roadway system.
- **Aerial Observation:** Airplanes, helicopters, drones, or even hot air balloons can observe and photograph traffic to collect O-D data. The images can be post-processed, via manual methods or computer algorithms, to track vehicle paths through the study area to measure O-D data. License plates are typically not visible in the photos, avoiding privacy concerns.
- **Third Party Probe Data Providers:** Third party companies like Streetlight, Teralytics, and others use "probe" data from GPS and cell phones to develop O-D matrices. The companies process, anonymize, and report the data in project-specific O-D zones. Purchased O-D data *may* have higher penetration rates than Bluetooth O-D data because of the multiple sources of probe data collected by third parties. Like, Bluetooth O-D data, third party probe data *may* provide an overrepresentation of heavy vehicles. The analyst *should* consider this potential overrepresentation when determining the sample size.

Forward the results of any O-D data collection efforts to WisDOT TFS (DOTTrafficForecasting@dot.wi.gov) for their reference and potential use within the TDM.

20.3.3 O-D Synthesis Using Traffic Count Data

Although there is a link between traffic volumes and O-D traffic demand, measuring traffic volumes in the field is often easier than measuring O-D demand data. Potential reasons for this include, but are not limited to, the following:

- Observations and data collection at spot/isolated locations (e.g., turning movement volumes at a single intersection or traffic flows on a basic freeway segment) can provide traffic volume data. However, congestion upstream or downstream of the count site *may* be metering traffic such that the spot location volume *may not* reflect the "true" demand. To capture "true" demand, it *may* be necessary to collect additional field data at the upstream or downstream locations, which *may* or *may not* be within the project study area.
- Multiple combinations of travel patterns can yield the same traffic volume at a spot location. Thus, to measure O-D data in the field, it is often necessary to track a vehicle from the point it first enters the roadway network to the point it exits the network.

Document, typically within the Traffic Forecasting Methodology Report, and save the results of any O-D synthesis efforts with the project files.

20.3.3.1 Manual Estimation Techniques

It *may* be possible to utilize manual estimation techniques to develop an O-D matrix from traffic counts. Analysts will typically use manual techniques for small O-D matrices or when TDM data is not available but *may* also choose to utilize manual techniques when obtaining O-D field data is time or cost prohibitive or when they wish to refine a previously developed O-D matrix. Typical manual techniques include gravity model estimation, by-hand estimation (such as using turning movement percentages or local traffic knowledge), or software designed for O-D estimation.

The gravity model is an algorithm used in transportation planning to measure the amount of traffic between activity centers. The model assumes the number of trips between two zones is directly proportional to the number of trip attractions in the destination zone and inversely proportional to a function of travel time between the two zones. In other words, the number of trips destined for a particular zone is dependent on the zones relative attractiveness and the length or difficulty of making the trip. The amount and type of land use in each zone determines this relative attractiveness based on the amount of travel people are willing to make for different trip purposes. Drivers usually take the shortest, fastest route and, as congestion makes one route less desirable, drivers will use other routes.

Employing the gravity model to create an O-D table will rarely lead to row and column totals that sum correctly so it is necessary to factor the cells within a matrix using biproportional matrix balancing (also known as the Fratar or Furness procedure). The Furness procedure factors the rows and columns by multiplying a row or column by the ratio of the desired to actual values. Figure 20.2 illustrates an example of the Furness procedure. After several iterations, the matrix *may* converge as the ratio of desired to actual values approaches one. If it does not converge, the analyst *should* perform enough iterations to result in a tolerable error. Additionally, the analyst could average the last row and column iterations to help improve the O-D estimation.

Figure 20.2 Example Biproportional Matrix Balancing (Fratar or Furness Procedure)

1. Sample OD Matrix

(Could be the output from a gravity model estimation)

	1	2	3	4	Sum	Desired	Row Factor
1	0	19	81	40	140	140	1.0
2	45	0	68	12	125	125	1.0
3	92	46	0	82	220	220	1.0
4	64	71	15	0	150	150	1.0
Sum	201	136	164	134			
Desired	190	145	200	150			
Column Factor	0.95	1.07	1.22	1.12			

Column totals do not match desired values.

2. Multiply Step 1 matrix cells by column factors

	1	2	3	4	Sum	Desired	Row Factor
1	0	20	99	45	164	140	0.85
2	43	0	83	13	139	125	0.90
3	87	49	0	92	228	220	0.97
4	60	76	18	0	154	150	0.97
Sum	190	145	200	150			
Desired	190	145	200	150			
Column Factor	1.0	1.0	1.0	1.0			

Row totals do not match desired values.

3. Multiply Step 2 matrix by row factors

	1	2	3	4	Sum	Desired	Row Factor
1	0	17	84	38	140	140	1.00
2	38	0	75	12	125	125	1.00
3	84	47	0	89	220	220	1.00
4	59	73	18	0	150	150	1.00
Sum	181	138	177	139			
Desired	190	145	200	150			
Column Factor	1.05	1.05	1.13	1.08			

Column totals do not match desired values.

4. Multiply Step 3 matrix by column factors…

5. Multiply Step 4 matrix by row factors…

6. Iterate until row and column sums converge to desired values

20.3.3.2 O-D Estimation Software

Another way for an analyst to synthesize an O-D matrix from traffic counts is through utilization of specialized O-D estimation software. Often the estimation software is part of a larger software suite, such as Cube Analyst (part of the Cube TDM software) or VISUM (part of PTV's suite of tools). O-D estimation software often requires several iterations and fine-tuning of algorithm parameters to produce an O-D matrix. The analyst *should* read and understand the parameters used by each software method. As true for any estimation methodology, it is critical to carefully check the resulting O-D matrix for reasonableness.

20.4 O-D Data Requirements

Model size and complexity are the primary factors in determining the O-D data requirements. The number of zones in the network determines the model size. Model complexity is more subjective. Factors that tend to influence the complexity of the model include weaving areas, closely-spaced intersections, and other locations where O-D patterns affect traffic operations. The number of zones in the model also increases complexity by requiring exponentially more data. For example, a model with 5 zones has 5x5=25 O-D pairs, while a model with 50 zones has 50x50=2500 O-D pairs. As the model increases in size and complexity, so does the need for more accurate sources of O-D data. Additionally, the larger and more complex the model, the more time and resources are necessary to develop the O-D matrix.

To allow for the discussion of O-D estimation data requirements, this policy divides model size and complexity into three categories:

- **Small** – Models with fewer than 20 zones
- **Medium** – Models with 20 to 50 zones
- **Large** – Models with more than 50 zones

Small models typically have less than 20 zones. O-D matrices for models of this size typically require limited or no field-measured O-D data. The analyst *should* gather traffic counts for the project area. Additionally, with some knowledge of local traffic patterns, the analyst often can develop the O-D by hand. If existing data sources cannot provide the information, at critical locations affected by O-D patterns, consider collecting field O-D data or performing sensitivity analysis.

Medium sized models have about 20 to 50 zones. Although the number of zone pairs increases substantially for models of this size, knowledge of regional trip patterns and basic trip distribution methods can result in acceptable O-D matrices without the need to use a special O-D estimation tool. Consider using the gravity model, or estimation software, to estimate the number of trips between known attractions. A TDM subarea extraction *may* also help in developing O-D matrices. It *may* be necessary to collect field data at critical locations affected by O-D patterns.

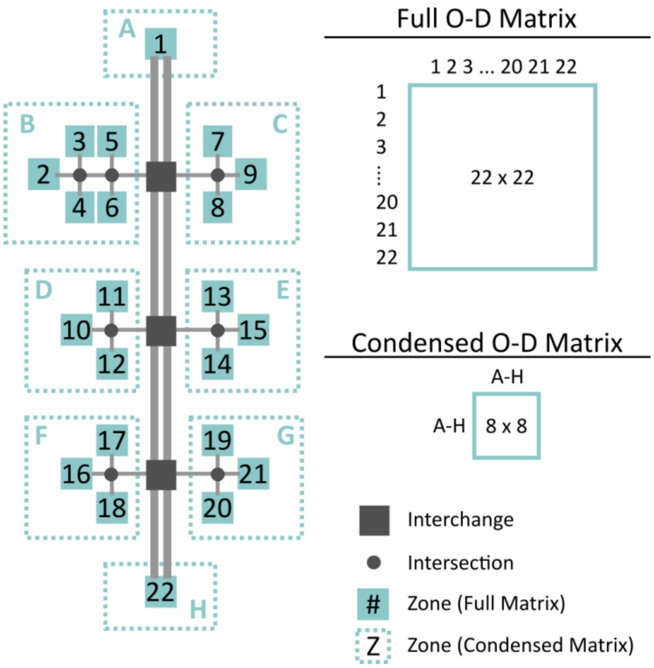
Large models tend to have more than 50 zones. Because of the number of O-D pairs, the analyst will need to employ multiple O-D estimation methods, and it will require considerable time and effort to deal with the amount of data. Use of a TDM subarea extraction will most likely be necessary for development of an O-D matrix. It *may* require the use of field data and hand-estimation to refine the matrix.

Regardless of the model size, before conducting any new O-D field surveys, coordinate with WisDOT regional staff and WisDOT TFS to verify there are no existing sources of relevant O-D data available.

Grouping zones to develop a condensed O-D matrix can be an effective technique for reducing data requirements, especially for large models or when working with TDM data. For example, a freeway focused model that includes arterial intersections could have its zones condensed to have one zone to represent each ramp terminal as shown in Figure 20.3. Figure 20.3 condenses the full 22x22 O-D matrix into an 8x8 O-D matrix. The condensed O-D matrix would require less detailed information, similar to what is available from most TDMs, and could reduce the level of effort for field data collection. Once the analyst has the condensed O-D matrix, they can expand it to the full zone structure using turning movement counts or local knowledge. Condensing and expanding O-D matrices allows broader patterns to be well-represented with less data requirements.

Prior to finalizing the details of the model and O-D matrices, the analyst *should* meet with WisDOT regional traffic staff to verify the O-D data requirements and needs. It *may* be advantageous to involve WisDOT TFS and BTO-TASU in these meetings, especially if they will be involved in the review of the traffic model (see TEOpS 16-25). Document any decisions pertaining to the O-D data requirements, typically within the Traffic Forecasting Methodology Report, and save with the project files.

Figure 20.3 Example Zone Grouping



20.5 Future Year O-D Estimation

Analysis of future year scenarios in microsimulation models require a future year O-D matrix. Typical techniques for developing future year O-D matrices include:

- Global scale factor
- Local scale factors
- Travel Demand Model

Of these methods, the TDM method is the most comprehensive method for integrating with traffic forecasts. Document the selected O-D estimation technique, typically within the Traffic Forecasting Methodology Report, and save with the project files.

The global scale factor method assumes all zones within the O-D matrix change by the same uniform amount. Typically, an analyst will limit the use of a global scale factor for future scenarios to sensitivity analysis testing, or for a simplified approximation to more rigorous forecasting. A global scale factor can be useful for interpolating or extrapolating a forecast to a different analysis year or helping to estimate how much spare capacity a facility *may* have.

The local scale factor method has the analyst apply changes to select O-D pairs to investigate the effects of a specific change in demand. For example, in a Traffic Impact Analysis (TIA), the analyst could change specific O-D pairs to reflect the expected development. An analyst can also use local scale factors to refine results from either the global scale factor or TDM methods for creating a future year O-D matrix.

Developing a future year microsimulation O-D matrix using TDM subarea extraction O-D matrices involves many steps as shown in Attachment 20.1 – O-D Process Flow Chart, and often requires many iterations to produce an acceptable future year O-D matrix for more detailed simulation analyses. The process starts with calculating the change in traffic between the TDM base and future year O-D matrices. As discussed in the *National Cooperative Highway Research Program (NCHRP) Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design* (4), there are two methods available for computing the change in traffic from the TDM:

- **Absolute change** – Takes the difference between the future year and base year TDM O-D matrices. For example: if one O-D pair has 100 trips in the base year and 200 trips in the future year, the change is +100 trips. The change in traffic would be negative if the future year trips were lower than base year trips.
- **Relative change** – Takes the ratio of the future year to base year TDM O-D matrices. Using the same example above, the relative change would be 200 trips future / 100 trips base = 2.0.

The process continues by applying the results from both methods to the base microsimulation O-D matrix. Consider an example where the same O-D pair in the example above has 80 trips in a microscopic simulation O-D matrix. The future year could have 180 trips (80 trips + 100 trips) using the absolute change method. The future year could also have 160 trips (80 trips * 2.0) using the relative change method. Since both the absolute change and relative change methods often yield reasonable results, the analyst will typically average the results of the two methods (170 trips) as a starting point.

In some cases, the absolute or relative change methods *may* yield extreme results, typically for TDM O-D pairs that have a very small number of trips. For example: consider an O-D pair that changes from 1 trip in the base year to 10 trips in the future year. This is a 10-times increase using the relative method, but only a 9-trip increase using the absolute method. Even after averaging, the future simulation O-D matrix *may* yield unreasonably high traffic volumes because of the large multiplicative increase from the relative change method. The analyst *may* consider using only the absolute method for this O-D pair instead.

20.6 Review

The analyst **shall** review the O-D matrices, specifically any future O-D matrices, for reasonableness. Performing validation tests on the microsimulation model (see TEOpS 16-20-8) and reviewing traffic growth or land use can help in determining reasonableness. This could include verifying that the change in traffic at the origin and destination zones reflect that shown in the traffic forecasts or TDM. Additionally, the relative change between the existing and future O-D matrices *should* mirror the trends from the traffic forecasts.

Another check *may* include looking for O-D pairs that show fewer trips in the future year than the base year. A no-build scenario (assuming the status quo for population, land use, and transportation trends), would typically assume zero O-D growth at a minimum (no negative growth) to demonstrate that demand in the future would at least be equal to what exists today. Future decreases in O-D *may* be appropriate if there is a definitive cause, typically in an alternative scenario analysis such as a route closure, new transportation mode, or alternative land use or population scenario. Reviewing minimum and maximum growth in the future O-D matrix within the context of the scenario assumptions can help in determining reasonableness.

The WisDOT regional staff and WisDOT TFS **shall** conduct a peer review of the O-D matrices developed for microsimulation models in accordance with the procedures outlined in TEOpS 16-25. The region will involve BTO-TASU in the peer review process as appropriate. The DT2291 and DT2340 forms provide a means to document the peer review. Save the DT2291, DT2340, and all other notes on the peer review of the O-D matrices with the project files.

20.7 Document

Document the O-D development methodologies and assumptions, typically within the Traffic Forecasting Methodology Report. Explain the rationale for the zone structure, including the numbering scheme and use of any “dummy” zones. Provide graphics and tables to illustrate the zone map schematic. Describe what the O-D data represents (e.g., day, month, year, analysis period, etc.) making sure to note the source(s) of the O-D data. Provide justification for the use of any new O-D data collection efforts.

Outline the techniques used to develop the O-D matrices (field-measured, synthesis, manual estimation, O-D estimation software, etc.) and describe any project-specific needs and other unique considerations taken into consideration.

Submit a copy of the Traffic Forecasting Methodology Report and any other documentation associated with the O-D development to WisDOT regional traffic staff and WisDOT TFS for review and approval. The region will involve BTO-TASU in the review as appropriate.

Save all the final O-D matrices and any associated documentation with the project files.

LIST OF ATTACHMENTS

Attachment 20.1	O-D Process Flow Chart

16-5-70 References September 2019

1. **Institute of Transportation Engineerings.** *Manual of Transportation Engineering Studies, 2nd Edition.* ITE, 2010. ISBN-13: 978-1-933452-53-1; ISBN-10: 1-933452-53-6.

2. **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.

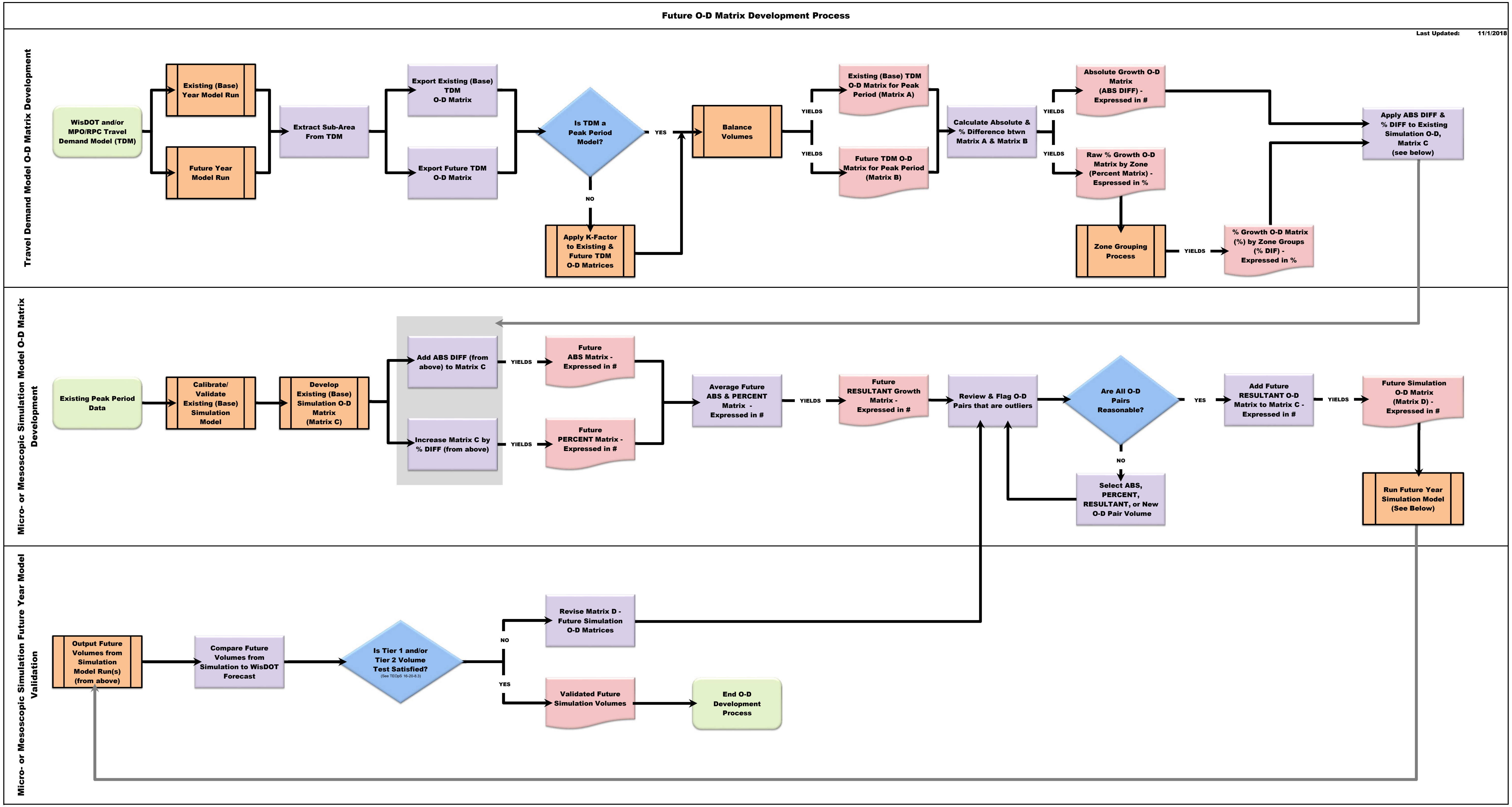
3. **Federal Highway Administration.** *Traffic Monitoring Guide.* Washington, D.C: U.S. Department of Transportation, 2016. FHWA-PL-17-003.

4. **Transportation Research Board.** *NCHRP Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design.* Washington, D.C. : National Cooperative Highway Research Program (NCHRP), 1982. ISBN 0-309-03450-7/ISSN 0077-5614.

5. **Shaw, J.** Automated Optimal Balancing of Traffic Volume Data for Large Access-Controlled Highway Networks and Freeway-to-Freeway Interchanges. *Proceedings from the TRB 2014 Annual Meeting.*

6. **Ren, J. & Rahman, A.** Automatically Balancing Intersection Volumes in a Highway Network. 12th TRB Transportation Planning Applications Conference, 2009.

Attachment 20.1 O-D Process Flow Chart



16-10-1 Overview of Available Traffic Analysis Tools December 2022

The Federal Highway Administration (FHWA) Office of Operations - Traffic Analysis Tools Program provides substantial background and guidance on the available types of tools and careful selection of the right tool for the task. FHWA's *Traffic Analysis Toolbox Volume II (TAT II)* (1) was prepared to assist traffic engineers and planners in selecting the most appropriate traffic analysis tool. For more information on the FHWA guidance, visit the Traffic Analysis Tools homepage and refer to the set of documents in the Traffic Analysis Toolbox series.

1.1 Categories of Traffic Analysis Tools

The primary categories of traffic analysis tools utilized at WisDOT include:

- HCM-based deterministic tools
- Signal optimization tools
- Work zone analysis tools
- Traffic simulation tools
- Dynamic traffic assignment (DTA) tools
- Travel-time reliability analysis tools

The following provides guidance on selecting the appropriate tool category before selecting from the WisDOT-supported software packages.

1.2 HCM-Based Deterministic Tools

The Highway Capacity Manual (HCM) provides several analytical or deterministic methodologies that can estimate roadway or intersection capacity, delay, density, and other performance measures for various elements of the street and highway system.

The HCM methodologies are based on the standard relationship between flow, speed, and density of the traffic stream. Since the HCM methodologies are deterministic, a fixed set of inputs will yield a single set of outputs. As such, tools that implement the HCM methodologies are typically simplistic and easy to utilize and *should* be the first choice for most traffic analyses.

Although the HCM procedures are good for analyzing the performance of isolated and non-congested facilities they do have limitations. For example, the HCM models do not have the ability to account for interactions between network elements (e.g., they cannot reflect a queue backup at a ramp terminal within 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 deciding if an HCM-based tool is appropriate for a specific analysis or study.

The *Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis (HCM6)* (2) is the most current version of the HCM. Unless the WisDOT regional engineer provides prior authorization, the traffic analysis shall follow the HCM6 methodologies. For project analysis initiated prior to November 2017, it may be acceptable to continue to follow the *HCM 2010* (3) methodologies. Coordinate with the regional traffic engineer or Bureau of Traffic Operations, Traffic Analysis and Safety Unit (BTO-TASU) to verify whether to continue using the HCM 2010 methodologies or whether to update to the HCM6 methodologies.

The WisDOT-supported tools that implement the HCM methodology for capacity analysis are:

- Highway Capacity Software (HCS), McTrans
- Synchro, Trafficware
- SIDRA, Akcelik and Associates (supported only for roundabout analyses)
- Vistro, PTV Group (requires prior approval from the WisDOT regional traffic engineer)

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports.

Although WisDOT does support the use of Vistro for the analysis of signalized and stop-controlled intersections, acceptance of Vistro is up to the discretion of the WisDOT regional office. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project and refer to TEOpS 16-15 for additional details on conducting HCM-based deterministic analyses.

1.3 Signal Optimization Tools

Signal optimization tools help identify the optimal signal cycle lengths, phase times, splits, and offsets for signal systems ranging from isolated signals to coordinated signal systems. Typically, the process begins with the analyst setting up a network representing the geometric layout and traffic demand in the intersection or corridor of interest. The software then tries thousands of different combinations of cycle length, split, and offset to determine the “optimal” signal timing.

In this context, the word “optimal” has a strict mathematical definition called the objective function, which typically tries to minimize the total delay per vehicle. The analyst can impose policy- or experience-based constraints on the signal phasing, such as the minimum green time provided to minor movements, to influence the optimization.

Use professional judgment to fine-tune the results from signal optimization efforts when deciding on new or updated traffic signal timing and phasing; this is particularly important when a corridor includes unsignalized intersections or major driveways that affect operations.

The WisDOT-supported tools that perform signal optimization are:

- Synchro, Trafficware
- Vistro, PTV Group (requires prior approval from WisDOT regional traffic engineer)

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports.

Although WisDOT does support the use of Vistro for signal optimization, acceptance of Vistro is up to the discretion of the WisDOT regional office. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

WisDOT previously supported HCS for signal optimization, however, recent studies found that the optimization features in HCS tended to underestimate the phase and cycle length requirements, especially for coordinated signal systems. As such, the analyst *should not* utilize HCS when optimizing signal timing plans for field implementation. Analysts may continue to utilize the optimization features of HCS for the evaluation, assessment, and comparison of the capacity/operation of alternative scenarios.

1.4 Work Zone Analysis Tools

Specialty tools are available for analyzing traffic in highway construction zones. These analysis tools typically provide a way to compare travel times with and without construction and compute the resulting work zone queue length, delay, and road user cost. Other frequently occurring issues that the analyst may need to assess for construction on rural and urban highways and freeways include, but are not limited to, the following:

- Selecting appropriate hours for lane closures
- Assessing the use of two-way, one-lane operation
- Identifying construction staging needs
- Quantifying the amount of traffic that could divert to alternate routes
- Evaluating potential mitigation measures (e.g. providing a temporary bridge to maintain traffic during construction), including cost-benefit analyses

The work zone traffic analysis tool (WZTAT) should be used for all freeway and expressway construction projects to determine queuing, delay and road user costs based on the capacity. Refer to FDM 11-50-30 and coordinate with the WisDOT regional work zone engineer or BTO Work Zone Engineers for assistance in determining work-zone related delay, queue, and road-user costs for freeways and highways as appropriate.

1.5 Traffic Simulation Tools

There are three primary categories of traffic simulation tools: macroscopic, mesoscopic, and microscopic simulation. Simulation tools usually provide visual animation of the traffic flow; however, it is possible to have a simulation tool without the visual component. The following describes each of these simulation tools in more detail.

1.5.1 Macroscopic Traffic Simulation

Macroscopic traffic simulation tools assess the operation/capacity of a facility or network utilizing the deterministic relationships of flow, speed, and density of the traffic stream. The simulation analyzes the movement of vehicles on a section-by-section basis. Travel demand models (TDMs) are an example of a macroscopic tool. The policy within this chapter does not cover macroscopic simulation tools or TDMs. Refer to the Transportation Planning Manual (TPM) for additional details regarding TDMs.

1.5.2 Mesoscopic Traffic Simulation

Mesoscopic traffic simulation tools analyze the movement of individual vehicles or vehicle cells as they travel through a simulated network using predefined capacity and speed-density relationships. Mesoscopic models incorporate a level of network and operational detail comparable to microsimulation models with the route choice flexibility of macroscopic simulation models (TDMs). Most mesoscopic simulation models incorporate dynamic traffic assignment (DTA), thus, this policy utilizes the term DTA model throughout to represent mesoscopic simulation models. Refer to TEOpS 16-10-1.6 for additional discussion on DTA tools.

1.5.3 Microscopic Traffic Simulation

Microscopic traffic simulation or microsimulation, refers to tools that analyze the movement of individual vehicles as they travel through a network. As the simulation progresses, it updates factors such as each vehicle’s position and its need to increase/decrease speed or change lanes several times a second. As a result, these tools are suitable for evaluating the interaction of different components of the transportation network, such as queues from an intersection that cause lane blockage 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.

Microscopic modeling work typically requires significantly more time, data, and effort than other tools. In addition, improperly calibrated microsimulation models can provide misleading outputs, such as showing congestion where none exists, or free-flowing traffic where there is congestion. When using the model outputs to make critical decisions, the project manager should insist on crosschecking with simpler tools to assure that microsimulation outputs are reasonable. WisDOT supports the use of microscopic simulation models, but prior to utilizing microsimulation, the WisDOT project team should first assess whether an HCM-based deterministic tool could sufficiently accommodate the traffic analysis needs of the project.

The WisDOT-supported programs that perform microscopic simulation are:

- Vissim, PTV Group
- SimTraffic, Trafficware

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports.

SimTraffic is only applicable for arterial analysis and is best suited for signalized corridors. WisDOT does not currently support the use of SimTraffic for roundabout analysis; however, contingent on approval from the WisDOT regional traffic staff, it may be acceptable to use SimTraffic to gauge how a roundabout might interact with an adjacent traffic signal. The analyst will often 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 for critical design decisions, the analyst shall calibrate and validate the SimTraffic model (TEOpS 16-20).

Prior to January 1, 2018, WisDOT supported the use of Paramics. As such, 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 there is a need to make major revisions to the traffic models (e.g., use of different base year conditions), the analyst should consider switching the traffic models over to Vissim. Consult with the WisDOT regional traffic contact or BTO-TASU to determine whether it is appropriate to switch software programs.

See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project and refer to TEOpS 16-20 for additional details on conducting microsimulation analyses.

1.6 Dynamic Traffic Assignment (DTA)

DTA is a modeling approach that captures the relationship between dynamic route choice behaviors (path and start time) and transportation network characteristics (travel speeds, signal timings, level of congestion, etc.) It is possible to incorporate DTA into any level of simulation models (macroscopic, mesoscopic, microscopic); however, the most common application of DTA is for mesoscopic simulation models. Therefore; this policy assumes all DTA models are mesoscopic models.

DTA tools are useful for analyzing roadway networks with parallel routes, especially when there is a need to evaluate potential diversion traffic. Other scenarios where a DTA model may be beneficial include those that involve shifts in the temporal distribution of traffic (i.e., peak spreading or contraction).

WisDOT does not currently support any DTA tools. However, BTO-TASU is willing to consider the use of DTA if the project needs support/justify its use. Coordinate with WisDOT regional traffic staff and BTO-TASU and obtain prior approval before utilizing DTA.

1.7 Travel-Time Reliability Analysis Tools

Travel-time reliability analysis tools allow the analyst to assess how travel times along a corridor fluctuate over time in response to various traffic, roadway, and weather conditions. The analysis considers both recurring and nonrecurring delays where nonrecurring delays are associated with crashes, work zone activities, and event activities, among other unexpected or atypical conditions.

Travel-time reliability analysis is data intensive in that it requires details on weather conditions, work zone activity, incident/crash data, and variation in traffic demands for a period of several days or more (ideally, the reliability analysis would cover one-year worth of data). As such, prior to conducting travel-time reliability analysis, the WisDOT project team *should* assess whether reliability is critical to meeting the goals and needs of the project. Review of the National Performance Management Research Data Set (NPMRDS) can provide insight into the variability of travel times along the corridor. If the roadway network is congested but has reliable travel times (i.e., the travel time along the corridor is always the same), there would be little benefit to performing reliability analysis. However, if the travel time along the corridor is highly unreliable (i.e., there is considerable variation in travel time along the corridor from one day to the next), then it may be necessary to evaluate travel-time reliability performance measures. Coordinate with WisDOT regional traffic staff to determine whether to conduct travel-time reliability analysis for a specific project.

The WisDOT-supported tool that performs reliability analysis is:

- HCS, McTrans

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports.

16-10-5 Traffic Analysis Tool Selection September 2019

There is no “one size fits all” traffic analysis tool. The tools used for each analysis vary in their data requirements, capabilities, methodology, and output. Tools that are more powerful require greater time and effort, so it is important to match the analysis methods with the scale, complexity, and technical requirements of the project. HCM-based deterministic tools *should* typically be the first choice for most traffic analyses. However, when the analysis requirements do not fit within the confines of the HCM-methodology or when there is a need to provide supplemental information, it may be necessary to utilize an alternative analysis tool such as microsimulation. Oftentimes, it is necessary to use a combination of multiple traffic analysis tools to meet the project goals and needs (e.g., the analyst may utilize Vissim as the primary analysis tool but may utilize HCS or Synchro at spot locations or to provide another reference point to aid in calibration of the Vissim model).

Attachment 5.1 provides a flowchart to help navigate and select the most appropriate WisDOT-supported traffic analysis tool(s) based on the type of traffic flow (uninterrupted or interrupted). If the project consists of both uninterrupted and interrupted flow facilities, follow the path for each type of flow independently. Utilize the tool that will best address both flow regimes and will result in the most efficient use of resources. This may require the use of the most comprehensive tool (Vissim) or it may require the use of multiple traffic analysis tools.

If the project does not justify the use of microsimulation analyses, but there is a need or desire for visualization or simulation of the traffic operations, the analyst may utilize the SimTraffic component of Synchro or the built-in Vissim module of Vistro. The resulting visualization can allow the analyst to observe driver behavior to conduct “reality checks” of the Synchro and Vistro outputs. Note that SimTraffic and the built-in Vissim module of Vistro are uncalibrated microsimulation models, so use caution when presenting the results.

Use the flowchart in Attachment 5.1 as a guide only. The final determination of the most appropriate traffic analysis tool depends on the specific details, needs, and goals of the project. Professional judgment and coordination with WisDOT regional traffic staff need to factor into the selection of the most cost effective and efficient traffic analysis tool. If unsure of which traffic analysis tool to utilize, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

Document the rationale for choosing the selected traffic analysis tool(s) in the Traffic Analysis Tool Selection memoranda and submit to the WisDOT regional traffic staff for approval.

LIST OF ATTACHMENTS

Attachment 5.1	Traffic Analysis Tool Selection

16-10-20 References September 2019

1. **Federal Highway Administration.** *Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools*. 2004. FHWA-HRT-04-039.

2. **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.

3. **Transportation Research Board.** *Highway Capacity Manual 2010*. Washington D.C. National Academy of Sciences, 2010. ISBN 978-0-309-16077-3.

Traffic Engineering, Operations & Safety Manual

Chapter 16 Traffic Analysis and Modeling

Section 15 Highway Capacity Manual (HCM) – Deterministic Analysis

16-15-1 Basic Principles August 2022

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. As of January 2022, the Highway Capacity Manual, 7th Edition: A Guide for Multimodal Mobility Analysis (HCM7) (1) is the most current version of the HCM. A list of the updates included with the release of HCM7 is noted in the “Forward” section of HCM7. The most significant changes include:

- A new two-lane highway methodology which incorporates new performance measures
- A new network analysis method for the evaluation of spillback between freeways and urban streets
- Addition of guidance on the application of HCM methods for determining impacts of connected and automated vehicles (CAVs)
- Enhancements to existing pedestrian analysis methods at signalized intersections and uncontrolled pedestrian crossings

Projects initiated prior to January 2022, can continue to utilize the HCM 6th Edition (HCM6) (2) methodologies for the duration of the project. Projects initiated between January 2022 and December 31, 2022, *may* follow either HCM7 or HCM6 methodologies. All projects initiated on or after January 1, 2023 **shall** follow the HCM7 methodologies unless otherwise authorized by WisDOT regional traffic staff.

The HCM 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 free user account)

Each chapter within Volume 2 and Volume 3 of the HCM 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. HCM, Volume 1, Chapter 7 provides additional guidance as to when an alternative (non-HCM based) analysis methodology *may* be appropriate.

The HCM procedures are good for analyzing the performance of isolated and non-congested facilities but do have limitations. For example, the HCM models *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. 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.

TEOpS 16-10 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 August 2022

5.1 Introduction

WisDOT accepts the use of the HCM, Chapter 19 methods for estimating the performance of a signalized intersection from the perspective of the motor vehicle, pedestrian, and bicycle modes. These procedures are applicable for three-leg and four-leg intersections that operate in isolation from nearby signals with a pre-timed, semi-actuated or fully-actuated controller. Signalized intersections that are not isolated, that operate in an actuated-coordinated manner, or are part of a system or corridor require the use of a combination of both the signalized intersection methods of Chapter 19 and the urban street segment procedures outlined in Chapter 18. For closely spaced signals, such as those found at freeway ramp terminals, the analyst *should* follow the methodology presented in Chapter 23 for interchange ramp terminals. If the project spans multiple contiguous urban street segments, consider applying the Chapter 16 urban street facilities methodologies.

The analyst *should* recognize and account for the methodological limitations of the signalized intersection methods. There are cases that *may not* fit within the analytical framework of the HCM, including but not limited to intersections with five or more approaches, those with more than two exclusive turn lanes on any approach or those with complex geometry or controller operations. When these, or similar limitations exists, the project manager *should* specify the use of an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported tools that implement the HCM methodology for signalized intersection analysis are:

- Highway Capacity Software (HCS), McTrans
- Synchro, Cubic|Trafficware
- Vistro, PTV Group (requires prior approval from WisDOT regional traffic engineer)

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

When conducting capacity analysis for signalized intersections, apply the basic signal parameters as outlined in the following section in conjunction with the HCM-based analysis methodologies.

5.2 Basic Parameters for Capacity Analysis

The Traffic Signal Design Manual, Section 3, Chapter 2-2 (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 (DOTTrafficAnalysisModeling@dot.wi.gov) 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 (TR) 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 or signage clearly dedicate the lane 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 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 conducted field studies throughout Wisconsin in 2009 (3), 2015 (4), and 2021 (5) to develop recommendations for estimating RTOR volumes (V_{RTOR}) in relation to total right-turn demand (V_{RT}) for both planning-level and design-level analyses.

WisDOT has not studied RTOR at any other intersection configuration than those shown in Equations 5.2 – 5.12, 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.

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

5.2.1.3.1 Planning-Level Assessment

For planning-level analyses, when signal timing or phasing is still in flux, analysts *should* use the following equations to calculate the RTOR volumes.

- Single Right-Turn Lanes at Intersections: $V_{RTOR} = 0.38V_{RT}$ [Equation 5.1]
- Single Right-Turn Lanes at Interchange Off Ramps: $V_{RTOR} = 0.74V_{RT}$ [Equation 5.2]
- Single Right-Turn Lanes at Interchange On Ramps: $V_{RTOR} = 0.25V_{RT}$ [Equation 5.3]
- Dual Right-Turn Lanes at Intersections: $V_{RTOR} = 0.30V_{RT}$ [Equation 5.4]
- Dual Right-Turn Lanes at Interchange Off Ramps: $V_{RTOR} = 0.53V_{RT}$ [Equation 5.5]
- Dual Right-Turn Lanes at Interchange On Ramps: $V_{RTOR} = 0.12V_{RT}$ [Equation 5.6]

Where:

V_{RTOR} = Right-turn on red volumes

V_{RT} = Total right-turn demand

5.2.1.3.2 Design-Level Assessment

For design-level analyses, specifically when refining the storage requirements for right turn lanes, it *may* be appropriate to consider signal timings when calculating the RTOR volumes. In such instances, the analyst *may* apply the following equations:

- Single Right-Turn Lanes at Intersections: $V_{RTOR} = 0.18V_{RT} \times e^{1.26 \times R_{\%}}$ [Equation 5.7]
- Single Right-Turn Lanes at Interchange Off Ramps: $V_{RTOR} = 0.24V_{RT} \times e^{1.35 \times R_{\%}}$ [Equation 5.8]
- Single Right-Turn Lanes at Interchange On Ramps: $V_{RTOR} = 0.07V_{RT} \times e^{2.90 \times R_{\%}}$ [Equation 5.9]
- Dual Right-Turn Lanes at Intersections: $V_{RTOR} = 0.04V_{RT} \times e^{3.34 \times R_{\%}}$ [Equation 5.10]
- Dual Right-Turn Lanes at Interchange Off Ramps: $V_{RTOR} = 0.08V_{RT} \times e^{2.59 \times R_{\%}}$ [Equation 5.11]
- Dual Right-Turn Lanes at Interchange On Ramps: $V_{RTOR} = 0.07V_{RT} \times e^{1.53 \times R_{\%}}$ [Equation 5.12]

Where:

V_{RTOR} = Right-turn on red volumes

V_{RT} = Total right-turn demand

$R_{\%} = (C - g_{RT})/C$ = Percentage of the cycle showing red for the right-turn movement (e.g., 0.25 for 25%)

C = Cycle Length

g_{RT} = Right-turn green time

5.2.1.4 RTOR Application

WisDOT supports the use of HCS for traffic signal analysis and supports the use of Vistro and Synchro for both traffic signal analysis and signal optimization (see TEOpS 16-10). Use and acceptance of Vistro for signal analysis and optimization, however, is up to the discretion of the WisDOT regional office. Due to limitations of the HCS optimization methodologies, WisDOT does not support the use of HCS for signal optimization.

Vistro 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 Vistro.

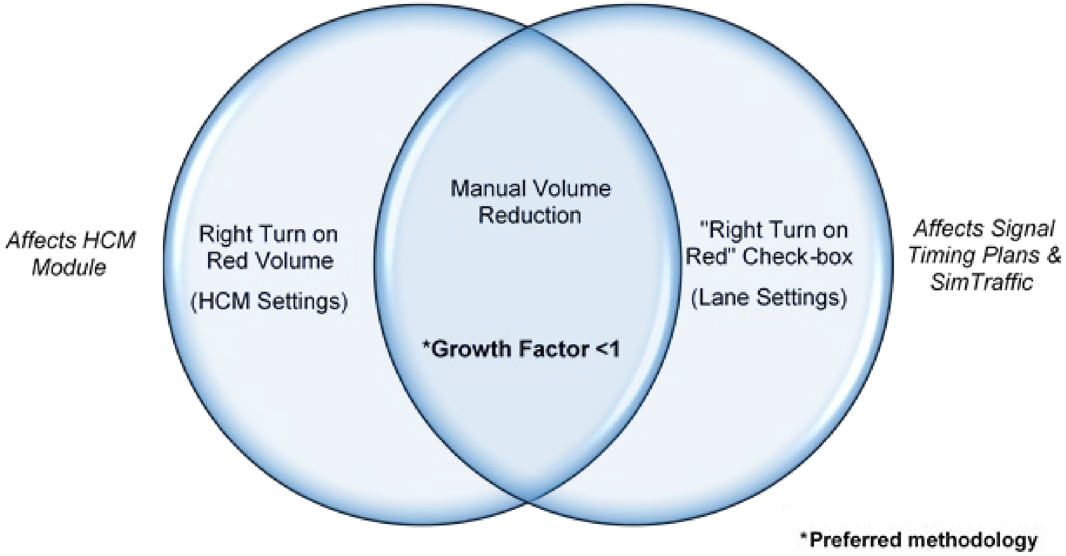
Figure 5.1 provides an overview of the various methodologies available for affecting RTOR in the two modules of Synchro. A subset of the methodologies, those which adjust demand, affect both Synchro modules. As noted in the figure, the “growth factor” method is the preferred methodology when the analyst 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. For planning-level analyses, apply the following growth factors, derived from Equations 5.1, 5.3, 5.4 and 5.6 unless field data is available and supports otherwise:

- 0.62 for Single Right-Turn Lanes at Intersections
- 0.75 for Single Right-Turn Lanes at Interchange On Ramps
- 0.70 for Dual Right-Turn Lanes at Intersections
- 0.88 for Dual Right-Turn Lanes at Interchange On Ramps

Note that the above rates do not include a growth rate for Single or Dual Right-Turn Lanes at Interchange Off Ramps. Applying Equations 5.2 and 5.5 would yield a growth factor of 0.26 and 0.47, respectively for these scenarios; however, Synchro currently sets a floor of 0.5 for growth rates preventing the use of the 0.26 or 0.47. When dealing with Single and Dual Right-Turn Lanes at Interchanges, or when calculating the RTOR volumes using Equations 5.7 – 5.12 for design-level analysis, 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 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 – 5.12).

- 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.
- Vistro: Check the “Right Turn on Red” boxes for the relevant approaches in the “Intersection Setup” tab. Enter the V_{RTOR}, rounded to the nearest whole vehicle per hour (veh/h), into the “Right-Turn on Red Volume (veh/h)” field in the “Volumes” tab.
- 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 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 two microsimulation software programs for traffic signal analysis: SimTraffic (associated with Synchro, affected by demand reductions but not by changes within the HCM module) and Vissim. 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 (DOTTrafficAnalysisModeling@dot.wi.gov).

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 HCM 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 HCM, Chapters 4 and Chapters 19.

This policy focuses on the saturation flow rate for left-turn lanes and through lanes.

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 conducted field studies in 2015 (4) and 2021 (5) to evaluate saturation flow rates at various signalized intersections across the state. 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 left-turn lanes (5) and through lanes (4).

The 2015 WisDOT sat. flow study (4) 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 the 2015 (4) study to develop a methodology to estimate the base saturation flow rate for exclusive through lanes and shared through-right lanes at signalized intersections in Wisconsin. The 2021 WisDOT sat. flow study (5) found that the observed left-turn movement saturation flow rate is approximately 95.26% of the estimated through movement saturation flow rate, which is consistent with the 95.24% that the

HCM suggests. Since the percentages are nearly identical, to calculate the left-turn saturation flow rate, WisDOT recommends first calculating the base saturation flow rate for through lanes using the WisDOT methodology described in section 5.2.2.3 below, and then applying the HCM default left-turn adjustment factor.

Since the methodology accounts for more variables and reflects Wisconsin-specific data, analysts *should* use the WisDOT sat. flow methodology as described below to estimate the base saturation flow rate for exclusive through lanes and shared through-right lanes at signalized intersections. 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 HCM default values.

Coordinate with WisDOT regional traffic staff to determine the most appropriate methodology for calculating the base saturation flow rate for exclusive left, exclusive through, and shared through-right lanes. At ramp terminals, since there is typically a negligible number of through vehicles on the exit ramp, treat the shared left-through lane as an exclusive left-turn lane. WisDOT did not study the shared left-through-right lane configuration, however, if the through movement is the dominant movement, the analyst *may*, with caution, treat this lane configuration the same as an exclusive through lane. Use the HCM default base saturation flow rates for all other lane groups (i.e., shared left-through, shared left-right, and exclusive right turn lanes) unless there is field data or other documentation supporting an alternative value or WisDOT instructs otherwise.

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 the HCM and calculates the base sat. flow rate for each lane group

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 (4)) and the following equation:

- $s_0 = 1980 \times f_{Pop} \times f_N \times f_{SL}$ [Equation 5.13]

Where:

$s_0 = Base\ saturation\ flow\ rate\ for\ exclusive\ left, exclusive\ through, and\ shared\ through-right\ lanes$

$f_{Pop} = Adjustment\ factor\ for\ population$

$f_N = Adjustment\ factor\ for\ number\ of\ approach\ lanes$

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

As with the WisDOT sat. flow spreadsheet, apply the adjustment factors by approach to determine the base sat. flow rate for each lane group. The lane adjustment factor (f_N) is dependent on the total number of lanes on the approach (i.e., includes all left, through, right, and shared lanes)[1] and the speed adjustment factor (f_{SL}) is based on the speed limit of the approach. Accordingly, the base saturation flow rate *may* differ from one approach to the next at a given signalized intersection (e.g., the base saturation flow rate for the eastbound through movement *may* be 1950 pc/h/ln while the base saturation flow rate for the northbound through lane *may* be 1825 pc/h/ln).

Due to rounding, use of the adjustment factors from Table 5.1 *may* result in a slightly different sat. flow rate than that calculated using 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 within an urbanized area that has 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, f_N = 0.97) and a posted speed limit of 40 MPH (f_{SL} = 1.00), the resulting base saturation flow rate would be:

$s_0 = 1980 \times 0.95 \times 0.97 \times 1.00$ $s_0 = 1825$ pc/h/ln

Use the resulting base saturation flow rate ($s_o = 1825$ pc/h/ln) for operational analysis of the left-turn lane and two through lanes on this approach. Use the HCM default values for the two right turn lanes unless there is field data or other documentation supporting an alternative value or WisDOT instructs otherwise. Calculate the base saturation flow rate for the left-turn and through lane groups on all other approaches in a similar manner.

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[1] Free-flow-right turn lanes do not count toward the number of lanes at an approach

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				
≥ 704,500	1.00				

Since the WisDOT sat. flow methodology calculates a Wisconsin, site-specific base saturation flow rate, the analyst *should* apply all other HCM adjustment factors (e.g., heavy vehicles, grade, lane width, Central Business District (CBD), left or right-turn vehicle presence, etc.) as appropriate to calculate the final adjusted sat. flow rate. These adjustments are typically applied within the individual software program (HCS, Synchro, Vistro).

It is important to note that the WisDOT sat. flow estimation methodology applies only to exclusive left, exclusive through, and shared through-right lanes. At ramp terminals, since there is typically a negligible number of through vehicles on the exit ramp, treat the shared left-through lane as an exclusive left-turn lane. WisDOT did not study the shared left-through-right lane configuration, however, if the through movement is the dominant movement, the analyst *may*, with caution, treat this lane configuration the same as an exclusive through lane.

5.2.2.4 Saturation Flow Rate Application

5.2.2.4.1 HCM-Compliant Analysis and Signal Timing Plan Development

As detailed in TEOpS 16-10, WisDOT currently supports three HCM-based software programs for traffic signal analysis, HCS, Vistro, and Synchro, although use of Vistro requires prior approval from the WisDOT regional traffic engineer. 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 movements. This field is in the “Traffic and Geometry” section within the HCS “Streets” module, which includes traffic signal analysis.
- Vistro: Check the “Override Base Saturation Flow Rate per Lane” box for the relevant lane groups in the “Saturation Flow” area of the “Traffic Control” tab. Enter the base saturation flow rate, rounded to the nearest 5 pc/h/ln, into the “User Defined Base Saturation Flow Rate per Lane (pc/h/ln)” field.
- Synchro: In the HCM module, used to generate fully HCM-compliant results, enter the base saturation flow rate, rounded to the nearest 5 pc/h/ln into the “Ideal Satd. Flow (vphpl)” field for the relevant movements. Alternately, edit this field through the “Lane Settings” module – changes made there carry through to the HCM module.

Note that the resulting base saturation flow rate calculated for a lane group containing a shared through-right lane would also be applied to the right turn movement unless there is an exclusive right turn lane on the approach.

Although the terminology within Synchro indicates that the base saturation flow rate is in vehicles per hour per lane (vphpl), further investigations found that this value is actually representative of passenger cars per hour per lane (pc/h/ln). Therefore, the analyst *should* enter the base saturation flow rate as calculated above in pc/h/ln without further adjustment.

As noted above (TEOpS 5.2.2.2), the field data used to develop the WisDOT sat. flow methodology purposely minimized the impact from heavy vehicles to lessen the impact of using pc/h/ln versus using veh/h/ln. Further, any of the adjustment factors beyond those included in the 2015 WisDOT sat. flow study (4) that are incorporated into the HCM base saturation flow rate calculations (heavy vehicles, grade, lane width, CBD, left or right-turn vehicle presence, etc.) will be applied on top of the WisDOT sat. flow rates within the software package used to calculate the final adjusted sat. flow rate in pc/h/ln.

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 the model meets the applicable validation thresholds and adequately replicates field behavior. Direct any questions regarding how to apply saturation flow rate within a specific microsimulation software program to BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

16-15-10 Two-Way Stop-Controlled (TWSC) Intersections August 2022

WisDOT accepts the use of the HCM, Chapter 20 methods for analyzing the performance of a two-way stop-controlled (TWSC) intersection from the perspective of the motor vehicle mode and the pedestrian modes. Currently, no specific methodology exists to assess the performance of bicycles at TWSC intersections. These methods are applicable to three-leg and four-leg intersections with stop-control only on the side street(s).

Analysts *should* recognize and account for the methodological limitations of Chapter 20 methods. Some of the limitations of the TWSC methodology include, but are not limited to, the following:

- Only applicable for TWSC intersections with up to three through lanes (either shared or exclusive) on each major-street approach and up to three lanes on each minor-street approach (max of one exclusive lane per movement)
- Limited to no more than four approaches
- Limited to one stop-controlled approach on each side of the major street

Additionally, apart from a TWSC intersection located between two signalized intersections, the HCM methodology typically does not account for the effects from other intersections. For TWSC intersections located on an urban street segment between two coordinated signalized intersections, to account for the interaction of the adjacent signalized intersections, the analyst *should* follow the methodologies presented in Chapter 18 for urban street segments. When these, or similar limitations exists, the project manager *should* specify the use of an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software programs for HCM-based TWSC intersection analysis are:

- *HCS, McTrans*
- *Synchro, Cubic|Trafficware*
- Vistro, PTV Group (requires prior approval from WisDOT regional traffic engineer)

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

16-15-15 All-Way Stop-Controlled (AWSC) Intersections August 2022

WisDOT accepts the use of the HCM, Chapter 21 methods for analyzing the performance of unsignalized intersections with stop control at all approaches (i.e., requires every vehicle to stop before entering the intersection). HCM, Chapter 21 methodologies focus on the motor vehicle mode but do offer some guidance for how to assess the performance of pedestrian and bicycles. The procedure is applicable for typical AWSC configurations of three-leg and four-leg intersections with no more than four approaches and no more than three lanes on any given approach.

Analysts *should* recognize and account for the methodological limitations of Chapter 21 methods. There are cases that *may* not fit within the analytical framework of the HCM, including but not limited to queue interactions from adjacent intersections, or the impact of pedestrians. When these, or similar limitations exists, the project manager *should* specify the use of an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software programs for HCM-based AWSC intersection analysis are:

- *HCS, McTrans*
- *Synchro, Cubic|Trafficware*
- Vistro, PTV Group (requires prior approval from WisDOT regional traffic engineer)

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

16-15-20 Roundabouts August 2022

20.1 Introduction

WisDOT accepts the use of the HCM, Chapter 22 methods for the analysis of isolated roundabouts with one-lane and two-lane entries, up to one yielding or non-yielding bypass lane per approach, and up to two circulating lanes. HCM, Chapter 22 methodologies focus on the motor vehicle mode but do offer some guidance for how to assess the performance of pedestrian and bicycles.

Analysts *should* recognize and account for the methodological limitations of Chapter 22 methods. For roundabouts that are not isolated, are part of a system or corridor of roundabouts, or are located within the influence area of an adjacent signal, the analyst *should* use a combination of the roundabout methods of Chapter 22 and the urban street segment procedures outlined in Chapter 18. For closely spaced roundabouts, specifically those found at freeway ramp terminals, the analyst *should* follow the methodology presented in Chapter 23 for interchange ramp terminals.

See TEOpS 16-15-20.4 for additional information on the use of supplemental tools for operational analyses and design.

20.2 Wisconsin-Calibrated Models

20.2.1 Driver Behavior

Critical headway (also referred to as ‘critical gap’) and follow-up headway are the driver behavior parameters that influence the capacity of a roundabout approach and intersection. Critical headway is the smallest gap in circulating traffic that an entering driver would accept to enter the roundabout. Follow-up headway is the time between two successive entering vehicles accepting the same gap in circulating traffic. Figure 20.1 diagrams the concept of critical headway and Figure 20.2 diagrams the concept of follow-up headway.

Figure 20.1 Critical Headway

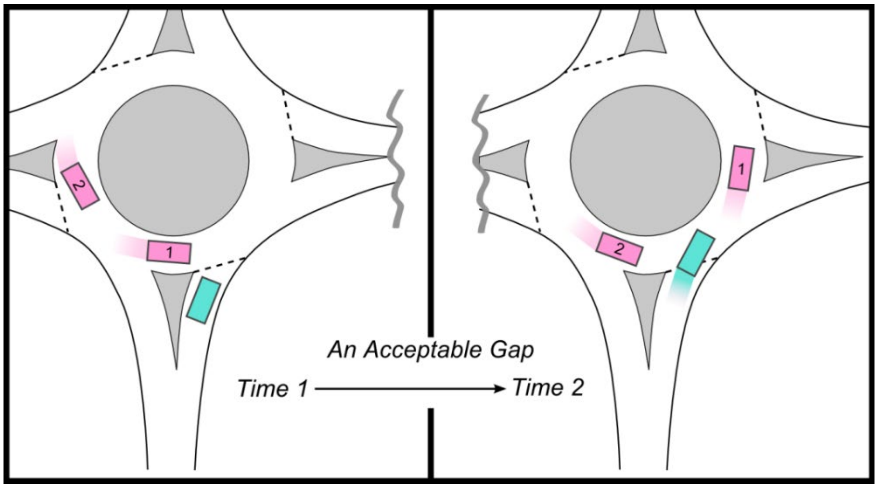
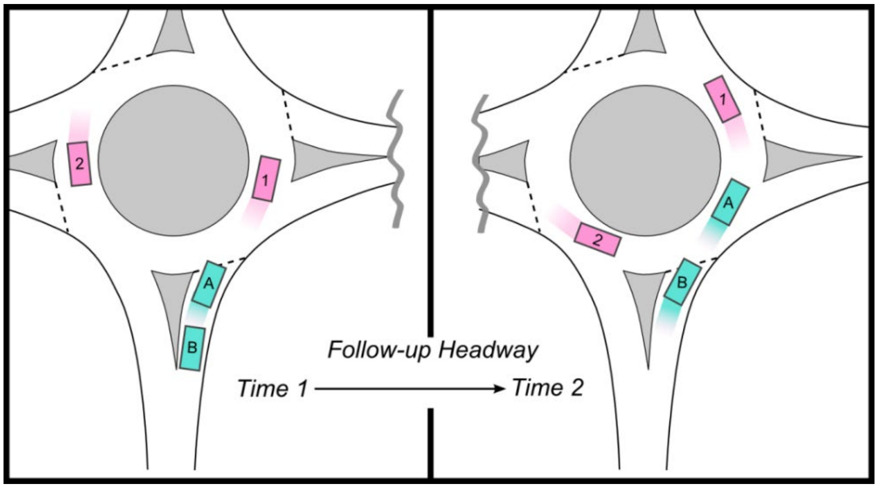


Figure 20.2 Follow-up Headway



As part of the National Cooperative Highway Research Program (NCHRP) Report 572 (6) and the 2015 Federal Highway Administration (FHWA)-sponsored report FHWA-SA-15-070 (7), researchers collected and analyzed critical and follow-up headways at several roundabouts across the US. The NCHRP Report 572 (6) and FHWA-SA-15-070 (7) report reflect 2003 and 2012 data collection efforts, respectively. Both these research efforts found that an exponential gap-acceptance theory combined with field determined headway values could provide an acceptable empirical capacity equation for estimating the operations of a U.S. roundabout (see HCM Chapter 22 and HCM Supplemental Chapter 33 for additional details). This method of analyzing roundabouts is the basis for Wisconsin's driver behavior-based approach to analyzing roundabout operations.

The general form of the capacity equation for a roundabout follows below in Equation 20.1 - Equation 20.3:

$$c_{pce} = Ae^{(-Bv_c)} \qquad \text{[Equation 20.1]}$$

$$A = \frac{3{,}600}{t_f} \qquad \text{[Equation 20.2]}$$

$$B = \frac{t_c - (t_f/2)}{3{,}600} \qquad \text{[Equation 20.3]}$$

where:

c_{pce} $= entry\ lane\ capacity, adjusted\ for\ heavy\ vehicles\ (pc/hr/ln)$

v_c $= lane\ capacity, adjusted\ for\ heavy\ vehicles\ (pc/hr)$

t_c $= critical\ headway\ (s), and$

t_f $= follow - up\ headway\ (s)$

Adjusting the critical and follow-up headways allow the capacity equation in Equation 20.1 to be calibrated to reflect local site conditions. The HCM provides default capacity equations based on observations of critical and follow-up headways made at US roundabouts in 2012 (7)

In an effort to calibrate the HCM capacity equations to reflect conditions in Wisconsin, in 2020, WisDOT completed a research project to observe headways at Wisconsin roundabouts (8). Table 20.1 lists the recommended headway values and the corresponding parameters A and B that were developed based on the findings of the study. The analyst **shall** use the values listed in Table 20.1 for roundabout capacity analyses statewide. Refer to Attachment 20.1 for an illustration of the roundabout lane configurations associated with the headway values in Table 20.1.

The values shown in Table 20.1 represent the headway numbers based on the 2020 Wisconsin research (8). Consult with the WisDOT regional traffic contact or contact BTO-TASU for information on or potential use of headway numbers based on older Wisconsin research.

Table 20.1 Recommended Headway Values[1]

	Critical Headway, t_c	Follow-up Headway, t_f	Parameter A	Parameter B
Single Circulating (Conflicting) Lane				
Single Lane Entry (1 - 1)	4.7	2.6	1385	0.000944
Two Lane Entry				
Left Lane (L2 - 1)	4.7	2.5	1440	0.000958
Right Lane (R2 - 1)	4.4	2.5	1440	0.000875
Three Lane Entry				
Left Lane (L3 - 1)	4.6	2.3	1565	0.000958
Center Lane (C3 - 1)	4.4	2.6	1385	0.000861
Right Lane (R3 - 1)	4.4	2.4	1500	0.000889
Yielding Slip/Bypass Lane (R-bypass - 1)	4.0	2.3	1565	0.000792
Multi-Circulating (Conflicting) Lanes[2]				
Single Lane Entry (1 - 2)	4.8	2.6	1385	0.000972
Two Lane Entry				
Left Lane (L2 - 2)	4.6	2.6	1385	0.000917
Right Lane (R2 - 2)	4.3	2.6	1385	0.000833
Three Lane Entry				
Left Lane (L3 - 2)	4.6	2.5	1440	0.000931
Center Lane (C3 - 2)	4.4	2.4	1500	0.000889
Right Lane (R3 - 2)	4.6	2.5	1440	0.000931
Yielding Slip/Bypass Lane (R-bypass - 2)[3]	4.8	2.8	1286	0.000944

[1] Refer to the TADI 2020 research study for details on how the recommended headway values were calculated (8).

[2] Values are based on observations of roundabouts with two circulating (conflicting) lanes but are assumed to be similar for roundabouts with three circulating (conflicting) lanes. For roundabouts with more than two circulating (conflicting) lanes, consider conducting field investigations to verify values.

[3] The TADI 2020 research study (8) did not evaluate bypass lanes for multi-circulating lane roundabouts with more than one entry lane.

20.2.2 HCM Analysis

The WisDOT-supported traffic engineering software programs for HCM-based roundabout analysis are:

- HCS, McTrans
- SIDRA (HCM mode only), Akcelik & Associates

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. Use of the WisDOT-supported software requires calibration with the recommended Wisconsin headway values listed in Table 20.1.

20.2.2.1 HCS

Consistent with the confines of the HCM methodology, HCS restricts analysis to no more than four approaches, a maximum of two entry lanes, and up to one yielding or nonyielding bypass lane per approach. . For other roundabout lane configurations, use of SIDRA or a supplemental tool (see TEOpS 16-15-20.4) is required.

20.2.2.2 SIDRA

SIDRA can analyze roundabouts with multiple models, including SIDRA Standard and HCM6 capacity models. As of April 2022, SIDRA does not yet incorporate HCM7 methodologies; however, the roundabout capacity models are the same for HCM6 and HCM7. When analyzing Wisconsin roundabouts, the analyst **shall** use the HCM6 capacity and delay models and **shall** treat the level of service the same as sign control. SIDRA (U.S. mode) expands upon the lane configuration limitations of the HCM methodology such that SIDRA (U.S. mode) is applicable for all roundabouts but is specifically required for the evaluation of roundabouts with three entry lanes, two right-turn bypass lanes, or five or more approaches. SIDRA applies the basic HCM procedures and provides essentially the same results as HCS. Verify the SIDRA results for three-lane entries and dual bypass lanes with one of the supplemental design-aid tools discussed in TEOpS 16-15-20.4.

Within SIDRA, there is the option to apply an HCM Roundabout Capacity Model extension to address unbalanced flow conditions. Additionally, SIDRA has an Extra Bunching parameter, that when checked, adjusts the proportion of platooned vehicles in the traffic stream according to the proximity of and level of queuing at an upstream signalized intersection. Prior to utilizing either the unbalanced flow model extension or the extra bunching parameter for operational analysis, the analyst *should* verify the appropriateness of their use with the WisDOT regional traffic engineer or BTO-TASU.

In addition to the HCM mode, SIDRA has its own roundabout capacity model (i.e., SIDRA Standard) which is based on Australian and international research. The analyst *may* use the SIDRA Standard model as a design-checking tool, but this mode is not acceptable for demonstrating that the roundabout provides sufficient capacity. See TEOpS 16-15-20.4 for additional information on the use of supplemental design-aid tools.

20.2.2.3 Selecting the Appropriate Analysis Tool

Use Table 20.2 as guidance in choosing the most appropriate WisDOT supported analysis tool for the specific roundabout lane configuration under consideration. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

Table 20.2 Choosing the Appropriate Analysis Tool

Analysis Tool	Appropriate Situations
HCS	One or two-lane entries, single-lane right-turn bypass lanes, no more than four approach legs
SIDRA Intersection	One, two or three-lane entries, one or two-lane right-turn bypass lanes, up to 8 approach legs

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version of HCS and SIDRA Intersection that WisDOT currently supports.

20.2.3 Calibrating the HCM Model

20.2.3.1 HCS

In order to calibrate the HCM model within HCS, the analyst will need to enter the headway values (both critical and follow-up) for each travel lane under the Roundabout Traffic Tab. Critical and follow-up headway values **shall** match the accepted Wisconsin headways listed in Table 20.1. The headway values entered depend on the number of entry lanes and the number of lanes circulating (conflicting) past a given entry, see Attachment 20.1. Refer to the HCS Users Guide for additional details on how to modify the critical and follow-up headway values.

20.2.3.2 SIDRA

To calibrate the model within SIDRA Intersection, the analyst, after entering the intersection geometry, will need to revise the default Parameter A and Parameter B values (located under the Roundabouts – Site Input - HCM6 Data tab) to reflect the Wisconsin-specific values shown in Table 20.1 (see Attachment 20.2 for a screenshot of the SIDRA Roundabout HCM6 Model Parameter data entry). Note that as of April 2022, SIDRA only allows you to enter the Parameter A and Parameter B values for the following roundabout configurations:

- Single Lane Circulating, Single Lane Entry (1-1)
- Multi Lane Circulating, Single Lane Entry (1-2)
- Multi Lane Circulating, Two Lane Entry – Right (Dominant) Lane (R2-2)
- Multi Lane Circulating, Two Lane Entry – Left (Subdominant) Lane (L2-2)

For all other lane configurations, the analyst will need to enter the headway values (both critical and follow-up) for each travel lane (located under the Roundabouts – Site Input – Gap Acceptance Data tab) making sure to specify the use of “Input” values rather than the default “Program” values (see Attachment 20.3 for a screenshot of the SIDRA Roundabout Gap Acceptance data entry).

SIDRA does allow for the entry of Parameter A and Parameter B values for a roundabout with a single circulating lane and two entry lanes; however, it assumes that both the right and left lane have the same values and would not allow for the use of the Wisconsin-specific values shown in Table 20.1. Therefore, analysis of the single-lane circulating, two-lane entry roundabout requires the user to enter the headway values as described above.

Future releases of SIDRA *may* allow the use of the Parameter A and Parameter B values for additional lane configurations, eliminating the need to modify the gap acceptance data. See the SIDRA User Guide for additional details on how to modify the Parameter A and Parameter B values and Gap Acceptance Data.

20.2.3.3 Reporting

Remember to revise the headway values or Parameter A and B values if the number of entry or circulating lanes change. Once the analysis is complete, print the formatted report(s). The format for results *should* follow the intersection control evaluation (ICE) FDM policy (FDM 11-25-3) and the Traffic Impact Analysis (TIA) guidelines for reporting on operational analysis. Include the analysis files as attachments and report all queues in feet.

Contact the regional traffic engineer or BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for specific guidance on how to conduct the roundabout operational analysis within any of the WisDOT supported analysis tools.

20.3 Calibration for Compact Roundabouts

The HCM methodology does not account for geometric parameters, such as the inscribed circle diameter (ICD), as factors in determining the operations of a roundabout. As international research has shown, changing the size of the ICD has an impact on overall operations. Therefore, without additional calibration, the current HCM single-lane roundabout methodologies will not correctly estimate the operations of a compact roundabout, generally overestimating the capacity.

Currently, both the presence of compact roundabouts and subsequently the research on compact roundabouts is minimal in the US. As such, as an interim approach until more research becomes available on in-service compact roundabouts operating at or near capacity, WisDOT studied the effects of known volume-based operational parameters of larger sized roundabouts (ICDs greater than 120 ft) on the varying ICDs and volume flow rates of compact roundabouts.

The analyses, completed with WisDOT-supported software (HCS and SIDRA), resulted in the development of volume calibration factors (VCFs) for two size ranges of compact roundabouts, those between 80-99 feet and those between 100-119 feet.

20.3.1 Volume Calibration Factor (VCF) Selection

Select a scaling factor based on the entering AADT and the proposed ICD size, as shown in Table 20.3.

Table 20.3 Volume Calibration Factor

Entering AADT	ICD	
	80 – 99 ft	**100-119 ft**
< 15,000	30%	20%
15,000 – 15,999	29%	19%
16,000 – 16,999	28%	18%
17,000 – 17,999	27%	17%
18,000 – 18,999	26%	16%
≥19,000	25%	15%

20.3.2 Application of VCFs using HCS

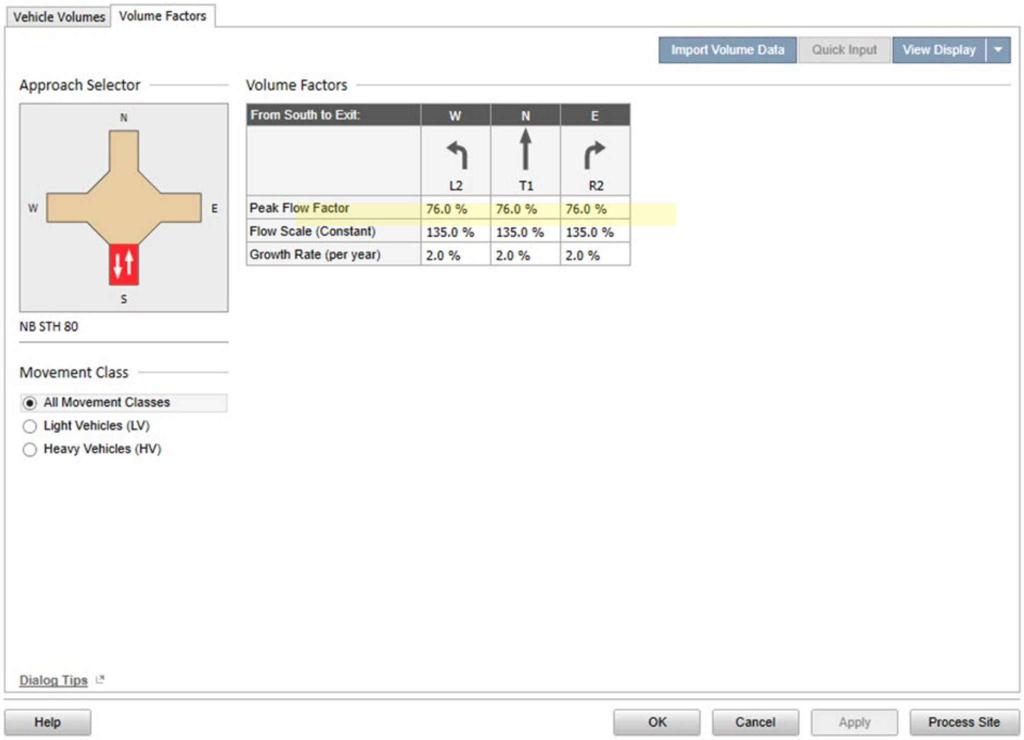
Manually scale the design year turn movement volumes by the appropriate VCF and enter them into the Traffic tab. Enter the PHF and Percent Heavy Vehicles as determined by the field count data. Enter the appropriate Wisconsin calibrated headway values as shown in Table 20.1.

20.3.3 Application of VCFs using SIDRA

The following outlines the four-step process for applying the VCFs within SIDRA.

1. Start by setting up a site in SIDRA based on the instructions in TEOpS 16-15-20.2.2.2 and TEOpS 16-15-20.2.3.2 and the associated attachments: Attachment 20.2 and Attachment 20.3. Enter the volumes, PHF, and Percent Heavy Vehicles as determined by the field count data.
2. Set the Roundabouts Site Input to use the US HCM 6 Roundabout Capacity Model.
3. To apply the VCF, open the Volumes window and activate the Volume Factors tab. Enter the VCF into the Flow Scale (Constant) cells under each movement, for every leg of the site. The new Flow Scale will be the VCF + 100, as shown in Figure 20.3.
4. Process the site as normal.

Figure 20.3 VCF Input as the Flow Scale



NB STH 80

From South to Exit:	W	N	E
	L2	T1	R2
Peak Flow Factor	76.0 %	76.0 %	76.0 %
Flow Scale (Constant)	135.0 %	135.0 %	135.0 %
Growth Rate (per year)	2.0 %	2.0 %	2.0 %

● All Movement Classes
○ Light Vehicles (LV)
○ Heavy Vehicles (HV)

20.4 Supplemental Tools for Operational Analysis and Design

When performing roundabout operational evaluations, analysts *should* recognize and account for the methodological limitations of the HCM. There are cases that *may not* fit within the analytical framework of the HCM, including but not limited to: volume-to-capacity ratio exceeding 0.80, high level of pedestrian or bicycle activity, priority reversal under extremely high flows, and flared entry lanes. When the volume-to-capacity ratio exceeds 0.80, the analyst *should* carefully consider predicted queues and delays and perform additional sensitivity analysis. Further analysis with microsimulation or design-aid tools such as SIDRA Standard, Rodel, or ARCADY can supplement the study if the effort is justifiable based on the site conditions.

Microsimulation is capable of system level analysis and allows the analyst to adjust roundabout designs indirectly. Additionally, microsimulation that provides for animation and visualization of operating predictions is useful for assessing lane utilization and capacity, especially when considering closely spaced roundabouts. Analysis with microsimulation *may* help identify lane imbalances or lane use problems within a series of intersections allowing for a more robust design of any single roundabout. Microsimulation *may* also prove beneficial for public outreach. Since microsimulation requires significantly more time, resources, and effort than HCM-based analysis, it is not appropriate to use for all roundabout analysis or design. Refer to TEOpS 16-10 for additional guidance on determining whether the use of a microsimulation tool would be appropriate. See TEOpS 16-20 for additional details on performing microsimulation analysis.

SIDRA Standard, Rodel, ARCADY and any other tool that designers have available to assist them in the design process can prove beneficial for the final geometric design of the roundabout. These programs provide for geometric sensitivity testing, allowing the user to test the effects of size and key geometric parameters (i.e., inscribed circle diameter, entry radius, phi angle, lane width and flared entry) along with varied flows on an existing or proposed roundabout design.

Rodel and ARCADY apply UK research producing a model that relates geometry to capacity, for roundabout capacity calculations. SIDRA Intersection, when used in Standard mode, implements a capacity estimation method that assumes a dependence of gap acceptance parameters on multiple factors. Roundabout geometry, circulating flows, entry lane flows, and model designation of dominant or subdominant lanes all influence gap acceptance parameters to account for lane-by-lane capacity variation. SIDRA Standard utilizes what they call the Environment Factor as one of the main parameters to calibrate the capacity model. The recommended Environment Factor for U.S. roundabouts is 1.05 for one-lane roundabouts (approach road or circulating road has one lane) and 1.2 for multi-lane roundabouts (both approach road and circulating road have two or more lanes). See the SIDRA Intersection User Guide Calibration Parameters for Roundabout Capacity Models for details on how to apply the Environment Factor in the SIDRA capacity model.

20.5 Special Considerations

Lane designation or lane assignments are critical to the success of the roundabout lane configuration and design. Conditions can be very complex with subtle problems that can reduce capacity and cause severe lane imbalance. Great care and sensitivity are required to achieve lane utilization balance. Supplementary software is especially suited to these situations.

- Unbalanced Conflicting Flows:

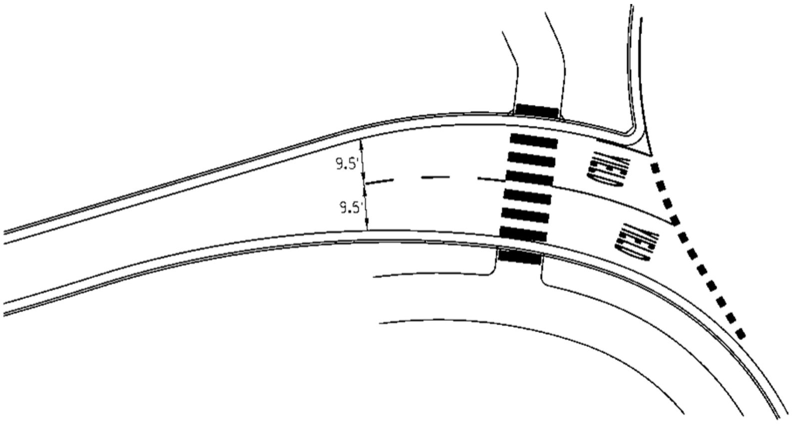
  At a roundabout with unbalanced conflicting flow patterns, a traffic stream with a low flow rate enters the roundabout having to yield to a circulating stream with a high flow or visa-versa.

  Unbalanced circulating flows highlight an operational condition that traffic engineers and designers *should* understand and interpret by taking into consideration all aspects including but not limited to the results of the analysis, the existing and future field conditions, and the traffic patterns to better inform the findings on the analysis. The SIDRA Standard capacity model is sensitive to the ratio of entering to circulating flow, and therefore *may* be able to reflect expectations of capacity when unbalanced flow conditions are expected. A microsimulation model can also supplement the analysis, but the level of data and effort to calibrate this model can be significant and *may not* be appropriate for an isolated roundabout analysis.

- Capacity Considerations of Flared Entries:

In some situations, the use of appropriate lane arrows can encourage balanced lane use, thus improving capacity. Traffic often has a bias towards the right-most lane. Lane arrows either can encourage this bias or can encourage lane balance. Figure 20.4 shows the preferred pavement marking scheme to encourage balanced lane demand. It is important for the analyst not to assume that flared entries at roundabouts will always provide for balanced lane use and therefore add capacity to that entry as HCS and SIDRA will predict. This scenario *may* occur on the approach to a roundabout that has little to no conflicting circulating traffic (e.g., a roundabout at an interchange ramp or any roundabout with a one-way street). The suitable marking for an approach will depend on the turning volume proportions. A methodology similar to that described in FDM 11-26-20.4.3 is used to assess lane designation alternatives.

Figure 20.4 Capacity Considerations of Flared Entries



In addition, assessment of the potential for one lane to fill and block the flared lane is necessary to achieve the predicted levels of service (i.e., the geometry must be effective to match the capacity prediction). Lane starvation is a primary failure mechanism for flared entries. Microsimulation models have various forms of lane-by-lane simulation features, which allow the analyst to test alternative lane configurations with visualization of the simulated flows accumulating and filling the flared lanes.

LIST OF ATTACHMENTS

Attachment 20.1	Roundabout Lane Configurations
Attachment 20.2	SIDRA Roundabout Parameters Screenshot
Attachment 20.3	SIDRA Gap Acceptance Screenshot

16-15-25 Alternative Intersections August 2022

Alternative intersections separate out one or more of the turning movement conflicts (typically left-turns) by rerouting them away from the center of the intersection to a secondary junction. Alternative intersections *may* be signalized or stop-controlled on the minor street movements. Examples of alternative intersections include, but are not limited to, the following:

- Restricted Crossing U-Turn (RCUT), also known as the J-Turn or superstreet,
- Median U-Turn (MUT), also known as the Michigan left turn or modified J-Turn, and
- Displaced Left Turn (DLT), also known as the continuous-flow intersection

Refer to FDM 11-25 Attachment 3.3 for a brief description, summary of the key elements to consider, and some of the potential benefits/concerns associated with these alternative intersections.

By rerouting one or more of the turn movements away for the center of the primary intersection, alternative intersections result in two or more closely spaced intersections that are operationally dependent on one another. Thus, the analyst *should* treat these intersections as a single unit.

WisDOT accepts the use of the HCM, Chapter 23 to assess the performance of the RCUT, MUT, and DLT from the perspective of the motor vehicle, pedestrian, and bicycle modes. Note that the Chapter 19 signalized methodology for pedestrians and bicycles is typically applicable for the minor street crossings at a signalized RCUT and for all crossings at the signalized MUT. The HCM, Chapter 23 methodology provides a means to measure experienced travel time and considers the control delay experienced at each intersection plus the additional travel time needed to travel from the primary/center intersection to the secondary junction and back to the primary/center intersection.

Analysts *should* recognize and account for the methodological limitations of the HCM methodology. Specifically, the analyst *should* bear in mind that the analysis methodology is relatively new. Additionally, the HCM Chapter 23 methodology is only applicable to the RCUT, MUT, and DLT. Consider using microsimulation analysis tools for those alternative intersections that do not fit within the methodological limitations of the HCM. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software for HCM-based analysis of alternative intersections is:

- HCS, McTrans

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

Trafficware has not yet implemented the HCM methodology for alternative intersections within Synchro; however, the analyst *may* be able to manipulate the coding within Synchro to analyze these intersections in accordance with the HCM methods. Confirm with the WisDOT regional traffic engineer whether it is appropriate to utilize Synchro for the analysis of alternative intersections.

16-15-30 Interchange Ramp Terminals August 2022

The close spacing and interdependency of most ramp terminals requires that the operational analysis consider all ramp terminals within the interchange as a single unit. WisDOT accepts the use of the HCM, Chapter 23 for the analysis of interchange ramp terminals. As no specific methodologies for pedestrian and bicycle operations at interchange ramp terminals currently exist, the HCM, Chapter 23 methodologies for interchange ramps focus on the motor vehicle mode. Chapter 23, however, does provide some guidance for addressing bicycles and pedestrians at interchanges.

The HCM, Chapter 23 methodology addresses the following conventional interchange designs:

- Diamond interchanges,
- Partial cloverleaf (parclo) interchanges, and
- Interchanges with roundabouts.

Additionally, the HCM, Chapter 23 methodology addresses the following alternative interchange designs:

- Diverging diamond interchanges (DDIs) and
- Single-point interchanges (SPI).

Refer to FDM 11-25 Attachment 3.3 for a brief description, summary of the key elements to consider, and some of the potential benefits/concerns associated with each of these interchange designs.

The HCM, Chapter 23 methodology calculates the control delay experienced at each ramp terminal plus any additional travel time associated with driving between ramp terminals within the interchange. This allows for an equal comparison of the various interchange designs.

The analysts *should* recognize and account for the methodological limitations of the HCM, Chapter 23 methods. Specifically, the analyst *should* bear in mind that the analysis methodology is not applicable for freeway-to-freeway or system interchanges. Additionally, the methodology does not cover interchanges with TWSC intersections or interchanges consisting of both a signalized and roundabout intersection. Consider using microsimulation analysis tools for those interchanges that do not fit within the methodological limitations of the HCM. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software programs for HCM-based analysis of interchange ramp terminals are:

- HCS, McTrans
- Synchro, Cubic|Trafficware (conventional ramp terminals only)

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

Trafficware has not yet implemented the HCM methodology for the alternative interchange ramp terminals (e.g., DDI, SPI) within Synchro; however, the analyst *may* be able to modify the coding within Synchro to analyze these types of interchange ramp terminals in accordance with the HCM methods. Confirm with the WisDOT regional traffic engineer whether it is appropriate to utilize Synchro for the analysis of the alternative interchange ramp terminals.

16-15-35 Urban Street Facilities August 2022

WisDOT accepts the use of the HCM, Chapters 16 and 18 for an integrated multimodal analysis of an urban street facility, including the intersections and segments that make up the facility. The methodology provides the analytical framework to assess the automobile, pedestrian, bicycle, and transit modes by calculating delay and other performance measures by mode for each direction of travel along each segment of the given urban street facility, in addition to mid-block access points and other study intersections. The analyst *should* also consider the methods for TWSC, AWSC, roundabouts, and signalized intersections to the extent that those facilities exist along the subject roadway.

For intersections along an urban arterial or collector street that do not operate in isolation (i.e., the operation of one intersection influences the operation of the adjacent intersection), follow the Chapter 18 Urban Street Segment methodology. If the project spans multiple contiguous urban street segments, consider applying the Chapter 16 Urban Street Facilities methodologies. The Chapter 16 Urban Street Facilities methods allow the analysis of corridors of coordinated signalized intersections to capture average-phase-duration and other analytical components related to progression and vehicular platooning. If travel time reliability performance measures are of interest, consider using the urban street reliability methodologies in HCM, Chapter 17. For additional information on incorporating travel-time reliability into the analysis, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

Analysts *should* recognize and account for the methodological limitations of the HCM urban streets methods. Accordingly, limitations of the individual intersection methods are also limitations of the urban street methods. For urban street facilities that do not fit within the analytical framework of the HCM, including but not limited to cases involving turn-lane spillover, mid-block parking maneuvers, or capacity constraints between intersections, the project manager *should* specify the use of an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software programs for HCM-based urban streets analysis are:

- HCS, McTrans
- Synchro, Cubic|Trafficware

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

16-15-40 Freeway Facilities August 2022

WisDOT accepts the use of the HCM analysis methods in Chapter 10 for a combined freeway facility, Chapter 11 for freeway reliability analysis, Chapter 12 for basic freeway segments, Chapter 13 for freeway weaving segments and Chapter 14 for freeway merge and diverge segments. Analysts *should* use these methods to assess uninterrupted flow facilities that typically have restricted access and consist of higher-speed roadways through rural, suburban, and urban areas. Since there is no pedestrian/bicycle traffic on freeways, the HCM methodology focuses on the vehicular travel mode of travel. For additional information on incorporating travel-time reliability into the analysis, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

Analysts *should* recognize and account for the methodological limitations of the HCM methods for freeway analysis. For freeway facilities that do not fit within the analytical framework of the HCM, the project manager *should* specify the use of an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software for HCM-based freeway analysis is:

- HCS, McTrans

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

16-15-45 Multilane Highways August 2022

WisDOT accepts the use of the HCM, Chapter 12 methods for the analysis of an expressway or multilane highway. The methodology provides the analytical framework to assess the automobile and bicycle modes of travel. The analyst *should* use these methods to assess uninterrupted flow on multilane highway facilities with free-flow speeds between 45 and 70 mph, and two miles or more between traffic signals. These facilities *may* be divided, undivided, or have a two-way left-turn lane (TWLTL).

Many multilane highways will have periodic signalized intersections that are more than two miles apart. In these cases, the analyst *should* evaluate the highway segment portion using the Chapter 12 method and evaluate the isolated intersection using the signalized intersection analysis tools outlined in TEOpS 16-10-5.

Analysts *should* recognize and account for the methodological limitations of the multilane highway methods. For multilane highway conditions that do not fit within the analytical framework of the HCM, including but not limited to; effect of lane drops and lane additions at the beginning or end of the multilane highway segment, queuing impacts at transition areas (i.e., transitions from a multilane to two-lane highway), significant presence of on-street parking, or significant pedestrian activity, the analyst *should* use an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software for HCM-based multilane highway analysis is:

- HCS, McTrans

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

16-15-50 Two-Lane Highways August 2022

WisDOT accepts the use of the HCM, Chapter 15 methods for the analysis of a two-lane highway. The methodology provides the analytical framework to assess the automobile and bicycle modes of travel. Use these methods to assess uninterrupted flow (i.e., there are no traffic control devices that interrupt traffic) on two-lane highways that have one lane in each direction. Passing takes place on these facilities in the opposing lane of traffic when there is adequate sight distance and safe gaps in the opposing traffic. The two-lane highway methodology also includes a procedure for predicting the effect of passing and truck climbing lanes on two-lane highways.

In general, this analysis includes any segments that have signalized intersections spaced two or more miles apart. Classify two-lane highways with signalized intersections spaced closer than two miles apart as an urban street or arterial and apply the methodologies of HCM, Chapter 16 as appropriate. Further, analyze any major signalized or unsignalized intersections within the two-lane highway corridor using the appropriate tools as outlined in TEOpS

16-10-5.

HCM7 (1) introduces a new methodological framework to analyze two-lane highways that is vastly different from the methodology in previous versions of the HCM. HCM7 uses follower density as the performance measure, with thresholds fo LOS based on posted speed limit. The HCM7 methodology uses three different segment types (passing zone, passing constrained, and passing/climing lane), which can be combined into a faciity-level analysis, and incorporates impacts from horizontal and vertical curves. Previous versions of the HCM broke out two-lane corridors into three classifications (Class I, Class II, and Class III) and used percent-time-spent-following (PTSF), average travel speed (ATS), or a combination of the two as the performance measures for determining LOS. The previous HCM methodology handled the impact of counter-directional passing on two-lane segment LOS through a “Percent no-passing zone (%)” rather than explicity requiring the identification of passing zones and passing constrained segments.

Projects initiated prior to January 2022, can continue to utilize the HCM6 (2) methodologies for the duration of the project, but *may* want to consider verifying the results with the HCM7 procedures. Projects initiated between January 2022 and December 31, 2022, *may* follow either HCM7 or HCM6 methodologies. All projects initiated on or after January 1, 2023 **shall** follow the HCM7 methodologies unless otherwise authorized by WisDOT regional traffic staff.

Analysts *should* recognize and account for the methodological limitations of the two-lane highway methods. . For two-lane highways that do not fit within the analytical framework of the HCM, the project manager *should* specify the use of an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software for HCM-based two-lane highway analysis is:

- HCS, McTrans

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

16-15-55 Network Analysis August 2022

HCM7, Chapter 38 introduces a new methodology for evaluating the interactions between freeways and urban streets. The methodology expands upon the analysis methods of individual intersections and segments to consider the spillback effects from the downstream facility. Since spillback affects each lane differently, the analysis is conducted on a lane-by-lane basis and provides performance measures at both the network and origin-destination level. The analysis methodology applies capacity adjustment factors dependent on the queue flow regime. There are five different flow regimes, regimes 0 – regime 4, with Regime 0 being no queues and Regime 4 have queues which block the adjacent lane.

WisDOT has not currently identified a specific HCM-based analysis tool for analyzing the interactions between freeways and urban streets. Direct any specific questions regarding the network analysis and spillback effects from the downstream facility to the WisDOT regional traffic engineer or BTO-TASU.

16-15-60 Pedestrian and Bicycle Facilities August 2022

60.1 Mid-Block Pedestrian Crossings

WisDOT accepts the use of the methods outlined by the HCM, Chapter 20-5 for one-stage and two-stage unsignalized mid-block pedestrian crossings, with or without a median refuge area, which are not located at an intersection. Assess the operations of mid-block pedestrian crossings by calculating seconds of delay per pedestrian or pedestrian-group.

Wisconsin-state law requires motorists to yield to pedestrians at designated mid-block pedestrian crossings. Motorist compliance, however, can vary. Implementation of pedestrian crossing treatments that are proven safety countermeasures (e.g., high visibility crosswalk markings, median refuges, and rectangle flashing beacons or pedestrian hybrid signals) have shown to increase motorist compliance rates and reduce pedestrian crashes. In the absence of local data, and subject to professional judgment, use the default motorist-yield-rates as recommended in the HCM7, Chapter 20 (Exhibit 20-28) for the analysis of mid-block pedestrian crossings.

Analysts *should* recognize and account for the methodological limitations of the mid-block pedestrian crossing methods (i.e., TWSC pedestrian mode method). For mid-block pedestrian crossings that do not fit within the analytical framework of the HCM, including but not limited to, signalized mid-block crossings or cases where the impact on the major street vehicular traffic is relevant, the project manager *should* specify the use of an alternative tool such as microsimulation. See TEOpS 16-20 for additional details on performing microsimulation analysis.

The WisDOT-supported traffic engineering software for HCM based mid-block pedestrian crossing analysis are:
- HCS, McTrans
- Synchro, Cubic|Trafficware

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

60.2 Off-Street Pedestrian and Bicycle Facilities

WisDOT accepts the use of the HCM6, Chapter 24 methods for the analysis of off-street pedestrian and bicycle facilities (i.e., non-motorized vehicle usage only). The methodology provides the analytical framework to assess the capacity and LOS for the following types of facilities:

- Walkways: pedestrian-only paved facilities (paths, ramps, and plazas) typically located more than 35 feet from an urban street
- Shared-use paths: paths, separated by a physical barrier from highway traffic, dedicated for the shared-use of all forms of non-motorized (pedestrian, bicyclists, runners, inline skaters, etc.)
- Exclusive off-street bicycle paths: separated by a physical barrier from highway traffic, dedicated for bicycle-only traffic

Analysts *should* recognize and account for the methodological limitations of the HCM. For off-street pedestrian and bicycle facilities that do not fit within the analytical framework of the HCM, the project manager *should* specify the use of an alternative tool.

WisDOT has not currently identified a specific analysis tool for analyzing off-street pedestrian and bicycle facilities. Direct any specific questions regarding the analysis of off-street pedestrian and bicycle facilities to the WisDOT regional and statewide bicycle and pedestrian coordinators.

16-15-70 References August 2022

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3. **R.A. Smith National.** *Right Turn on Red Methodology Evaluation.* 2009.

4. **TranSmart Technologies, Inc.** *Signalized Intersection Capacity Data Collection: A Statewide Evaluation of Saturation Flow Rate and Right Turn on Red.* November 2015.

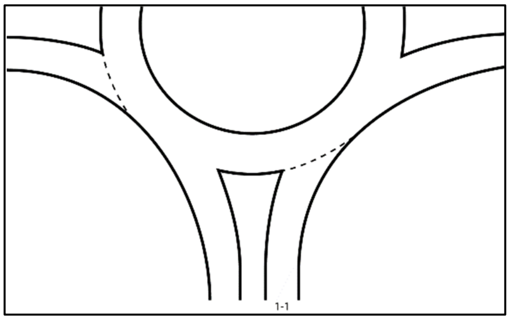
5. **Traffic Analysis and Design, Inc. (TADI).** *Signalized Intersection Data Collection - Phase III.* October 2021.

6. ***NCHRP 572.*** *Roundabouts in the United States.* 2007.

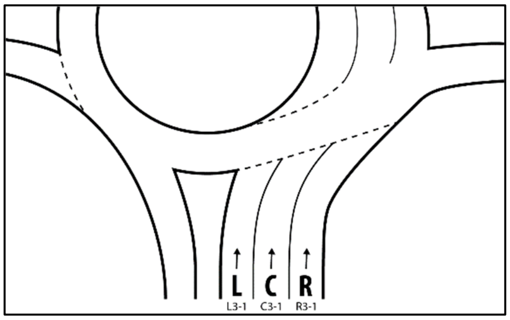
7. **Rodegerdts, L.A., A. Malinge, P.S., Marnell, S.G. Beaird, M.J. Kittelson, and Y.S. Mereszcak.** *Assessment of Roundabout Capacity Models for the Highway Capacity Manual: Volume 2 of Accelerating Roundabout Implementation in the Unites States.* Washington, D.C. : Federal Highway Administration, Sept. 2015. Report FHWA-SA-15-070.

8. **Traffic Analysis and Design, Inc. (TADI).** *Statewide Roundabout Traffic Operations Analysis.* March 2020.

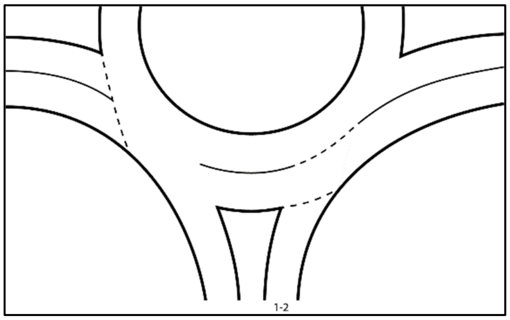
One-Lane Entry Conflicted by
One Circulating Lane (1-1)



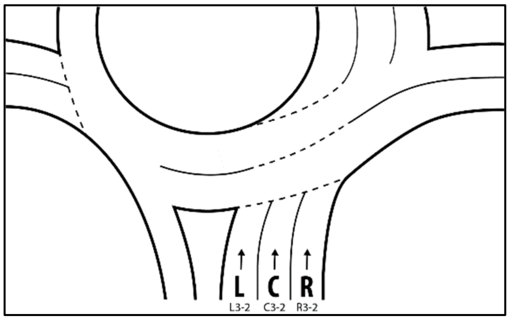
Three-Lane Entry Conflicted by
One Circulating Lane (L3-1/C3-1/R3-1)



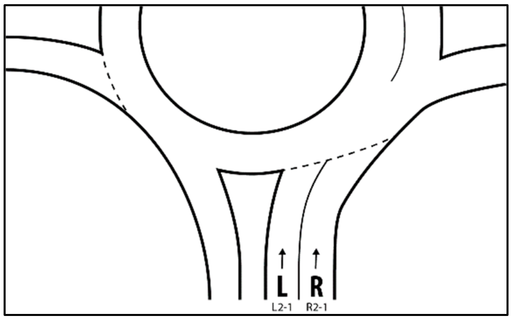
One-Lane Entry Conflicted by
Two Circulating Lanes (1-2).



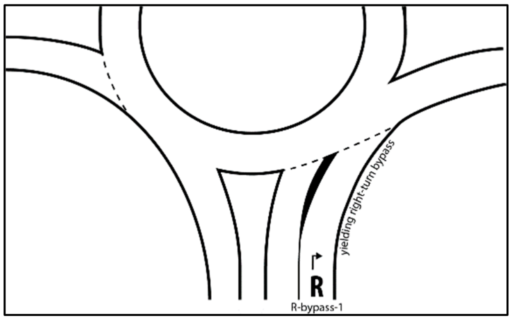
Three-Lane Entry Conflicted by
Two Circulating Lanes (L3-2/C3-2/R3-2)



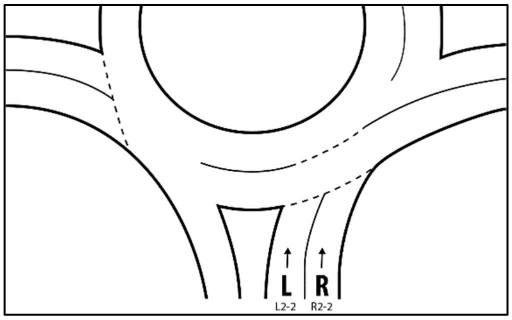
Two-Lane Entry Conflicted by
One Circulating Lane (L2-1/R2-1)



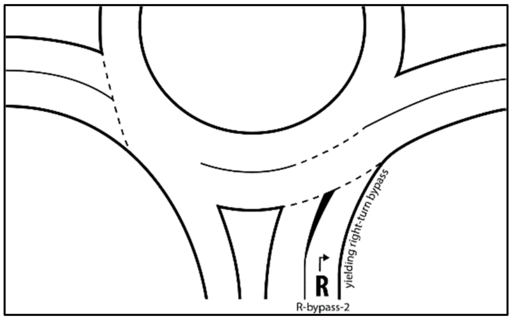
Right Yielding Bypass Lane Conflicted by
One Exiting Lane (R-bypass - 1)

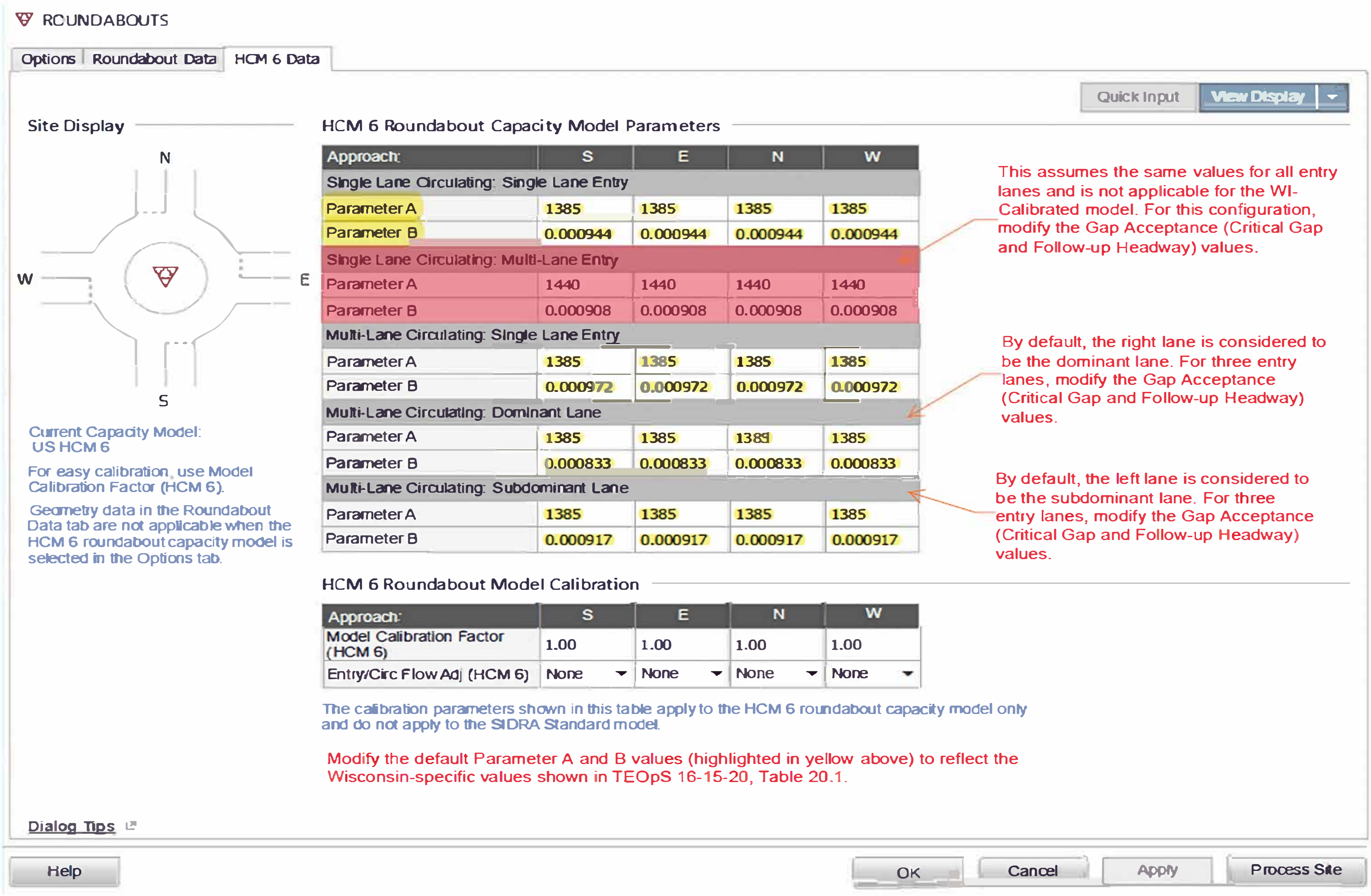


Two-Lane Entry Conflicted by
Two Circulating Lanes (L2-2/R2-2).



Right Yielding Bypass Lane Conflicted by
Two Exiting Lanes (R-bypass - 2)





HCM 6 Roundabout Capacity Model Parameters

Approach:	S	E	N	W
Single Lane Circulating: Single Lane Entry				
Parameter A	1385	1385	1385	1385
Parameter B	0.000944	0.000944	0.000944	0.000944
Single Lane Circulating: Multi-Lane Entry				
Parameter A	1440	1440	1440	1440
Parameter B	0.000908	0.000908	0.000908	0.000908
Multi-Lane Circulating: Single Lane Entry				
Parameter A	1385	1385	1385	1385
Parameter B	0.000972	0.000972	0.000972	0.000972
Multi-Lane Circulating: Dominant Lane				
Parameter A	1385	1385	1385	1385
Parameter B	0.000833	0.000833	0.000833	0.000833
Multi-Lane Circulating: Subdominant Lane				
Parameter A	1385	1385	1385	1385
Parameter B	0.000917	0.000917	0.000917	0.000917

This assumes the same values for all entry lanes and is not applicable for the WI-Calibrated model. For this configuration, modify the Gap Acceptance (Critical Gap and Follow-up Headway) values.

By default, the right lane is considered to be the dominant lane. For three entry lanes, modify the Gap Acceptance (Critical Gap and Follow-up Headway) values.

By default, the left lane is considered to be the subdominant lane. For three entry lanes, modify the Gap Acceptance (Critical Gap and Follow-up Headway) values.

Current Capacity Model:
US HCM 6

For easy calibration, use Model Calibration Factor (HCM 6).

Geometry data in the Roundabout Data tab are not applicable when the HCM 6 roundabout capacity model is selected in the Options tab.

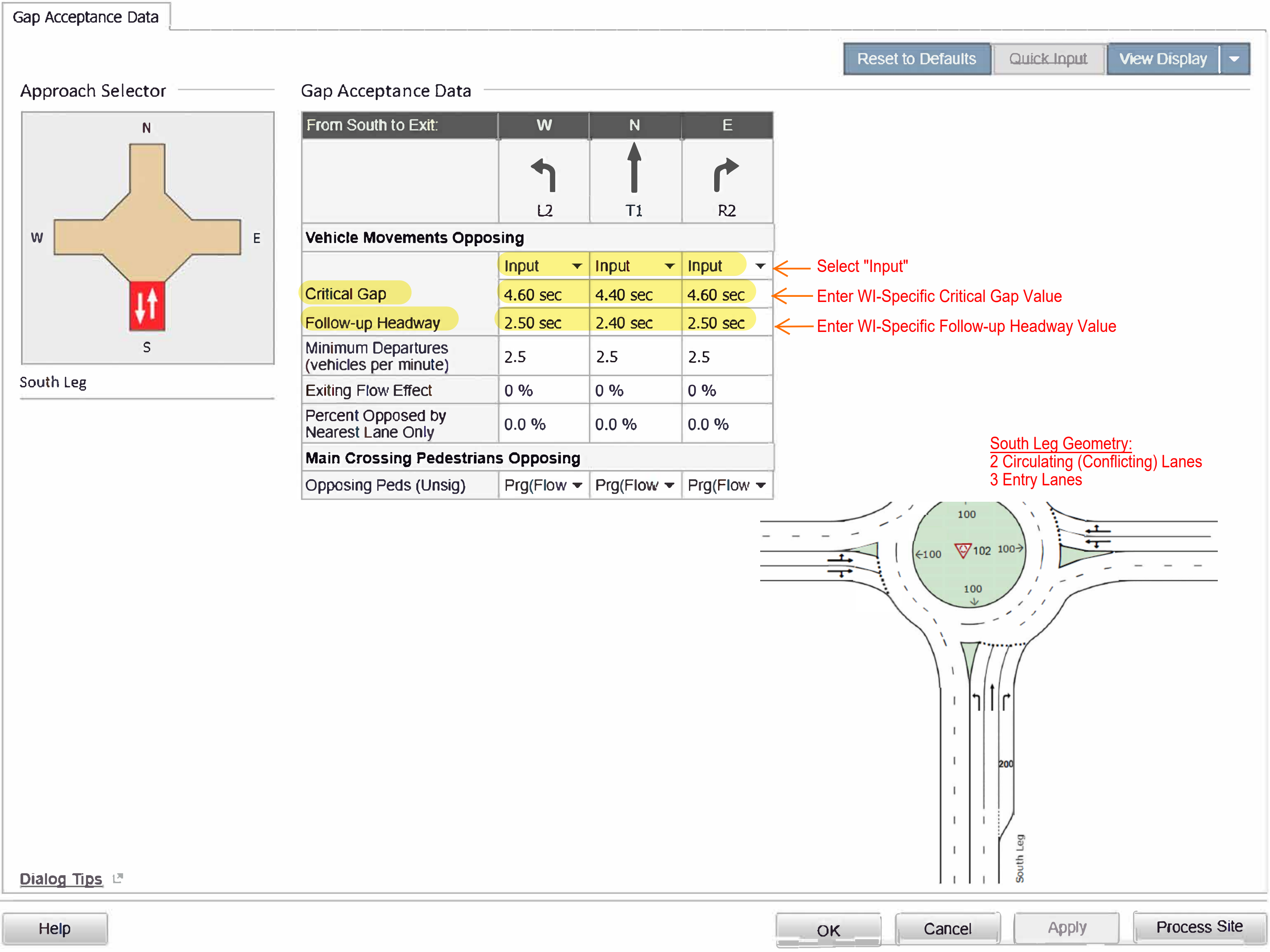
HCM 6 Roundabout Model Calibration

Approach:	S	E	N	W
Model Calibration Factor (HCM 6)	1.00	1.00	1.00	1.00
Entry/Circ Flow Adj (HCM 6)	None	None	None	None

The calibration parameters shown in this table apply to the HCM 6 roundabout capacity model only and do not apply to the SIDRA Standard model.

Modify the default Parameter A and B values (highlighted in yellow above) to reflect the Wisconsin-specific values shown in TEOpS 16-15-20, Table 20.1.

Attachment 20.3 SIDRA Gap Acceptance Screenshot



Gap Acceptance Data

From South to Exit:	W	N	E
	L2	T1	R2
Vehicle Movements Opposing			
	Input	Input	Input
Critical Gap	4.60 sec	4.40 sec	4.60 sec
Follow-up Headway	2.50 sec	2.40 sec	2.50 sec
Minimum Departures (vehicles per minute)	2.5	2.5	2.5
Exiting Flow Effect	0 %	0 %	0 %
Percent Opposed by Nearest Lane Only	0.0 %	0.0 %	0.0 %
Main Crossing Pedestrians Opposing			
Opposing Peds (Unsig)	Prg(Flow	Prg(Flow	Prg(Flow

Select "Input"

Enter WI-Specific Critical Gap Value

Enter WI-Specific Follow-up Headway Value

South Leg Geometry:
2 Circulating (Conflicting) Lanes
3 Entry Lanes

Traffic Engineering, Operations & Safety Manual

Chapter 16 Traffic Analysis and Modeling

Section 20 Microscopic Simulation Traffic Analysis

16-20-1 Basic Principles

September 2019

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 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. TEOpS 16-10-5 provides additional information and guidance on selecting the most appropriate traffic analysis tool(s).

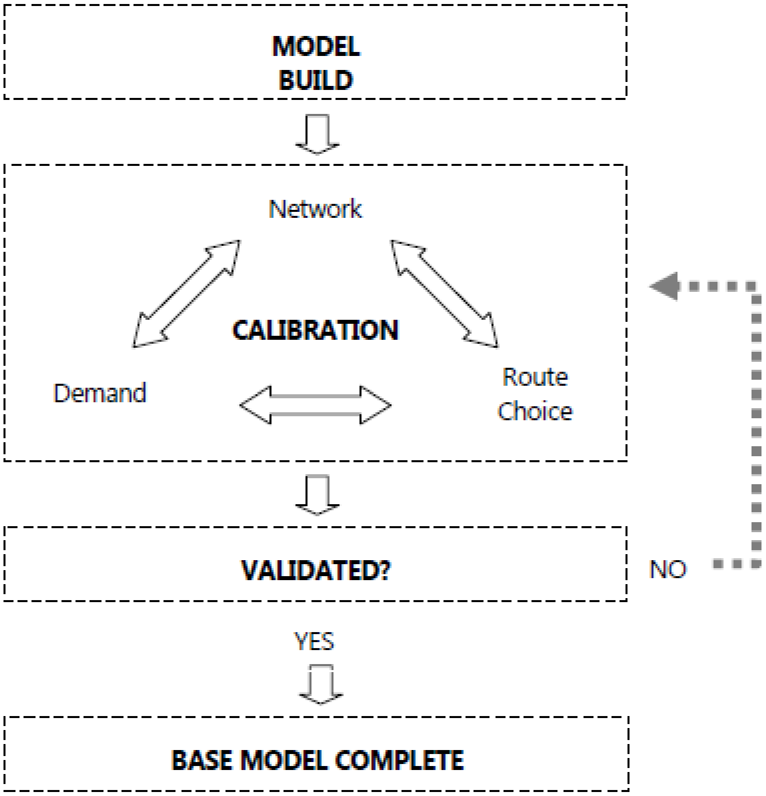
1.2 Calibration vs. Validation

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 including headway and reaction times, driver aggressiveness, etc. and roadway elements like 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 benchmark data for traffic volumes, travel speeds, travel times, intersection queuing, and trip-making patterns (e.g., weaving volumes), among others. 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 depicts 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 the 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.

16-20-2 Traffic Model Development May 2021

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 beyond the level of detail initially 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 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 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 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 strategies, especially if the future improvement may result in a shift in travel patterns. Other adjacent 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., it may be necessary to extend the traffic model 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 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 extension of the traffic model (spatially or temporally) to capture 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. 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 (25X25 = 625) while a 50-zone model has 2,500 O-D pairs (50X50 = 2,500). The time to complete the network coding, calibration, and validation processes increase with every O-D pair added to the traffic model. 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 to assess whether to break one large model into smaller models. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.) 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 2004 publication of the *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 DT2290. Document all assumptions and methods regarding the geographical limits for the traffic model within the modeling methodology report and 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 the following, among others:

AM Peak Period (AM):	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.
Midday Peak Period (MD):	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.
PM Peak Period (PM):	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.
Friday Peak Period (Fri):	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.
Sunday Peak Period (Sun):	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.
Seasonal/Special Event (SP):	This period is relevant in areas that experience unusual traffic patterns due to holidays, tourism, or special events. This may coincide with the Friday or Sunday peak period.

The length of the TAP is dependent on the extent of congestion in the study area. Although the TAP will vary depending on local field conditions, FHWA's 2004 publication of TAT III (2) and 2007 publication of 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. All key stakeholders *should* agree on the approach to use to compensate for any congestion that occurs outside the established TAPs.

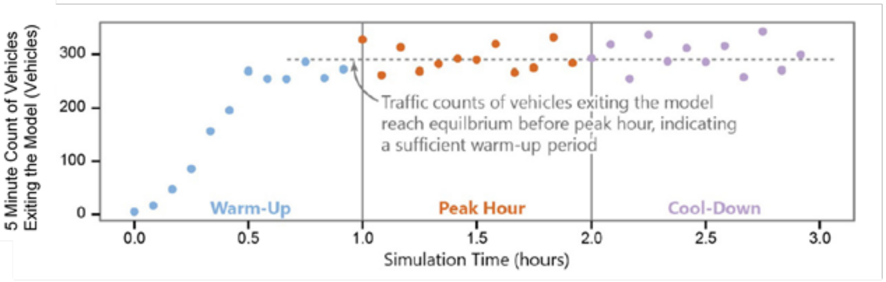
Provide a brief discussion of the TAPs within DT2290. Document all assumptions and methods regarding the TAPs for the traffic model within the modeling methodology report and other project memoranda as appropriate.

2.1.2.2 Warm-Up/Cool-Down Periods

In addition to the analysis period, 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 2004 publication of 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 DT2290. Document all assumptions, methods, and exemptions regarding the warm-up and cool-down periods for the traffic model within the modeling methodology report and 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 sufficiently 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 extraordinary 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 DT2290 form and document the rationale for selecting the existing conditions within the modeling methodology report and 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 inclusion of a planned improvement project in the FEC model is contingent on it occurring after the existing year but prior to the proposed project's design year. 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, or “constrained” conditions within the modeling methodology report and 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 represents future with existing plus committed plus minor improvements (FEC+) conditions. The project team *should* document these minor improvements within the modeling methodology report and other project memoranda as appropriate.

The driving factor for inclusion of a design year with minor improvements (or FEC+) model is frequently the need to eliminate the geometric constraints within or adjacent to the traffic model that prevent the realization of the true demand. Thus, the FEC+ model is typically (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 or “unconstrained” conditions within the modeling methodology report and 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 HCM-based deterministic analysis tools to narrow down the number of 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” or “unconstrained” conditions within the modeling methodology report and 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 to develop a model that represents the conditions that will exist the first year the proposed project improvements will be open 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 an 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.

2.3 Traffic Model Tree

Prior to development of the microsimulation traffic model, the analyst *should* coordinate with the project team and WisDOT regional traffic staff to develop the traffic model tree. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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.

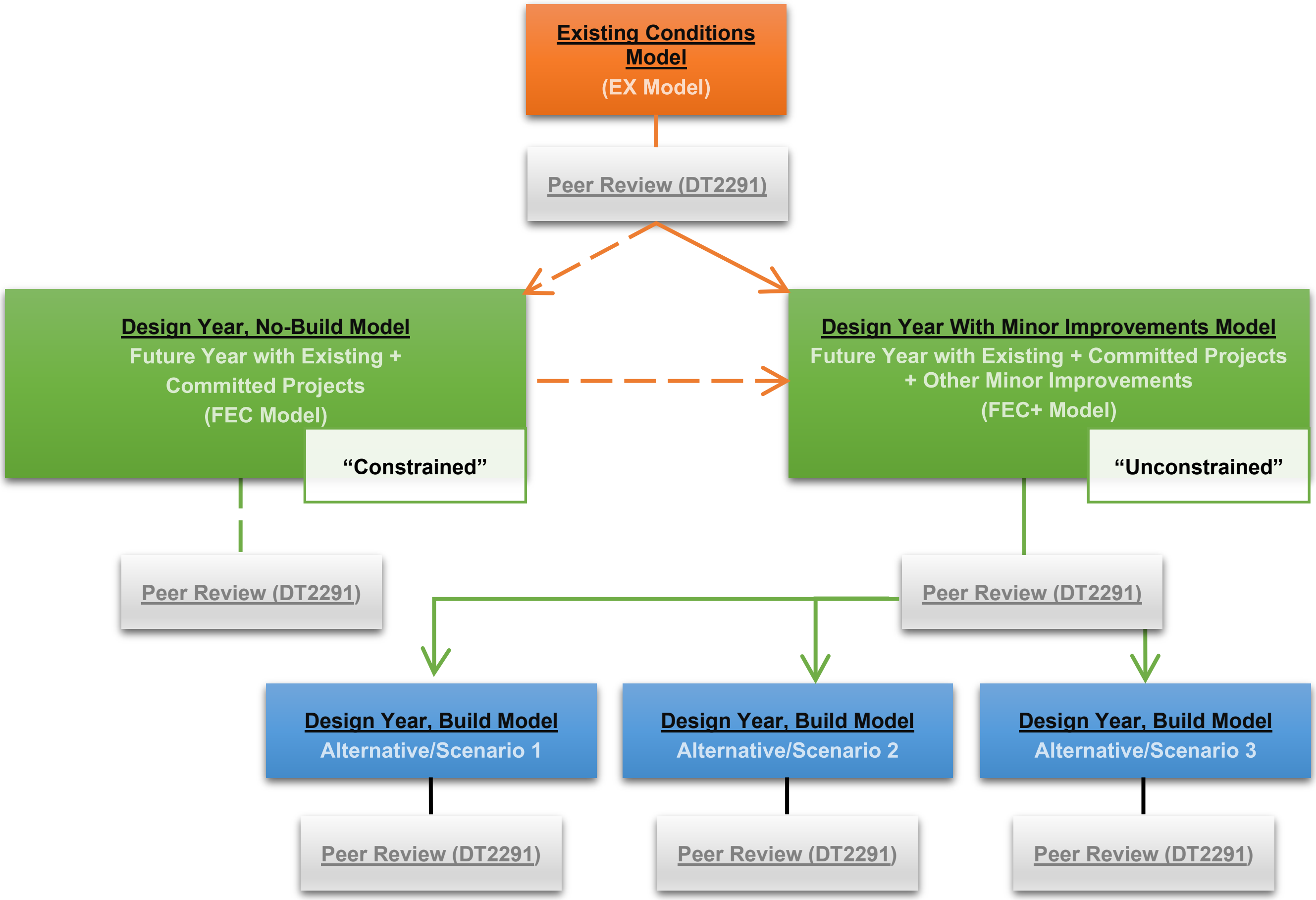
As illustrated in Figure 2.2, each version of the traffic model *should* undergo the peer review process prior to the development of the model for a new scenario. Refer to TEOpS 16-25 for additional details on the peer review process. When the project has a compressed schedule, there may be a temptation 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 or design plans as background images to aid in the review
- Minimize the amount of non-link space (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 or software limitations. This will make it easier to assess whether the adjustment factor is applicable for other modeling scenarios.
- Avoid introducing new driving behaviors in the design year, build (ALT) beyond those previously included in the existing models. When necessary, limit the use of new driving behaviors to locations where there have been significant changes in roadway geometry.

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 the following, among others:

- Traffic Forecasting Methodology Report, typically will include the following attachments
  - Design Hour/K-Factor Selection Methodology
  - 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
- DT2291 for each model

For sample formats or questions on any of the above deliverables, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

16-20-3 Measures of Effectiveness (MOEs) September 2019

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 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 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 the following, among others:

- WisDOT interactive count map: WisDOT TCMap (Traffic Count Map) 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 selecting 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.

3.1.2 Traffic Speeds

Validation tests for traffic speeds may be representative of spot speeds or segment speeds. Common sources for spot speed data include, loop detectors, radar detection, or other resources. Common sources for segment speed data include, Bluetooth detectors, probe data, or floating car studies. Document the methodology used to collect and calculate the spot and 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 during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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 during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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 under 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 using queues 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, 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 triple left-turn lanes, 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* field measurements of queues occur?

Discuss the locations of intersection queues required for model validation with WisDOT regional traffic staff during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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. When reviewing lane utilization data, be cognizant of the lane numbering scheme (i.e., lane numbering goes from inside/median lane to outside/shoulder lane or vice versa), as the lane number scheme can vary depending on the type of detector or software. 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 during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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 prior to using lane density as a validation metric. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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 intersection queue lengths. Validation of bottlenecks in a traffic model typically occurs through conducting visual observations or by creating spatiotemporal graphics displaying observed versus modeled MOEs. If observations indicate the presence of recurring congestion (a bottleneck) under 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. Potential 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 or benchmark 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 during the scoping stage of a project. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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

Like 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, and travel times. The secondary MOEs include 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	
Link and Turning Movement Volumes	Required for all projects	**Summary of MOEs for Model Validation** • 3 to 4 Primary • 2 to 3 Secondary • 6+ Upon WisDOT Approval
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

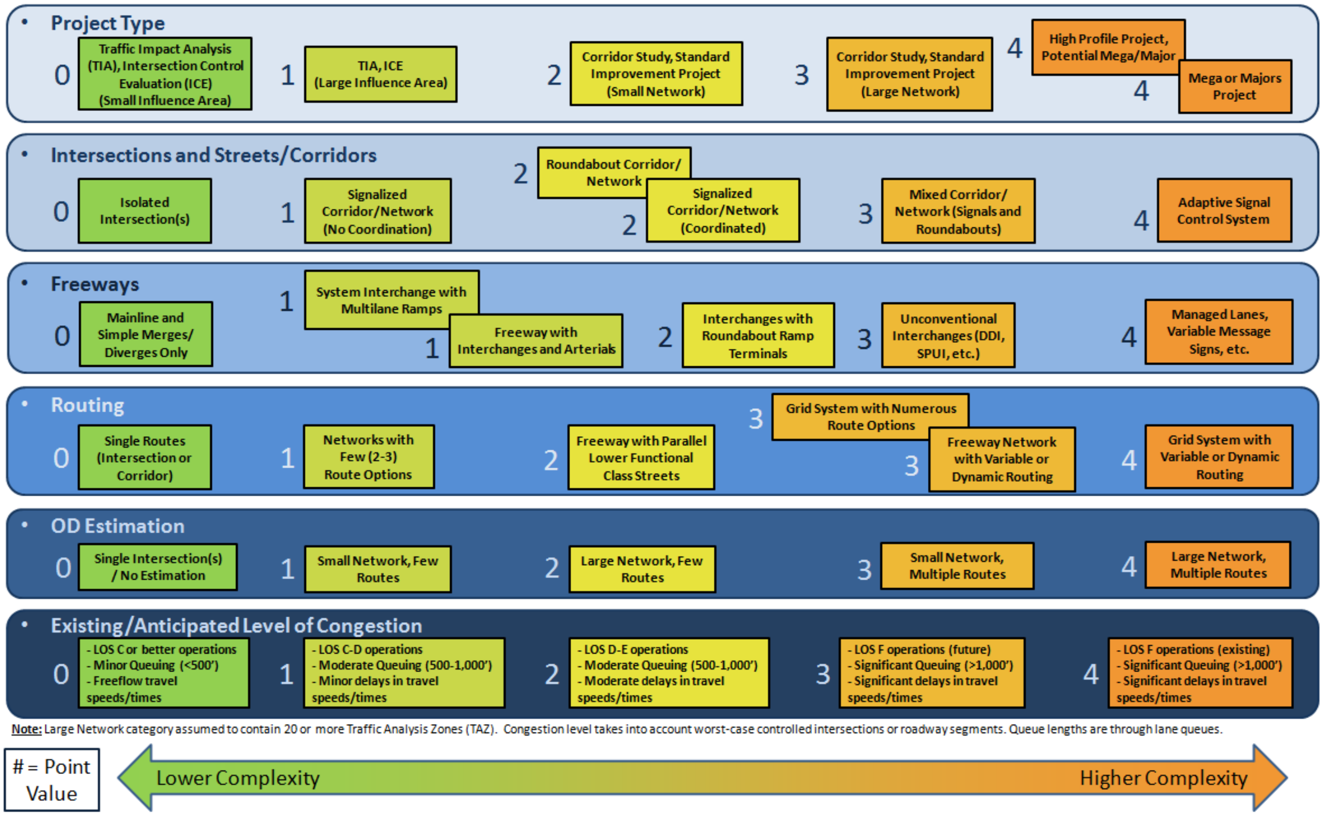
The number of MOEs required for validation will vary depending on the complexity of the traffic model, which is dependent on the project type, project scope, corridor type, traffic control, roadway congestion level, and type of microsimulation tool used for analysis. To quantify the complexity of the 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 the scenarios (existing and future alternatives) dictates the number of primary and secondary MOEs required for base model validation.

Figure 3.1 Traffic Model Complexity Scoring Diagram



Note: Large Network category assumed to contain 20 or more Traffic Analysis Zones (TAZ). Congestion level takes into account worst-case controlled intersections or roadway segments. Queue lengths are through lane queues.

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 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 other project memoranda as appropriate.

LIST OF ATTACHMENTS

Attachment 3.1	Traffic Model Complexity Scoring Template

16-20-4 Microsimulation Analysis Software September 2019

4.1 WisDOT Supported Software

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

- SimTraffic, Trafficware
- Vissim, PTV Group

Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of the above software that WisDOT currently supports.

Prior to January 1, 2018, WisDOT supported the use of Paramics. As such, 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 there is a need to make major revisions to the traffic models (e.g., use of different base year conditions), the analyst should consider switching the traffic models over to Vissim. Consult with the WisDOT regional traffic contact or BTO-TASU to determine whether it is appropriate to switch software programs.

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 is either already complete or is in the development process.

4.2 SimTraffic Overview

Trafficware, a CUBIC 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. Oftentimes, 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 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, 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 or remove microsimulation tools to/from WisDOT’s traffic analysis toolbox. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) 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 you are looking at a relatively small scale/simple arterial network, consider the use of SimTraffic. All other scenarios, specifically freeway models, will typically require the use of Vissim for microsimulation analyses. As of January 1, 2018, do not initiate any new microsimulation analyses using Paramics. See TEOpS 16-10-5 for additional guidance on how to select the most appropriate traffic analysis tool for a specific project.

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 May 2021

5.1 Introduction

Calibrating a traffic model requires the analyst to review and potentially 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.

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 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 actuality.

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 or temporal limits of the model 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, 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.

Vissim contains a feature, referred to as “diffusion”, 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. Using this feature leads to undercounting vehicles and is not realistic. The use of “diffusion” 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. Refer to TEOpS 16-5-20 for additional details on the development and use of O-D matrices in microsimulation models.

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 rarely 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 or ramp traffic counts for multiple locations along the corridor at various times/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. Refer to TEOpS 16-5-15 for details on volume balancing methodologies.

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 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 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.

SimTraffic automatically includes the default values as part of the initial model set-up. Vissim, however, requires the analyst to load in the vehicle characteristics files. BTO-TASU worked with a consultant team to develop Wisconsin-specific fleet default values for Vissim. Analysts *should* use the Wisconsin-specific fleet default values for the initial input values into Vissim and adjust them based on project-specific field data as appropriate.

Details on the Vissim WisDOT vehicle fleet settings and the “WisDOT Defaults inpx” Vissim input files are available for download on the BTO Traffic Analysis, Modeling and Data Management Program area webpage.

5.5 Route Assignment

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

16-20-6 Calibration Parameters and Simulation Settings May 2021

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 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 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., no traffic can use that particular roadway segment, link, or lane). Restrictions represent links or lanes that limit travel, 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 is typically applicable 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 taper parallel to the entrance ramp.

6.1.5 Lane Use Parameters

Lane use parameters control the amount and 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 loads 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 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) influence 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 high-level screening of alternatives. 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				

*Recommendation is to have the peak 15-minute interval be the 2nd or 3rd interval in the simulation.
**Seeding interval *should* 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. Unless field data or experience 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 11User 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 25 of the *Synchro Studio 11 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

As noted in TEOpS 16-20-4.3, prior to January 1, 2018, WisDOT supported the use of Paramics. As such, 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. Thus, 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. Unless field data or experience supports doing otherwise, modify only those parameters recommended as settings to adjust. Obtain WisDOT staff approval prior to modifying non-recommended adjustment parameters.

6.4 Vissim Calibration Parameters

Given the complex and iterative nature of model calibration and the vast 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 using 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 performance. 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 “WisDOT Defaults inpx” vehicle compositions [HVS-D1]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 or speed distributions. Direct any specific questions on adjusting the vehicle fleet in Vissim to BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

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

The analyst can define additional car-following and lane-change parameter sets separately as global settings and then only apply them to 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 prepositioning and last-minute lane-changing behavior that may arise.

6.4.8 Other Adjustable Parameters

Unless field data or experience 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 mispresent 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 several 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 (DOTTrafficAnalysisModeling@dot.wi.gov) 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:

1. 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 (runs 11-17 have an increment of 150, runs 18-22 have an increment of 6, and runs 23-28 have an increment of 90). 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.
2. 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. After reviewing the national guidance, BTO-TASU chose to use the methodology outlined in the *Guidance on the Level of Effort Required to Conduct Traffic Analysis Using Microsimulation* (7), published by FHWA in March 2014 as the basis for WisDOT’s policy on determining the number of simulation runs. The FHWA 2014 Guidance (7) methodology 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. 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 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
- Experiences higher-than-average traffic demand during the peak period

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. In other words, filter out data points with atypical conditions such as incidents or inclement weather when modeling normal operating conditions. Likewise, use only comparable situations when analyzing a special condition, such as an event at a stadium. 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, 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 greater than or equal to the estimated number of runs, the test is complete for that location. Continue for other locations and 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, TEOpS 16-20-7.4.5).

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 (DOTTrafficAnalysisModeling@dot.wi.gov).

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 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 meeting (and often exceeding) the required number of runs 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 to assess whether to conduct additional model runs, as it may be necessary to perform additional model calibration. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed and to request the seed values to use for any additional runs beyond 30.

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 for 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).

Identify model run outliers in both the initial seven runs and in any additional required runs. 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 models. 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 are 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 September 2019

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 is effective as of January 1, 2018.**

As of 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 completion date of the existing conditions traffic model is prior to January 1, 2018
- The existing conditions traffic model has undergone the peer review process
- The WisDOT regional traffic engineer or BTO-TASU determined that the model was sufficiently 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. Contact BTO-TASU (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 MOEs. If the model outputs fail to satisfy the validation thresholds 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 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:

- Considering that the acceptance targets for GEH were initially developed for travel demand models, are they 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 did not blend in with travel speeds (i.e., the calculation of travel speeds was simply 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?

Considering 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 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 were previously 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 inputs 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 prior to finalizing the modeling methodology report or proceeding with the development of additional modeling scenarios. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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:

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

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 ± (Mainline Posted Speed X 20%) for >85% of locations
Travel Times	All Routes > 1.5 Miles	Tier 1:	RMSPE <10.0%
		Tier 2:	Within ± 15% for >85% of routes
Queues	All Critical(b) Queue Locations	Tier 1:	Not Applicable
		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 1:	Not Applicable
		Tier 2:	RNSE <3.0% for >85% of locations Consistent with field conditions

(a) All traffic models **shall** undergo volume validation (Tier 1) tests

(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

RMSPE = Root Mean Squared Percent Error, See TEOpS 16-20-8.4 for equation

RNSE = Root Normalized Squared Error, See TEOpS 16-20-8-5.1 for equation

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%

(a) All traffic models **shall** undergo volume validation (Tier 1) tests

(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

RMSPE = Root Mean Squared Percent Error, See TEOpS 16-20-8.4 for equation

8.3.1 Traffic Volumes

All microsimulation traffic models **shall** undergo the Tier 1 volume validation test, 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, contact BTO-TASU (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, contact BTO-TASU (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 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, contact WisDOT regional traffic staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed. 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, contact BTO-TASU (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] All traffic models that do not pass the Tier 1 validation test **shall** undergo the Link/Segment Volume Tier 2 validation tests. All traffic models that include intersections **shall** undergo the Turning Volume Tier 2 validation tests.

[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

All microsimulation traffic models **shall** undergo the volume validation test, however, only those models that fail to pass the Tier 1 volume validation test require the completion of the Tier 2 volume validation test for links/segments. Conversely, the analyst **shall** 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. Literature reviews and evaluation testing informed the development of the RNSE metric. The equations for GEH and RNSE are below.

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

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).

The local link volume test requires a RNSE of less than 3.0 for greater than 85 percent of links over 100 vehicles per hour. The local turning movement volume test requires a RNSE of less than 3.0 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, BTO-TASU(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, contact BTO-TASU (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 for the local travel time validation test. Literature reviews, surveys of other state DOT practices, and evaluation testing informed the development of this validation metric. 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, contact WisDOT regional traffic staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed. 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, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

8.4.4 Queue Lengths

Refer to TEOpS 16-20-3 to identify whether 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).

The validation metric for intersection queue length is a combination of absolute error and percent error. Literature reviews, surveys of other state DOT practices, and evaluation testing informed the development of this validation metric. 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. As with other tests, this metric requires 85 percent of the locations 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 to assess the need for further model calibration. This coordination **shall** occur prior to finalizing the modeling methodology report or proceeding with the development of additional modeling scenarios. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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, contact BTO-TASU (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 BTO-TASU encourages the analyst to perform the quantitative lane utilization validation test for areas where lane usage has a considerable 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, contact BTO-TASU (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. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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 considerable 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 September 2019

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 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, 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, contact BTO-TASU (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 WisDOT-TFS typically provide forecasts for the annual average daily traffic (AADT) and peak-hour intersection turning movement volumes (if requested). The microsimulation models, however, often require the use of O-D matrix tables in addition to or instead of turning movement volumes and typically 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 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. 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, as well as WisDOT-Bureau of State Highway Programs (BSHP), WisDOT-TFS, BTO-TASU, and other stakeholders 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, as well as WisDOT-TFS, BTO-TASU, and other stakeholders as appropriate, to develop the O-D matrices for microsimulation models.

16-20-10 Documentation/Reporting/Presentation of Results September 2019

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 what is the justification for the use of microsimulation?
- 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 the model includes changes to default parameters). 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, contact BTO-TASU (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 varying 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 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 more difficulty understanding how future traffic conditions are going to affect them if density increases by 100%.

Typically, 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 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 usually 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

Most microsimulation models can output a seemingly endless amount of data. 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 overall project.

Understanding the strengths of microsimulation software and knowing how the software calculates different performance measures 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 evaluation 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 distinct colors can help to increase discrimination between the various 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 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 September 2019

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.

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 analyst 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 and WisDOT regional traffic engineering staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed. 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 a critical 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. Typically, 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), it may be possible to justify updating the model to apply the new features. Since major version releases of the software typically involve larger changes to the analysis methodologies, upgrading the traffic model to the latest version release may introduce problems that did not exist previously. As such, BTO-TASU encourages the analyst 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 the use of a specific version of the traffic modeling 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 to a new release of the software. 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 software 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 problems that did not previously exist:

- Current project is almost complete
- Analyst is still using the current model to run test scenarios
- Model is very large and complex
- Newer version if not available to the peer review team

Under the above scenarios, the analyst and project team may decide to upgrade the model later or not at all. Ultimately, before upgrading the model to a new software version, the analyst **shall** consult with the WisDOT project team and WisDOT regional traffic engineering staff. Contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov) for additional support or guidance as needed.

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 analyst an idea of how much work is necessary 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 analyst *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 May 2021

1. **NSW Transport Roads & Maritime Services.** *Traffic Modelling Guidelines.* New South Wales (NSW), Australia: s.n., 2013. ISBN 978-1-922194-21-3.

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 11 User Guide.* 2019. Published December 12, 2019.

5. **Transportation Research Board.** *Highway Capacity Manual 2010.* Washington D.C. 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.

SimTraffic Calibration Settings

Last Updated: 11-27-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per SimTraffic v. 10.1.1.1)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
GLOBAL SETTINGS (Adjusted within SimTraffic)	***Driver Parameters***	Yellow Deceleration (ft/s^2)	7.0 - 12.0	8 to 10	Yes	Increase to make drivers less prone to running red lights.
		Speed Factor (%)	0.85 - 1.15	No range specified	Yes	Can be changed to increase or decrease the range of driver speeds (e.g. for a link speed of 50 mph and a speed factor of 1.1, the driver will attempt to maintain a speed of 55 mph).
		Courtesy Deceleration (ft/s^2)	3.0 - 10.0	7 to 9	Yes	Amount of deceleration a vehicle will accept in order to allow a vehicle ahead to make a mandatory lane change. Higher value = more courteous driver.
		Yellow Reaction Time (s)	0.7 - 1.7	No range specified	No	Amount of time it takes a driver to respond to a signal changing to yellow. More aggressive drivers will have a longer reaction time to yellow lights. Longer reaction times tends to reduce red light running for higher speed approaches and vehicles slowing to make a turn, however, may increase red light running for low speed approaches.
		Green Reaction Time (s)	0.2 - 0.8	0.5 to 2.0	Yes	Amount of time it takes the driver to respond to a signal changing green. More aggressive drivers will have a shorter reaction time to green lights.
		Headway at 0 mph (s)	0.35 - 0.65	No range specified	Yes, typically modify last	Interpolation used between these factors. May be necessary to change to match local driver parameters. The default headways provide an Saturation Flow Rate similar to the HCM (1900 vphpl) from 25 to 50 mph.
		Headway at 20 mph (s)	0.80 - 1.80	2 to 2.5		
		Headway at 50 mph (s)	1.00 - 2.20	1.7 to 2.0		
		Headway at 80 mph (s)	1.00 - 2.20	2.0 to 2.5		
		Gap Acceptance Factor	0.85 - 1.15	No range specified	Yes	Gap vehicles will accept at unsignalized intersections, for permitted left-turns, and for right turns on red. Higher values represent more conservative drivers.
		Positioning Advantage (veh)	1.2 - 15.0	Use defaults	No	Drivers will make a positioning lane change when there is >x vehicles ahead in the target lane than in the current lane. Higher values are associated with more conservative drivers and cause drivers to line up in correct lane. Lowe values are associated with aggressive drivers and cause drivers to avoid lining up in the correct lane until reaching the mandatory lane change point.
		Optional Advantage (veh)	0.5 - 2.3	Use defaults	No	Drivers will make a desired lane change when <x vehicles are ahead in the target lane than in the current lane. Higher values are associated with more conservative drivers and cause drivers to have unbalanced lane use. Lower values are associated with aggressive drivers and cause drivers to use lanes evenly.
		Mandatory Distance Adjustment (%)	50 - 200	No range specified	Yes	Global multiplier for local lane change settings.
		Positioning Distance Adjustment (%)	60 - 150	No range specified	Yes	Global multiplier for local lane change settings.
		Average Lane Change Time (s)	10 - 55	No range specified	No	Average time between lane change maneuvers. Applies only to optional lane changes, which are made to choose a lane with less congestion. Less time applies to more aggressive drivers.
		Lane Change Variance +/- (%)	10 - 30	No range specified	No	Adjustment similar to Average Lane Change Time, but base on driver type. Applies only to optional lane changes, which are made to choose a lane with less congestion. Higher percentage leads to increased awareness of lane change.
	Vehicle Parameters	Vehicle parameters (Occurrence, acceleration, dimensions, etc.)	See Synchro Studio 10 User Guide, Chapter 26 (page 26-7)	Defaults typically acceptable Modify vehicle fleet based on field classification counts if needed	Yes	Modify vehicle percentages based on nearest classification count. Fleet mix should add up to 100% for all truck types and 100% for all car types.

SimTraffic Calibration Settings

Last Updated: 11-27-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per SimTraffic v. 10.1.1.1)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
LOCAL SETTINGS (Adjusted within Synchro)	***Synchro Settings***	Link Speed (Lane Settings)	30	Start with posted. Adjust to reflect free flow speed (typically posted + 5 mph), if needed.	Yes	May be adjusted to match field speeds if data is available and speeds are not being used for validation
		Ideal Saturation Flow Rate (Lane Settings)	1,900	Adjust to match field if field data is available	Yes	Refer to TEOpS 16-15-5 for additional guidance on saturation flow rates for through lanes
		Growth Factor (Volume Settings)	1.0	Use for sensitivity testing or future year scenarios. Do not use for RTOR	No	
		Headway Factor (Simulation Settings)	1.0	0.8 to 1.2	Yes	Can be set on a per-movement basis. Can be used to calibrate the Saturated Flow Rates.
		Turning Speed (Simulation Settings)	9 mph (right-turns) 15 mph (left-turns)	Right turns = 12 to 15 mph	Yes	Default speeds are set for small radius urban intersections. With large suburban intersections, turning speeds may be significantly higher. Right-turns speeds need to be adjusted to or near the freeway speeds when simulating entrance ramps. At low speeds, the Saturated Flow Rate is highly sensitive to small changes in speed. Right-turns: SimTraffic = 9 mph (1545 vph). HCM for protected rights = 1615 vphpl Left-turns: SimTraffic = 15 mph (1883 vph). HCM for protected left-turns = 1805 vph.
		Mandatory Distance (Simulation Settings)	333	Base on field conditions	Yes	Distance ahead vehicle is forced to make lane change. Measured from Stop bar. Increase to allow vehicles to shift into correct lane earlier. Decrease to allow vehicles to shift into lane at the last possible moment. Large cities: Shorter mandatory distances Small towns: Longer mandatory distances. Useful to adjust with congested signals or lane drops after signals. With long turn bays consider setting this to less than the storage distance to allow for some late lane changes.
		Positioning Distance (Simulation Settings)	1320	Base on field conditions	Yes	Distance ahead vehicle starts to attempt lane change. Measured from Stop bar.
		Mandatory Distance2 (Simulation Settings)	880	Base on field conditions	Yes	Additional mandatory distance to make 2 lane changes. Measured from Stop bar. Typically used more for high-speed facilities. See Synchro Studio 10 User Guide, Chapter 28 (pages 28-5 to 28-18)
		Positioning Distance2 (Simulation Settings)	1760	Base on field conditions	Yes	Additional positioning distance to make 2 lane changes. Measured from Stop bar. Typically used more for high-speed facilities. See Synchro Studio 10 User Guide, Chapter 28 (pages 28-5 to 28-18)
		Lane Alignment (Simulation Settings)	Right for right-turns Left for left-turns and thru movements Right-NA for U-turns	Base on field conditions	Yes	
		Enter Blocked Intersection (Simulation Settings)	"No" for intersections	Code 1 vehicle if used Yes for driveways No for high speed movements	Yes	Enter "No" for high speed approaches and movements. "Yes" can help capacity of driveways. In general, controls gridlock avoidance.
		Taper Length (Simulation Settings)	25	Code as part of storage based on field conditions	Yes	Impacts when vehicles can start entering the storage.

Paramics Calibration Settings

Last Updated: 08-31-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Paramics v. 6.9.3)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
GLOBAL SETTINGS	***Core Settings***	Time steps	2	2 to 4, Typically 4 for models with freeway merging	Yes	Higher Time Step allows vehicles to make decisions based on the car following and lane change logic at a higher frequency.
		Queue gap distance (ft)	32.81	Typically not modified	No	Maximum distance between queuing vehicles.
		Queuing speed (mph)	4.47	Typically not modified	No	Maximum speed of queuing vehicles.
		Heavy vehicles weight (ton)	2.95	Typically not modified	No	Minimum weight of a heavy vehicle.
		Mean target headway (s)	1.00	Urban areas: 0.85 to 0.90 Small Cities: 0.90 to 0.95 Rural areas: 0.95 to 1.00	Yes	Raise to increase distance between vehicles and represent more passive drivers. Lower to decrease distance between vehicles and represent more aggressive drivers.
		Mean driver reaction time (s)	1.00	Urban areas: 0.85 to 0.90 Small Cities: 0.90 to 0.95 Rural areas: 0.95 to 1.00	Yes	Value is associated with the lag in time between a change in speed of the preceding vehicle and the following vehicle's reaction to this change. Raise for more passive drivers. Lower for more aggressive drivers.
		Speed memory	3	1.5x the Time steps value	Yes, if time step value is changed.	Speed Memory is used to store previous vehicle speeds at each Time Step. Speed Memory x time step should be > than the global Driver Reaction Time.
		Minimum gap (ft)	6.56	Typically not modified	No	Minimum gap between stationary vehicles in a queue.
		Loop length (ft)	6.56	Typically not modified on global level	No	Default distance between upstream and downstream edges of a loop detector (2 meters). Detector lengths may be modified locally as well.
		Amber time (s)	3	Typically not modified on global level	No	Default yellow time included in traffic signal phases. This setting should be modified locally based on field signal timing and phasing settings.
		Red time (s)	5	Typically not modified on global level	No	Default red time included in traffic signal phases. This setting should be modified locally based on field signal timing and phasing settings.
		Default curve speed factor	1	Typically not modified	No	Allows vehicles to make turns at a safe speed. Typically not modified.
		Speed drift unit	5	Typically not modified	No	Specifies minimum number of units that the link speed can be altered by in the Link Editor. Typically not modified.
		Wrong lane diversion time (s)	300	Typically not modified	No	Additional cost a vehicle would tolerate in order to reach its destination by choosing an alternative route. Only applies to links that have the "re-route stuck vehicles" flag enabled.
	Assignment Settings	Assignment settings-Time Cost Coefficient	1.000	0.667	Yes, change from default in initial network setup.	Coefficient that defines how travel time affects routing for all vehicles in the network.
		Assignment settings-Distance Cost Coefficient	0.000	0.333	Yes, change from default in initial network setup.	Coefficient that defines how distance affects routing for all vehicles in the network.
		Assignment settings-Toll Price Cost Coefficient	0.000	0	Only if tolling applies. Should be based on prevailing wage rate in the study area.	Coefficient that defines how toll pricing affects routing for all vehicles in the network.
		Assignment settings-Dynamic Assignment: Feedback Period	0	Start with 5 minute feedback period	Yes, change in small increments	Sets period at which link times are fed back into the routing calculations. At the beginning of each feedback period route cost tables are calculated for each viable network node to each destination zone.
		Assignment settings-Dynamic Assignment: Feedback Smoothing	0.500	Adjust to reflect field conditions	Yes, change in small increments	Determines the percentage of historical data to be included in the routing table calculations. The lower the value the more emphasis is placed on historic data.
		Assignment settings-Dynamic Assignment: Feedback Decay	0.995	0.3 to 0.5	Yes, change in small increments	Reduces dynamic feedback costs over time if there is no new data to make new calculations with. This avoids having a rapid oscillation in costs.
		Assignment settings-Dynamic Assignment: Feedback Envelope	0	Adjust to reflect field conditions	Yes, change in small increments	Defines how delay at a distance from a vehicle affects routing decisions. The further away a delay value is from the driver's position, the less weight the driver applies to their route choice decision.
		Assignment settings-Matrix Tuning Level	None	Typically not modified	No	Modifies the demand distribution during simulation. For large networks there is a performance penalty with selection this option.
	Other Parameters	Other parameters-Vehicle types (proportion, familiarity, kinematics, dimensions, etc.)	-	Use Wisconsin-tailored vehicles file. Adjust vehicle type proportions to represent field conditions if possible.	Yes	Adjust to reflect vehicle proportions observed in the field.
		Other parameters-Other global parameters (options menu, etc.)	-	1) Check "Heavies Use All Lanes" 2) TWOPAS HGV climbing model 3) Gap reduction for stopped buses	1) Always check "Heavies Use All Lanes" 2) TWOPAS HGV climbing model use is project specific. 3) Gap reduction for stopped buses use is project specific	1) Allows heavy vehicles (i.e. trucks) to drive in all lanes. WI does not require trucks to stay in right lane. 2) TWOPAS HGV climbing model allows for grades coded in model to affect truck kinematics. Additional effort in coding grades accurately and correctly is needed. 3) Gap reduction for stopped buses should only be used in special-case scenarios where pick ups and drop offs are being modeled.

Paramics Calibration Settings

Last Updated: 08-31-2017

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Paramics v. 6.9.3)	Recommended Parameter Value	Typical Parameters Adjusted During Calibration	Parameter Description
LOCAL SETTINGS	***Link Parameters***	Link Speed	Varies, set by link category	Use field data to code links speeds. If field data is not available, code link speed as posted speed	Yes, changes that stray from posted speed limit should be based on field data.	Drivers typically drive 10% over the posted speed limit in uncongested conditions. Link speed may need to be adjusted to reflect observed travel speeds.
		Link Signpost and Signrange	Varies, set by link category	Base on field conditions. Allow signpost to enter zone on freeways.	Yes	Controls how and when vehicles move to the correct lane upstream of a hazard. Propagation of signposting can be used for widening hazards.
		Link Force Merge	unchecked	Lower priority use	Yes, use sparingly	For links with priority other than major, drivers that have exceeded their patience threshold will force their way into the flow of traffic as long as a conflicting vehicle is not in the driver's path.
		Link Force Across	unchecked	Lower priority use	Yes, use sparingly	For links with priority other than major, drivers that have exceeded their patience threshold will force their way across traffic to join any desired traffic stream as long as a conflicting vehicle is not in the driver's path.
		Link Force Vehicle Aware	unchecked	Could be adjusted if applicable	Yes, if applicable	Used in shared-space pedestrian applications. Can be used to improve the quality of vehicle/pedestrian interaction logic by forcing all vehicles to be aware of pedestrians.
		Link Reaction factor	1.00	Lower priority use, small adjustments only	Yes, use sparingly	Value is associated with the lag in time between a change in speed of the preceding vehicle and the following vehicle's reaction to this change. Raise for more passive drivers. Lower for more aggressive drivers.
		Link Headway factor	1.00	Lower priority use, small adjustments only	Yes, use sparingly	Raise to increase distance between vehicles and represent more passive drivers. Lower to decrease distance between vehicles and represent more aggressive drivers.
		Link Approach Visibility	Normal Link = 0 Roundabout approach = 32.8	Important for roundabouts. Can be used with other unsignalized control.	Yes, typically adjusted with roundabouts.	Aids in vehicles identifying gaps at an unsignalized intersection approach. Important for roundabout calibration.
		Link Stimulus Time	5	Typically not modified based on survey results	No	Lower value results in faster decision time for lane change
		Link Transition Time	5	Typically not modified based on survey results	No	Lower value results in faster lane changing maneuver
		Category Cost Factors	0.8 to 1.0	Typically not modified from defaults	No	Aids in routing control for unfamiliar drivers
		Link Cost Factor	1.00	Adjust as needed to correct local routing issues.	Yes	Aids in routing control for all drivers
	Node Parameters	Node parameters-Allow sneaking	Unchecked	Could be used at congested intersections	Yes	Applies only when multiple vehicles are waiting to transfer to the same outbound link. Allows blocked vehicles to perform their movement before other vehicles of a higher priority. Could be used to reduce queue lengths and simulate more aggressive driving behavior.
		Node parameters-Anticipate gaps	Unchecked	Could be used at congested intersections	Yes	By default vehicles wait for crossing vehicles to complete clear a node before completing their turning movement. This option allows vehicles to complete turning movement once the driver's path across the node is cleared. Could be used to reduce queue lengths and simulate more aggressive driving behavior.
		Turning Penalties	1.00	No range specified	No	Aids in routing control for all drivers
	Entrance Ramp Parameters	Entrance ramp settings-Minimum Ramp Time (s)	2	0 to 2 Typically 1	Yes	Specifies amount of time vehicles must spend on the ramp prior to considering merging maneuver. Use 0 seconds as last resort after modifying headway, ramp aware, or other parameters to calibrate entrance ramp. Use of 0 seconds may be necessary with high volume merges and/or freeway segments.
		Entrance ramp settings-Headway Factor	1.00	0.80 to 1.00	Yes	Target headway for all vehicles on the entrance ramp. Raise to increase distance between vehicles and represent more passive drivers. Lower to decrease distance between vehicles and represent more aggressive drivers.
		Entrance ramp settings-Ramp Aware Distance (ft)	656.2	Modify on case-by-case basis depending on field conditions (topography, visibility of onramp, signing, etc.) and driver behavior or courtesy in study area	Yes	Defines point at which vehicles on the mainline become aware of the entrance ramp. Mainline drivers will only change lanes to allow for merging gaps and will not decelerate or accelerate to create gaps.
	Other Parameters	Other parameters-Gap Acceptance Rules	-	Lower priority use	Yes	Estimation of the minimum time required to clear the theoretical collision point with oncoming vehicles. If time is less than estimation, the driver will complete their movement. Typically used to calibrate queues at unsignalized intersections.
		Other parameters-Variable Speed Limit Rules	-	Typically not modified	No	Controls the speed limit on a route over a set timeframe. Transition times can be specified to avoid abrupt changes.
		Other parameters-Dynamic Tolling Rules	-	Typically not modified	No	May be used in HOT analysis.
		Other parameters-Spatial Test Transfer Rules (Merge or Crossing)	-	Could be used	Yes, typically with roundabouts or short links	Aids in gap acceptance. Generally used with roundabouts or areas with short links.
		Other parameters-Spatial Test Movement Rules	-	Could be used	Yes, typically with roundabouts or short links	Aids in gap acceptance. Generally used with roundabouts or areas with short links.

VISSIM Calibration Settings

Last Updated: 03-30-21
Source: PTV Vissim 2020 User Manual

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Vissim v. 2020.00-11)	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)	100: Car, 50:50 km/h, 0.980 200: Car, 50:50 km/h, 0.020	Adjust to represent field conditions	Yes	Adjust relative flows to represent field conditions
		Pedestrian Composition (Ped Type; DesSpeedDistr; RelFlow)	100: Man, 1022:IMO-M 30-50, 1.000 Woman 1023:IMO-F 30-50, 1.000	Adjust to represent field conditions	Yes	Adjust relative flows to represent field conditions
	Base Settings	Vehicle Fleet		Use "WisDOT Defaults inpx" as default	Yes	Adjust to represent field conditions
		Vehicle/Pedestrian Types	Car, HGV, Bus, Tram, Pedestrian, Bike	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
		Vehicle/Pedestrian Classes	Car, HGV, Bus, Tram, Bike Man, Bike Woman, Man, Woman, Woman & Child, Wheelchair	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)	-	Use "WisDOT Defaults inpx" as default	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 "WIsDOT Defaults inpx" 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 us 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

VISSIM Calibration Settings

Last Updated: 03-30-21
Source: PTV Vissim 2020 User Manual

Type of Setting	Parameter Grouping	Parameter Name		Default Settings (per Vissim v. 2020.00-11)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description
LOCAL (CONT)	***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/s2	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/s2	Typically not modified	No	Desired acceleration when starting at 80 km/h, approximately 50 mph, (limited by maximum acceleration defined within the acceleration curves).
	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/s2	-15 to -12	Yes	Upper bound of deceleration for own vehicle. Higher absolute value means more aggressive lane changing behaviors
		-1 ft/s2 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/s2	-12 to -8	No	Upper bound of deceleration for trailing vehicle. Higher absolute value means more aggressive lane changing behaviors
		-1 ft/s2 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	99999.00	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.

VISSIM Calibration Settings

Last Updated: 03-30-21
Source: PTV Vissim 2020 User Manual

Type of Setting	Parameter Grouping	Parameter Name		Default Settings (per Vissim v. 2020.00-11)	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 stoping 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). $p = \frac{1}{1+e^{-\alpha-\beta_1 v-\beta_2 dx}}$ 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

VISSIM Calibration Settings

Last Updated: 03-30-21
Source: PTV Vissim 2020 User Manual

Type of Setting	Parameter Grouping	Parameter Name	Default Settings (per Vissim v. 2020.00-11)	Recommended Parameter Range	Typical Parameters Adjusted during Calibration	Parameter Description
LOCAL (CONT)	***Connector-level***	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
	Point-level	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.

Traffic Engineering, Operations & Safety Manual

Chapter 16 Traffic Analysis & Modeling

Section 25 Traffic Model Peer Review Policy

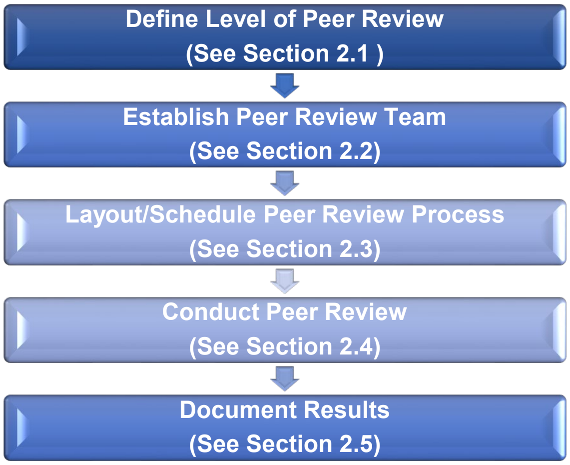
16-25-1 Introduction September 2019

This policy addresses the peer review process for traffic models utilized to conduct traffic operations analysis for the evaluation and design of all transportation improvement projects. For this policy, traffic models refer to both the Highway Capacity Manual (HCM)-based traffic analyses and microscopic simulation (microsimulation) analyses. This policy does not cover the travel demand models (TDMs) utilized to generate traffic forecasts. Refer to the Transportation Planning Manual (TPM) for additional details regarding traffic forecasting protocols. All projects that include traffic models **shall** follow the peer review process. Coordinate with the WisDOT regional traffic staff to determine how best to implement the peer review process. Contact the Bureau of Traffic Operations (BTO) – Traffic Analysis and Safety Unit (TASU) for additional guidance and support as needed.

1.1 Overview

A peer review is a structured process for reviewing a traffic model to ensure the use of sound engineering judgment. The primary goal of the peer review process is to protect the department's and public's interests by verifying the integrity of the traffic model by assuring that it provides a reasonably accurate representation of traffic conditions that exist in the field. There are four levels of peer review, which are dependent on the complexity of the traffic model. It can take anywhere from six weeks to over four months to conduct a peer review of the traffic model for one analysis scenario. This may significantly affect the overall schedule and budget for a project. Thus, the project team *should* consider time, budget, and other resource requirements of the peer review process early on during project scoping. Figure 1.1 highlights the key steps of the peer review process for HCM and microsimulation traffic models.

Figure 1.1. Traffic Model Peer Review Process Overview



1.2 Background

Historically, there was a lack of consistency in when and how the department reviews the HCM and microsimulation traffic models. To improve consistency across the state concerning the review of these traffic models, BTO-TASU developed the Traffic Model Peer Review policy, focusing on steps 6 and 11 of the overall traffic model (does not include TDMs) development and review process. See TEOpS 16-1-1, Attachment 1.1 for an illustration of the overall traffic model development and review process.

16-25-2 Process September 2019

2.1 Define Level of Peer Review

It is the responsibility of the project manager to ensure that the traffic model is peer reviewed, while it is up to region traffic operations to define the peer review requirements. To assist with defining the peer review requirements, this policy defines four levels of peer review for traffic models:

1. Project team level review – The WisDOT project team leads the peer review process, providing a high-level (e.g., spot-check) and independent (i.e., the reviewer cannot be part of the team developing the

traffic model) review of the traffic model. The WisDOT regional traffic modeler (if available) or regional traffic staff will provide an in-depth review of the traffic model as needed. If the regional office does not have the available knowledge or resources, they may contact BTO-TASU for assistance with the in-depth review.

2. Region level review – The WisDOT regional traffic modeler/traffic staff lead the peer review process. The WisDOT project team will provide oversight of the peer review process and BTO-TASU, WisDOT Traffic Forecasting Section (TFS), and other statewide bureaus (SWBs) will assist in the peer review as needed. The WisDOT regional office will provide an in-depth review of the traffic model. If the WisDOT regional office does not have the available knowledge or resources, they may contract with an independent consultant (one that is not a member of the consultant team developing the traffic model) to assist as necessary.
3. Independent consultant level review – An independent consultant typically leads the peer review process but works closely with the WisDOT regional traffic modeler/traffic staff on all aspects of the review. The WisDOT project team will provide oversight of the consultant's peer review and BTO-TASU, WisDOT TFS, and other SWBs will assist in the peer review as needed. The independent consultant will provide an in-depth review of the traffic model while the regional traffic modeler/traffic staff will typically provide a high-level review. In cases where the regional office has the knowledge and resources available, they may choose to forego the use of an independent consultant.
4. SWB level review with Federal Highway Administration (FHWA) oversight - An independent consultant typically leads the peer review process but works closely with the WisDOT regional traffic modeler/traffic staff, BTO-TASU, WisDOT TFS, and other SWBs on all aspects of the review. The independent consultant will provide an in-depth review of the traffic model while the regional traffic modeler/traffic staff and SWBs will typically provide a high-level review. In cases where the regional office has the knowledge and resources available, they may choose to forego the use of an independent consultant.

   Projects constructed with federal funds require FHWA oversight of the peer review process to ensure that the traffic model adheres to federal guidelines. The extent of FHWA involvement will vary depending on the specifics of the proposed project.

   Note: See the TPM for details on WisDOT TFS involvement with traffic model peer reviews.

The level of peer review will vary depending on the complexity of the traffic model, which is dependent on the project type (mega/major project, high profile project, routine improvement project, etc.), project scope, corridor type, traffic control, roadway congestion level, and traffic analysis tool(s) utilized. However, a project team or region level review is typically sufficient for most HCM-based traffic models. The SWBs, specifically BTO-TASU and WisDOT TFS, will be involved on high-profile projects, mega/major projects, and those projects that have potential for FHWA involvement.

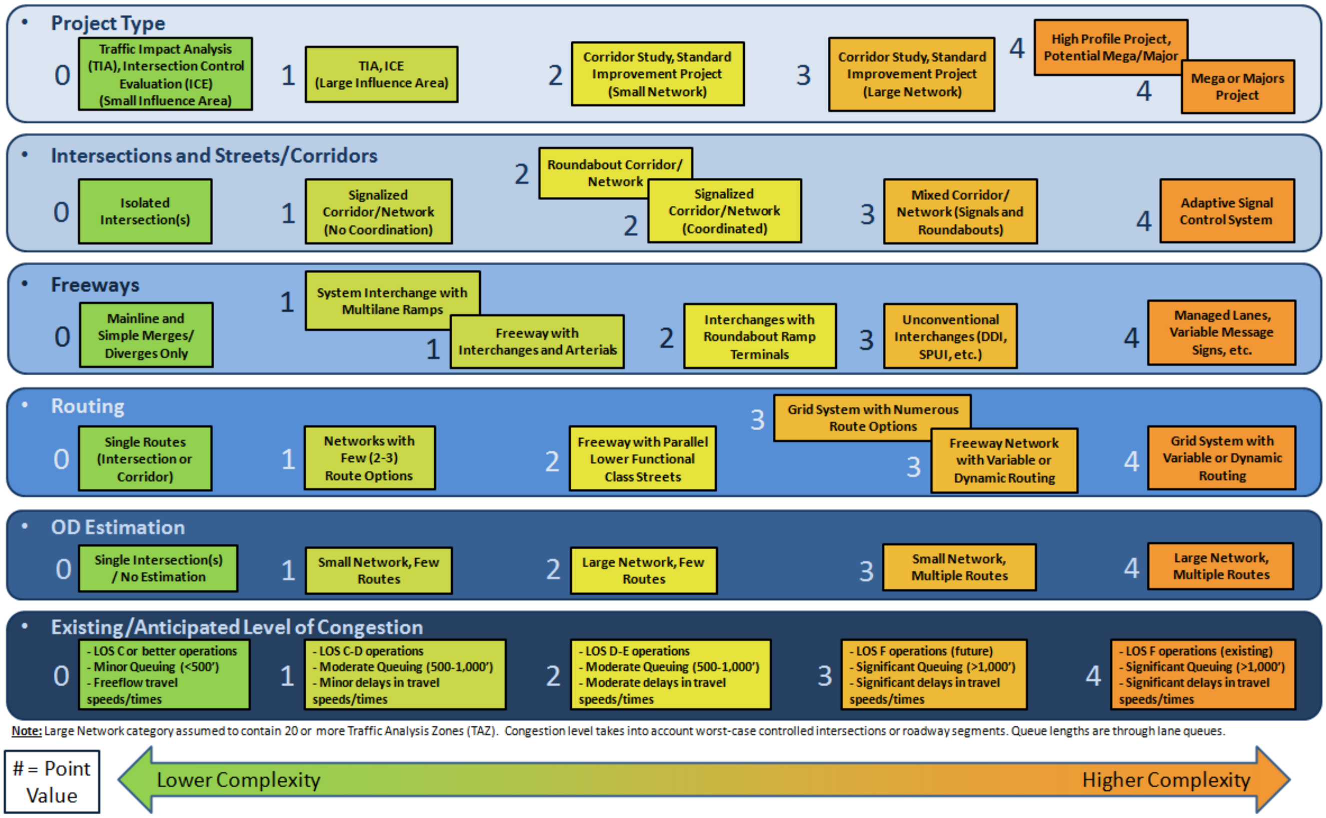
The level of peer review may significantly impact the overall schedule and budget for a project and *should* be determined early on during project scoping. However, the project team often must wait for the initiation of the traffic analysis to define the level of peer review required. Therefore, the project team *should* assume the need for the highest potential peer review level when defining the schedule and budget for a project.

To quantify the level of complexity associated with building and reviewing a traffic model (specifically a microsimulation traffic model), the department worked with a consultant to establish a scoring system. The scoring system defines the level of complexity and the level of peer review required by assigning points within the following categories:

1. Project type
2. Geometric conditions
   a. Arterial corridor
   b. Freeway corridor
3. Traffic pattern/conditions
   a. Routing options
   b. Origin-destination (O-D) matrix development
   c. Level of congestion (existing and future)

Within the geometric conditions category there are two subcategories to define the type of corridor included in the analysis: arterial corridor (includes individual intersections, streets, or corridor segments) and freeway corridor. The traffic pattern/conditions category contains three subcategories: routing options, O-D matrix development, and existing/anticipated level of congestion. Figure 2.1 provides an illustration of the traffic model level of complexity scoring system.

Figure 2.1. Traffic Model Complexity Scoring Diagram



Note: Large Network category assumed to contain 20 or more Traffic Analysis Zones (TAZ). Congestion level takes into account worst-case controlled intersections or roadway segments. Queue lengths are through lane queues.

As illustrated in Figure 2.1, there are several factors within each category and subcategory that define the complexity of a traffic model. For example, the complexity of a traffic model for an arterial corridor is dependent on whether the traffic model is an isolated intersection, an uncoordinated signalized corridor, a coordinated signalized corridor, a roundabout corridor, a mixed traffic control corridor (e.g., a corridor with signals and roundabouts), or an adaptive signal control system. Every factor has an associated level of complexity based on a scale of 0 to 4 (an isolated intersection has a complexity score of 0 while an adaptive signal control system has a complexity score of 4). If multiple factors are applicable, the score associated with the highest level of complexity dictates the overall score for that category or subcategory. For example, a Traffic Impact Analysis (TIA) project with a small influence area by itself has a complexity score of 0; however, if the TIA is a high-profile project the score for the “project type” category would be 4. Sum the highest score within each category/subcategory to determine an overall complexity score for the traffic model (maximum score of 24). The higher the overall complexity score, the more likely it is that microsimulation traffic models will be necessary. Refer to Attachment 2.1, an Excel-based template, for assistance with developing the overall complexity score for the traffic model. In coordination with WisDOT regional traffic staff, the WisDOT project team’s traffic lead or project manager *should* complete the traffic model complexity-scoring template.

The overall traffic model-complexity-score defines the minimum peer review requirements for the project. It is possible to complete a higher (more intense) level of peer review. Ultimately, it is up to WisDOT regional traffic staff to define the final peer review requirements. Refer to Table 2.1 for the complexity score associated with each peer review level.

Due to modified roadway geometry, increased traffic volumes, reduced levels of congestion, etc., it is possible for the traffic 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 level of peer review required. The highest traffic model-complexity-score across all the scenarios (existing and future alternatives) dictates the minimum peer review requirements.

Table 2.1. Peer Review Level Requirements

Total Complexity Score [(a)]	Minimum Required Peer Review	Notes
0-3	Project Team Level Review [(b)]	• WisDOT project team leads peer review • WisDOT regional traffic staff provides in-depth review as needed
4-7	Region Level Review [(b)]	• WisDOT regional traffic staff provides in-depth review, • SWBs provide assistance as needed • Independent consultant review as needed
8-10	Independent Consultant Level Review	• Independent consultant leads review [(c)] • WisDOT regional traffic staff provides high-level review • SWBs provide assistance as needed
11+	SWB Level Review with FHWA Oversight [(d)]	• Independent consultant leads review [(c)] • WisDOT regional traffic staff and SWBs provide high-level review • FHWA oversight may be necessary

(a) The scoring system identified within this table **shall** act as a guide and not as a rigid requirement. Ultimately, determination of the necessary level of peer review requires professional judgment.

(b) A project team or region level review is sufficient for most HCM-based traffic models.

(c) If the WisDOT regional office has the required knowledge and resources, they may choose to forego the use of an independent consultant.

(d) This indicates when there is a high probability for FHWA oversight. Prior to developing the traffic models, the WisDOT project team *should* coordinate with FHWA to determine their level of involvement (if any).

2.2 Establish Peer Review Team

Upon defining the peer review requirements, the WisDOT project team *should* meet with WisDOT regional traffic operations to identify the peer review participants and establish all internal and external stakeholders. This meeting *should* occur as early as possible but **shall** occur prior to the initiation of the traffic analysis.

Table 2.2 provides a summary of the stakeholders to consider for inclusion on the peer review team. The peer review process will vary slightly from one project to another, thus Table 2.2 *should* serve as a guide (not a rigid requirement) when establishing the peer review team.

Although Table 2.2 provides insight into when to involve the SWBs or FHWA with the peer review, unique situations not covered in the table may also trigger the need to involve a SWB or FHWA. Thus, the project team *should* coordinate with the SWBs and FHWA during project scoping to verify their level of involvement (if any) in the peer review process. In general, the SWBs (specifically BTO-TASU) will be involved on all mega/major projects and projects where FHWA participation in the peer review process is desired or required.

If the WisDOT regional office does not have the knowledge or resources available to conduct the peer review of the traffic model, the project manager, in all likelihood, will need to select and procure an independent consultant to complete the peer review, regardless of the traffic model complexity. If desired, the WisDOT regional office may contact BTO-TASU for support. BTO-TASU may also be able to conduct the peer review of the simpler traffic models (traffic model-complexity-score of 0-7).

Table 2.2. Potential Peer Review Participants

Stakeholder (a)	Level of Involvement	Notes
Region		
• WisDOT Regional Traffic Operations • WisDOT Regional Traffic Modeler (if available)	• All levels of peer review	Roles/responsibilities will vary based on level of review required
Statewide Bureaus		
• BTO-TASU • Other SWBs as necessary	• SWB with FHWA oversight level review	Provides assistance as needed on all levels of peer review Provides high-level review of all projects with potential for FHWA involvement
• WisDOT TFS	• All levels of peer review	See the TPM for details on TFS involvement with traffic model reviews
External Stakeholders		
• Independent Consultant	• Independent consultant level review • SWB with FHWA oversight level review	May get involved on lower level reviews if WisDOT regional staff do not have the necessary resources (b)
• FHWA	• FHWA oversight review	Typically involved on mega/major projects and federally funded Interstate Access Justification Reports (IAJRs)
• Local Municipalities, Regional Planning Commissions (RPCs), Metropolitan Planning Organizations (MPOs)	Typically, will not review the traffic model, but may participate in peer review discussions to ensure that the traffic model addresses local concerns(c)	

(a) The peer review team established for a specific project may include more or fewer members than those listed above.

(b) WisDOT regional traffic staff *should* assess whether they have the knowledge and resources to complete the peer review; if not BTO-TASU may be able to help with the peer review for models with a complexity score of 7 or less. If neither WisDOT regional staff nor BTO-TASU has the capability to conduct the peer review, the WisDOT project team **shall** select/procure an independent consultant to complete the peer review regardless of the traffic model complexity.

(c) Early coordination with the Southeastern Wisconsin Regional Planning Commission (SEWRPC) for mega/major projects located in the SE region is highly recommended.

If there is a need for an independent consultant, the WisDOT project team *should* follow the process outlined in the department's Facilities Development Manual Chapter 8, Section 5 (FDM 8-5) to select and procure a consultant team to perform the necessary peer review. The Statewide Master Contract for Traffic Analysis and Modeling (BTO 03) and the Statewide Master Contract for Traffic Engineering Services (BTO 01) identifies the consultants that have been previously selected and authorized to conduct traffic engineering services (including traffic model peer reviews). The list of consultants on the master contracts are updated every two-years and are available through the Contract Administration Reporting System (CARS) application or through BTO-TASU. If desired, BTO-TASU can provide assistance with the selection of the independent peer review consultant.

To ensure a truly independent peer review, it is critical that the consultant chosen to conduct the peer review does not have any affiliation or conflict of interest with the consultant team selected to perform the traffic analysis.

2.3 Layout/Schedule Peer Review Process

Upon establishing the peer review team, the WisDOT project manager **shall** coordinate with the peer review team (typically via a coordination meeting) to identify the following components of the peer review process:

1. Project milestones which will trigger the need for a peer review
2. Roles of the individual peer review members
3. Data requirements

4. Schedule for conducting the peer review(s)
5. Transfer process for traffic model(s) and peer review comments

The following provides additional discussion on each of these components.

2.3.1 Identify Project Milestones

There are typically three major project milestones for a peer review: (1) completion of the existing year traffic model, (2) completion of the design year no-build traffic model and (3) completion of each design year build/project alternative traffic model. Complex traffic models may warrant the need for peer reviews at additional project milestones, such as after the initial coding of the traffic model but prior to the full calibration of the traffic model. At the completion of the coordination meeting, both the project team and peer review team *should* have a clear understanding of where the peer review(s) *should* fall within the overall project timeline.

With HCM-based traffic models, the review of the existing year, design year no-build, and design year build/project alternative traffic models can occur simultaneously. However, due to their complexity, microsimulation traffic models will typically require a peer review at each of the three milestones described above. BTO-TASU strongly encourages the consecutive review of the existing year, the design year no-build, and the design year build/project alternative traffic models.

In other words, 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 (e.g., design year no-build, design year build, etc.). If the analyst chooses to develop the model alternatives prior to calibrating and validating the existing conditions model 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, or peer review process of the existing conditions model, it may end up being counterproductive, and thus, BTO-TASU strongly discourages doing such.

The subsequent text provides a description of the three major milestones.

Milestone 1: Completion of Existing Year Traffic Model

The existing 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 extraordinary circumstances may dictate the need to use older data or data from multiple years.

This project milestone requires a peer review to ensure that the traffic model provides an accurate representation of field conditions based on data collected by the project team or peer review team. At this milestone, WisDOT TFS *should* verify that the traffic model and traffic forecasts utilize a consistent existing volume data set.

Milestone 2: Completion of Design Year No-Build (FEC) Traffic Model

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 modification. As such, another name for this scenario is the future with existing plus committed (FEC) scenario. The inclusion of a planned improvement project in the FEC model is contingent on it occurring after the existing year but prior to the proposed project's design year. 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. Thus, WisDOT TFS *should* verify that both the traffic model and traffic forecasts reflect the same assumptions (e.g., number of travel lanes).

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 represents future with existing plus committed plus minor improvements (FEC+) conditions. The project team *should* document these minor improvements within the modeling methodology report and other project memoranda as appropriate.

This project milestone requires a peer review to confirm that the traffic model accurately depicts design year traffic volumes and to verify that the basic structure of the model is consistent with the existing year traffic model. If the analyst properly addresses and carries forward comments from the existing year model, the peer review process at the FEC project milestone *should* be less intensive than the initial peer review.

Milestone 3: Completion of Each Design Year Build/Project Alternative Traffic Model

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.

Each project alternative model requires a peer review. Peer reviews are necessary at this project milestone to ensure that the traffic model is consistent with the previous traffic models and to verify that it accurately captures the proposed improvements. Checking for geometric improvements, changes in travel demand/traffic patterns, and consistency against the existing and no-build traffic models *should* be the focus of the design year alternative model reviews. WisDOT TFS *should* verify that both the design year build traffic models and traffic forecasts reflect the same assumptions (e.g., number of travel lanes).

2.3.2 Outline Roles/Responsibilities

Table 2.1 and Table 2.2 (shown previously) may be able to assist in the assessment of the general roles (e.g., high-level review, assistance as needed, etc.) for each peer review team member. The project manager, however, *should* clarify the specific team member responsibilities (e.g., responsible for reviewing model network, responsible for reviewing traffic volume data, etc.) during the coordination meeting.

2.3.3 Define Data Requirements

In an ideal world, the analyst will collect all the traffic data needed to validate that the traffic model is properly calibrated (i.e., provides an accurate representation of real-world conditions) during the development of the traffic model. In some instances, however, it may be necessary for the peer review team to gather additional data as part of the peer review process. If there is a need to collect additional data, during the initial coordination meeting, the project team *should* define the data collection plan (e.g., how to obtain the data, when to collect the data, and who will collect the data). Refer to TEOpS 16-5 for additional details on data assembly and preparation.

Additionally, the peer review team *should* discuss whether there are any previously developed traffic models (specifically microsimulation traffic models) that could serve as a resource for the development, calibration, validation, and peer review of the proposed traffic model.

2.3.4 Define Preliminary Schedule

The schedule for the peer review is highly dependent on the complexity of the traffic model and level of peer review required. The peer review of a highly complex traffic model that requires FHWA oversight will take longer to complete than the peer review of a relatively simple traffic model that only requires a project team level review. Since the peer review schedule impacts the overall schedule of the project, it is critical for the project team to define the peer review timeline as early in the project as possible, preferably during project scoping. The project team can utilize Table 2.3 to approximate the amount of time within the overall project schedule to allow for the peer review process. The timelines provided in Table 2.3 assume that WisDOT TFS have already generated or reviewed and approved the traffic forecasts utilized within the traffic model.

Except for FHWA, all members of the peer review team may conduct their review of the traffic model(s) simultaneously. With concurrent reviews, the peer review members *should* coordinate often during the review process to avoid unnecessary duplication of review efforts. WisDOT *should* complete all internal department peer reviews (project team, region, independent consultant, statewide bureau reviews) prior to FHWA reviewing the traffic model(s). FHWA, however, may be available to answer questions and to provide suggestions for items to consider during internal department reviews.

Table 2.3. Peer Review Time Requirements

Level of Peer Review	Approximate Time Required to Complete Initial Peer Review (Including data collection, coordination, etc.)
Project Team Level Review	• 1-2 weeks for existing conditions • 1-2 weeks for each additional project milestone/alternative
Region Level Review	• 3-4 weeks for existing conditions • 3-4 weeks for each additional project milestone/alternative
Independent Consultant Level Review	• 4-8 weeks for existing conditions • 4-8 weeks for each additional project milestone/alternative
SWB Level Review *Without FHWA Oversight*	• 4-8 weeks for existing conditions • 4-8 weeks for each additional project milestone/alternative
With FHWA Oversight	• 12-16 weeks for existing conditions • 12-16 weeks for each additional project milestone/alternative

Notes:

- The time ranges shown here are approximate, thus the project team *should* only utilize these timelines to approximate the amount of time within the overall project schedule to allow for the peer review process. Actual timelines are dependent on individual project details such as the amount of data collection and the complexity of the future models.
- All timelines shown here are associated with the review of a microsimulation traffic model. The review time required for HCM-based traffic models is dependent on the WisDOT regional office resources.
- The peer review schedule may assume concurrent review by all internal WisDOT peer review team members (project team, regional traffic staff, independent consultant, SWB). However, the schedule *should* assume that FHWA peer reviews will only occur after the completion of WisDOT's review.
- If an independent consultant is part of the peer review team, add extra time to the schedule to account for scoping/contracting the independent consultant's work.
- Add additional time (a minimum of 6 weeks per milestone/alternative) to account for WisDOT TFS review of the traffic volume demand utilized in the traffic models. See the TPM and DT2340 for additional details on WisDOT TFS's role in the review of microsimulation traffic models.

2.3.5 Detail Traffic Model/Peer Review Comment Transfer Process

During the initial coordination meeting, the peer review team *should* layout the process for handing off the data (traffic model, peer review comments, etc.) between the analyst and the peer review team. It may be helpful for the project manager to set up a schedule for check-in-meetings or conference calls over the course of the peer review to help facilitate the exchange of data. The number and timing of these meetings will vary depending on the complexity of the traffic model, but could include the following:

- A hand-off meeting when the traffic model is ready to go to the reviewer(s),
- A preliminary finding meeting when the reviewer(s) has completed the initial review and developed their first thoughts and questions on the model,
- An ultimate finding meeting when the reviewer(s) has completed the peer review, and
- A response meeting when the analyst has addressed the comments raised by the review team.

2.4 Conduct Peer Review

A key concept of the peer review process is to assess whether the traffic model is suitable for meeting the goals and objectives of the study without violating current WisDOT policies (i.e., is the traffic model fit-for-purpose?). To assist the reviewer with making this decision, the project manager *should* provide the peer review team with a summary of the project scope, project goals, and intended purpose of the traffic model prior to initiating the peer review. It is important to affirm that the project scope is stable and unambiguous, as it will be difficult for the reviewer to assess the traffic model's fitness-for-purpose if the purpose itself is subject to change over the duration of the project. The project manager *should* also emphasize that the role of the reviewer is to identify problems and make suggestions to improve the quality of the traffic model, but not fix problems associated with the traffic model.

The following provides specific details on how to conduct a peer review for both HCM-based and microsimulation traffic models.

2.4.1 HCM Traffic Model Peer Review

A project team or region-level review will be sufficient for most HCM traffic models, although mega/major projects will require SWB involvement. The WisDOT regional traffic modeler/traffic operations **shall** conduct, at a minimum, a high-level review of the HCM traffic model(s) to verify that the analyst has followed standard protocols. To ensure consistency with the review of the traffic models, the reviewer (typically WisDOT regional traffic staff) *should* complete DT1887 – HCM Analysis Review Checklist while conducting their review. The reviewer, as appropriate, *should* insert "not reviewed" on DT1887 to denote which components of the traffic model they did not address during their review. Attachment 2.2 provides a copy of DT1887.

The primary purpose of DT1887 is to provide a coversheet that summarizes the major concerns/issues the reviewer has on the traffic model. The reviewer *should* document the specific/detailed comments on the traffic model in a separate memorandum and attach it to DT1887.

DT1887 provides a mechanism for the reviewer to easily identify whether the specific parameters within the traffic model (e.g., lane geometry, signal timings, etc.) and overall traffic model is acceptable, conditionally acceptable, or unacceptable. With regards to the peer review, these terms have the following definitions:

- Acceptable - The traffic model is acceptable as is without any revisions,
- Conditionally acceptable - The traffic model is acceptable based on the condition that the traffic analyst addresses a few (no more than 5) specific issues or concerns either by revising the traffic model or providing additional justification as to why no additional revisions are necessary,
- Unacceptable – The traffic model needs major revisions.

As illustrated in DT1887, the typical components of the HCM traffic model that the peer review team *should* review include:

Traffic Analysis Tool/Version

Prior to developing the traffic model, WisDOT regional traffic staff and the analyst *should* have agreed upon the appropriate analysis tool to utilize. The reviewer *should* confirm that the analyst used the agreed upon analysis tool, specifically that they used the correct software, software version, and software build (e.g., Synchro 10.3.122, Sidra 8.0.5.7916, etc.) to develop the traffic model. The traffic models *should* only utilize the department-supported software packages. TEOpS 16-10 identifies the explicit software packages that the department supports. Refer to the BTO Traffic Analysis, Modeling and Data Management Program area webpage for the version and build of software that WisDOT currently supports.

The reviewer *should* note any differences in the version or build of the software package utilized during the development and review of the traffic model.

Lane Geometry

The reviewer *should* confirm that the traffic model depicts the proper lane geometry, including lane configurations, turn bay lengths, lane widths, right-turn channelization, and distance between intersections. In some situations, the HCM methodology may not allow the coding of the actual lane geometrics (e.g., the HCM methodology limits the number of approaches/lanes). In these cases, it may be necessary to utilize an alternative tool for the analysis. The analyst **shall** obtain prior approval from WisDOT regional traffic staff prior to utilizing modified lane geometry within the HCM traffic model. Note the agreed upon modifications to actual lane geometries on DT1887 or in the accompanying comment memorandum.

Traffic Volumes/Percent Trucks/Peak Hour Factor (PHF)

The reviewer *should* verify that the analyst accurately coded the appropriate traffic volumes for the defined analysis year into the traffic model. Design year traffic volumes *should* reflect official WisDOT traffic forecasts (i.e., forecasts prepared or reviewed and approved by WisDOT TFS).

If applicable, the analyst *should* provide documentation on the process completed to develop design hour volumes (K30, K100, K250, weekday AM/PM peak, etc.), to produce O-D matrices, and balance the traffic volumes along the corridor. The reviewer *should* look at the documentation and check the volume adjustments for reasonableness.

The reviewer *should* verify that the analysis includes the appropriate percentage of trucks or heavy vehicles. Unless there is one movement that is predominately trucks (e.g., the movement goes into a truck parking facility), as prescribed in the HCM, the traffic model *should* include the percent of trucks/heavy vehicles based on intersection approach and not by the individual turning movement.

Per FDM 11-5-3, in most cases, the analysis *should* utilize a PHF based on data collected in the field, and is typically calculated for the intersection rather than approach or turning movement. If the existing field-derived PHF is less than 0.92 (the recommended HCM default), however, it may be appropriate to utilize a higher PHF for the analyses of design year conditions. Use of any value other than the field-derived PHF requires approval from the WisDOT regional traffic engineer.

Signal Timing Parameters

At a minimum, the reviewer *should* verify that all traffic models that involve traffic signals utilize appropriate signal timing and phasing plans, saturation flow rates, and right-turn-on red (RTOR) volumes. The reviewer *should* refer to the Traffic Signal Design Manual (TSDM 3-2-2) and TEOpS 16-15-5 for guidance on the recommended traffic signal timing parameters, where TEOpS 16-15-5 is the controlling policy for saturation flow rates and right-turn-on-red (RTOR) usage. WisDOT regional traffic staff may have additional guidance on the signal timing parameters.

Stop-Control/Roundabout Parameters

The reviewer *should* verify that all traffic models that involve stop-controlled intersections utilize appropriate and reasonable critical gap, follow-up times, saturation flow rates, vehicle storage in the median, and the presence of an upstream traffic signal. Unless justified otherwise by a field study, the traffic model *should* utilize default values for most parameters.

WisDOT has established Wisconsin specific critical and follow-up headway values for the analysis of roundabouts (see FDM 11-26-20.4, Table 20.3). The reviewer *should* check for proper usage of these headway values for traffic models that include roundabouts.

Freeway/Highway Parameters

For freeway weaving analysis, the reviewer *should* look at the source of the weaving volumes and verify that the assumptions made to determine the volumes are in accordance with the previously agreed upon methodology. Additionally, the reviewer *should* check the weaving segment length, number of maneuver lanes, and the minimum number of lane changes utilized in the analysis.

For freeway merge or diverge analysis, the reviewer *should* inspect the basic number of lanes, acceleration or deceleration lengths, and volume inputs for accuracy.

For basic highway segments, the reviewer *should* examine the road classification, access density, no-passing zone inputs, and free-flow speed for accuracy.

Other

The reviewer *should* note any other aspects of the traffic model (e.g., growth rates, gap acceptance, lane utilization, link speeds, etc.) that they checked during their evaluation. Additionally, the reviewer *should* provide any general comments they have regarding the overall performance of the traffic model.

Upon completion of their evaluation, the reviewer *should* provide a copy of the completed DT1887 to the project team and analyst for their response. The reviewer only needs to complete one DT1887 for an entire corridor; there is no need to complete DT1887 for every intersection along the corridor.

The analyst *should* note on the DT1887 form how they propose to respond to any comments on the traffic model (e.g., revise the traffic model or provide justification for their original assumptions). TEOpS 16-25-2.5 provides additional detail on how to document this correspondence.

2.4.2 Microsimulation Traffic Model Peer Review Overview

Due to their complexity, microsimulation traffic models typically require an independent consultant or SWB level of review. Each member of the peer review team *should* complete DT2291 – Microsimulation Peer Review Report to document their findings, comments, and concerns related to the traffic model. The TFS will document their review in DT2340 – Traffic Forecasting Section Microsimulation Checklist (see TPM for additional details). The reviewer, as appropriate, *should* insert “not reviewed” on DT2291 to denote which components of the traffic model they did not address during their review. The reviewer **shall** complete a peer review after each project milestone; however, they may combine their comments from each milestone onto one form. Attachment 2.3 provides a copy of DT2291.

The first page of DT2291 is where information regarding the peer review and traffic model is denoted (e.g., review date, reviewer, and analyst contact information, model completion/revision date, etc.).

The heart of the DT2291 form (pages 2 through 8) is where the reviewer documents their observations regarding the traffic model features and characteristics. This section of the form uses a three-column format. The left side of the form is where the reviewer identifies the overall acceptably of the traffic model component (acceptable, conditionally acceptable, or unacceptable) and notes the extent of the required revisions (no revisions, minor revisions, moderate revisions, or major revisions).

The center of the form provides space for detailed technical comments including reviewer-to-analyst communications. The reviewer *should* attach or insert additional sketches, screen shots, calculations, or other information that will assist the analyst in understanding the problems identified in the traffic model. Where relevant, DT2291 may include suggested techniques for improving the traffic model.

The right side of the form provides an area for the analyst to address the reviewer’s comments. This is where the analyst *should* identify if and how they will revise the traffic model. If the analyst feels that no revisions to the traffic model are necessary, they *should* provide justification for their original assumptions.

The final section of DT2291 is the reviewer's sign-off. In this section, the reviewer *should* unequivocally inform the analyst and project team whether the model is (or is not) suitable for the intended purpose. If the reviewer deems the traffic model unacceptable, they *should* summarize the number and severity of the revisions required (e.g., model requires 2 minor revisions and 1 major revision).

While DT2291 provides documentation of the overall peer review process, it *should* not serve as the sole means of communication between the reviewer and the analyst. The reviewer *should* document all communications with the analyst and attach them to DT2291 for future reference. Ultimately, it is the responsibility of the project manager to monitor the peer review process to ensure efficient communication between the peer review team and the analyst.

2.4.3 Conducting the Peer Review

Regardless of the software program utilized to develop the traffic model, a good first step is to open the traffic model and observe the simulation. This allows for a visual inspection of the traffic model to identify if there is anything that just does not look right (e.g., vehicles make dramatic movements, vehicles suddenly drop off the network, vehicles are turning left from an exclusive right-turn lane, etc.). The visual inspection can help the reviewer identify which portions of the traffic model they *should* concentrate their review efforts.

As illustrated in DT2291, the typical features and characteristics of a microsimulation traffic model that the reviewer *should* review include:

- Network Coding
- Intersection Traffic Control and Ramp Metering
- Closures, Restrictions, and Incidents
- Entrance Ramps
- Lane Use Parameters
- Zone Structure/Vehicle Inputs
- O-D Matrices, Demand Profiles, and Time Periods
- Core Simulation Parameters
- Routing Parameters/Vehicle Routes
- Vehicle Types and Proportions
- Stuck/Stalled Vehicles
- Special Features
- Consistency with Related Traffic Models
- Calibration/Validation
- Documentation

This list is not all-inclusive and *should* only serve as a starting point for the peer review. It is possible for the reviewer to deem a traffic model acceptable based on all features listed above and yet the traffic model may still not be fit-for-purpose. The reviewer *should* keep a clear understanding of the project scope, goals, and intended purpose of the traffic model in mind while conducting the peer review. Additionally, the peer review process *should* always take into consideration the current capabilities and limitations of the software package and version utilized in development of the traffic model as new software features are seldom foolproof. The following text provides details on the key parameters of the traffic model that the reviewer *should* assess during their evaluation.

Currently, the department supports the use of SimTraffic and Vissim, for microsimulation, although prior to January 1, 2018, Paramics was the primary WisDOT-supported microsimulation software. 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. Thus, it is possible that Paramics will still be in use in Wisconsin for several more years necessitating the need to provide some guidance on peer reviewing Paramics models. Refer to DT2291 for guidance on peer reviewing Paramics models.

The guidance below is specific for SimTraffic and Vissim; however, the general principles are applicable for all microsimulation software packages.

See below for additional information about how to evaluate each key feature of the traffic model.

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.

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 signal/ramp meter-timing plans.

Closures, Restrictions, and Incidents

Closures represent temporary or permanent roadway segment, link, or lane closures (i.e., no traffic can use that roadway segment, link, or lane). Restrictions represent links or lanes that limit travel, either temporarily or permanently, to specific vehicle types (e.g., lanes designated for high-occupancy-vehicles (HOV) or lanes restricting truck use). Incidents include simulated vehicle breakdowns, crashes, etc.

Entrance Ramps

Entrance ramps or freeway merge areas typically require careful coding in microsimulation. This section is typically applicable 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 taper parallel to the entrance ramp.

Lane Use Parameters

Lane use parameters control the amount and 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.

Zone Structure/Vehicle Inputs

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

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 or demand profiles (e.g., there may be one matrix for cars and a second matrix for trucks). The reviewer *should* evaluate the source of the demand profile and time selection. WisDOT TFS *should* weigh in on the appropriate use of these features within the traffic model and may provide suggestions for source data (e.g., annual traffic recorders [ATR] data).

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. Thus, the reviewer *should* check all core simulation values for reasonableness.

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.

Vehicle Types and Proportions

The proportion and types of vehicles (such as trucks, buses, and HOVs) influence the overall performance of each part of the network. The reviewer *should* verify that the traffic model utilizes actual field data to the best extent possible.

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 reviewer *should* note any problems with stuck or stalled vehicles, including intermittent problems.

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.

Consistency with Related Traffic Models

Complex projects often involve a series of related traffic models (existing, future no-build, future build alternatives, AM/PM peak period, etc.). To assure the integrity of the study, these traffic models must be consistent. Additionally, adjacent and overlapping model areas *should* utilize consistent analysis methodologies. The results of the traffic model *should* not contradict the results of the TDM.

Calibration/Validation

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

Validation is the independent process where the analyst checks the traffic model outputs against field measured or benchmark data including traffic volumes, travel speeds, travel times, intersection queuing, and trip-making patterns (e.g., weaving volumes), among others. See TEOpS 16-20-8 for additional details on the validation process.

A properly calibrated and validated traffic model *should* accurately reflect real-world traffic conditions and *should* meet the purpose and need of the project. The analyst *should* document the methodology and assumptions utilized to calibrate and validate the traffic model and *should* submit the modeling methodology report along with the traffic model to the peer review team for review.

The reviewer *should* spot-check the traffic model outputs and compare them to the results documented in the modeling methodology report. If the reviewer cannot produce similar outputs, it may indicate an issue with the traffic model's calibration. See TEOpS 16-20 for additional details on model calibration and validation.

Documentation

Proper documentation of modeling methods and assumptions establishes accountability and facilitates efficient revision, updating, and follow-up. The review team *should* verify proper documentation of the modeling methods.

2.5 Document Results

It is critical to document any correspondence between the peer review team and traffic analyst regarding the peer review process. The peer review team members and traffic analyst *should* document the correspondence within, or as attachments to, the appropriate review form (DT1887 or DT2291). The correspondence **shall** include how the traffic analyst revised the traffic model to address the peer review comments or provide justification as to why the analyst chose not to revise the traffic model. On projects where the peer review team and traffic analyst interact frequently, it may be necessary to provide a separate document to detail all the correspondences. Attachment 2.4 provides examples of ways to document the communication between the project team and traffic analyst. The project manager **shall** include the additional documentation along with all completed DT1887 and DT2291 forms within the project's records file.

The region **shall** provide a summary of the peer review process for all microsimulation traffic models (including all SimTraffic models used for project or study decisions, especially any related to critical aspects of the design) to BTO-TASU for information and tracking purposes. The summary **shall** identify the following aspects associated with the peer review process:

1. Project information (project identification number, project name, study area, study limits)
2. Name of analyst
3. Name of lead peer reviewer
4. Summary of peer review results (DT1887, DT2291, correspondence documentation)
5. Copy of all FHWA comments on the traffic model

Even if BTO-TASU is not part of the peer review team, it is generally advantageous for the project team to inform BTO-TASU of any pending peer reviews, specifically those for a microsimulation traffic model. This allows BTO-TASU to assess whether there are any potential overlapping peer reviews that may impact the project's schedule.

The project manager or region traffic operations **shall** email a copy of all interim and final DT2291 forms, including FHWA comments, to BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov). WisDOT regional traffic staff **shall** also include a copy of the relevant DT1887 and DT2291 forms with the submittal of all Phase II – Alternative Selection Intersection Capacity Evaluation (ICE) reports.

LIST OF ATTACHMENTS

Attachment 2.1	Traffic Model Complexity Scoring Template
Attachment 2.2	DT1887 HCM Analysis Review Checklist
Attachment 2.3	DT2291 Microsimulation Peer Review Report
Attachment 2.4	Sample Correspondence

Attachment 2.1 Traffic Model Complexity - Scoring Template

WisDOT Traffic Model Complexity - Scoring Template

Last Updated: 07-19-17

Applicable for determining the number of MOEs required for model validation and for determining the required level of peer review

Instructions: Fill in gray boxes to determine the model complexity, the number of MOEs needed for validation, and the level of traffic model peer review effort required. Choose appropriate project category in **Table 1: Project type**. Choose primary network type in **Table 2: Geometrics Scoring** and mark applicable categories. Mark all applicable categories in **Table 3: Traffic Pattern and Congestion Scoring**. Final scoring reflects the highest point value in each table (maximum of 24 points). **Table 4** shows the overall model complexity score. **Table 5** shows recommended procedure for identifying the type/number of MOEs to use for model validations and scoping the traffic model peer review. Consider existing conditions and potential future alternatives that the project/study is anticipated to cover.

WisDOT Region:		Ex: SE, SW, NE
Project:		Ex: STH __ Corridor Study
Project ID:		Ex: 1234-56-7890
Project Description:		Ex: City - City
Highway:		Ex: STH __
County:		Ex: Dane County
Traffic Conditions:		Ex: Base (Existing), Base and Future
Modeling Software:		Ex: Paramics, Vissim, SimTraffic

General Project Description:
Ex: Limits of project (Size of Network, # of TAZs), other software used for analysis, anticipated O-D data source, assumptions on Future scenarios, etc.

Table 1: Project Type

Complete (1):	Check all that apply:						
(1) Project Type	Category	Traffic Impact Analysis (TIA), Intersection Control Evaluation (ICE), or similar (Small Influence Area)	Traffic Impact Analysis (TIA), Intersection Control Evaluation (ICE), or similar (Large Influence Area)	Corridor Study/Operational Needs Study or Standard Improvement Project (Small Network)	Corridor Study/Operational Needs Study or Standard Improvement Project (Large Network)	High Profile Project, Potential Mega/Major Project (EA, PEL, EIS)	Mega or Majors Project
	Point Total	0	1	2	3	4	4
	Applicable?	0	0	0	0	0	0

Note: Large Network category assumed to contain 20 or more Traffic Analysis Zones (TAZs).

Table 2: Geometrics Scoring

Choose (1) or (2):	Check all that apply:						
(1) Intersections and Streets/Corridors	Category	Isolated Intersection(s)	Signalized Corridor / Network (No Coordination)	Roundabout Corridor / Network	Signalized Corridor / Network (Coordinated)	Mixed Corridor / Network (Signals and Roundabouts)	Adaptive Signal Control System
	Point Total	0	1	2	2	3	4
	Applicable?	0	0	0	0	0	0
Or							
(2) Freeways	Category	Mainline and Simple Merges/Diverges Only	System Interchange with Multilane Ramps	Freeway with Interchanges and Arterials	Interchanges with Roundabout Ramp Terminals	Unconventional Interchanges (DDI, Echelon, SPUI, etc.)	Managed Lanes, Variable Message Signs, etc.
	Point Total	0	1	1	2	3	4
	Applicable?	0	0	0	0	0	0

Table 3: Traffic Pattern and Congestion Scoring

Complete (1), (2), and (3):	Check all that apply:						
		All-or-Nothing Routing Assignment				Dynamic/Variable Routing	
(1) Routing	Category	Single Routes (Intersection or Corridor)	Networks with Few (2-3) Route Options	Freeway with Parallel Lower Functional Class Streets	Grid System with Numerous Route Options	Freeway Network with Parallel Route Options	Grid System with Numerous Route Options
	Point Total	0	1	2	3	3	4
	Applicable?	0	0	0	0	0	0
(2) OD Estimation	Category	Single Intersection(s) / No Estimation	Small Network, Few Routes	Large Network, Few Routes	Small Network, Multiple Routes	Large Network, Multiple Routes	
	Point Total	0	1	2	3	4	
	Applicable?	0	0	0	0	0	
(3) Existing/Anticipated Level of Congestion	Category	- LOS C or better operations - Minor queuing (<500') - Free flow travel speeds/times	- LOS C-D operations - Moderate queuing (500-1,000') - Minor delays in travel speeds/times	- LOS D-E operations - Moderate queuing (500-1,000') - Moderate delays in travel speeds/times	- LOS F operations (future) - Significant queuing (>1,000') - Significant delays in travel speeds/times	- LOS F operations (existing) - Significant queuing (>1,000') - Significant delays in travel speeds/times	
	Point Total	0	1	2	3	4	
	Applicable?	0	0	0	0	0	

Note: Large Network category assumed to contain 20 or more TAZs. Congestion level takes into account worst-case controlled intersections or roadway segments. Queue lengths are through lane queues.

Table 4: Scoring Results

Project Type	Total	0
Geometrics Subtotal	Intersections and Corridors	0
	Freeways	0
	Total	**0**
Traffic Pattern and Congestion Subtotal	Routing	0
	OD Estimation	0
	Level of Congestion	0
	Total	**0**
Total Points		**0**

Table 5: Recommendations

Point Scale	Minimum # of MOEs Required for Validation	Level of Peer Review Recommendations	
		Recommendation Type	Estimated Schedule for Initial Review (including data collection, coordination, etc.)
0 - 3	1 to 2 Primary MOEs	High-level WisDOT Region review.	1-2 weeks existing conditions 1-2 weeks per alternative
4 - 7	1 to 2 Primary MOEs 1 Secondary MOE	WisDOT Region conducts peer review with assistance from independent consultant or BTO as necessary.	3-4 weeks existing conditions 3-4 weeks per alternative
8 - 10	2 to 3 Primary MOEs 1 Secondary MOE	Independent consultant conducts peer review with WisDOT Region input and BTO assistance as necessary.	4-8 weeks existing conditions 4-8 weeks per alternative
11+	2 to 3 Primary MOEs 1 to 2 Secondary MOEs	Independent consultant conducts peer review with WisDOT Region, BTO, other WisDOT Bureau involvement and FHWA oversight.	2-4 months existing conditions (no FHWA) 2-4 months per alternative (no FHWA) 3-4 months existing conditions (with FHWA) 3-4 months per alternative (with FHWA)

***Note:** A minimum of 6 weeks should be allowed for Traffic Forecasting to review the existing/future volumes for all levels of peer review

Access Excel file via the following link: **http://wisconsindot.gov/dtsdManuals/traffic-ops/programs/analysis/trafficmodelpeerreview.xlsx**

HCM ANALYSIS REVIEW CHECKLIST

Wisconsin Department of Transportation (WisDOT)
DT1887 3/2019

			Date(s) Reviewed (m/d/yyyy)		
Project ID(s):	Highway(s)/Intersection(s):	Region:	1st Review	2nd Review	3rd Review
Lead Reviewer	Name:	Contact Information:			
Lead Analyst	Name:	Contact Information:			

TRAFFIC MODEL DESCRIPTION

Identify the model completion/revision date, the scope of the model, the analysis year(s), the analysis time period(s), and analysis tool/version

SUMMARY OF REVIEW

Traffic Analysis Tool/Version	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		
Lane Geometry	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		
Traffic Volumes, % Trucks, Peak Hour Factor (PHF)	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		

HCM ANALYSIS REVIEW CHECKLIST *(continued)*

Wisconsin Department of Transportation (WisDOT) **DT1887**

SUMMARY OF REVIEW *(continued)*

Signal Parameters (Including RTOR)	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		
Stop Control/ Roundabout Parameters	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		
Freeway/ Highway Parameters	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		
Other:	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		
Overall Model	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required ☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required ☐ ☐ ☐ Unacceptable/ Major Revision Required		

MICROSIMULATION PEER REVIEW REPORT

Wisconsin Department of Transportation (WisDOT)
DT2291 9/2015

Reviewer, please email completed form to:

To: Project Manager & Region Contact
CC: DOT Traffic Model Peer Review
Subject: DT2291 for Project ID; Traffic Model Name

	1st Review	2nd Review	3rd Review
Date Reviewed (m/d/yyyy):			
Reviewed By:			
Model Completion/Revision Date(m/d/yyyy):			

CONTACT INFORMATION

Lead Reviewer	Lead Analyst	Region Contact
Name (First, MI, Last)	Name (First, MI, Last)	Name (First, MI, Last)
Organization/Firm	Organization/Firm	Region/Bureau
(Area Code) Telephone Number	(Area Code) Telephone Number	(Area Code) Telephone Number
Email Address	Email Address	Email Address

TRAFFIC MODEL DESCRIPTION

Project ID(s)	Project Name/Description	Region:	Highway(s)
Traffic Model Name/Description	Analysis Scenario/Alternative	Analysis Year(s)	

Analysis Time Period (s)

☐ Weekday AM Peak	☐ Weekday Midday Peak	☐ Weekday PM Peak	☐ Fri Peak	☐ Sat Peak	☐ Sun Peak	☐ Other:
Hours:	Hours:	Hours:	Hours:	Hours:	Hours:	Hours:

Analysis Tool(s) Utilized

☐ SimTraffic- Version: ☐ Paramics - Version: ☐ Vissim - Version: ☐ Other: - Version:

SCOPE AND EXTENT OF PEER REVIEW

Purpose & Scope of Review

Description/Limit of Model

Configuration Settings

Number of Zones:	Number of Time Steps:	Speed Memory:	Assignment Type:
Mean Target Headway:	Mean Reaction Time	Matrix Structure	Vehicle Classifications/Splits

Seed Values Used for Calibration:	
Seed Values Used for Review:	
Other:	

Were any changes to the model made by the review team? If yes, please describe.

DIRECTIONS

This form is applicable for the review of all microsimulation traffic models, regardless of the traffic software program utilized to develop the traffic model. However, this form focuses on the SimTraffic, Paramics and Vissim microsimulation software packages.

When noting problems or concerns, identify the severity of the issue and the revisions recommended using the following scale: Minor, Moderate, or Major. Check the appropriate box associated with each review (the blue box for the 1st review, the green box for the 2nd review and the purple box for the 3rd review).

If more than one review of the traffic model is required, use different color text to distinguish the comments associated with each review (e.g., comments from the 1st review should be in blue text, comments from the 2nd review should be in green text, and comments from the 3rd review should be in purple text). Provide any supporting tables, screenshots, or additional images in a separate attachment to this form.

OBSERVATIONS, MODEL FEATURES AND CHARACTERISTICS

Geometrics /Traffic Control	***Network Coding***	*Network Coding establishes the horizontal and vertical geometry of the network. It also includes the appropriate use of settings such as link free-flow speed.* - *For SimTraffic, this is coded within the Synchro module and includes placement and interconnection of nodes and links, number of lanes, lane widths, lane configurations, roadway curvature, storage lengths, and other intersection and network geometry.* - *For Paramics this includes placement and interconnection of nodes, links and link categories, curb points, curves, turn lanes, merge points, stop bars, signposts, and other network infrastructure.* - *For VISSIM this includes the placement and interconnection of links, connectors, desired speed decisions, reduced speed areas, conflict areas, and priority rules.*	
	As a whole, network coding is:	**Observations/Comments:**	**Analyst Response**
	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review
	Intersection Traffic Control & Ramp Metering	*Intersection Controls are devices that regulate traffic flow at intersections, such as signals, roundabouts, and stop-controlled intersections. Elements of the signals may include the controller type, detector placement, signal heads, signal groups, and/or coordination between signals. Ramp meters control the rate of entry to a freeway. Comments on signal and ramp meter timing plans may be included in this section.*	
	As a whole, intersection controls are:	**Observations/Comments:**	**Analyst Response**
	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review

Geometrics /Traffic Control

Closures, Restrictions, & Incidents	*Closures represent links or lanes that are temporarily or permanently closed to traffic. Restrictions represent links or lanes that are temporarily or permanently closed to specific types of vehicles (such as lanes designated for High Occupancy Vehicles or lanes restricting truck use). Incidents include simulated vehicle break-downs, etc.* - *This feature is **not** applicable for SimTraffic*

As a whole closures, restrictions & incidents are:	**Observations/Comments:**	**Analyst Response**
☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review

Entrance Ramps	*Driver behavior and lane utilization approaching entrance ramps should be reviewed in this section.* - *For SimTraffic, modifications to the default mandatory distance and positioning distance settings should be reviewed.* - *For Paramics, modifications to default ramp headway, minimum ramp time, and ramp aware distance should be reviewed. The minimum ramp time setting specifies how long a driver will stay on the parallel entrance ramp before beginning to look for a gap to merge onto the freeway.* - *For VISSIM, the effective merging area defined by the positions of the links and connectors should be reviewed.*

As a whole, the vehicle behavior approaching entrance ramps is:	**Observations/Comments:**	**Analyst Response**
☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review

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*

As a whole, lane use parameters are:	**Observations/Comments:**	**Analyst Response**
☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review

Traffic/Global	***Zone Structure/Vehicle Inputs***	*Zone structure and vehicle inputs define where and how traffic is loaded into the network.* - *For SimTraffic, the intersection turning movement volumes from the Synchro module determine how the traffic is loaded into the network. If volumes are imbalanced in the Synchro network, SimTraffic will assume a traffic source or sink between nodes (such as driveways). Reviewer should note imbalances that may not be realistic or representative of the network.* - *For Paramics, zone structure relates to the placement of the zones representing the locations where traffic enters or leaves the network. Observations related to sectors and zone connectors should be included in this section. If the microsimulation model zones are derived from a travel demand model, reviewers should use this section to note any issues related to the consistency of the Paramics input data with respect to the travel demand model data.* - *For VISSIM, vehicle inputs control where traffic is loaded into the network and how much is loaded. Reviewer should use this section to note any issues related to the consistency of input data related to the sources.*	
	As a whole, zone structure and vehicle inputs are:	**Observations/Comments:**	**Analyst Response**
	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review
	O-D Matrices, Demand Profiles, & Time Periods	*Origin-Destination (O-D) matrices contain the network demand patterns (number of trips between each pair of zones). Time Periods and Demand Profiles control the timing of the release of the trips into the network. In some cases multiple matrices are used (for example separate matrices for cars and heavy trucks). The reviewer should evaluate the source of the demand profile and time period selection.* - *For SimTraffic, network-wide O-D Matrices and demand profiles are not applicable. The intersection turning movement volumes, rather than network-wide O-D matrices, determines the origin and destination of the traffic. The Link O-D volumes setting can be modified within Synchro to model the weaving interaction between 2 adjacent intersections (such as zeroing out an off-ramp left-turn to on-ramp left-turn movement at a diamond interchange). Volume adjustment factors, rather than demand profiles, dictate the percentage of peak hour traffic to load into the network for each analysis period. Thus the intersection turning movement volumes, Link O-D volumes, volume adjustment factors (such as growth factor and PHF adjust settings), and the time and duration of the seeding (i.e., warm-up period) and recording (i.e., analysis period) periods should be reviewed.*	
	As a whole, O-D matrices, demand profiles, & time periods are:	**Observations/Comments:**	**Analyst Response**
	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review

<table>
<tr><td rowspan="6">**Traffic/Global**</td><td>***Core Simulation Parameters***</td><td colspan="2">*Core simulation parameters affect fundamental aspects of vehicle behavior in the network, such as driver aggressiveness and the willingness to merge into small gaps. Modifications to default software values should be reviewed.*
• *For SimTraffic, examples of core simulation parameters to review include driver and vehicle characteristics and behaviors.*
• *For Paramics, examples of core simulation parameters to review include mean target headway, mean target reaction time, perturbation, global routing cost coefficients, driver familiarity, time steps, speed memory, allowing heavy vehicles to use all lanes, and matrix tuning.*
• *For VISSIM, examples of core simulation parameters to review include Driving Behaviors, Simulation Resolution, and Speed Distributions.*</td></tr>
<tr><td>As a whole, core simulation parameters are:</td><td>**Observations/Comments:**</td><td>**Analyst Response**</td></tr>
<tr><td>☐ ☐ ☐ Acceptable
☐ ☐ ☐ Conditionally Acceptable
☐ ☐ ☐ Unacceptable
Extent of Revisions Required:
☐ ☐ ☐ No Revisions Required
☐ ☐ ☐ Minor Revisions Required
☐ ☐ ☐ Moderate Revisions Required
☐ ☐ ☐ Major Revisions Required</td><td>1st Review
2nd Review
3rd Review</td><td>1st Review
2nd Review
3rd Review</td></tr>
<tr><td>***Routing Parameters/ Vehicle Routes***</td><td colspan="2">*Routing parameters or vehicle routes influence the way vehicles travel through the network. If coded improperly, these controls can cause unrealistic or erratic routing.*
• *This feature is* ***not*** *applicable for SimTraffic. However, interaction between intersections can be checked as noted with the Link O-D feature in the O-D Matrices, Demand Profiles, & Time Periods section.*
• *For Paramics, routing parameters (such as cost factors, turn penalties, modification of the link type hierarchy, and waypoints) override the default routing behavior and profoundly influence the route choice in the network. They are occasionally used to increase or decrease the traffic volume on specific links.*
• *For VISSIM, vehicle routes and vehicle routing decisions control the flow of traffic from the entrance points through the network. They can be coded using either actual vehicle flows or percentages.*</td></tr>
<tr><td>As a whole, traffic routing parameters are:</td><td>**Observations/Comments:**</td><td>**Analyst Response**</td></tr>
<tr><td>☐ ☐ ☐ Acceptable
☐ ☐ ☐ Conditionally Acceptable
☐ ☐ ☐ Unacceptable
Extent of Revisions Required:
☐ ☐ ☐ No Revisions Required
☐ ☐ ☐ Minor Revisions Required
☐ ☐ ☐ Moderate Revisions Required
☐ ☐ ☐ Major Revisions Required</td><td>1st Review
2nd Review
3rd Review</td><td>1st Review
2nd Review
3rd Review</td></tr>
</table>

Traffic/Global

Vehicle Types & Proportions	*The proportion of vehicles (such as trucks, buses, and High Occupancy Vehicles) influences the overall performance of each part of the network. Vehicle lengths (such as heavy truck lengths) should be reviewed.*	
As a whole, vehicle types & proportions are:	**Observations/Comments:**	**Analyst Response**
☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review
Stuck/Stalled Vehicles	*This section should be used to note any problems with stuck or stalled vehicles (including intermittent problems). These are vehicles that unexpectedly slow or stop partway through their route (which can cause backups that do not exist in the field).* • *For Paramics, this section should also be used for comments on the use of blockage removal tools, if used.* • *For SimTraffic, this section should be used to comment on if short links may be resulting in stuck or stalled vehicles within the network.*	
As a whole, stuck/stalled vehicle occurrence is :	**Observations/Comments:**	**Analyst Response**
☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review
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, Application Programming Interfaces (APIs), etc* • *At present, SimTraffic will not model bus stops, bus routes, bus and carpool lanes, light rail, on-street parking, or short term event; thus, the use of special features is typically not applicable in SimTraffic.*	
As a whole, use of special features is :	**Observations/Comments:**	**Analyst Response**
☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review

Traffic/Global	***Consistency with Related Traffic Models***	*Modeling studies often involve a series of related models (base model, future no-build, and build alternatives, different times of day, etc.). To assure the integrity of the study as a whole, these models must be consistent.*	
	As a whole, model consistency is :	**Observations/Comments:**	**Analyst Response**
	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review
Calibration/Validation/Documentation	***Calibration/Validation***	*Calibration refers to the process where the analyst adjusts selected parameters within the traffic model (e.g., global and local headway and reaction times, driver aggressiveness, etc.) in order to get the traffic model to reproduce conditions observed in the field. Validation refers to the process where the analyst checks the traffic model outputs against field measured data including traffic volumes, travel speeds, travel times, intersection queuing and trip-making patterns (e.g., weaving volumes). The reviewer should spot-check the traffic model outputs and compare them to the results documented in the calibration/validation report. If the reviewer cannot produce similar outputs, it may indicate an issue with the traffic model's calibration.*	
	As a whole, model calibration is :	**Observations/Comments:**	**Analyst Response**
	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review
	Documentation	*Proper documentation of modeling methods and assumptions establishes accountability and facilitates efficient revision, updating, and follow-up. Review team should verify that proper documentation has been provided.*	
	As a whole, model documentation is :	**Observations/Comments:**	**Analyst Response**
	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review	1st Review 2nd Review 3rd Review

SUMMARY OF REVIEW

	As a whole, the traffic model is :	**Summary of the review team's findings and recommendations**
Overall Traffic Model	☐ ☐ ☐ Acceptable ☐ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable Extent of Revisions Required: ☐ ☐ ☐ No Revisions Required ☐ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	1st Review 2nd Review 3rd Review

REVIEWER'S CONCULSION (Check One)

☐ ☐ ☐ *It is the opinion of the review team that the model as reviewed and tested is an accurate and reasonable representation of the traffic conditions in the study area for the analysis year, time period, and scenario/alternative indicated in the title block of this document.*

☐ ☐ ☐ *It is the opinion of the review team that the model as reviewed and tested requires correction of ______ errors before it can be regarded as a reasonable representation of the traffic conditions in the study area for the analysis year, time period, and scenario/alternative indicated in the title block of this document. (Indicate number and severity of errors: Minor, Moderate, or Major).*

Prepared By (Signature)	**Date** *Click here to enter a date.*	**Contact Information** Phone: Email:
Prepared By (Signature)	**Date** *Click here to enter a date.*	**Contact Information (Phone, Email)** Phone: Email:
Prepared By (Signature)	**Date** *Click here to enter a date.*	**Contact Information (Phone, Email)** Phone: Email:

HCM ANALYSIS REVIEW CHECKLIST

Wisconsin Department of Transportation (WisDOT)
DT1887 3/2019

Page 1 of 2

			Date(s) Reviewed (m/d/yyyy)		
Project ID(s): 85-75-3072	Highway(s)/Intersection(s): USH 888 (N/S) & STH 747 (E/W)I	Region: NE	1st Review 3/12/2019	2nd Review 4/11/2019	3rd Review
Lead Reviewer	Name: Review is All We Do (RIAWD)	Contact Information: RIAWD@email.com			
Lead Analyst	Name: Traffic Models 'R Us (TMRU)	Contact Information: TMRU@email.com			

TRAFFIC MODEL DESCRIPTION

Identify the model completion/revision date, the scope of the model, the analysis year(s), the analysis time period(s), and analysis tool/version

Synchro model for USH 888 (N/S) & STH 747 (E/W) in Blue Moose, WI, Analysis is for the 2040 AM (7-9) & PM (3:30-5:30) peak hours for the baseline and alternative #2 (enhanced signal) scenarios. Used Synchro 10.3.28. Model was completed on 11/15/2018

SUMMARY OF REVIEW

	Acceptability		Reviewer Comment(s):	Analyst Response(s):
Traffic Analysis Tool/Version	☒ ☒ ☐	Acceptable/ No Revision Required	Used the most recent version of Synchro available at time model was completed. This is acceptable. As a note for future projects, WisDOT is now utilizing Synchro 10.3.122	Thanks for the info about the new version of Synchro.
	☐ ☐ ☐	Conditionally Acceptable/ Minor Revision Required		
	☐ ☐ ☐	Unacceptable/ Major Revision Required		

	Acceptability		Reviewer Comment(s):	Analyst Response(s):
Lane Geometry	☐ ☒ ☐	Acceptable/ No Revision Required	WB right turn lane is channelized in the plans but not in the model. Please correct.	WBR should be channelized. This has been corrected
	☒ ☐ ☐	Conditionally Acceptable/ Minor Revision Required	WBR is now shown as channelized in the model	
	☐ ☐ ☐	Unacceptable/ Major Revision Required		

	Acceptability		Reviewer Comment(s):	Analyst Response(s):
Traffic Volumes, % Trucks, Peak Hour Factor (PHF)	☐ ☒ ☐	Acceptable/ No Revision Required	Heavy vehicle (HV) percentage set to 2% for all approaches. From the 2018 turning movement count, the NB AM has 8% HV and NB PM has 13% HV. Other approaches should also be examined in both peak periods.	2018 field data now incorporated into both the AM and PM models. These percentages are expected to remain constant.
	☒ ☐ ☐	Conditionally Acceptable/ Minor Revision Required	Truck percentages are now acceptable.	
	☐ ☐ ☐	Unacceptable/ Major Revision Required		

SUMMARY OF REVIEW *(continued)*

Signal Parameters (Including RTOR)	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☒ ☐ Acceptable/ No Revision Required	The EBR Saturated Flow Rate (RTOR) is set to 90vph, or half of the 180vph AM demand; it should be set to 68vph per TEOpS 16-15-5.2 (0.38*180 = 68)	Saturated Flow Rate (RTOR) has been set to 68 vph. All other RTOR volumes were checked and are in compliance with TEOpS 16-15-5.2
	☒ ☐ ☐ Conditionally Acceptable/ Minor Revision Required	RTOR volumes were updated and are now acceptable	
	☐ ☐ ☐ Unacceptable/ Major Revision Required		

Stop Control/ Roundabout Parameters	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required	N/A	
	☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required		
	☐ ☐ ☐ Unacceptable/ Major Revision Required		

Freeway/ Highway Parameters	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☐ ☐ Acceptable/ No Revision Required	N/A	
	☐ ☐ ☐ Conditionally Acceptable/ Minor Revision Required		
	☐ ☐ ☐ Unacceptable/ Major Revision Required		

Other: Pedestrian Movements	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☒ ☐ Acceptable/ No Revision Required	NB pedestrian traffic was included in the base year analysis - why is this not included here?	Though not documented here, an off-road paved path will be constructed to the west as part of this alternative. This will serve NB pedestrian traffic destinations and remove almost all NB pedestrian traffic. Please confirm that it is acceptable to not include any NB pedestrian traffic in the analysis.
	☒ ☐ ☐ Conditionally Acceptable/ Minor Revision Required	Given the construction of the path, it is acceptable to not consider pedestrian impacts here.	
	☐ ☐ ☐ Unacceptable/ Major Revision Required		

Overall Model	**Acceptability**	**Reviewer Comment(s):**	**Analyst Response(s):**
	☐ ☒ ☐ Acceptable/ No Revision Required	EBL movement has LOS E in the PM while the NBT/SBT have LOS B. Can signal timings be adjusted to make green time more equitable? See other comments above	Signal timings have been adjusted to allocate more green time to the EBL movement. Now EBL is LOS C, NBT is LOS B, and SBT is LOS C, all of which are acceptable.
	☒ ☐ ☐ Conditionally Acceptable/ Minor Revision Required	The adjusted signal timing results in acceptable LOS for all approaches. Overall model is now acceptable.	
	☐ ☐ ☐ Unacceptable/ Major Revision Required		

MICROSIMULATION PEER REVIEW REPORT

Wisconsin Department of Transportation (WisDOT)

DT2291--8/2015

Reviewer, please email completed form to:			1st Review	2nd Review	3rd Review
To:	Project Manager & Region Contact	Date Reviewed (m/d/yyyy):	2/29/2016	3/17/2016	4/20/2016
CC:	DOT Traffic Model Peer Review	Reviewed By:	RIAWD	RIAWD	RIAWD
Subject:	DT2291 for Project ID; Traffic Model Name	Model Completion/Revision Date (m/d/yyyy):	2/15/2016	3/14/2016	4/18/2016

TRAFFIC MODEL DESCRIPTION

Project ID(s) 0-11-23-68	Project Name/Description Cold Corridor - STH 999 & IH-O, Red Bayou, WI	Region: NW	Highway(s) STH 999 & IH-O
Traffic Model Name/Description Paramics Base Condition Model	Analysis Scenario/Alternative AM, PM, FRI, SUN	Analysis Year(s) 2013	

Analysis Time Period (s)

☒ Weekday AM Peak	☐ Weekday Midday Peak	☒ Weekday PM Peak	☒ Fri Peak	☐ Sat Peak	☒ Sun Peak	☐ Other: °°°°°
Hours: 6:30-8:30	Hours: °°°°°	Hours: 3:15-5:15	Hours: 4:30-6:30	Hours: °°°°°	Hours: 3:00-5:00	Hours: °°°°°

Analysis Tool(s) Utilized

☐ SimTraffic - Version: °°°°°
☒ Paramics - Version: 7.01
☐ Vissim - Version: °°°°°
☐ Other: °°°°° - Version: °°°°°

SCOPE AND EXTENT OF PEER REVIEW

Purpose & Scope of Review

Provide a detailed review of the base condition model coding and calibration

Description/Limit of Model

STH 999 & IH-O, 0.5 miles south of Random Road north to the West River Bridge

Configuration Settings

# Zones: 25	# Time Steps: 5	Speed Memory: 8	Assignment Type: All-or-nothing
Mean Target Headway: 0.87	Mean Reaction Time 0.93	Matrix Structure 2 O-D matrices, 1 for passenger vehicles & 1 for heavy vehicles	Vehicle Classifications/Splits Separate matrices
Seed Values Used for Calibration:	113, 683, 23, 149, 593, 1039, 28567		
Seed Values Used for Review:	23, 28567		
Other: Variable Speed Limit	Variable speed limit (VSL) applied on IH-O		

Were any changes to the model made by the review team? If yes, please describe.

No

OBSERVATIONS, MODEL FEATURES AND CHARACTERISTICS

metrics /Traffic Control

Network Coding

Network Coding establishes the horizontal and vertical geometry of the network. It also includes the appropriate use of settings such as link free-flow speed.

- *For SimTraffic, this is coded within the Synchro module and includes placement and interconnection of nodes and links, number of lanes, lane widths, lane configurations, roadway curvature, storage lengths, and other intersection and network geometry.*
- *For Paramics this includes placement and interconnection of nodes, links and link categories, curb points, curves, turn lanes, merge points, stop bars, signposts, and other network infrastructure.*
- *For VISSIM this includes the placement and interconnection of links, connectors, desired speed decisions, reduced speed areas, conflict areas, and priority rules.*

As a whole, network coding is:	Observations/Comments:	Analyst Response
☐ ☒ ☐ Acceptable ☒ ☐ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable	1st Review Intersection of This Rd and That Dr - the EB approach currently has an exclusive right turn lane, which is not coded in the model (Link 523:524). It is possible that this exclusive right turn lane was added after the model base year	1st Review Lane appears to have been in place prior to 2012 and is marked for buses, bicycles, and right turns only. An exclusive EB right turn lane has been added that extends back to the WB ramp terminal intersection. This change is not expected to affect the results
Extent of Revisions Required: ☐ ☒ ☐ No Revisions Required	2nd Review ***An EB exclusive right turn lane was added on link 523:524. This is used only by buses and right turns, since bicycles are not included in this model.***	2nd Review °°°°°
☒ ☐ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	3rd Review °°°°°	3rd Review °°°°°

Routing Parameters/Vehicle Routes

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

- *This feature is **not** applicable for SimTraffic. However, interaction between intersections can be checked as noted with the Link O-D feature in the O-D Matrices, Demand Profiles, & Time Periods section.*
- *For Paramics, routing parameters (such as cost factors, turn penalties, modification of the link type hierarchy, and waypoints) override the default routing behavior and profoundly influence the route choice in the network. They are occasionally used to increase or decrease the traffic volume on specific links.*
- *For VISSIM, vehicle routes and vehicle routing decisions control the flow of traffic from the entrance points through the network. They can be coded using either actual vehicle flows or percentages.*

As a whole, traffic routing parameters are:	Observations/Comments:	Analyst Response
☐ ☐ ☒ Acceptable ☒ ☒ ☐ Conditionally Acceptable ☐ ☐ ☐ Unacceptable	1st Review Link cost factors are applied in 13 locations. It was noted that link 709:708 has an exceptionally high cost factor of 1000. Why is this so high? This link is located on STH 999 between the Random Rd ramp terminal intersections.	1st Review Link 709:708 cost factor will be adjusted. Other cost factors were generally used for routing purposes at interchanges to prevent vehicles from exiting then re-entering the freeway. No additional changes are proposed - please confirm.
Extent of Revisions Required:	2nd Review ***This is an acceptable approach.***	2nd Review ***Update completed.***
☐ ☐ ☒ No Revisions Required ☒ ☒ ☐ Minor Revisions Required ☐ ☐ ☐ Moderate Revisions Required ☐ ☐ ☐ Major Revisions Required	3rd Review The cost factor for link 709:708 was changed to 1 which is acceptable.	3rd Review °°°°°

Microsimulation Peer Review Form Responses

Date of Last Response: February 29, 2016

Project: 0-11-23-58
Cold Corridor – STH 999 & IH-O
Up North

Analyst: Traffic Models 'R Us (TMRU)

Traffic Model Name/Description: Future Year (2040) AM Model

Analyst's Response Code

A = Agree completely; will revise (no written response required)

RFS = Requires further study in next phase (no written response required)

P = Agree partially; will revise to some degree (see written response)

D = Disagree; will not revise (see written response)

	1st Review:	2nd Review:	3rd Review:
Model Completion/Revision Date(m/d/yyyy):	01/07/16		
Reviewer 1: **An Employee of the State (EOS)**	02/04/16		
Reviewer 2: **Review is All We Do (RIAWD)**	02/11/16		
Reviewer 3: **FHWA**	02/14/16		

Category	**Reviewer**		**Analyst**		
	Initials	**Review Comments**	**Response Code**	**Response**	**Markup Complete**
Network Coding	EOS	#1(Link 422:413) # 2 (Link 1109:209 kerb points) #3 (Link 344:229 stopline rotation)	A A A	#1 Link adjusted to provide two lanes	TMRU – 3/02/15
	RIAWD	#1 (Model weave lengths) #2 (Ramp at node 447)	P A	#1 The study team has modified the upstream lane choice rules associated with the mainline weaves between Fake Rd. and False Dr. While there is always a degree of early or late lane changing within the model due to randomly assigned degrees of aggressiveness, awareness, etc., this issue has been mitigated to the greatest extent possible. #2 Ramp parameters modified to mitigate this issue as much as possible. The future AM model should now match the draft PM model, as this issue was more prominent during the future PM peak period.	TMRU – 03/02/15
	FHWA	#1 (Link 29:30 and 29:31) #2 (81st St./St. Peter Ave geometry)	D RFS	#1 The left turn lane here (Link 29:31) has been modeled as separate to prevent vehicles from attempting to move over, therefore blocking the lane and causing a queue. No change is proposed. #2 The design team has indicated that while the DXF does not indicate an allowable movement from SB 81st St to the IH-0 EB entrance ramp, this access could be provided as the team continues to work on design refinements. Movement from SB 81st to IH-0 EB will be modeled, and results of this will help inform the final design decision.	TMRU – 03/02/15

Traffic Engineering, Operations and Safety Manual

Chapter 16 Traffic Analysis and Modeling

Section 30 Operations Certification Process

16-30-1 Basic Principles November 2022

1.1 Overview

The Operations Certification Process (OCP) is a performance-based, data-driven process for determining whether to consider the inclusion of operational-driven intersection or mainline improvements as part of a project already prioritized for program approval for non-operational reasons. The process includes quantifying alternatives, monetizing the resulting operational benefits, completing benefit-cost comparisons of the alternatives, and documenting decisions and judgements made throughout the process.

The OCP is for use on locations where a less than desirable level of operation *may* exist and has the potential for improvement through geometric modifications or a change in traffic control. These locations, known as Operational Sites of Promise (OSOP), can be generated through local knowledge, or can be identified through the WisDOT network screening tools.

The OCP applies asset management and traffic operational benefit-cost metrics to determine if the proposed improvements provide sufficient benefit to the State Trunk Network (STN) to validate consideration for prioritization and to justify partial or total State Highway Rehabilitation (SHR) improvement funding.

The regional analyst does not need to complete the OCP for every location identified as an OSOP. However, unless other asset management certification processes (pavement treatment, safety, bike/pedestrian needs, structures, etc.) can justify the improvement, regional staff must complete the OCP to warrant inclusion of any operational-driven improvement as part of a perpetuation or rehabilitation project.

WisDOT's Bureau of Traffic Operations - Traffic Analysis and Safety Unit (BTO-TASU) is the lead for the OCP. Direct any questions regarding the OCP to DOTTrafficAnalysisModeling@dot.wi.gov.

1.2 Purpose

The primary purpose of the OCP is to assess the asset management validity of intersection or mainline improvements solely intended to fix an operational issue on the STN. The improvements must address the operational issue without degrading the overall safety.

1.3 When to Apply

1.3.1 Typical Applications

Identification of an operational site of promise alone does not trigger the need to complete the OCP. The OCP becomes required when there is a desire to include operational-driven improvements as part of a perpetuation or rehabilitation project. These improvements could include geometric modifications or a change in traffic control.

If completed, the OCP is a certification element necessary for the Final Scope Certification (FSC) approval as it helps to define an improvement project's purpose and need. Mainline facilities, intersection, or interchange improvements can have significant impacts on scope, schedule, and budget. WisDOT regional staff *should* apply the OCP as early as possible during the Financial Integrated Improvement Program System (FIIPS) Life Cycle 10 (LC10), the Project Definition phase of scoping, to maximize the time that the Programmatic Scoping and FSC processes have for identifying all the resultant scoping impacts from any OCP justified improvement. If any improvements trigger an Intersection Control Evaluation analysis, complete the OCP in conjunction with that effort. For additional information on the Intersection Control Evaluation process, see FDM 11-25-3.

1.3.2 When Not Applicable

If the proposed improvements do not extend outside the limits of the existing roadway footprint (i.e., does not require additional pavement or grading), then the WisDOT regional staff can likely include the improvement in the project without going through the OCP. For example, retiming an existing signal or restriping an existing 16-foot painted median to a 4-foot painted median and a 12-foot left turn lane would not trigger the need to complete the OCP unless additional pavement or grading is also necessary.

Improvements that include additional pavement or grading, such as modifying an existing raised-median to add or extend a left turn lane or adding pavement to the shoulder to provide a right turn lane, would trigger the need to complete the OCP for funding consideration. Improvements that *may* have a negative safety impact (e.g., narrowing lane widths), even those without the need for additional pavement, would also need to go through the OCP to justify inclusion in a perpetuation or rehabilitation project.

The OCP is not applicable for modernization projects; however, the WisDOT regional analyst can use the OCP benefit-cost tools to evaluate the potential benefit of operational improvement alternatives under consideration.

1.3.3 Local Considerations

Local agencies can follow a process similar to the OCP to evaluate operational improvements along their local roadway network; however, since the focus of the OCP is on the STN, use of the OCP tools *may* require modification to address local needs. WisDOT's BTO-TASU is available to provide guidance to the local agency on the OCP and associated tools; however, completion, review, and approval of any documentation on the analysis methodology and results is the responsibility of the local agency.

1.4 Acronyms

Table 1.1 provides common acronyms used throughout the Operations Certification Process.

Table 1.1 Acronyms

Acronym	Definition
B/C	Benefit-Cost Ratio
BPD	Bureau of Project Development
BSHP	Bureau of State Highway Programs
BTO	Bureau of Traffic Operations
FDM	Facilities Development Manual
FSC	Final Scope Certification
HCS	Highway Capacity Software
HCM	Highway Capacity Manual
IBCT	Intersection Benefit-Cost Tool
MFBCT	Mainline Facility Benefit-Cost Tool
NPMRDS	National Performance Management Research Data Set
OAPM	Office of Asset and Performance Management
OCP	Operations Certification Process
OSOP	Operational Sites of Promise
SCP	Safety Certification Process
SHR	State Highway Rehabilitation
SOBCR	State Trunk Network-Only Benefit-Cost Ratio
SOCD	Safety and Operations Certification Document
STN	State Trunk Network
TASU	Traffic Analysis and Safety Unit

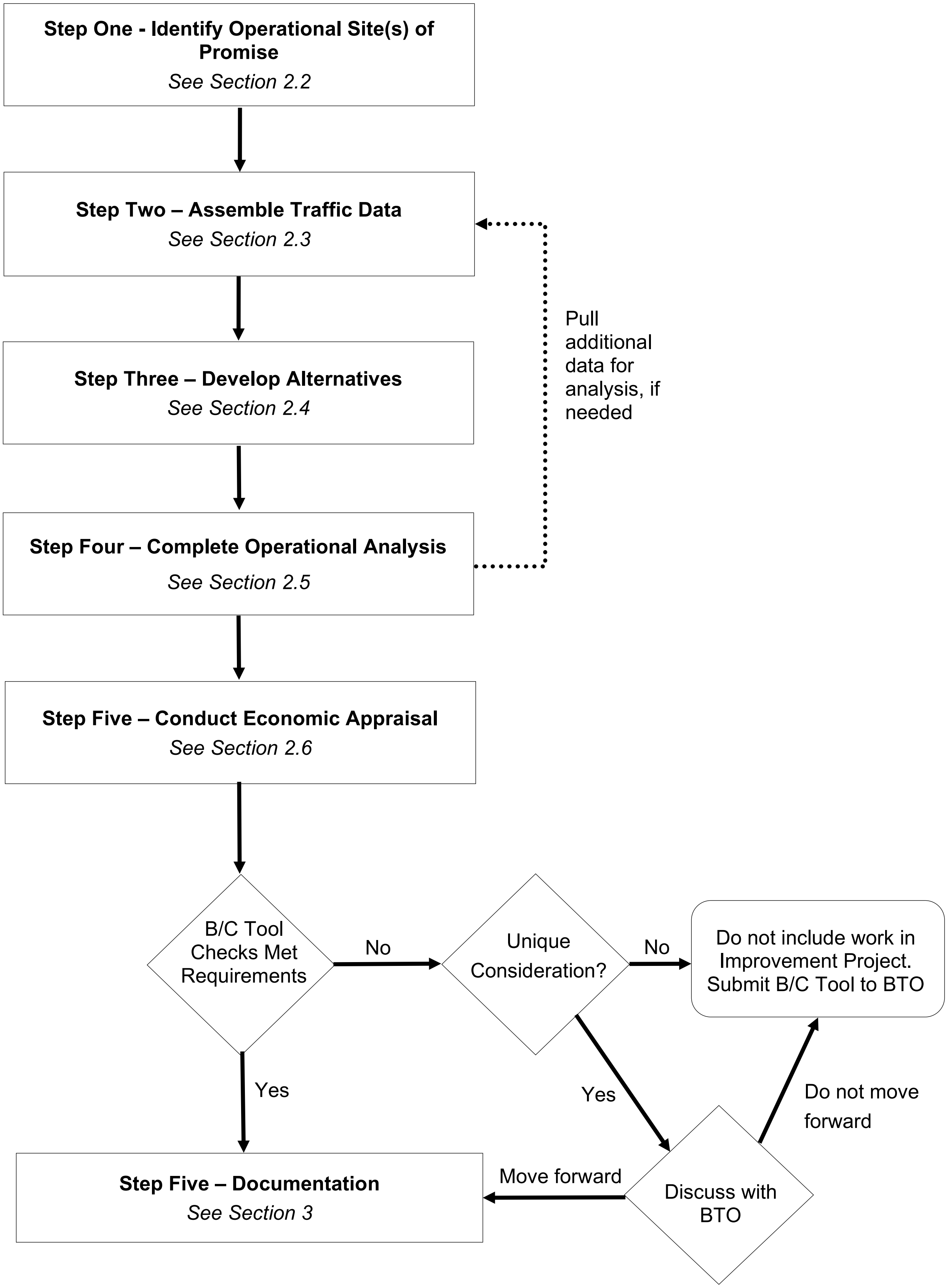
16-30-2 Policy November 2022

2.1 General

The purpose of this section is to introduce the methodology and expectations for evaluating the benefits of operational-driven improvements to the STN under performance-based practical design through the implementation of WisDOT's OCP. If applicable, the OCP is a certification element necessary for FSC approval.

Figure 2-1 and the following sections illustrate and define each step within the OCP, respectively.

Figure 2-1 Operations Certification Process Flow Chart



2.2 Identify Operational Site(s) of Promise

2.2.1 OSOP Definition

An Operational Site of Promise (OSOP) is an intersection or mainline location where a less than desirable level of operation *may* exist and has the potential for improvement through geometric modifications or a change in traffic control. Performance metrics that *may* describe locations with less than desirable levels of operation include, but are not limited to, locations with:

- Excessive user delay (e.g., > 50 seconds of delay/vehicle)
- Recurring poor operations (e.g., level of service E or worse)
- Long queues (e.g., queues block adjacent intersections or back onto the freeway, etc.)
- Other factors (e.g., inadequate gaps, poor merge/weave performance).

Refer to FDM 11-5-3.2 for additional performance metrics that could help define a potential OSOP.

2.2.2 Locate and Assess OSOP

The goal of this step is to identify OSOPs that exist within the limits of an improvement project. Identification of an OSOP does not automatically trigger the need to complete the OCP. However, identification of an OSOP *should* encourage additional evaluation to assess the potential benefits of completing the OCP.

WisDOT regional staff can identify an OSOP through network screening or through local knowledge (see below for more details).

2.2.2.1 Identification Through Network Screening

Operational network screening allows for a high-level planning assessment of all intersections and segments on the STN to flag locations that *may* have a less than desirable level of operation and warrant additional evaluation. The purpose of network screening is to identify potential system-wide OSOPs and to support the OCP as part of performance-based practical design. Operational network screening is not a requirement, but rather a highly recommended step within the planning phase of an improvement project.

There currently are two tools available for conducting operational network screening:

- Intersection operations screening tool
- Mainline operations screening tool

Regional analysts can review the results of the network screening tools to identify OSOPs within the limits of an improvement project relatively quickly. They can then make the determination as to whether to conduct an evaluation of the OSOP to verify the level of operations and to assess if completion of the OCP would be beneficial.

Additional details on the intersection and mainline operations screening tools follow.

2.2.2.1.1 Intersection Operations Screening Tool

The *intersection operations screening tool* consists of five Excel-based files (one for each region) that evaluate every intersection on the STN (over 26,000 intersections statewide). The tool applies planning-level methodologies to determine an operational score for each intersection and flags those that *may* be operating at a deteriorated level of service.

The high-level analysis tool utilizes available information and incorporates several assumptions for missing information related to lane configurations, volumes, turning movement percentages, and signal timings to name a few. As such, the regional analyst *should* update the assumptions in the tool with site-specific data where possible and confirm the results of the initial screening. This will allow for a more accurate estimate of the intersection’s operational performance and provide a better gauge as to whether further evaluation through the OCP *may* be beneficial.

The *intersection operations screening tool* evaluates and flags intersections following the steps outlined below:

Step 1: Basic data processing (all control types) - The primary objective of this step is to determine peak hour traffic volume per lane for each approach. This step includes assumptions when there is no data available.

Step 2: Estimate volume and capacity (by control type) - The primary objective of this step is to calculate the critical lane volume and capacity per lane, per approach, or both depending upon the control type.

Step 3: Estimate delay and level of service (by control type) - This step follows the guidelines of the Highway Capacity Manual, 7th Edition (HCM7) and the National Cooperative Highway Research Program

(NCHRP) 825 to calculate control delay per approach and per intersection. Level of service is then determined based on the control delay.

Step 4: Flag intersections – Through sensitivity analysis, using the assumptions from above, this step flags those intersections anticipated to operate at a deteriorated level of service.

Additional details on the analysis methodology for the *intersection operations screening tool* is available on the BTO Traffic Analysis, Modeling and Data Management Program area webpage. For support or guidance on the use of the tool, contact BTO-TASU (DOTTrafficAnalysisModeling@dot.wi.gov).

2.2.2.1.2 Mainline Operations Screening Tool

Historically, Meta-Manager Mobility has been the primary source for identifying mainline locations that *may* be operating at a less than desirable level of service. (See FDM 11-5.3.5 for additional discussion on level of service analysis within Meta-Manager). Although this will continue to be the primary source for obtaining a planning-level assessment of operations for multilane highways, rural two-lane highways, and urban arterial roadways, an additional tool, the *mainline operations screening tool*, is available to provide a more detailed assessment for mainline freeway segments.

The *mainline operations screening tool*, developed by the Bureau of State Highway Programs (BSHP), uses Meta-Manager Mobility data, combined with speed data from the National Performance Management Research Data Set (NPMRDS), and crash frequency data for rear-end and same-side, side-swipe crashes to determine an operational score for all basic freeway segments (i.e., no auxiliary lanes) on the STN. Using the operational score, the tool currently flags those locations that *may* benefit from extended acceleration or deceleration lanes or the addition of an auxiliary lane. The results of the *mainline operations screening tool* are available via a map and spreadsheet format.

Future enhancements of the tool *may* allow for its use on other facilities, but until such time, WisDOT regional analysts *should* continue to use Meta-Manager Mobility to identify potential operational issues on non-freeways or freeways with an existing auxiliary lane. The results from Meta-Manager Mobility are an acceptable starting point to flag a segment as an OSOP; however, the WisDOT regional analyst *should* use available data on crashes, delay, and other relevant performance metrics to assess whether additional exploration through the OCP *may* be beneficial.

For support or guidance on the use of the *mainline operations screening tool*, contact BSHP – Program Development and Analysis Section.

2.2.2.2 Identification Through Local Knowledge

The goal of the screening tools is to aid the regions by identifying locations that *may* benefit from operational improvements, but the results are not all inclusive. Outside of the screening tools, regions *may* use local knowledge of areas with operational concerns to identify an OSOP. This could be in the form of comments from the traveling public, local officials, transportation management center observations, or WisDOT personnel knowledge from monitoring and traveling the network.

2.3 Assemble Traffic Data

2.3.1 Site Data

After identifying the OSOP, the regional analyst *should* assemble additional site-specific traffic data for each OSOP within the project limits. Required site-specific data includes:

- Roadway/intersection geometry, such as turn lane storage lengths for intersections and the merge/diverge section lengths for mainline facilities
- Existing and proposed intersection traffic control, including warrant analysis and signal timings
- Posted speeds

Additional site-specific data that could help define the existing user and travel characteristics and support the need for potential operational improvement(s) include, but are not limited to:

- Sight distance data
- Freight routing data
- Traffic generating events
- Existing access
- Multimodal accommodations

2.3.2 Traffic Counts and Forecasts

Consult with BTO-TASU for questions on the appropriate use of existing counts, necessity of getting new counts, and the acceptable forecasting methods for the specific site. In most cases, planning-level forecasts *should* be sufficient for completion of the OCP. Additional guidance on the assembly of traffic data is available in TEOpS 16-05.

The OCP requires the use of two forecasted years – the first year and the last year of the operational analysis period. They are described as follows:

- The first year of the operational analysis period is the first year the roadway is open to traffic after construction (i.e., the analysis period begins the year after completing construction of the improvement)[1].
- The last year of the operational analysis period is determined by adding the fixed service life of the project's improvement concept to the first year of the operational analysis period. For consistency, the OCP **shall** use the following prescribed service life durations:
    - Resurface - 10 years
    - Pavement Replacement using new asphalt - 15 years
    - Pavement Replacement using new concrete - 20 years

2.3.3 Safety Data

Safety data collection and analysis *should* follow the Safety Certification Process (SCP). See FDM 11-38 for details on the data needed and steps to complete the SCP. Direct questions regarding the SCP to DOTBTOSafetyEngineering@dot.wi.gov.

2.4 Develop Alternatives

When developing operational-driven alternatives, WisDOT regional staff *should* focus on improving the operational needs along the STN without degrading safety. In most cases, an alternative with a safety disbenefit will result in denial of the improvement alternative regardless of the funding agency or source. Improvements *should* incorporate performance-based practical design principles.

Often times there are multiple alternatives for addressing the operational needs at an OSOP, where each alternative could consist of one or more improvements to the state highway, the local roadway, or both. Carrying each alternative through the OCP and completing the economic appraisal for each alternative will help to determine which alternative(s) to investigate further based on the benefit-cost metrics.

Improvements to the local roadway will require additional documentation to illustrate how the improvement(s) will provide a direct benefit to the STN. For alternatives that include multiple improvements, the documentation needs to show how each individual improvement will help address an identified operational need while also working together to improve overall operations at the OSOP.

2.5 Complete Operational Analysis

2.5.1 Analysis Periods and Scenarios

Complete the intersection and/or mainline operational analysis for the following scenarios:

- No-build Operational Analysis Start Year (Construction Year + 1)
- No-build Operational Analysis End Year (End of Service Life)
- Build Operational Analysis Start Year (Construction Year + 1)
- Build Operational Analysis End Year (End of Service Life)

Conduct analysis for the time period(s) when there is known or estimated congestion or other operational concerns. This typically is one-hour during the morning and one-hour during the typical weekday afternoon when traffic demand is the highest (i.e., the AM and PM peak hour), but can vary by location.

2.5.2 Analysis Methodology and Tools

In most cases, the traffic analysis for the OCP will utilize HCM-based traffic analysis tools (e.g., Synchro, HCS, SIDRA). Use of microsimulation tools (e.g., SimTraffic, Vissim) are only necessary under certain conditions to get a more accurate assessment of queuing impacts, or when the analysis exceeds the limitations of the HCM-methodology and construction costs are high enough to justify the additional expenditure of resources. Refer to TEOpS 16-10 for additional guidance on the supported analysis software tools for use within the OCP.

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[1] For proposed advanceable projects, base the first year of the analysis period on the original letting (LET) date, not the advanceable LET date.

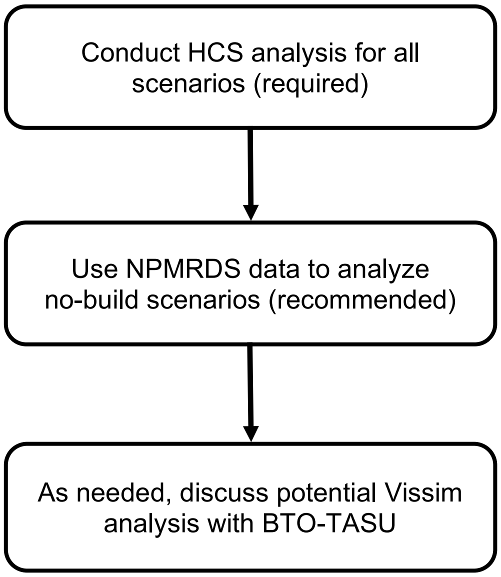
2.5.2.1 Intersection Analysis

The intersection operational performance metrics necessary for completion of the OCP economic appraisal are delay (in vehicles per hour) and 95th percentile queue lengths (in feet). Synchro is the recommended analysis software because the benefit-cost tools used to complete the economic appraisal allow for the automatic input of performance metrics from Synchro. However, the benefit-cost tools allow for the manual entry of this information to accommodate the use of other supported traffic analysis tools.

2.5.2.2 Mainline Analysis

The primary mainline operational performance metric necessary for completion of the OCP economic appraisal is travel speed (in miles per hour). The economic appraisal tool will utilize the travel speed, volume, and segment length to calculate travel time and user delay. The mainline analysis includes a multi-step operational analysis from up to three different sources as presented in Figure 2-2. Refer to TEOpS 16-10 for additional guidance on the supported analysis software tools for use within the OCP.

Figure 2-2 Mainline Operational Analysis Flow Chart



2.5.2.2.1 HCS Analysis

HCS is the recommended software tool to evaluate mainline operations for the OCP. The benefit-cost tools developed to complete the economic appraisal allow for the automatic input of outputs from the HCS freeway facilities module. Users can manually input data into the benefit-cost tool from other HCS mainline analysis modules, such as the HCS two-lane highway or HCS multilane highway modules, or other WisDOT supported traffic analysis tools.

2.5.2.2.2 NPMRDS Analysis

Ideally, the evaluation of the no-build conditions will use a combination of both HCS results and NPMRDS data. Use of NPMRDS data allows the analysts to ground the HCS model results to field data, thus providing a realistic assessment of observed speeds. After completing the HCS analysis and reviewing the results for reasonableness, the analyst *should* pull the raw NPMRDS speed data for the OSOP(s). The benefit-cost tools use volume data from HCS and location code, time stamp, and speed data from NPMRDS to assess the no-build conditions. The benefit-cost tool contains detailed information on the NPMRDS data collection. If NPMRDS data is not available, the analyst can use HCS to calculate the speeds for use in the economic appraisal.

2.5.2.2.3 Vissim Analysis

It is important to determine the appropriateness of using Vissim as the models can be time consuming and expensive to complete. Conduct an initial economic appraisal following HCM-methodologies prior to considering a Vissim analysis. If initial economic appraisal results following HCM-methodologies are well below the thresholds, it is unlikely that a Vissim model will produce results that would meet the thresholds, thus decreasing the potential benefit of the extra level of effort. As such, limit the use of Vissim analysis to only those locations:

- with poor existing operations not accurately captured with higher-level analyses
- that do not fit within the confines of the HCM-methodology
- with improvement costs greater than $2.5 million, and/or
- that have economic appraisal results which border the thresholds

Contact BTO-TASU to discuss the potential use of Vissim before starting the analysis. If justified, use the Vissim models to obtain both the no-build and build results.

2.6 Conduct Economic Appraisal

The OCP uses benefit-cost metrics to determine program prioritization validity of proposed operational improvements. The benefit is determined by comparing the user-delay cost over the typical life expectancy of the perpetuation or rehabilitation improvement concept with and without the proposed operational improvements through calculating the net-present value.

BTO developed two Excel-based tools to calculate the benefit-cost metrics used in the economic appraisal, the *Intersection Benefit-Cost Tool* (IBCT) and the *Mainline Facility Benefit-Cost Tool* (MFBCT), both of which are able to analyze multiple alternatives at one or more OSOPs. The analyst enters information on the operational analysis results, the Safety Certification Process results, and the construction costs into the appropriate tool. The benefit-cost tools use the input to perform the associated safety and operational checks as outlined below (see section 2.6.2).

2.6.1 Construction Cost Estimate

The construction cost is the cost of the proposed operational improvement(s) being evaluated through the OCP, not the total project cost. These costs must include the construction costs and subsequent costs, including noise walls and associated real estate costs for the improvement. The economic appraisal *should* exclude any design or oversight costs and maintenance or operating costs.

If analyzing multiple improvements or locations, the economic appraisal *should* include the construction cost for all proposed improvements. However, the analyst must document and justify each individual improvement within the Operations Certification Summary.

2.6.2 Safety and Operational Checks

Proposed intersection and mainline improvements must pass a set of safety and operational checks in order to be considered for inclusion in a SHR-funded project.

The safety checks provide an assessment on whether the proposed operational improvement generates any safety disbenefits as defined under the Safety Certification Process (SCP), see FDM 11-38. In most cases, a safety disbenefit will result in denial of the improvement alternative regardless of the funding agency or source. BTO recommends conducting the safety check before running the operational analysis as a negative impact to safety for a proposed solution *may* deter further investigation.

The operational checks look at benefit-cost ratios to determine if the project has sufficient operational benefit to justify prioritization for inclusion in an approved SHR-improvement program project. If the proposed improvement does not meet the operational checks, it does not mean the project will not provide any operational benefits. It just means the benefits are not sufficient to justify shifting funding from prioritized projects and accepting a resultant decrease in system health.

There *may* be instances where an improvement does not meet the safety and operational checks but *should* have unique considerations for use of SHR funds. Coordinate with BTO-TASU, Bureau of Project Development (BPD), and Division of Transportation Investment Management (DTIM) – Office of Asset and Performance Management (OAPM) for additional review of these improvements. Unique considerations could include the conversion of an all-way stop-controlled intersection to a signalized intersection or an off-ramp with queues that exceed the ramp length and back out onto the freeway.

2.6.2.1 Safety and Operational Checks

There are three safety and operational checks for applicable for both intersections and mainlines:

1) Safety benefit-cost ratio must be 0 or greater
2) No increase in fatal and injury (KABC) crashes
3) Safety and operations benefit-cost ratio must be 3.0 or greater

Intersections have an additional operational check to assess the benefit to the STN. For intersections to qualify for 100% SHR funding, the STN-only benefit-cost ratio (SOBCR) must be 1.0 or greater. The SOBCR considers operational benefits only and does not take into consideration any potential safety benefits to the STN. A SOBCR less than 1.0 *may* allow for less than 100% SHR improvement funding if all the following conditions are met:

1) All the other safety and operational checks received passing values,
2) A local or other approved non-SHR improvement funding source has been identified to cover the remaining project costs,
3) There is a signed State Municipal Financial Agreement within the FSC that documents the local share for the scope of the operational improvements.

The operational-driven improvements must pass all the above safety and operational checks to be considered for 100% SHR funding. If not all the checks are met, then there *may* still be an opportunity for partial funding. The OCP identifies improvements for funding consideration and does not guarantee funding.

2.6.2.2 Changes to Benefit-Cost Thresholds

DTIM-OAPM is responsible for maintaining the department’s asset management metrics which identify system needs for prioritization of approved funding. Depending on level of needs and available funding, program prioritization thresholds can change over time. As DTIM-OAPM regularly performs necessary updates to the system asset management metrics, it will also determine if any adjustments to the benefit-cost thresholds occur.

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3.1 Operations Certification Summary

The purpose of the Operations Certification Summary is to articulate the purpose and need of the proposed improvements. A successful purpose and need clearly defines the system’s needs, identifies the negative impacts to the system from those needs, and describes how each proposed improvement works individually and in harmony with any other individually proposed project improvements to cost effectively resolve the need.

The Operations Certification Summary must clearly explain and robustly justify the inter-dependent necessity of each improvement. The Operations Certification Summary **shall** identify the specific existing operational problem(s) at the OSOP, define the proposed improvements, and clearly illustrate how the improvements directly reduce or eliminate the operational problem(s) without degrading the overall safety of the OSOP.

The reason for requiring this type of documentation is illustrated in the following ways:

- It is very possible that one improvement element out of the several proposed for a site could be singularly generating more than the required benefit-cost ratio. Satisfying all the required checks within the OCP, *should not* arbitrarily allow the inclusion of other proposed improvements.
- The Operations Certification Summary must explain how and why all the individual improvement elements are necessary for the totality of the project as proposed.
- Failure to clearly identify and explain those engineering and operational linkages within the Operations Certification Summary could result in the rejection of some or all the proposed improvement elements.
- State Statutes 20.395(3)(cq) and 20.395(3)(cx) prohibit WisDOT from spending SHR-improvement funds on the local system without having documented justification on the direct STN benefits that expenditure provides. If the proposed project includes improvements to the local system, the Operations Certification Summary must clearly articulate the inter-dependent necessity of those improvements to the total project and how they provide direct operational or safety benefit to the STN to justify any expenditure of SHR improvement funds on them.

An Operations Certification Summary template along with the Operations Certification Summary Guidance document are available to guide the user on the content and format for the Operations Certification Summary itself. Submit the Operations Certification Summary as an attachment to the Safety and Operations Certification Document and submit to BTO-TASU for review. See FDM 11-38-15.1 for additional details on the Safety and Operations Certification Document.

3.2 Operations Certification Amendment

An amendment must be submitted if WisDOT regional staff want to consider other alternatives or additional operational improvements after the Safety and Operations Certification Document has been signed and the Operations Certification Summary has been approved. The new alternatives or additional operational improvements will need to follow the OCP. Document the results in the Operations Certification Summary amendment and attach to the Safety and Operations Certification Document amendment. See FDM 11-38-15.2 for additional details on the Safety and Operations Certification Document Amendment. If the project is still within the scoping phase, the WisDOT regional analyst **shall** include the amended Safety and Operations Certification Document within the FSC. The amended Safety and Operations Certification Document will supersede the original. If the amendment occurs after the scoping phase, the WisDOT regional analyst **shall** document the amended Safety and Operations Certification Document within the Design Study Report and environmental document, as appropriate.

An Operations Certification Summary Amendment template and Operations Certification Summary Amendment Guidance document are available to guide the user on the content and format of the amendment itself. Submit the Operations Certification Summary Amendment as an attachment to the Safety and Operations Certification Document Amendment and submit to BTO-TASU for review. See FDM 11-38-15 for additional details on the Safety and Operations Certification Document.

3.3 Project Approval and Funding

The OCP serves as an aid, not an absolute determinant, in the WisDOT SHR Scoping process. The OCP identifies when it is a valid asset management consideration to add the proposed operational improvements to a perpetuation or rehabilitation project. Passing the safety and operational checks during the economic appraisal validates consideration for adding the proposed improvement(s), but it does not automatically guarantee funding for the evaluated improvement(s).

Different variables can impact the SHR Improvement Program in either positive or negative ways with little or no advance notice. World events can trigger sudden economic downturns or upturns that *may* result in funding changes or rapid construction cost inflation which lead to re-calibration of asset management metrics and existing programming priorities. Recent or current OCP approvals *may* require reassessment under re-calibrated benefit-cost ratio values.

Similarly, certain highway segments within the SHR Improvement Program *may* experience unanticipated accelerated deterioration resulting from physical attributes or historically harsh weather conditions. This can require re-prioritization of needs and treatments within the SHR Improvement Program that could negatively impact previous program assumptions within a regional or statewide program.

Inclusion of operational improvements in the project’s scope requires BTO-TASU approval of the OCP analysis methodology, Operations Certification Summary, and Safety and Operations Certification Document. BTO approval; however, does not guarantee funding. The regional programing unit (3R Program) or the BSHP (Backbone Program) has the final approval for including operational improvements into the FSC. WisDOT regional staff *should* work with the respective programming sections early in the process to discuss the system health impacts of adding additional operational improvement project costs to the program.