



# Aimsun Next Modeling Guidelines June 2018

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# Disclaimer

This document provides guidance for developing and reviewing Aimsun Next models in Nevada. These guidelines are only considered as a general framework for model development, calibration and validation with a focus on the methodology. The parameters suggested in these guidelines are to be considered as a starting point and the values can be further adjusted to fit specific site circumstances if justified. It is the responsibility of the modeler to ensure that the models they develop are fit for their intended purpose. The application of these guidelines does not guarantee the resulting Aimsun Next model will be fit for the project purpose.

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<b>1</b>	<b>INTRODUCTION</b>	<b>5</b>
<b>1.1</b>	<b>PURPOSE OF GUIDELINES</b>	<b>5</b>
<b>1.2</b>	<b>SCOPE OF GUIDELINES</b>	<b>5</b>
<b>2</b>	<b>AIMSUN NEXT BACKGROUND</b>	<b>7</b>
<b>2.1</b>	<b>WHY AIMSUN NEXT</b>	<b>7</b>
<b>2.2</b>	<b>AIMSUN NEXT MODELING PROCESS</b>	<b>8</b>
<b>3</b>	<b>MULTI-RESOLUTION MODELING WITH AIMSUN NEXT</b>	<b>11</b>
<b>3.1</b>	<b>MACROSCOPIC MODELING</b>	<b>12</b>
3.1.1	STATIC ASSIGNMENT INPUTS	14
3.1.2	STATIC ASSIGNMENT OUTPUTS	14
3.1.3	DEMAND ADJUSTMENT	15
3.1.4	OPTIMIZATION OF DETECTOR LOCATION	15
3.1.5	SUBNETWORKS AND TRAVERSALS	16
<b>3.2</b>	<b>MICROSCOPIC MODELING</b>	<b>16</b>
3.2.1	MICROSCOPIC MODEL INPUTS	17
3.2.2	MICROSCOPIC MODEL OUTPUTS	17
<b>3.3</b>	<b>MESOSCOPIC MODELING</b>	<b>18</b>
3.3.1	NETWORK REPRESENTATION	20
3.3.2	BEHAVIORAL MODELS	20
3.3.3	DYNAMIC TRAFFIC ASSIGNMENT	21
3.3.4	MESOSCOPIC MODEL INPUTS	22
3.3.5	MESOSCOPIC MODEL OUTPUTS	22
<b>3.4</b>	<b>HYBRID MODELING</b>	<b>22</b>
<b>4</b>	<b>MASTER NETWORK</b>	<b>27</b>
<b>4.1</b>	<b>BASE NETWORK</b>	<b>29</b>
<b>4.2</b>	<b>DEMAND</b>	<b>30</b>
<b>4.3</b>	<b>ATTRIBUTES AND ATTRIBUTE OVERRIDES</b>	<b>30</b>
<b>4.4</b>	<b>GEOMETRY CONFIGURATIONS</b>	<b>31</b>
<b>4.5</b>	<b>MASTER CONTROL PLANS</b>	<b>32</b>
<b>4.6</b>	<b>PUBLIC TRANSPORT (TRANSIT) PLANS</b>	<b>32</b>
<b>4.7</b>	<b>MODELED AREA AND SUB-AREAS</b>	<b>33</b>
<b>4.8</b>	<b>MASTER NETWORK CALIBRATION AND VALIDATION</b>	<b>35</b>
<b>5</b>	<b>MANAGING CONCURRENT MODELING TASKS</b>	<b>37</b>
<b>5.1</b>	<b>INTRODUCTION TO AIMSUN NEXT REVISIONS</b>	<b>37</b>

<b>5.2</b>	<b>PREPARING THE NETWORK</b>	<b>39</b>
<b>5.3</b>	<b>CREATING A REVISION</b>	<b>39</b>
<b>5.4</b>	<b>EDITING REVISIONS</b>	<b>41</b>
<b>5.5</b>	<b>MERGING REVISIONS BACK TO MASTER NETWORK</b>	<b>41</b>
<b>5.6</b>	<b>ADDITIONAL REVISION NOTES</b>	<b>42</b>
<b>6</b>	<b>MANAGING SCENARIOS</b>	<b>43</b>
<b>6.1</b>	<b>STATIC SCENARIOS</b>	<b>44</b>
6.1.1	STATIC SCENARIO PARAMETERS	45
6.1.2	STATIC SCENARIO OUTPUTS	46
<b>6.2</b>	<b>DYNAMIC SCENARIOS</b>	<b>46</b>
6.2.1	DYNAMIC SCENARIO PARAMETERS	46
6.2.2	DYNAMIC SCENARIO OUTPUTS	47
<b>6.3</b>	<b>APPLYING SCENARIO MANAGEMENT</b>	<b>47</b>
<b>7</b>	<b>GUIDANCE FOR SOUTHERN NEVADA MASTER NETWORK</b>	<b>51</b>
<b>7.1</b>	<b>NDOT LINK BETWEEN AIMSUN NEXT MASTER NETWORK AND REGIONAL PLANNING MODEL</b>	<b>51</b>
<b>7.2</b>	<b>MANAGEMENT OF MASTER AND PROJECT FILES</b>	<b>52</b>
<b>7.3</b>	<b>PROVIDING THE MASTER NETWORK TO CONSULTANTS</b>	<b>53</b>
<b>7.4</b>	<b>NAMING CONVENTION</b>	<b>54</b>
<b>8</b>	<b>ADDITIONAL GUIDANCE</b>	<b>55</b>
<b>8.1</b>	<b>SOFTWARE MANAGEMENT</b>	<b>55</b>
<b>8.2</b>	<b>CONTINUATION OF GUIDELINES</b>	<b>55</b>

# 1 Introduction

## 1.1 Purpose of Guidelines

The Nevada Department of Transportation (NDOT) developed the Aimsun Next Modeling Guidelines (the Guidelines) to provide consistency across projects when using Aimsun Next. While these Guidelines were developed in conjunction with the Southern Nevada Transportation Study (SNTS), the information contained within the Guidelines can be applied to other areas and regions as well.

The Guidelines should be used by both model developers and model reviewers completing modeling projects in this region. These Guidelines should allow both users and decision makers to follow a consistent process, allowing NDOT to efficiently manage projects and integrate projects into the appropriate regional context, specifically meeting the following objectives defined by NDOT for the Southern Nevada Region:

- Serve as a guide for the development of Aimsun Next models;
- Provide guidance for NDOT when reviewing Aimsun Next models; and
- Provide recommended techniques for managing projects to fit into NDOT's overall vision for regional modeling and evaluation of projects into the concept of Aimsun Next master files for larger regional areas.

To support these objectives, the Guidelines provide basic information on Aimsun Next key features and their applications to models. These Guidelines can be supplemented with information from the Aimsun Next software user manual and Aimsun Next training material. It is recommended that any user unfamiliar with the Aimsun Next software also seek out training and technical support, as needed.

## 1.2 Scope of Guidelines

The Guidelines will address the following:

- Developing and maintaining a master network;
- Managing sub models and versions;
- Passing Aimsun model versions from the master network to consultants for project work;
- General calibration and validation for various model levels (macro, meso, micro); and
- Integration with the current strategic model.

These Guidelines will not provide specific calibration or validation parameters as these should be defined and developed for each project based on the project needs and data availability. The Guidelines will also not address feedback from models developed outside of Aimsun Next.

In addition, these Guidelines will provide guidance on approach and management of models for NDOT. Specific how-to and step-by-step software use guidance can be found in the Aimsun Next User's Manual and the Tutorials provided with the software.

In addition, these Guidelines should be periodically reviewed and updated to remain relevant and applicable in a dynamic environment. This version of the Guidelines relates to features available in Aimsun Next Version 8.2 and the objectives identified above. For simplicity, the software will be referred to in this document as Aimsun Next.

## 2 Aimsun Next Background

### 2.1 Why Aimsun Next

NDOT oversees statewide transportation facilities, including the maintenance, improvements, and expansion of these facilities. To determine the best investment of statewide transportation investments, NDOT utilizes transportation analysis methods and techniques through a variety of transportation analysis software. As the systems themselves become more congested, the improvement alternatives and associated analyses also become more complex. Not only are individual facilities more difficult to analyze but the regional impact of any network changes is more critical, leading NDOT to evaluate each facility not only on its own but in a larger regional context. In addition, many improvements may happen concurrently or need to be scheduled based on short-term impacts (such as construction impacts) and long-term impacts.

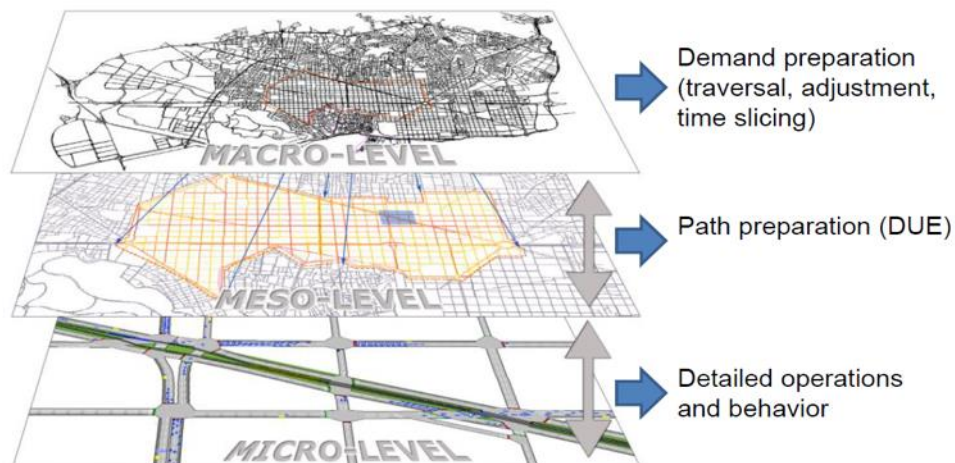
Based on this, NDOT sought to find a software platform that would allow the agency to manage projects in a more efficient manner and in a way that would allow them to evaluate multiple changes and/or combinations of changes concurrently. Aimsun Next was chosen as this platform for the Southern Nevada Region based on some of the unique features that help NDOT meet their overall objectives, including:

- overall modeling process that supports the modeling workflow from network building to analysis;
- multi-resolution and hybrid modeling for evaluating regional and localized impacts of network changes and traffic conditions without requiring sub-area cuts and multiple project files;
- single integrated platform for data consistency and efficiency for in-house staff knowledge transfer;
- revisions for managing multiple concurrent projects with different project teams;
- Scenario Management for evaluation and comparison of alternatives; and
- simulation speed that allows for large-scale modeling support and future live / real-time traffic predictions.

The following sections describe the modeling process and the single-platform multi-resolution modeling in Aimsun Next to give the user a foundation for the application of other features and techniques described later in the Guidelines.

## 2.2 Aimsun Next Modeling Process

Aimsun Next is unique in that it is a fully integrated, single-platform, multi-level modeling platform that incorporates macroscopic, mesoscopic, and microscopic modeling into a single software package, as shown in Figure 1. This means that there is only a single network file and network data entry is only required one time as all objects and attributes are directly accessible for each level of modeling, meaning that changes to the network only need to happen once as all levels of modeling will utilize the same information.



**Figure 1 Aimsun Next Multi-resolution Modeling.**

Regardless of the level of modeling and platform used, most modeling projects will follow the same general process:

1. Define Project Scope, including objectives, study area, analysis, scenarios, and alternatives.
2. Define calibration, validation, and analysis methodologies, including measures of effectiveness and thresholds.
3. Define Data Needs.
4. Create Base Model.
5. Calibrate and Validate Base Model.
6. Create and Evaluate Scenarios.
7. Provide analysis and final recommendations.

Steps 1-3 occur outside of any modeling platform. Steps 4-7 can be applied to specific platforms and are applied in Aimsun Next as follows:

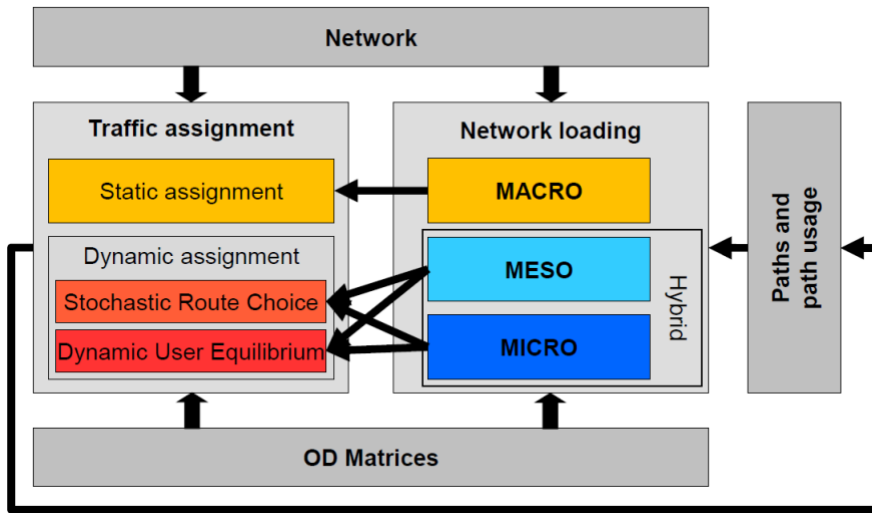


4. [Create Base Model] - Develop Master Network;
5. [Calibrate and Validate Base Model] - Refine the network as necessary for the relevant modeling level (macro, meso, or micro) and calibrate and validate this base model;
6. [Create and Evaluate Scenarios] - using the Scenarios and scenario manager in Aimsun Next, develop scenarios for each horizon year, time period, and other variations; and
7. [Provide Analysis and Final Recommendations] - analysis can be summarized in Aimsun Next and stored for future references.

Focusing on the modeling process itself within Aimsun Next, modelers will follow these general steps:

1. Create New Project.
2. Import Data.
3. Edit Network / Refine Network, including:
  - a. Geometry (Model, Geographic Information System),
  - b. Transit Lines / Schedules (General Transit Feed Specification),
  - c. Demand (Counts, OD Matrices), and
  - d. Traffic Control (Signal Timing Imports).
4. Edit Vehicle & User Types to Segment Traffic Demand (Cars, Trucks, Pedestrians, etc.).
5. Run Model to Obtain Outputs.

Aimsun also provides management tools to manage this process across multiple scenarios, using the Aimsun Architecture in Figure 2 below.



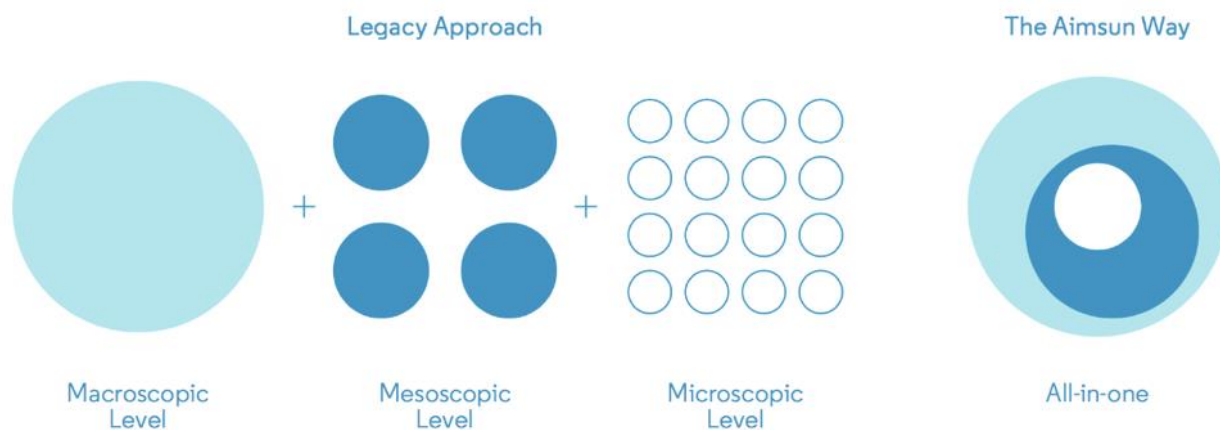
**Figure 2 General Architecture for Aimsun Next Modeling Projects**

The various components will be described in detail in later sections.

### 3 Multi-Resolution Modeling with Aimsun Next

As stated above, Aimsun Next is a single integrated platform for macroscopic, mesoscopic, and microscopic modeling. This integrated nature is natively designed to minimize sources of inconsistencies across the modeling levels, which is critical for any multi-resolution modeling study.

It is a unique approach in that a single network file or Master Network can be maintained and all subarea modeling can be managed within the same file, rather than the legacy approach of maintaining a macroscopic model and “cutting” subareas to form new networks for mesoscopic or microscopic modeling, as demonstrated in Figure 3.



**Figure 3 Aimsun Next traffic Modeling Software True Integration**

Within this integrated platform, data across all levels of modeling are contained in a single network file and applied to the appropriate and relevant modeling level. For example, the influence of control plans and traffic signs (Stop or Yield) is an important aspect that the modeler must maintain: the meso and micro levels explicitly consider the effect on driver behavior while the macro is sensitive to cost functions. Therefore, at the meso and micro levels, the modeler will input real signal timings and traffic control for the entire area being modeled at the meso, micro, or hybrid levels. At the macro level, the modeler will, at minimum, ensure that the Turn Penalty Functions (TPFs) appropriately reflect the effect of intersection control on delay. If desired, control plans can be used at the macro level as well, which will result in better macro paths to then feed into the first dynamic simulations. Version 8.2 now allows seamless integration of control plans and traffic signs in the TPFs.

The following sections provide additional background on the various modeling levels within the Aimsun Next platform.

### 3.1 Macroscopic Modeling

The Aimsun Next solution for Transportation Planning and Demand Analysis has been designed and implemented to support the analyst in the application of the main stages of the Four Step Transportation Planning Methodology:

1. Trip Generation,
2. Trip Distribution,
3. Mode Split, and
4. Assignment (Private Vehicle Assignment and Transit Assignment).

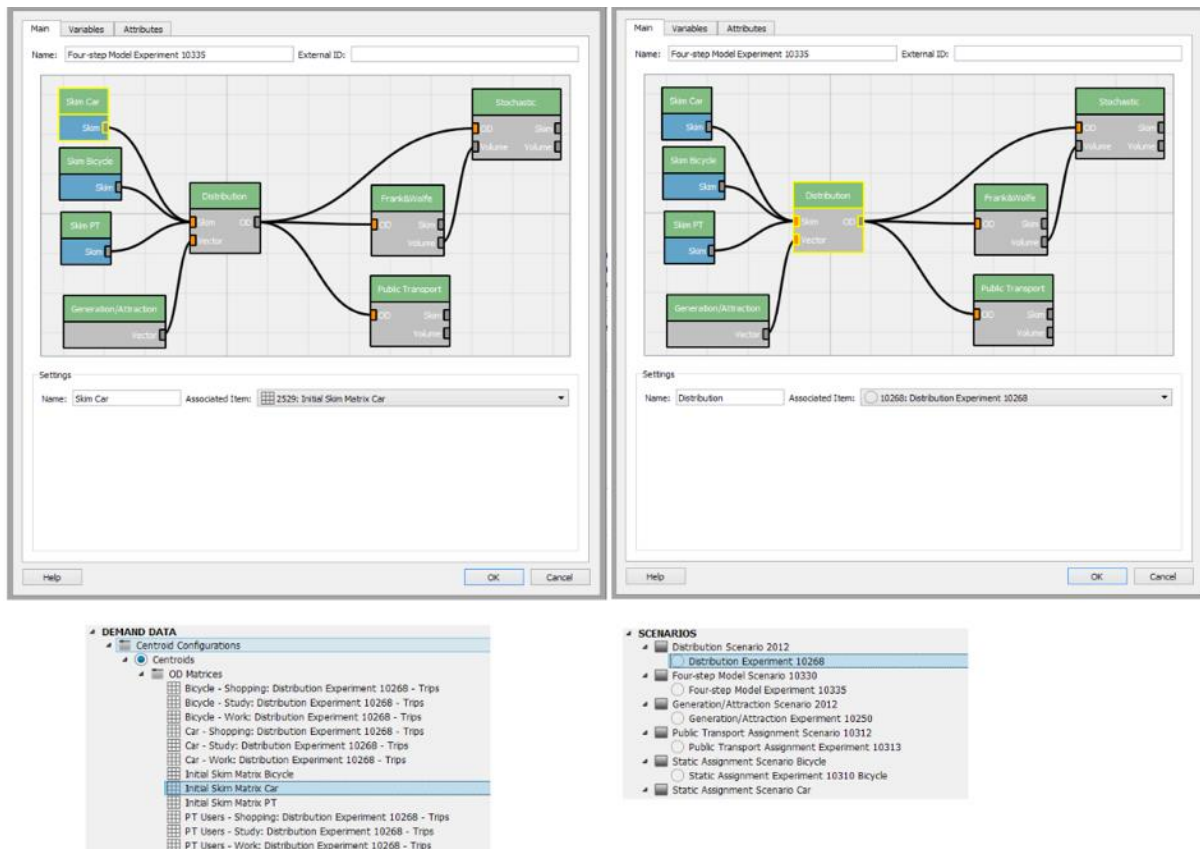
The main functions for this in Aimsun Next are

1. Static Traffic Assignment (Single-User and Multi-User);
2. Demand Analysis (including Matrix import and export, Matrix manipulation, Matrix Balancing, Detector Location Analysis and Demand Adjustment); and
3. Static Traversal Generation.

Aimsun Next utilizes the general process to prepare and adjust the demand, which includes these tasks:

- Static assignment (Simple or multi-user assignment) is managed by the Macro Assignment Experiment, which is located inside a Macro Assignment Scenario.
- OD demand adjustment is managed by the Macro Adjustment Experiment, which is located inside a Macro Adjustment Scenario.
- Traversal demand generation is accessed, once a macro assignment experiment has been executed and a subnetwork has been defined.
- Optimal location of detectors. The Detector Location analysis tool is located in the Infrastructure folder in the Project Window.
- The Matrix Balancing feature is accessible via the OD Matrix Editor as one of the operations that can be applied to a matrix.

Demand Modeling and Demand Forecasting are supported in Aimsun Next with the completion of the Four-step Model. A Four-step Model Scenario and Experiment collects all the steps and data interactions in the process in a work-flow diagram Figure 4.



**Figure 4 Four Step Experiment**

The Aimsun Next travel demand model incorporates objects such as

- Transportation Modes,
- Time Periods,
- Vectors,
- Areas,
- Generation/Attraction and Distribution Data Sets,
- Public Transport Sections and Stations,
- Distribution + Modal Split,
- Public Transport functions, and
- Others.

Static assignment is used to calculate flows in the network, generate static routes and produce a traffic state.

### 3.1.1 Static Assignment Inputs

The inputs for static assignment will generally include the following:

- a network (each section/turn should have a correctly defined cost function),
- traffic demand (with OD matrices),
- public transport plan (optional),
- master control plan (optional),
- a real data set with detection data for validation (optional); and
- parameters.

Users have a choice of several Static Assignments Methods for private transportation, including

- All-or-Nothing,
- Incremental,
- Method of Successive Averages (MSA),
- Equilibrium Assignment (Frank&Wolfe algorithm), and
- Stochastic.

In addition, modelers have three elements in Aimsun Next for calculating path costs for assignment:

- VDFs (Volume Delay Functions) are related to the sections and connections. They determine the cost according to parameters such as traffic volume, capacity, speed, width, etc.
- TPFs (Turn Penalty Functions) are related to the turns. They give a cost according to attributes such as volume, speed, the turn geometry, the green time proportion, etc.
- JDFs (Junction Delay Functions) are specified at the turns. They show the cost due to the conflicts of a turn with the rest of the turns in an intersection.

The Default Macro functions in Aimsun give the cost in minutes. In addition, different costs can be considered for different vehicle types and/or purposes.

### 3.1.2 Static Assignment Outputs

Upon completion of the traffic assignment, the modeler will be able to obtain outputs such as

- traffic flows,

- densities,
- flow bundles, and
- isochrones.

The output can be summarized by

- totals: Volume [PCUs] and cost [VDF units] for sections and turns, occupation by section, function components; and/or
- vehicle type: Volume [vehicles] and cost [VDF units] for sections and turns, occupations by section, percentages of turn by turn, function components.

### 3.1.3 Demand Adjustment

Demand adjustment is used to refine prior matrices and produce time profile matrices from a single matrix. This requires the following inputs:

- calibrated macro network (valid cost functions),
- demand with the initial OD matrices,
- public transport (optional),
- master control plan(optional),
- real data set for sections or detectors and/or turn or flow counts, and
- other parameters.

### 3.1.4 Optimization of Detector Location

Optimization of detector location is used to

- evaluate if available detection data for matrix adjustment covers enough demand; and
- report on optimal positions for installing new detectors and broadening coverage of the demand.

The input requirements to utilize optimization of detector location are

- calibrated macro experiment,
- set of detectors, and
- definition of parameters.

### 3.1.5 Subnetworks and Traversals

Traversal calculation is used to evaluate a subnetwork (network and demand) for later dynamic simulation. It simply requires:

- a calibrated macro experiment,
- a polygon that demarcates the subarea or a list of sections, and
- definition of parameters.

The macro assignment process generates a dataset and path file that will be used to run the traversals. These supporting files must be in place. If the network is updated or changed, the assignment must be re-run to generate new database and path files to use for new traversals.

## 3.2 Microscopic Modeling

The microsimulation approach means that the behavior of each vehicle in the network is continuously modeled throughout the simulation time period while it travels through the traffic network, according to several vehicle behavior models (e.g., car following, lane changing). The Microscopic simulator in Aimsun Next is a combined discrete/continuous simulator. This means that there are some elements of the system (vehicles, detectors) whose states change continuously over simulated time, which is split into short fixed time intervals called simulation cycles or steps. There are other elements (traffic signals, entrance points) whose states change discretely at specific points in simulation time. The system provides highly detailed modeling of the traffic network, it distinguishes between different types of vehicles and drivers, it enables a wide range of network geometries to be dealt with, and it can also model incidents, conflicting maneuvers, etc. Most traffic equipment present in a real traffic network is also modeled in the Microsimulator: traffic lights, traffic detectors, Variable Message Signs, ramp metering devices, etc.

The main components of a traffic microsimulation model are as follows:

- Road network:
  - geometric representation of the road traffic network:
    - road sections,
    - intersections, and
    - turning movements; and
  - traffic management schemes:
    - vehicle speeds,
    - turning movements allowed,
    - traffic signal control schemes (phasing, timings, offsets), and



- associated roadside detectors, traffic signals and variable message signs.
- Traffic demand:
  - input flow patterns at input sections to the road model and turn percentages at intersections,
  - time-sliced OD matrices for each vehicle class, and
  - dynamic traffic assignment models which control route choice.
- Individual vehicle behavioral models:
  - car-following,
  - lane-changing, and
  - gap acceptance.

### 3.2.1 Microscopic Model Inputs

To utilize microscopic simulation, at minimum, the following must be defined:

- Network: Detailed geometrical representation of roads, intersections and traffic devices;
- Demand: Time dependent OD Matrices or Traffic States. Pedestrians;
- Control: Detailed description of the intersections (traffic lights, give-ways, stops, ...). Transit priority, actuated control. Emulators for adaptive control;
- Public Transport Plan (optional); and
- Associated parameters.

### 3.2.2 Microscopic Model Outputs

As stated above, microscopic simulation will provide outputs for individual vehicles in the network as well as aggregation on various levels. Some examples of outputs available for microscopic models are summarized below:

- Global and time interval outputs for
  - Sections: Count, Flow, Density, Speed, Travel Time, Delay, Queue, Number of Lane Changes, Number of Stops, Stop Time, Fuel Consumption, Pollution Emissions, Total Distance Travelled, Total Travel Time;

- Lanes: Flow, Density, Speed, Travel Time, Delay, Queue; and
- Turns: Count, Flow, Speed, Travel Time, Delay, Queue, Total Distance Travelled, Total Travel Time.
- Detection outputs such as
  - Count, Speed, Density, Headway, Occupancy, Presence.
- Time series outputs.
- Network outputs such as
  - Delay Time, Density, Flow, Number of Stops, Speed, Travel Time, Vehicles Waiting to Enter (Network), Waiting Time in Virtual Queue, and others.
- View modes to visualize output on the network.
- Animation to review the actual simulation and movement of each vehicle.

### 3.3 Mesoscopic Modeling

Mesoscopic simulation is an intermediate mode of simulation between microsimulation of individual vehicles and macro assignment of traffic flows. Mesoscopic traffic simulation can take many different forms, some oriented closer to microsimulation, some closer to macroscopic modeling, each traffic modeling methodology defining mesoscopic differently.

In Aimsun Next, Mesoscopic Simulation refers to a link and lane-based simulation of individual vehicles where the level of knowledge of vehicle activity is reduced from that used in microsimulation. In Aimsun Next mesoscopic simulation, a vehicle is considered only as it enters and as it exits a road section and the intervening movement is not simulated. Figure 5 below summarizes the difference between the three levels of simulation and how mesoscopic fits in.

Microsimulation (Time-based)



Mesosimulation (Event-based)



Macrosimulation (Flow-based)

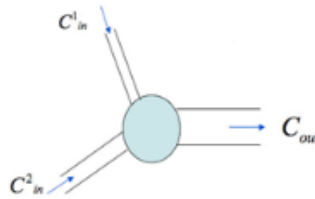


Figure 5 Simulation Levels

- In microsimulation; time is incremented by  $\Delta t$  at every time step, every vehicle then considers its speed and lane choice and is moved by the distance determined for that time step.
- In mesoscopic simulation, time is moved to the next event where the event is a vehicle entering or leaving a section or node. In Figure 5, at time  $t_1$ , the vehicle enters a section, at  $t_2$  it leaves that section at a predicted speed and in a predicted lane and at  $t_3$ , it enters the next section. Not all vehicles are updated every time, only those vehicles that are at the head of the queue are considered, leading to a large reduction in the computer resources required to run the simulation.
- In macroscopic simulation, there are no individual vehicles; instead vehicles are aggregated to flows from their OD pairs, which are assigned to the network to balance load and minimize journey time.

In Aimsun Next, the mesoscopic simulation approach is based on a discrete-event simulation, where each node works as a queue server for all input sections. The simulation time changes as the simulation proceeds to the points in time at which an event occurs, where an *event* is defined as an instantaneous occurrence that may change the state of the system, in this case the state of the traffic network. There are different types of events:

- vehicle generation (Vehicle Entrance),
- vehicle system entrance (Virtual Queue),
- vehicle node movement (Vehicle Dynamics),
- change in traffic control state (Control),

- statistics (Outputs), and
- matrix changed (Traffic Demand).

All events in Aimsun Next have a time and a priority. Both are used to sort the events on the event list. For example, events related to a change a traffic light or a new vehicle arrival will be treated before events related to statistics or vehicle node movements.

In the mesoscopic approach, the vehicle is modeled as an individual entity, exactly as in the Microscopic approach but the behavioral models (e.g., car following, lane changing, etc.) are simplified with a slight loss of realism in order to be simulation event oriented. The following subsections provide additional detail for mesoscopic modeling and its components.

### 3.3.1 Network Representation

The Aimsun Next mesoscopic model uses a node/section representation of the network based on a directed graph. Basically, there are four geometric elements in the mesoscopic network representation.

1. Nodes: in the mesoscopic representation they are treated as node servers, where vehicles are transferred from a section to a turning and then to their next section.
2. Turns: the connections that vehicles use in their path. These turns connect some/all lanes from the origin section to some/all lanes of the destination section. The turning speed as well as the turning length is used to calculate the turning travel time. All vehicles are assumed to travel without any restriction, namely at a free flow speed in turns.
3. Sections: the connectors between nodes. Each section has information about its geometry: number of lanes, speed limits and jam density.
4. Centroids: the source and sink of vehicles. They are used to generate vehicles.

### 3.3.2 Behavioral models

The mesoscopic level in Aimsun Next uses a vehicle-based representation of the traffic flow and include behavior models for:

- sections: car-following and lane-changing, and
- nodes (node model): gap-acceptance and lane selection mode.

The car-following model implemented in the mesoscopic model relies on a simplified version of the Gipps car-following model used for the microscopic level. In the mesoscopic model,

car-following and lane-changing models are applied to calculate the section travel time. This is the earliest time a vehicle can reach the end of the section, considering the current status of the section (that is, the number of vehicles in the section).

The gap-acceptance model used in the mesoscopic approach is a simplification of the gap-acceptance model used in the microscopic simulator. The model considers the travel time from both vehicles to the collision point; then it determines how long the vehicles need to clear the node/intersection and, finally, it produces the decision.

### 3.3.3 Dynamic Traffic Assignment

For Dynamic Traffic Assignment, the traffic demand is defined in terms of OD matrices, each one giving the number of trips from every origin centroid to every destination centroid, for a time slice and for a vehicle type. When a vehicle is generated at its origin, it is assigned to one of the available paths, connecting this origin to the vehicle's destination. These paths are computed as the simulation starts and re-computed at the route choice cycle time interval.

The vehicle will travel along this path to its destination unless it is allowed to dynamically change it en-route (i.e. it is a guided vehicle) and a better route exists from its current position to its destination.

General simulation-based approaches explicit or implicitly split the process in two components: a route choice mechanism determining how the time dependent path flow rates are assigned onto the available paths at each time step and a method to determine how these flows propagate in the network.

In Aimsun Next, the mesoscopic simulation approach is based on a discrete-event simulation, where each node works as a queue server for all input sections. The simulation time changes at different points in time. These points in time are the ones at which an event occurs, where an event is defined as an instantaneous occurrence that may change the state of the system, in this case the state of the traffic network. There are different types of events:

- vehicle generation (Vehicle Entrance),
- vehicle system entrance (Virtual Queue),
- vehicle node movement, (Vehicle dynamics),
- change in traffic light (Control),
- statistics (Outputs), and
- matrix changes (Traffic Demand).

All events in Aimsun Next have a time and a priority. Both are used to sort the event list. For example, events related to a change at a traffic light or a new vehicle arrival are going to be treated before events related to statistics or vehicle node movements.

### 3.3.4 Mesoscopic Model Inputs

The mesoscopic model requires more detail than the macroscopic model and can be summarized as follows.

- Network: Detailed geometrical representation of roads and intersections. Only exceptions compared to micro are the solid lines in sections and stop lines in turns.
- Demand: Time dependent OD Matrices or Traffic States.
- Control: Detailed description of the intersections (traffic lights, give-ways, stops, ...) Actuated with some restrictions.
- Public Transport Plan: Route and schedule information for public transport (optional).

### 3.3.5 Mesoscopic Model Outputs

As stated above, mesoscopic modeling in Aimsun Next tracks the individual vehicles under simplified behavior conditions. The analysis then focuses on aggregated outputs such as those below.

- Global and time interval outputs
  - Sections: Count, Flow, Density, Speed, Travel Time, Delay, Queue, Number of Lane Changes, Total Distance Travelled, Total Travel Time;
  - Lanes: Flow, Density, Speed, Travel Time, Delay, Queue; and
  - Turns: Count, Flow, Speed, Travel Time, Delay, Queue, Total Distance Travelled, Total Travel Time.
- Time series outputs.
- Network summaries.
- View modes to visualize output on the network.
- Batch simulation only.
- Animation with view modes and statistical outputs

## 3.4 Hybrid Modeling

Traffic modeling is often used to model large complex systems that require different simulation approaches in different areas. The wider area can be modeled with simplified vehicle dynamics while small sub areas require more detailed simulation.

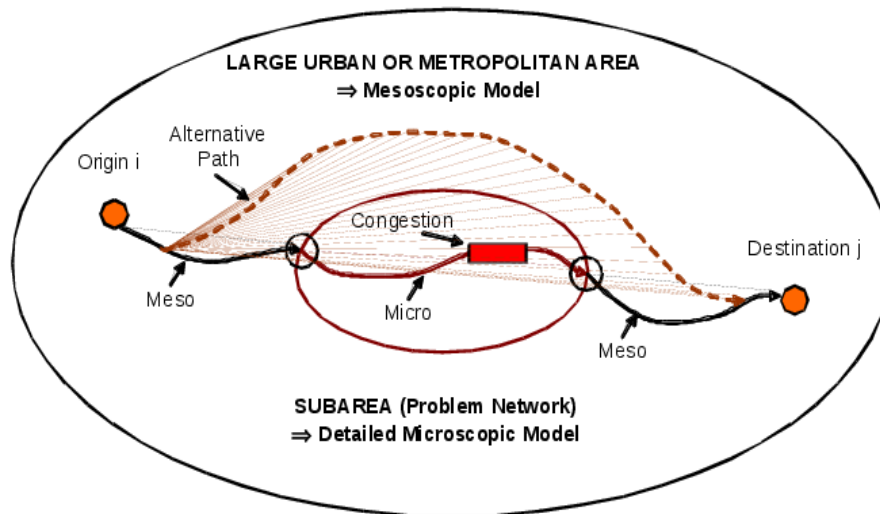
A hybrid simulation concurrently applies the microscopic model in selected areas and the mesoscopic in the remainder of the network. The hybrid model is recommended for large-scale networks with specific areas that require a microscopic level of detail but with a global network evaluation.

Using the hybrid model is beneficial for networks where changes or strategies that require precise knowledge of when a vehicle passes over a detector located inside a road section (such as adaptive control, transit signal priority, or ramp metering) but may have a wider influence in terms of rerouting on the network. Running the entire network at microscopic level would increase the computation time, so the use of the mesoscopic model outside of the areas where micro is strictly needed allows the user to increase the size of the model without impacting adversely on the runtime.

One example of the need for a hybrid simulation combining a simplified mesoscopic simulation for much of the area with a more detailed microsimulation in critical areas is shown here where the study is focused on the congested central area, but vehicles passing through that area may re-route and avoid it. A full analysis should include the effect of this route choice.

In Figure 6, the central congested area is modeled with microsimulation while the rest of the network is modeled with mesoscopic simulation. A vehicle travelling from Origin “i” to Destination “j” is simulated mesoscopically until it arrives at the simulation mode boundary when it is moved into a microsimulation model before resuming the rest of the trip in mesoscopic mode. As the Aimsun Next mesoscopic model is based on individual vehicles, just as in microsimulation, a particular vehicle-trip may be modeled in both modes and moved between modes as required. If the vehicle enters the microsimulated area, it is simulated microscopically, if its route choice avoids that area, then it is simulated in mesoscopic mode for its entire journey.

The same network representation and the same flow, speed, and delay information is used in both simulation modes shared in a common database. Route choice decisions for example are therefore consistent between both modes of simulation.



**Figure 6 Combining Meso and Micro Approaches**

In the Hybrid simulation process, for a hybrid model to function, the meso model and the micro models must exchange information about vehicles. There are three classes of information:

- Vehicles attributes and statistics,
- Vehicle paths, and
- Network conditions at boundaries.

In Aimsun Next this information is exchanged through two general modules:

- *The DTA Server*, ensures the consistency of vehicle paths through the network and,
- *The Hybrid Simulator*, ensures consistency at the boundaries. There are two different types of boundaries:
  - Entrance points represented by centroids: Where vehicles are generated using the specific arrival distribution defined by the user.
  - Boundary nodes: In these boundary nodes, the vehicles in the upstream sections use different dynamic network models from the downstream sections. For instance, in the upstream section a vehicle is controlled by a mesoscopic model while in the downstream section the vehicle is controlled by a microscopic model.



The boundary nodes move vehicles from one model to the other model in a similar way to that which vehicles are generated by centroids but in these cases the virtual queues represent modeled road sections rather than the unmodeled areas outside the model boundary.

Figure 7 below shows that, as the vehicle travels through the network and through time, it may cross several boundary nodes between micro and meso throughout the simulation. The same vehicle is tracked through each as it crosses and data evaluated for the appropriate model level.

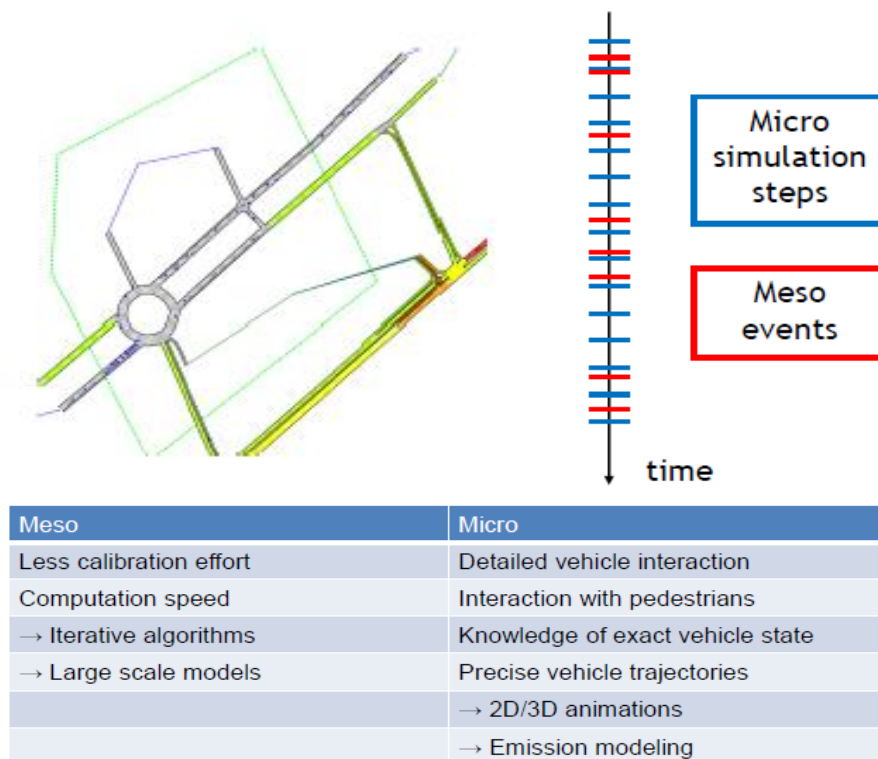


Figure 7 Hybrid Meso - Micro Approach

Both models must also be synchronized. As the mesoscopic approach uses an event-oriented approach and the microscopic approach uses a time discrete simulation approach, a general clock module is used to generate synchronization events for the mesoscopic model that will update that part of the network.

*Meso to Micro:* To transfer vehicles from the mesoscopic to the microscopic area, the Aimsun Next Hybrid simulator adopts the same approach that is used to decide if a vehicle can enter the network during a microsimulation.

*Micro to Meso:* To transfer vehicles from the microscopic to the mesoscopic area, the Aimsun Next Hybrid simulator uses the time at which a vehicle exits the last microscopic turn as

entrance time of the vehicle in the first mesoscopic section. A vehicle in the microscopic area is then given a leader in the mesoscopic area so it is able to apply the normal car-following model and maintain realistic behavior as it approaches the boundary. The hybrid simulator therefore creates dummy vehicles whose speed and position is calculated based on a triangular density-flow fundamental diagram.

## 4 Master Network

As stated previously, Aimsun Next incorporates the macro/meso/micro modeling levels in a single platform. This allows for the management of an entire regional network in a single model file or Master Network in Aimsun Next. The Master Network is established and from there, relevant subareas can be managed and modified for other project purposes. The Master Network will also contain the revisions, geometric configurations, and attribute overrides that define alternate (usually future) networks. The Base Model is a subset of this and the foundation upon which the alternatives are built.

Often, the Master Network will be developed for the macroscopic level. This can be fully developed in Aimsun Next or can be converted from another platform, as in the case for Southern Nevada where a Base Model was developed by importing the existing regional model and then calibrated in Aimsun Next. Once this is done, the model can be refined to add details for mesoscopic and microscopic modeling for various projects. Subareas can also be defined without “cutting” and creating new models. Rather, the subareas are maintained within the overall Master Network and defined on a scenario level in Aimsun Next.

Developing the Master Network in Aimsun Next follows a general procedure that can be applied to most models and incorporate the Aimsun Next-specific elements shown in Figure 8 below.

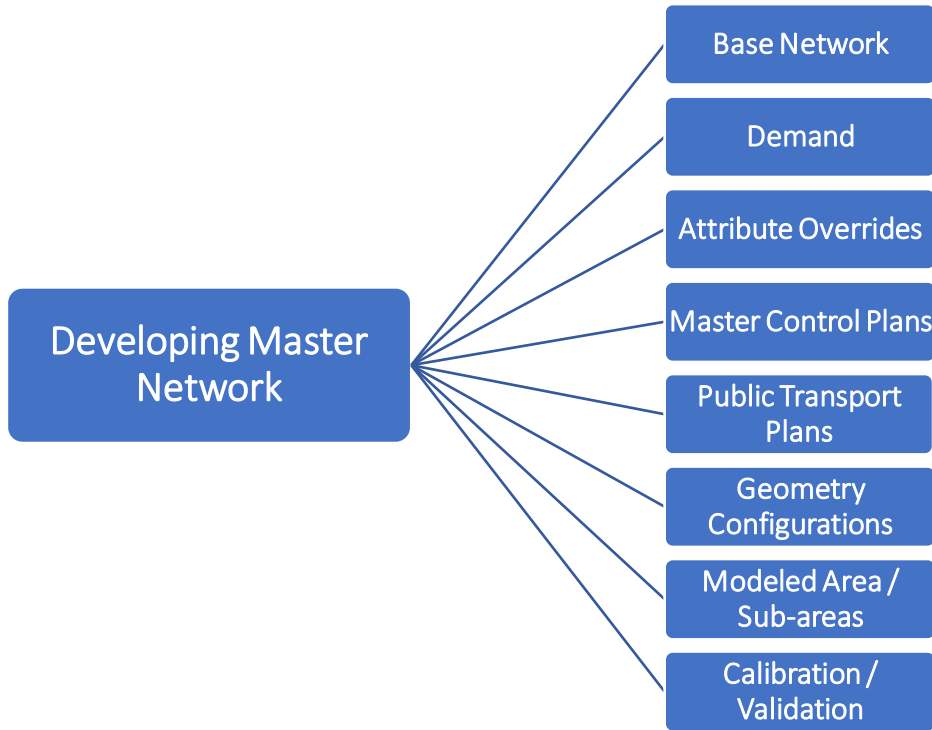


Figure 8 Developing Master Network

It should be noted that the Master Network level of detail and components will depend on the level of modeling that is desired. Some components are required at all levels and some components are either required at specific modeling levels or optional altogether. Figure 9

Master Network Component	Macro	Meso	Micro	Hybrid
Base Network	●	●	●	●
Demand	●	●	●	●
Attributes & Attribute Overrides	○	○	○	○
Master Control Plans	○	●	●	●
Public Transportation Plans	○	○	○	○
Geometry Configurations	○	○	○	○
Modeled Area	●	●	●	●
Modeled Sub-Areas	○	○	○	○

● = Required
○ = Optional

below summarizes this.

Figure 9 Master Network Component Requirements

For work with NDOT, the base network has been developed for the entire Southern Nevada Region at a macro level. The freeway system was then enhanced for the meso/micro levels through the Southern Nevada Transportation Study. This was and will be developed into subareas for further study on a project level.

Each of the components of the Master Network development shown above are described in the following sub-sections.

## 4.1 Base Network

There are two mandatory components of a traffic network:

- Base Network and
- Travel Demand.

The Base Network is the road traffic network and the core of the modeling project and upon which the rest of the model is built. The network holds sections (representing links and segments) and nodes (representing intersections and junctions). It also contains fundamental objects, such as Vehicle Types, Trip Purposes, and User Classes that describe the vehicles in the network.

Base networks can be developed from a variety of sources, including GIS databases, Open Street Map files, networks developed in third-party software platforms.

Images and vector drawings may be imported into in Aimsun Next as blueprints to create the network. The accepted formats are:

- Vector formats: CAD files in DXF, DWG and DGN formats, and GIS files in Shapefile format.
- Raster Images, manual geolocation: JPEG, GIF, PNG, BMP.
- Raster Images, automatic geolocation: JPEG 2000, ECW, MrSID.

Typically, any file to be used as a background will be available in one of these formats or can be converted to one of them.

The Master Network for the Southern Nevada Region was developed as part of the Southern Nevada Traffic Study (SNTS) in 2017. The SNTS base model was created by first importing the 2017 base regional model previously developed in TransCAD into Aimsun Next and converting the model to an Aimsun Next model, using custom scripts to support the importation of the necessary objects from TransCAD to the Aimsun Next format. This process also used another script to import the future 2040 network from TransCAD into Aimsun Next as Geometry Configurations (see below for more details).

The existing TransCAD model data that was transferred includes the

- road network (including all the attributes associated with links and nodes),
- centroids and centroid connectors, and
- OD matrices.

Once the network was in Aimsun Next, it was refined to ensure accuracy and consistency for attributes such as sections, lane configurations, turns, route types, nodes, and centroids. A macro assignment in Aimsun Next was then developed, tested, and compared with the TransCAD model results to ensure consistency.

## 4.2 Demand

The traffic demand for the base network represents the trips made by people traveling in the network. For vehicle trips, this is represented in Aimsun Next as Origin-Destination Matrices (OD Matrices) and Traffic States. Both of these can be used in the same network.

A Traffic Demand object is a collection of OD Matrices or Traffic States, but not a mixture of both, which can be placed as a single object in different scenarios. A Traffic Demand object is conveniently intended to simplify the process of managing demand states and facilitate allocating them consistently across scenarios. It also allows some editing of the demand.

Both the Traffic States and the OD matrices are created for a single vehicle type (plus trip purpose in the case of OD matrices, that is, for a single user class) and for a single time interval. Several OD matrices or Traffic States will be grouped into a Traffic Demand which thus contains traffic data for several vehicles (or several user classes) and time intervals and are used as input for one or more Aimsun Next Scenarios.

In the SNTS model, the demand was also imported from the TransCAD regional model in the form of OD matrices and included horizon years, time periods and vehicle classifications.

The OD matrices were based on the zone structure that was established for the TransCAD regional model and were not changed in Aimsun Next. Maintaining this consistency in zone structure between the regional model and the Aimsun Next model is important for future updates and the ability to leverage demand updates from the regional model for future evolutions of the Aimsun Next model for the Southern Nevada Region. For this version of the model, this included 1658 zones.

## 4.3 Attributes and Attribute Overrides

Every object in the model has a set of attributes, some of which are assigned from the regional model and some that are defined explicitly. These attributes can also be changed

using the Aimsun Next Attribute Overrides, allowing changes to be made without changing the layout of the network itself.

This can be applied at a scenario level to modify parameters such as speed limits, lane restrictions, and reaction times on sections; capacity and bus behavior at public transport stops; turn speeds and yellow box behavior at nodes. Any attribute of any of the network objects may be overridden but the list of objects remains the same.

For the SNTS model in Aimsun Next, all attributes from the regional TransCAD model and refined as the Base Network. The attributes imported include:

Object	Regional Model Attribute	(Imported to) Aimsun Next Attribute
Section	ID	External ID
Section	Length	2D Length
Section	DIR	
Section	STNAME	Name
Section	AB_LANES, BA_LANES	Number of Lanes
Section	AB_SPEED, BA_SPEED	Speed
Section	FTYPE_NUM_	Road Type
Section	ALPHA, BETA	Volume Delay Function Parameters
Node	ID	External ID
Centroid Connection	FTYPE_NUM_: External Link	Centroid Connection

#### 4.4 Geometry Configurations

Geometry Configurations contain the geometric differences between the base network and the network to be tested in a scenario and extends what can be adjusted using Attribute Overrides by changing the list of objects. For example, a base network may model a small town, the project may also include a set of Geometry Configurations based on this network; one may add a bypass to that model, others may include intersection improvements to existing roads, one per configuration. Scenarios can then be created that model the town, the town with different sets of intersection improvements, or the town with a bypass. In each case, the core network remains the same, only the differences or, with multiple Geometry Configurations, combinations of differences, are applied in each scenario.

Geometry configurations can be applied individually or in combination with other geometry configurations, enabling testing of several network changes and combinations of those changes.

Currently, the SNTS model utilizes geometry configurations to represent the future 2040 Base Network. Geometry configurations will also be used to analyze potential network change options.

## 4.5 Master Control Plans

Master Control Plans specify the control parameters applied to signalized intersections. A Master Control Plan is a collection of multiple control plans for different areas of the model and different times of day and a project may contain several Master Control Plans. A scenario, or an experiment in a scenario, will have a Master Control Plan assigned to it to provide the signal control options to be included in the model. Extending the example of different Geometry Configurations above, a scenario with different options of intersection improvements may now be tested in different experiments using a different Control Plan in each experiment ranging from fixed time plans to Public Transport pre-emption and active signal control plans.

For the Southern Nevada Region, a script was developed to import the traffic control plans directly from the database maintained by the Freeway and Arterial System of Transportation (FAST) of the Regional Transportation Commission of Southern Nevada (RTC). Any changes to the existing traffic control plans should be checked against this database. Depending on how significant these changes are, the traffic control plans may be updated manually or re-imported from the using the script for the FAST database. The script can be provided based on approval by NDOT and FAST.

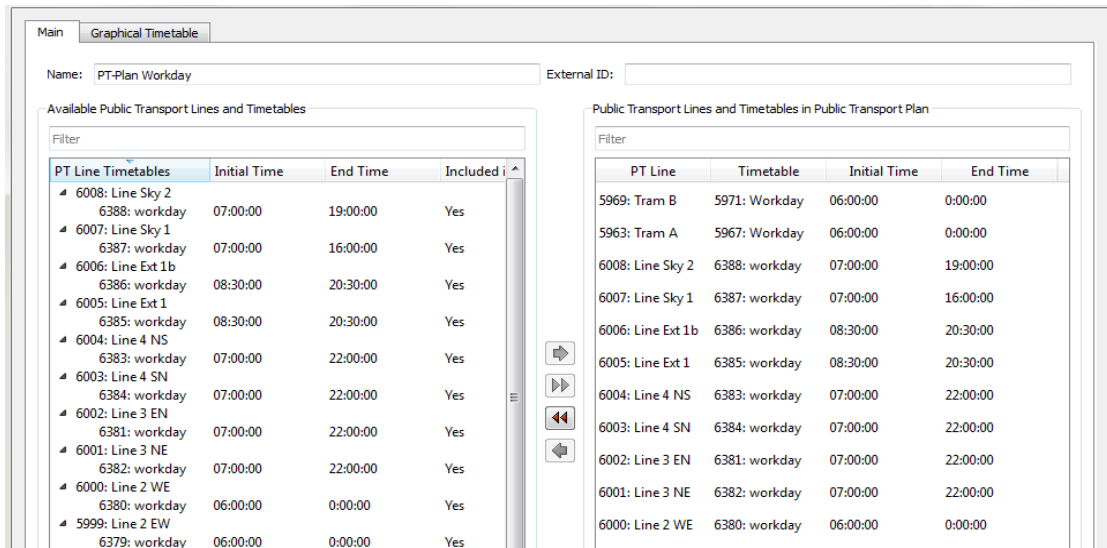
For future traffic control plans, manual entry may be required. In this case, signal timings should be obtained from the appropriate agency and built directly in Aimsun Next.

## 4.6 Public Transport (Transit) Plans

A Public Transport Plan (PT Plan) is required by a Scenario when public transport vehicles are to be included in the simulation. The PT Plan is used to create a combination of routes and the timetable chosen for each PT route. Multiple Public Transport plans may be generated in a single Aimsun Next document and included in scenarios as required and as appropriate to the Traffic Demand, Control Plan, and the road network configurations being tested.

A Public Transport Plan consists of a list of Timetables for the PT lines that will be included in the plan Figure 10. A Timetable consists of a set of Time Slices, each one describing the Public Transport Vehicle's Departure Schedule and the Dwell Times (time the vehicle remains stopped) at each PT stop allocated to the line.





**Figure 10 Public Transport Plan Editor**

Each Schedule has an Initial Time and a Duration to define the interval when the Public Transport Vehicles will be generated using that schedule. Multiple schedules allow for programming a timetable with for example departures every 20 minutes in the off-peak period and every 10 minutes in the peak period. The PT Vehicle Departures Schedule can be defined in terms of Departure intervals or by a set of Fixed Departure Times. In all the cases, the Deviation value will be used as standard deviation to sample the PT vehicles departures from a Normal Distribution.

As many PT Plans as required can be defined. These are listed in the Project Window in the Public Transport Plans folder inside the Public Transport main folder. To create a new public transport plan, select the New/Public Transport Plan option either in the Project Menu, in the Project Window Public Transport folder's context menu or in the Project Window Public Transport Plans folder's context menu. Once done, the new public transport plan will be listed in the Public Transport Plans folder in the Project Window.

During the SNTS project, public transport was not considered, however, this should be considered in the case of future projects that may include transit.

#### 4.7 Modeled Area and Sub-areas

Aimsun Next has two mechanisms for simulating sub-areas in a traffic network. A sub-area may be small area where microsimulation is used in a hybrid model to model vehicle interactions while the rest of the simulation is run with mesoscopic simulation, or a sub-area may be cordoned out of a larger traffic network and scenarios generated to run within that sub-area only.

With the Aimsun Next integrated platform, models can be developed for a large area and maintained as a master network, while still allowing for more focused and detailed analysis in smaller sub-areas. Because everything is maintained in a single network file with a single software platform, the management of the sub-areas is unique in that no sub-area “cuts” need to be done in order to focus on specific areas.

A hybrid sub area is created by defining a polygon, or selecting road sections and marking them as a microsimulation area. The areas that are then to be run in microsimulation are selected at the hybrid experiment level. More details on this are provided above in the hybrid modeling discussion.

A cordoned sub-area is created by converting a polygon shape into a sub-area. The sub-area must have its own Centroid Configuration and Demand Plans but can share Public Transport Plans, Master Control Plans, Geometry Configurations and Attribute Overrides with the main network. Scenarios generated within the sub-area are run using the traffic network within that area only and hence run much faster than the larger model.

Traffic demand in sub-areas can be created automatically using a Static Traversal or a Dynamic Traversal method which generates a new centroid configuration for the subarea and a set of OD matrices calculated using either a static assignment experiment or a replication from a dynamic simulation based on the demand in the whole model area, see Figure 11.

It should be noted that, when generating static travelersals within a subarea, the subarea static assignment may not always match the original base network static assignment.



Figure 11 Traversal Matrices

## 4.8 Master Network Calibration and Validation

In traffic systems, the behavior of the actual system is usually defined in terms of the traffic variables, flows, speeds, occupancies, queue lengths, etc., which can be measured by traffic detectors at specific locations in the road network. To validate the traffic simulation model, the simulator should be able to emulate the traffic detection process and produce a series of simulated observations. A statistical comparison with the actual measurements is then used to determine whether the desired accuracy in reproducing the system behavior is achieved. The calibration and validation processes are illustrated in Figure 12.

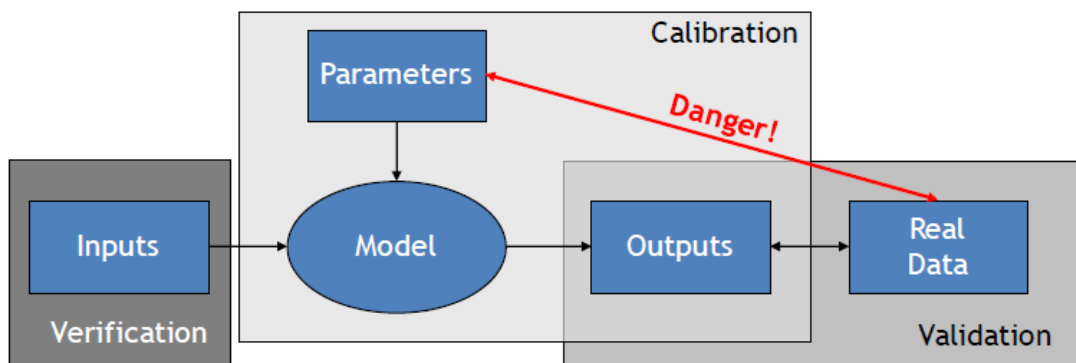
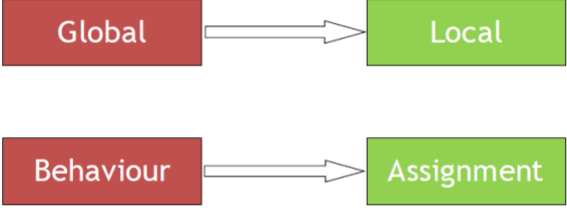
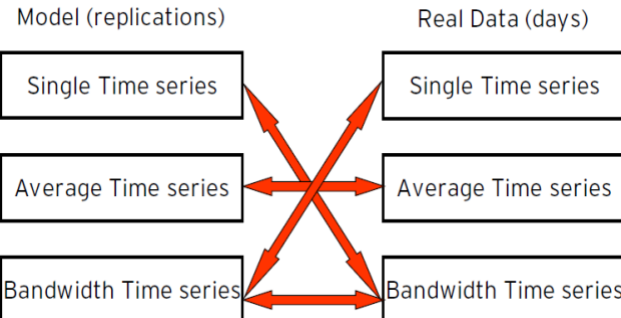


Figure 12 Calibration vs. Validation

All of these components interact, and none should be taken in isolation to calibrate and validate a network. As indicated by the red line in the Figure 12, real data must not be used as input parameters in the model but rather used to compare with the model outputs during the validation process.

There is also a process in building a model and there are appropriate actions taken to calibrate it at each step. Table 1 describes the process.

**Table 1 Who does Validation and Calibration?**

Validation	Calibration
<ul style="list-style-type: none"> <li>- Should be software independent.</li> <li>- Interest of end user (project client)</li> <li>- Public Guidelines</li> </ul>	<ul style="list-style-type: none"> <li>- Software dependent</li> <li>- Interest of analyst (doing the project)</li> <li>- Product Guidelines</li> </ul>
<p style="text-align: center;">Workflow</p>  <pre> graph LR   Global[Global] --&gt; Local[Local]   Behaviour[Behaviour] --&gt; Assignment[Assignment]   </pre>	<p style="text-align: center;">Comparing with real data</p>  <pre> graph LR   subgraph Model [Model (replications)]     M1[Single Time series]     M2[Average Time series]     M3[Bandwidth Time series]   end   subgraph RealData [Real Data (days)]     R1[Single Time series]     R2[Average Time series]     R3[Bandwidth Time series]   end   M1 &lt;--&gt; R1   M1 &lt;--&gt; R2   M1 &lt;--&gt; R3   M2 &lt;--&gt; R1   M2 &lt;--&gt; R2   M2 &lt;--&gt; R3   M3 &lt;--&gt; R1   M3 &lt;--&gt; R2   M3 &lt;--&gt; R3   </pre>

Specific calibration and validation parameters and thresholds should be identified at the beginning of each project and will be dependent on the level of modeling, project objectives, and data availability. This is meant to provide general guidance on the calibration and validation of models and will ensure that the model is built to incorporate the level of detail and attributes required to obtain the calibration outputs.

## 5 Managing Concurrent Modeling Tasks

Aimsun Next allows multiple modeling tasks to be completed concurrently, meaning that multiple projects or subarea modeling tasks can be completed by separate software users from the same Master Network.

This is done through Revisions in Aimsun Next, as shown in Figure 13 below. The concept starts with the Master Network and subareas, or project study areas, are defined within the Master Network. These smaller model areas are then modeled as Revisions. Once the modeling of the Revision is complete, the Revision is brought back and consolidated with the Master Network, resulting in an updated Master Network incorporating all project work.

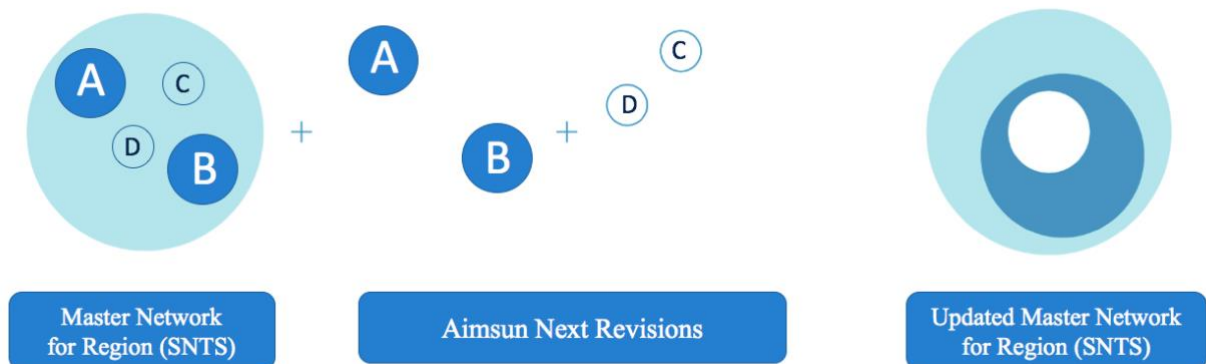
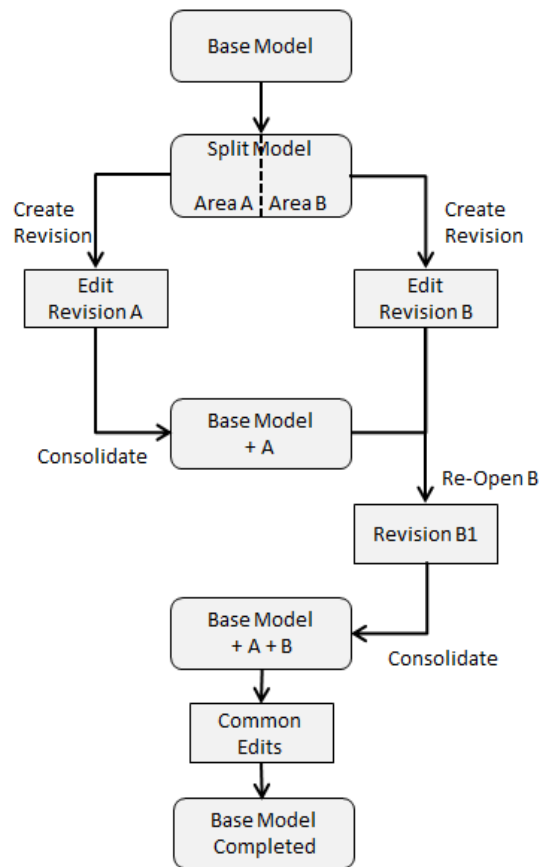


Figure 13 Managing Concurrent Modeling Tasks

The following sub-sections provide additional details on the management of concurrent tasks using Revisions.

### 5.1 Introduction to Aimsun Next Revisions

Network Revisions allow making changes in the base network model and applying the edits automatically to all related future scenarios. Network revisions also allow simultaneously storing of different edits in individual future scenarios without affecting the base model and keeping all the scenarios in the same file for easy reference, Figure 14 shows the process for a simple revision example.



**Figure 14 Simple Revision Example**

A Revision is a link to a base model which only stores those elements that have been changed. Initially, a revision is linked to an existing model and contains no objects itself. When a modeler works on a revision, objects that are edited in the revision are marked as changed, stored in the revision model file and are used instead of those which are unchanged and stored in the base model file. This process is invisible to the modeler, apart from the condition that the base model file must be available to the modeler’s computer across the network. If the base document is not available, it will not be possible to edit the revision until the link is modified, either by restoring the network connection or relinking to a relocated base document.

In this example, a base model is marked with two distinct areas with a small buffer (2 nodes per section) between them. This buffer is critical to ensure that both areas can be modified and consolidated back to the base model. In the simple case, two revisions are created, and two modelers edit them independently. Revision A is first consolidated into the base and at this point the changes made in A are now visible in revision B. Revision B is then consolidated into the base to update it with the changes from both revisions. Any changes which access objects edited in both revisions A and B must be made in the base after both revisions have been consolidated. If an object appears revised in multiple revisions, the modifications from

the last revision consolidated will be the modifications visible in the base. For example, in this simple case, if a node is edited in both revisions A and B and the order of revisions is A then B, only changes made in revision B will be visible in the base after consolidating both.

At appropriate intervals, the project manager can choose to integrate the changes from any revision model into the base model at which point the changes from that revision will be available in all other revisions linked to the base model. When dealing with large networks, particularly when working on tight deadlines or complex projects, it can be useful to have several people working on the same model at the same time, as shown in Figure 15.

The Revisions tool in Aimsun Next makes collaboration faster and means the whole team can work in a single file, which reduces errors and duplication of effort.

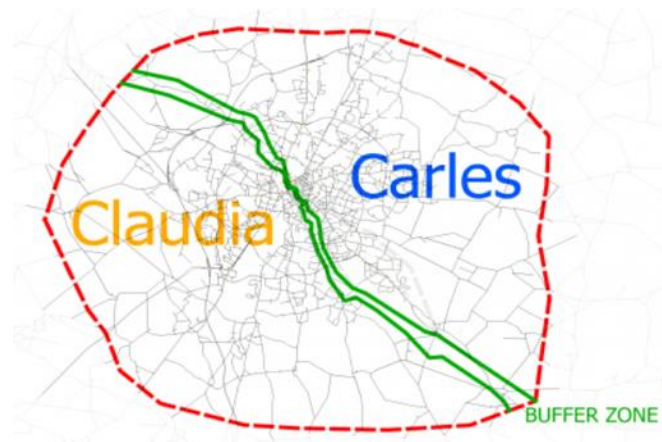


Figure 15 Areas Defined and Separated by a Buffer Zone

## 5.2 Preparing the Network

The network should have as many areas as revisions (and modelers in the team). These areas need to be well defined and separated by a buffer zone; this one helping to avoid changing objects that are in another area, which is why the buffer zone should include at least two nodes.

Each user focuses solely on their own working area and must be careful not to delete any objects outside of their boundaries.

## 5.3 Creating a Revision

To create a new Revision, under Project tab, select New Revision, as shown in the Figure 16. In the Create New Revision dialog, locate the Base Network, give the revision a name and for each revision, set a New Initial ID. The ID of every new object created in the revision will

begin with this number. In our example, the first new object created in Revision 1 (named “Claudia”) has ID 3,000,000, the second object has ID 3,000,001, and so on. Meanwhile, in Revision 2 (“Carles”), the new object IDs all start with 5,000,000. As shown in Figure 17.

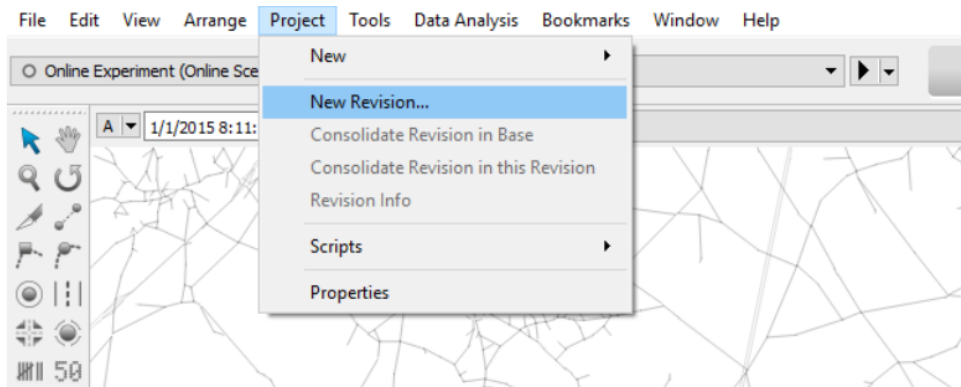


Figure 16 Create a New Revision, Select Project/New Revision

It is important that every Revision should have a different New Initial ID and that these numbers should be separated enough to avoid having objects with the same ID in the different revisions. The same goes for the object’s name: name each one (team members could be used as shown in the Figure 17, Claudia and Carles - or just Revision 1, Revision 2 etc.) so that all objects from all the Revision Regions will have different names.



Figure 17 Setting New Initial ID for Revisions. In this case ‘Carles’ (left) and ‘Claudia’ (right)



## 5.4 Editing Revisions

In each revision, new objects can be edited, deleted and created such as geometry objects (sections, nodes, roundabouts...), reserved lanes or section objects (detectors, controllers, stops...). Pay special attention to

- control plans,
- sub-paths,
- public transport lines,
- signal groups,
- traffic demands,
- traffic management,
- scenarios,
- sections belonging to a sub-path or a public transport line, and
- any object that may belong to another object affecting the whole network (and thus, the other revision regions).

Looking in the Project/Revision Info window after finishing editing the revisions, one may see all of the changes that were made in Added Objects, Changed Objects and Deleted Objects. This window will show if there are any accidentally edited or deleted objects outside the specific working area.

## 5.5 Consolidating Revisions Back to Master Network

Once all of the editing is done in each revision, the next step is to consolidate all the revisions to the Base Model. First consolidate one Revision (“Revision 1”) to the Base Model, and then consolidate another revision (“Revision 2”) with the updated file (Revision 1 + Base

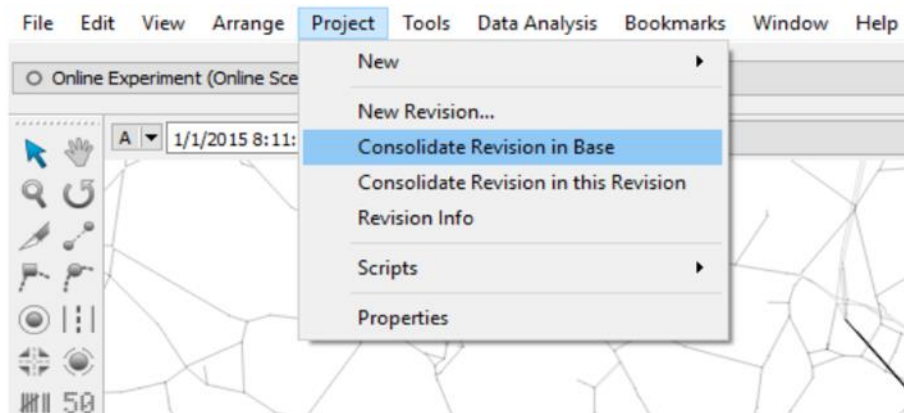


Figure 18 Consolidate All the Revisions to the Base Model

Model), and so on. Revisions do not need to be consolidated in any particular order but must simply one revision at a time.

Once all Revisions have been consolidated in the Base model, see Figure 18, the Master Network will be updated with all changes made by each person working on the modeling team. Once this is completed, assignments for the newly consolidated model will need to be run again to ensure the assignment incorporates all consolidated changes. This tool can dramatically reduce the time a modeling team needs to work on a network and particularly comes into its own for large-scale, complex projects.

## 5.6 Additional Revision Notes

The key to efficiently editing large models with multiple modelers undertaking a variety of tasks is to plan the workflow to make best use of the revisions capability.

Note that, it is essential that individual modelers do not edit the common template objects as this will have an effect on all revisions during the consolidation. In general, the template objects may be added to during this edit stage, but it would require strong justification to adjust them from the standard defaults used by that company or client.

In the case of control plans or public transport, there may be many shared objects (i.e. public transport routes) or a small number of complex objects (i.e. signal control plans) and the scripting option is the best to adopt. In other cases, the shared objects may be both simple to edit and few in number and in this case it would be easier to delay that stage until after the revisions have been consolidated.

And finally, to summarize key points regarding revisions, please note the following:

- Ensure there are no overlapping geographic area for subnetworks. Leave a buffer zone in between.
- An object must only be modified in one revision.
- Use filters and layers to contain modifications within assigned area.
- Do not edit the base file after revisions have been distributed.
- Pay special attention to control plans and public transport lines.

## 6 Managing Scenarios

Aimsun Next Revisions allow multiple people to work on simultaneous tasks and combine those efforts back into a Master Network.

Aimsun Scenarios allow the modeling team to run various scenarios from the same Master Network, retain the scenarios, analyze the output, and even compare scenarios within the software interface. For most projects, scenarios will represent different analysis years, time periods, build scenarios, and any associated data variations for each of those. An example is shown below in Figure 19.



Figure 19 Scenario Definition Example

A scenario is the container for the input data and experiments to execute one of several processes: microsimulations, mesoscopic simulations, hybrid simulations, static traffic and public transport assignments, static demand and public transport adjustments, trip generation, distribution + modal split and the generic four-step model process.

The scenarios for the microscopic, mesoscopic and hybrid simulators are Dynamic Scenarios, while the scenario for the static traffic assignment is called Macro Assignment Scenario and the one for the static demand adjustment is the Macro Adjustment Scenario.

A scenario is composed of several parameters. For the ones mentioned above, the main parameters

are a traffic demand (a group of OD matrices or traffic states), and optionally, a public transport plan, and a master control plan (a group of control plans) for micro, meso and hybrid.

In Aimsun Next Microscopic, Mesoscopic and Hybrid simulators, each dynamic scenario can have different dynamic experiments and each experiment can have different replications. A replication will be the object to be simulated.

Each Macro Assignment Scenario can have different macro experiments to calculate a static traffic assignment. The experiment will be the object to be assigned. The same happens with Macro Adjustment Scenarios, where the experiment will be used to execute the adjustment.

The Trip Generation Scenario, the Distribution + Modal Split Scenario and Four-step Model Scenario and corresponding Experiments are additional processes that together with the Macro Assignment, Public Transport Assignment and respective Adjustment Scenarios and Experiments offer the complete functionalities for the Travel Demand. In Aimsun Next there are two types of scenarios, Static and Dynamic.

In a *Static Assignment Scenario*, flows are assigned to the network using a deterministic algorithm. A Static Assignment does not use individual vehicles, it is oriented about trip volumes and about speed and flows on road sections. It is typically used in wide area models with time periods, used to define the demand in an OD matrix measured in hours, i.e. peak, off-peak time periods.

A *Dynamic Scenario* is run using micro, meso or hybrid vehicle-based simulation. It may be run with paths generated externally by the modeler, by another scenario (Static or a DUE) or it may use paths based on the transit costs extant in the network as it runs.

## 6.1 Static Scenarios

A Static Assignment uses one of five methods to distribute traffic in the network:

1. The All or Nothing Assignment calculates a single shortest path for each OD pair in free flow conditions (empty network) and assigns the whole OD pair demand to its shortest path. Costs are not updated after assignment, so results will show free-flow costs.
2. The Incremental Assignment adds iterations to the process. The user will specify the load/unload percentages for each iteration, and costs will be updated always after the load and before the unload step. A shortest path with updated costs will be calculated per OD pair at each step.
3. The MSA Assignment is a method based on Frank&Wolfe but simpler and faster because it skips one calculation, the search for the optimal step lambda, substituting this value by  $1/n$  (being "n" the iteration number). In general, with a sufficient number of iterations this method will behave well enough and tend towards an equilibrium situation, though this is not assured.

4. The Equilibrium Traffic Assignment is based on Wardrop's user optimal principle: No user can improve his travel time by changing routes. In Aimsun Next, the Frank&Wolfe algorithm is used to calculate the flows according to this principle. The algorithm is based in a Shortest Paths Algorithm and an ad hoc implementation of a Linear Approximation Algorithm. When using Junction Delay Functions, uniqueness and convergence of solution are compromised.
5. The Stochastic Assignment calculates the k-shortest paths for each OD pair and splits the OD pair demand among them, according to a Utility function defined by the user.

The first four are deterministic methods and they are listed in order of complexity. All five are based on the calculation of shortest paths and path percentage usage. These calculations use the cost of the different network elements.

#### 6.1.1 Static Scenario Parameters

The parameters of the static scenario, which are the defaults for the experiments in this scenario, include:

- The name and external ID of the scenario.
- The simulation time and duration. Note the date is for information and not used by the simulation.
- The Traffic Demand: An OD based Traffic Demand. which can contain one or more OD matrices for one or more user classes.
- A Public Transport Plan with a set of Public Transport routes and schedules. The PCU's corresponding to the volume represented by Public Transport vehicles along their public transport lines will be automatically taken into account in the total volume for all the travel time calculations.
- A Path Assignment with a set of routes derived from a prior experiment can be selected in MSA and Frank&Wolfe Assignments, so that the Assignment calculations start from this and not from an empty network. How these routes are used is described in the Path Assignment Section of the OD Matrix Editor. Setting a Path Assignment and choosing 1 iteration for the experiment would mean applying the apa file to the demand, with no extra calculation. At least 2 iterations would be needed to adjust the demand.

- A Validation Data Set: This is data used to compare simulation outputs with observed data.
- A set of Geometry Configurations: These are the optional variations in the network applied to this scenario.

### 6.1.2 Static Scenario Outputs

The outputs in static assignment are limited to:

- The flow and speed data on road sections and at junctions.
- Date for Groupings.
- Path assignments.
- Skim cost matrices.

These may be stored in the project database or in an external database.

## 6.2 Dynamic Scenarios

The minimum requirement for a Dynamic Scenario is a base transport network and a Traffic Demand. There are options for a Path Assignment, a Public Transport Plan, a Master Control Plan and set of Geometry Configurations to be included in the scenario and the Data Output options, Traffic Management Actions, and Real Data Sets may also be specified for the scenario.

### 6.2.1 Dynamic Scenario Parameters

The parameters of the scenario, which will be the defaults for the experiments in this scenario are:

- The name and external ID of the scenario.
- The simulation time and duration, the date is for information and not used by the simulation.
- The detection cycles. This is the time interval at which on street detectors update their data and may differ from the simulation time step.
- The traffic demand:
  - A Traffic Demand with either OD matrices or a set of Traffic States. This must already exist in the Aimsun Next document for the entire model, or if this

scenario is contained within a subnet, the demand plan must also be contained in the subnet folder for the project.

- A Public Transport Plan with a set of PT routes and schedules.
- A Path Assignment with a set of routes derived from a prior experiment. How these routes are used is described in the Path Assignment section of the OD Matrix editor.
- A Master Control Plan which sets the signal control systems for the scenario.
- A Detection Pattern. This is a recording of the vehicle detections made by roadside detectors from a prior simulation. Its prime role is to test adaptive control plans by bringing in the detection data without necessarily requiring the traffic demand that produced the data.
- A Validation Data Set: This is data used to compare simulation outputs with observed data.
- A set of Geometry Configurations: These are the variations in the network applied to this scenario.

## 6.2.2 Dynamic Scenario Outputs

The Outputs generated by the experiments in the dynamic scenario are:

- Store Locations: Where to store output data.
- Statistics: What data to collect.
- Paths: The path statistics to collect.
- Relative Gap Matrices: Relative Gap by each OD pair.
- XML Animation: Storing vehicle positions in an xml format suitable for input to Legion.
- Individual Vehicles: The vehicle trajectories are recorded in the database.
- Controllers: Creating Log files for signal controllers

## 6.3 Applying Scenario Management

In Aimsun Next, the ability to create scenarios and experiments with different options of network topology, transport demand, simulation method, and sets of calibration variables provides an efficient method of generating the multiple model variants of a single traffic network and supporting the model management task.

Aimsun Next holds all options in one document and only brings them together as a model for each of the variants modeled by an experiment within a scenario. Multiple scenarios may be

created in one document and as there is only one copy of each model component rather than multiple copies spread around multiple different models, the task of ensuring all model variants are consistent is greatly reduced. Furthermore, the method of simulation, (micro, meso, or hybrid), or whether this is to be a macro assignment is determined by the scenario and the model generated from the same data in the document, as discussed above.

If a scenario is used to describe the conditions of the transport network, an experiment is then used to describe the actions the transport planners may adopt in mitigation. For example, one scenario may be based on the premise that residential or commercial development has been planned and the experiments in that scenario look at the effect of options to cope with the increased demand. Another scenario in the same network may keep the network and demand constant and contain a set of experiments which look at the effect of signal and ITS control options on the existing congestion.

Well-planned use of scenarios and experiments has the ability to save time in the transport modeling process and reduce the amount of error prone data transfers between modeling systems.

A scenario is based in the method of running the model; as a macroscopic assignment model, as a four-stage planning model, or as a micro, meso, or hybrid simulation. Once the method of running the model is selected, the base network and demand configuration is described for the scenario and different experiments are created which contain the options to be tested.

Aimsun Next Managing scenarios feature allows to work with several scenarios from the same project, comparing data from two scenarios, create network attribute overrides, work with revision networks and use different geometry configurations. For example, the difference in the scenarios may be in the demand placed on the network, and the signal control plan.

Traffic Demand for the new scenario, is created by making a copy of the existing Traffic Demand and renaming it. Change the Traffic Demand Factor from instance from 100% to

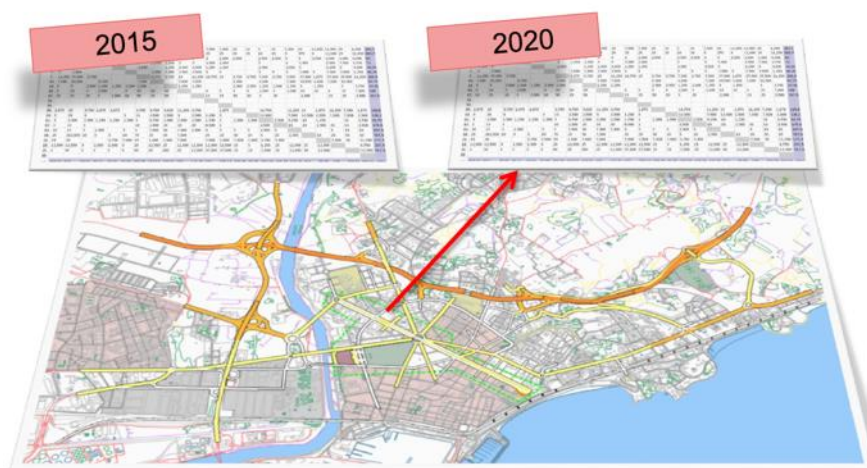


Figure 20 Demand Adjustment

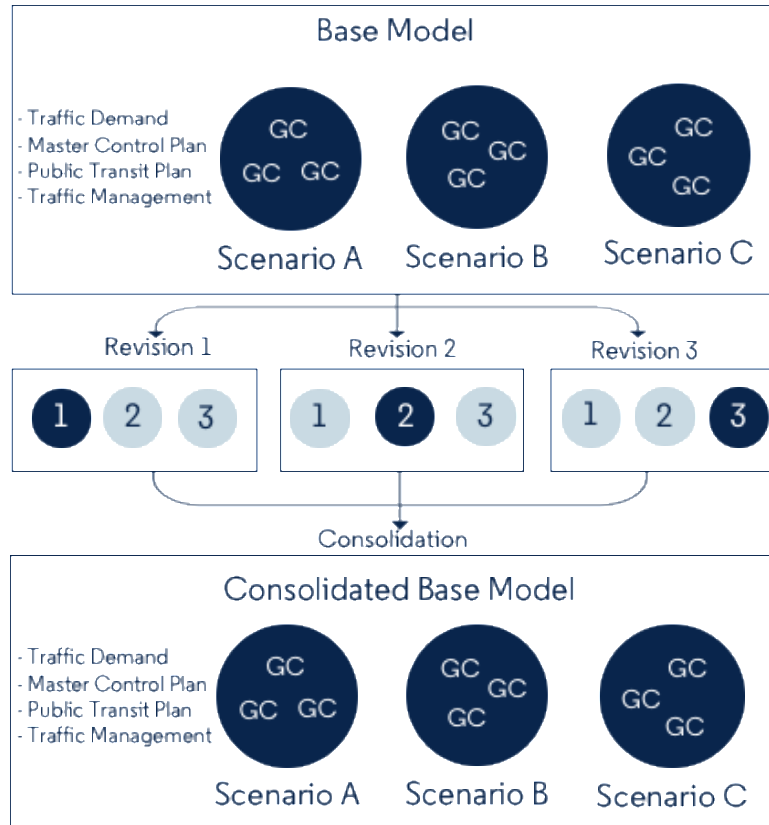


120%, which will increase the number of trips of all the OD matrices in the Traffic Demand by 20%. Now the project has two Traffic Demand objects, the next step is to create another the Scenario, by copying the current Scenario to the head of the Scenarios section in the Project folder. Rename it and assign the new Traffic Demand to it. As the Scenario was copied, the Experiment and Replication were included too. Demand adjustments between a base and future scenario as seen in Figure 20 can be also managed.

The differences between Scenarios, Geometry Configurations, and Revisions can be summarized as below:

- Scenarios reside inside the same model, for instance this could have an AM and PM scenarios in the same model but multiple people will not be able to work on them at the same time, instead revisions will allow that. Aimsun Next allows to still have AM and PM scenarios and simultaneous edits can be made. However, both scenarios and revisions can be used together. Scenarios are used when Public Transit, Control Plans, or Demand change.
- In using revisions, the same model can be divided into fragments, that can be assigned to different teams to work together in parallel at the same time, without creating different versions of the original model. A Revision is a link to a base model which only stores those elements that have been changed.
- Geometry Configurations contain the geometric differences between the base network and the network to be tested in a scenario and extend what can be adjusted using Attribute Overrides by changing the list of objects. This feature is used to compare base and future scenarios, for instance, that involve changes in the network geometry.

This can be further described in Figure 21 below. Geometry Configurations are represented by “GC”, Revisions are numbered “1”, “2”, and “3” and Scenarios are lettered “A”, “B”, and “C”.



**Figure 21. Scenarios, Geometry Configurations, and Revisions**

## 7 Guidance for Southern Nevada Master Network

### 7.1 NDOT Link between Aimsun Next Master Network and Regional Planning Model

The RTC completed an update of its regional TransCAD based model in 2017. This was the version that was imported into Aimsun Next, refined, and static assignments compared to the TransCAD assignment results to ensure consistency. The future 2040 demand and coding were also imported and integrated into the same Aimsun Next platform, through scripts, geometry configurations and attribute overrides.

This base model was then modified and enhanced to include additional micro or mesoscopic details for specific subareas, as required for the completion of the SNTS. Once this study completed, the Aimsun Next regional model would retain all of the new enhancements and be ready to be distributed to other study teams for any additional work, either completing and extending the micro/meso areas or refining and detailing the ones already in place.

The original strategic planning model will remain in its original format, allowing RTC to proceed with its own agenda. Whenever that regional model is upgraded, typically on a four-year cycle, NDOT will always have the possibility of applying these changes to its Aimsun Next based platform, that will also have been enhanced during the same, through a method similar to the one used to create the 2040 network. Through network comparisons, geometry configurations and scripts, the next base and future will be able to reflect the changes, as long as the other software platform can be imported into Aimsun Next.

Based on discussions with NDOT, as the strategic model is updated in TransCAD, the zone structure will be updated in the Aimsun Next Master Network. Using this updated zone structure, new origin-destination (OD) matrices will be brought into the Aimsun Next Master Network.

Network changes that are developed through the TransCAD modeling efforts will be reflected in the Aimsun Next Master Network. This may be done through a re-import of portions of the network or manually, depending on the magnitude of the changes to be incorporated.

Often times, projects will result in an Aimsun Next Master Network that reflects future updates to the network that should be incorporated at the regional strategic modeling level. As the strategic model will continue to reside in TransCAD, no direct feedback from Aimsun Next to TransCAD will be provided at this time. Currently, discussions with RTC resulted in agreement that any network changes required for strategic modeling will be updated manually using information from the Aimsun Next Master Network, as required.

## 7.2 Management of Master and Project Files

Building an Aimsun Next model can be a significant task as models often cover large areas with many road sections, intersections, signals, public transport stops and lines and annotations. A large model also requires an often-complex demand zone scheme and its corresponding centroid configuration and connections. Building the model in a reasonable time frame will often require input from multiple modelers and their individual contributions must be efficiently managed and consolidated with each other.

Similarly, once a model is built and calibrated, it will typically be used for multiple sets of option tests where designs for new road layouts, changes to signal controls, changes to the demand in the network, or tests to evaluate traffic management strategies are carried out. In each of these cases, a committed development will be agreed upon and this will need to be consolidated into the base model to be included in subsequent option tests. Often, a model will be used to undertake more than one set of tests at the same time, requiring a working copy of the model for each set of tests but with the ability at the end to integrate the final design into the base model.

Managing the workflow processes when more than one modeler needs access to the model as it is being modified, or more than one assessment task is in progress using a completed model is a complex task. This task is eased by the use of Revisions, which enable a modeling project manager to employ multiple modelers on a single project, or to simultaneously use a single base model on multiple projects and to efficiently manage the task of merging changes into a core base model.

it is recommended that while work is being undertaken in revisions, then the base model is kept unchanged until the revisions are consolidated. The objects added, changed or deleted in a Revision may be reviewed from the Project Context Menu Revision Info as shown in the

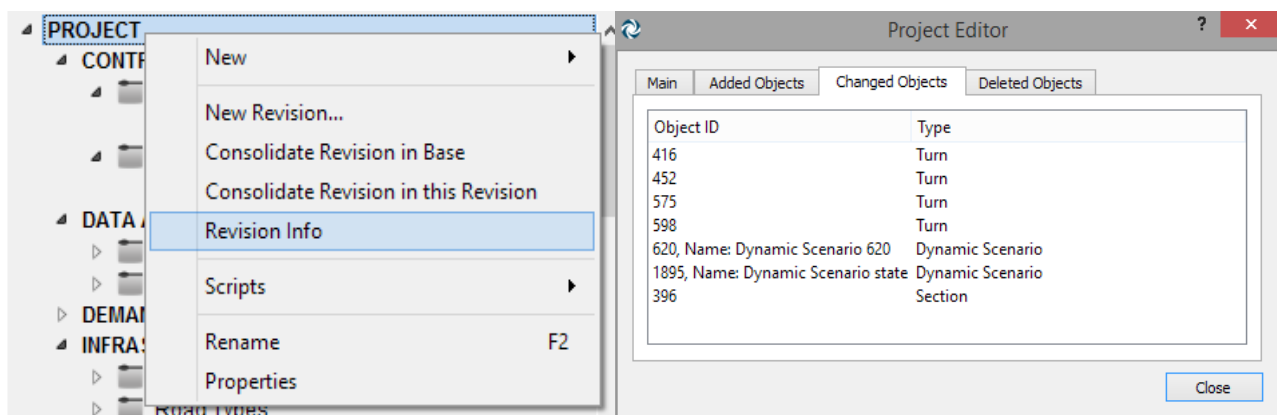


Figure 22 Revision Context Menu & Review

Figure 22.

As a recommendation, consolidated models should be updated by modelers every week or at least on a bi-weekly basis. In person meetings are strongly recommended to ensure enough discussion over what has been done, what else needs to be done and what needs to be fixed in the model, however these should be decided on a project-by-project basis and done to enhance consistency throughout the model.

### 7.3 Providing the Master Network to Consultants

Once the Master Network has been established through SNTS, it will be available for application to future projects in order to more effectively create Aimsun Next models for NDOT. The intent is that the Master Network will be used to provide a base model for future projects and have the project work incorporated back into the Master Network. The architecture of Aimsun Next allows this to be done for multiple projects concurrently and still allows NDOT to maintain a single Master Network.

Any modelers performing modeling tasks for NDOT using this Master Network are requested to comply with these Guidelines unless some prior arrangement with the NDOT has been agreed upon.

For practicality and efficiency, the Master Network will be divided into subareas and, on a project basis, the study area for the project may be divided into subareas as well. This approach allows these subareas to be edited and completed concurrently by multiple parties rather than a single entity attempting to code and complete the entire area.

The subarea network build includes refinements to the model road hierarchy levels, section geometry, zone connection coding, intersection coding, and inclusion of the key network details. It excludes comprehensive signal information collaboration and analysis, Public Transport (PT) routes, demand data and model calibration/validation.

The subarea models may then be joined to form the original model network and the model development process can then be continued from the updated and consolidated base model at this point, either as a whole or by creating a new set of revisions.

For the parallel subarea network build process to work, it is crucial to maintain consistency between subarea networks; each area needs to be coded to the same level of detail in all aspects of network coding, and correctly georeferenced.

In order to achieve consistency, the following rules should be agreed upon and followed when building the subarea networks:

- **Model Settings:** The parameters set to initially develop the model.
- **Network Refinement:** Process for importing georeferenced aerials, and for refining and amending the road hierarchy and section geometry.

- **Zone Connections:** Instructions and examples on connecting centroids.
- **Intersection Coding:** Intersection coding principles and instructions for different types of intersections.
- **Other Network Details:** Additional operational details that need to be included as part of the sub area network build such as bus stops, reserved lanes and time-dependent operations.
- **Attributes Overrides:** Use of attributes overrides.

The starting point for the subarea network build will always be the updated and consolidated Aimsun Next Master Network.

## 7.4 Naming Convention

In addition to providing files, guidance, and rules to follow when working on Aimsun Next projects, it is also recommended to establish a naming convention for any work being done in the Southern Nevada region using the Master Network.

A general recommendation would be use the use the first capital letters of the Agency name, followed by the project name, model category, date and the consulting team who works in the specific project sub model or revision, as Table 2 below shows.

**Table 2 Naming Convention**

<b>Agency</b>	<b>Project</b>	<b>Model Type</b>	<b>Date</b>	<b>Task</b>	<b>Modeler</b>
NDOT	ABC	Base	November27	Revision	Aimsun
Example: NDOT_ABC_Base_November27_Revision_Aimsun					

As the project grows, new combinations to contain more details can be created to continue to maintain efficiency and ease of tracking the Master Network and associated projects.

## 8 Additional Guidance

### 8.1 Software Management

As stated above, these guidelines were developed for Aimsun Next Version 8.2. There is an R number under each Aimsun Next version. Some R numbers refer to an interim-version while others refer to an official version (the version published in the Aimsun website <https://www.aimsun.com/aimsun/download/>). Users should make sure the version they use is an official version. It is also the modelers' responsibility to ensure the consistency of software versions between the base models and the future year models.

As software versions are updated, NDOT should adopt the new version as their working or official version and ensure that all projects from that point forward utilize this version of the software. This not only ensures consistency across the projects but provides specific guidance to consultants when completing projects using Aimsun Next.

### 8.2 Continuation of Guidelines

These Guidelines were developed for NDOT using the Southern Nevada region as the basis for discussions and decisions. It is recommended that these guidelines be revisited regularly by NDOT and Aimsun. NDOT and Aimsun should work together to update the guidelines as needed to reflect current conditions, additional elements of modeling not included in this version, additional details, and application to other regions within the state.