SHRP 2 Reliability Project L04

Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools: Vehicle Trajectory Processor User's Guide

SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
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Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools: Vehicle Trajectory Processor User's Guide

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Contents

CHAPTER 1
Introduction

The purpose of this document is to describe the use of the Vehicle Trajectory Processor developed as part of the second Strategic Highway Research Program (SHRP 2) L04 Reliability project titled Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools. The purpose and role of the Trajectory Processor in the overall framework for network reliability analysis, as well as the underlying methodological principles, are described in separate documents developed as part of the project deliverables (*1*, *2*). The main purpose of the present document is to serve as a companion to the Trajectory Processor tool that is made available to researchers and potential users interested in its capabilities.

The Trajectory Processor is an essential part of the analytical framework developed under the SHRP 2 L04 project to produce travel time reliability performance measures from planning and simulation model outputs. It calculates and visualizes travel time distributions and associated reliability indicators (such as 95th percentile travel time, buffer time index, planning time index, etc.) at link, path, origin–destination (OD), and network levels. These distributions and associated indicators are derived from individual vehicle trajectories defined as sequences of geographic positions (nodes) and associated passage times. These trajectories are obtained as output from particle-based microscopic or mesoscopic simulation tools. Such trajectories may alternatively be obtained directly through measurement [e.g. Global Positioning System (GPS)–equipped probe vehicles], thereby enabling validation of simulation tools. User-centric reliability measures (i.e., user-experienced or perceived travel time reliability) such as probability of on time arrival, schedule delay and volatility, and sensitivity to departure time can also be calculated based on the experienced travel time and the departure time of each vehicle as obtained from the vehicle trajectory.

The above-mentioned concept and functions of the Trajectory Processor were realized by using the existing transportation network analysis tool NEXTA, which provides a basic visualization platform for processing and analyzing traffic assignment simulation results. It is noted that this document only addresses the functions of the Trajectory Processor that are specifically developed under the SHRP 2 L04 project for the travel time reliability analysis. For other general features in NEXTA, users are referred to the NEXTA User's Guide available at https://code.google.com/p/nexta/.

The main functions of the Trajectory Processor bundled into the NEXTA package include the ability to:

- Read vehicle trajectory files produced as simulation outputs from DYNASMART and other packages, such as Aimsun.
- Read GPS vehicle trajectory data.
- Display individual trajectories or available paths on the network maps.

- Calculate and visualize travel time reliability measures for user-specified links, paths, OD pairs, or the entire network.
- Export the extracted reliability measures to text files for further analysis.

CHAPTER 2
Overview

In order to promote the use of end-to-end travel time reliability measures in the professional community for region-wide transportation operations planning, it is important and critically needed to develop a flexible visualization platform for analyzing microscopic and mesoscopic dynamic simulation results—in particular, tracking vehicular movement, path, and time-dependent trip-related statistics.

As a generic visualization platform for analyzing travel time reliability, the Trajectory Processor designed and developed in the SHRP 2 L04 project and incorporated into the NEXTA package aims to apply new methods of communication between transportation practitioners, decision makers, and the public. This software package aims to assist stakeholders from departments of transportation and metropolitan planning organizations to effectively apply data processing and visualization tools to (1) understand advanced but sophisticated model structures and reliability-related output and (2) utilize higher fidelity transportation simulation and measurement results to estimate and calibrate underlying transportation system processes under different traffic conditions.

Figure 2.1 shows the overall vehicle trajectory processing procedure, which entails pre-processing input data that might come from various sources (e.g., GPS data and different simulation models), processing vehicle trajectories to produce reliability measures at different levels of scale (e.g., link, path, OD, etc.), and presenting results and statistics in various formats (e.g., table, chart, map, etc.) to facilitate the analysis of travel time reliability.

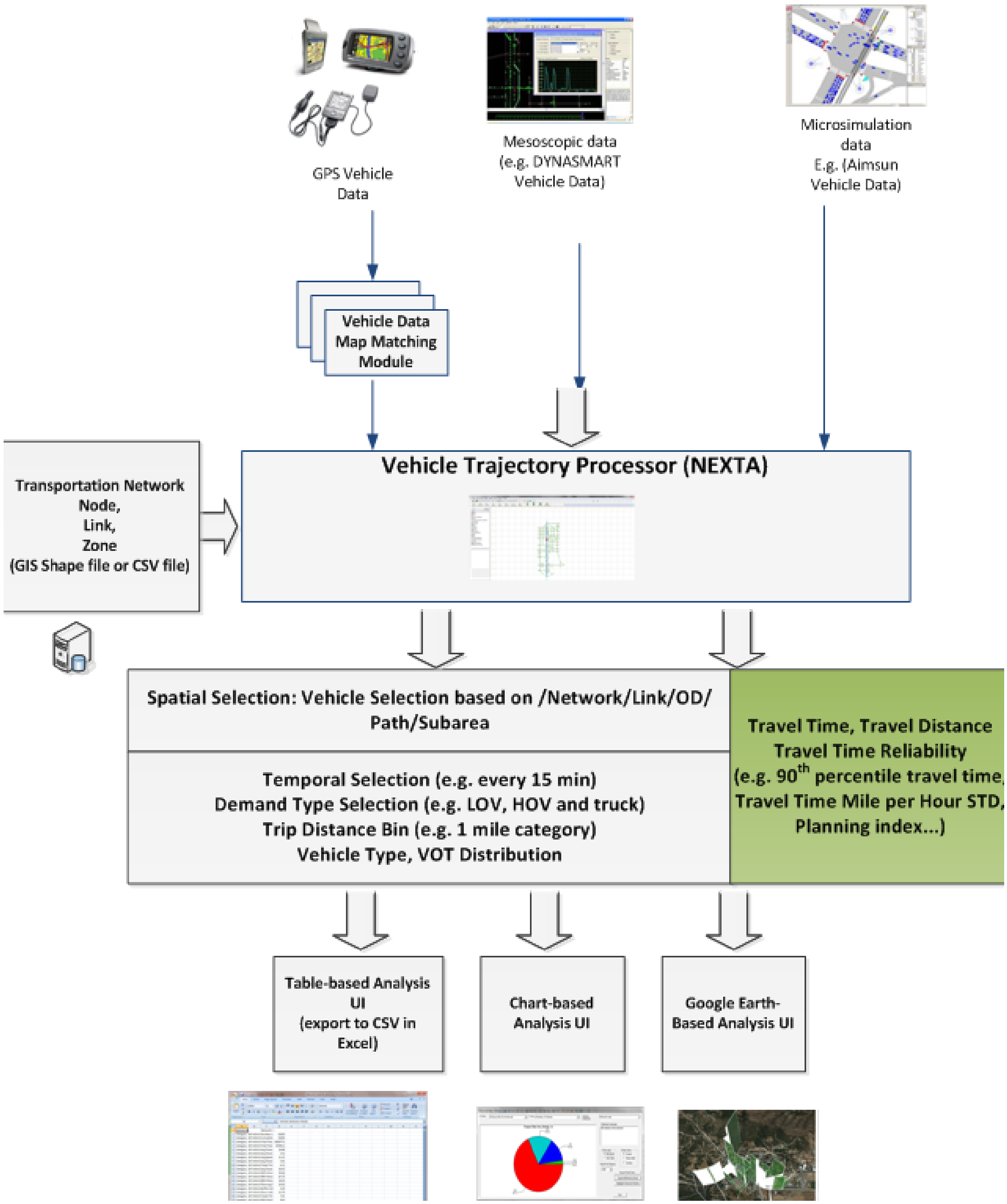


Figure 2.1 Overall vehicle trajectory processing procedure

(GIS = geographic information systems; CSV = comma-separated values; LOV = light operational vehicle; HOV = high-occupancy vehicle; VOT = value of time; STD = standard deviation; UI = user interfaces).

The Vehicle Trajectory Processor Module is a core data fusion and visualization component. The inputs for reliability analysis are a set of simulated vehicle trajectories from different data sources or real-world GPS vehicle trajectories. The tasks performed by this module are described as follows.

1. Based on the users' spatial selection criteria such as link level, path level, or subarea, the Trajectory Processor will scan vehicle trajectories for all vehicles,
2. Select vehicles satisfying the given spatial selection criterion (e.g., passing through a link, or passing through a path, traveling from a given origin to a given destination, or passing through the subarea),
3. Select vehicles satisfying the given vehicle attribute criterion (e.g., departure time interval, demand type, vehicle type),
4. Tally statistics for selected vehicles (e.g., calculating average travel time and the resulting standard deviation), and
5. Output statistics in different data format [e.g., comma-separated values (CSV), chart, or keyhole markup language (i.e., KML) files for Google Earth].

To generate a wide range of statistics, individual travel time records are used as samples to produce network-level, OD-level, and path-level travel time statistics. Three styles of user interfaces (UI) are used to facilitate better understanding of either OD-level or path-level travel time variability.

- *Table-based statistic presentation UI*
  : Travel time statistics are presented in CSV tables for all spatial selections so that users can make scenario-specific comparisons.
- *Chart-based statistic presentation UI*
  : The OD-level travel time distribution is visualized with different departure time intervals, different travel distance bins as well as different vehicle groups.
- *Google Earth–based 3D presentation UI*
  : In order to view and compare paths, this UI is able to display link volume (as height) vs. link travel time (as color code) on Google Earth. With this capability, it is much easier to identify whether a path is a normal path or a detour.

When the Trajectory Processor (i.e., NEXTA program) first loads itself, a user will see the following window (Figure 2.2). This is the main window, where the user displays and explores study networks on the network view; selects specific links, paths, subareas, or individual vehicle trajectories for an analysis using functions available on the geographic information systems (GIS) layer panel; and performs detailed analyses at various levels (i.e., network, link, path, and OD levels) using analytical tools launched from the toolbar.

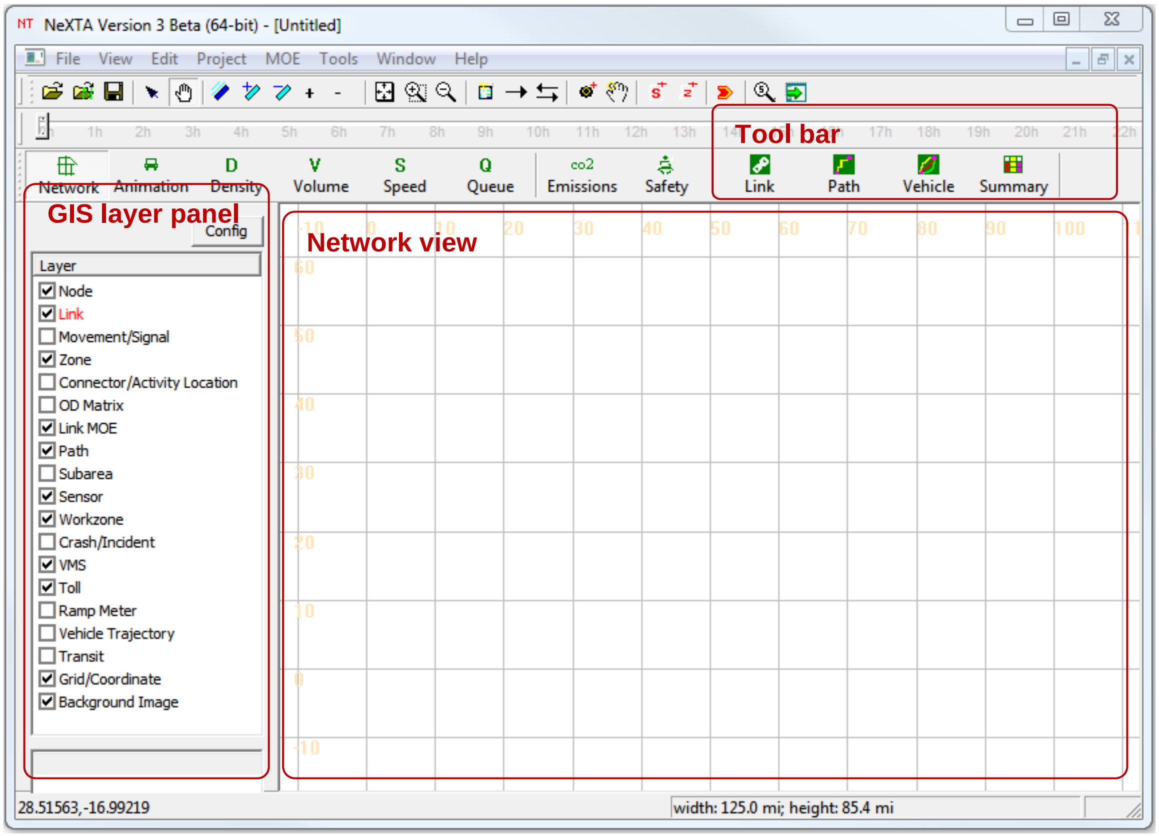


Figure 2.2 Trajectory Processor (NEXTA) start-up window (MOE = measure of effectiveness; VMS = variable message sign).

CHAPTER 3

Network and Input Data Loading

Three types of input data are presented in this guide: simulated vehicle trajectories from mesoscopic model DYNASMART-P, simulated vehicle trajectories from microscopic model Aimsun, and observed vehicle trajectories from GPS data.

3.1 Mesoscopic Simulation Data (DYNASMART-P)

In NEXTA, go to File -> Open Traffic Network Project, or left click  in the Control Toolbar. Locate the directory where the DYNASMART-P input files including the simulation results (i.e., VehTrajectory.dat) are present. Select the DYNASMART-P project file (*.dws) and click "Open" in the Open dialog. A simulation network in the New York City area titled "NYC_sub.dws" is used as an example in Figure 3.1. Once the input data are loaded, the File Loading Status dialog will show up (Figure 3.2), and the associated network will be displayed on the network view (Figure 3.3).

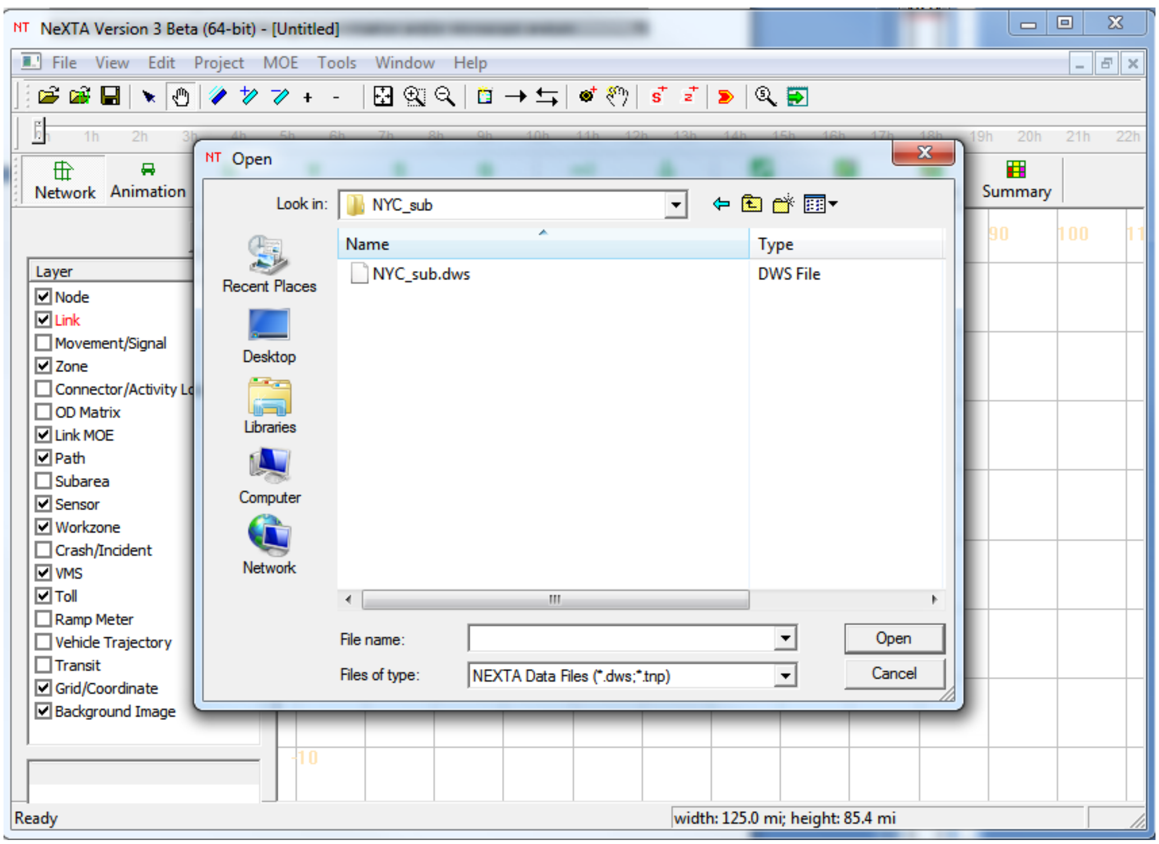


Figure 3.1 Opening the DYNASMART-P project file.

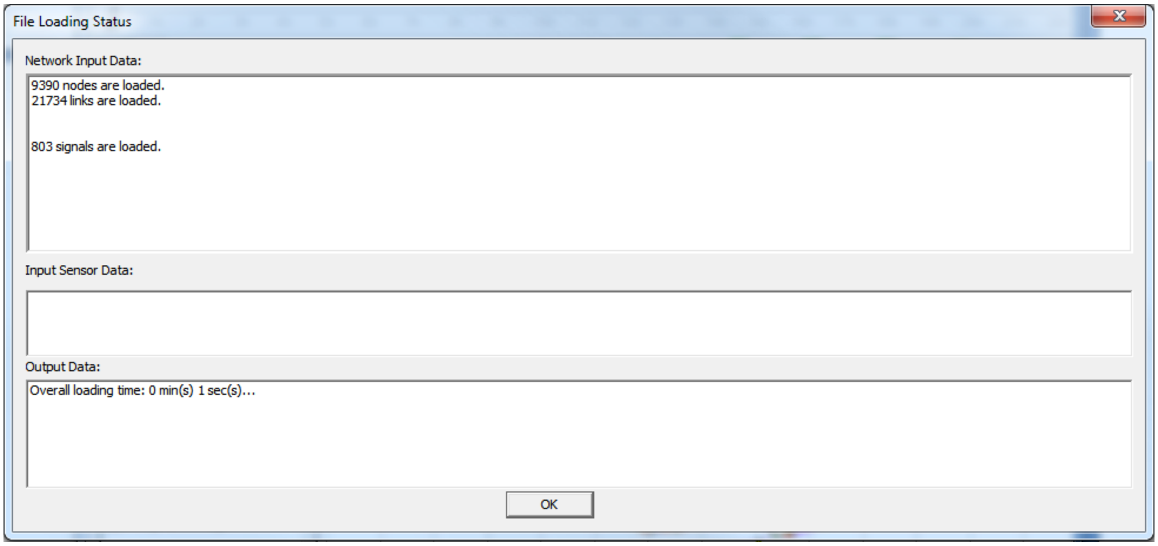


Figure 3.2 File Loading Status dialog.

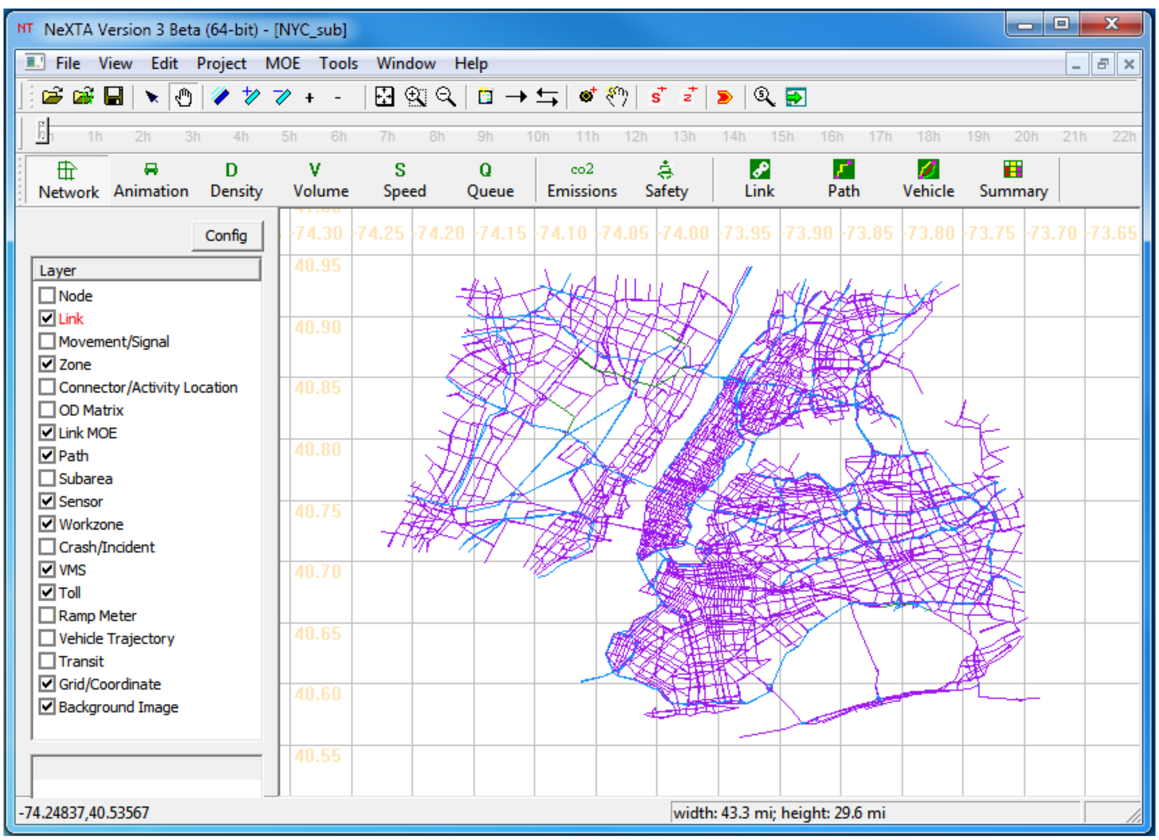


Figure 3.3 DYNASMART-P network loaded on the network view.

3.2 Microscopic Simulation Data (Aimsun)

In NEXTA, go to File -> Open Traffic Network Project, or left click  in the Control Toolbar. Locate the directory where the Aimsun input files are present. Select the Aimsun project file (*.tnp) and click “Open” in the Open dialog. A simulation network in Manhattan, New York, titled “Aimsun.tnp,” is used as an example in Figure 3.4. Once the input data are loaded, the File Loading Status dialog will show up (Figure 3.5), and the associated network will be displayed on the network view (Figure 3.6).

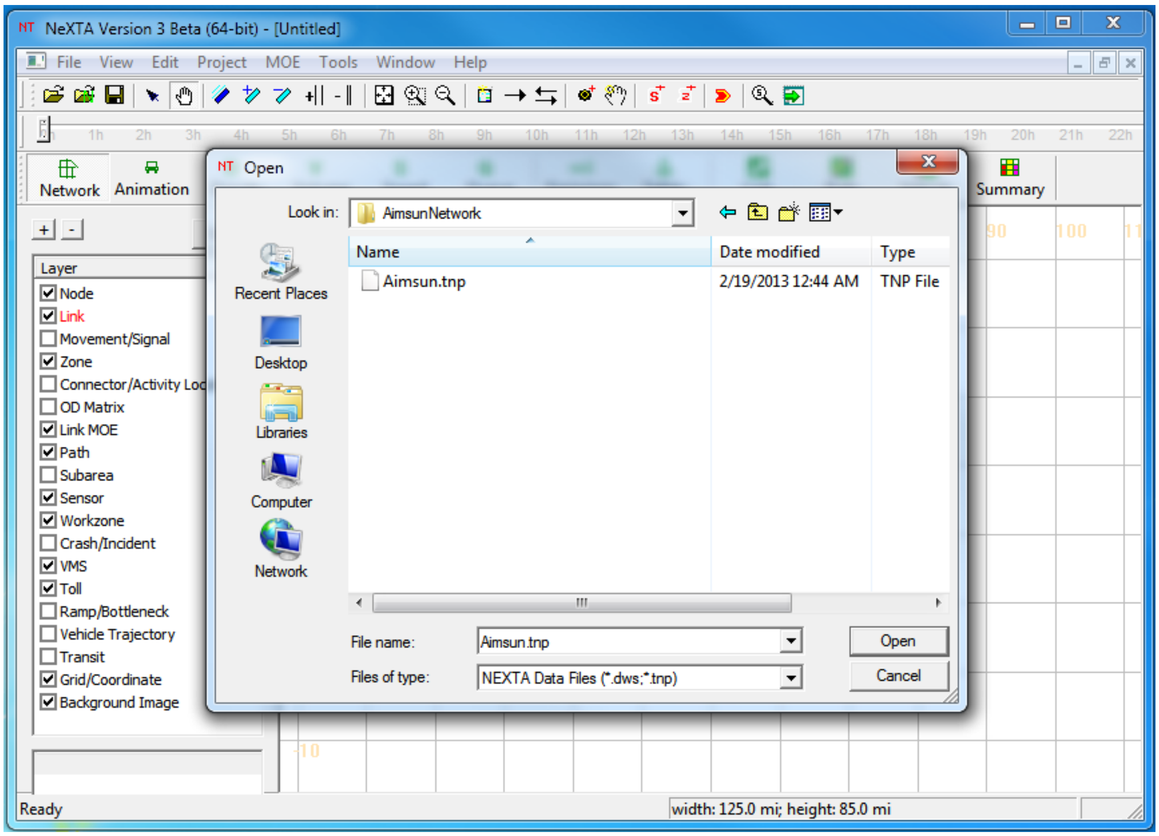


Figure 3.4 Opening Aimsun data file.

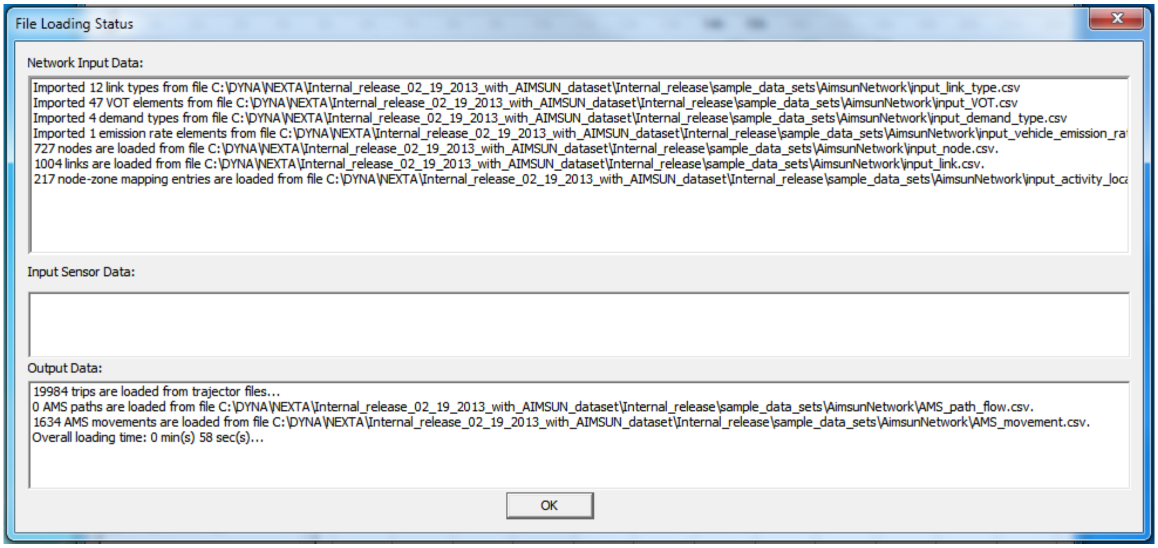


Figure 3.5 File Loading Status dialog.

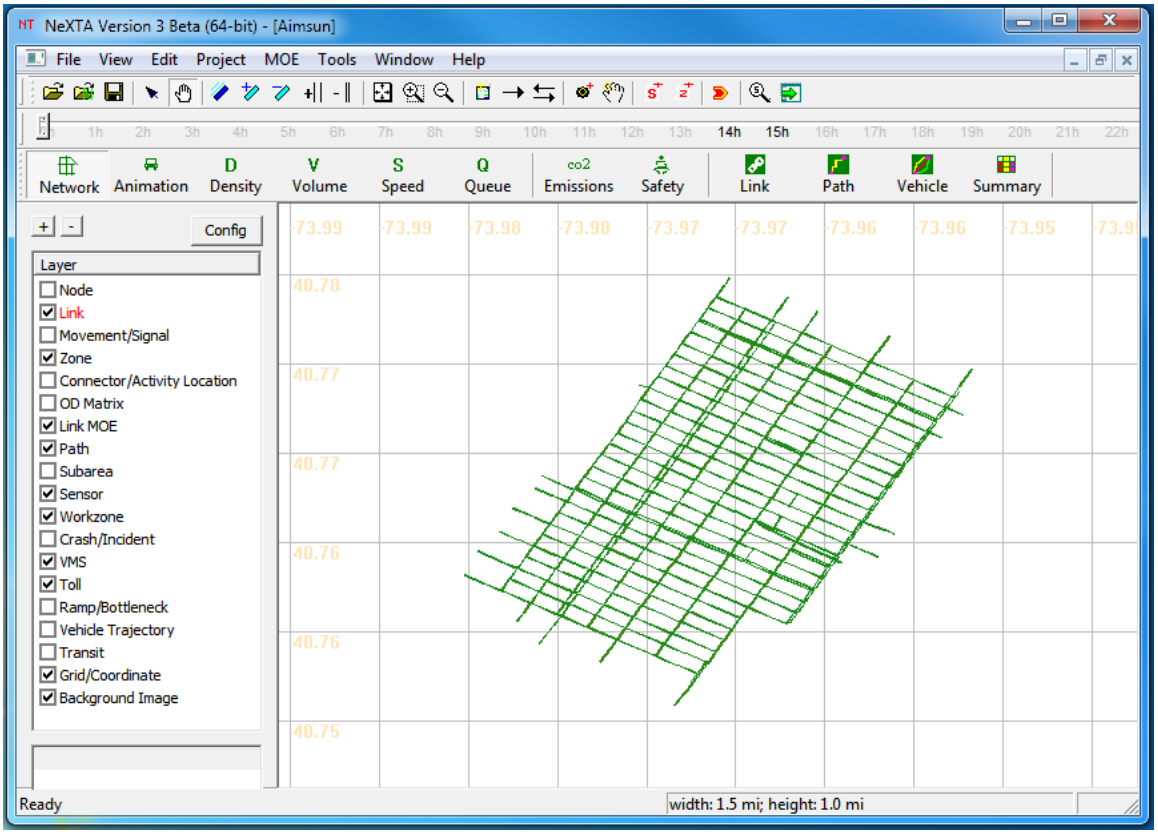
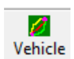


Figure 3.6 Aimsun network loaded on the network view.

3.3 GPS Data

In order to analyze real-world GPS data in a consistent manner regardless of their source and original data format, raw data need to be pre-processed in a way that vehicle location information in trajectories, which is based on a real-world latitude and longitude coordinate system, is matched to a desirable transportation network representation. The Trajectory Processor internally performs such a pre-processing in the map-matching module shown in Figure 2.1 and allows users to investigate and analyze the trajectory data in the same manner as for the simulated trajectories. The GPS traces obtained from TomTom International were used to demonstrate the role of the Trajectory Processor as a part of the unifying and platform-independent analytical framework developed under the SHRP 2 L04 project. The GPS input data set was designed such that the GPS vehicle trajectories, once pre-processed via the map-matching module, can be represented by links, nodes, and zones that are consistent with the best practice model for the New York region. The loading process for the GPS data is the same as above.

In NEXTA, go to File -> Open Traffic Network Project, or left click  in the Control Toolbar. Locate the directory where the GPS input data set is present. Select the project file (*.tnp) and click “Open” in the Open dialog. A transportation network in the New York region, titled “regional_network.tnp,” is used as an example in Figure 3.7. Once the input data are loaded, the File Loading Status dialog will show up (Figure 3.8), and the associated network will be displayed on the network view (Figure 3.9).

Click 

in the toolbar or go to Menu->MOE > Vehicle Path Analysis, and the Vehicle Analysis dialog will open the Find/Filter Vehicles window (Figure 3.10). This dialog shows how vehicle trajectories in GPS data are mapped into the OD pairs and paths in the given network. Users can display individual vehicles’ traces for a specific path on the network by checking “Vehicle Trajectory” on the GIS layer panel and clicking a row in the Path List in the Find/Filter Vehicles dialog, as shown in Figure 3.11.

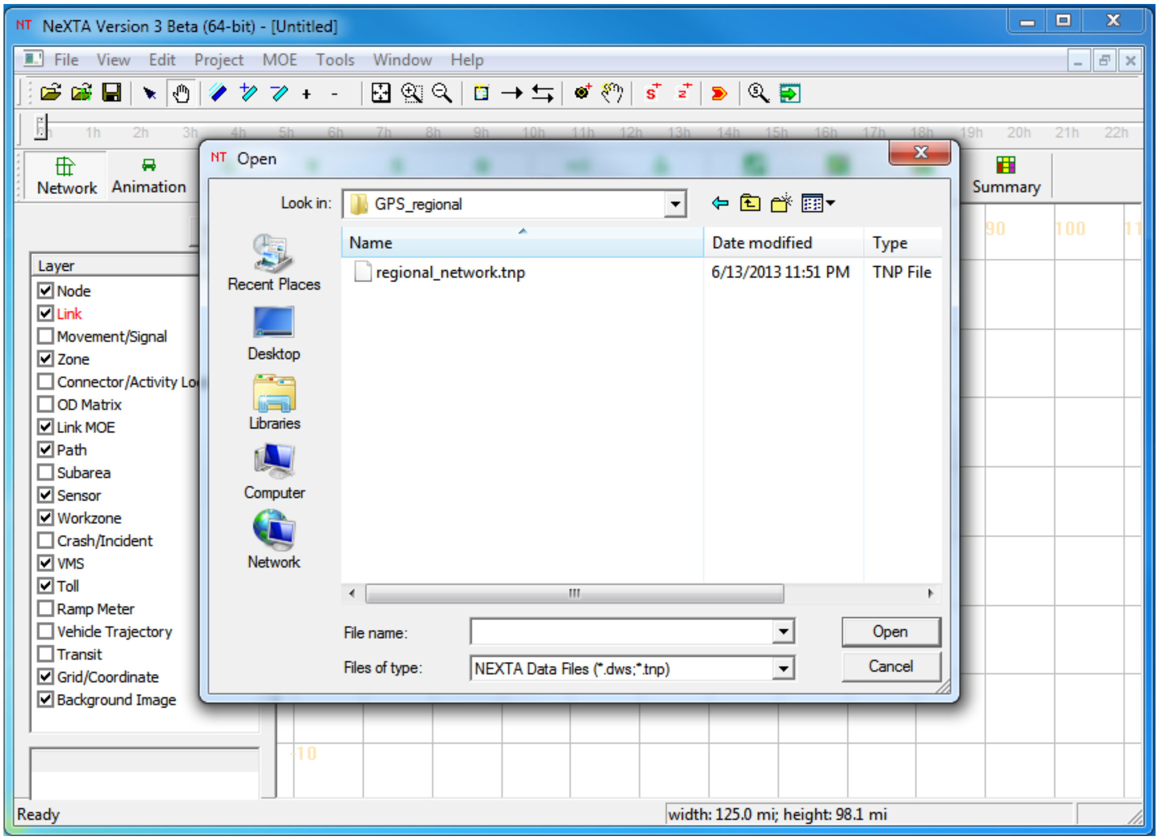


Figure 3.7 Opening GPS data file.

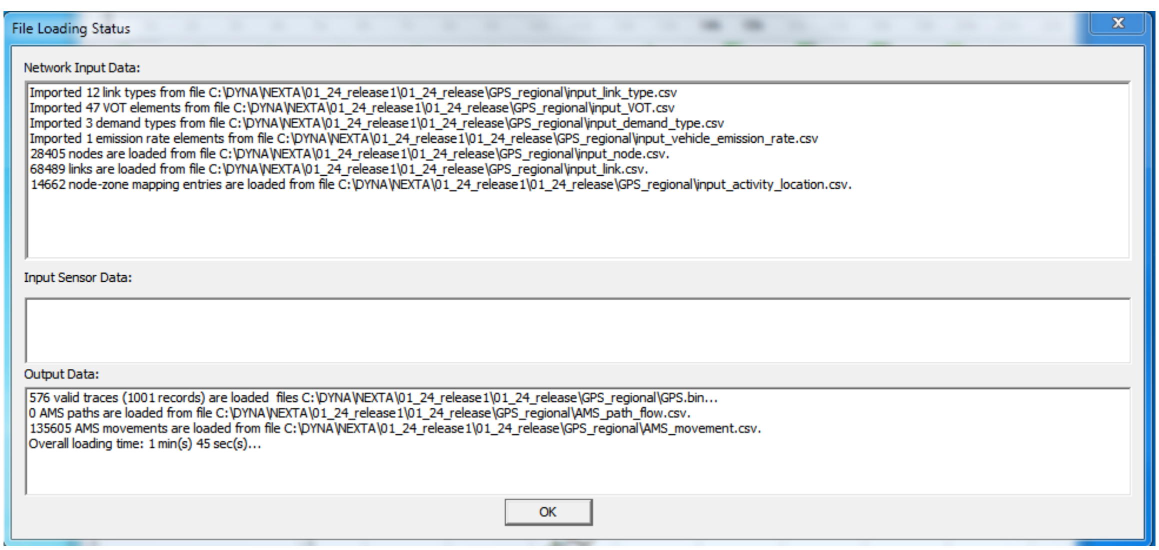


Figure 3.8 File Loading Status dialog.

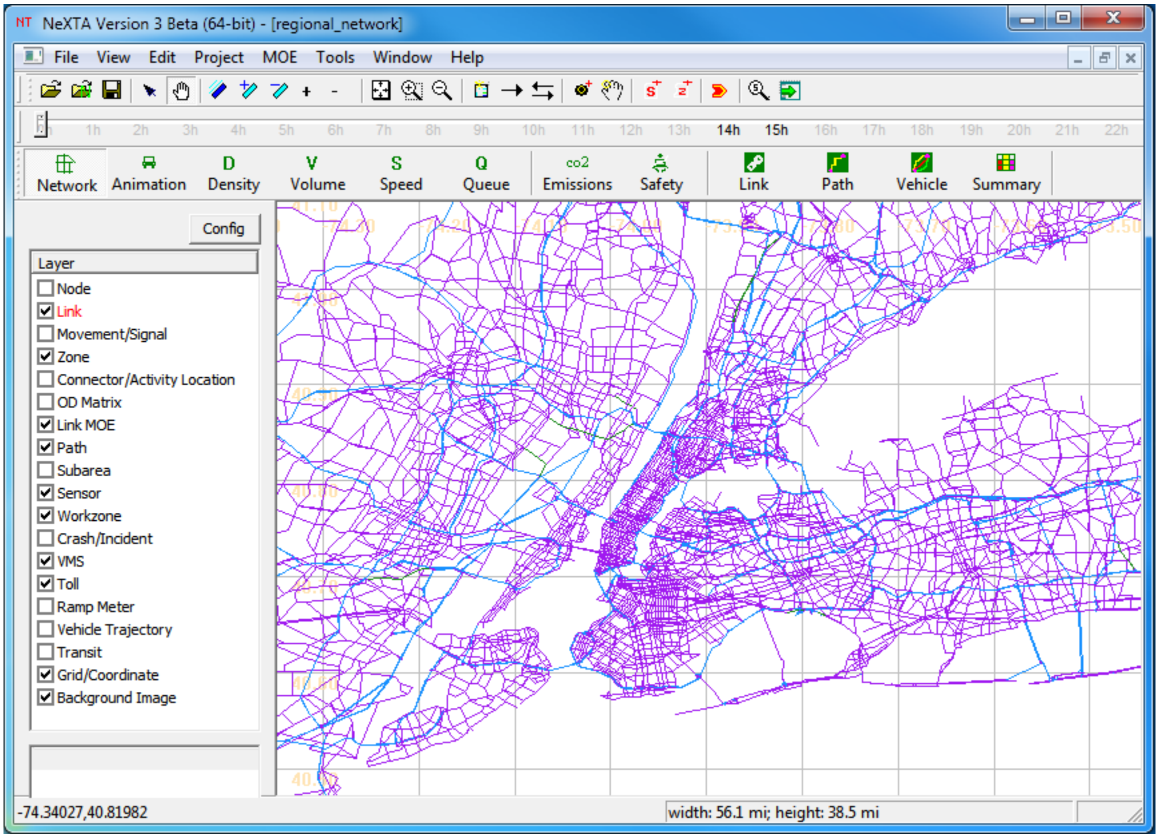


Figure 3.9 GPS data-mapped network loaded on the network view.

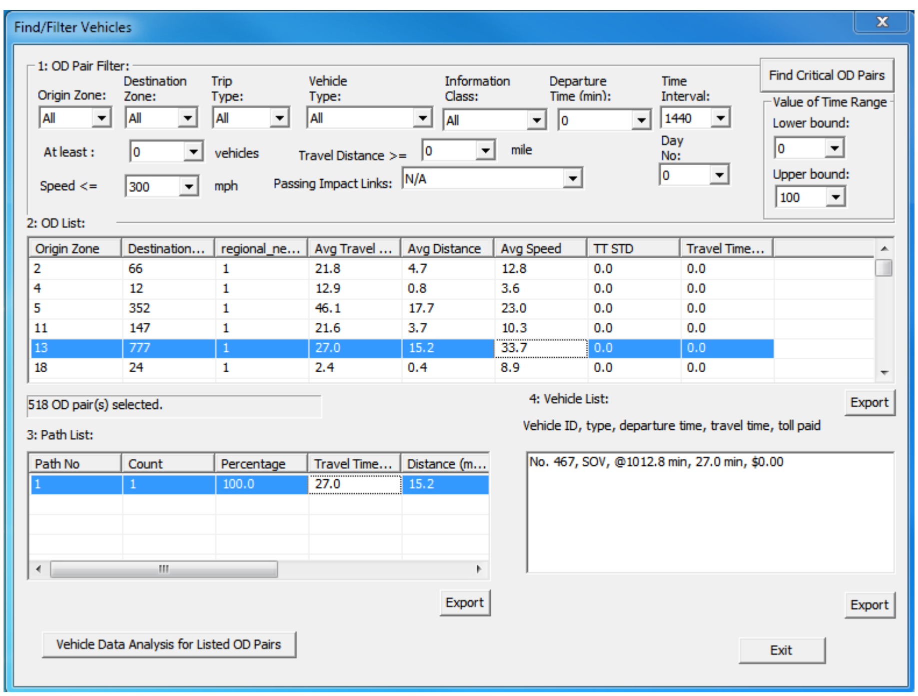


Figure 3.10 Vehicles in GPS data categorized by OD and path.

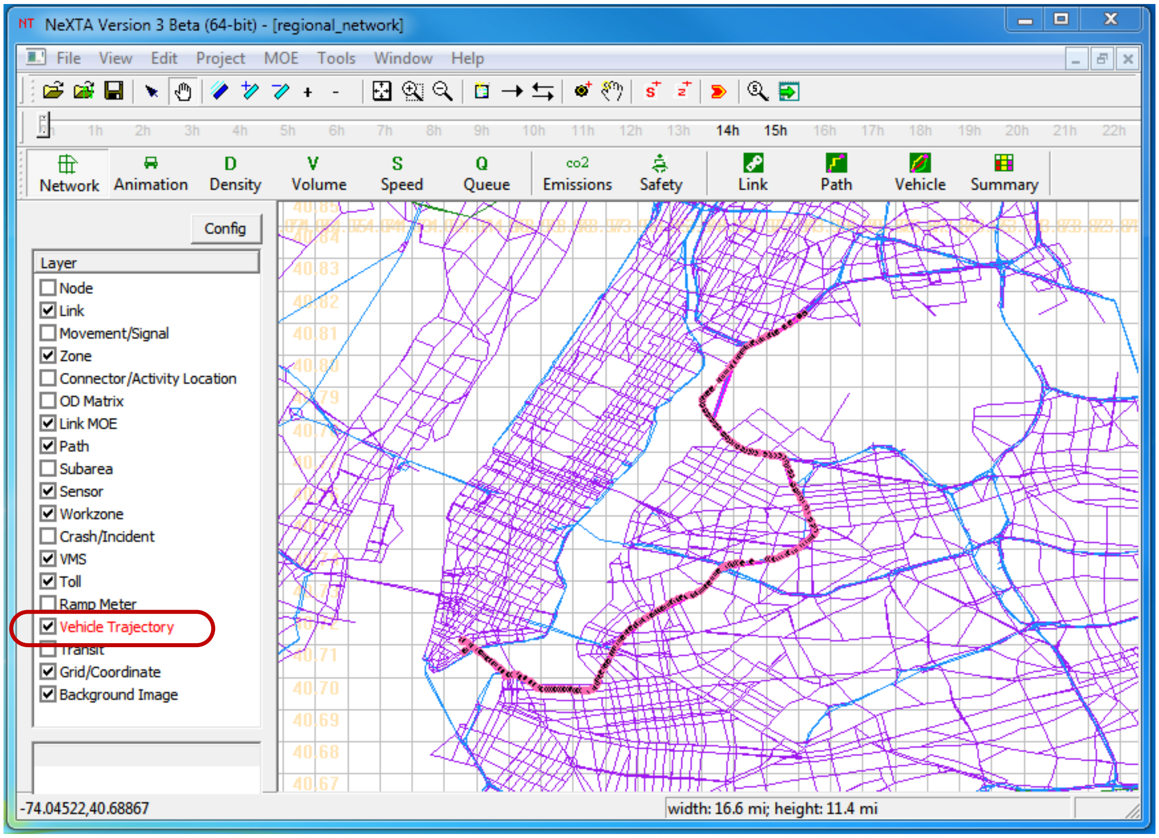


Figure 3.11 GPS vehicle trajectory displayed on the network.

CHAPTER 4
Travel Time Reliability Analysis

4.1 Network-Level Analysis

4.1.1 Select network-wide data

The Data Summary Tool is used to examine travel statistics for all vehicles in the network. By going to Menu->MOE > Network Statistics Dialog or clicking Summary in the toolbar (Figure 4.1), the Data Summary Dialog appears as shown in Figure 4.2.

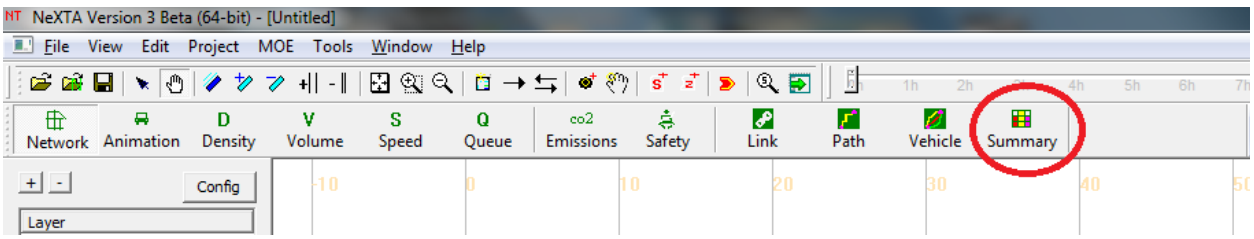


Figure 4.1 Toolbar.

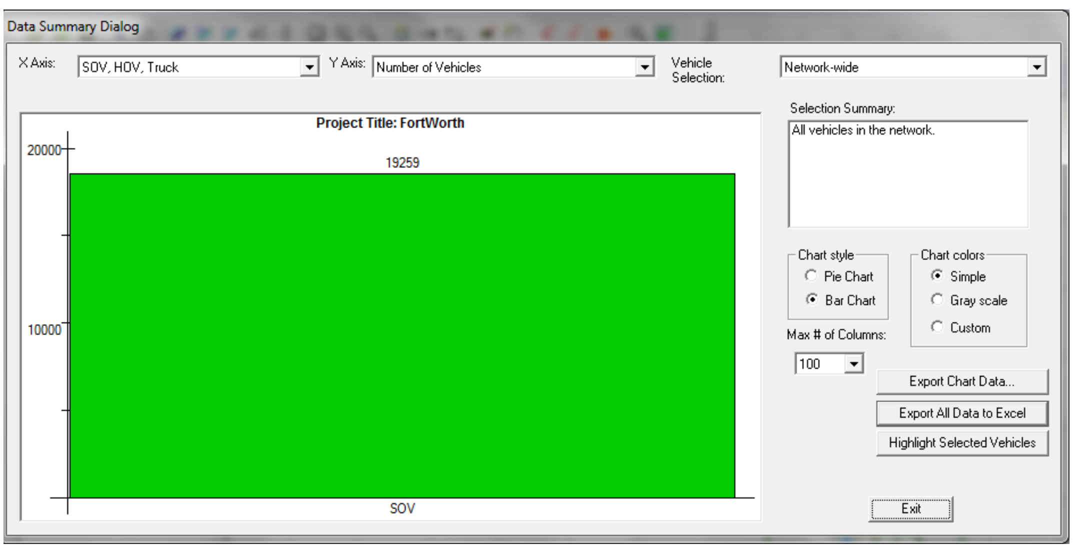


Figure 4.2 Data Summary Dialog (network-wide analysis).

Three key selections are needed as an integrated process to create vehicle filtering (X axis), measure of effectiveness (MOE) selection (Y axis), and vehicle selection (network vs. link or path).

1. The first drop-down list is the vehicle filter as X Axis that allows users to select vehicles based on their departure time, value of time (VOT), vehicle type, traveler information class, and by distance intervals (Figure 4.3).

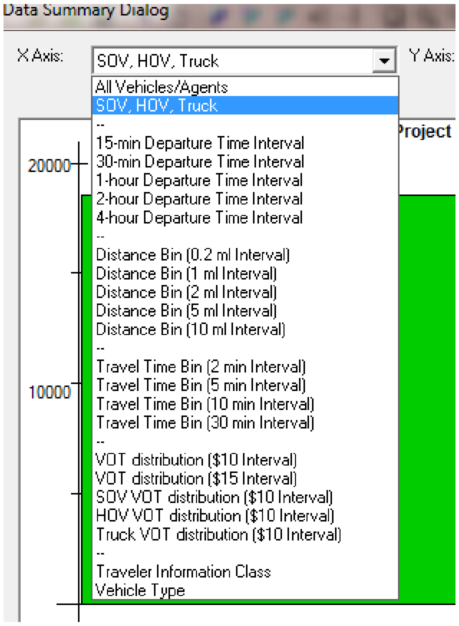


Figure 4.3 Data Summary Dialog (network-wide analysis).

2. The second drop-down list is the MOE selection as Y Axis, allowing a selection of a wide range of MOEs, such as Number of Vehicles, Total and Average Travel Times, Total and Average Travel Distance, Travel Time Index, and many reliability-related statistics, which include Percentile Travel Times, Planning Time Index, Buffer Index, and Skew Index (Figure 4.4).

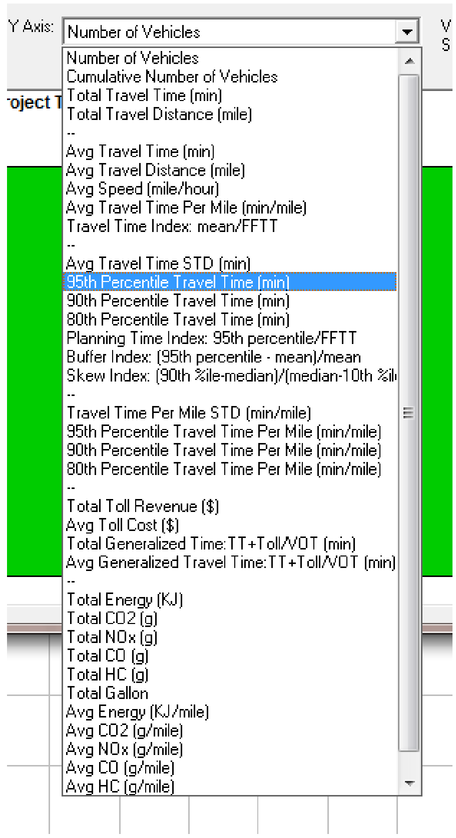


Figure 4.4 Data Summary Dialog (network-wide analysis) (FFTT = free-flow travel time).

3. The Spatial Selection options allow users to define a selection criterion such as Network-wide, Selected OD Pairs from Vehicle Path Dialog, Passing Selected Link Set, Trips Passing Selected Path, Partial Trips Passing Selected Path, Originating from Subarea, and Traversing through Subarea (Figure 4.5).

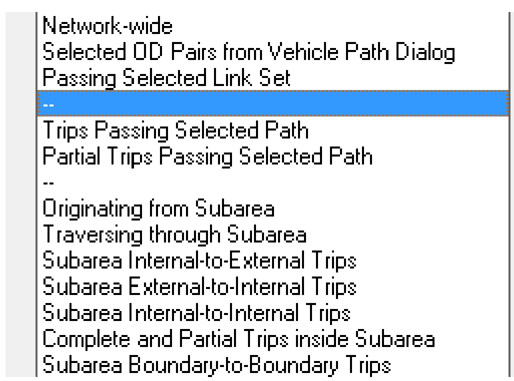


Figure 4.5 Data Summary Dialog (network-wide analysis).

4.1.2 Produce network-wide performance measures

The following steps illustrate how to create a few key statistics commonly used in traffic analysis.

1) Time-dependent demand profile (Figure 4.6)

- Choose 15-min Departure Time Interval as X Axis, and Number of Vehicles as Y Axis.

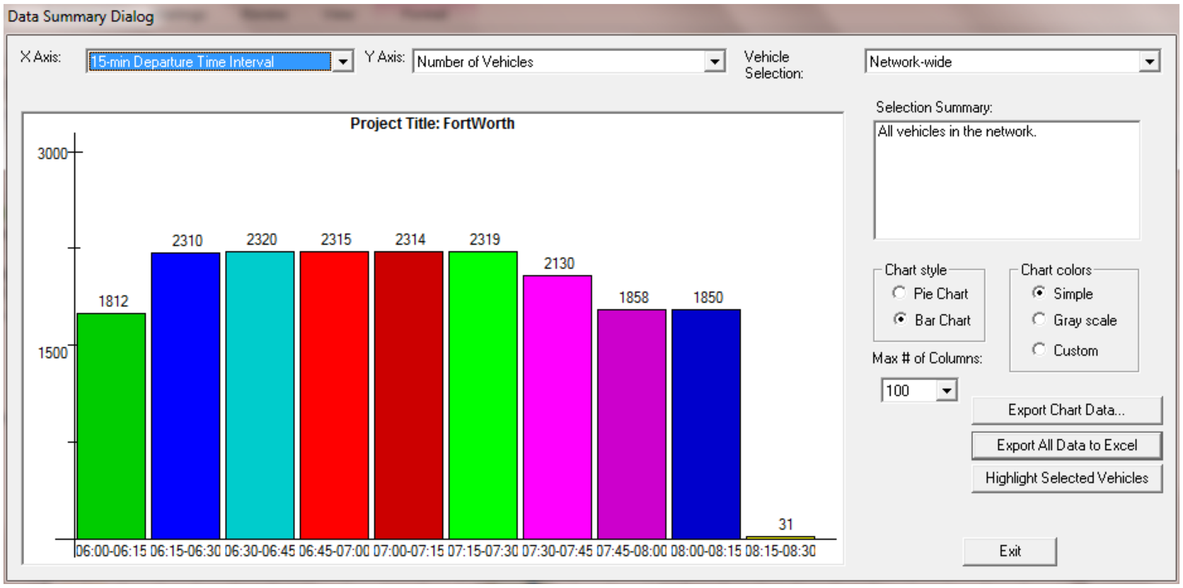


Figure 4.6 Data Summary Dialog (network-wide analysis).

2) Time-dependent average travel time (Figure 4.7)

- Choose 15-min Departure Time Interval as X Axis and Avg Travel Time (min) as Y Axis.

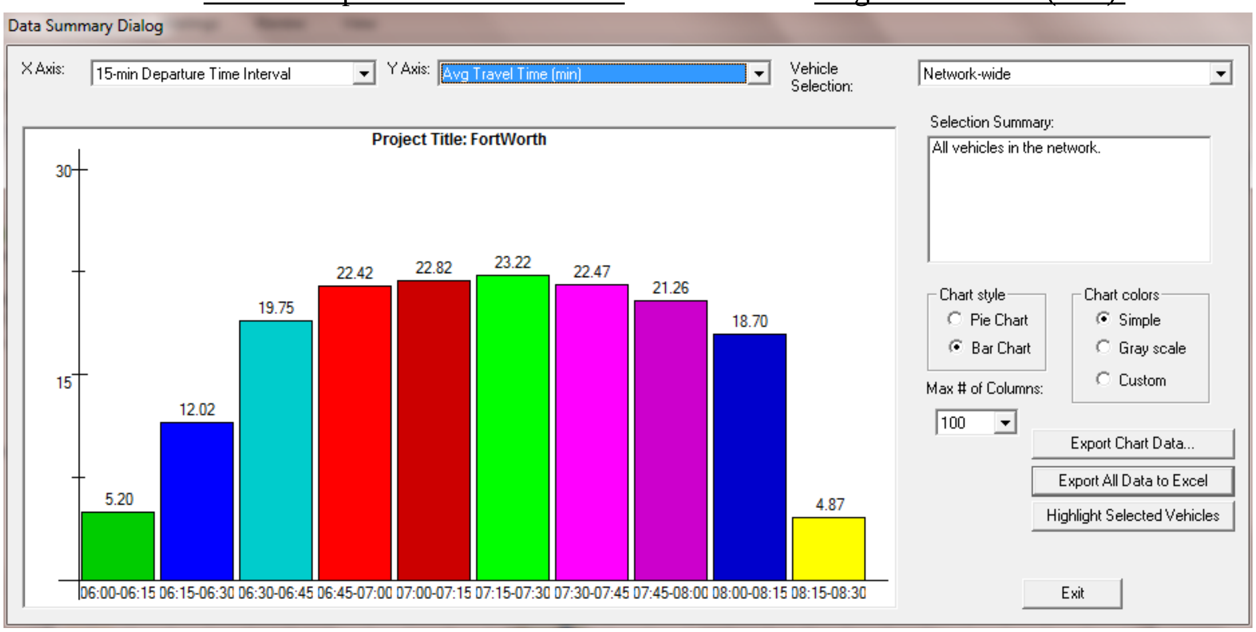


Figure 4.7 Data Summary Dialog (network-wide analysis).

3) Time-dependent travel time reliability (Figure 4.8)

- Choose the 15-min Departure Time Interval as X Axis.
- Select 80th Percentile Travel Time (min) as Y Axis.

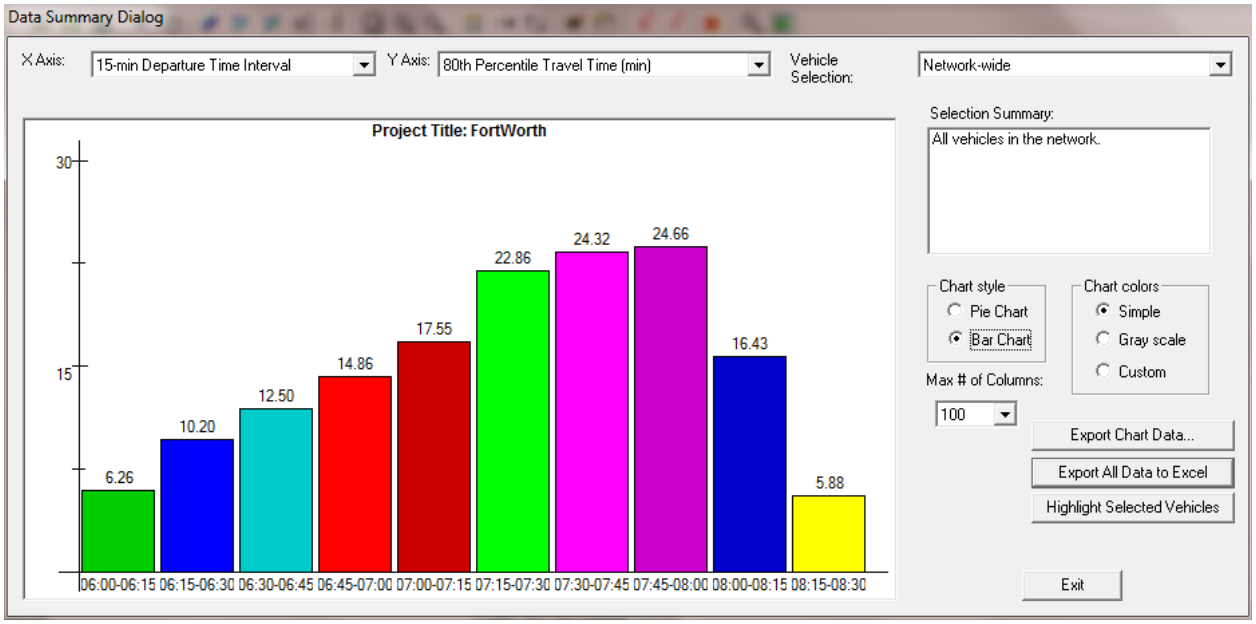


Figure 4.8 Data Summary Dialog (network-wide analysis).

4) Time-dependent travel distance (Figure 4.9)

- Select <u>15-min Departure Time Interval</u> as X Axis.
- Select <u>Avg Travel Distance (mile)</u> as Y Axis.

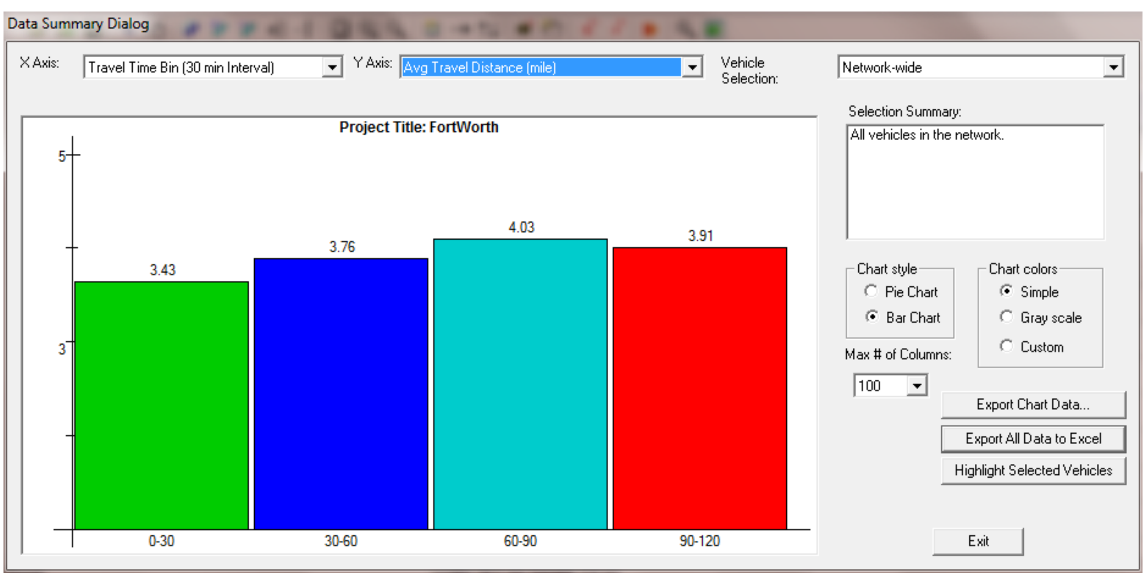


Figure 4.9 Data Summary Dialog (network-wide analysis).

5) Distance pie chart (Figure 4.10)

- Choose the pie chart as <u>chart style</u>.
- Select distance bin as X axis and number of vehicles as Y axis.

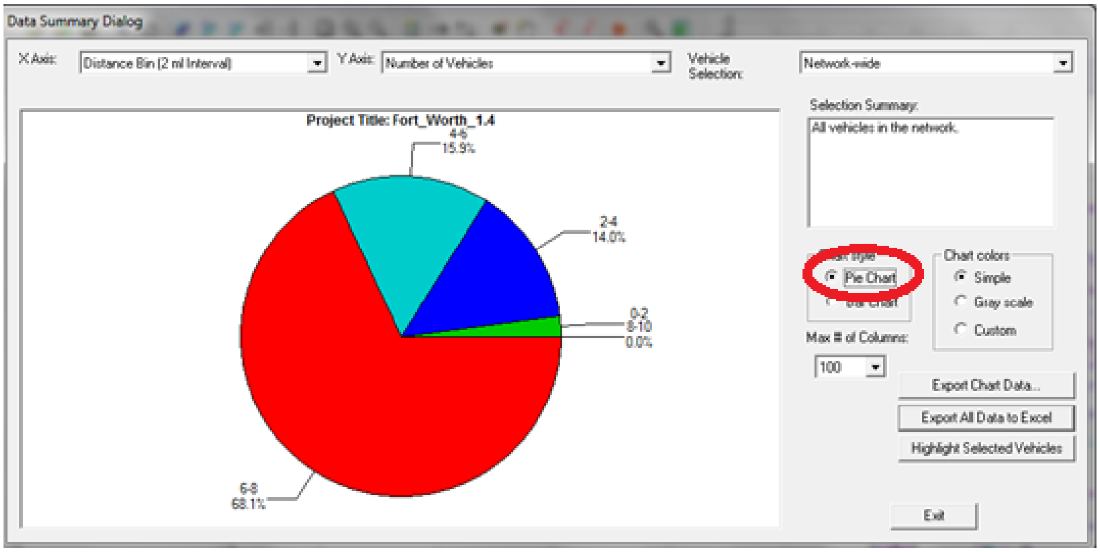


Figure 4.10 Data Summary Dialog (network-wide analysis).

4.1.3 Export data to CSV file

The Key export functions include Export Chart Data…, Export all Data to Excel, and Highlight Selected Vehicles.

First, click the Export Chart Data... button, and a CSV file is generated for statistics included for the current selection only (Figure 4.11).

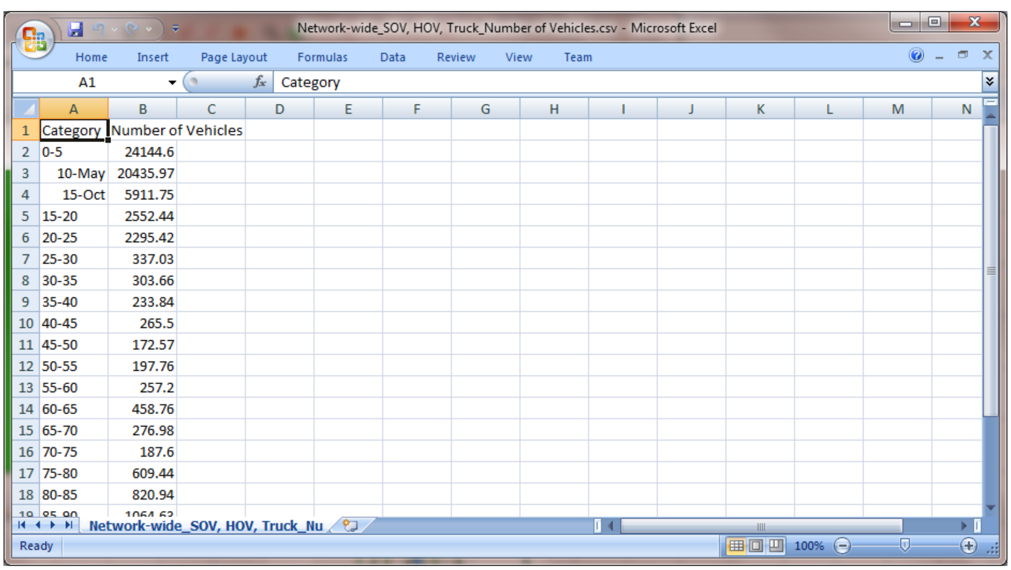


Figure 4.11 Data exported to CSV file (network-wide statistics).

And click Export All Data to Excel. A CSV file is generated for all possible vehicle selections and all MOE types under the current spatial selection (Figure 4.12).

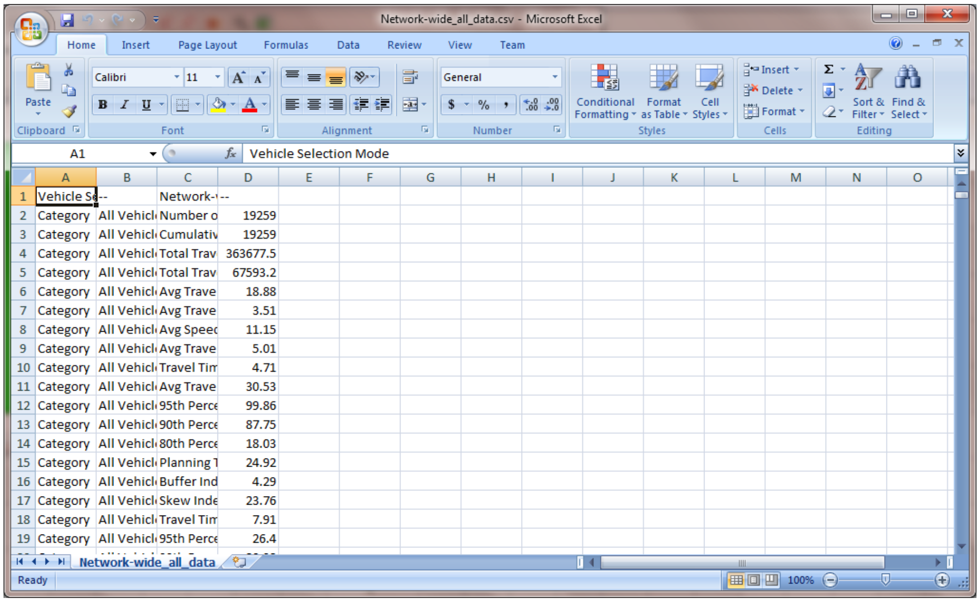


Figure 4.12 Data exported to CSV file (network-wide statistics).

By clicking the Highlight Selected Vehicles button, we can highlight all links that selected vehicles pass through, as shown in Figure 4.13.

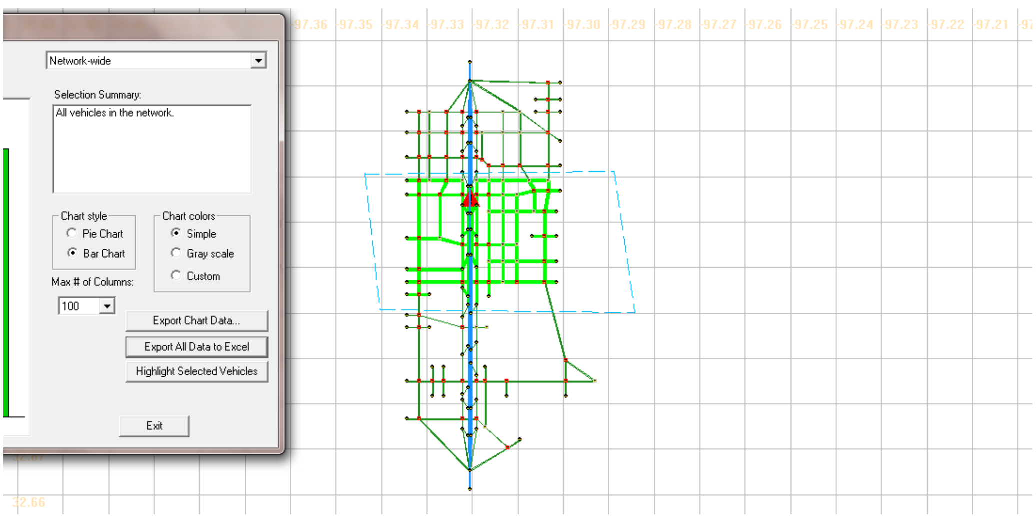


Figure 4.13 Data Summary Dialog (network-wide statistics).

4.2 Link-Level Analysis

4.2.1 Select link

Click the “Link”" layer on the GIS layer panel; the corresponding layer becomes red when this layer is selected. And then, you can directly select the link on the display view. If you know the node ID of a link, the search function “Ctrl+F” can be used (Figure 4.14). Finally, the selected link’s color will be in red (Figure 4.15).

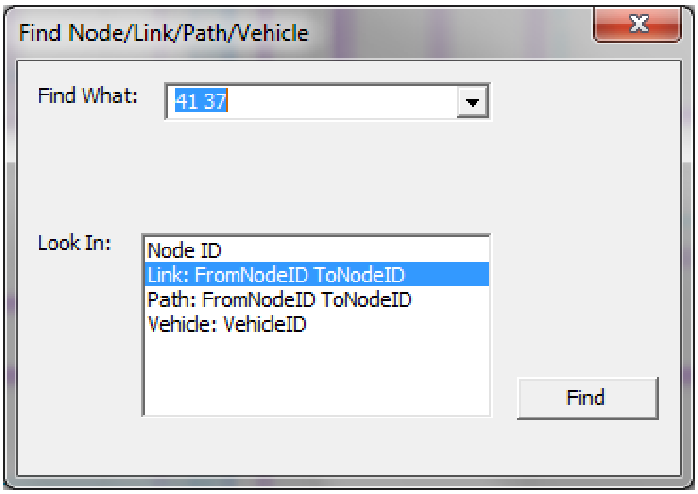


Figure 4.14 Dialog for searching for links (link-level analysis).

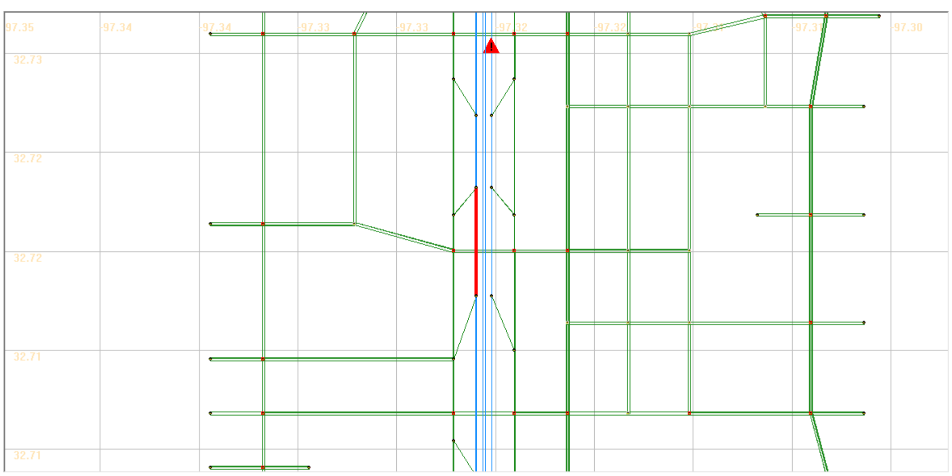


Figure 4.15 Display a selected link (link-level analysis).

Right click the link to bring the following menu for link-related functions (Figure 4.16).

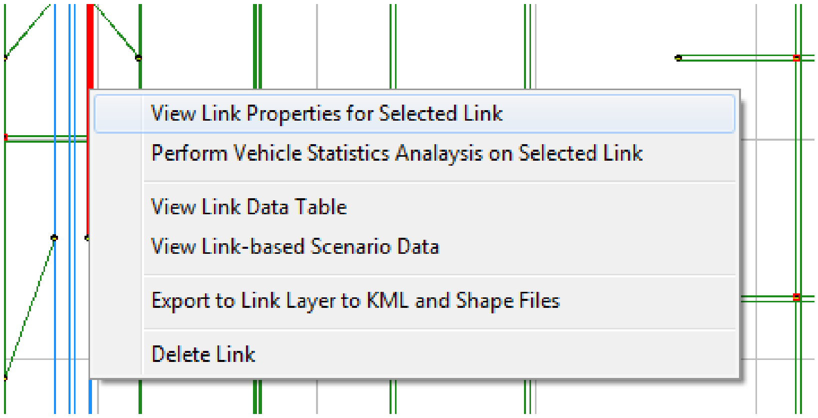


Figure 4.16 Link-related functions (link-level analysis).

Click Perform Vehicle Statistics Analaysis on Selected Link to examine travel statistics for groups of vehicles of the selected link (Figure 4.17).

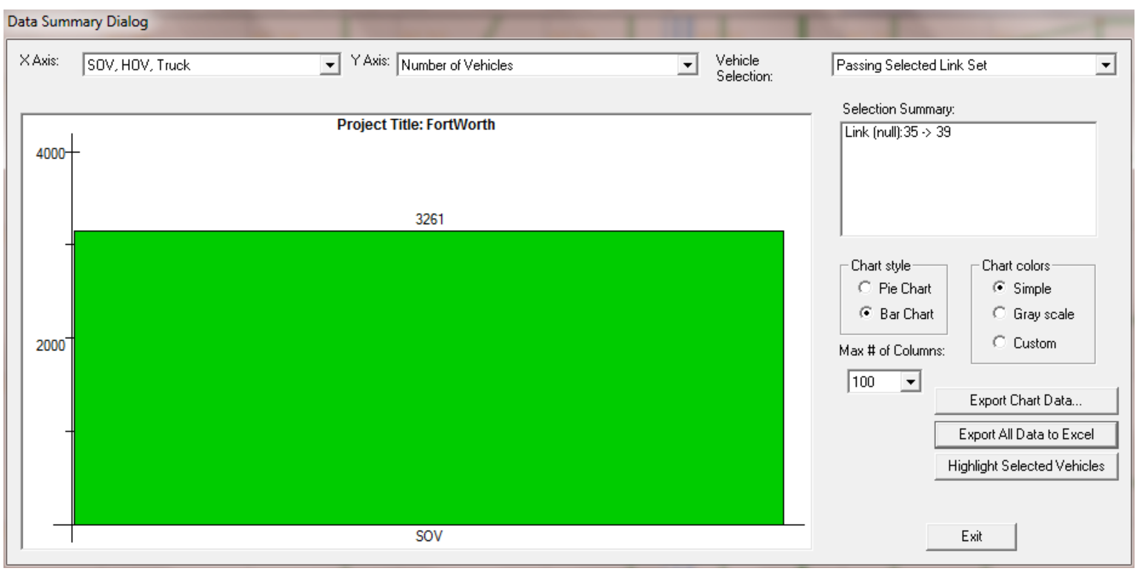


Figure 4.17 Data Summary Dialog (link-level analysis).

4.2.2 Produce link performance measures

If you want to check time-dependent demand, travel time, and reliability and highlight selected vehicles about the link, just operate the Data Summary Dialog as described in the network-level analysis above (Section 4.3.2). Figure 4.18 to Figure 4.21 show the associated screenshots for the case of the link-level analysis.

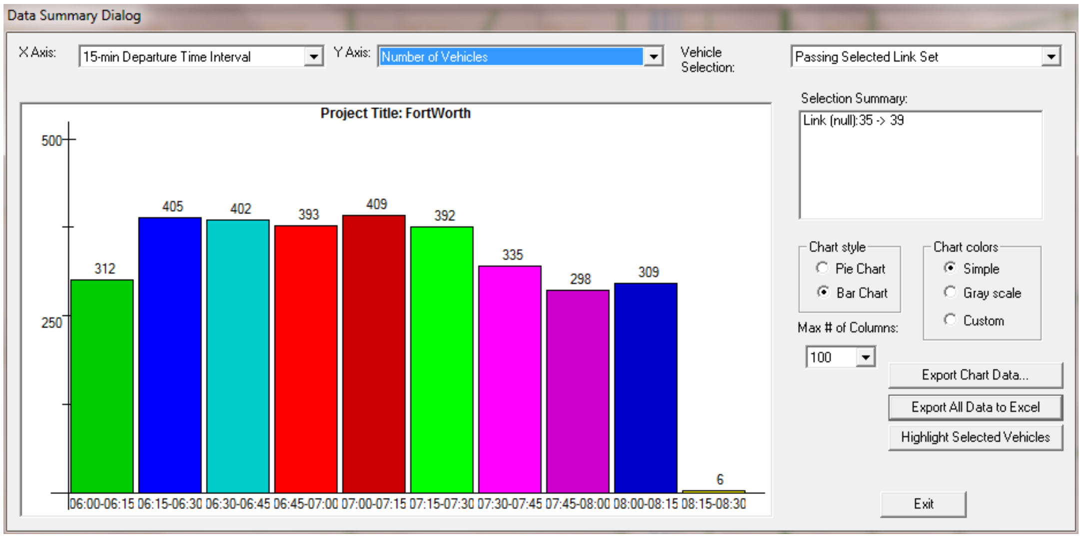


Figure 4.18 Time-dependent demand (link-level analysis).

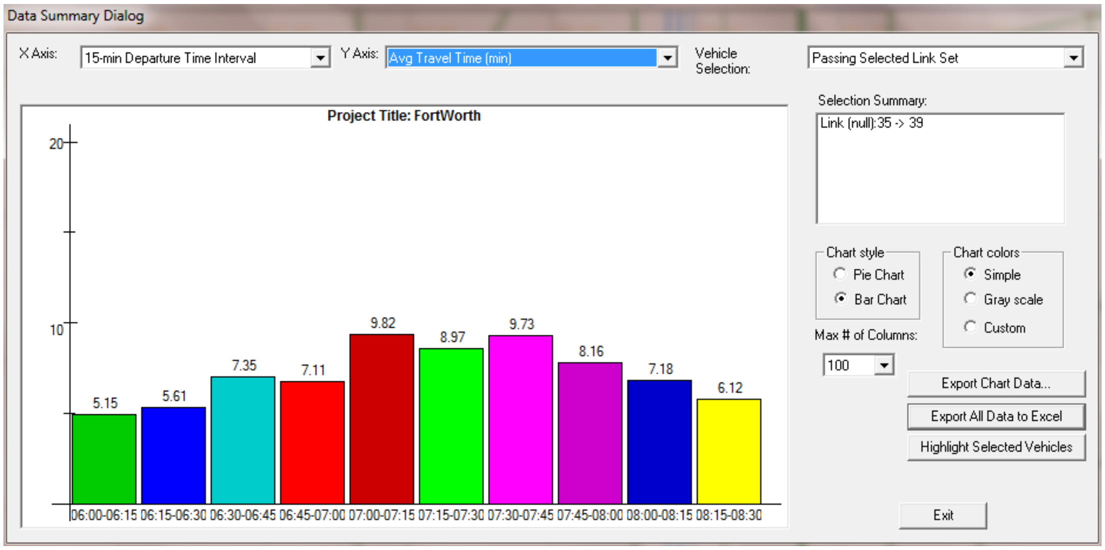


Figure 4.19 Time-dependent travel time (link-level analysis).

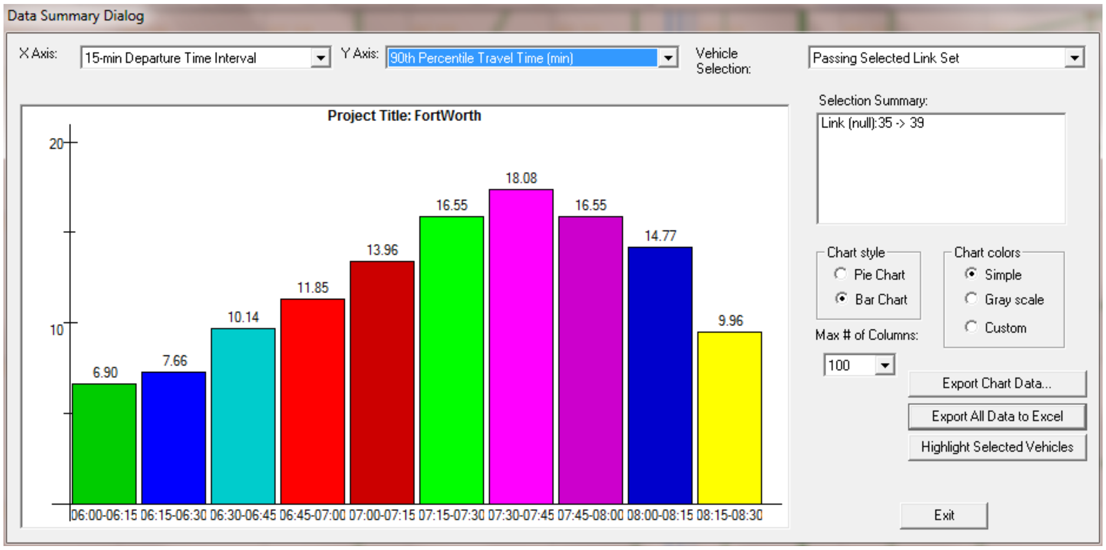


Figure 4.20 Time-dependent reliability (link-level analysis).

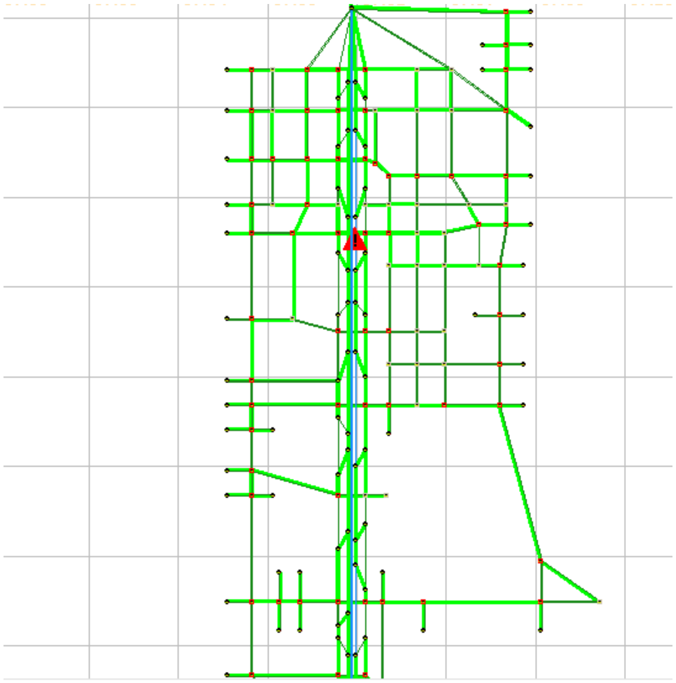


Figure 4.21 Highlight selected vehicles (link-level analysis).

4.3 Path-Level Analysis

4.3.1 Select path

Click the “Path” layer on the GIS layer panel (Figure 4.22).

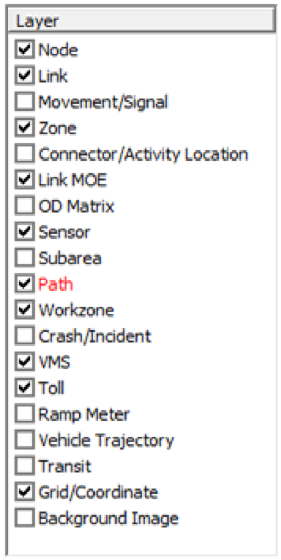


Figure 4.22 GIS layer panel (path-level analysis).

Right click a node on the display view to bring up the context menu for selecting a path (Figure 4.23).

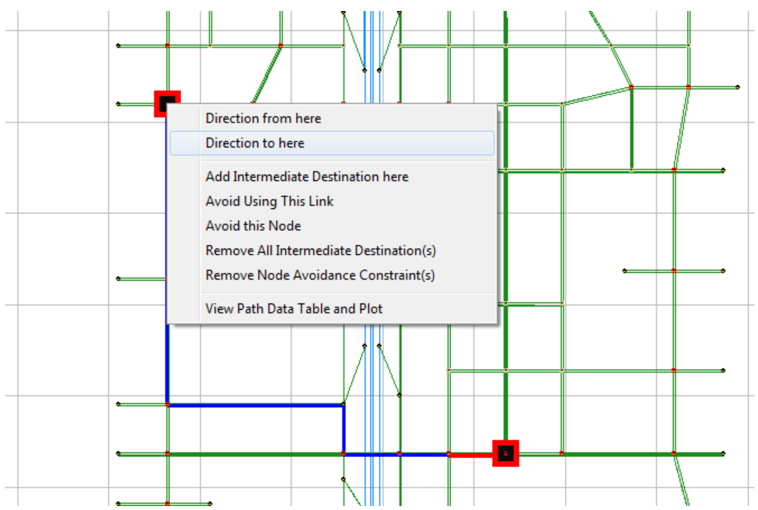


Figure 4.23 Context menu for selecting a path (path-level analysis).

And check on menu Direction from here to define the original point of a path. Right click another node, which you want to set as the destination. Check on menu Direction to here to confirm this node as the end point of the path. You now see the path from the selected origin to selected destination.

4.3.2 Produce path performance measures

Check on menu View Path Data Table and Plot to view path information in a Path Information dialog (Figure 4.24). You can choose one path to see the associated information. Please check number of miles and path travel time (dependent on speed limit).

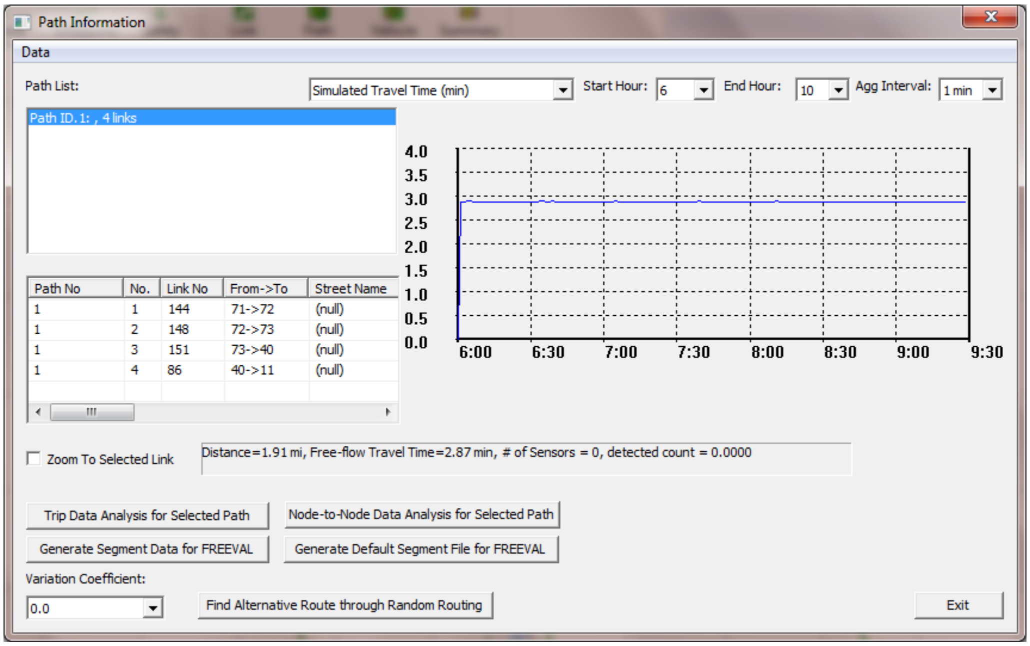


Figure 4.24 Path Information dialog (path-level analysis).

There are two different ways of extracting path-level performance measures: Trip Data Analysis for Selected Path and Node-to-Node Data Analysis for Selected Path. For the former, statistics are calculated based on the complete journey times (i.e., OD travel times) of all the vehicles that pass through the selected path. For the latter, on the contrary, statistics are calculated based on the partial trip times (i.e., the portion of trip times spent to travel the path). Detailed definitions of vehicle selection methods are provided in Table 4.2.

Clicking Trip Data Analysis for Selected Path will open the Data Summary Dialog associated with the analysis of trip data (i.e., complete trip time data) for the selected path, as shown in Figure 4.25.

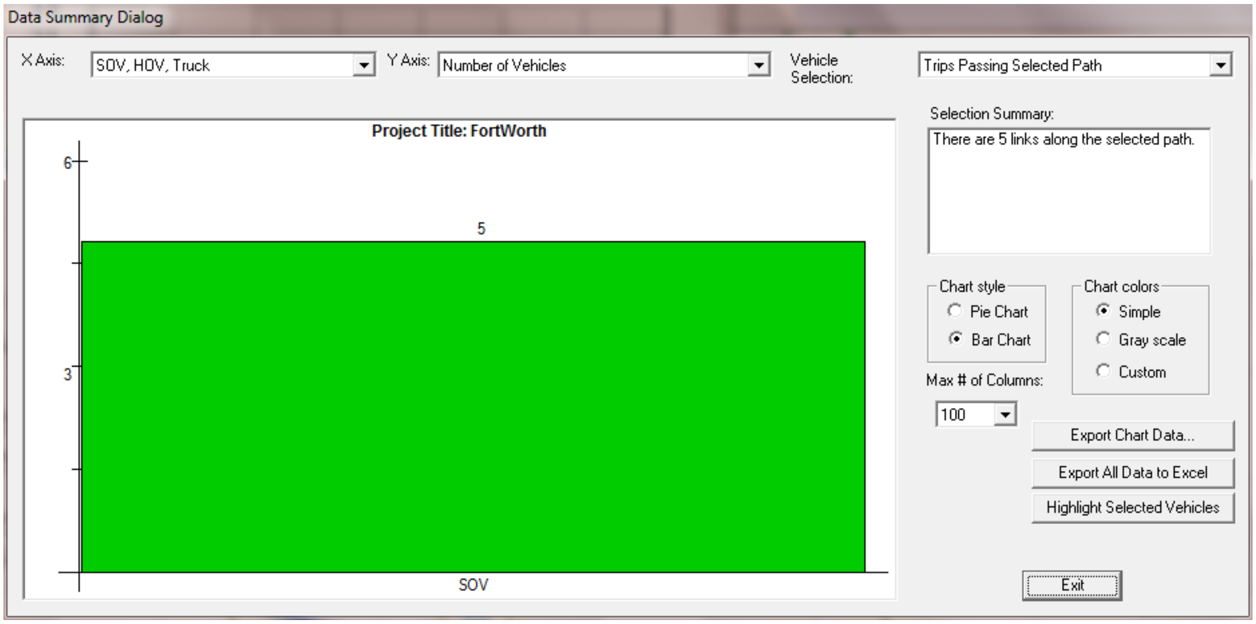


Figure 4.25 Data Summary Dialog (path-level analysis).

Clicking Node-to-Node Data Analysis for Selected Path will open the Data Summary Dialog associated with the analysis of node-to-node data (i.e., partial trip time data) for the selected path, as shown in Figure 4.26.

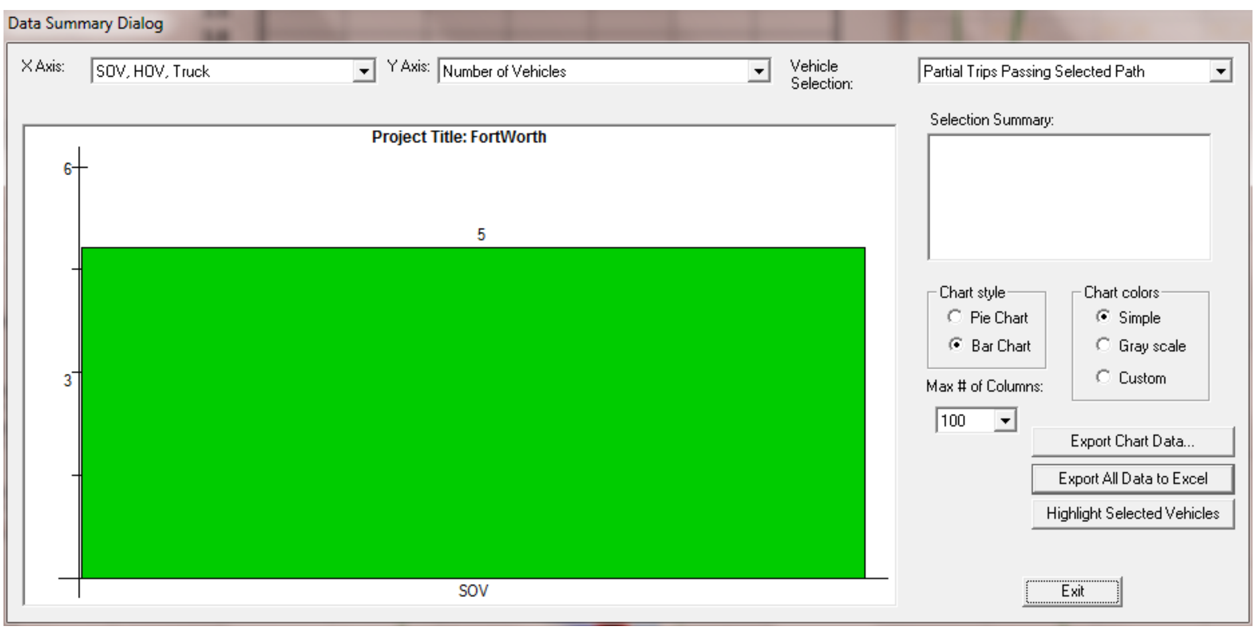
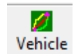


Figure 4.26 Data Summary Dialog (path-level analysis).

4.4 OD-Level Analysis

4.4.1 Select OD pair

The OD Pair Analysis Tool is a powerful analysis feature used to examine travel statistics for individual vehicles or groups of vehicles. Click 

in the toolbar or go to Menu->MOE > Vehicle Path Analysis; the Vehicle Analysis dialog will open the Find/Filter Vehicle window (Figure 4.27 and 4.28), which is divided into four sections: the OD Pair Filter, OD List, Path List, and Vehicle List.

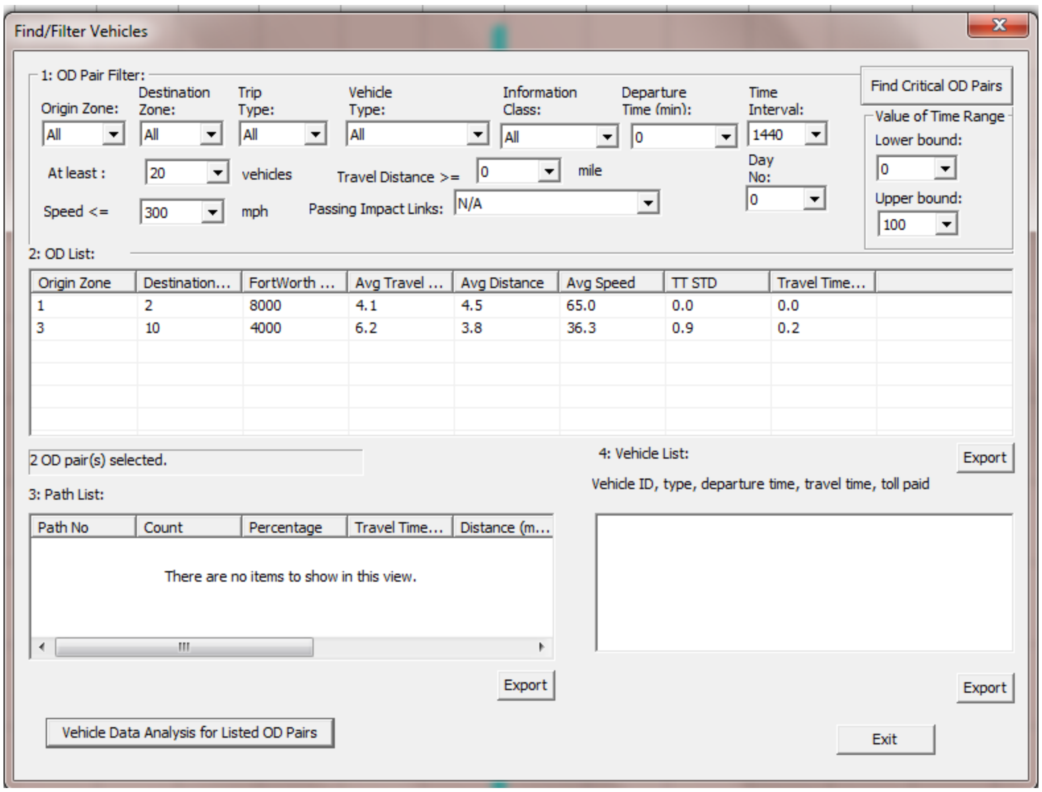


Figure 4.27 OD pair analysis tool (OD-level analysis) (TT = travel time).

1. The OD Pair Filter, located at the top of the window, offers several filtering options for limiting an analysis based on specific criteria. The top row of drop-down lists primarily provides filterable criteria related to the vehicle, including the Origin and Destination Zone ID, Demand Type, and Vehicle Type, a vehicle's Information Class and Departure Time, and whether the vehicle was traveling within a certain Time Interval. Also relevant to vehicle characteristics, a filter based on a range for the Value of Time is offered at the far right side of the window. The OD lists immediately to the right of the OD List are filterable criteria related to path attributes, including the Number of Vehicles using a path, the Total Travel Distance (in miles), and Travel Time Index on the path.

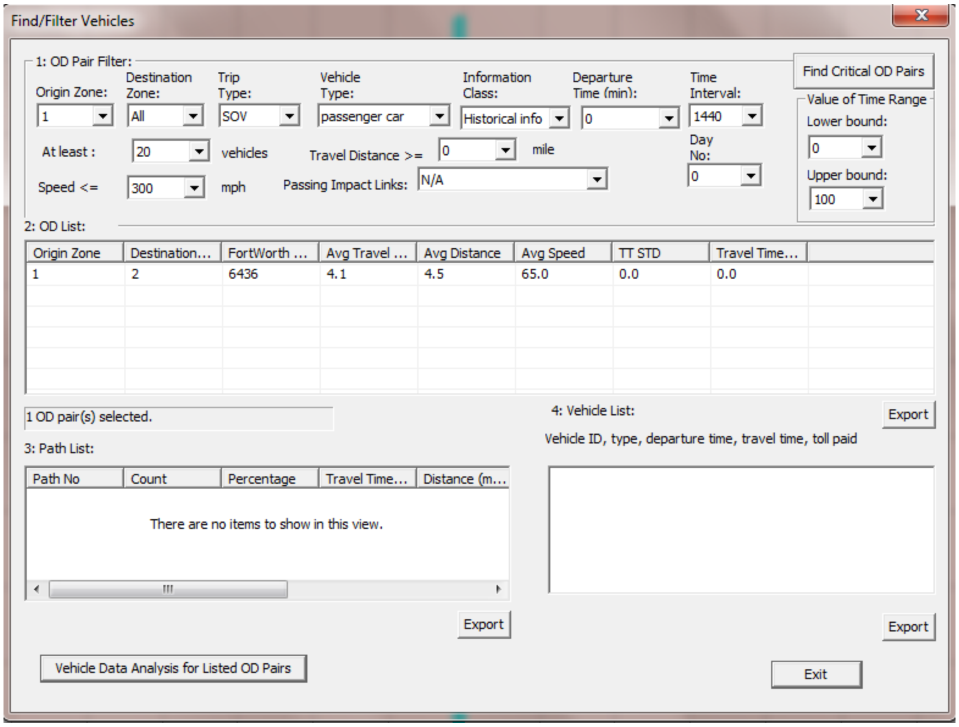


Figure 4.28 OD pair analysis tool (OD-level analysis).

The Find Critical OD Pairs button, found at the top right corner of the window, uses some default filter criteria (path with more than 500 vehicles and at least 2 miles in length) to find the most important OD pairs. So the OD List shows any OD pairs that meet the criteria used in the OD Pair Filter. Each pair is listed with the number of vehicles, along with its average travel time, distance, speed, and travel cost.

2. By clicking a specific OD pair in the OD List, the Path List and Vehicle List are populated with paths and vehicles associated with that specific OD pair. Selecting different paths in the Path List highlights those paths in the network, as shown in Figure 4.29, and further limits the vehicles shown in the vehicle list to only those vehicles using the selected path. Export buttons are located near the bottom of each list so that the user may export the items in the separate lists and save them as CSV files.

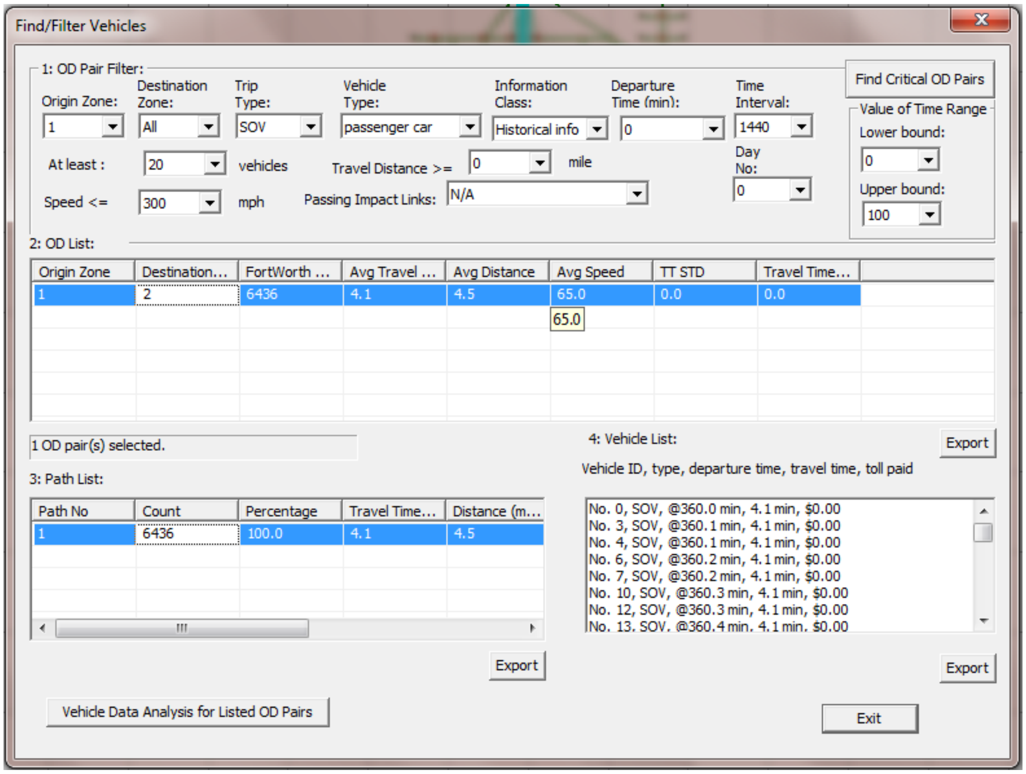


Figure 4.29 OD pair analysis tool (OD-level analysis).

4.4.2 Produce OD performance measures

Click button "Vehicle Data Analysis for Listed OD Pairs" to perform statistics analysis for selected OD pairs (Figure 4.30).

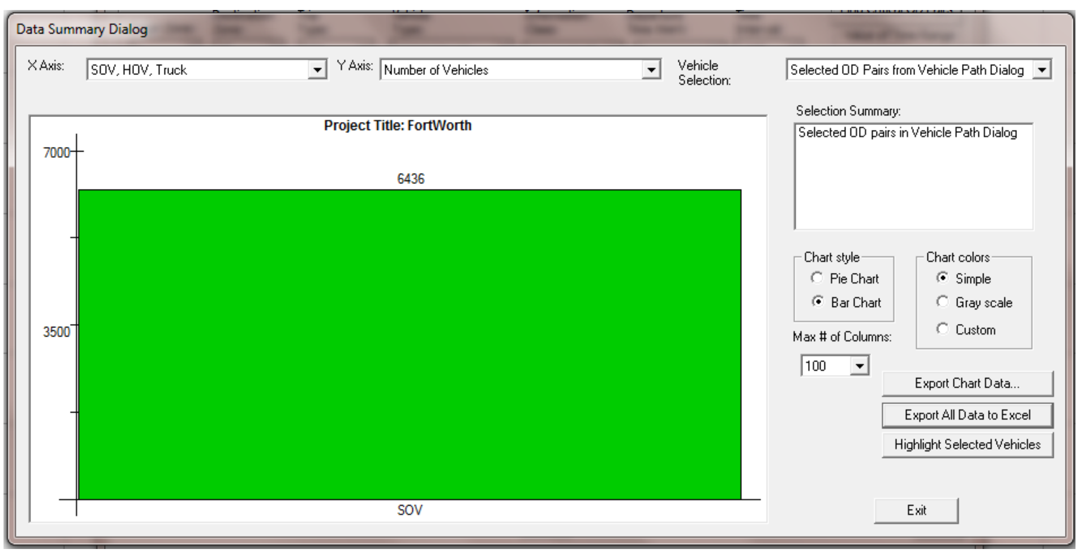


Figure 4.30 Data Summary Dialog (OD-level analysis).

4.5 Subarea-Level Analysis

4.5.1 Select Subarea

Click , and the cursor's shape will become SA. Begin by clicking the mouse at a corner of the zone, and a feature point will be created at that location. Move the mouse cursor to a new location and click again. A dashed line will be drawn to define the edge of the zone. Repeat this process until the zone is complete. You can close the zone by double clicking the mouse anytime the zone will be defined by at least three points. Alternatively, you may move the mouse over the starting point and click to close the subarea. When the subarea is closed a zone number will appear centered in the zone. Figure 4.31 shows the example of a selected subarea displayed on the network view.

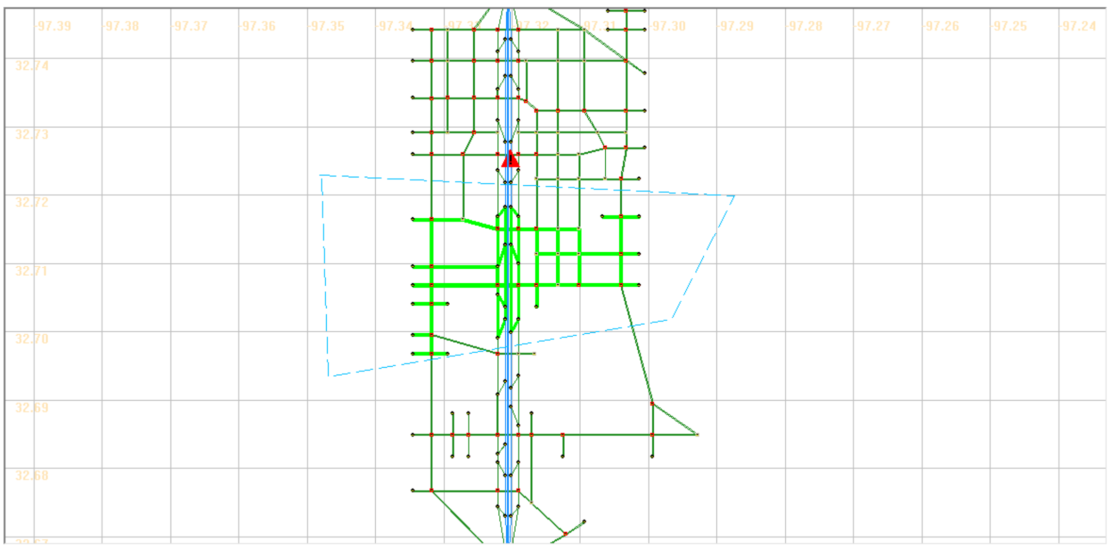
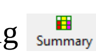


Figure 4.31 Create subarea (subarea-level analysis).

Click the "Subarea**"** layer on the GIS layer panel, and the corresponding layer becomes red when this layer is selected.

By going to <u>MOE > Network Statistics Dialog</u> or left clicking 

in the toolbar, the <u>Data Summary Dialog</u> opens, as shown in Figure 4.32.

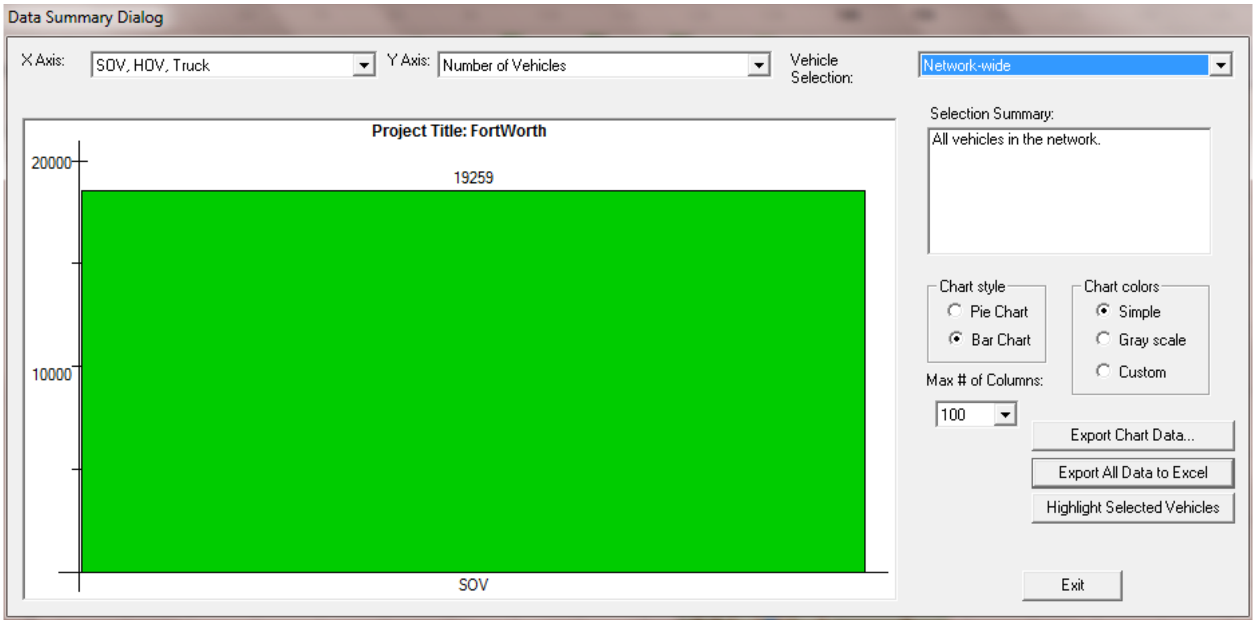


Figure 4.32 Data Summary Dialog (subarea-level analysis).

And choose an option of the Vehicle Selection, such as Originating from Subarea (Figure 4.33).

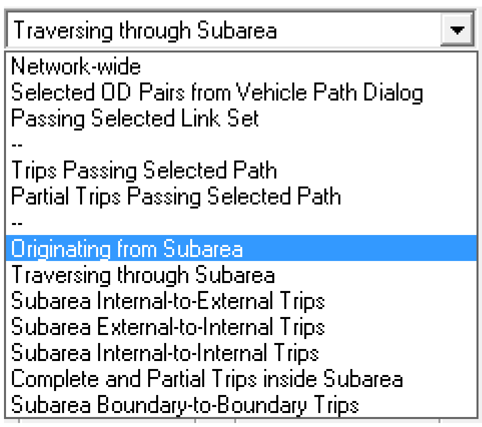


Figure 4.33 Data Summary Dialog (subarea-level analysis).

Then you can get the statistics of the subarea as shown in Figure 4.34.

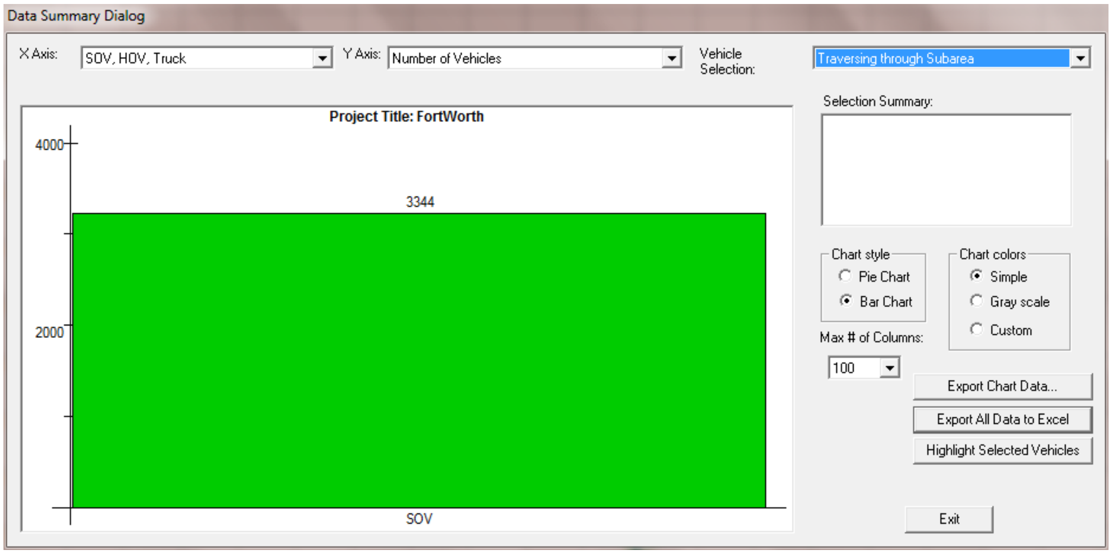
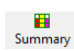


Figure 4.34 Data Summary Dialog (subarea-level analysis).

4.6 Summary Tables

Table 4.1 provides the summary of the steps for selecting various spatial elements: network, link, path, OD pair, and subarea, as discussed in the previous sections.

Table 4.1 Summary of Steps for Spatial Selection

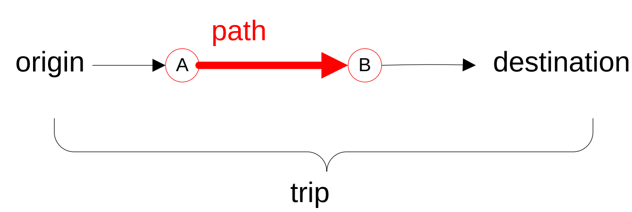
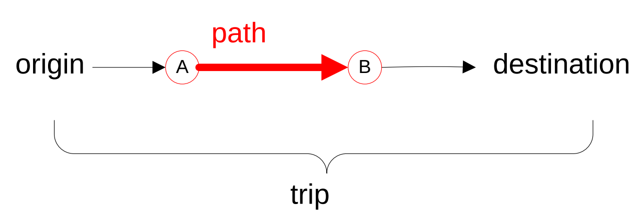
Spatial selection	Steps for Creating Selection	Use Secondary Selection Criteria
Network	Click Summary button  in the toolbar	
Select link	1. Select GIS Link Layer 2. Select a link (or use Ctrl+F to find a link) 3. Right click to use menu item “perform vehicle analysis on selected link”	
Select path	1. Select GIS Path Layer 2. Use mouse and right click to define origin node and destination node 3. Right click to use menu item “View Path Data Table and Plot”	1. Perform trip data analysis for selected path 2. Perform node-to-node data analysis for selected path

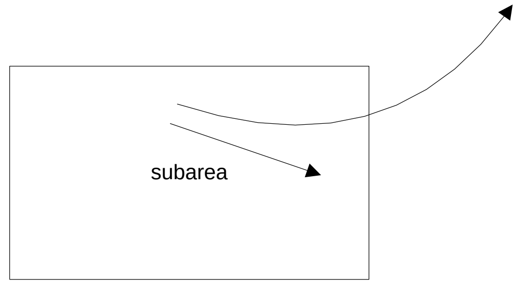
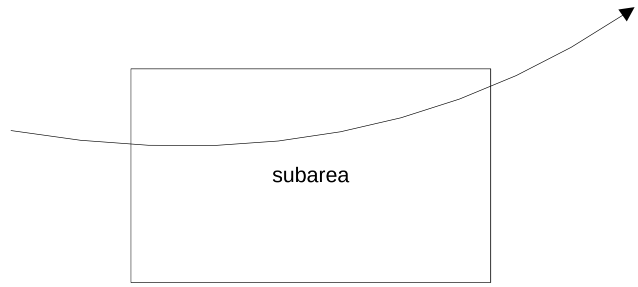
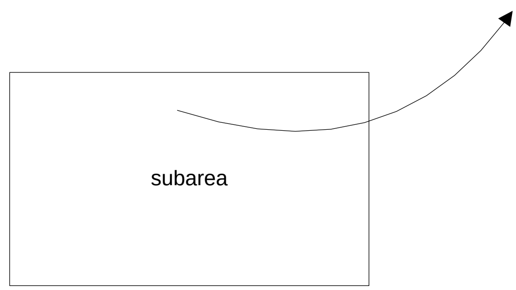
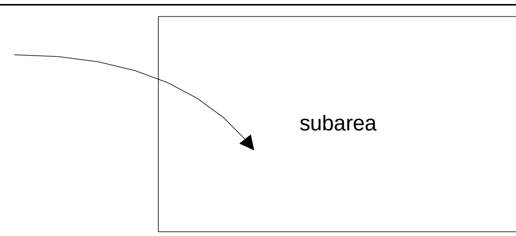
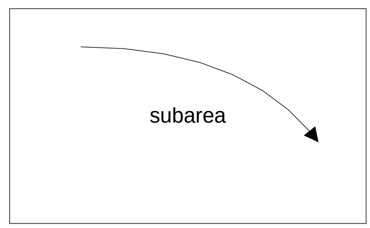
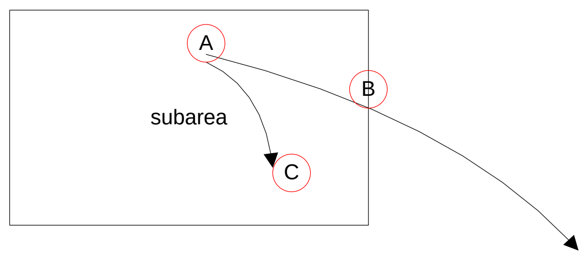
Select OD pair	1. Click Vehicle button in the toolbar to activate Vehicle Path dialog 2. Click OD List to select OD pair 3. Click button “Vehicle Data Analysis for Selected OD Pairs” to perform statistics analysis	1. Loading time interval 2. Travel distance 3. Vehicle type
Subarea	1. Select GIS Subarea layer, 2. Define subarea zoom boundary using button in the toolbar 3. Click Summary button in the toolbar	1. Trips passing selected path 2. Partial trips passing selected path 3. Originating from subarea 4. Traversing through subarea 5. Subarea internal-to-external trips 6. Subarea internal-to-internal trips 7. Subarea boundary-to-boundary trips

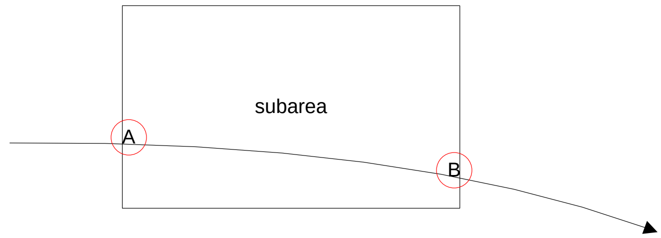
For the path- and subarea-level analyses, the Trajectory Processor provides various options for extracting performance measures depending on how to select vehicles and what portion of travel times are included in the statistics calculation.

Table 4.2 summarizes definitions of vehicle selection methods available in the Trajectory Processor (i.e., in Data Summary Dialog).

Table 4.2 Definitions of Vehicle Selection Categories

Trips Passing Selected Path: The origin-to-destination trip travel time is used for a vehicle passing through path from A to B.	
Partial Trips Passing Selected Path: When a path from A to B is defined, the path travel time from A to B is used for a vehicle passing through path A to B.	

Originating from Subarea: A vehicle has its first link in the subarea area, while the trips might end inside or outside of the subarea.	
Traversing through Subarea: A vehicle starts outside of the subarea, and then enters the subarea and finally leave the subarea.	
Subarea Internal-to-External Trips: A vehicle starts inside the subarea and ends its trip outside of the subarea.	
Subarea External-to-Internal Trips: A vehicle starts outside of the subarea and ends its trip inside the subarea.	
Subarea Internal-to-Internal Trips: A vehicle's entire trip is inside the subarea.	
Complete and Partial Trips Inside Subarea: A vehicle starts from the subarea, while its trip might end inside the subarea (defined as a complete trip) or outside of the subarea (defined as a	

partial trip). When collecting travel time statistics, we use the travel time from point A (i.e., origin node) to point B (i.e., boundary node) for a partial trip, and the trip travel time from point A to point C (i.e., destination node) is used for a complete trip.	
Subarea Boundary-to-Boundary Trips: A vehicle starts outside the subarea, passes through the subarea and then ends its trip outside of the subarea. When collecting travel time statistics, we use the travel time from point A (boundary node) to point B (boundary node).	

References

1. Mahmassani, H. S., J. Kim, Y. Chen, Y. Stogios, A. Brijmohan, and P. Vovsha. *SHRP 2 Report S2-L04-RR-1: Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools.* Transportation Research Board of the National Academies, Washington, D.C., 2014.

2. Mahmassani, H. S., J. Kim, T. Hou, A. Talebpour, Y. Stogios, A. Brijmohan, and P. Vovsha. *SHRP 2 Report S2-L04-RW-2: Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools: Applications Guidelines*. Transportation Research Board of the National Academies, Washington, D.C., 2014.

APPENDIX A
Quick-Start Guide with Sample Data Set

The purpose of this Quick-Start Guide is to quickly walk the user through basic features of the Trajectory Processor using a small sample data set. This guide assumes that the user has access to the demonstration package consisting of the "Release" and "SampleData" folders that reside in the software directory. The demonstration package is structured as follows in Figure A.1.

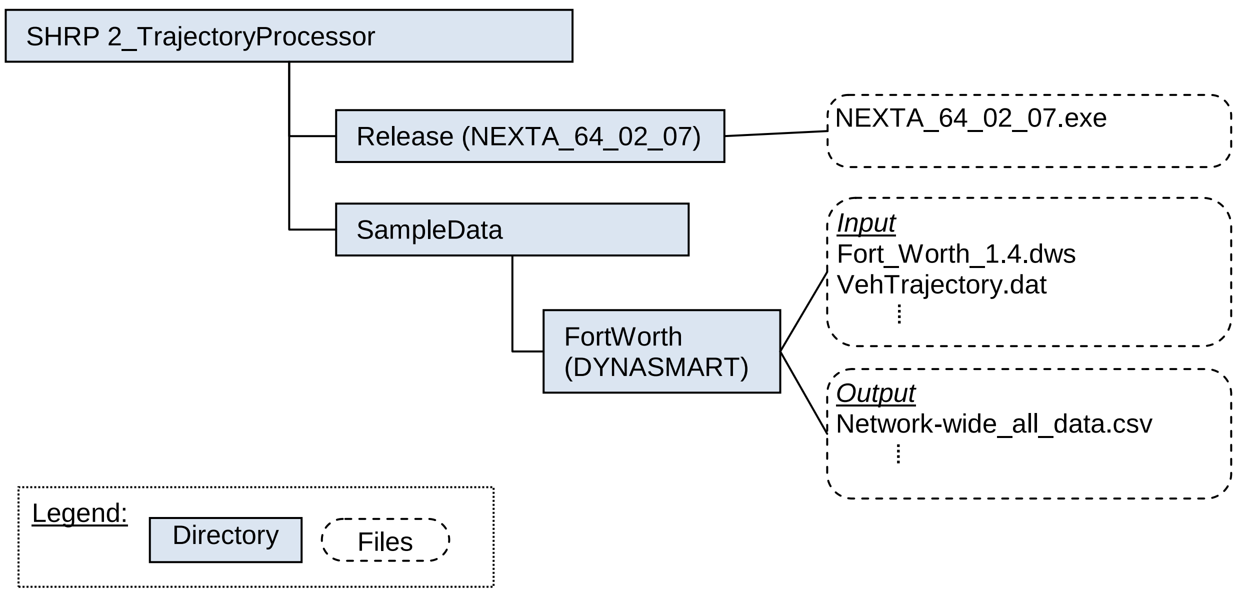


Figure A.1 Structure of sample demo package.

This Quick-Start Guide presents four basic steps for using the Trajectory Processor, which include

- Step 1) Launching Trajectory Processor Application
- Step 2) Importing Input Data
- Step 3) Analyzing Travel Time Reliability Performance
- Step 4) Exporting Performance Measures to File

Step 1) Launching Trajectory Processor Application

In the directory "…\Release (NEXTA_64_02_07)," the user will find the released executable file "NEXTA_64_02_07.exe." Double clicking the file will launch the NEXTA software package equipped with the Trajectory Processor developed under the SHRP 2 L04 project and show the start-up window as shown in Figure A.2.

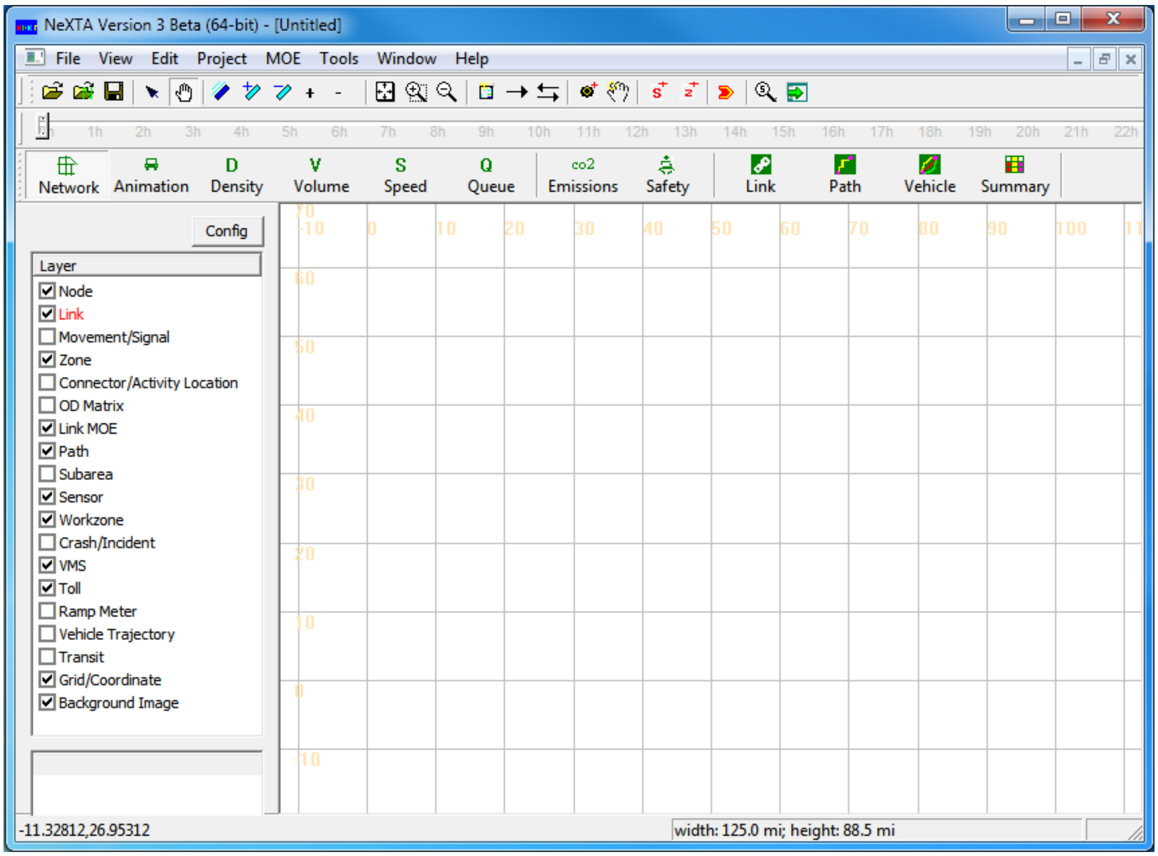


Figure A.2 Trajectory Processor (NEXTA) start-up window.

Step 2) Importing Input Data

The data used in this demo is the Fort Worth DYNASMART-P network. Go to File -> Open Traffic Network Project, or left click in the Control Toolbar. Select "Fort_Worth_1.4.dws" in "..\SampleData\FortWorth (DYNASMART)," which is a DYNASMART-P project file for the Fort Worth, Texas, network (Figure A.3). When prompted by a message box asking if the vehicle trajectory data will be loaded (Figure A.4), click "Yes." Then the File Loading Status dialog will show up (Figure A.5), and closing the dialog will display the network as shown in Figure A.6.

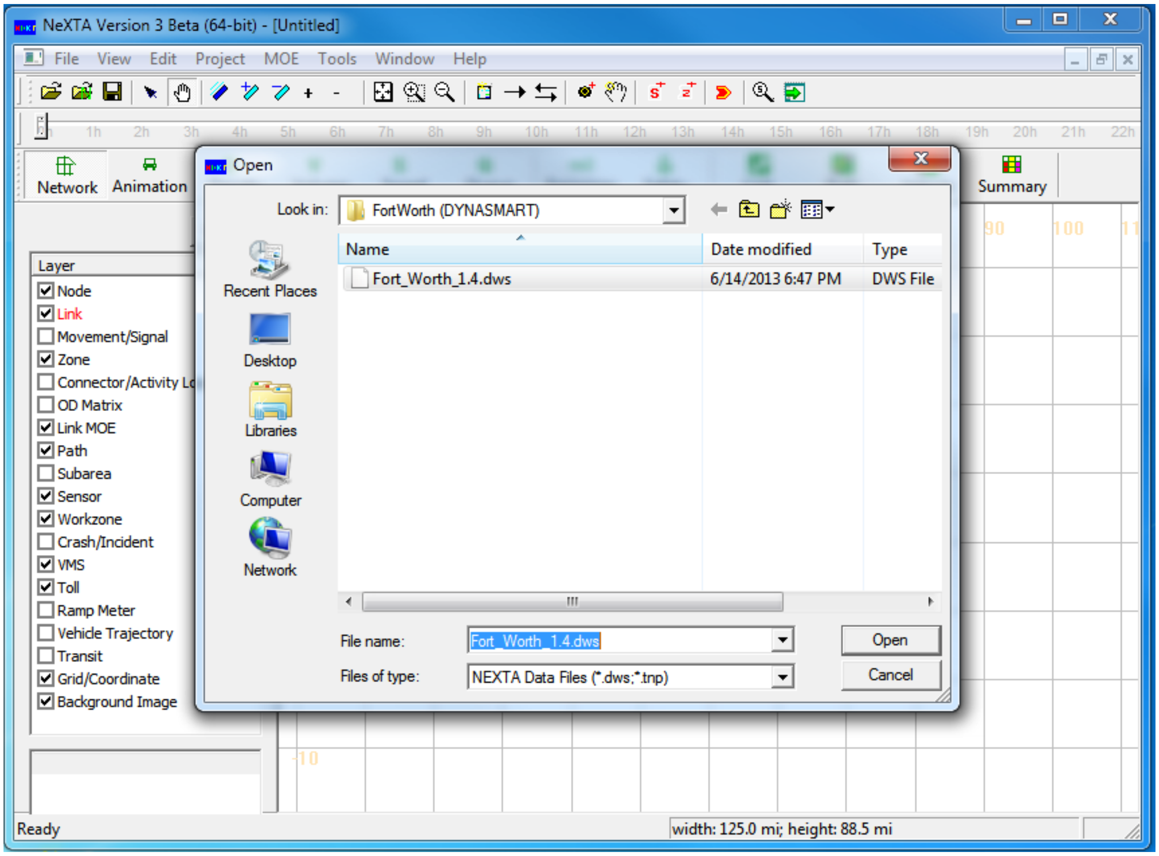


Figure A.3 Opening sample data set.

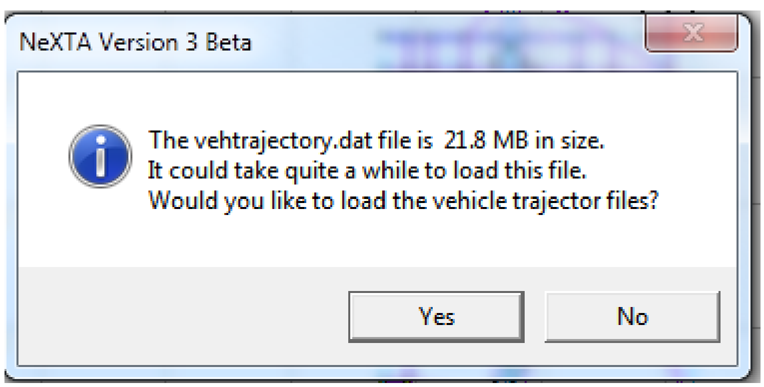


Figure A.4 Message box for loading vehicle trajectory data.

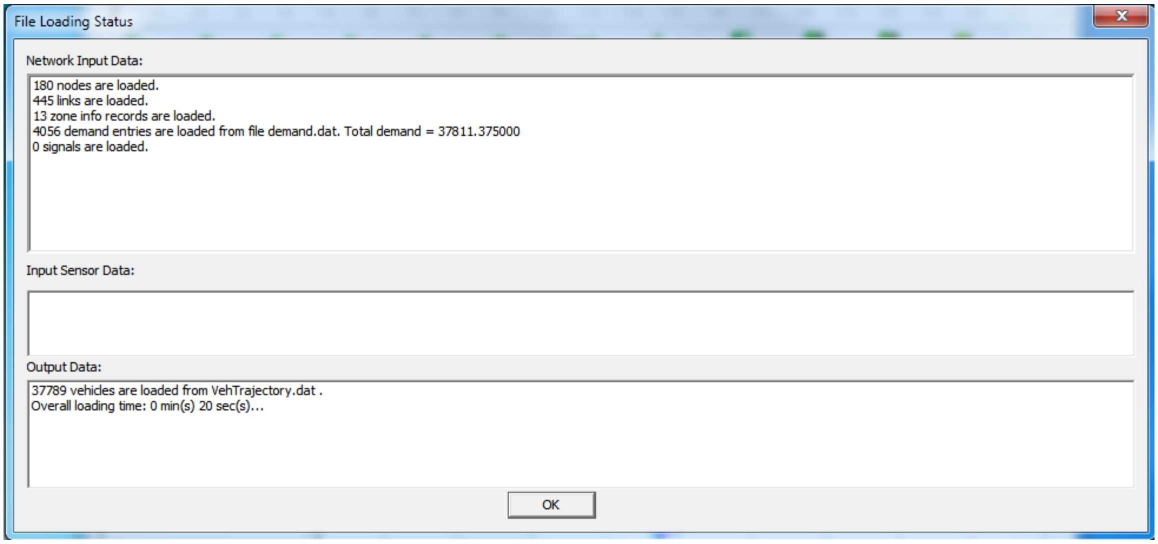


Figure A.5 File Loading Status dialog.

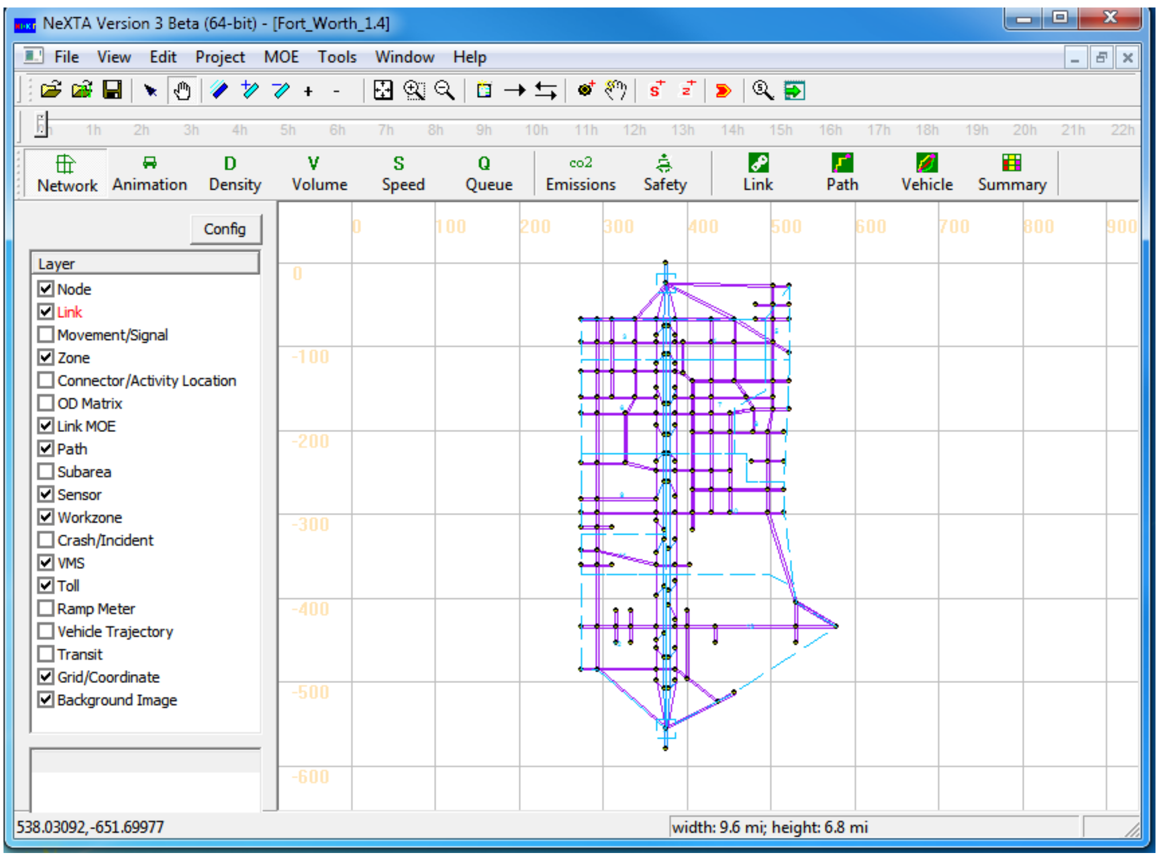


Figure A.6 Fort Worth network displayed on the window.

Step 3) Analyzing Travel Time Reliability Performance

Clicking the “Summary” button on the toolbar (Figure A.7) will open the Data Summary Dialog (Figure A.8), which provides users with the environment for exploring a wide variety of performance measures for a given spatial boundary (e.g., link, path, subarea, OD, or network). The performance measures available in the dialog can be found in Figure A.9. Two examples are presented in this demo: travel time distribution (or histogram) for a selected OD pair (Figure A.11) and time-dependent network-wide reliability measured by the 95th percentile travel time per unit distance (Figure A.12). For the former, the OD pair can be selected by clicking the “Vehicle” button on the toolbar (Figure A.7) to open the Find/Filter Vehicles dialog and selecting the row representing a desirable O- D pair (in this example, the origin zone = 8 and the destination zone = 3) on “2: OD List” as shown in Figure A.10. Clicking the “Vehicle Data Analysis for Listed OD Pairs” will directly open the Data Summary Dialog for the selected OD pair as shown in Figure A.11.

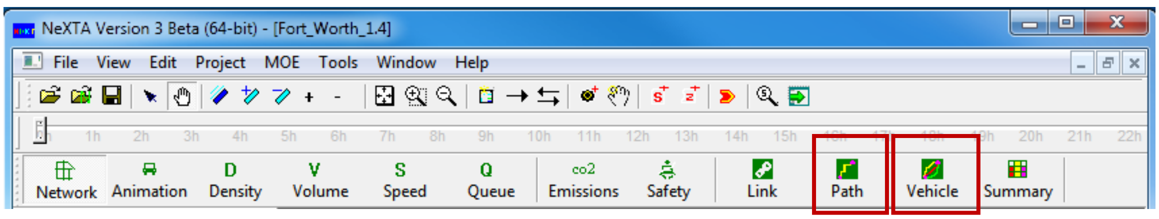


Figure A.7 Toolbar.

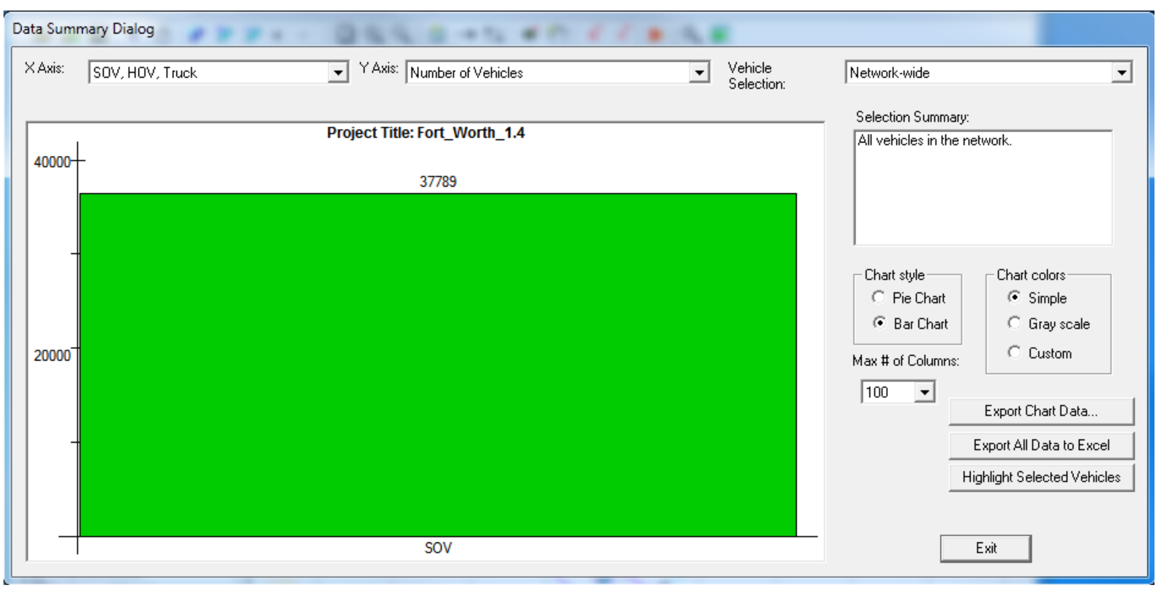


Figure A.8 Data Summary Dialog (network-level analysis).

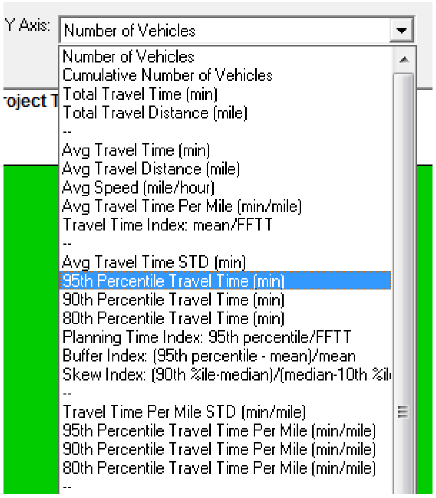


Figure A.9 Various performance measures available in the Trajectory Processor.

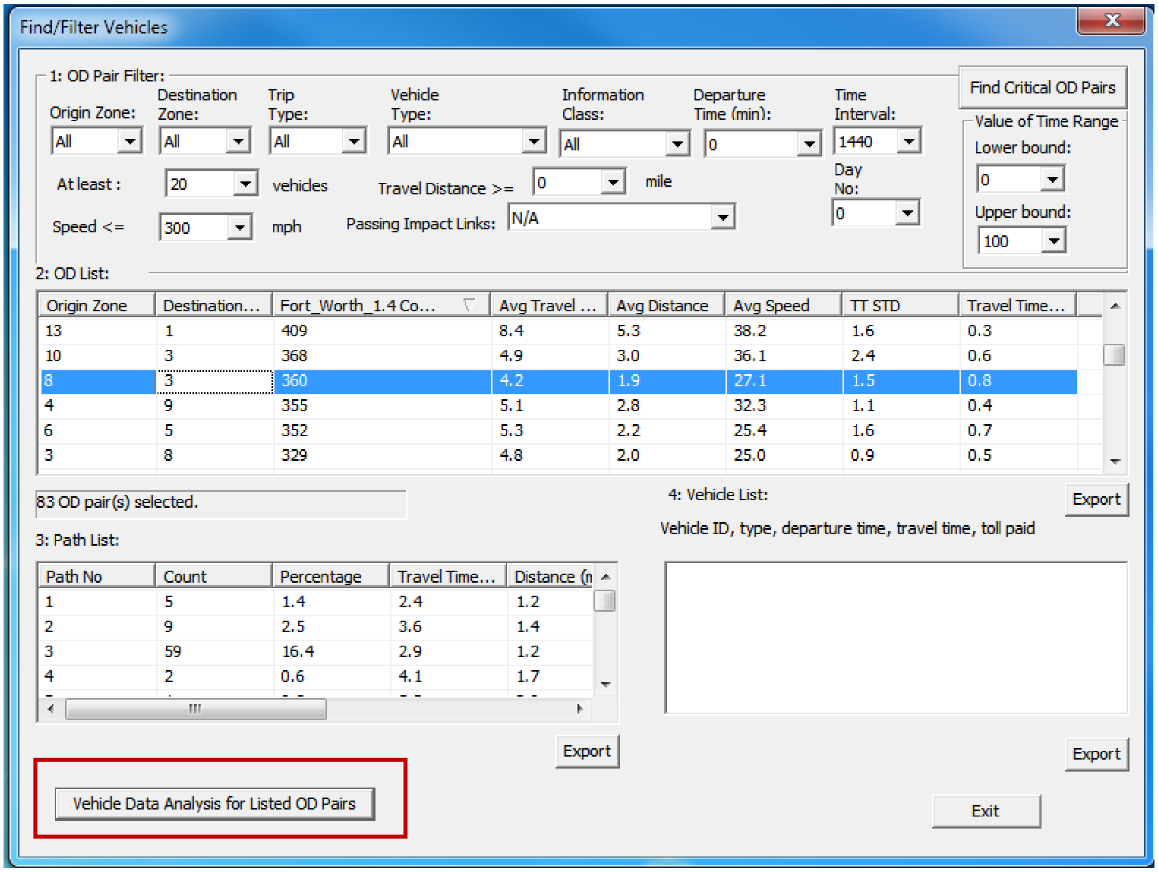


Figure A.10 Selecting an OD pair.

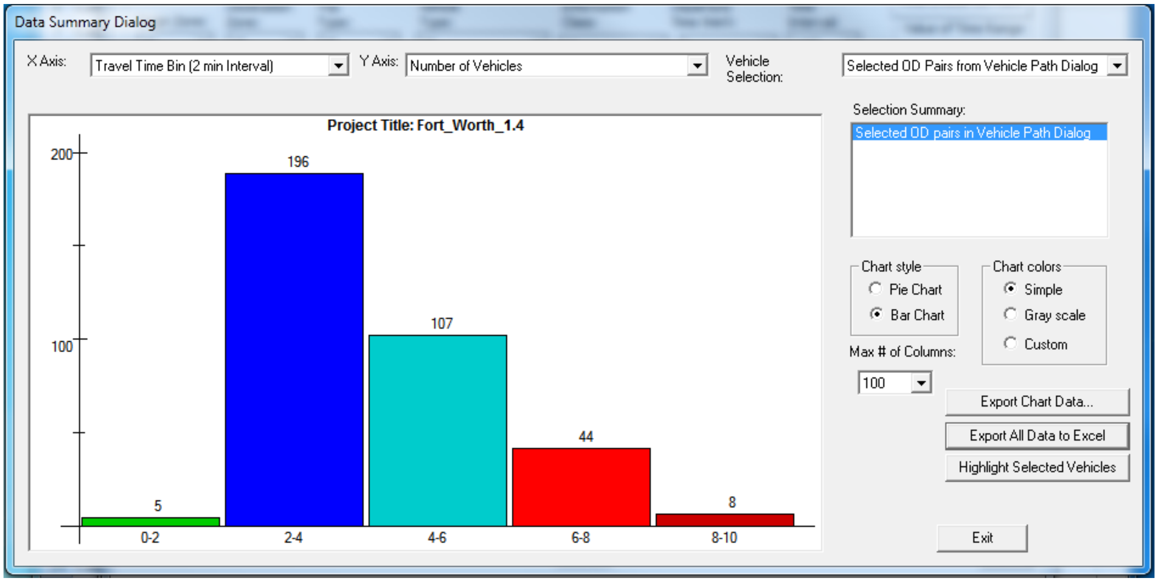


Figure A.11 Travel time distribution of a selected OD pair.

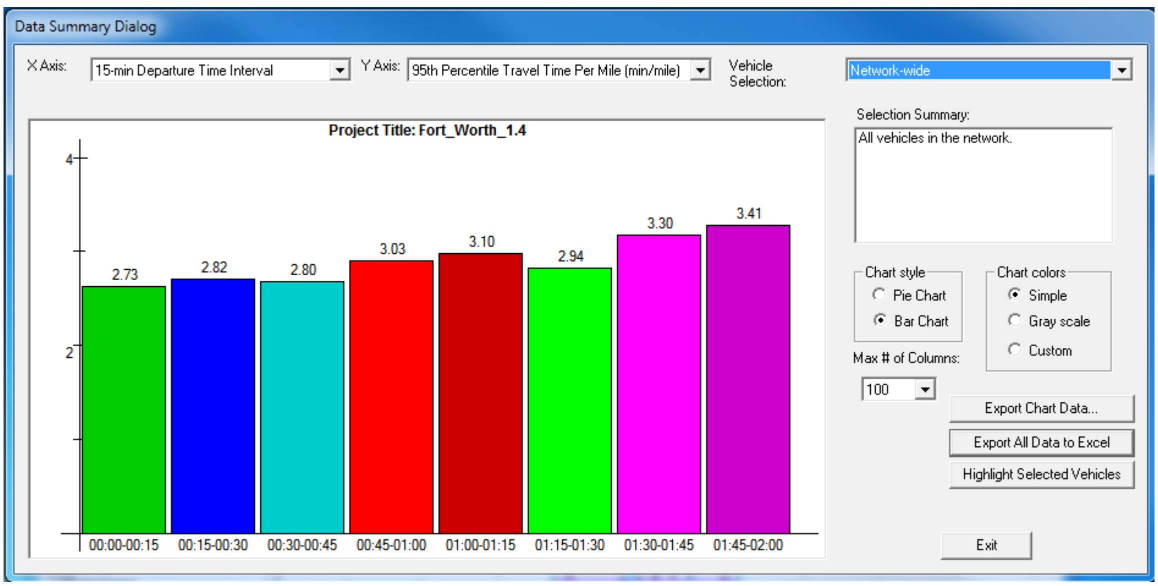


Figure A.12 Time-dependent travel time reliability for the entire network.

Step 4) Exporting Performance Measures to File

Clicking the "Export All Data to Excel" button on the Data Summary Dialog (Figure A.12) will create a CSV file that contains all the information available in the Data Summary Dialog as shown in Figure A.13. The exported CSV file, which is titled "Network-wide_all_data.csv," can be found in the input data folder, that is, "…\SampleData\FortWorth (DYNASMART)."

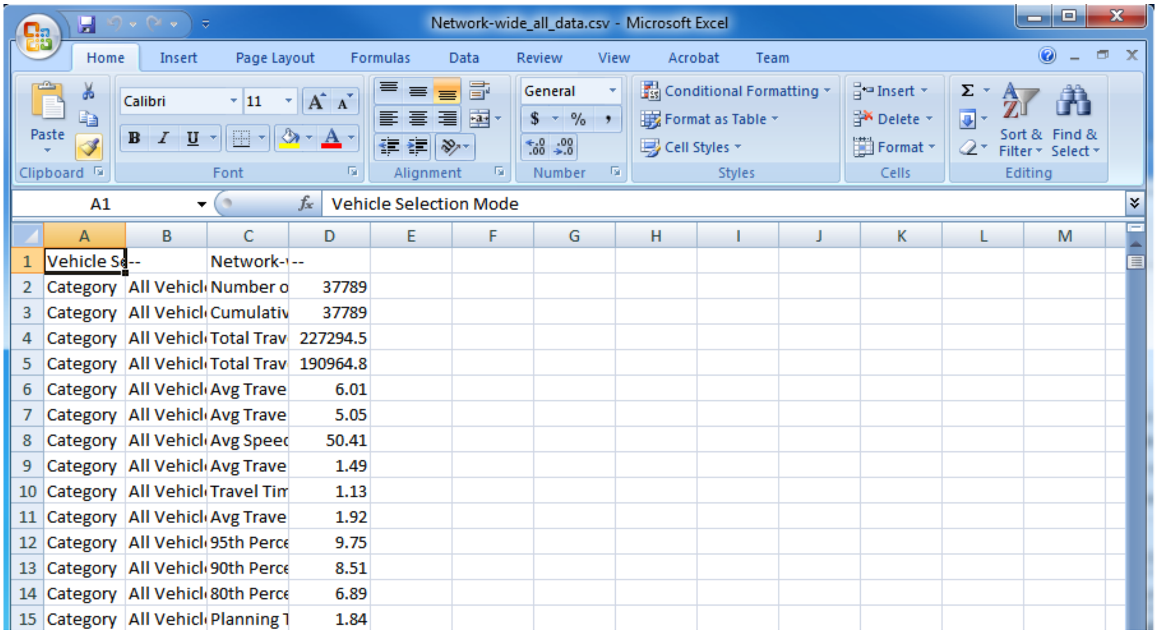


Figure A.13 Performance measures exported to CSV file.