



U.S. Department of Transportation
Federal Highway Administration

TRB

SHRP 2 Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools (L04)

SHRP 2 Tuesdays Webinar Series
September 16, 2014

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As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

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REGISTERED CONTINUING EDUCATION PROGRAM

Today's Learning Objectives

Purpose: To demonstrate the incorporation of travel time reliability into micro- and meso-simulation models and other model systems. The models include first-generation software that potentially can be integrated into many simulation packages in order to address travel time reliability.

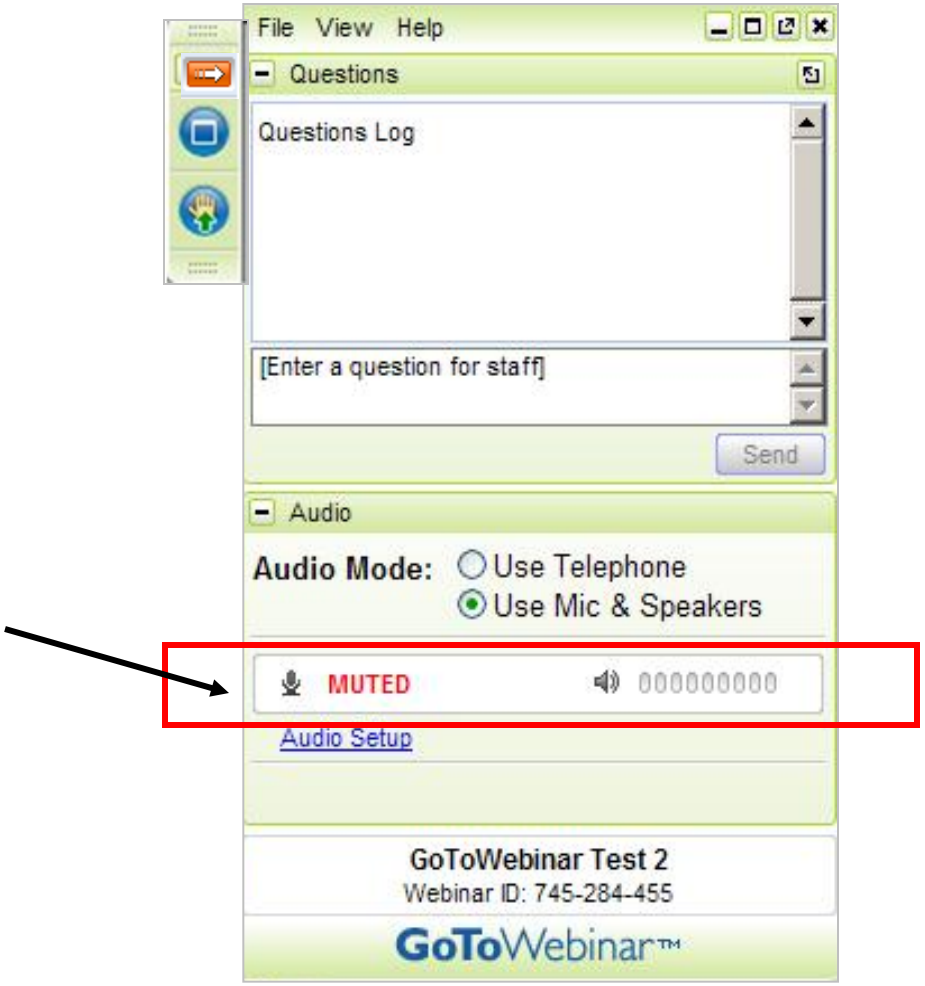
Learning Objectives: At the end of this webinar, participants will be able to:

- Identify opportunities to incorporate travel time reliability into micro- and meso-simulation models and the integration demand and network models;
- Integrate first generation software to explicitly address travel time reliability; and
- Identify realistic reliability performance measures for travel time reliability.

PDH Certificate Information

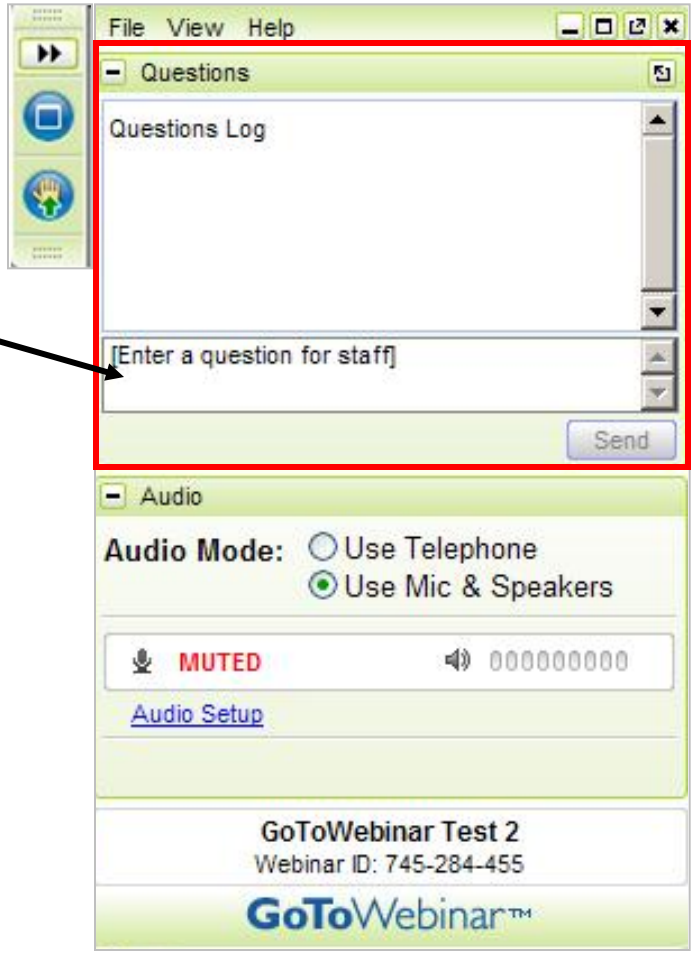
- This webinar is valued at 1.5 Professional Development Hours (PDH).
- Instructions on retrieving your certificate will be found in your webinar reminder and follow-up emails.
- You must register and attend as an individual to receive a PDH certificate.
- TRB will report your hours within one week.
- Questions? Contact Reggie Gillum at RGillum@nas.edu

All Attendees Are Muted



Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many questions as time allows.



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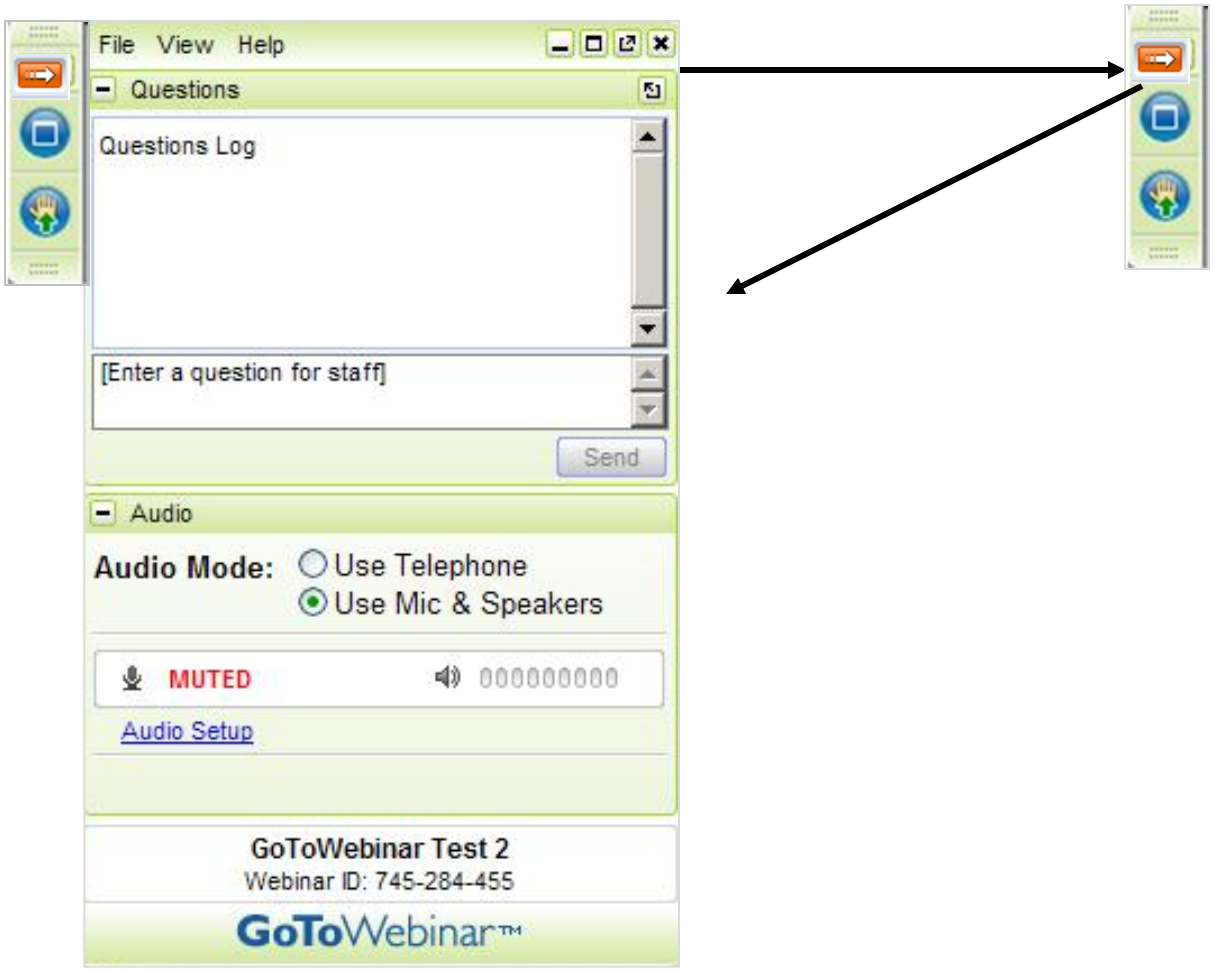


Panelist Presentations

http://onlinepubs.trb.org/onlinepubs/webinars/140916.pdf

After the webinar, you will also receive a follow-up email containing a link to the recording

Today's Panelists and Moderator

- **Hani Mahmassani,** *Northwestern University*
  masmah@northwestern.edu
- **Peter Vovsha,** *Parsons Brinckerhoff*
  vovsha@pbworld.com
- **Yannis Stogios,** *Parsons Corporation*
  Yannis.Stogios@parsons.com
- **John Halkias,** *Federal Highway Administration*
  John.Halkias@dot.gov
- **Bill Hyman,** *Transportation Research Board*
  whyman@nas.edu

L04 Project Report and Guide

- The prepub report is available here: http://www.trb.org/Main/Blurbs/170716.aspx

- The prepub guide is available here: http://www.trb.org/Main/Blurbs/170717.aspx

Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools (L04)

Bill Hyman
Senior Program Officer, SHRP 2

WHAT IS SHRP2 ?

- $232 million, federally funded research program to address critical transportation challenges
  - Making highways safer
  - Fixing deteriorating infrastructure
  - Reducing congestion

- Managed by TRB of the National Academies
- Collaborative effort of TRB, AASHTO, and FHWA
- Originally operates from 2006 to 2013 – extended to 2015
- Aims to advance innovative ways to plan, renew, operate, and improve safety on the Nation's highways

FOUR RESEARCH FOCUS AREAS

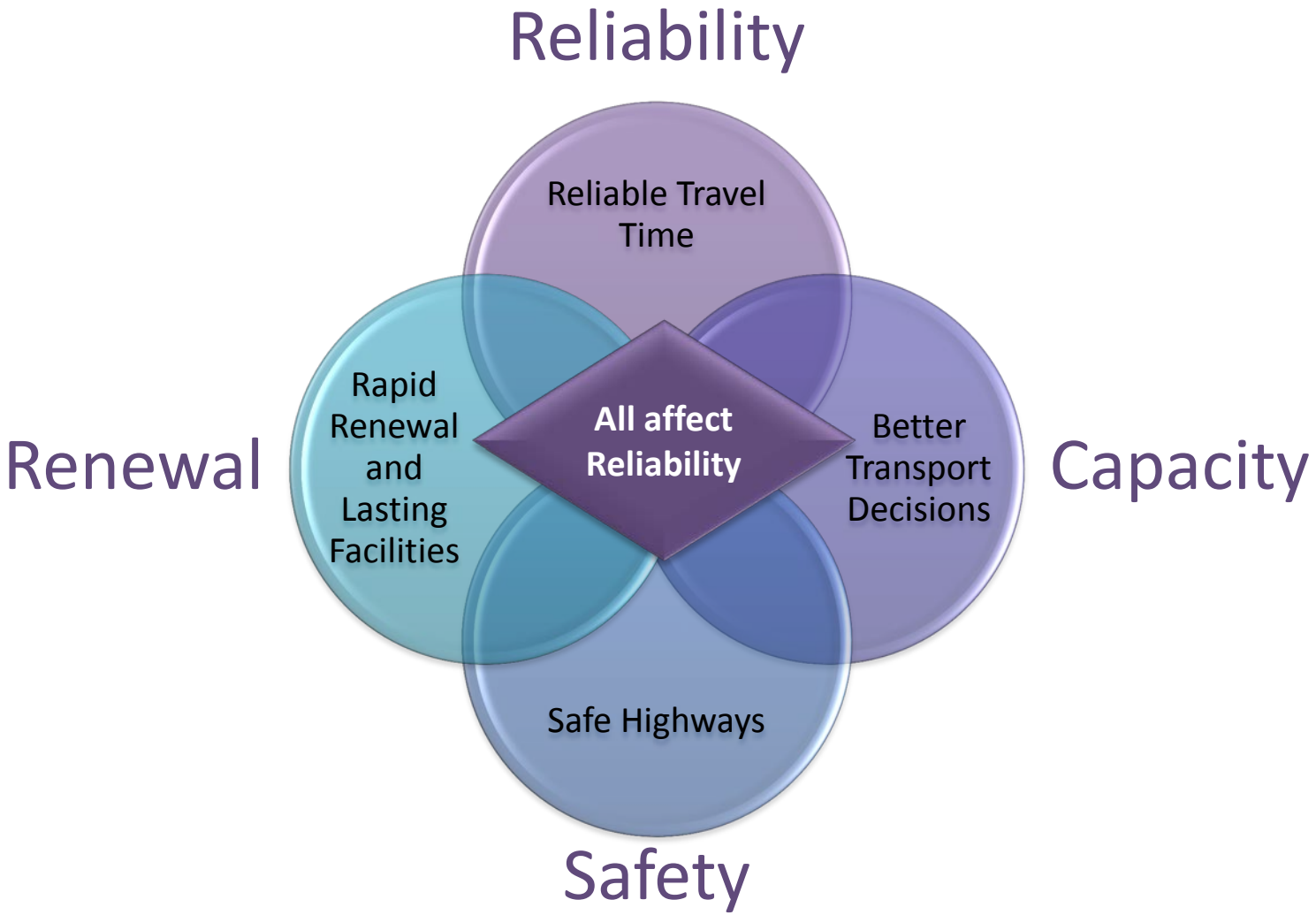
Safety: to prevent or reduce the severity of highway crashes by understanding driving behavior.

Renewal: to renew aging infrastructure through rapid design and construction methods that minimize disruption and produce long-lived facilities.

Capacity: to integrate mobility, economic, environmental, and community needs into the planning and design of new highway capacity.

Reliability …. How travel time varies over time…….

FOCUS AREAS


Reliability
Reliable Travel Time
Rapid Renewal and Lasting Facilities
All affect Reliability
Better Transport Decisions
Renewal
Capacity
Safe Highways
Safety

Relation of Capacity and Reliability Research

Capacity Research
Tackles *recurring* congestion

CONGESTION

Reliability Research
Tackles *nonrecurring* congestion

RELIABILITY FOCUS AREA OBJECTIVE

"To provide reliable travel times by preventing and reducing non-recurring congestion"

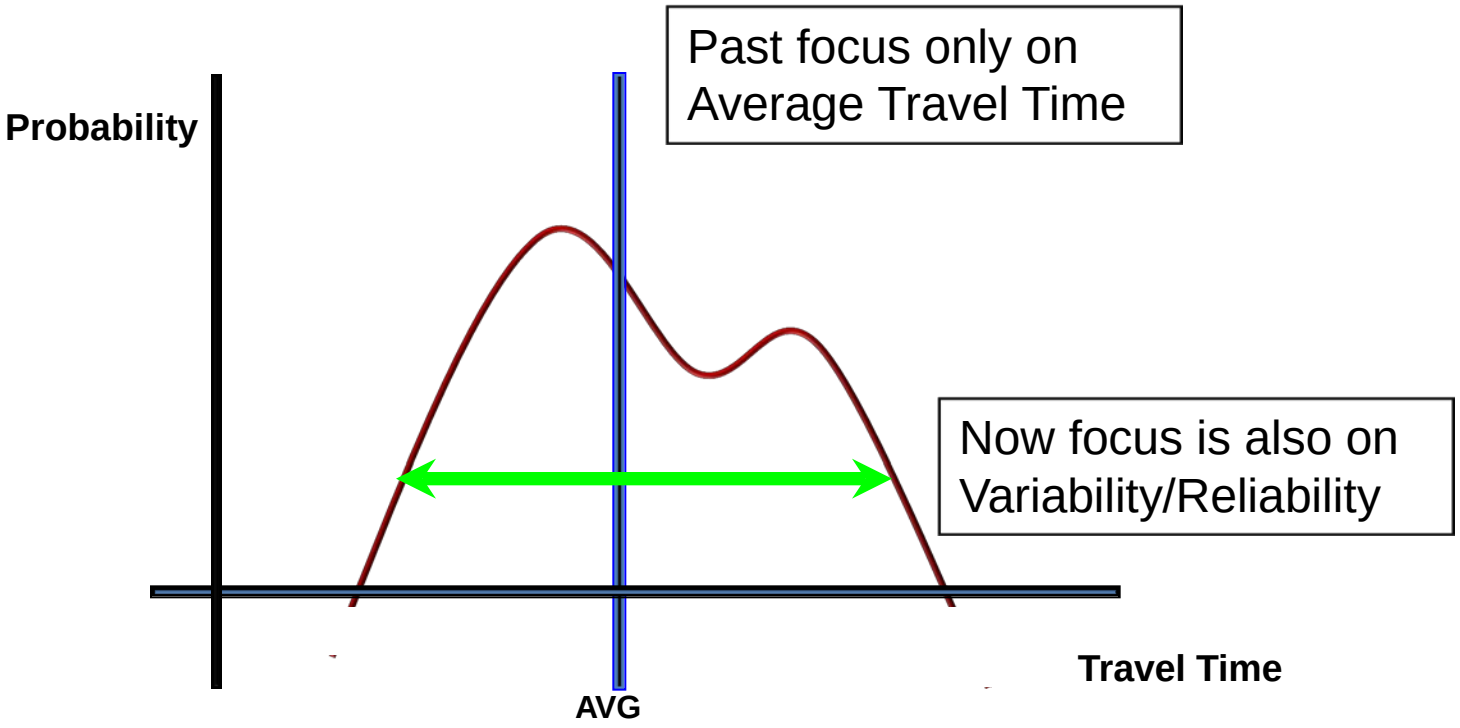
- *i.e., reduce the variability of travel time through reducing the underlying causes*

THE SEVEN CAUSES OF UNRELIABILITY

The Reliability Focus Area research has attributed variability in travel time to seven primary causes

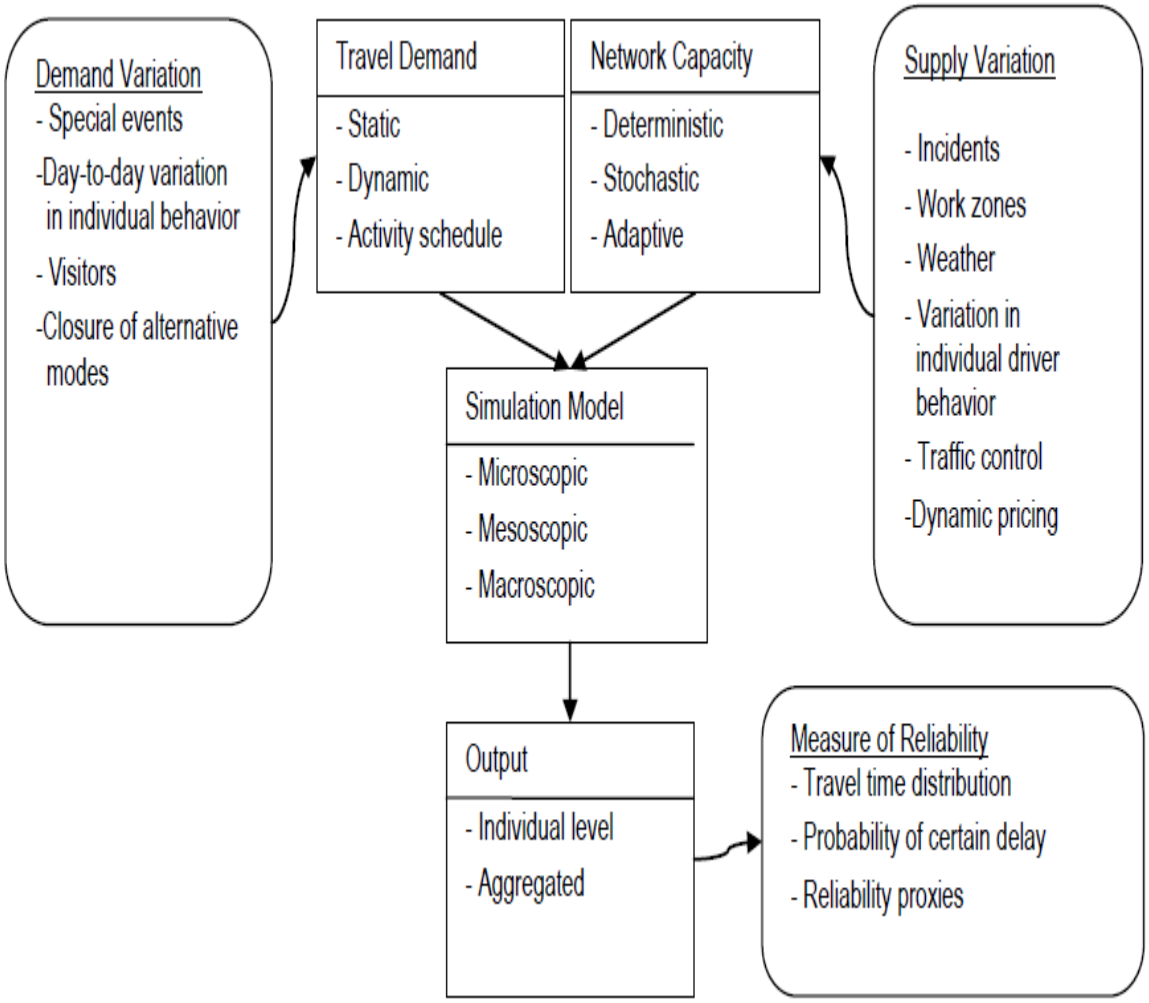
1. Incidents
2. Weather
3. Work zones
4. Fluctuations in demand
5. Special events
6. Traffic control devices
7. Inadequate base capacity

RELIABILITY, A NEW FOCUS



SHRP 2 L04 Overview

- Objective
- Highlights
  - Determined how travel demand forecasting models can use reliability measures to produce revised estimates of travel patterns
  - Developed a Scenario Manager and a vehicle Trajectory Processor to incorporate reliability metrics in traffic simulation and planning models.



SHRP2 TUESDAYS

Upcoming Webinars

September 30 – **TRB's SHRP 2 Tuesdays Webinar: Techniques to Fingerprint Construction Materials in the Field (R06B)**

Learn about future webinars at

www.TRB.org/SHRP2/webinars




SHRP 2 Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools (L04)

SHRP 2 Tuesdays Webinar Series

September 16, 2014

Presentation Components

- Project Overview (Yannis Stogios – Parsons Corp.)
  - Key Objectives, Major Achievements and Products for Immediate Distribution & Use
- Travel Time Reliability Measures in Traffic Simulation Models (Hani Mahmassani – Northwestern University)
  - Concept Development, Analytical Framework, and Key Tools (Scenario Manager & Trajectory Processor)
- Travel Time Reliability Measures in Travel Demand Models (Peter Vovsha – Parsons Brinckerhoff)
  - Concepts & Opportunities for Further Exploration and Application

How the L04 fits within the SHRP 2 Reliability Focus Area

- Overall goal to reduce unexpected congestion and improve travel time reliability
- Numerous technical measures and policies identified and developed within SHRP 2 research projects to confront the problems of traffic congestion and devise means to improve reliability
- L04 to improve planning and operations models in order to create suitable tools for the evaluation of projects and policies that are expected to improve reliability

Main Objectives

- develop the capability to produce measures of reliability performance from traffic simulation models and planning models
- examine how travel demand forecasting models can use reliability measures to produce revised estimates of travel patterns

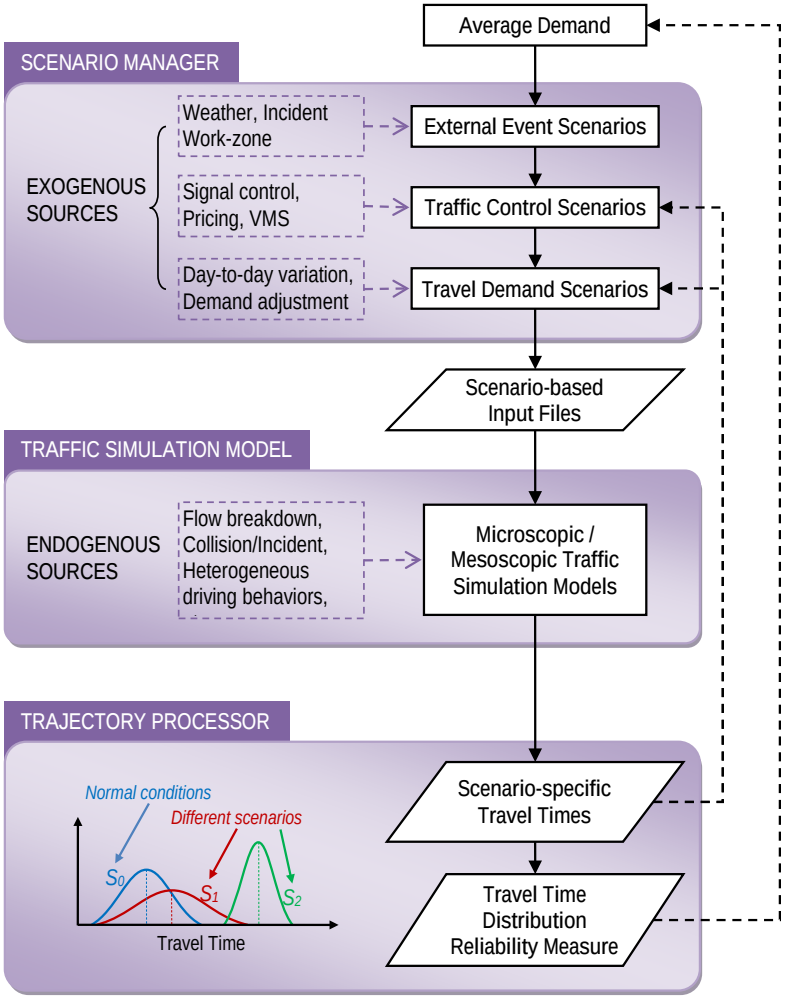
Overall intent of L04 to close the gap in the underlying conceptual foundations of travel modeling and traffic simulation, and provide practical means of generating realistic reliability measures using network simulation models

Key Achievements

- addressed the need for a comprehensive and conceptually coherent set of methodologies to
  - better characterize reliability;
  - assess its impacts on users and the system; and
  - determine the effectiveness and value of counter measures.
- developed a unifying framework for reliability analysis based on vehicle travel trajectories
- identified multi-level reliability performance measures
- produced analytical tools readily available for application and practical use

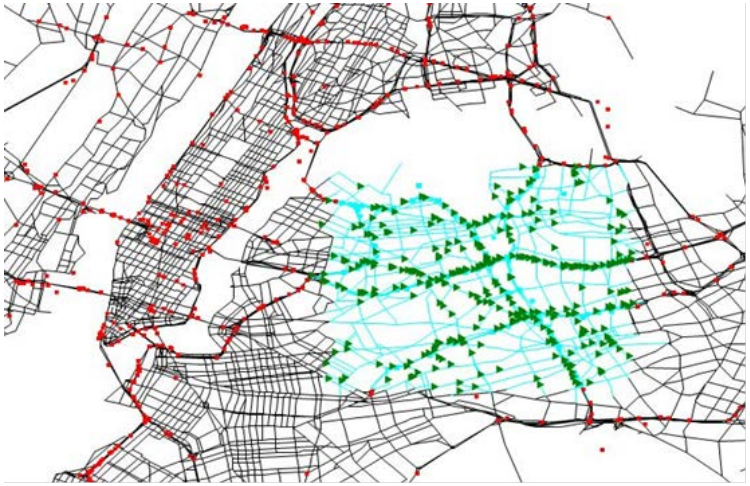
A Unifying, Practical Framework for Reliability Analysis

- Exogenous and endogenous sources of travel time variability
- Scenario-based analysis
- Trajectory data processing to generate travel time distributions and reliability performance measures
- Potential feedback to travel demand and scenario generation



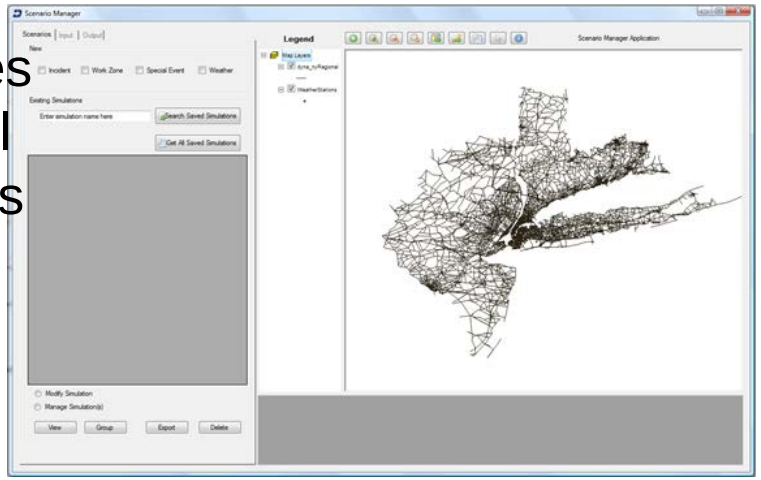
Model & Data Requirements

- Network simulation models
  - particle-based microsimulation or mesosimulation models that produce vehicle travel trajectories
- General data requirements
  - exogenous sources of travel time variation
- Vehicle trajectory data
  - standard GPS-type data for individual vehicles (time/location stamp)

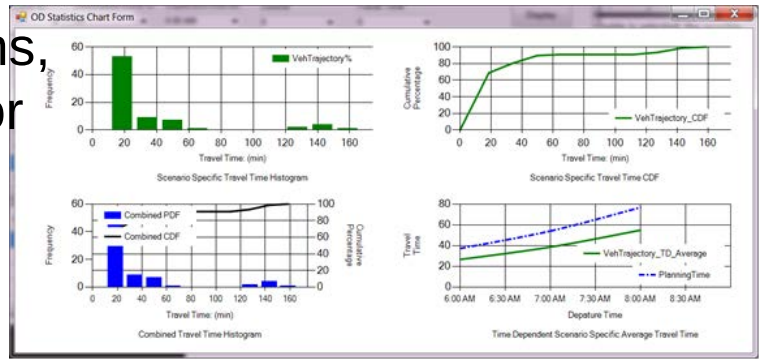


Key Add-On Modeling Tools

- Scenario Manager
  - a pre-processor of simulation input files for capturing external sources of travel time variation and unreliability (such as special events, adverse weather, and work zones)

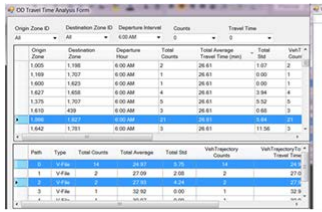


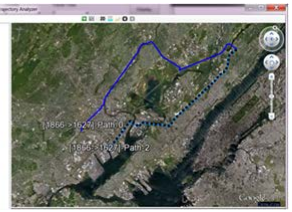
- Trajectory Processor
  - a post-processor that produces and helps visualize reliability performance measures (e.g., travel time distributions, reliability descriptors) from observed or simulated trajectories



Demonstration Case

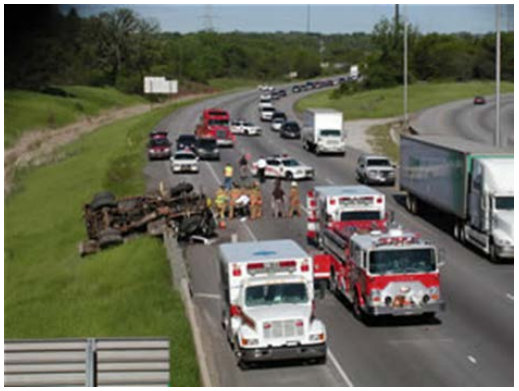
- New York Metropolitan Region
- Three levels of modeling
  - Regional activity-based model (Best Practices Model –BPM)
  - Regional mesoscopic DTA model (Dynasmart)
  - Manhattan microsimulation model (Aimsun)
- Travel Trajectory Data (TomTom PND)
- Scenario Manager & Trajectory Processor application testing
- Multi-level reliability performance measures (network, O-D, path/segment/link)





Potential Use of L04 Products

- Researchers
  - pursuing the next frontier in reliability analysis
- Transportation Agencies & Operators
  - incorporating the value of reliability in planning and decision making
- Other Practitioners
  - using current models and data sources to improve and enrich their work
- Modeling Software Vendors
  - developing, enhancing and integrating reliability tools in their offerings



Key Success Factors

- Greater awareness of the importance of reliability analysis for major planning and operations projects
- Scenario-based analysis as the primary, default approach for conducting reliability evaluations
- Better appreciation and recognition of the entire distribution of travel time, rather than simply mean values
- Utilities/tools to manage the generation of scenarios and analyze model output to obtain travel time distributions and reliability descriptors

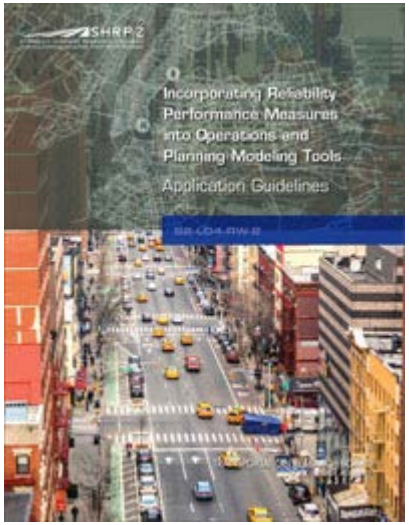
Project Deliverables & Products

- Main L04 Report
- Application Guidelines
- Software / tool prototypes
  - Scenario Manager
  - Trajectory Processor
- Reference Material

All readily available for broader distribution and use
(through TRB - SHRP 2)

http://www.trb.org/Main/Blurbs/170716.aspx

http://www.trb.org/Main/Blurbs/170717.aspx



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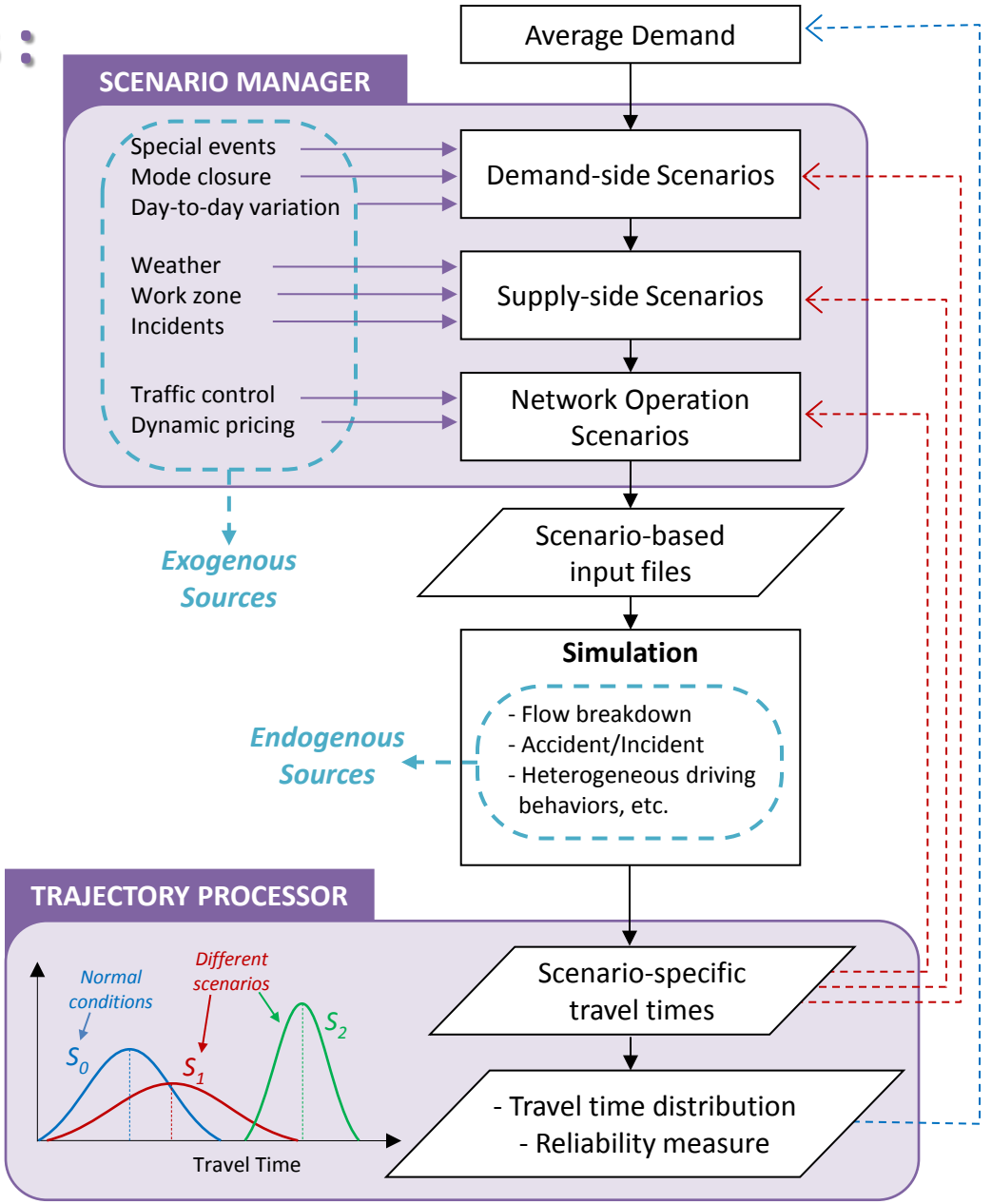
Methodological Framework Summary

Exogenous sources Input	*Scenario manager*	
	Demand -Special events -Day-to-day variation -Visitors -Closure of alternative modes	Supply -Incidents -Work zones -Adverse weather
Endogenous sources Reliability-integrated Simulation model (meso, micro)	*Improvements to existing simulation tools*	
	Demand -Heterogeneity in Route Choice and User Responses to Information and Control Measures -Heterogeneity in vehicle type	Supply -Flow breakdown and incidents -Heterogeneity in car following behavior -Traffic control -Dynamic pricing
Performance measures Output	*Vehicle trajectory processor*	
	- Travel time distribution - Reliability performance indicators - User-centric reliability measures	

Traffic Simulation Models : *Capture Sources of Unreliability*

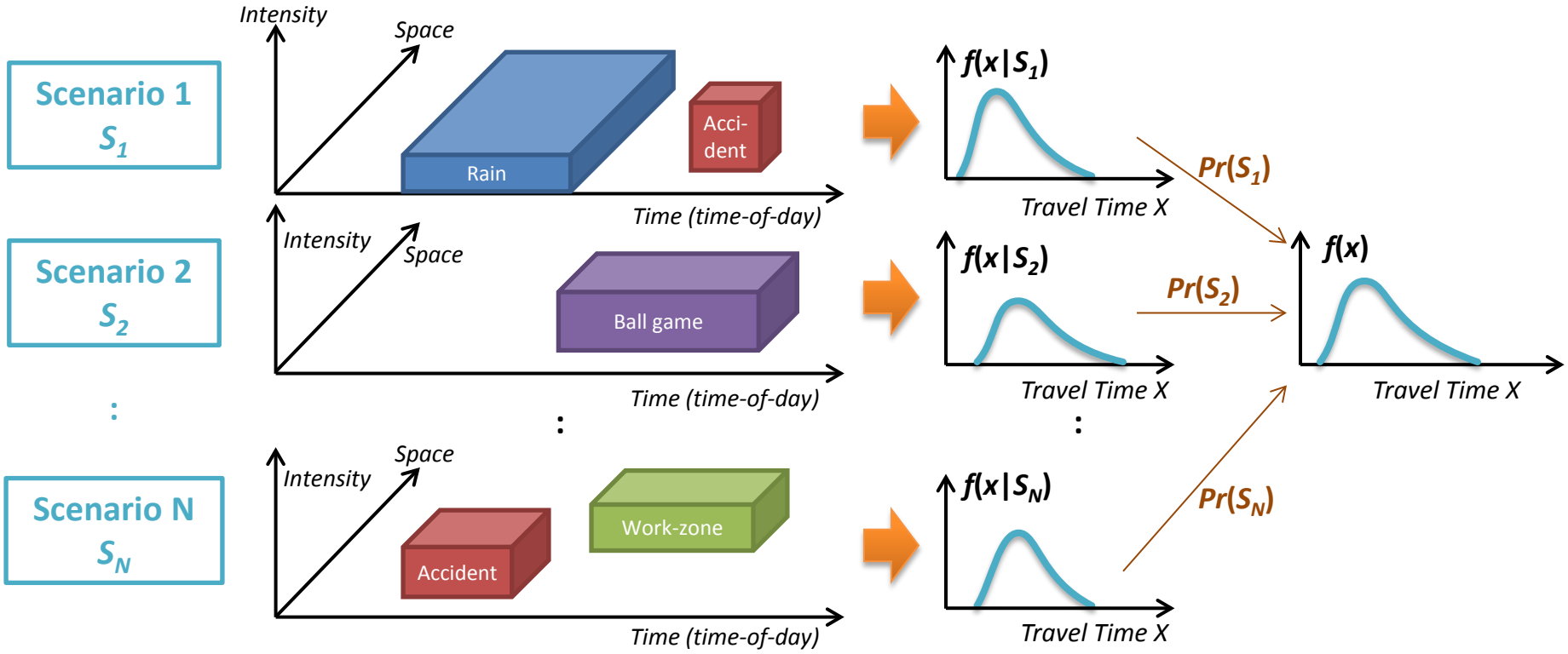
- **Scenario Manager**
  - Construct scenarios with various combinations of external events, demand, supply and traffic control elements.
  - Construct "What-if" scenarios using Monte Carlo sampling.

- **Trajectory Processor**
  - Extract reliability-related measures from the vehicle trajectory output of the simulation models.



Scenario-based Reliability Analysis

Capture travel time variability by simulating multiple likely scenarios that reflect various exogenous sources of uncertainties in the road network.



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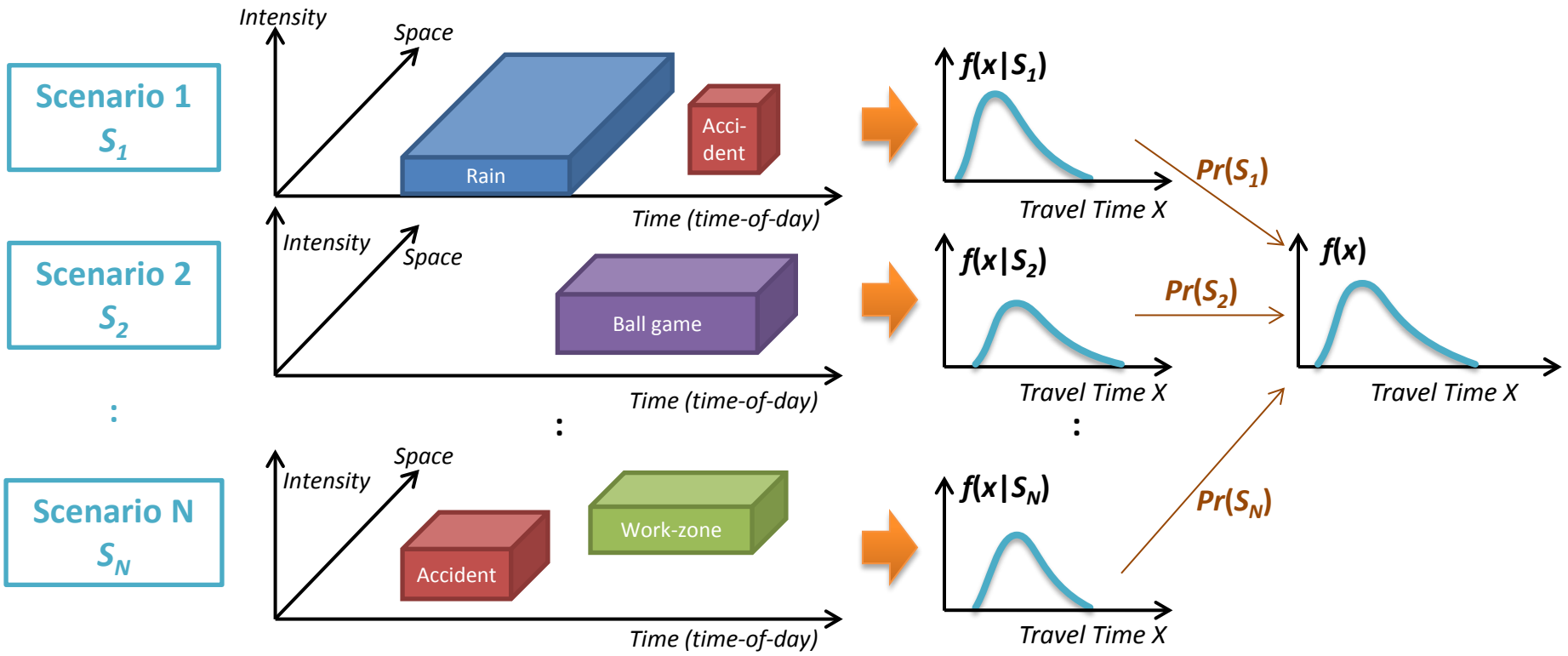
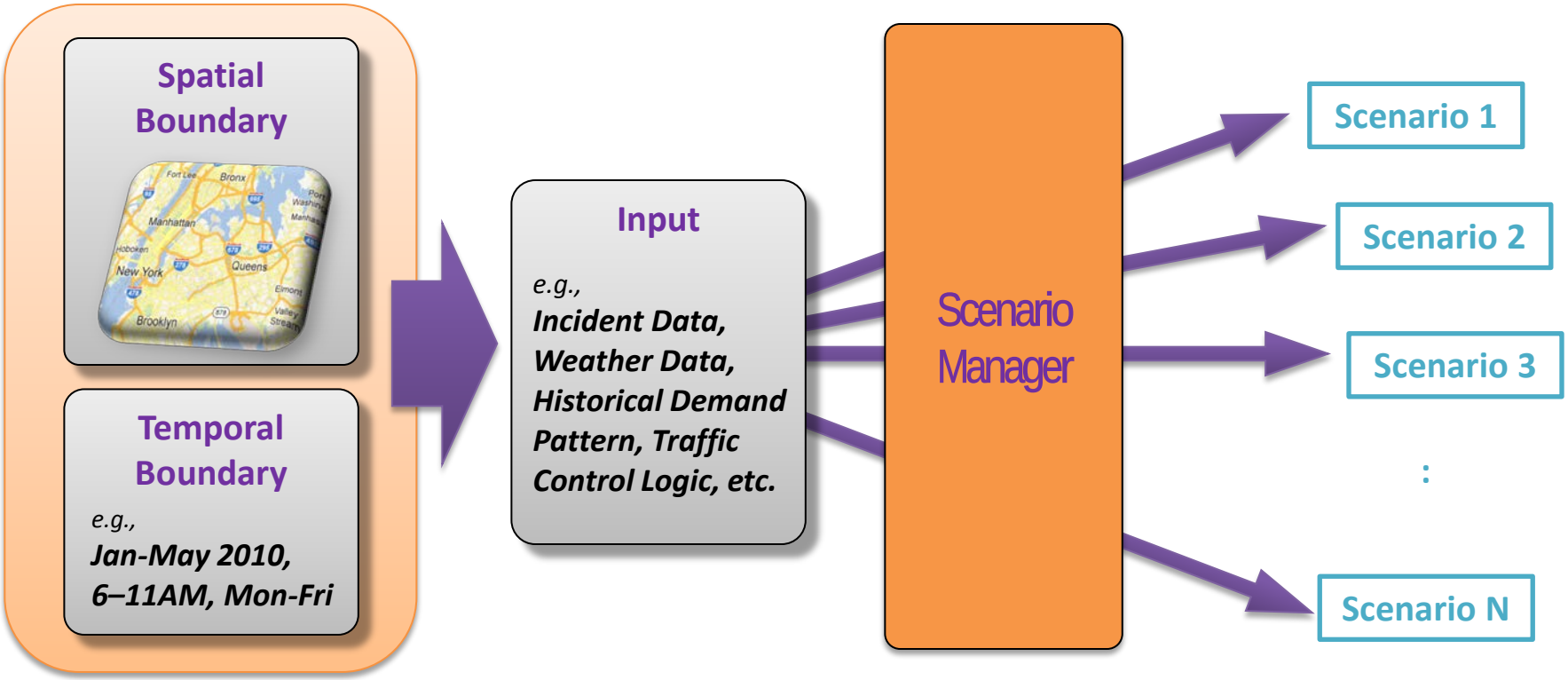


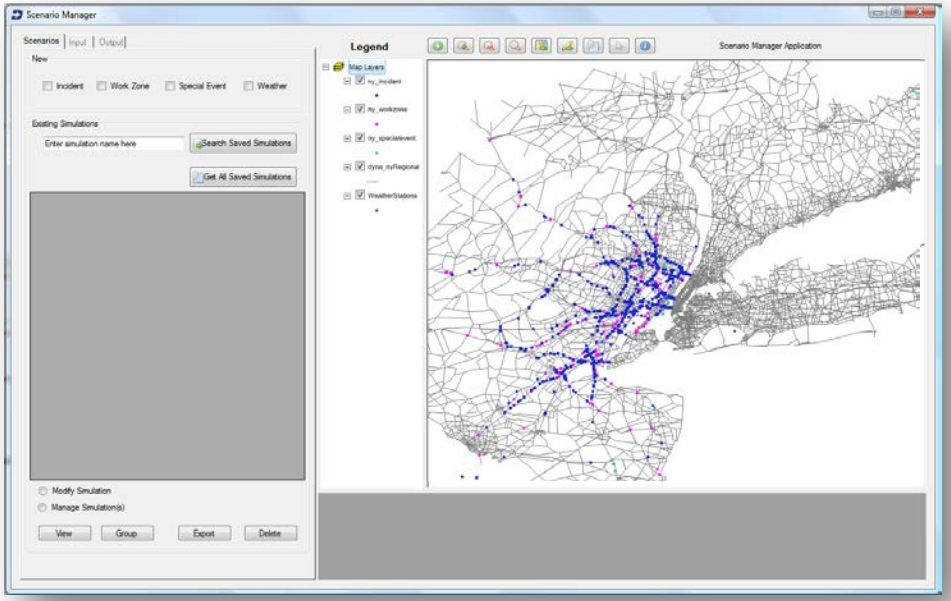
Scenario Manager

Main Role: Construct scenarios that entail any mutually consistent combination of external events, demand, supply and traffic control elements of the simulation model



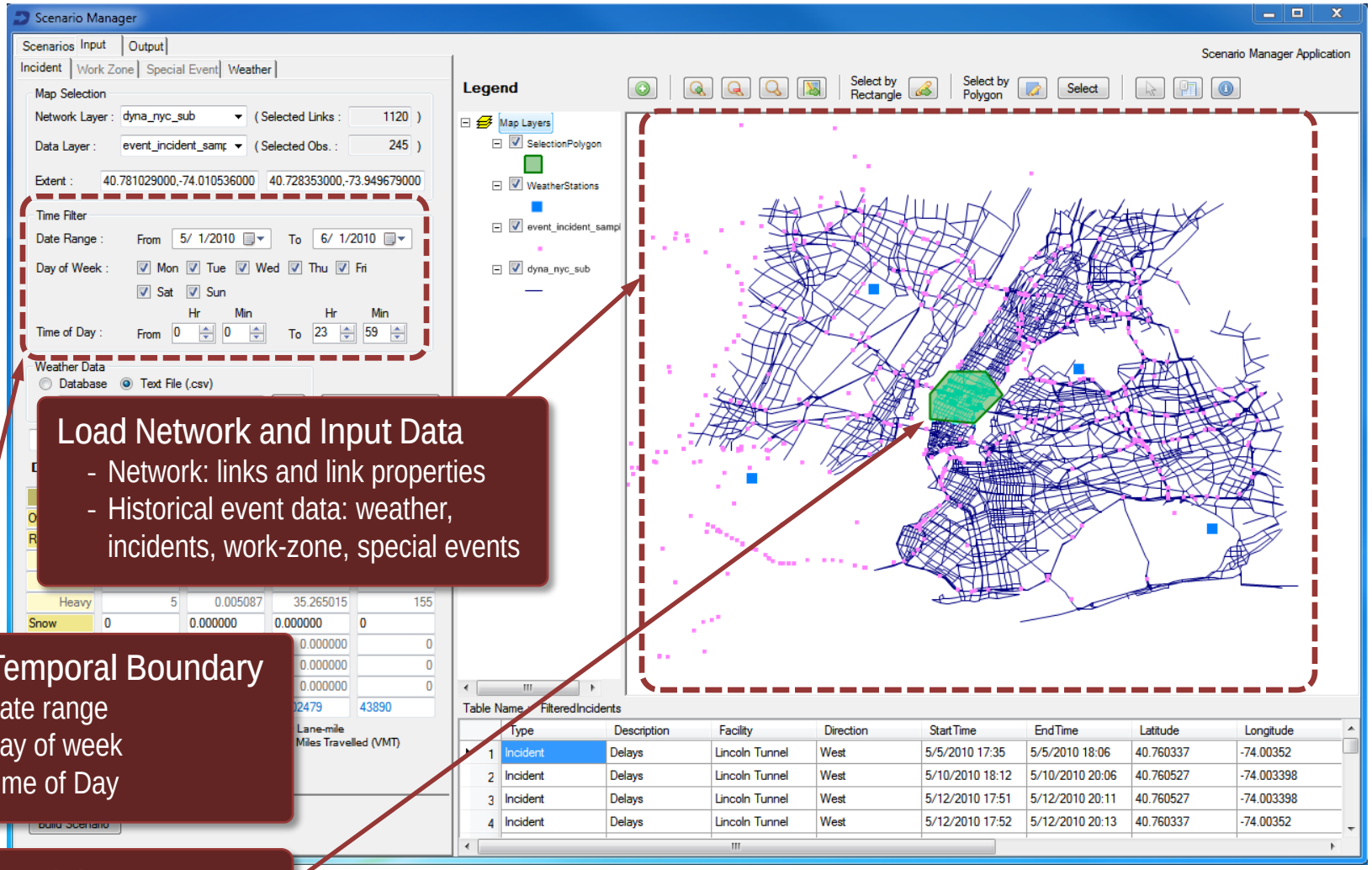
Application Main Functionalities

- **Scenario Generation**
  - Populated with historical weather and incident data
  - Automatic estimation of parameters for event properties(e.g., frequency, duration, intensity, etc.) for selected time and space
  - Generate scenarios considering dependencies between scenario components (e.g., weather-dependent incident rate)
  - Provides software-specific scenario files and the associated scenario probabilities
- **Scenario Management**
  - Store generated scenarios
  - Easy retrieval of historically occurring scenarios



Step 1) Load Network and Input Data
Step 2) Define Time and Space Domains

↙ Scenario Manager Main Window



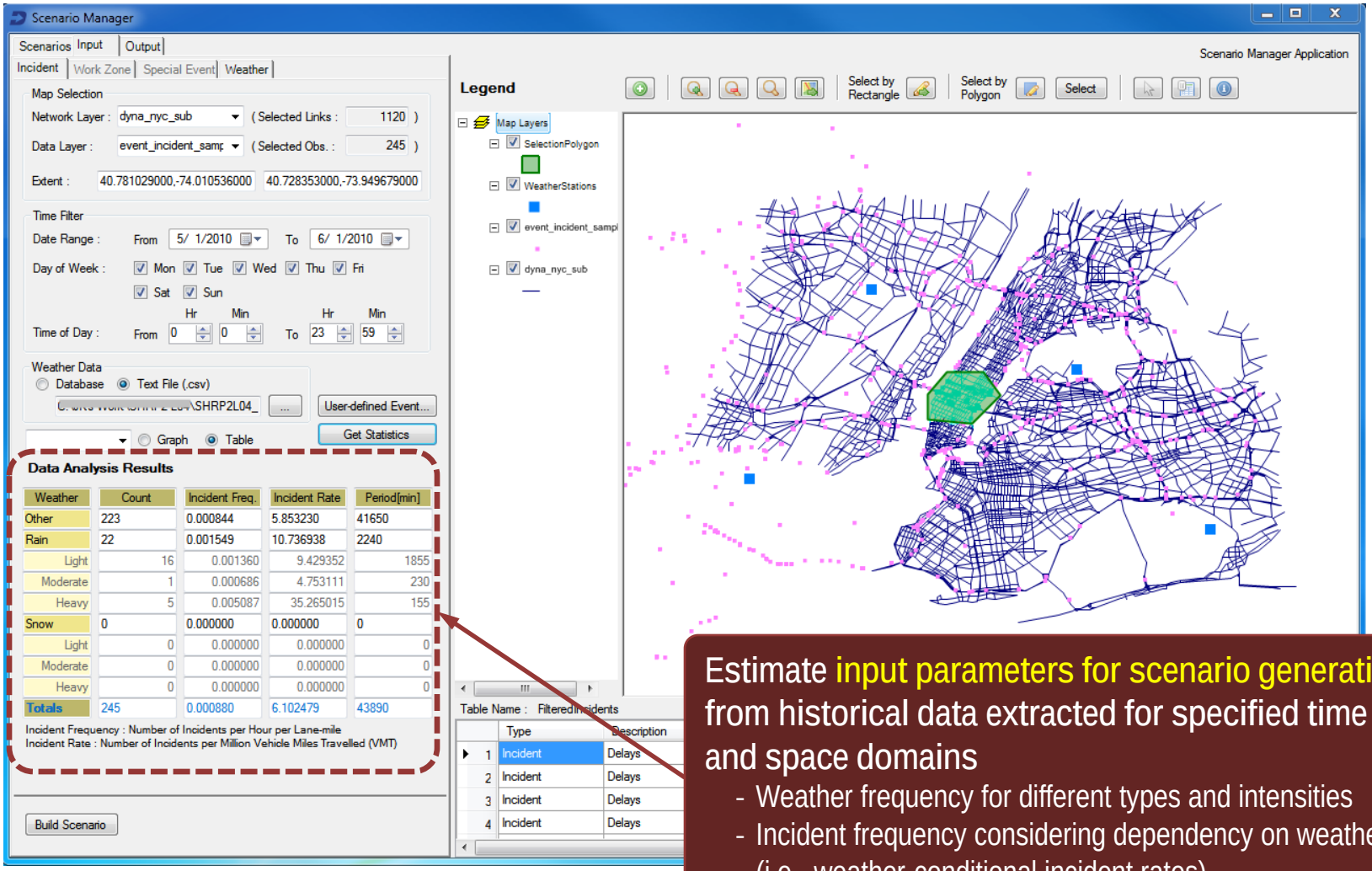
Load Network and Input Data
- Network: links and link properties
- Historical event data: weather, incidents, work-zone, special events

Set Temporal Boundary
- Date range
- Day of week
- Time of Day

Set Spatial Boundary

Step 3) Estimate Input Parameters from Historical Data

↙ Scenario Manager Main Window

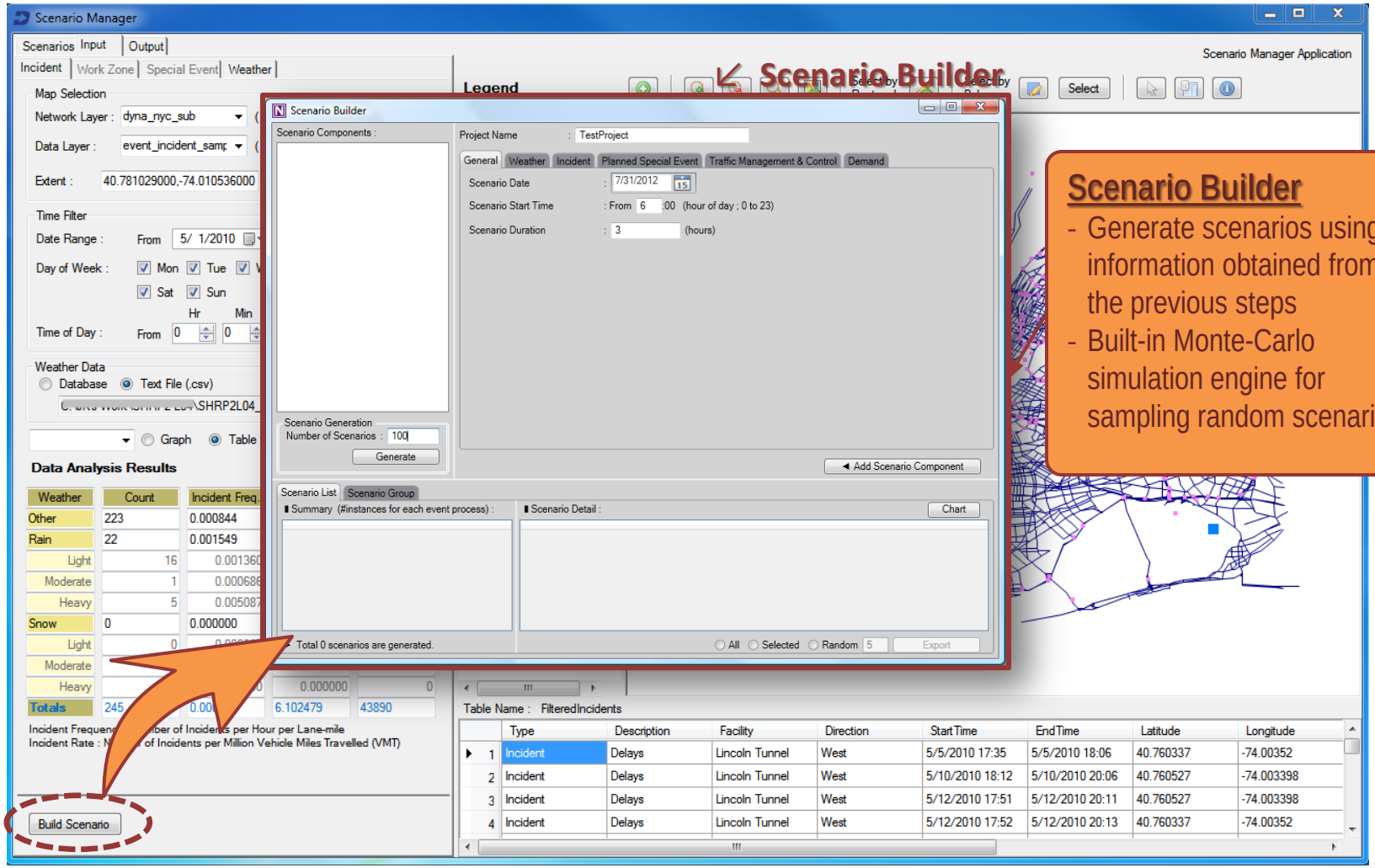


Estimate input parameters for scenario generation from historical data extracted for specified time and space domains

- Weather frequency for different types and intensities
- Incident frequency considering dependency on weather (i.e., weather-conditional incident rates)

Step 4) Launch Scenario Generation Tool

↙ Scenario Manager Main Window

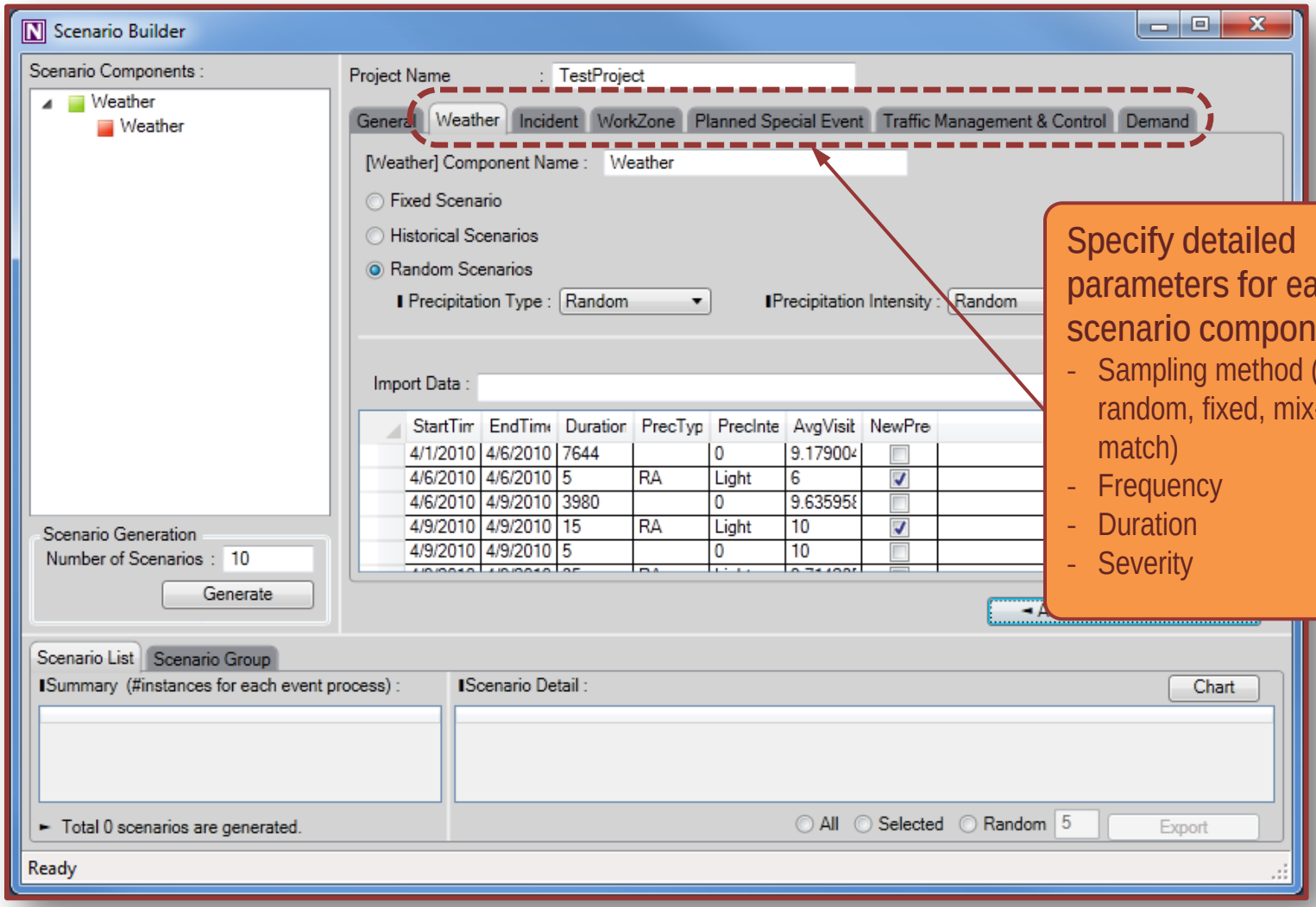


Scenario Builder

- Generate scenarios using information obtained from the previous steps
- Built-in Monte-Carlo simulation engine for sampling random scenarios

Step 5) Parameter Settings for Scenario Generation

↙ Scenario Builder

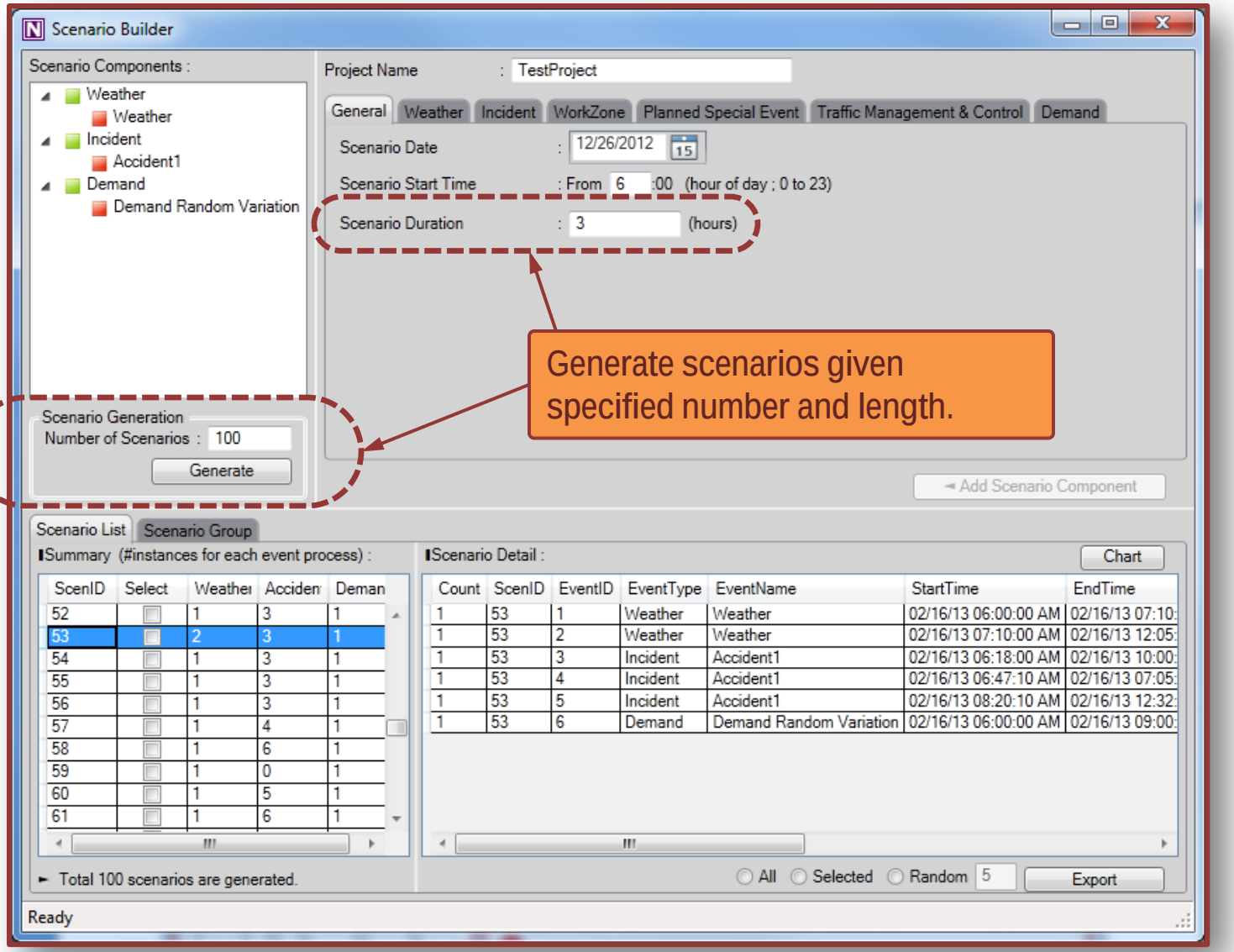


Specify detailed parameters for each scenario component

- Sampling method (e.g., random, fixed, mix-and-match)
- Frequency
- Duration
- Severity

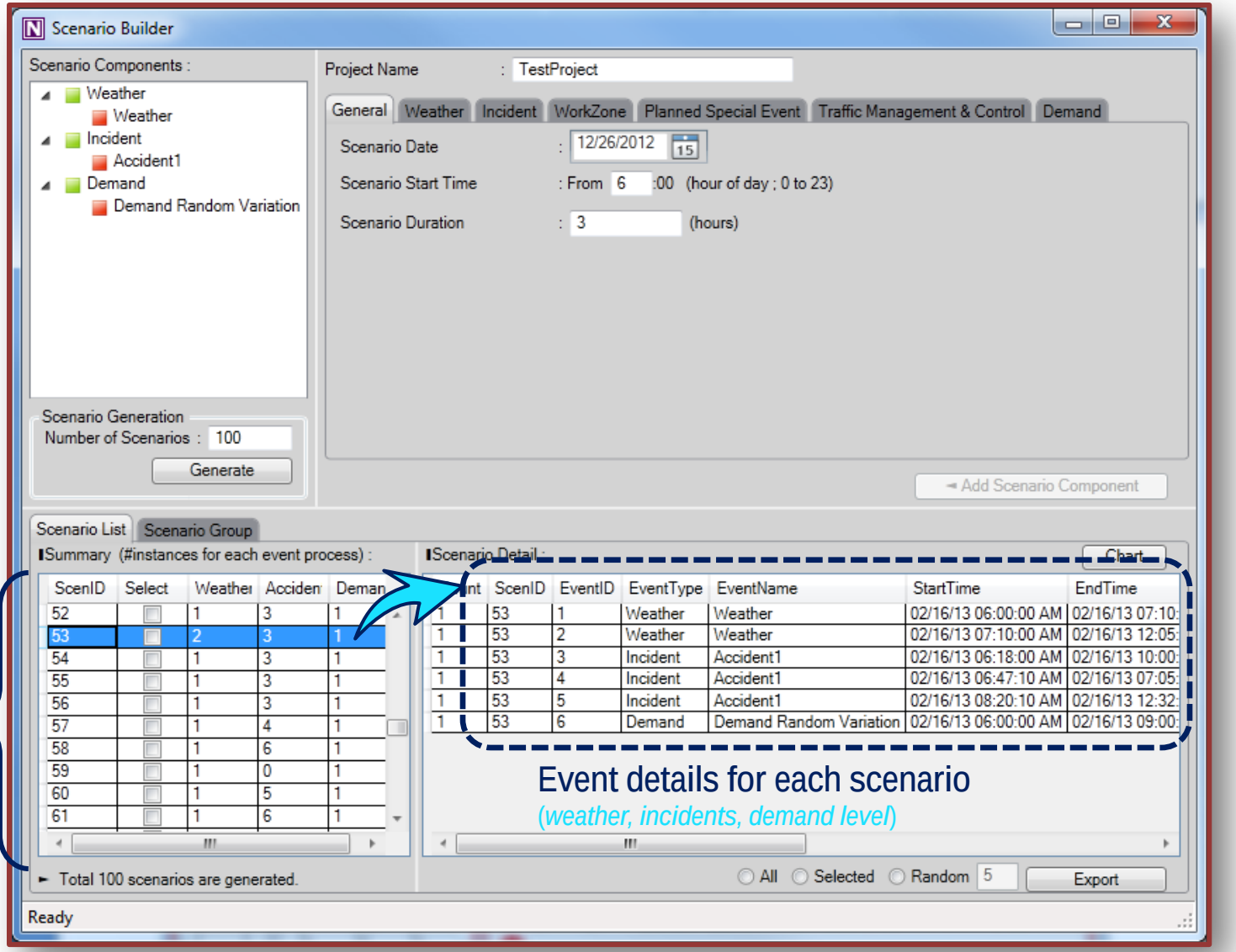
Step 6) Generate Scenarios

↙ Scenario Builder



Step 6) Generate Scenarios

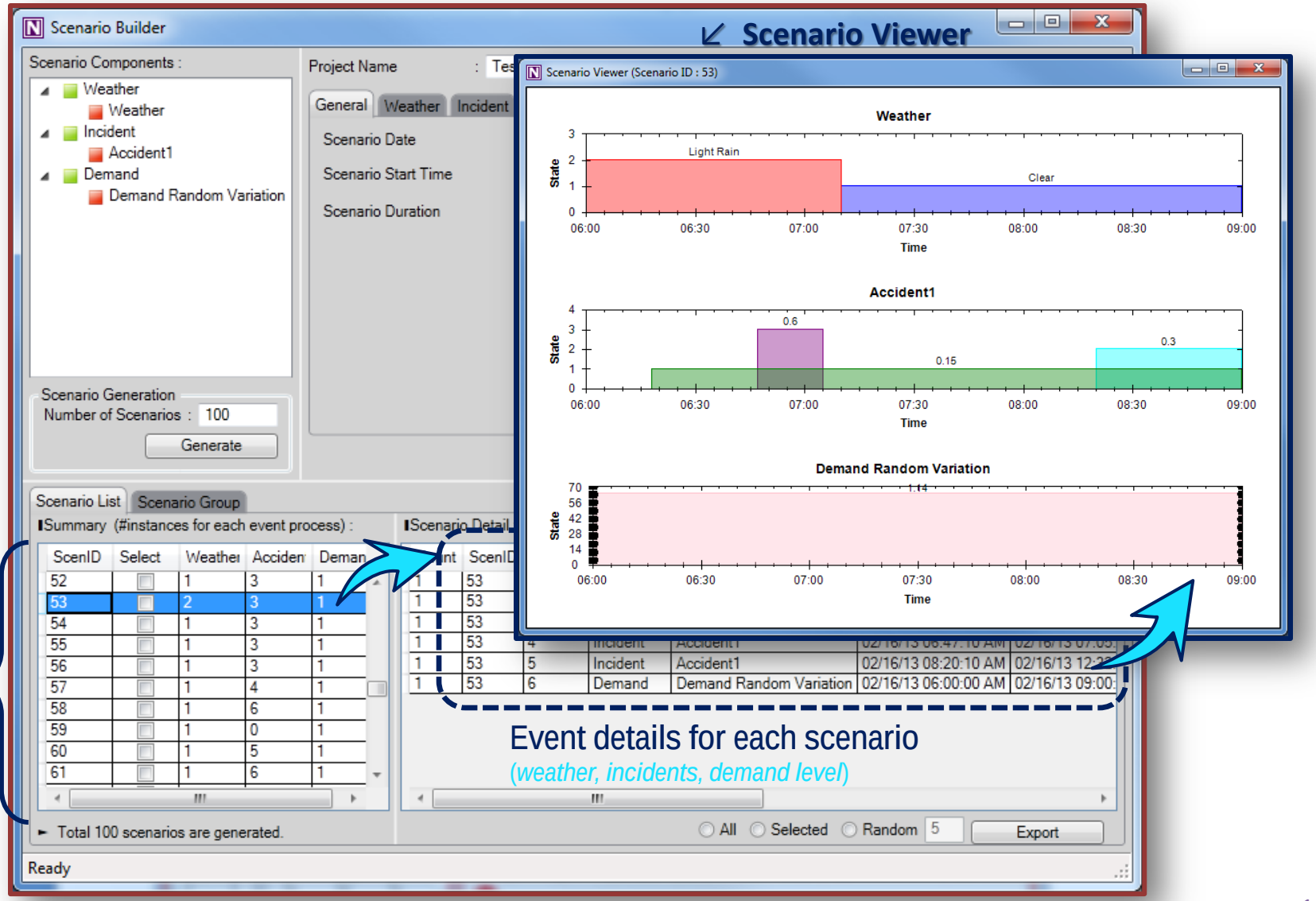
↙ Scenario Builder



List of generated scenarios (e.g., *100 daily scenarios*)

Event details for each scenario (*weather, incidents, demand level*)

Step 6) Generate Scenarios



List of generated scenarios (e.g., *100 daily scenarios*)

Event details for each scenario (*weather, incidents, demand level*)

Step 7) Compute Scenario Probabilities

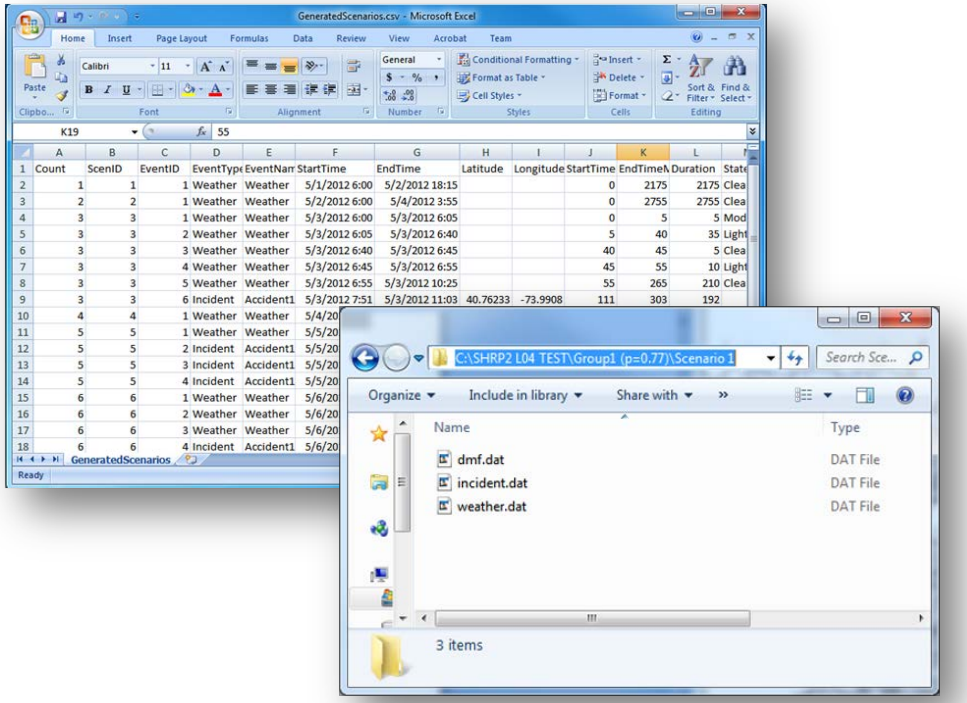
- Scenario Manager provides the ability to define *Scenario Groups* and compute the probability of each scenario group.

Example of Scenario Groups

Scenario Groups		Incident		*Marginal Probability*
		Accident	No Accident	
Weather	Clear	*P=0.610*	*P=0.242*	*P(CL)=0.85*
	Rain	*P=0.072*	*P=0.023*	*P(RA)=0.10*
	Snow	*P=0.049*	*P=0.004*	*P(SN)=0.05*
Marginal Probability		*P(Acc)=0.73*	*P(NoAcc)=0.27*	*1.00*

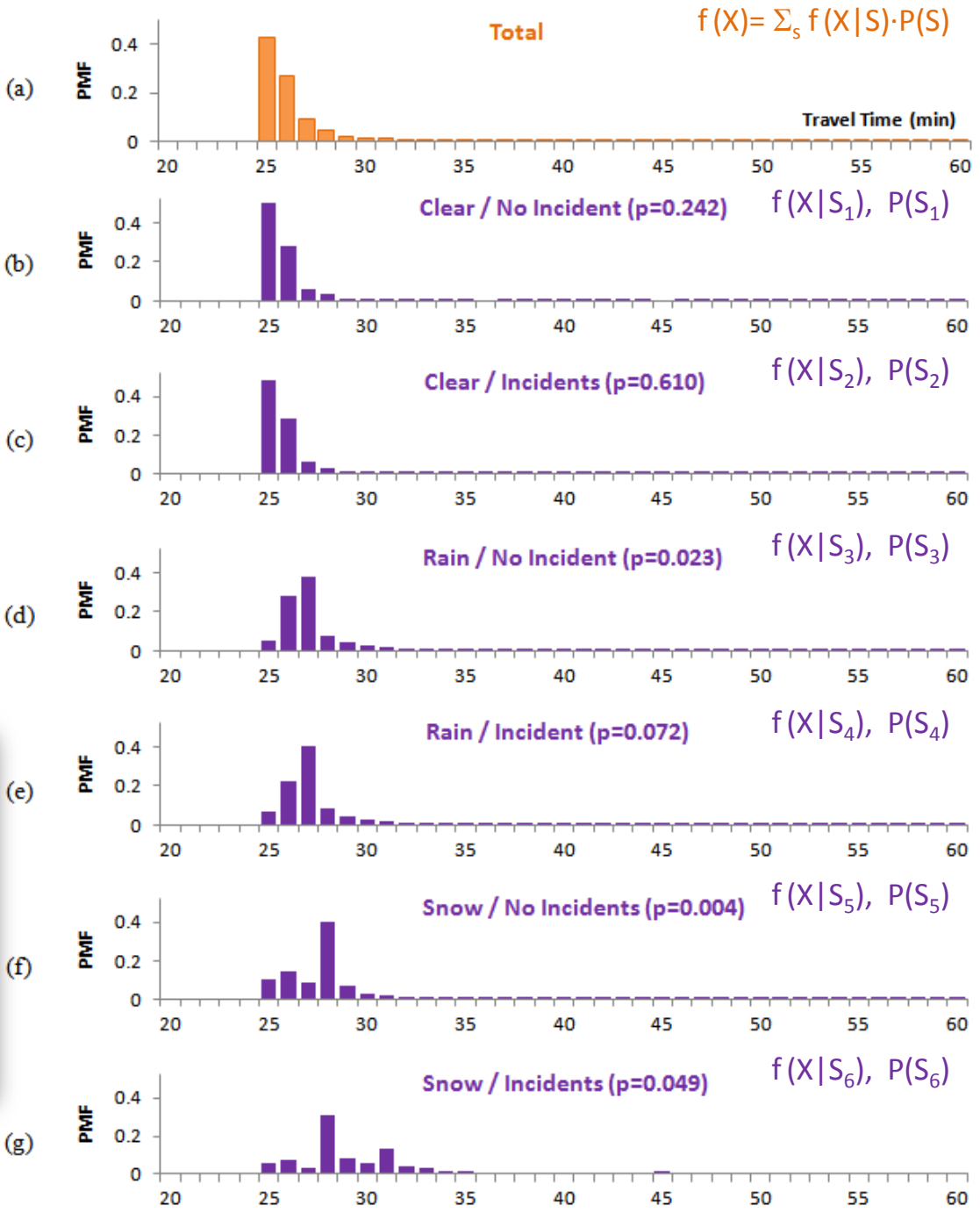
Step 8) Export Scenarios

- Export generated scenarios to a general format (e.g., TXT or CSV file)
- Export generated scenarios to software-specific input files (e.g., DYNASMART or Aimsun input files)



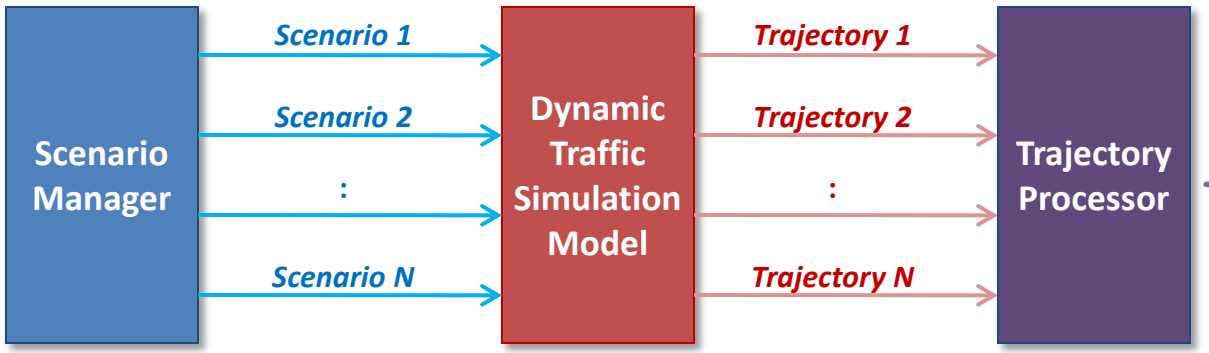
Example of Scenario Groups

- **Investigate travel time distributions considering weather and accident**
  - Long Island Expy
  - 6-10 AM, Mon-Fri
  - Nov. 2010-Feb. 2011
  - Historical weather and accident data



Vehicle Trajectory Processor

Main Role: Extract reliability-related measures from the vehicle trajectory output of the simulation models.

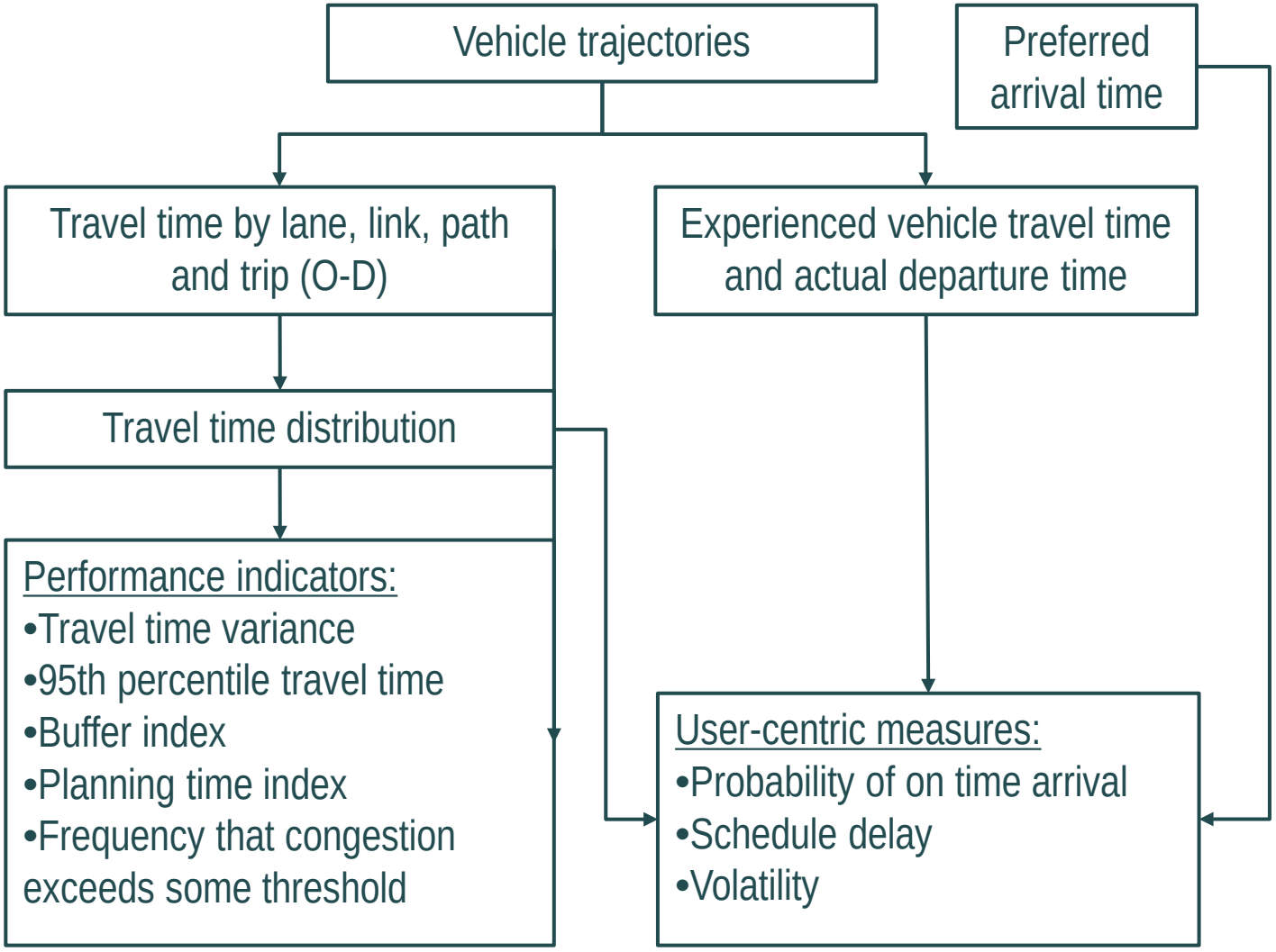


- **Reliability performance indicators**
  - *Travel time variance*
  - *95th Percentile Travel Time*
  - *Buffer Index*
  - *Planning Time Index*
- **User-centric reliability measures**
  - *Probability of on time arrival*
  - *Schedule delay*
  - *Volatility*

Vehicle Trajectories: Unifying Framework for Micro and Meso Simulation

- Vehicle (particle) trajectories in the output of a simulation model enable
  - construction of the path and O-D level travel time distributions of interest
  - extraction of link level distributions
- Vehicle trajectories could be obtained from both micro- and meso-level simulation models
- Trajectories also obtained from direct measurement in actual networks, enabling consistent theoretical development in connection with empirical validation.

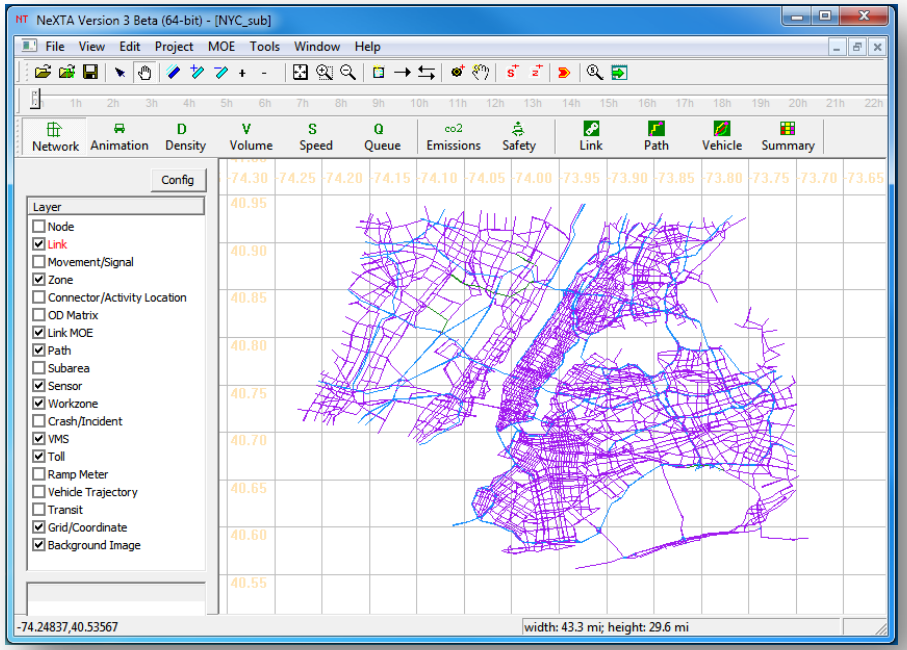
Vehicle Trajectory Processor



Application Main Functionalities

- Trajectory Processor is bundled into the NEXTA package, which provides a basic visualization platform for processing and analyzing traffic assignment simulation results.
- Main functions:
  - Read simulated vehicle trajectories 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.

↙ **Trajectory Processor**

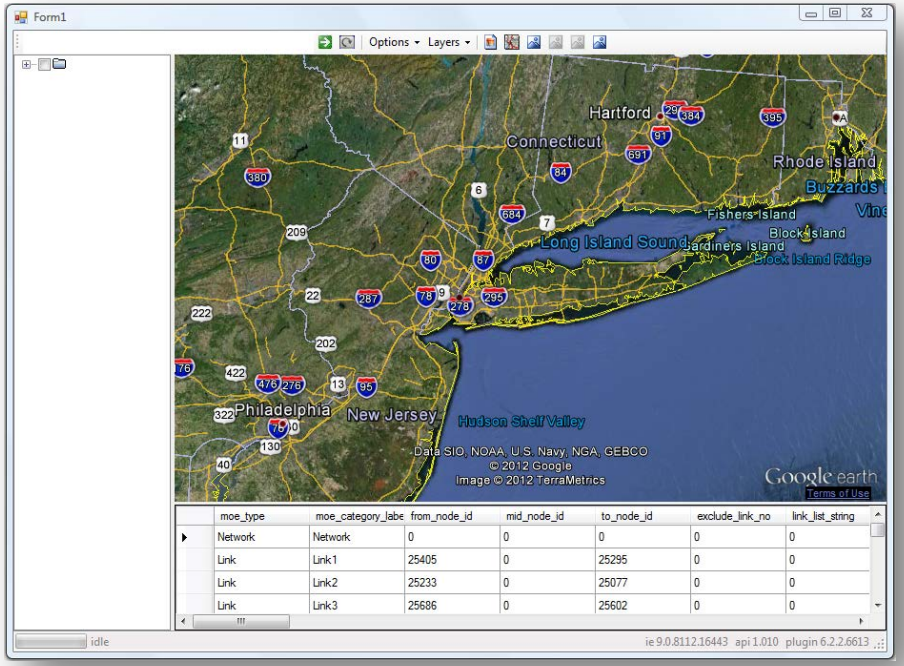


Application Main Functionalities (ctd.)

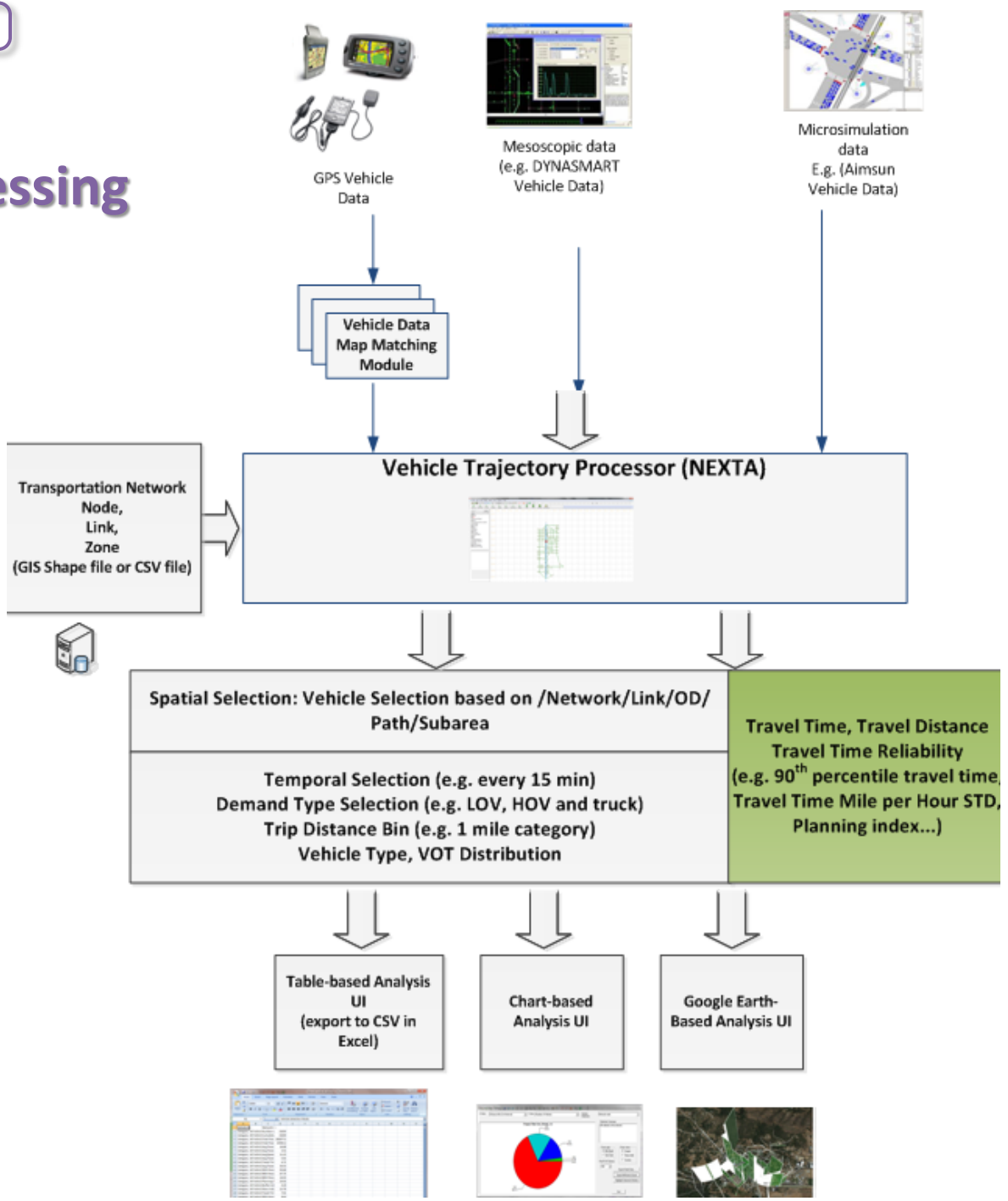
- From simulation outputs, for selected OD/path/links:
  - show scenario-specific travel time distributions
  - show combined travel time distribution (weighted by scenario probabilities)
  - extract various reliability performance measures

- Compare simulated trajectories with observed trajectories (e.g., TomTom GPS data)

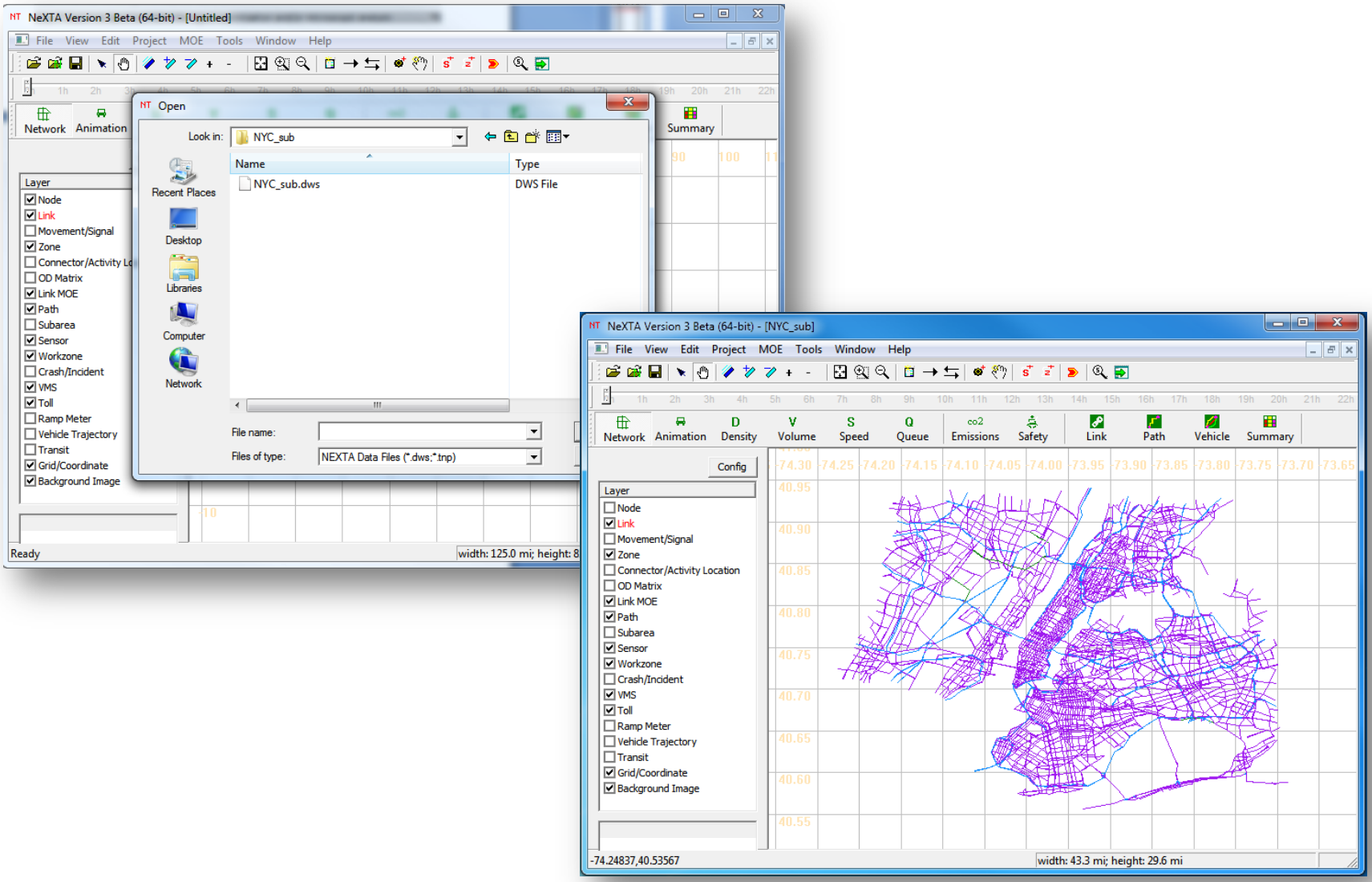
↙ **Trajectory Processor**



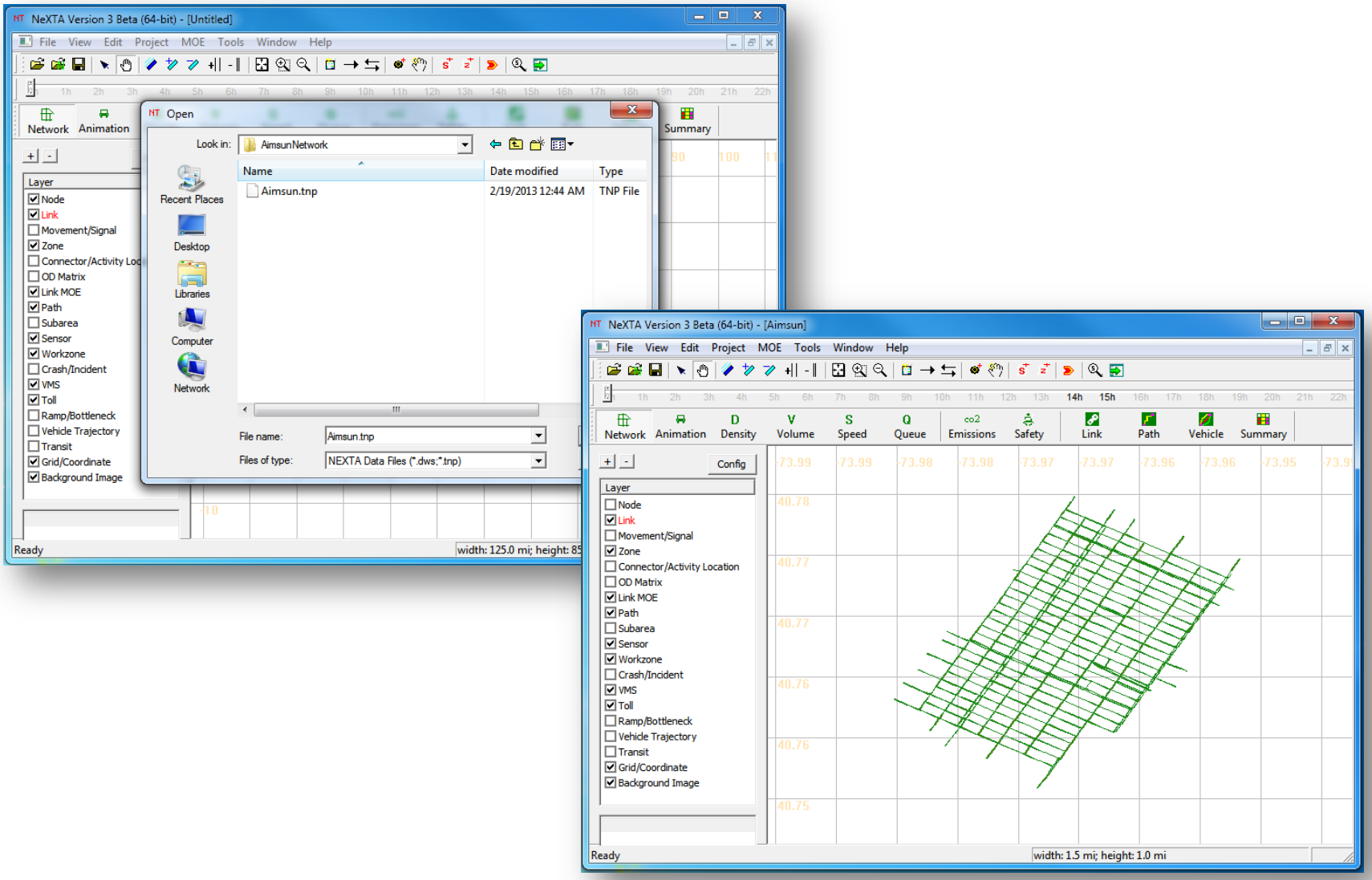
Overall Vehicle Trajectory Processing Procedure



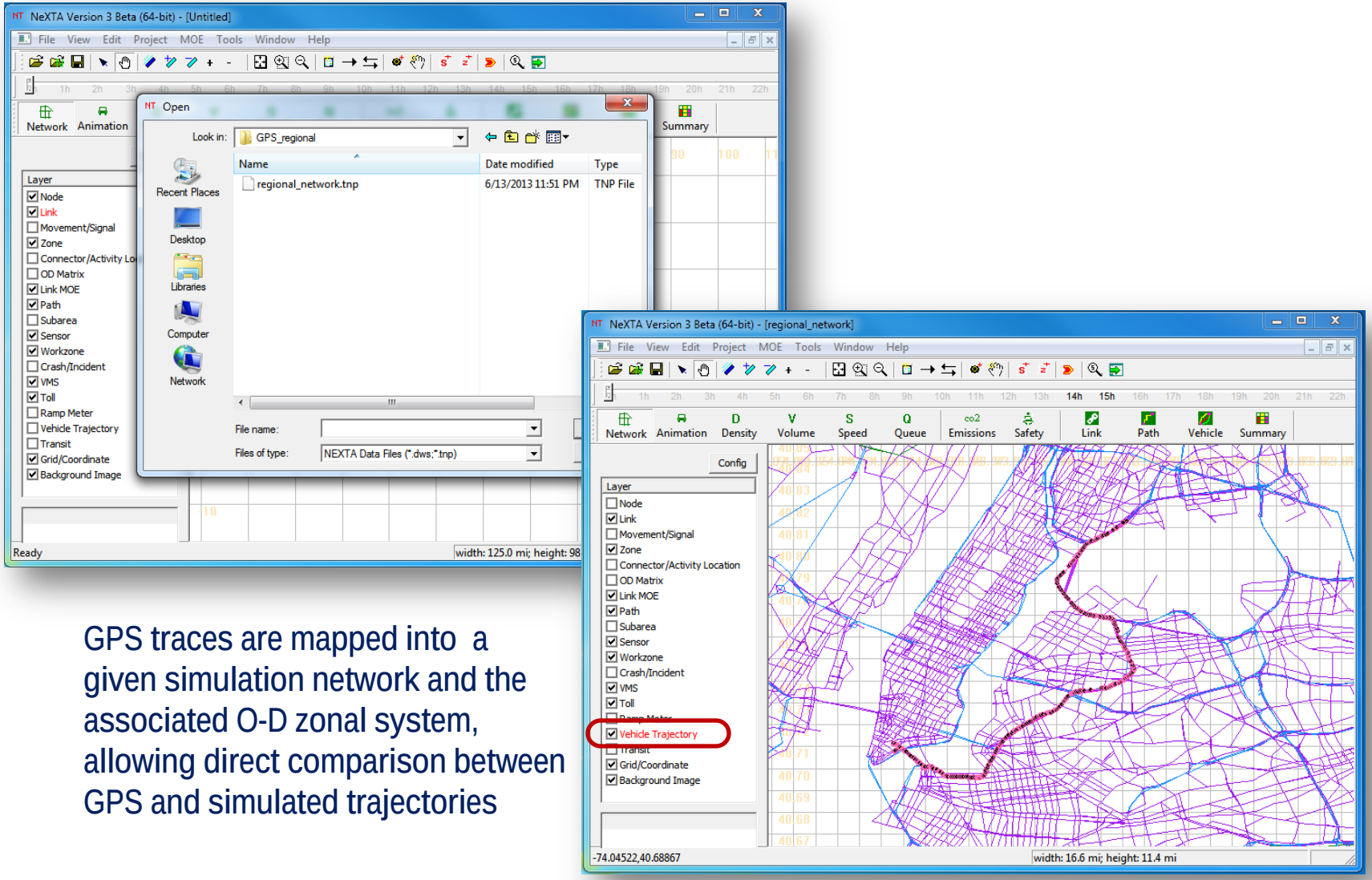
Import and Load Mesoscopic Simulation Data (DYNASMART)



Import and Load Microscopic Simulation Data (Aimsun)

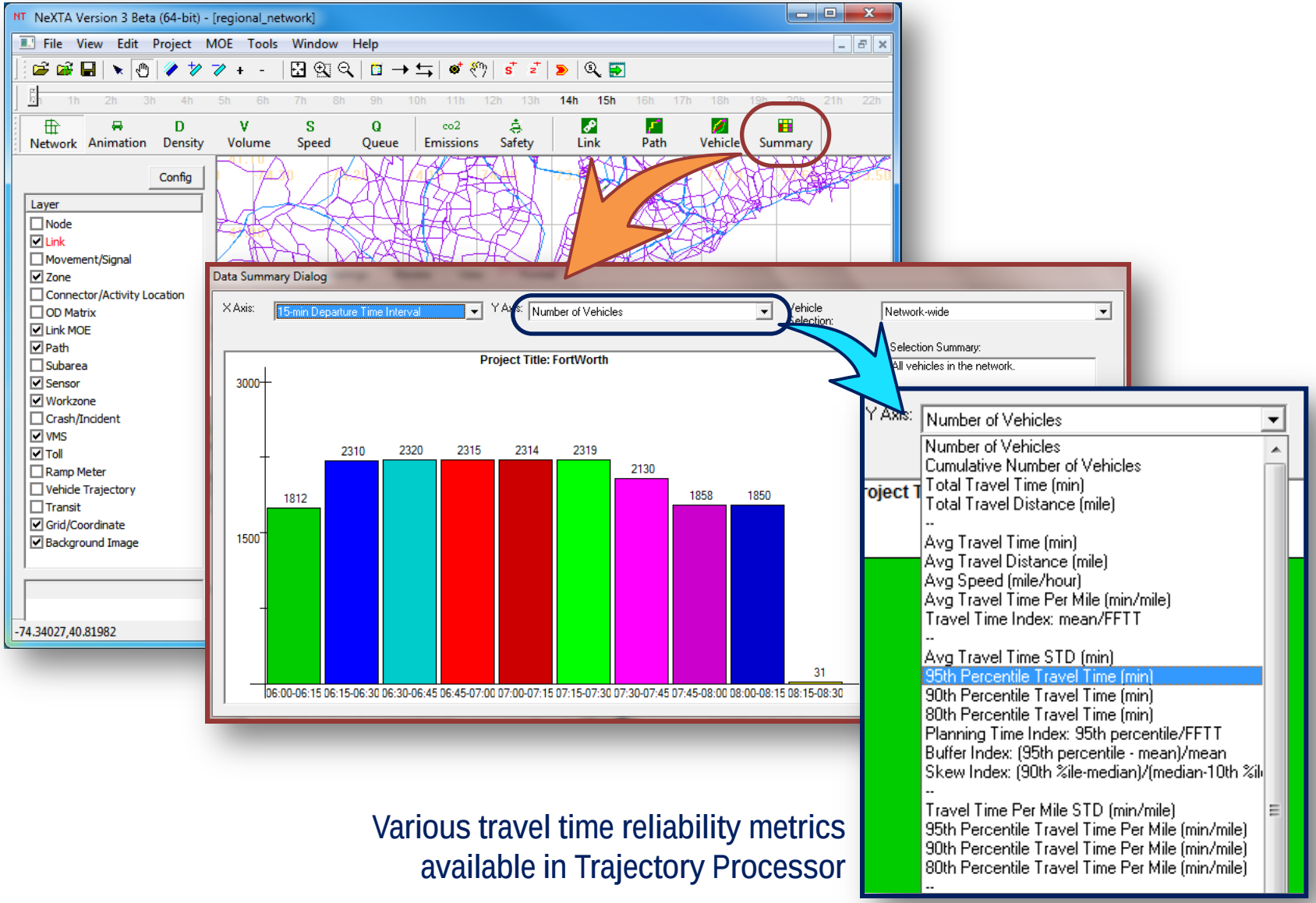


Import and Load GPS Trajectory Data (TomTom)



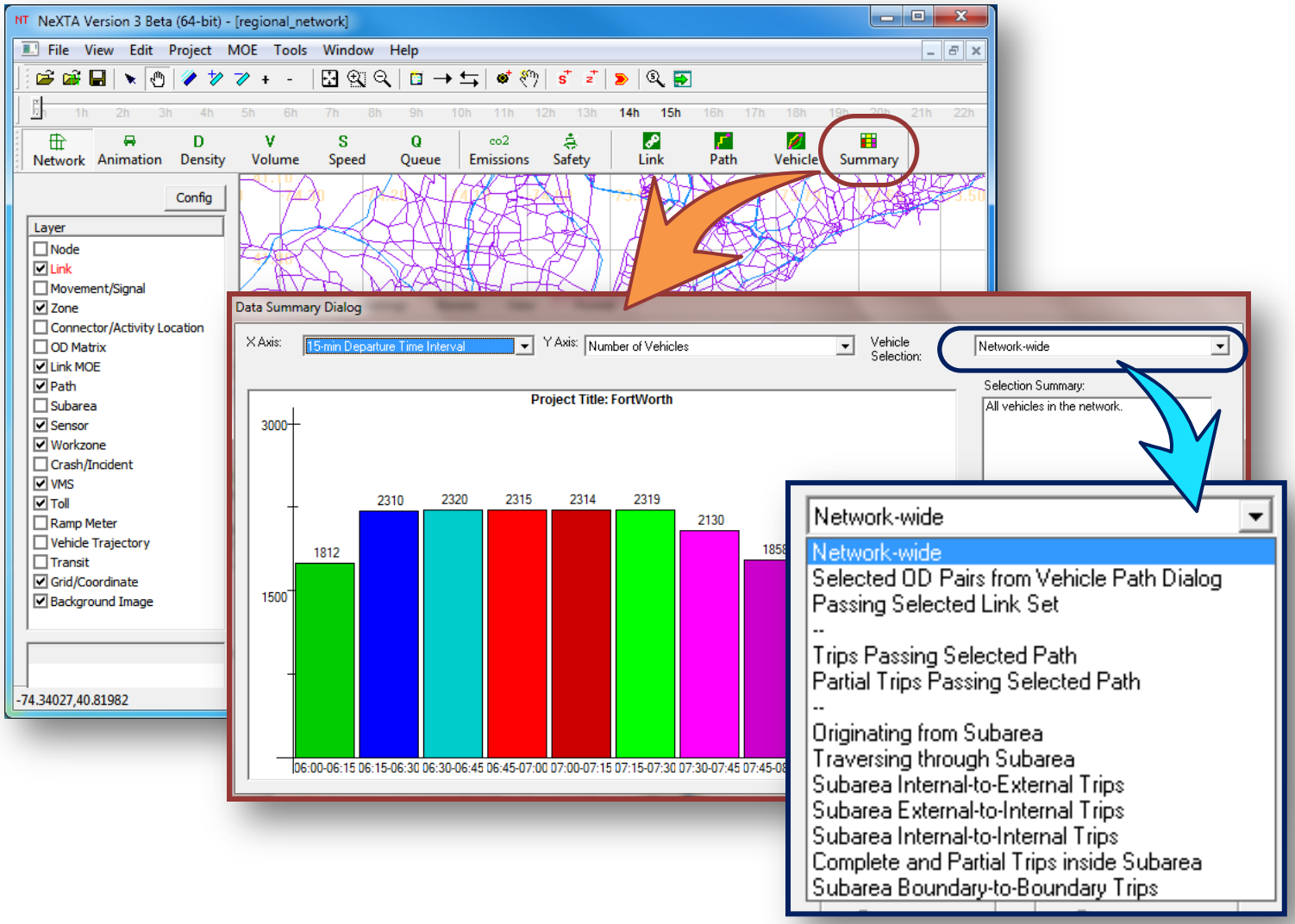
GPS traces are mapped into a given simulation network and the associated O-D zonal system, allowing direct comparison between GPS and simulated trajectories

Extract Travel Time Reliability Measures



Various travel time reliability metrics available in Trajectory Processor

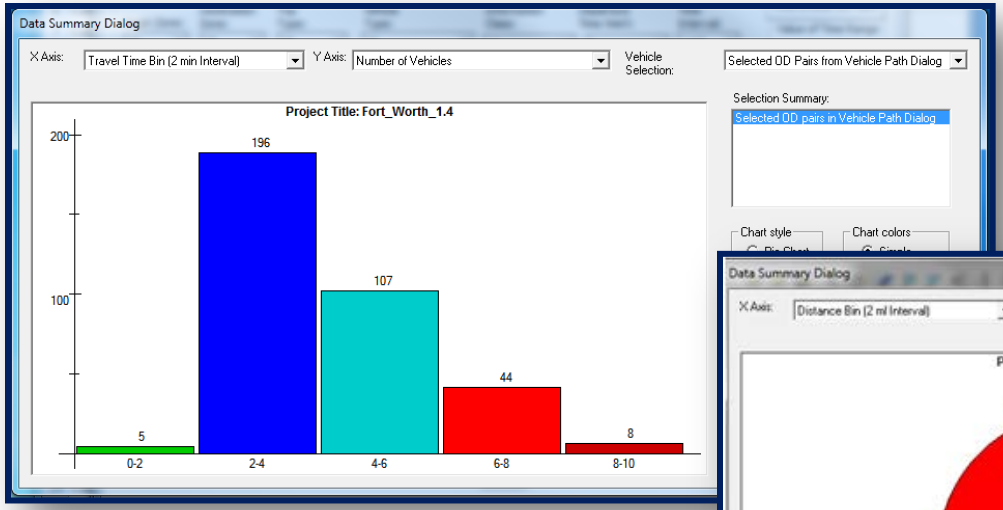
Construct Travel Time Distribution at Different Levels



Various ways of selecting target location:

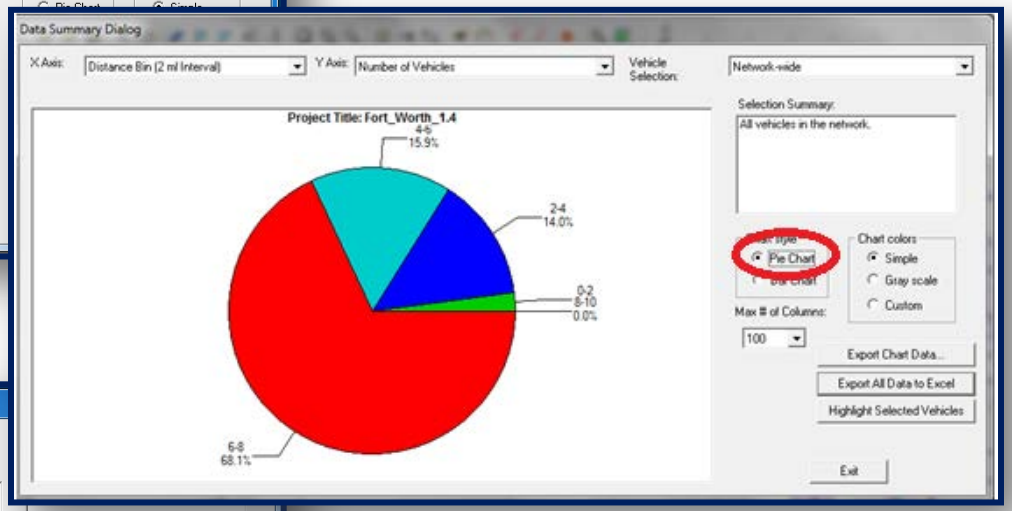
- Network-level
- OD-level
- Path-level
- Link-level
- Subarea-level

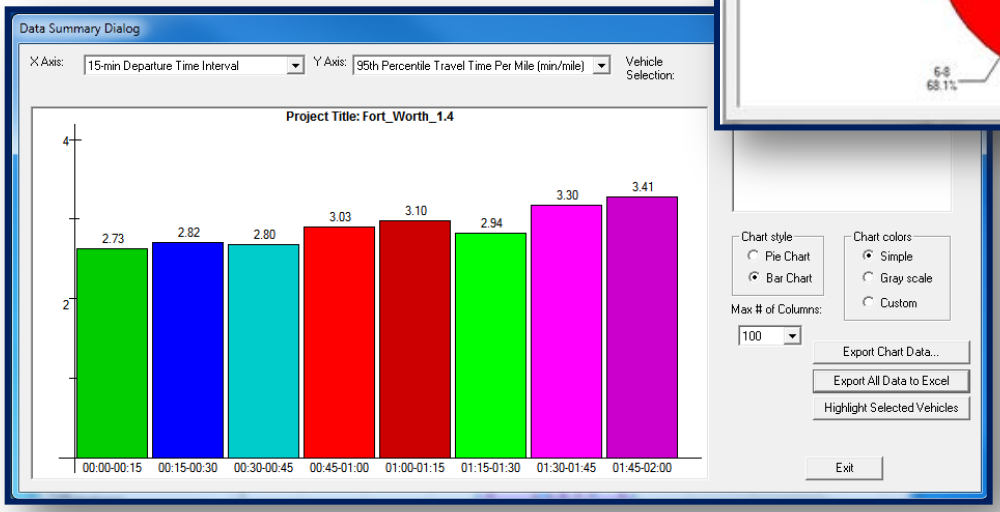
Visualize Reliability Measures in Different Ways



Frequency Chart

Pie Chart

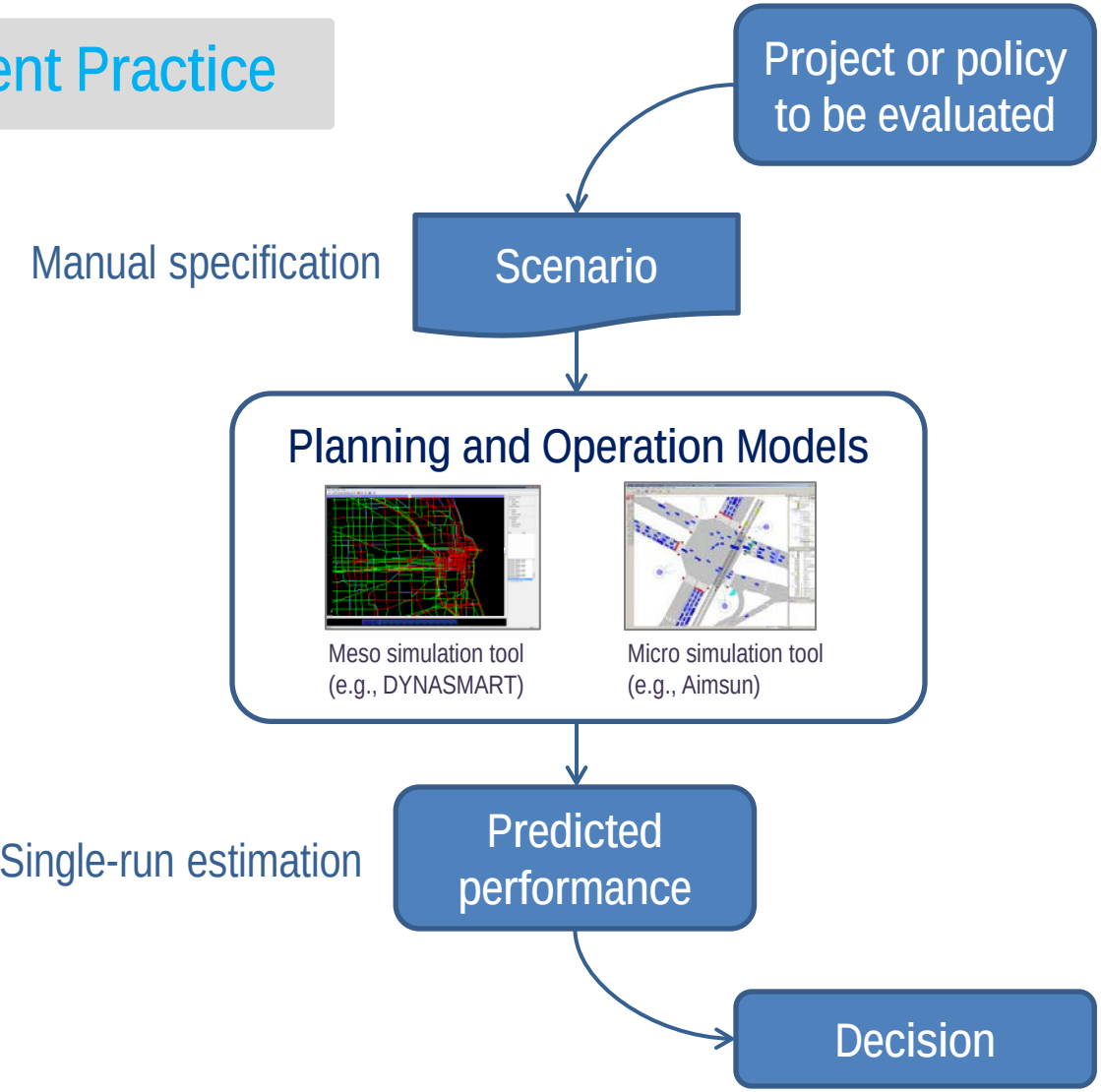




Reliability Measure Over Departure Time Intervals

Future Direction: *Scenario Management for Policy and Project Evaluation*

Current Practice

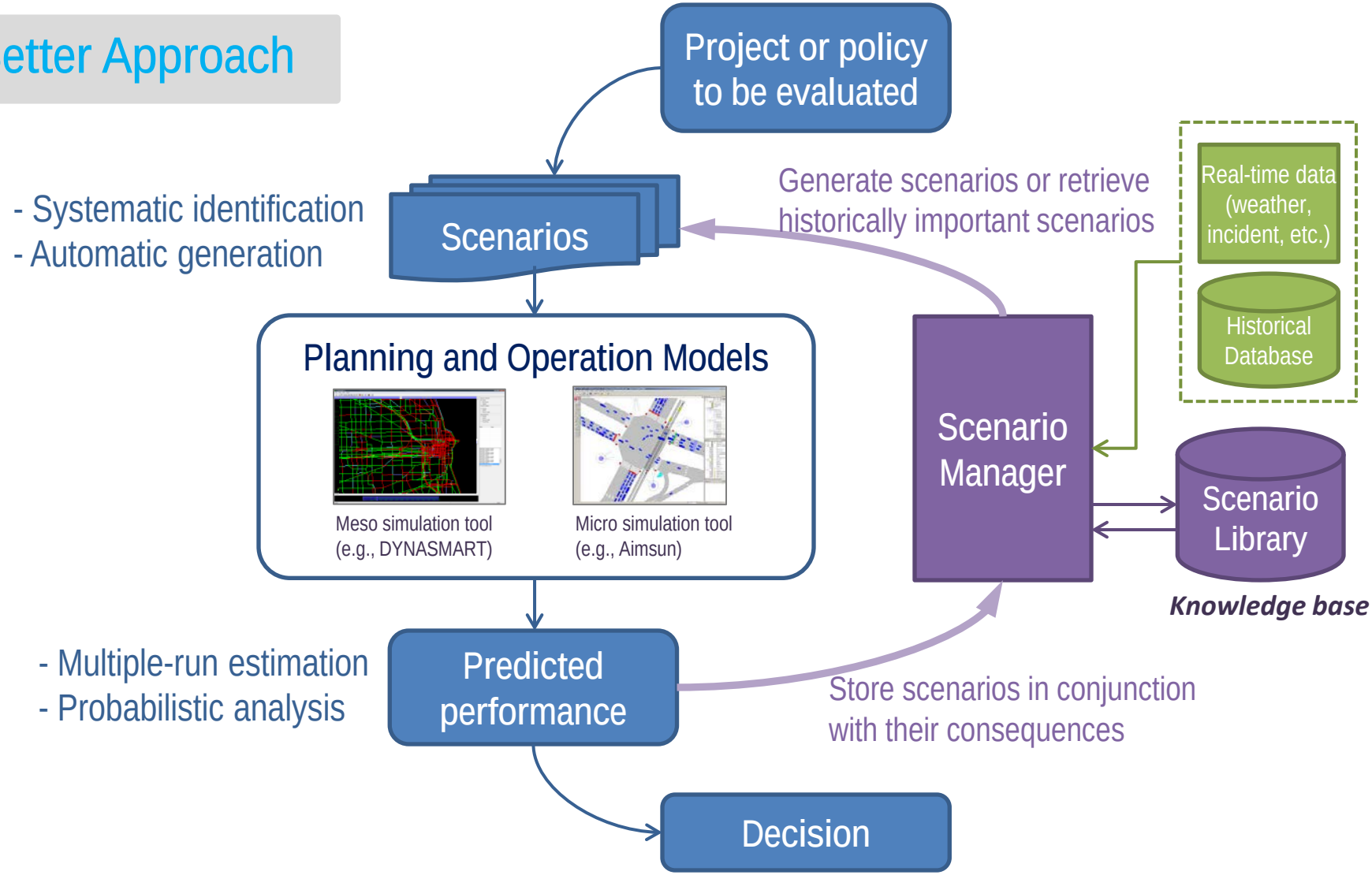


One-time Analysis

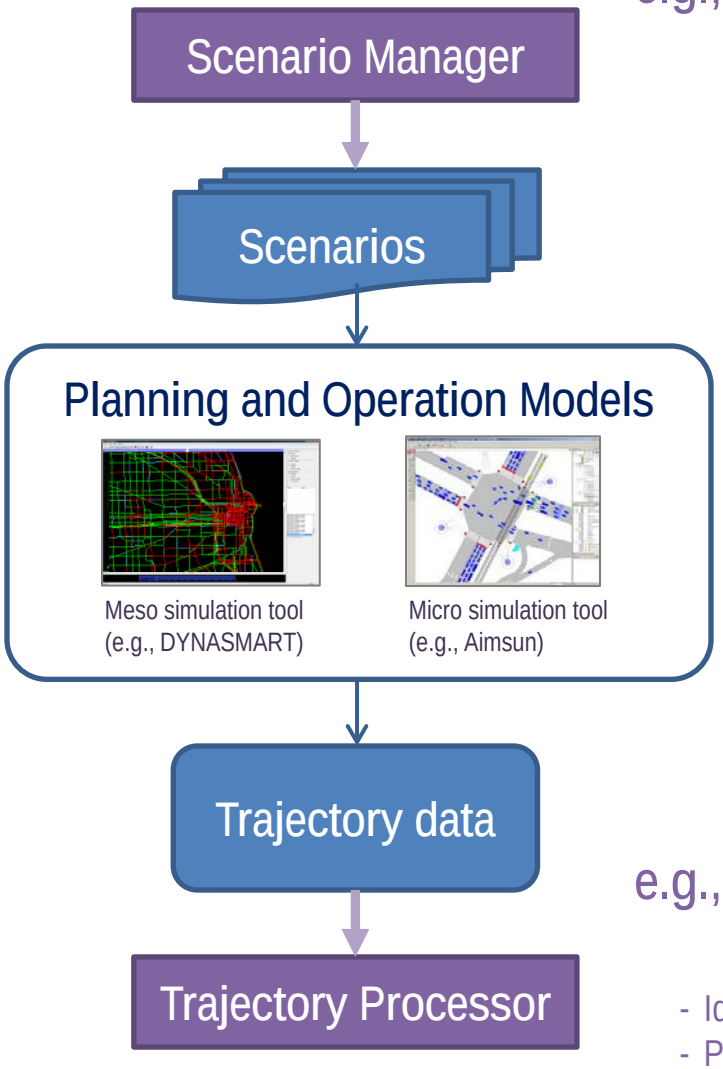
No system for storing, retrieving, sharing, and reusing knowledge

Future Direction: *Scenario Management for Policy and Project Evaluation*

Better Approach

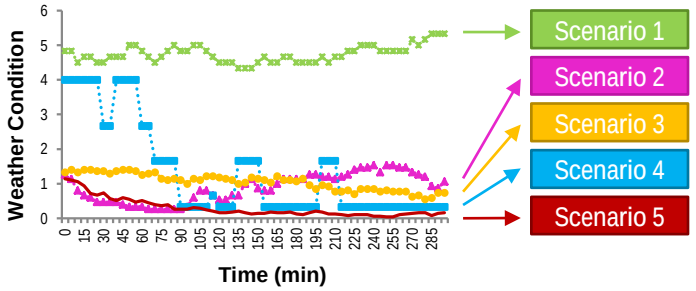


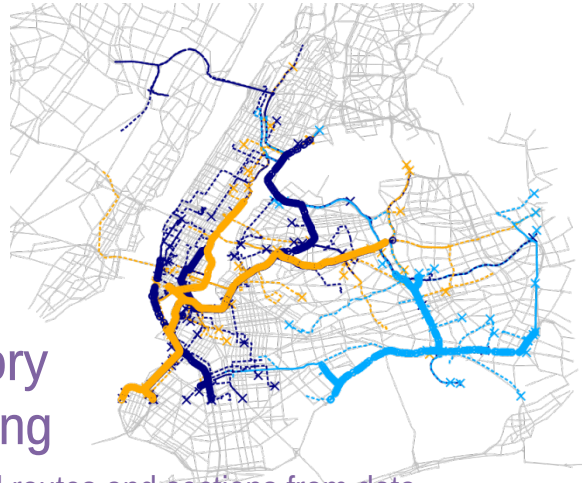
Future Direction: *Incorporating Data Mining Techniques into Pre- and Post- Processors*



e.g., Scenario Clustering

- Identify a few distinct scenarios
- Reduce the number of simulation runs





e.g., Trajectory Clustering

- Identify critical routes and sections from data
- Perform cluster-level travel time reliability analysis

THANK YOU

Q/A




SHRP 2 Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools (L04)

SHRP 2 Tuesdays Webinar Series

September 16, 2014

2 Principal Ways

- New network tools open a way to incorporate travel time reliability in travel demand models:
  - (Single run) Travel time reliability measure added to utility functions in choice models
  - (Multiple runs) Travel demand variation as additional factor for Scenario Manager

Travel Time Reliability Added to Utility Functions of Travel Choices

SINGLE RUN FRAMEWORK

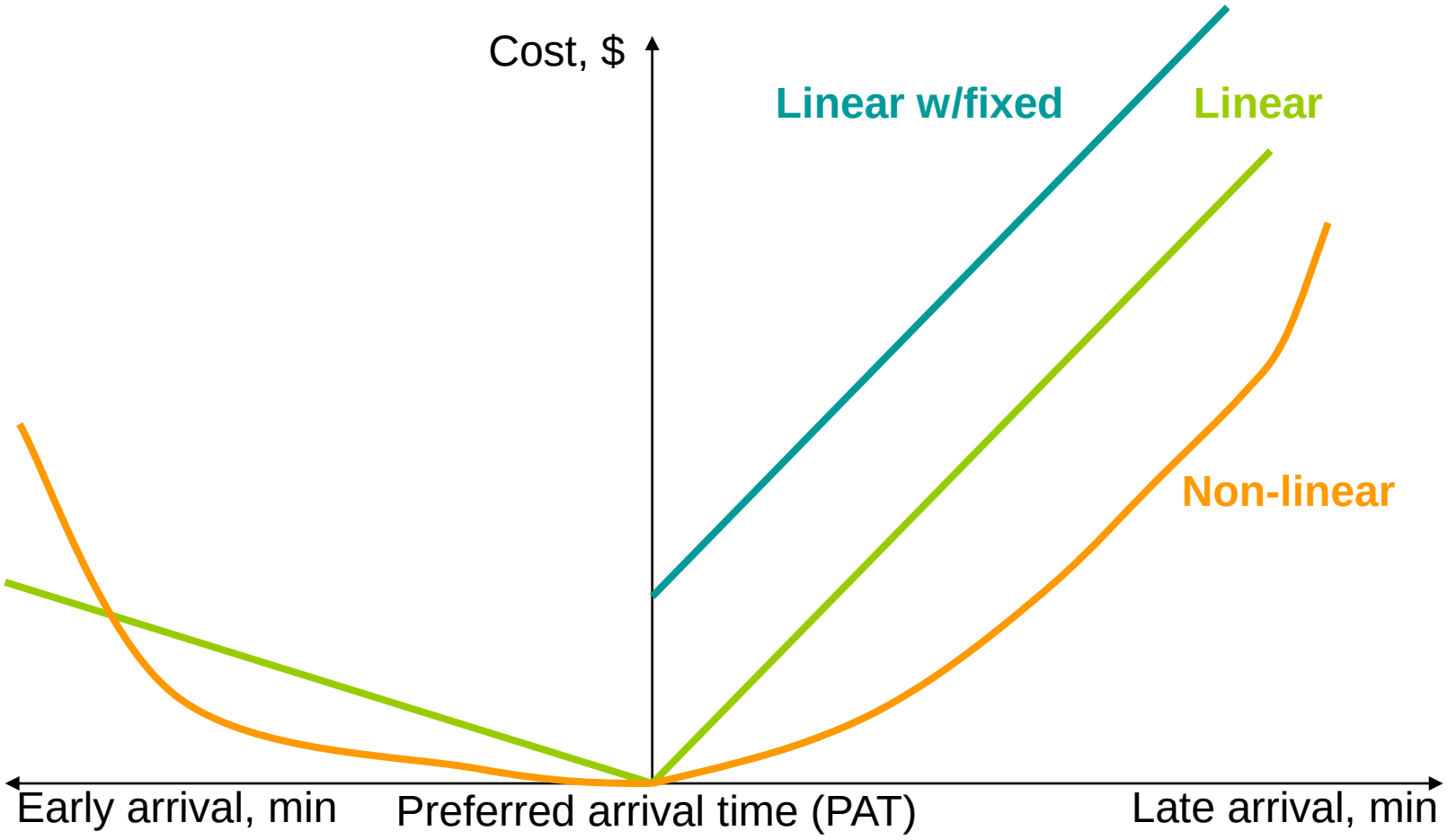
Time Distribution Measures

- (**Mean-Variance**) Standard Deviation (symmetric)
- (**Buffer time**) Difference between 80-90-95th and 50th percentile (asymmetric)
- (**Risk measure**) Probability of delay of certain length (asymmetric)
- (**Lateness measure**) Average delay (asymmetric)

Reliability Ratio (ρ)

- **U = α × Time + β × Cost + γ × Reliability**
  - VOT=**α**/**β**
  - VOR=**γ**/**β**
  - **ρ**=**γ**/**α**=VOR/VOT
- It is more complicated with non-linear models:
  - VOT, VOR, and **ρ** becomes functions of time, cost, or distance
  - These variables must be fixed at certain values to calculate VOT, VOR, and **ρ**

Schedule Delay Cost



Schedule Delay Cost

- $U = \alpha \times T + \beta \times C + \lambda \times SDE + \gamma \times SDL + \delta \times L$
- In presence of random travel times:
  - *f(T)* – travel time distribution
  - *E(U)* – expected utility dependent on *f(T)* and departure time/*PAT*
  - Improvement of reliability in terms of *f(T)* can be evaluated in terms of *E(U)*
- Considerable body of literature:
  - SP estimates: $\gamma \geq \alpha$

Recommended Values for ρ

Population segment	Travel segment	Perceived congested time vs. free-flow	STD vs. mean time	Buffer 90th-50th vs. median time	Lateness against PAT vs. mean time
High income (60K+)	To work	2.0	0.8	1.0	3.0
	From work	1.5	0.6	0.7	2.0
	Non-work	1.2	0.4	0.5	1.8
Low income (U60K)	To work	2.5	1.0	1.2	6.0
	From work	1.2	0.3	0.4	1.7
	Non-work	1.1	0.2	0.2	1.5

Differences across Income Groups

- Low-income workers compared to high-income workers:
  - More constrained schedules
  - Higher sensitivity to reliability although VOT is lower
- Social equity concerns w.r.t. low-income commuters revisited:
  - More opportunities to carpool
  - Benefit from improved reliability even more
  - HOT lanes will be very beneficial

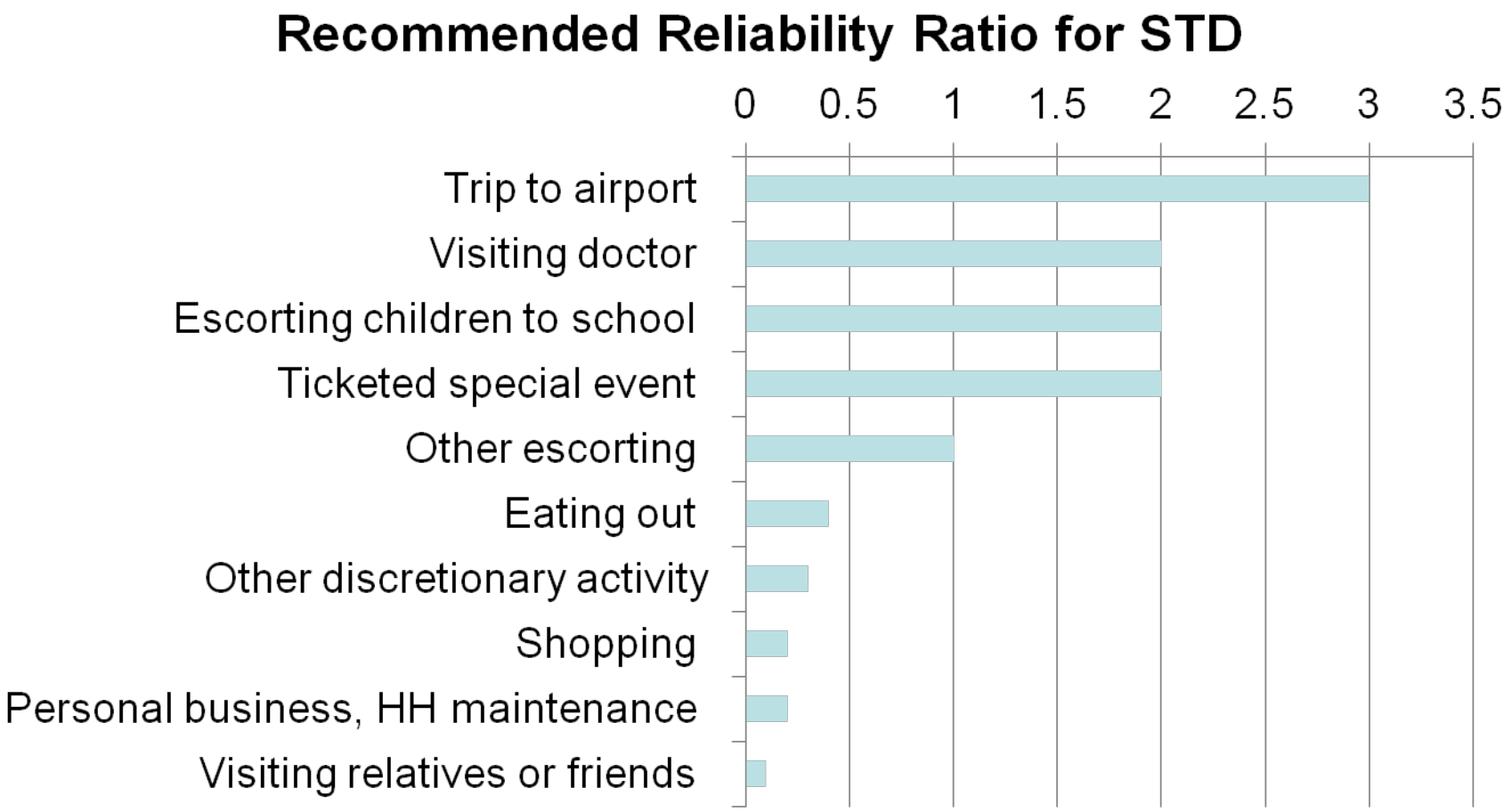
Summary for Willingness to Pay

Income	To work		From work		Non-work	
	Average travel time savings	Reduction in STD of travel time	Average travel time savings	Reduction in STD of travel time	Average travel time savings	Reduction in STD of travel time
$25,000	$6/h	$5/h	$5/h	$1/h	$4/h	$1/h
$50,000	$10/h	$8/h	$8/h	$2/h	$7/h	$2/h
$75,000	$15/h	$11/h	$12/h	$4/h	$12/h	$4/h
$100,000	$20/h	$13/h	$15/h	$8/h	$16/h	$6/h
$150,000	$28/h	$17/h	$21/h	$12/h	$23/h	$9/h
$200,000	$34/h	$21/h	$26/h	$16/h	$30/h	$12/h

Difference across Trip Purposes

- Reliability is crucial for fixed-schedule activities
- Schedule constraints not yet in travel models in practice; trip purpose and direction as proxy:
  - Trips to work – highest VOR
  - Trip from work – median VOR
  - Non-work trips – lowest VOR:
    - Some can have rigid schedule constraints thus more details can be added

Possible Details for Non-Work Trips



Improving Mode Choice

- Reliability measure (STD) in mode choice:
  - Largely eliminates geography-specific mode-specific constants ("Transit to CBD")
  - Explains choice of toll route vs. free route in addition to travel time savings; eliminates bizarre positive toll bias
  - Accounts for advantages of reliable modes such as Rail and dynamically priced toll road/lane
- Transit reliability has to be incorporated as well

Improving TOD and Destination Choices

- TOD and Destination Choices affected by Reliability through mode choice logsums:
  - Explain peak spreading with growing congestion for future years
  - Helps explain impacts on commercial activity in addition to average travel times

Travel Demand Scenarios

MULTIPLE RUN FRAMEWORK

Sources of Variability of Travel Demand

- Day-to-Day:
  - Inherent randomness of base demand (trips made by residents)
  - Trips made by visitors
  - Impact of weather (on travel demand!)
- Special events:
  - Mini trip table for each event

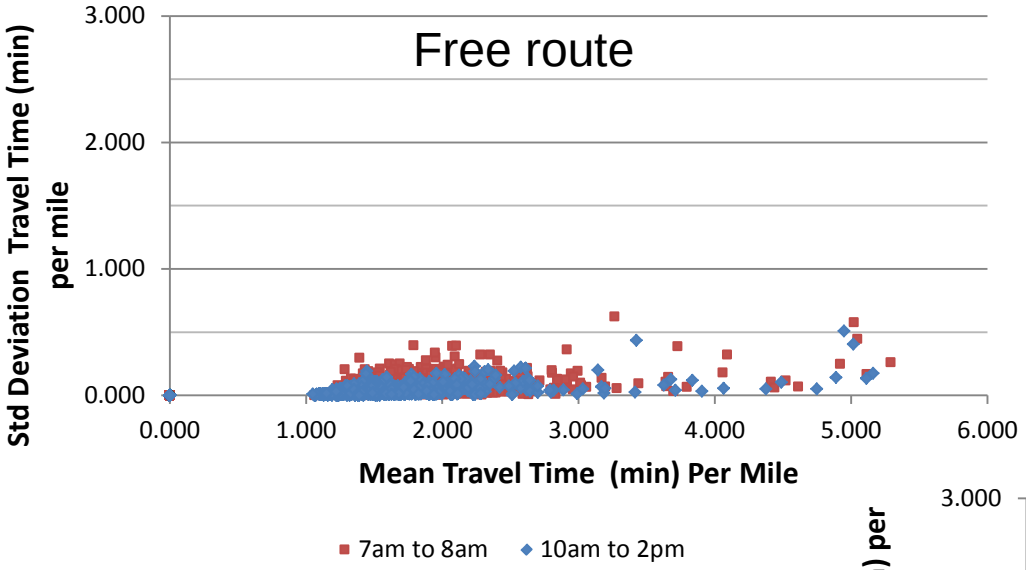
Observed Daily Levels of Variation in Trip Generation

Land-use type	STD of daily trip generation
Residential area (population-based trip rate)	1-2%
Industrial area (employment-based trip rate)	2-5%
Offices area (employment-based trip rate)	5-10%
Commercial area (retail employment-based trip rate)	5-20%
Hotel / visitor / entertainment area-based trip rate)	10-30%

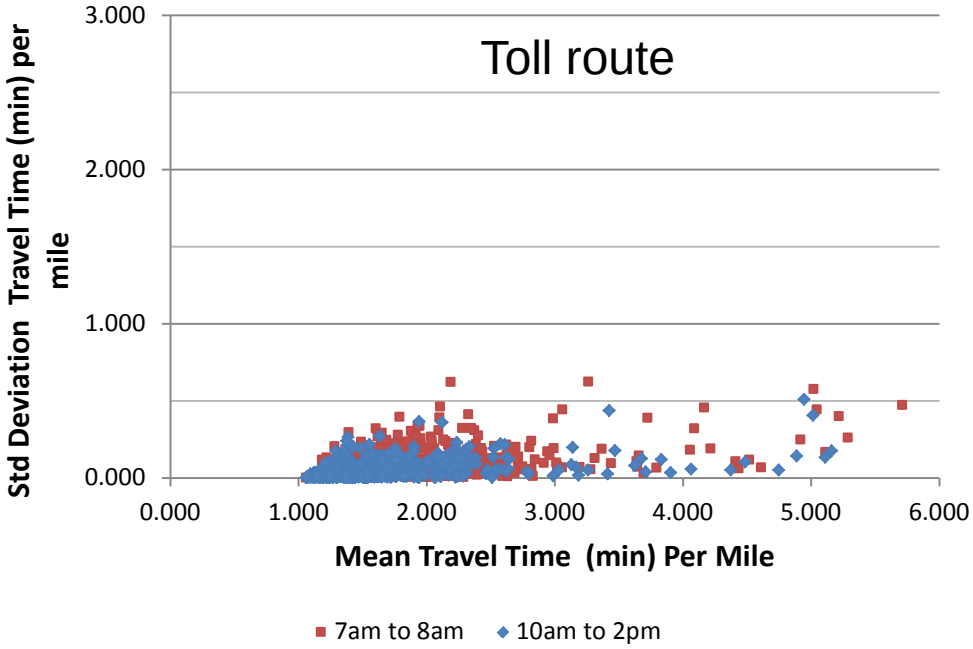
Practical Approach to Generate Demand Scenarios (Day-to-Day)

- Base year:
  - 10-20 demand scenarios (trip tables) by adjustment of average trip table to scenarios of contemporaneous sets of traffic counts
  - Robust stat relationship between the level of variation (STD/mean) and land-use variables
- Future years (handled through Scenario Manager):
  - 10-20 demand scenarios by of production and attraction variation factors as functions of land-use:
  - Average trip table factored for each scenario

New York Region Example



Reasonable generation of travel time distribution through multiple runs



Conclusions

- Travel demand is sensitive to reliability:
  - Mode choice
  - Other choices through mode choice logsums & accessibility measures
- (Single run framework) travel demand model needs only minor adjustment:
  - Add travel time reliability measure to mode choice utility function
- (Multiple run framework) travel demand scenarios:
  - Time taking but can address specific details

SHRP 2 L04 Project Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools: Implementation plan

John Halkias, Ph.D, P.E.
FHWA, Office of Operations

Implementation Plan

Objective:

Assist Public Agencies (i.e., State DOTs, MPOs, etc.) in moving Reliability into their business practices through the piloting of the SHRP 2 L04 products, where the application of these products will be demonstrated

Implementation Plan

What We Heard:

- Held a workshop at TRB to bring together software vendors of traffic simulation models the discuss the products
- Broader implementation is more likely if vendors incorporate these products in their commercial models
- State DOTs need to request or push the L04 products
- Advanced modeling capabilities required
- Pilot testing is needed to further demonstrate the application and usefulness of these products

Implementation Plan

Our Approach:

- Released RFP to pilot the products developed by SHRP 2 L04 in two sites
- Received and evaluated proposals and recommended a Contractor
- The award is expected this month

Implementation Plan

The Study:

- To demonstrate how the products can be integrated into an agency's business processes to improve its capability to analyze and improve travel time reliability
- To provide feedback to FHWA on the applicability and usefulness (benefits and value) of the products piloted and lessons learned
- Recommend potential refinements and approaches for implementation in other agencies

Implementation Plan

The Study (con't):

- Developing a Data Collection Plan with demand and supply characteristics and sources of variation
  - Demand – special events, closure of alternate modes, day-to-day variation in individual behavior, visitors, etc.
  - Supply – incidents, work zones, adverse weather, variation in individual driver behavior, traffic control, etc.
- The Plan will have data collection methods and platforms, types and coverage for both spatial and temporal data, the required level of detail and accuracy, and other relevant data needs

Implementation Plan

The Study (con't):

- Developing an Analysis Framework
  - Travel Time Reliability Analysis plan that incorporates the two essential components, the Scenario Manager and the Trajectory Processor
- Proof of Concept Pilots
  - Two Pilot Sites to be selected to demonstrate the application and usefulness of these two products
    - One site will be a corridor site and the other on a broader regional scope
    - Working in partnership with the public agencies in those sites
- Developing a Proof of Concept Test Plan using the data identified and the Analysis Framework
- Will analyze the baseline reliability issues (operational conditions) and alternative strategies Operational strategies) to improve reliability

Implementation Plan

The Study (con't):

- Evaluate the Functionality and Usefulness of the Products
  - Will evaluate the functionality and outcomes that resulted from these two pilots including:
    - The technical feasibility of the products
    - Whether the outcomes were understood by decision makers and regarded as credible
    - Lessons learned in using the products
    - Deployment tips
- Goal is to mainstream Operations, with a Reliability focus, in the Planning and Decision-Making Process