SHRP2  Round 7
Implementation Assistance Program Webinar

Reliability in Simulation and Planning Models (L04)

March 16, 2016
Agenda

• SHRP2 Overview
  ▪ SHRP2 at a Glance
  ▪ Focus Areas
  ▪ Implementation Update
• Implementation Assistance Program
• Reliability in Simulation and Planning Models (L04) product description
• Implementation assistance opportunities timeline
• Questions
SHRP2 at a Glance

• **SHRP2 Solutions** – 63 products

• **Solution Development** – processes, software, testing procedures, and specifications

• **Field Testing** – refined in the field

• **Implementation** – 350 transportation projects; adopt as standard practice

• **SHRP2 Education Connection** – connecting next-generation professionals with next-generation innovations

350 SHRP2 projects nationwide
Focus Areas

**Safety**: fostering safer driving through analysis of driver, roadway, and vehicle factors in crashes, near crashes, and ordinary driving

**Capacity**: planning and designing a highway system that offers minimum disruption and meets the environmental and economic needs of the community

**Renewal**: rapid maintenance and repair of the deteriorating infrastructure using already-available resources, innovations, and technologies

**Reliability**: reducing congestion and creating more predictable travel times through better operations
SHRP2 Implementation: Moving Us Forward

- **Funding Assistance:** $122 million
- **SHRP2 Solutions:** 63
- **Projects Implemented:** 350

Recipient Breakdown:
- DOT: 52 Recipients
- MPO/Local: 29 Recipients
- University: 10 Recipients
- Federal/tribal: 7 Recipients

- **Renewal:** 179
- **Capacity:** 95
- **Reliability:** 65
- **Safety:** 11
SHRP2 Implementation: Moving Us Forward

145,831
PARTICIPANTS ENGAGED

5,713
OUTREACH ACTIVITIES

6,155
HOURS OF TECHNICAL ASSISTANCE

TRAINING: 5,474
WORKSHOPS: 152
PEER EXCHANGES: 40
DEMOS: 29
SHOWCASES: 18
SHRP2 Implementation Assistance Program

- Designed to help State DOTs, MPOs, local agencies, and other interested organizations deploy SHRP2 Solutions.

<table>
<thead>
<tr>
<th>Proof of Concept Pilot</th>
<th>Lead Adopter Incentive</th>
<th>User Incentive</th>
</tr>
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<tbody>
<tr>
<td>To evaluate product readiness.</td>
<td>To help offset costs associated with product implementation and risk mitigation.</td>
<td>To support implementation activities, such as conducting internal assessments, changing processes, and organizing peer exchanges.</td>
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Challenge

- Agencies are increasingly concerned both with improving travel-time reliability and producing performance measures to track their progress.
- By enhancing traffic simulation and planning models, agencies can better produce performance measures that would show the relationship between certain projects and strategies and how they could affect travel-time reliability.

Solution

- Application guidelines for incorporating reliability into micro- and meso-simulation models that identify key steps for integrating demand and network models.
- First-generation software that offers a new way of applying simulation models.
Benefits

• Closes an important gap in the underlying conceptual foundations of travel modeling and traffic simulation.

• Can provide a practical means of generating realistic reliability measures using network simulation models in a variety of application contexts.

• Useful for evaluating the effects of scenarios, strategies, projects, or practices on non-recurring congestion.
Scenario Manager
- A preprocessor that produces randomized input into simulation models in regards to incidents, work zones, weather, etc.

Vehicle Trajectory Processor
- A post-processor that portrays the variability in travel-time and reliability performance metrics from origins to destinations and for segments and links.
Sources of Congestion & Travel-Time Variation

**Demand side:**
- Special events
- Day-to-day variation in individual behavior
- Visitors
- Closure of alternative modes

**Supply side:**
- Incidents
- Work zones
- Weather
- Variation in individual driver behavior
- Traffic control
- Dynamic pricing
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.
Generating Scenarios

Monte Carlo Sampling

- Random draw from the distribution of the input parameters
  - Realization 1: weather+incident ($X_1$)
  - Realization 2: Incident ($X_2$)
  - Realization 3: No event ($X_3$)
  - Realization N: weather ($X_N$)

- Traffic Simulation model
  - Output ($Y|X_1$)
  - Output ($Y|X_2$)
  - Output ($Y|X_3$)
  - Output ($Y|X_N$)

- Travel time distribution aggregated over multiple scenarios

- Overall travel time reliability for given spatial and temporal boundaries
Generating Scenarios

Scenario-based Approach

- Normal day Scenarios ($S_0$)
- Accident Scenarios ($S_1$)
- Work-zone Scenarios ($S_2$)
- Heavy Rain Scenarios ($S_n$)

Traffic Simulation model

Output ($Y|S_0$)

Output ($Y|S_1$)

Output ($Y|S_2$)

Output ($Y|S_n$)

1-$p(S_1)$

$p(S_1)$

$p(S_2)$

$p(S_n)$

Travel time distribution weighted by scenario probabilities

Travel time reliability considering accidents (e.g., travel time reliability considering 5% accident rate on a road section)

Travel time reliability in the presence of work zone

Travel time reliability considering weather events (travel time reliability considering 10% chance of heavy rain)
Two Common Questions Addressed in Reliability Analysis

1. **What is the overall travel-time reliability of a given network for a given time period?**
   - e.g., What is the travel-time reliability of a road section during morning peak (6 a.m. and 10 a.m.) between April and June?
   - Monte Carlo (MC) sampling
     1. Simulate randomly generated multiple scenarios.
     2. Obtain reliability measures from aggregated travel time distribution.

2. **What is the travel-time reliability considering a certain scenario component?**
   - e.g. What is the probability of at least one incident occurring on the selected area during morning peak period (6 a.m. and 10 a.m.)?
   - Scenario-based approach
     1. Perform MC to generate random scenarios and calculate the probability of the scenario of interest.
     2. Obtain reliability measures from weighted travel time distribution.
• Construct scenarios that entail any mutually consistent combination of external events, demand, supply, and traffic control elements of the simulation model.
Scenario Generation Procedure

**Scenario Components**
- Weather
- Incident
- Demand

**Input**
- Historical Weather Data
- Historical Incident Data
- Average Demand / Daily Variation Data
- Network Map

**User-defined**

**Deterministic**
- Use existing scenario files for all scenario components (e.g., incident.dat, weather.dat)

**Partially Randomized**
- Use existing scenario files for certain scenario components (control variables)
- Use MC sampling for other scenario components (random variables)

**Random sampling**

**Fully Randomized**
- Use MC sampling for all scenario components
Vehicle Trajectory Processor

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

Vehicle trajectories

- Travel time by lane, link, path and trip (O-D)
- Travel time distribution

Performance indicators:
- Travel time variance
- 95th Percentile Travel Time
- Buffer Index
- Planning Time Index
- Frequency that congestion exceeds some expected threshold

Preferred arrival time

Experienced vehicle travel time and actual departure time

User-centric measures:
- Probability of on time arrival
- Schedule delay
- Volatility
Constructing Travel-Time Distributions

Scenario-based Reliability Analysis

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

Scenario 1

Scenario 2

: 

Scenario N
Key Features in Trajectory Processor

• Process vehicle trajectories (simulation output or actual observations) to construct travel-time distributions.
  – Generate a combined travel-time distribution aggregated over different scenarios and measure an overall travel time reliability.
  – Generate a weighted travel-time distribution and associated reliability measures based on scenario probability.

• Extract various reliability measures to quantify and qualify travel-time variability.
  – Standard deviation, Buffer Index, Planning Time Index, Percent on Time, Misery Index.

• Present and visualize reliability indicators at different levels of detail (e.g., network, OD, path, segment) to support scenario comparison and evaluation.
Incorporating Reliability into Modeling Tools

Wayne Kittelson
Senior Principal Engineer
Kittelsoon & Associates, Inc.
Project Team

• Federal Highway Administration
  – John Halkias (Innovative Operations Strategies Team Leader)
  – Doug Laird (Congestion Management and Pricing)
  – James Sturrock (ITS Operations Engineer)
  – Tracy Scriba (SHRP2 Reliability Coordinator)

• Maricopa Association of Governments (MAG)
  – Sarath Joshua
  – Eric Nava

• Metro
  – Peter Bosa
  – Dick Walker
Pilot Test Stakeholders

- **Southwest Corridor (Portland, OR)**
  - Metro
  - ODOT
  - City of Portland
  - Washington County

- **Phoenix AZ Freeway System**
  - FHWA – Arizona Division
  - MAG
  - ADOT
  - City of Phoenix
  - Maricopa County
Purpose

- Demonstrate the usefulness of reliability metrics
- Build upon already-completed work
- Employ accessible models and methods
Why Incorporate Reliability into Planning Models?

- Travel time has been the traditional mobility measure for a corridor but it’s not a complete descriptor of the traveler’s experience.
Traditional Method
Analytic Tools That Do Not Incorporate Reliability:
- The effect of the proposed operational improvement will be to change the **weekday p.m. peak hour level of service (LOS) from F to D.**

*Often calibrated to a single day’s traffic count.*

Value-Added Method
Analytic Tools That Incorporate Reliability:
- The effect of the proposed operational improvement will be to reduce the number of **peak hour failures from 15 per month to 5 per month.**

*Requires more data for baseline and multiple scenarios.*
Project Overview

MAG Regional Subarea Pilot Test Site

- Entire freeway system is included
- 19 corridors and 366 loop detectors
- Demonstrates tool applicability to a large subarea
**Southwest Corridor Pilot Test Site**

- Multimodal analysis opportunities
- Includes major arterial and parallel freeway
- DynusT already calibrated and operational

Sources of unreliability are all in play

- Weather
- Crashes
- Special events
- Work zones
L04 Pilot Test Analysis Approach

Whole-Year Data Set

Inter-Seasonal Cluster Analysis

- Aggregate to system level
- Aggregate to 4-hour period
- Associate each day w/ its solar season
- Use mean, max, min, and STDEV
- Enumerate seasons

X Distinctive Seasons

Intra-Seasonal Cluster Analysis

- Aggregate to system level
- Aggregate to 4-hour period
- Use mean, max, min, and STDEV
- Enumerate intra-season clusters
- Tabulate transition probabilities

Cluster Analysis Variables:

- Demand (Total VMT during 4-hr period per lane-mile)
- Speed (Avg space-mean speed during 4-hr period, mph)
- Crash Duration (# hrs of crash presence per 4-hr period per lane-mile)
- Crash Severity (# lanes blocked during 4-hr period per lane-mile)
- Weather (# min in each weather type during 4-hr period)
  - Clear
  - Light rain
  - Medium rain
  - Heavy rain

Scenario Development

- Season-by-season analysis
- 15-minute aggregation of daily data
- SM generates scenarios based on
  - Cluster centroid properties
  - Transition probabilities

DYNUST & NeXTA
Flow Diagram of Tool Application Sequence Process

LO4 Scenario Manager → METRO & MAG Model DynusT → LO4 Vehicle Trajectory Processor (NeXTA) → Proof of Concept Evaluation
Scenario Generator
Conceptual Implementation

Scenario Generator

Weather
Incident
Work Zones
Volume

Scenarios
1.)
2.)
3.)
4.)

DynusT

Vehicle Trajectories Processor

Travel Time
Compare Simulated vs. Observed Travel-Time (Mean and Variability)

<table>
<thead>
<tr>
<th>Route</th>
<th>Time</th>
<th>Simulation (min.)</th>
<th>TomTom (min.)</th>
<th>Trajectory Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Ave @ 74th St to 5th Ave @ 48th St.</td>
<td>7-8 AM</td>
<td>7.7</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>Queensboro Bridge to Madison Ave @ 74th St.</td>
<td>10-11 AM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th Ave @ 74th St to Queensboro Bridge</td>
<td>9-11 AM</td>
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<td></td>
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</tr>
<tr>
<td>Queensboro Bridge to Lexington Ave @ 48th St.</td>
<td>10-11 AM</td>
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Rich Visualization Tool for Subarea Reliability MOEs
New Enhancements

- From DYNASMART trajectory format to DynusT format
- From single-day to multi-day analysis
  - Incorporates multi-scenario capability to accommodate a whole-year analysis
Preliminary Observations – Test Plan Components

- Data Collection
- Calibration and Validation
- TSM&O Strategies
- Analysis Metrics
Data quality (consistency) is currently a challenge

- Corridor travel time & incident characteristics
Southwest Corridor Test Site
I-5 SB

<table>
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<tr>
<th>XX.XX</th>
<th>INRIX-Reported Hourly Corridor Travel Time</th>
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<tbody>
<tr>
<td></td>
<td>Incident Reported in ODOT Incident Log</td>
</tr>
</tbody>
</table>

Cleared 15:19
39 minutes
2 lanes blocked

Cleared 17:54
79 minutes
2 lanes blocked

XX.XX
INRIX-Reported Hourly Corridor Travel Time
Incident Reported in ODOT Incident Log
• Reliability may be more applicable to a system (area) than a corridor (segment).
  – Corridor travel time is often affected by incidents and/or bottlenecks external to the corridor.
Corridor Congestion Originates Externally
Preliminary Observations – TSM&O Strategies

• Importance of factors affecting corridor travel time (most important to least important)
  – VMT
  – Incidents
  – Weather
### Assistance Opportunities

<table>
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<tr>
<th>Type of assistance</th>
<th>Number Available</th>
<th>Amount of assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof of Concept Pilot</td>
<td>2</td>
<td>Up to $200,000 per opportunity</td>
</tr>
</tbody>
</table>

**Who can apply:** State DOTs and MPOs
Round 7 Implementation

- Reliability Analysis Framework.
- Reliability Data Guide.
- Trajectory Validation Framework.
- One microsimulation model and one meso model.
- Develop the product further into a market-ready technology.
Key Opportunities for Future Planning Efforts

• Explicit accounting of sources of travel time variability.
  – Volume fluctuations
  – Incidents
  – Weather
  – Work zones
  – Special events

• Evaluations based on whole-year analysis period and preferably multi-year.

• Incorporation of day-to-day learning and habit forming into driver route-choice decisions.
  – Capability conceived and developed in current project.
  – Time and budget constraints did not allow for detailed testing.
Key Challenges for Future Planning Efforts

• Existing conditions datasets are large and varied with gaps.
  - Cluster analysis may be necessary for a manageable set of scenarios.
  - Data needs to be screened for quality and consistency.

• Corridor improvement strategies usually need to be evaluated in a system context.
  - Requires a subarea or area-wide modeling effort to be undertaken to evaluate corridor improvement strategies.
Recipient Requirements

- Commitment of state DOT or MPO leadership.
- Make it part of the agency’s business process.
- Location or project experiencing significant travel-time variations.
- Active leadership and participation by the agency.
- Commitment to work closely with FHWA, AASHTO and TRB staff.
- Commitment to making institutional changes.
- Willingness to share knowledge and lessons learned.
Application Tips

**Dos**

☑ Make your application clear and concise

☑ Describe your plan to advance reliability into practice at your agency

☑ Describe your plan to conduct your project, including available resources

☑ Describe the outcomes and deliverables you expect to achieve

☑ Expect to share the results of your product implementation

**Don’ts**

☒ Forget that implementation assistance is to advance the use of reliability analysis tools

☒ Assume reviewers are familiar with details about your agency or application settings; your narrative should be complete

☒ Apply without leadership endorsement

☒ Apply if you do not represent a State DOT or MPO

☒ Be late: applications are due by April 29, 2016
Timeline

• Product-specific webinars
  – March 8 – March 22, 2016

• Round 7 application period
  – April 1 – April 29, 2016

• Round 7 recipients announced
  – June 2016
For More Information

Product Leads:
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FHWA Product Lead
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Gummada Murthy
AASHTO Product Lead
gmurthy@AASHTO.org

Additional Resources:
GoSHRP2
Website: fhwa.dot.gov/GoSHRP2

AASHTO
SHRP2
Website: http://shrp2.transportation.org

GoSHRP2
Alert Sign Up: fhwa.dot.gov/goshrp2/contact

Email: GoSHRP2@dot.gov

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