



U.S. Department of Transportation
Federal Highway Administration



SHRP 2 Local Methods for Modeling, Economic Evaluation, Justification and Use of the Value of Travel Time Reliability in Transportation Decision Making (L35)

SHRP 2 Tuesdays Webinar Series

September 9, 2014



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Today's Learning Objectives

Purpose: Highlight the process used to develop, justify, apply, and assess the use of travel time reliability in project evaluation and decision making.

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

- Describe two different approaches to determining the economic value of reliability;
- Discuss how reliability can be incorporated into a number of different types of models and benefit-cost analysis; and
- Summarize key elements of business processes for planning and decision making that a Metropolitan Planning Organization and state department of transportation could use in evaluating project priorities including those with the potential to enhance reliability and improve transportation system management and operations.

PDH Certificate Information



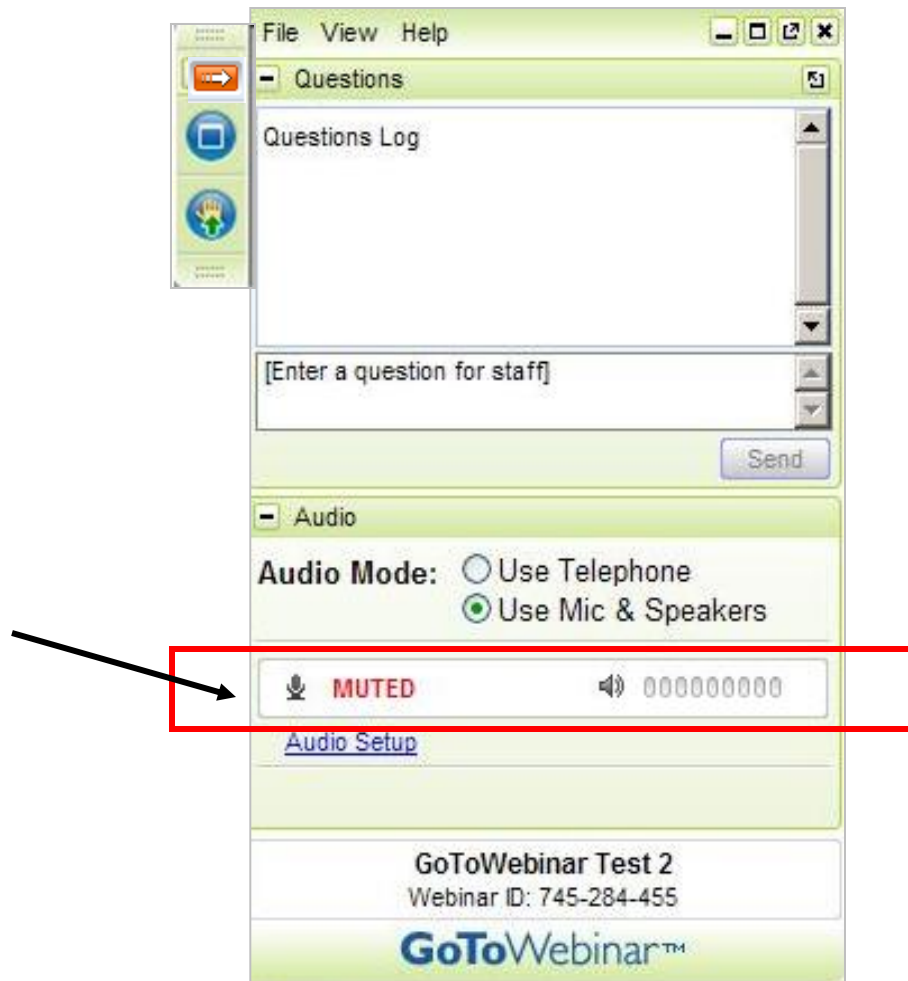
- This webinar is valued at 1.5 Professional Development Hours (PDH).
- Instructions on retrieving your certificate will be found in your webinar reminder and follow-up emails.
- You must register and attend as an individual to receive a PDH certificate.
- TRB will report your hours within one week.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

American Institute of Certified Planners

The logo graphic consists of several parallel diagonal lines in white and blue, extending from the top right corner towards the center of the slide.

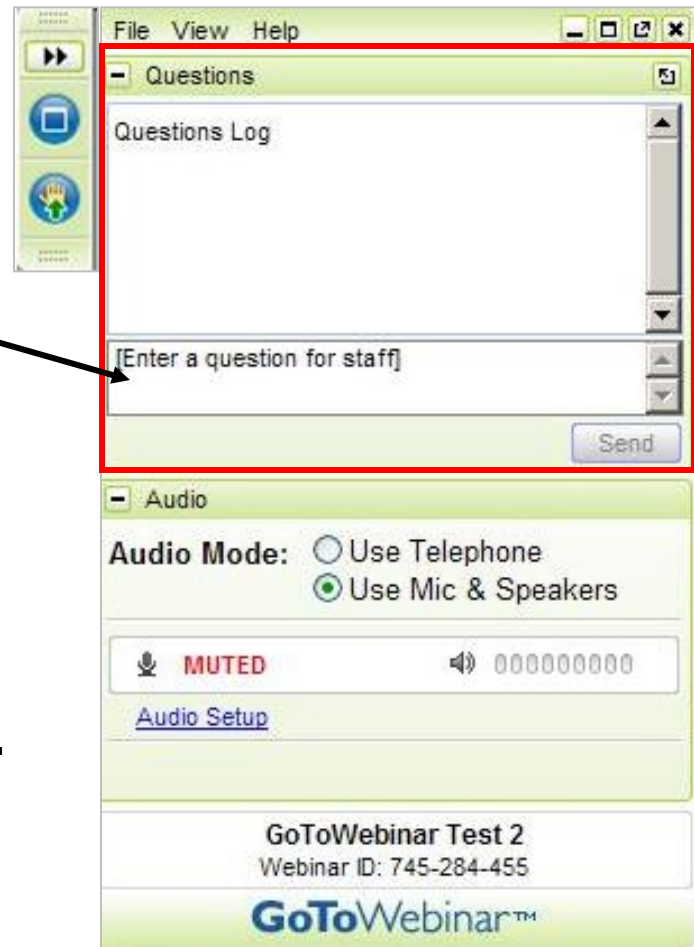
- Attendees may claim 1.5 Certification Maintenance Credits for attending this webinar
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All Attendees Are Muted

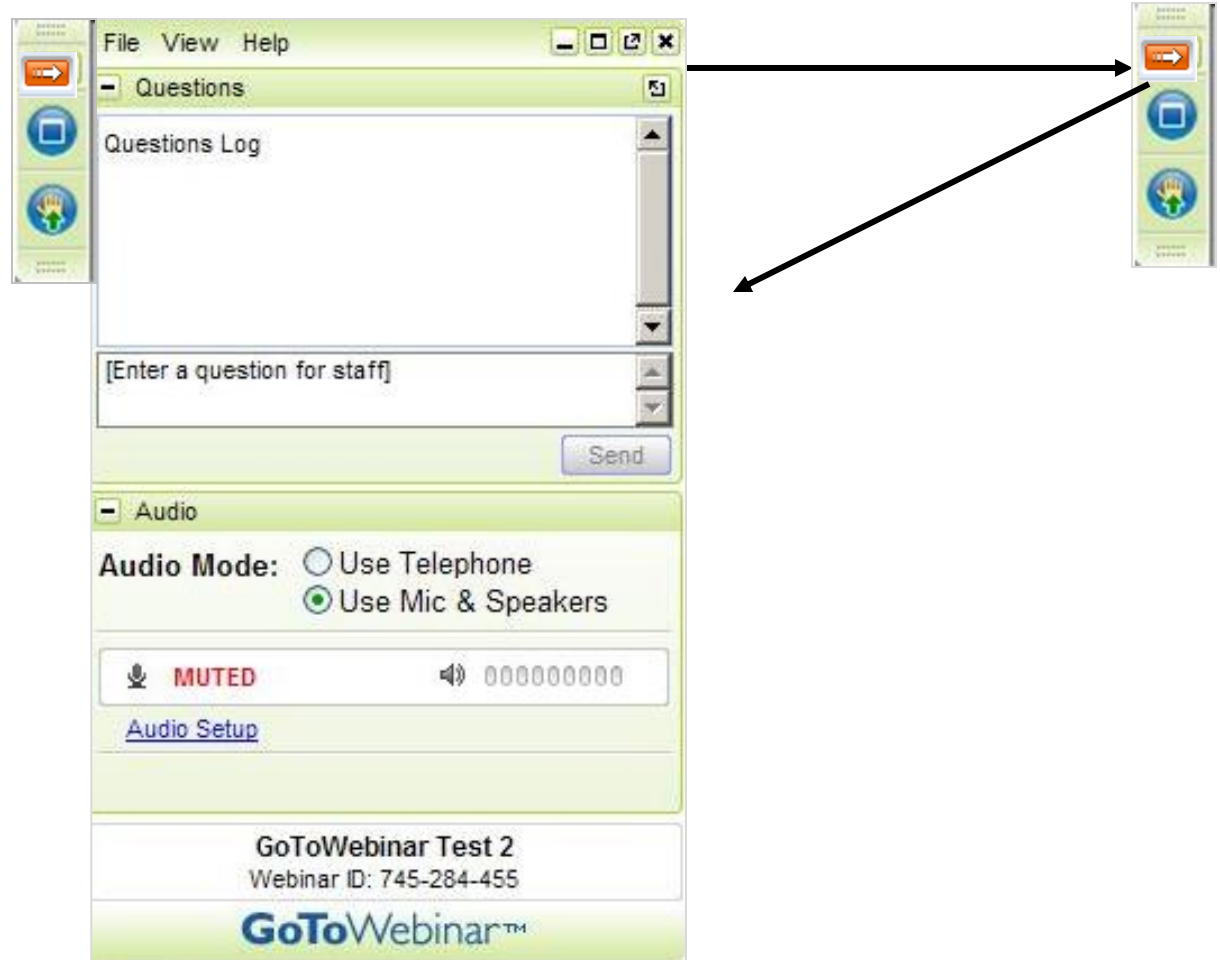


Questions and Answers

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- 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/140909.pdf>

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

Today's Panelists and Moderator

- **Yi-Chang Chiu**, *University of Arizona*
chiu@email.arizona.edu
- **Peter Bosa**, *Portland Metro*
Peter.Bosa@oregonmetro.gov
- **Thomas Jacobs**, *University of Maryland*
tjacobs@umd.edu
- **Richard Taylor**, *Federal Highway Administration*
rich.taylor@dot.gov
- **Steve Andrle**, *Transportation Research Board*
sandrle@nas.edu

Now it's time for a poll question.





Panelist Presentations

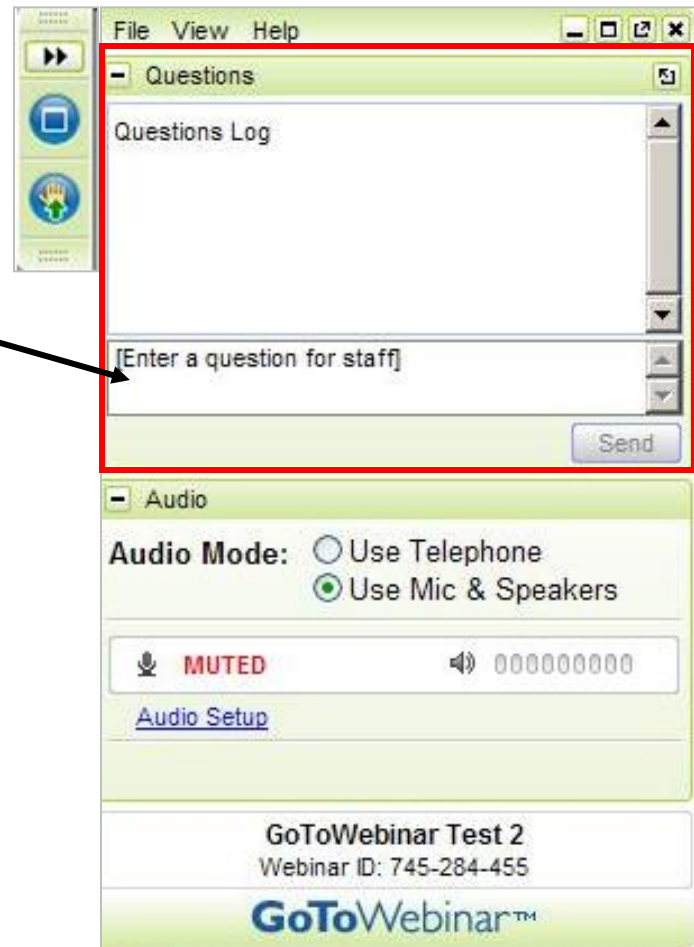
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Local Methods for Modeling, Economic Evaluation, Justification and Use of the Value of Travel Time Reliability in Transportation Decision Making

Project L14

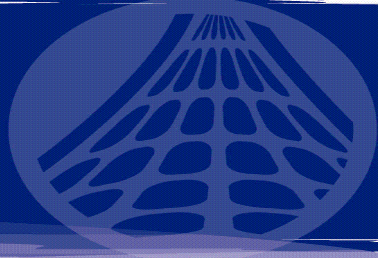
**Steve Andrle
Deputy Director
SHRP 2 Reliability Focus area**

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.

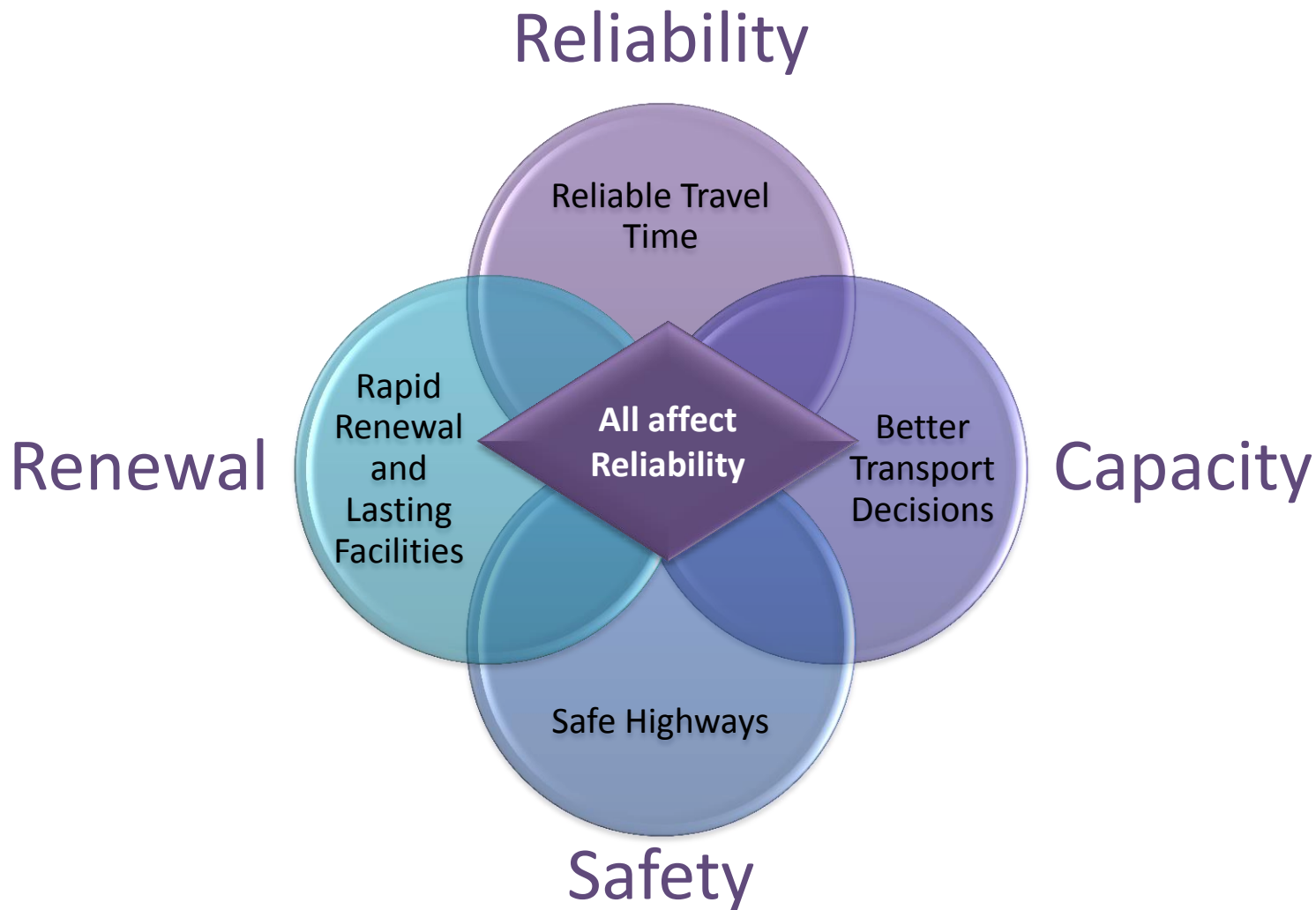


Capacity: to integrate mobility, economic, environmental, and community needs into the planning and design of new highway capacity.



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

FOCUS AREAS



RELATION OF CAPACITY AND RELIABILITY RESEARCH

Capacity Research

Tackles *recurring* congestion



CONGESTION



Reliability Research

Tackles *nonrecurring* congestion



RELIABILITY FOCUS AREA

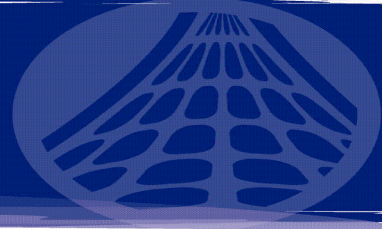
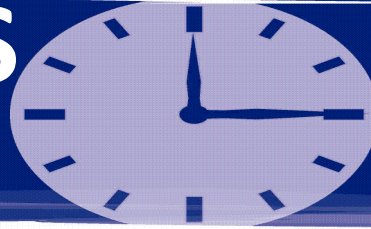
OBJECTIVE



“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

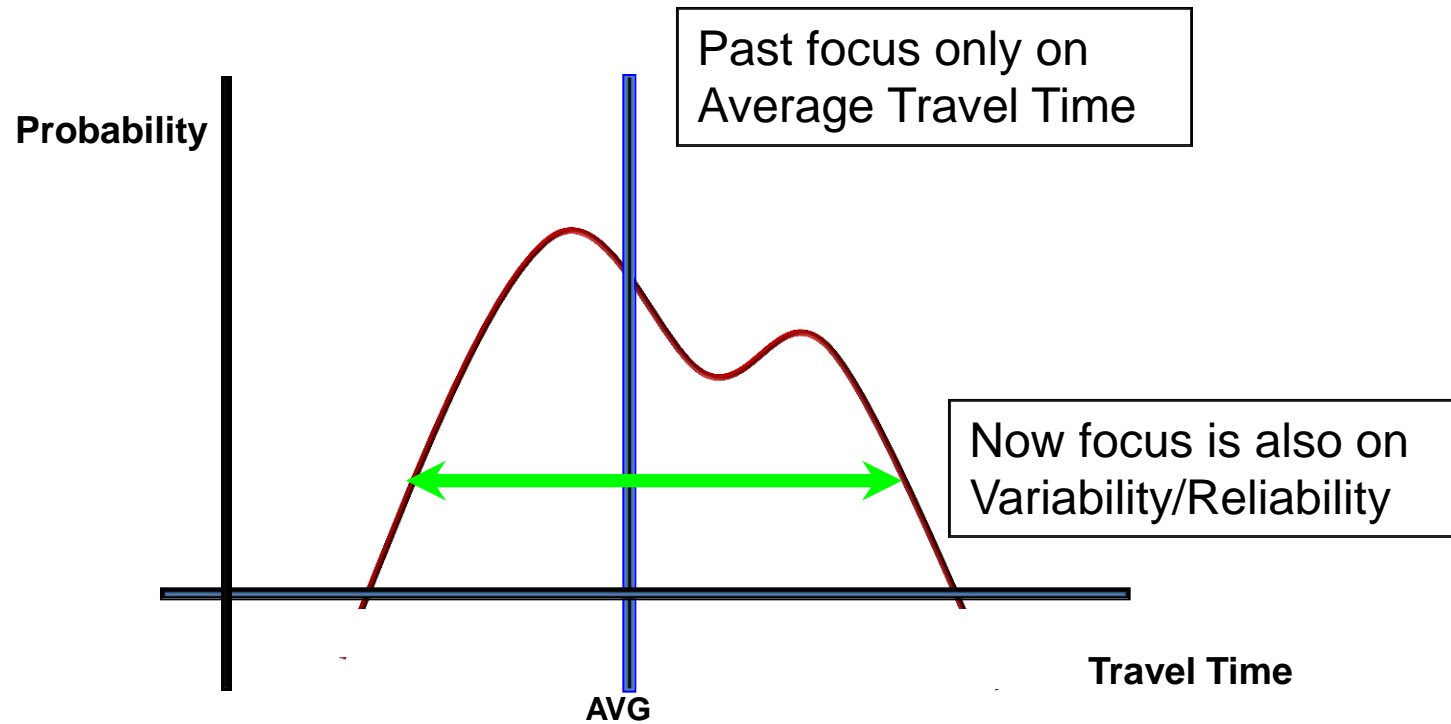


The Reliability Focus Area research has attributed variability in travel time to seven primary causes

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



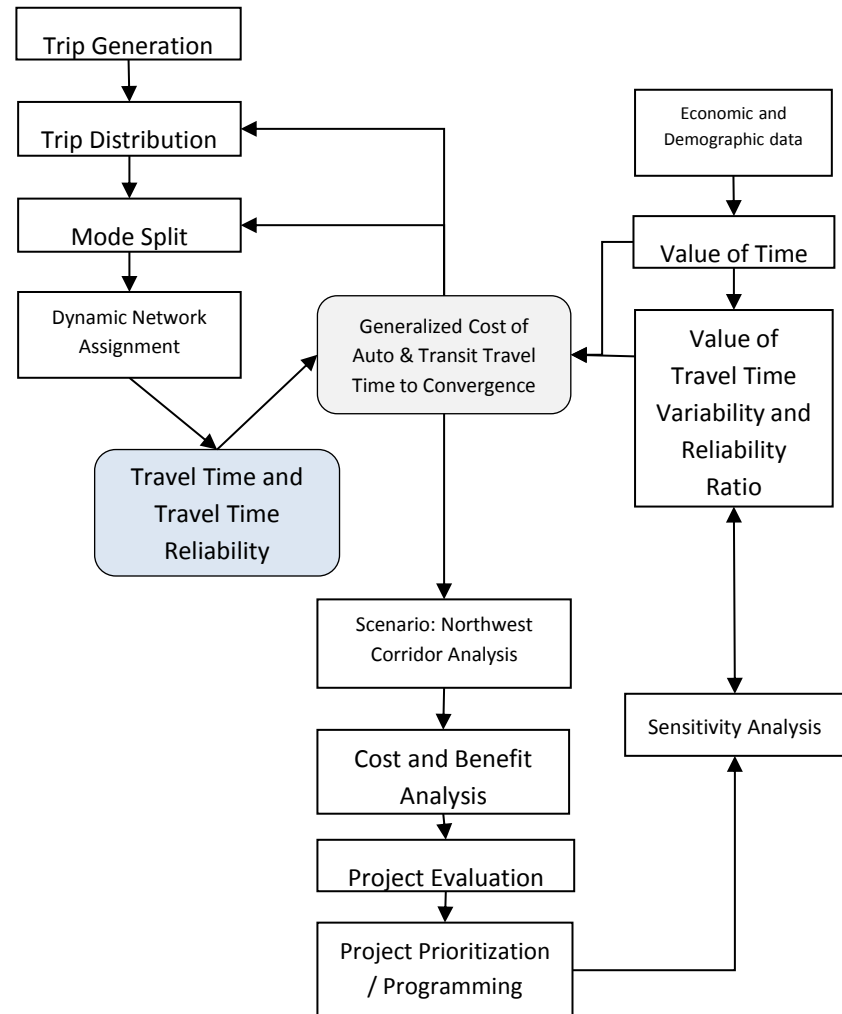
RELIABILITY, A NEW FOCUS



SHRP 2 L35A

PROJECT DETAILS

- What it Did:
- Relevance:
 - Incorporates a Portland-based value of reliability into the local travel demand model for planning and evaluation purposes.
 - Integrates the value of reliability with transit using Fast-TrIPs (flexible assignment and simulation tool for transit)



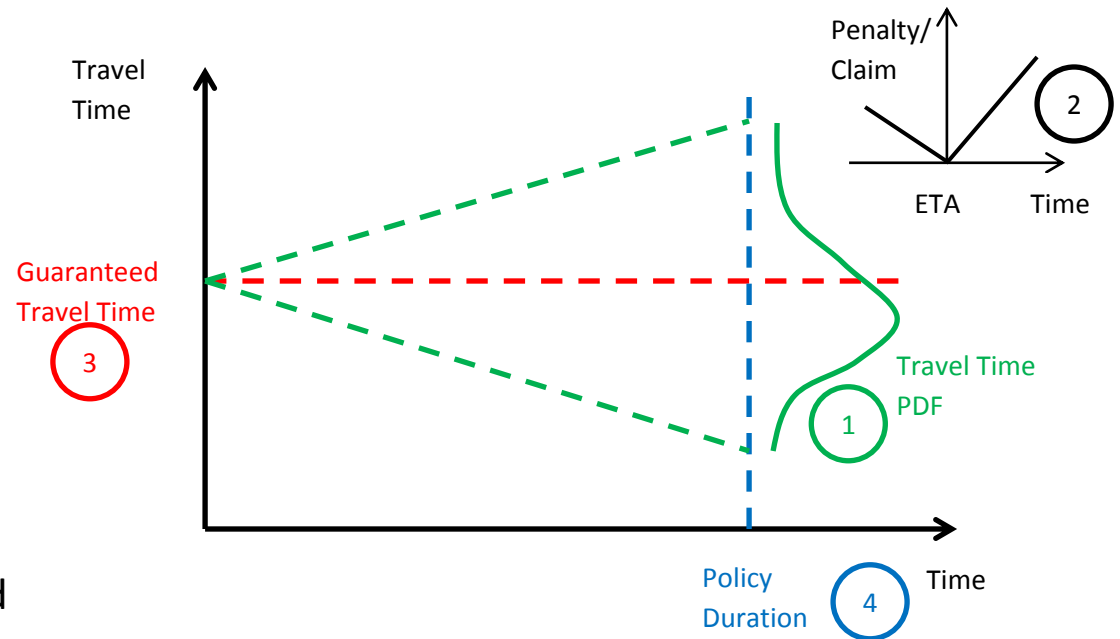
SHRP 2 L35B

PROJECT DETAILS

- What it Did:

- Relevance:

- Develops a new data-driven method to estimate future distributions of travel time which can supplement or potentially supplant revealed and stated-preference survey methods
- Uses local probe-based data to estimate a range of values for reliability that can be applied to project selection processes.



SHRP2 TUESDAYS

Upcoming Webinars

September 9 – “Local Methods for Modeling, Economic Evaluation, and Travel Time Reliability in Transportation Decision Making (L35)”

September 16 – Incorporating Reliability Performance Measures in Operations and Planning Modeling Tools (L04)

Learn about future webinars at
www.TRB.org/SHRP2/webinars



Rich Taylor

Operations Performance Measures &
Management Program Manager

FHWA Office of Operations

September 9, 2014

Travel Time Reliability



- Understanding and measuring Travel Time Reliability is important
 - Understand variations in travel time, why they happen, and what we can do to “normalize” them
- What is the value of Travel Time Reliability?
 - L35 is trying to help answer that
 - Agencies “choose” value of travel time reliability and incorporate it into planning/programming process

Operations & Travel Time Reliability



- Using Travel Time Data and Reliability measures to support Operations
 - Focus on before/after evaluations of projects and operational strategy implementation
 - If projects results in improved travel time reliability, the value of travel time reliability can be applied to produce a cost-based benefit
 - These cost-based benefits and then be used to support future related projects/operational strategy implementation in the planning process

Operations Performance Management



- The core principles of good Operations Performance Management are:
 - Understand how the system performs and report it (*monitor; report*)
 - Understand the benefits/costs of operational strategies and capacity improvements (*evaluate*)

Once these first two items are obtained, then:

- Set goals and/or targets for performance in the area of congestion/mobility/reliability (*manage*)
- Input knowledge of potential solutions to reach goals and/or targets into the planning process (*make data-driven decisions*)
- Invest in strategies/projects that help achieve goals/targets (*make data-driven investments*)
- Evaluate, Report Results and Repeat (*evaluate; report; iterate*)

How Can SHRP 2 Help?



- Travel Time Monitoring Program (L02)
 - Archived Travel Time data for before/after evaluations
- Agency decision on a value of travel time reliability (L35)
- Input into the planning process (L05/L38)
- Use in modeling/simulation (L04)
- Evaluating Alternative Strategies (L11)



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The Estimation and Use of Value of Travel Time Reliability for Multi-Modal Corridor Analysis: L35A Project

Overarching Goals



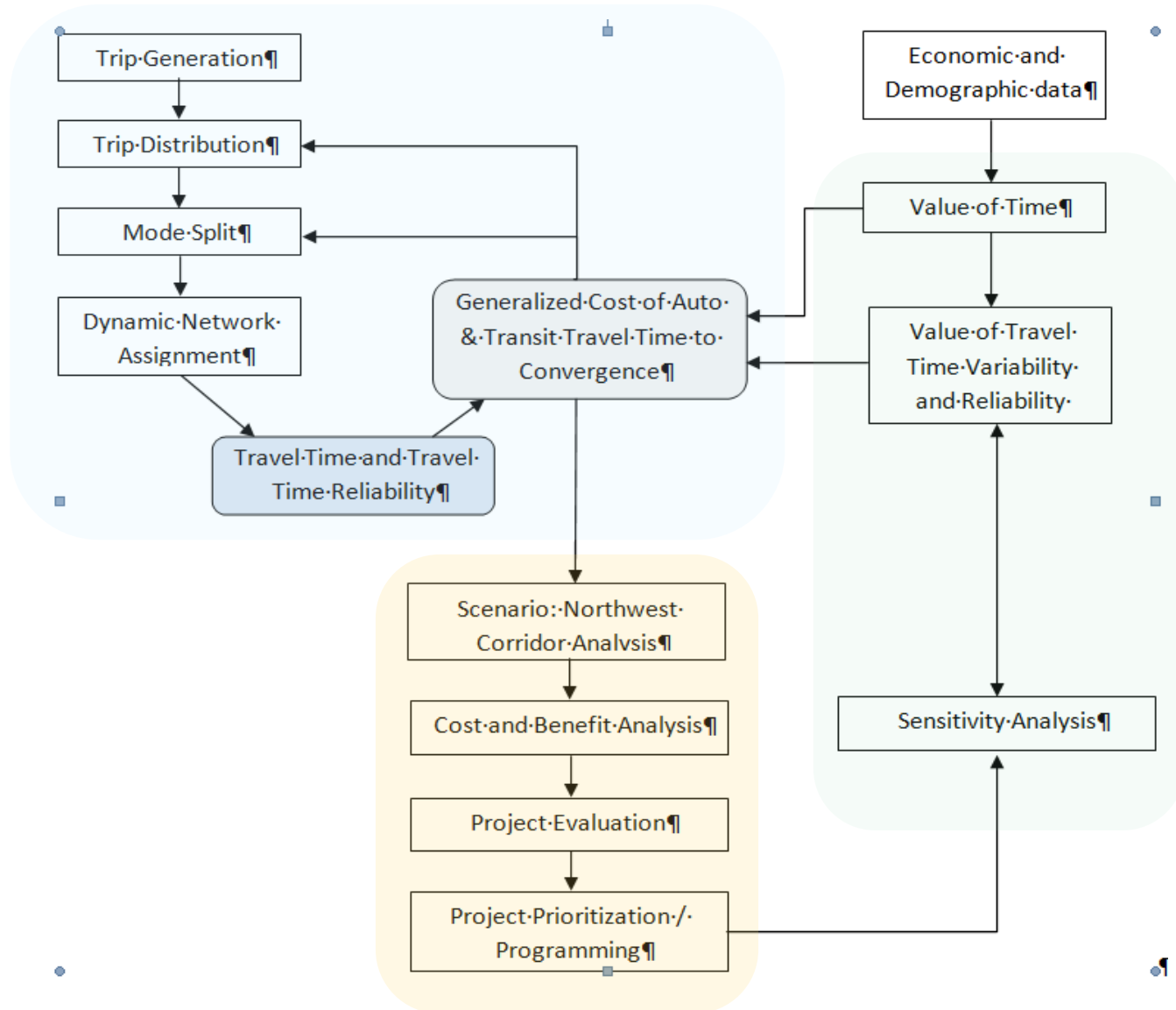
- Demonstrate the economic value and the use of TTRM (**t**ransport **t**ime **r**eliability **m**easures) in project evaluation and program development
- Demonstrate a process to engage policy makers to better understand how reliability measurement would affect scenario assessment outcomes.

Major Accomplishments

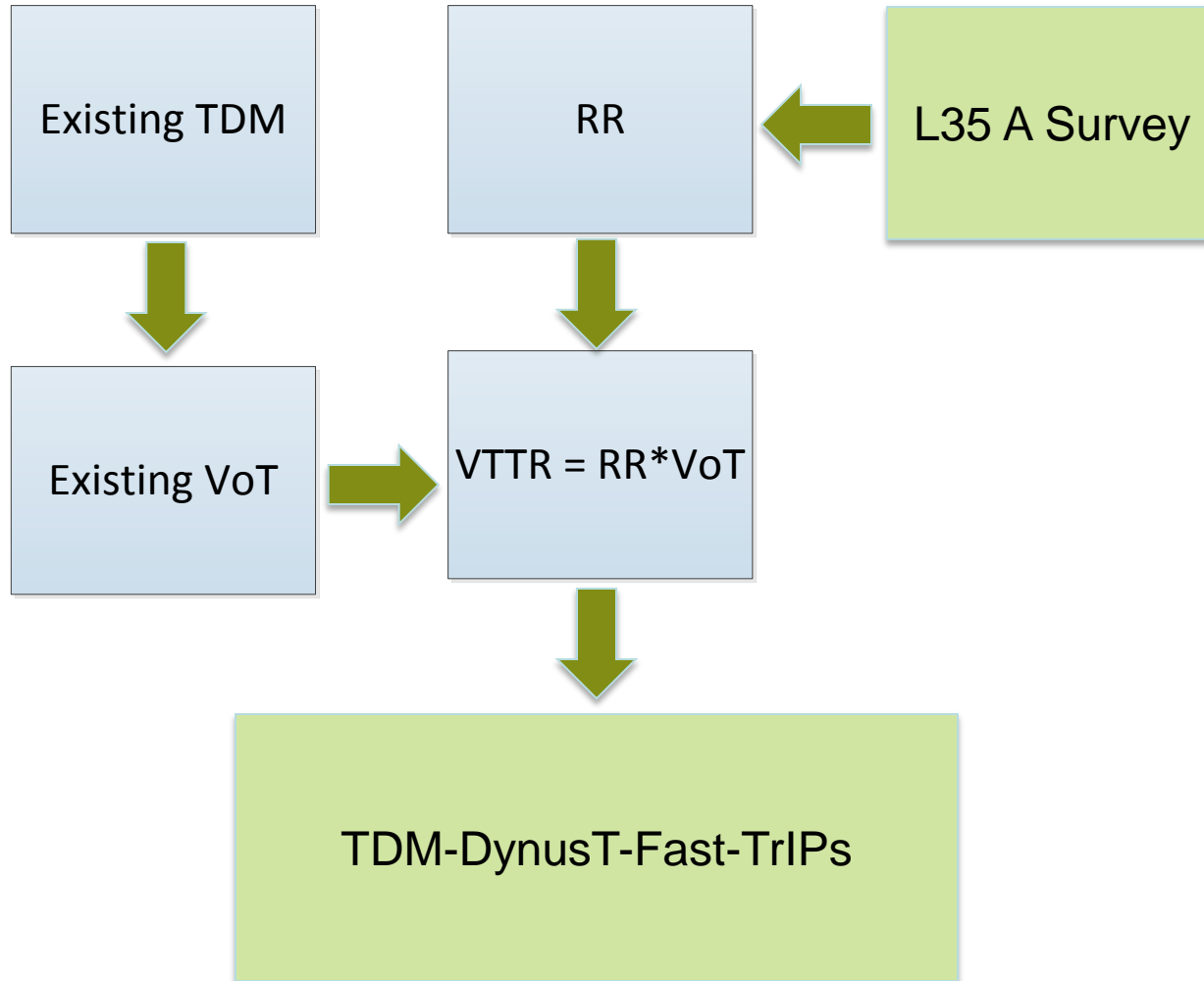


- Methodology – reliability ratio with existing estimated parameters
- Survey – cost-effective and Reliability Ratio
- Modeling significance – trip-based+SHRP2 C10B methods in a feedback framework
- Case study and findings – intuitive and insightful

Research Framework



Incorporating Reliability Ratio

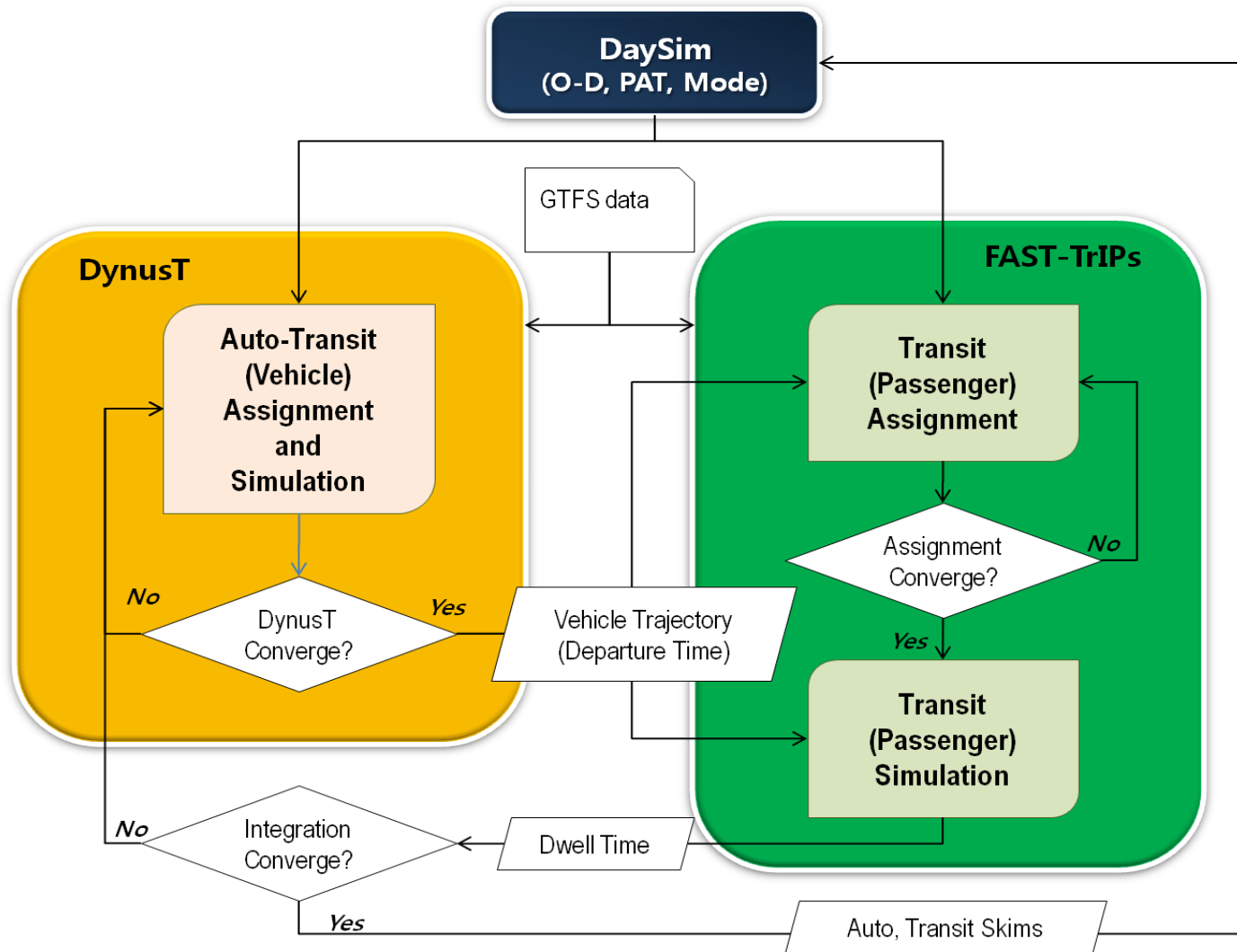


Incorporating Transit Reliability



- Dynamic Transit Assignment
- Model micro passenger-level transit usage decisions
 - Rich passenger behavior
 - Bus stop/park-and-ride facility choice
 - Boarding behavior
 - Transfer
 - Bus overflowing
 - Transit simulation (traffic mix, dwell time, holding, bunching, etc.)

FAST-TrIPs



Reliability Ratio (RR) Estimation

- Phase 1: Clicker exercise at July 2013 Workshop
 - 10+ PG participants
 - Dutch study questionnaire format
 - Estimated RR value: 0.78

18. Which route will you choose?

Route 1

A. Route 1
B. Route 2

Route 2

Route 1	
Start Time 07:00	
16 min	→ 07:36
34 min	→ 07:34
20 min	→ 07:31
40 min	→ 07:30
30 min	→ 07:30

Route 2	
Start Time 07:00	
12 min	→ 07:16
50 min	→ 07:18
22 min	→ 07:27
20 min	→ 07:20
44 min	→ 08:24



Reliability Ratio (RR) Estimation

- Phase 2: Google survey to 36 Metro staff
 - 34 for auto, 24 for transit
- Five questions for each trip purpose
 - Work, peak hour
 - Non-work, peak hour
 - Off-peak

Travel Time Reliability Survey

* Required

Auto travel reliability survey

This is a survey of your choice between two auto routes given the following five-day travel time situations.

There are 15 questions below. All the trips are for auto travel. The given travel time for each route represents your experience of the last five travels on the route under the assumed situation.

Please pick the one that you prefer for your next trip for the given trip purpose (work or non-work) and travel time (peak hour or off-peak).

Work trip, Peak hour *

This refers to a trip to work in the morning peak travel period. Arrival time is important.

☒ Route 1: 22, 13, 17, 20, 12 min

☐ Route 2: 21, 22, 23, 16, 21 min

Work trip, Peak hour *

This refers to a trip to work in the morning peak travel period. Arrival time is important.

☐ Route 1: 33, 14, 22, 41, 10 min

☐ Route 2: 16, 24, 11, 17, 24 min

Work trip, Peak hour *

This refers to a trip to work in the morning peak travel period. Arrival time is important.

☐ Route 1: 50, 55, 31, 33, 55 min

☐ Route 2: 17, 50, 18, 28, 40 min

Reliability Ratio (RR) Estimation

- Model formula $U = \beta_0 + \beta_t T + \beta_r R$
- Reliability ratio = $VTTR/VOT = \beta_r / \beta_t$

	Reliability Ratio	
	Auto	Transit
Work, Peak hour	0.83	1.55
Non-Work, Peak hour	0.35	1.51
Off-peak	0.27	0.76
Overall	0.45	1.06

Reliability Ratio Findings (Auto)

Study	Country	RR
MVA (1996)	UK	0.36 – 0.78
Copley, Murphy et al. (2002)	UK	Pilot survey: 1.3
Hensher (2007)	Australia	0.30 – 0.95
Eliasson (2004)	Sweden	NCHRP 431: 0.80 – 1.10 SHRP 2 C04: 0.40 – 0.90
Mahmassani (2011)	USA	0.8
Significance, et al. (2013)	The Netherlands	Commuting: 0.4 Business: 1.1 Other: 0.6
L35A Study	USA	0.27 – 0.83

Reliability Ratio Findings (Transit)

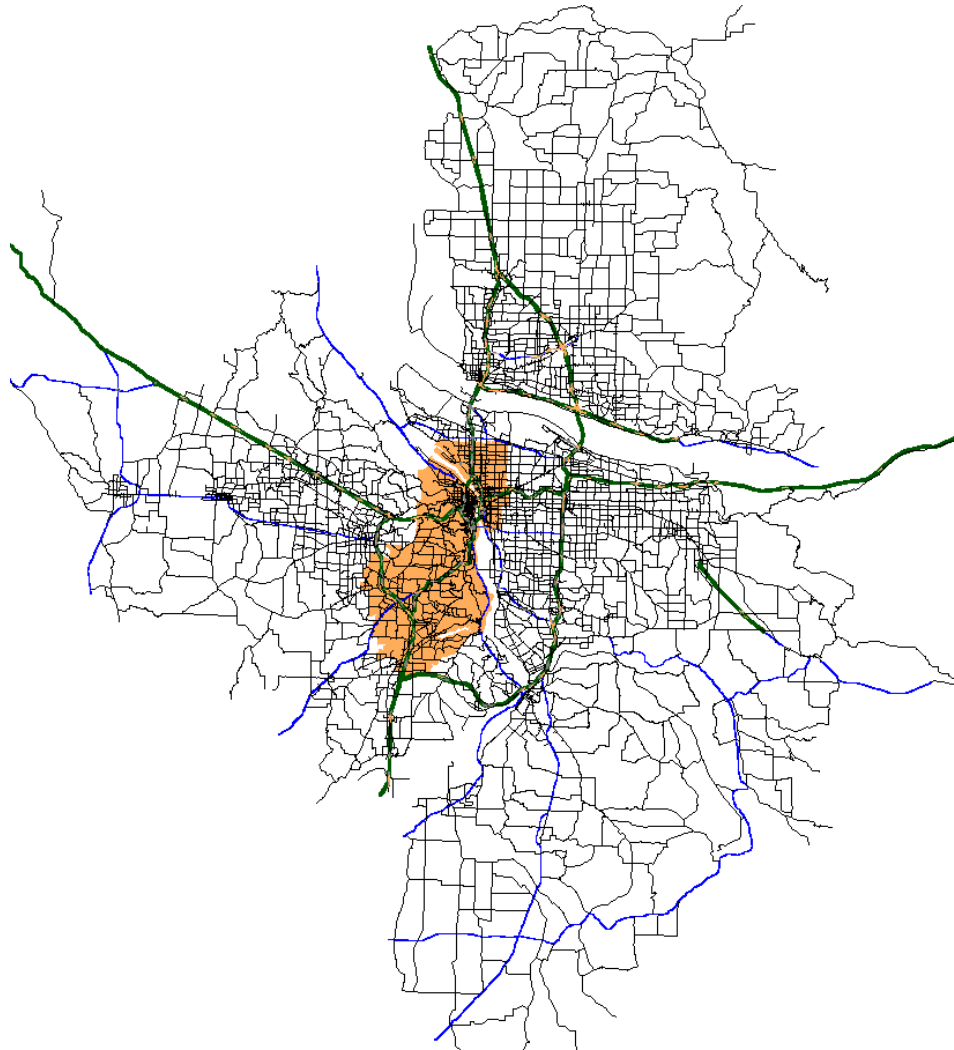
Study	Country	RR
MVA (2000)	Norway	Short trips: 0.69 Long trips: 0.42
Ramjerdi, Flügel et al. (2010)	The Netherlands	1.4
Significance, VU University Amsterdam et al. (2013)	The Netherlands	Commuting: 0.4 Business: 1.1 Other: 0.6
L35A	USA	0.75 -1.55

Modeling Process



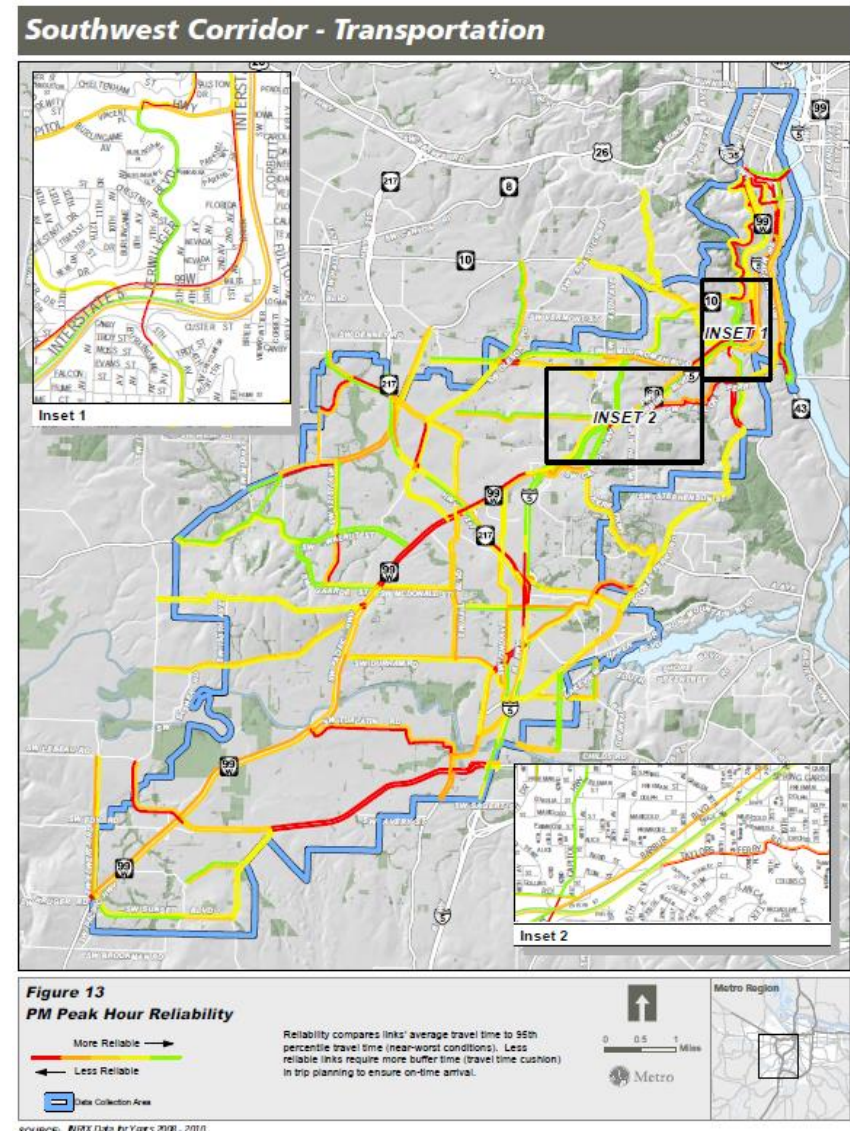
- Integrated DynusT / FAST-TrIPs assignment model developed in 6 months
 - Development of regional FAST-TrIPs transit network
 - Linking DynusT and FAST-TrIPs
 - Integration with Travel Demand Model
- All scenarios modeled under Existing Conditions
- BRT alignments are *loosely* representative of proposed alternatives

Southwest Corridor Study Area



Southwest Corridor Study Area

- On-going, multi-modal corridor study
- Evaluation of auto and transit TTR
- Established TAC for Professional Panel
- Prior exposure to concept of TTR
- Established, calibrated DynusT network



Metro Travel Demand Model

Initial Assignment (Skim Building)

Regional zone-to-zone travel times

Regional static assignment model
auto + transit



Trip Generation

How many trips by category?



Destination Choice

Where do those trips go?



Mode Choice

How do those trips get there?



Initial Assignment (Skim Building)

SW Corridor zone-to-zone travel times

Integrated dynamic assignment model



DynusT

FAST-TrIPs

auto

transit

Final Assignment (Route Choice)

Zone-to-zone travel times

Integrated dynamic assignment model



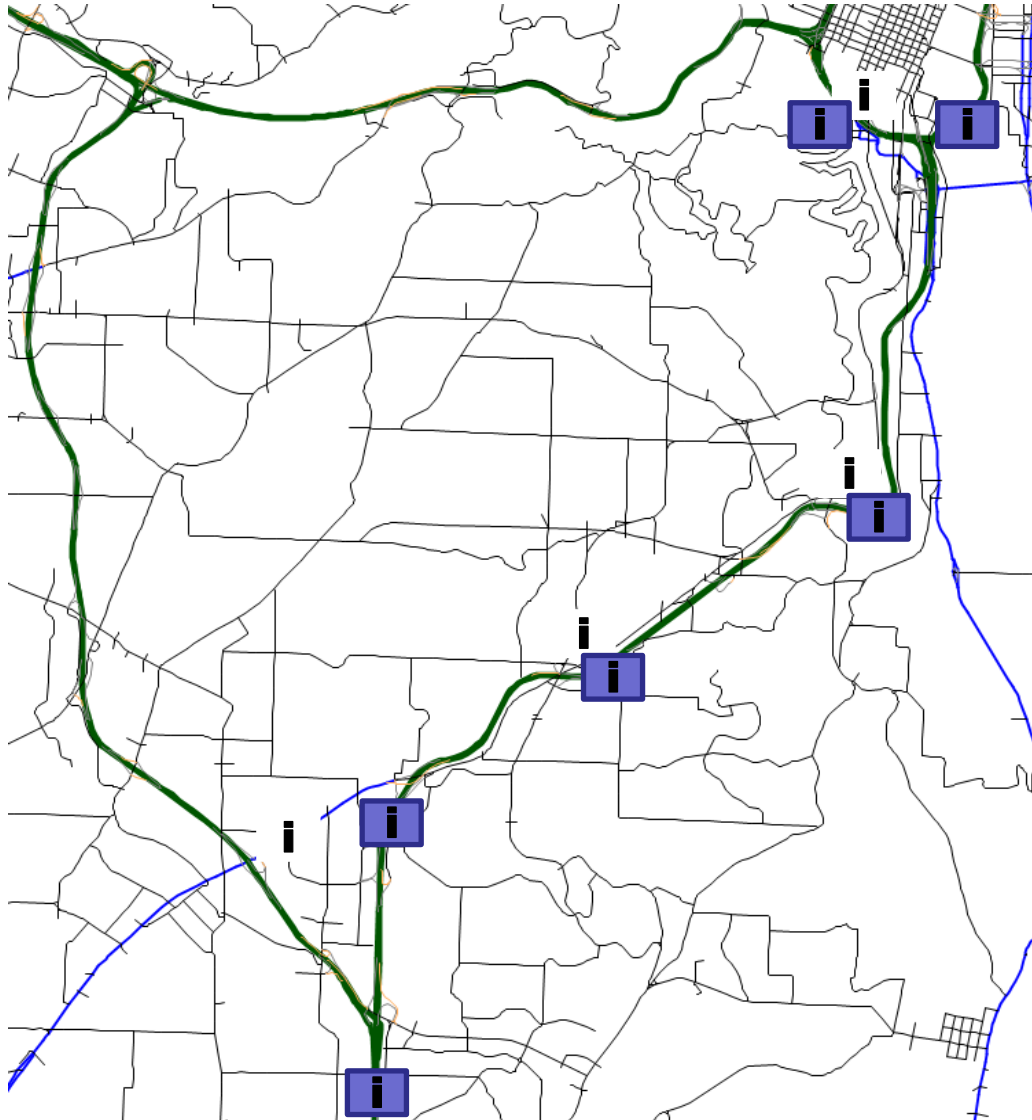
DynusT

FAST-TrIPs


auto


transit

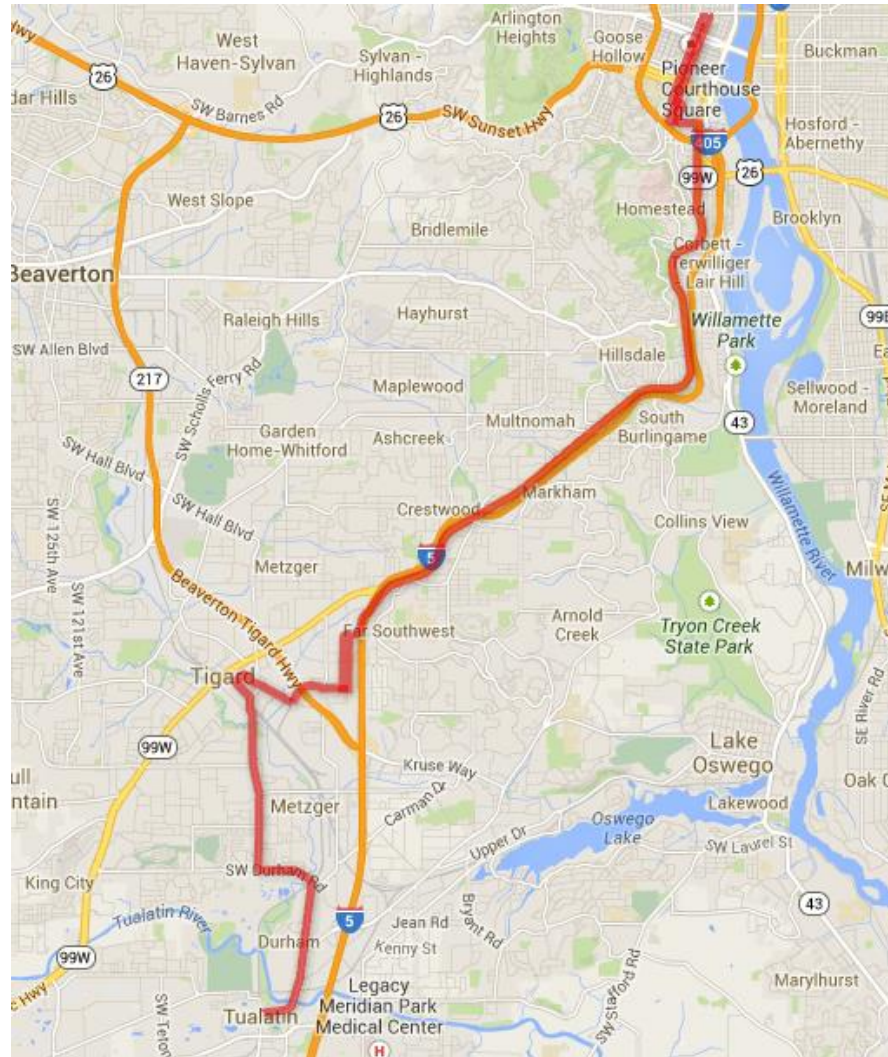
Variable Message Sign (VMS) locations



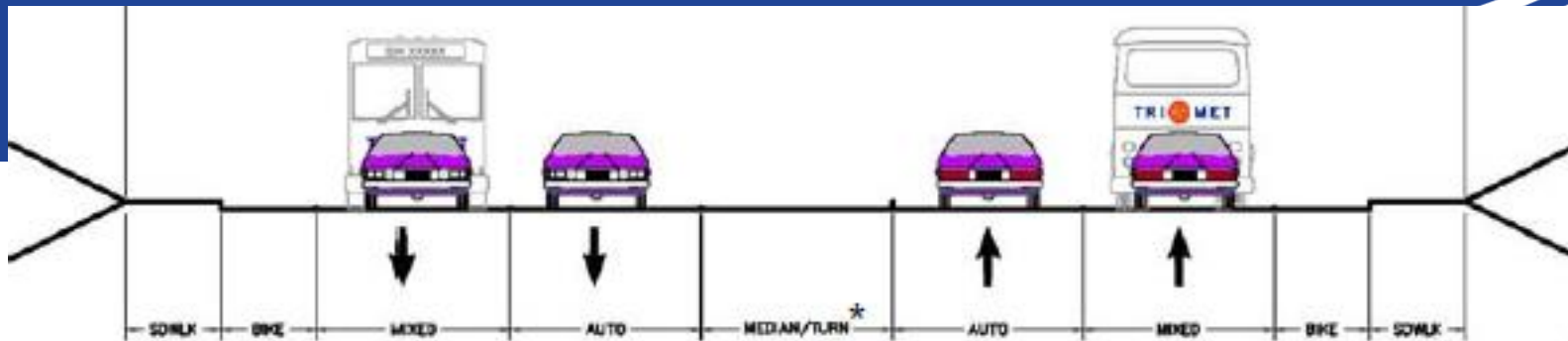
Source: Wikimedia Commons

 VMS on Barbur Blvd

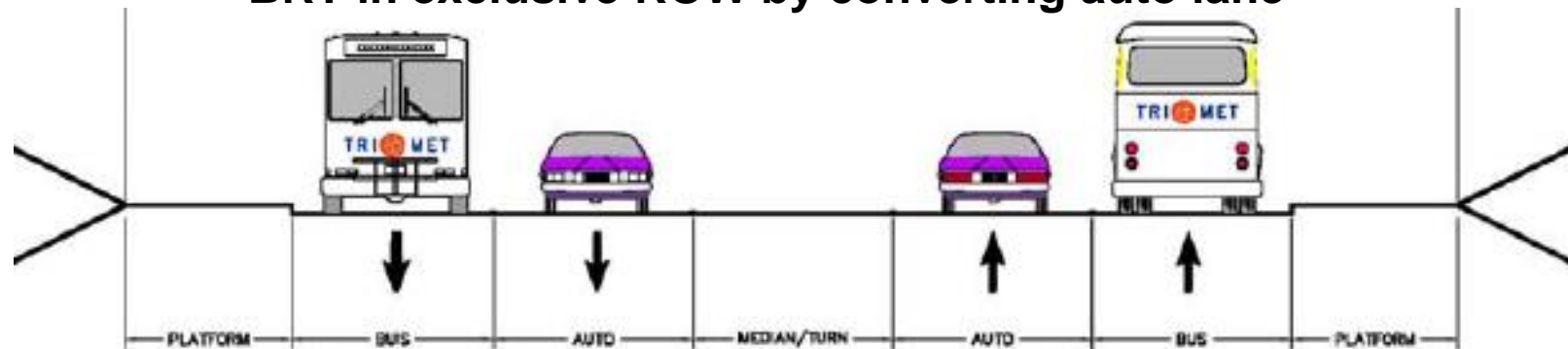
 VMS on I-5 / I-405



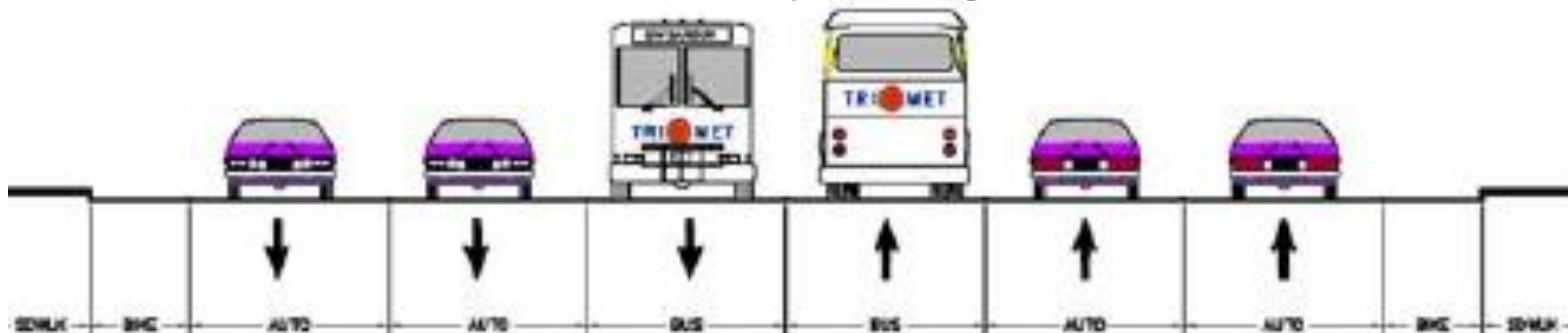
Existing Transit (Baseline) and BRT in Mixed Traffic



BRT in exclusive ROW by converting auto lane



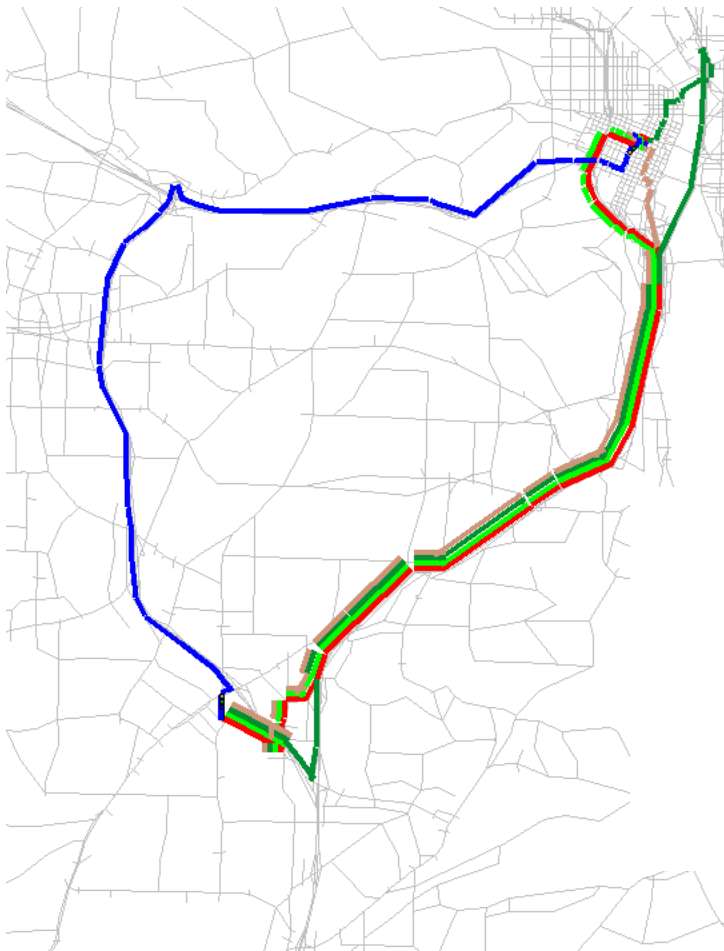
BRT in exclusive ROW by adding transit lane



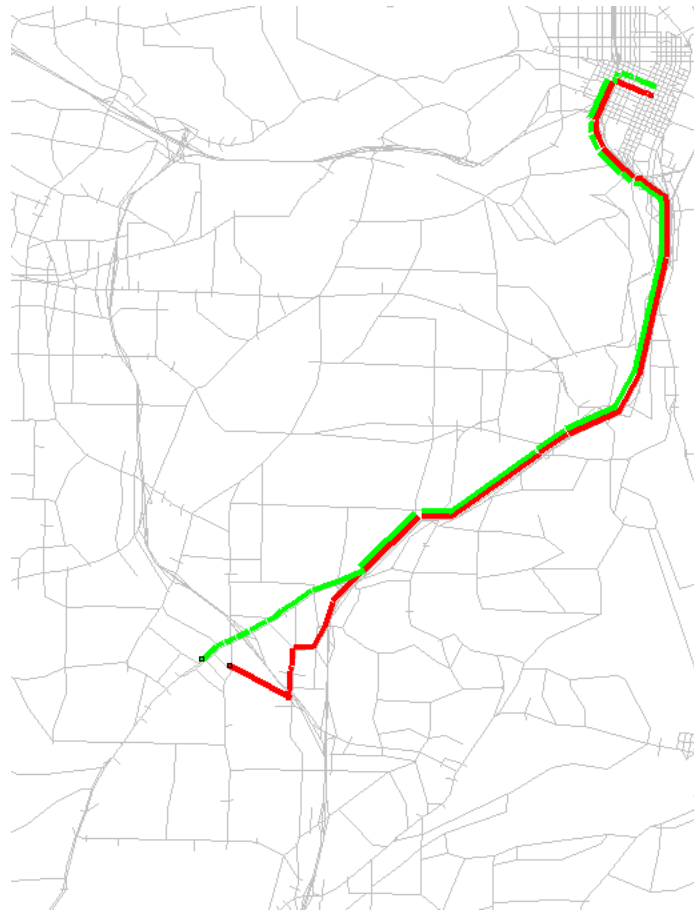
Impact of Reliability on Auto Route Choice

Route options between Portland CBD and Tigard

Without Reliability

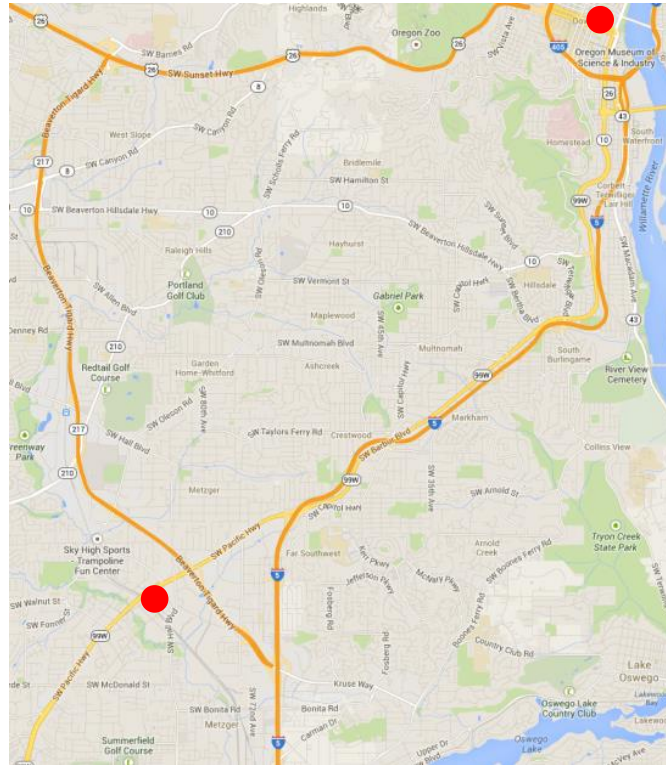


With Reliability



Impact of Reliability on Perceived Travel Times

Peak period travel time equivalent between Tigard and Portland CBD

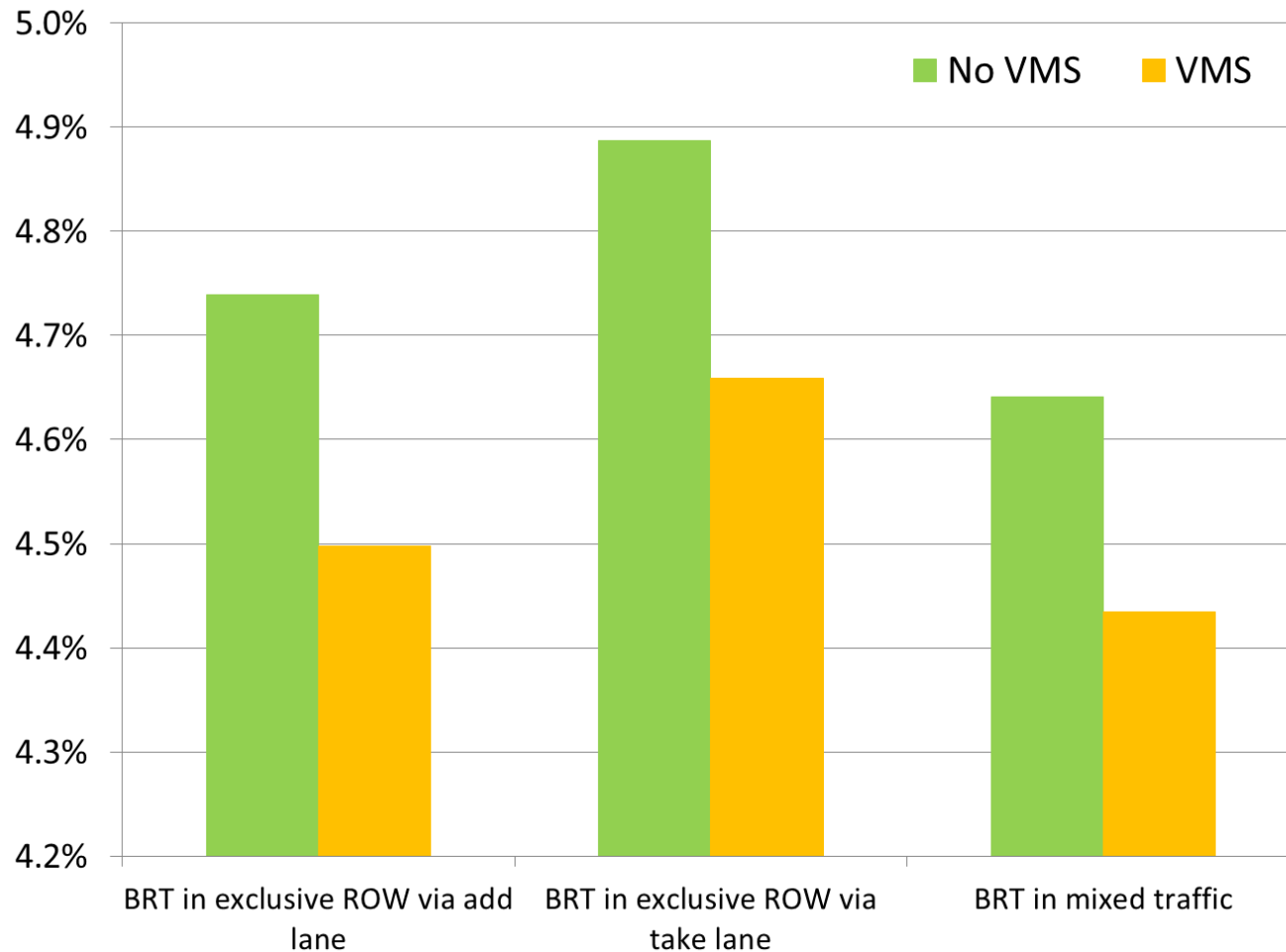


Single Occupancy Vehicle

	Total travel time equivalent (min)	Travel time (min)	Travel time equivalent of reliability (min)
Baseline (no reliability)	38	38	--
Baseline (reliability)	48	41	7
BRT in exclusive ROW via add lane (no reliability)	35	35	--
BRT in exclusive ROW via add lane (reliability)	46	40	6

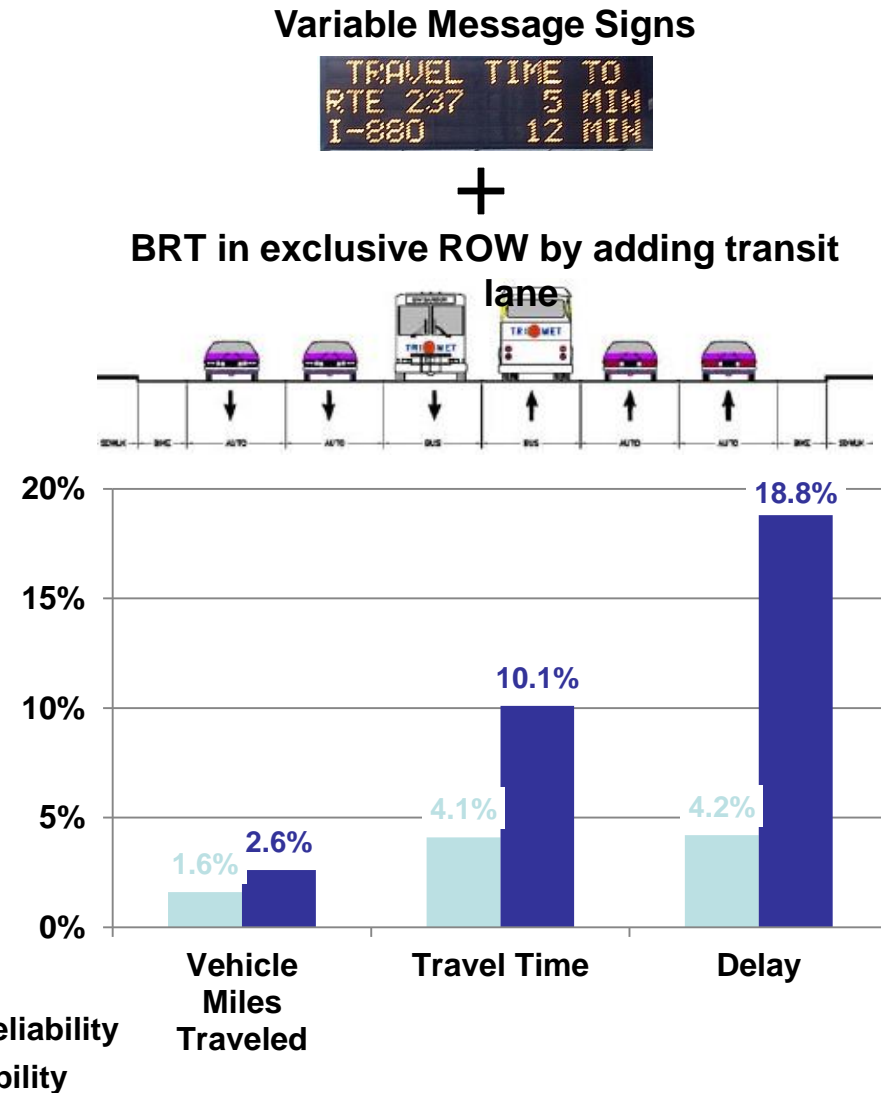
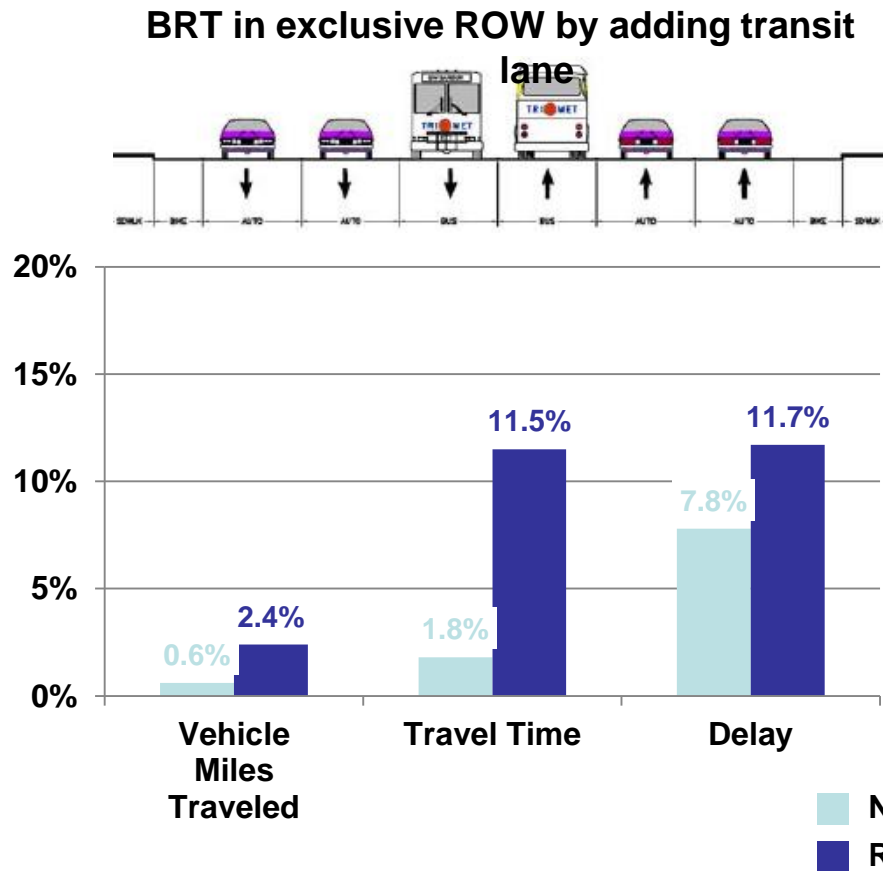
Impact of VMS on Transit Mode Shares

Intra Southwest Corridor Transit % (all scenarios w/ reliability)



Impact of Reliability on Scenario Analysis

Average % reduction from Baseline scenario
for all person trips on Barbur (auto & transit)



Conclusions from Professional Panel



- SHRP2 L35(A) research well regarded
- Effectively captured reliability in route and mode choice analysis
- Demonstrated ability to implicitly capture corridor improvements related to operational strategies (VMS)
- Recognized limitations of the VTTR Stated Preference survey, expressed interest in expanding survey in future

Next Steps for Metro



- Expand VTTR Stated Preference survey to larger group
- Traveler perception of VTTR within travel decision making process (destination, mode, and route choices)
- Re-estimate a travel demand model
- Build Metro staff capability to better utilize transit reliability (FAST-TripS or another method)
- Promote integrated model methodology





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SHRP 2 Local Methods for Modeling, Economic Evaluation, Justification and Use of the Value of Travel Time Reliability in Transportation Decision Making (L35B)

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September 9, 2014

Today's Presentation



- Introduction
- SHRP 2 L35B Objectives & Research Approach
- Existing Congestion Relief Process
- Approaches to VTTR
- Travel Time Data Driven Methodology (TTDDM)
- TTDM Application Results & Implementation
- Caveats & Conclusions

L35B Project Objectives



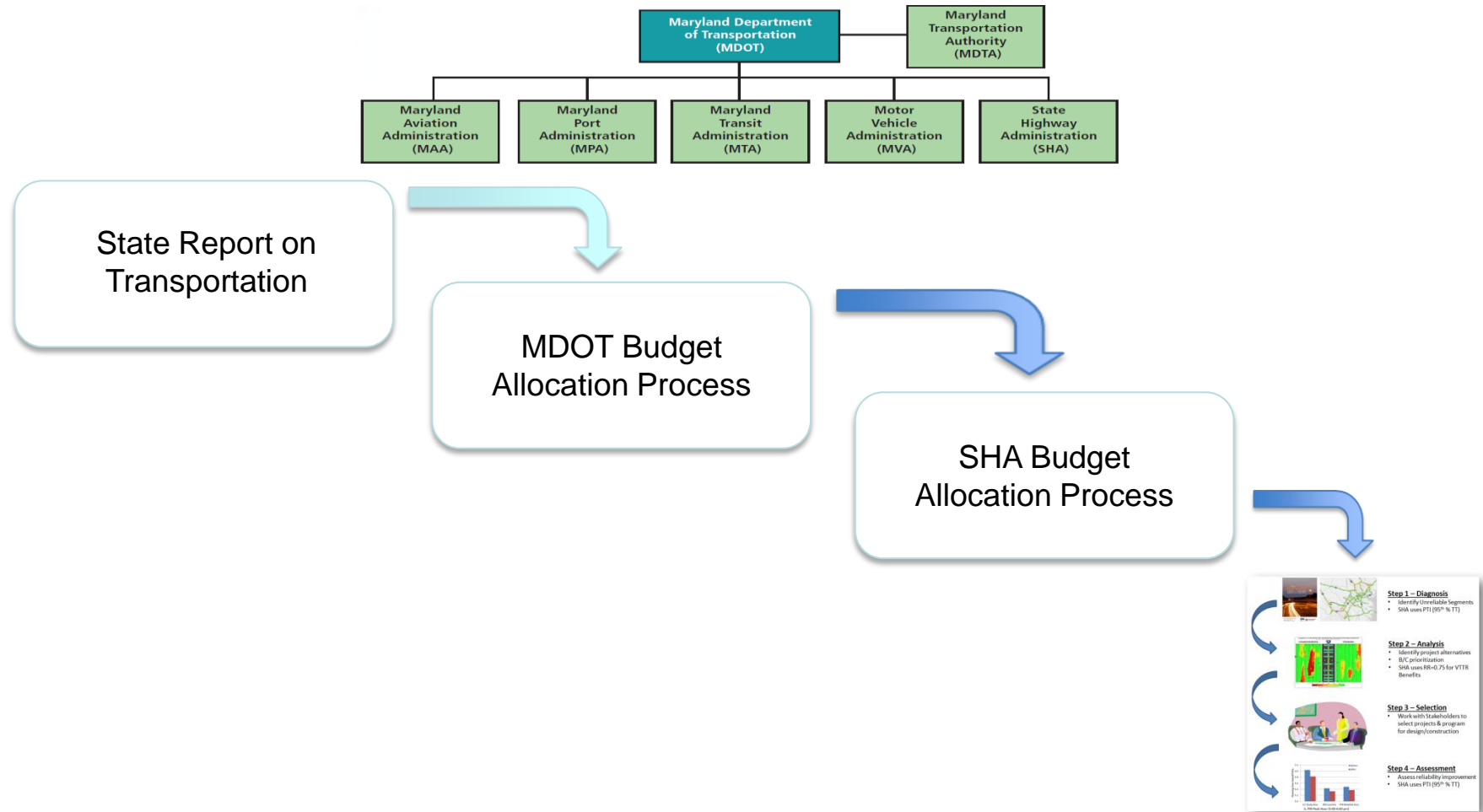
- “Select and defend a value or range of values for travel time reliability for the Maryland State Highway Network”;
- “Use the VTTR in the Maryland SHA project development process to prioritize operational and capital improvements and determine if (and how) the ranking of projects changes due to the addition of VTTR”; and
- “Report for the benefit of others the step-by step process used to develop, justify, apply, and assess the use of VTTR in the Maryland SHA project evaluation and decision process.”

Research Approach

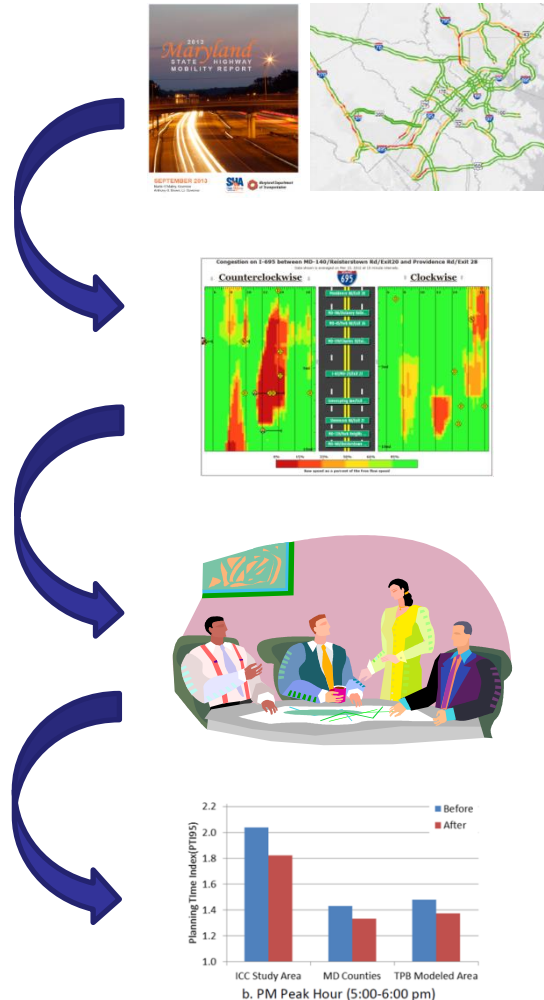


- Documented established processes
- Conducted detailed literature search
- Developed travel time data driven methodology
- Acquired data needed
- Applied TTDDM to multiple corridors to calculate RR/VOR
- Incorporated RR/VOR results in short term and long term project selection processes

Overview of Existing Process(es)



Congestion Relief DM Process



Step 1 – Diagnosis

- Identify unreliable segments
- SHA uses PTI (95th % TT)

Step 2 – Analysis

- Identify project alternatives
- B/C prioritization
- SHA uses RR=0.75 for VTTR benefits

Step 3 – Selection

- Work with stakeholders to select projects & program for design/construction

Step 4 – Assessment

- Assess reliability improvement
- SHA uses PTI (95th % TT)

Congestion Relief Project DM

- Some Step 2 Analysis Details
 - Benefits: VOT and VTTR

Value of Time (VOT)

- Passenger: U.S. Census Bureau data
- Truck driver: Bureau of Labor Statistics, US DOT, and FHWA's HERS
- Cargo: TTI, and other studies

Value of Travel Time Reliability (VTTR)

- Reliability Ratio (RR=0.75)
- Based on literature review and current practice in other parts of the world

Saving Type	Parameter	Unit	Categories	SHA Value*
Travel time	VOT	\$/hr	Passenger	29.82
			Truck driver	20.21
			Cargo	45.40
Travel time reliability	VTTR	\$/hr	Passenger	22.36
			Truck driver	15.16
			Cargo	34.05
Fuel cost		\$/gal	Gasoline	3.69
			Diesel	3.97

**Parameters used by SHA in project benefit estimation (2012 values)*

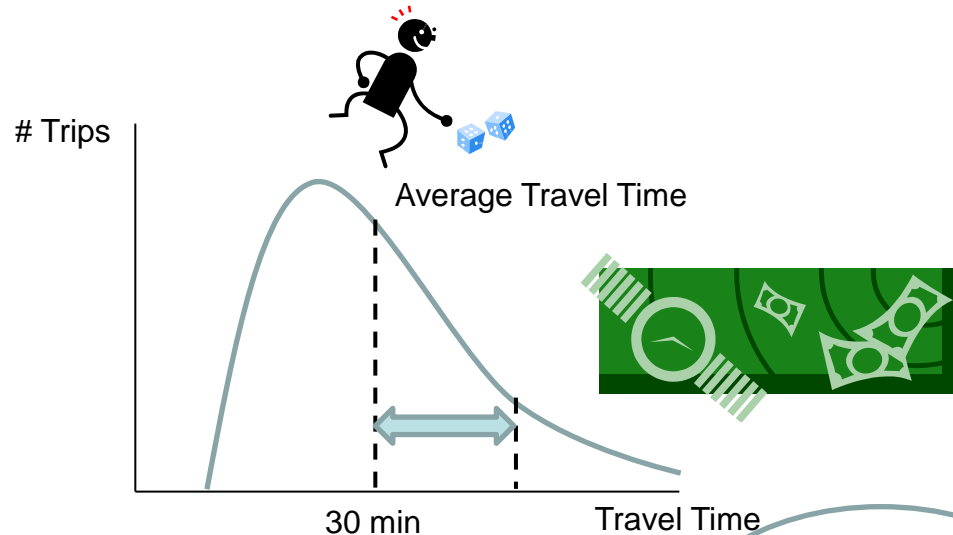
Previous Approaches to Estimate VTTR

- **Statistical methods (early studies)**
 - Directly estimate TT distribution and variations
 - Mean-variance
 - Scheduling delay
 - Combined mean-variance and scheduling delay
- **Survey-based methods (later)**
 - Discrete choice models
 - Disaggregate survey data, stated preferences (SP) or revealed preferences (RP) or combination
- **Options Theory (emerging)**
 - Unique approach based on statistical/financial concepts
 - Uses an analogy where premiums are set for an insurance policy that guards against being late
 - Data driven
 - uses historical travel time, speed and volume data as input readily available to most agencies
 - Easy to update, generalize and localize

Travel Time Data Driven Methodology



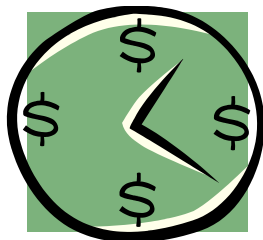
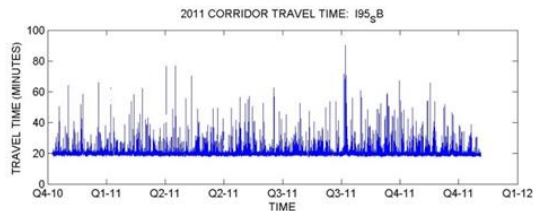
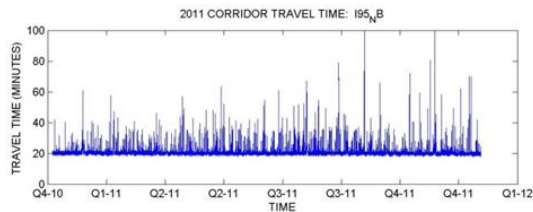
- Expected Travel Time
- Level of Travel Time Variations
- Tolerance Level for Travel Time Variations
- Impacts of longer/shorter Expected Travel Times



Travel Time Data Driven Methodology

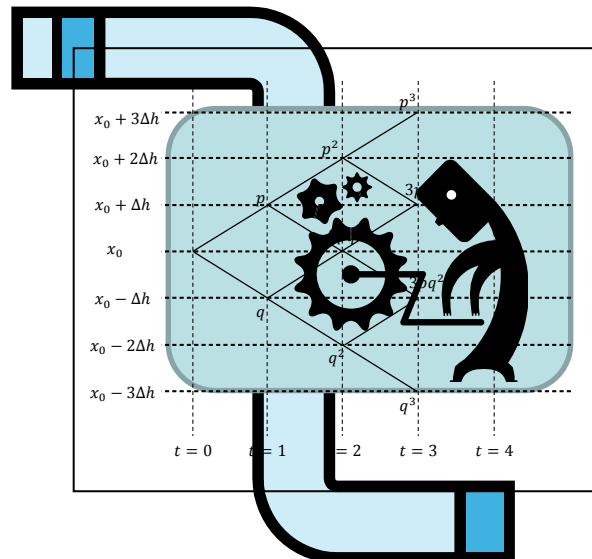
Inputs

- Mass quantities of historical travel time data (INRIX)
- Value of time



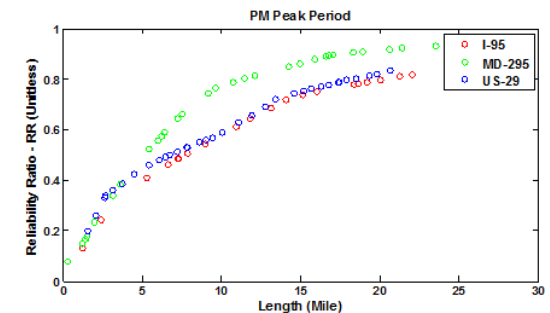
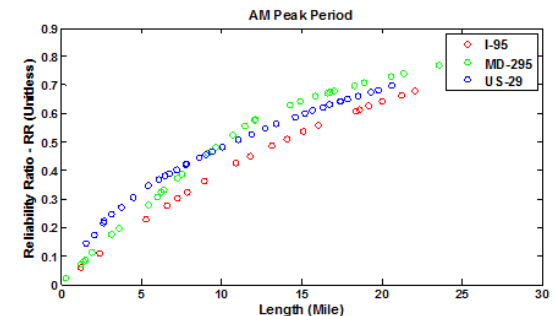
Calculations

- Travel time distribution
- Stochastic process
- Binomial tree
- Certainty-equivalent probabilities

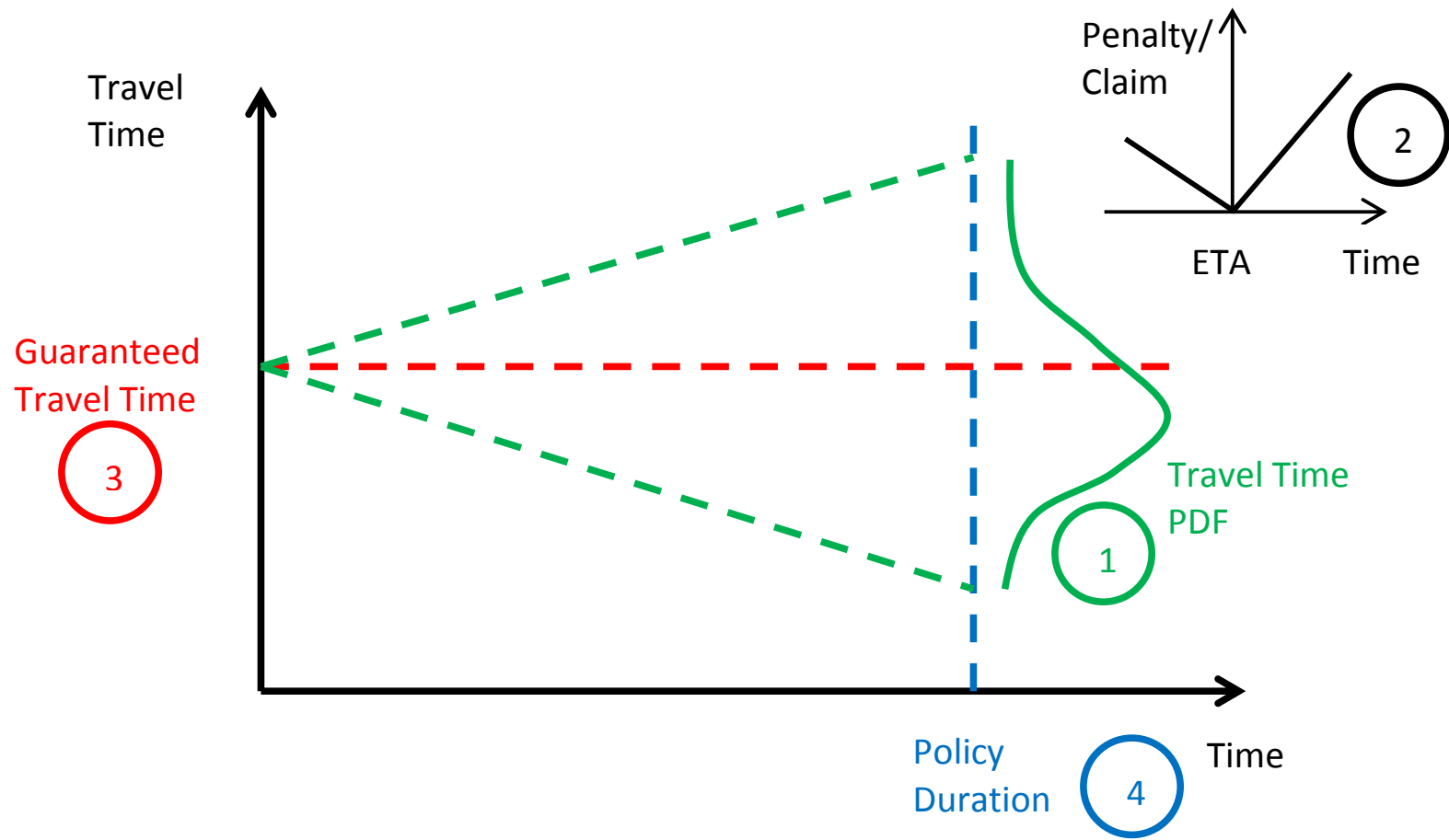


Outputs

- Value of reliability
- Reliability ratio



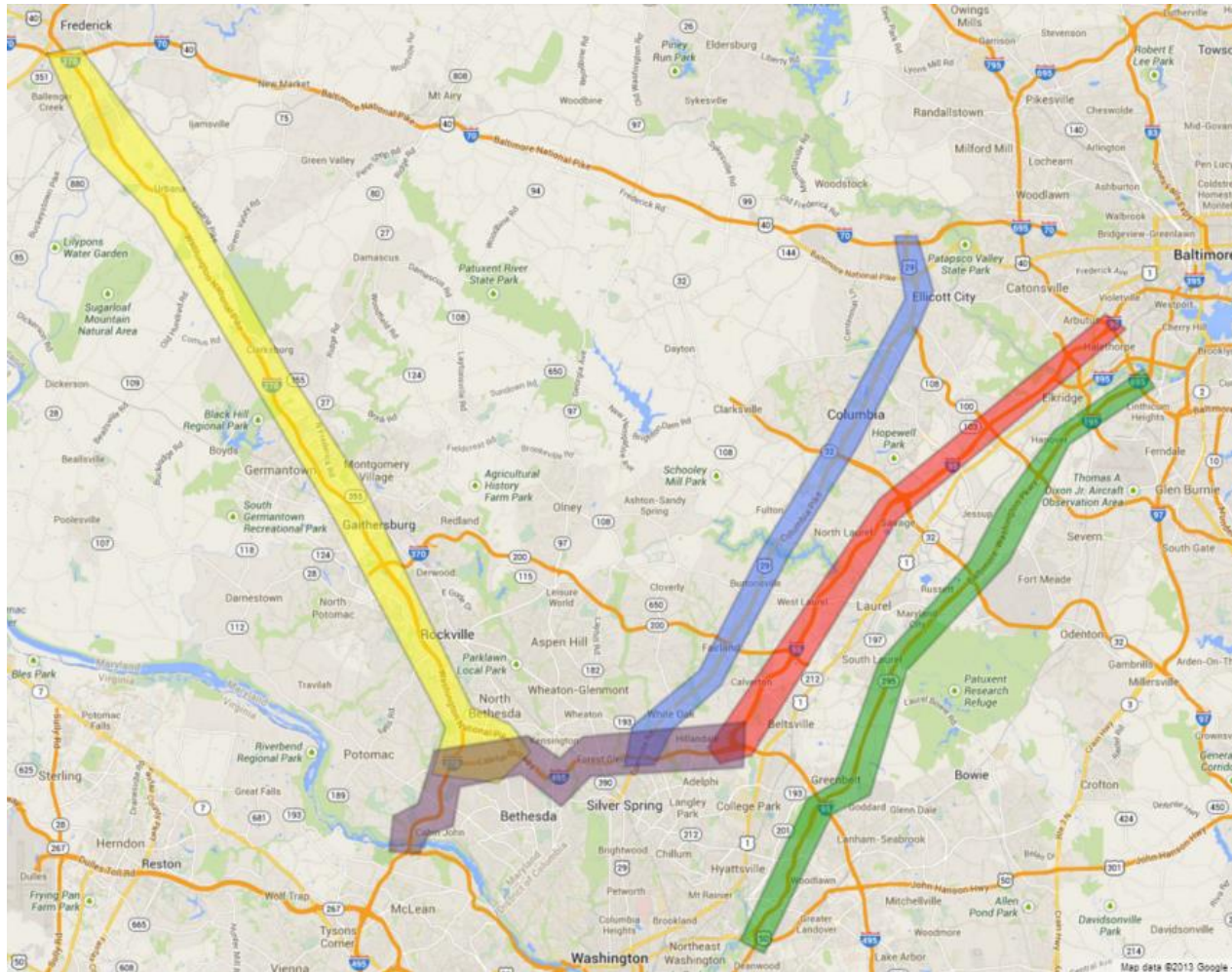
Components of TTDDM



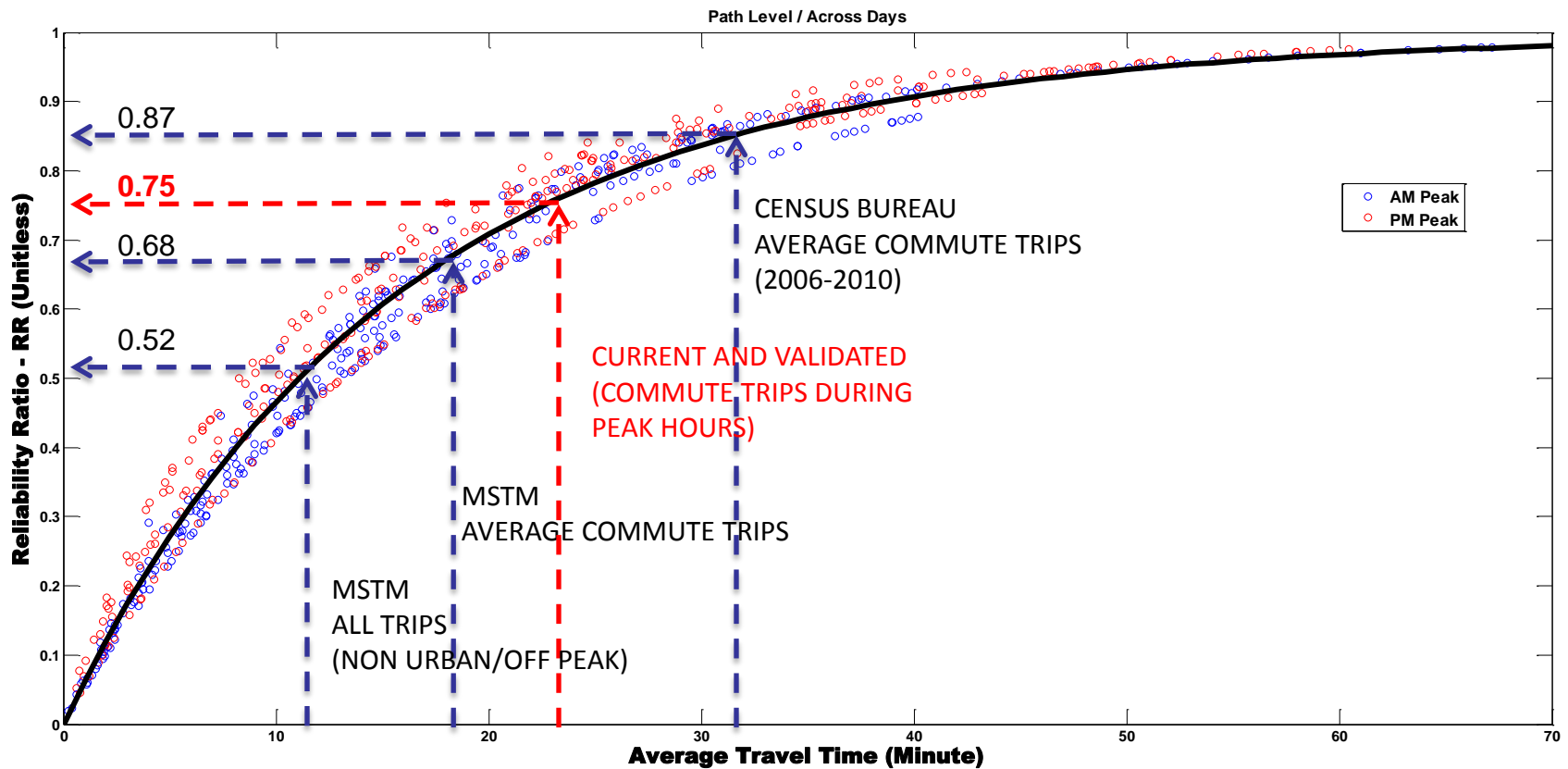
Steps Involved in the TTDDM

Step	Description
1. How can travel time evolutions over time be modeled?	Travel time series can be characterized as Geometric Brownian Motion (GBM) with drift stochastic process; hence, given the process parameters, future travel time probability distributions can be specified.
2. How can a penalty/reward (payoff) of early/late arrivals at the destination be determined?	Penalty is simply defined as an asymmetric bilinear function of the amount of time by which the traveler is late or early at the destination.
3. What is the guaranteed level of travel time?	Expected travel time is taken as the guaranteed travel time level.
4. What is the duration of time for which the travel time insurance policy is issued?	Travel time insurance policy is issued for the longest trip time possible under recurrent congestion scenarios (95th percentile travel time is used for this purpose).
5. How the future payoffs get valued at the outset of trip ?	A certainty-equivalent payoff valuation strategy is adopted. This payoff valuation method takes advantage of the GBM assumption for the travel time process to greatly simplify the insurance valuation process.

Corridors Analyzed

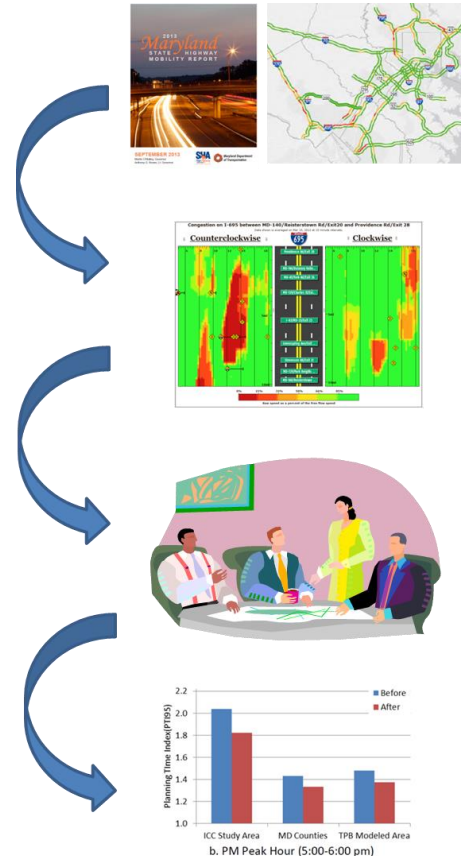


TTDDM Application Results



Incorporating Application Results (Short Term Projects)

- Improvement Projects Identified for I-695 Using Existing Process Selected as Case Study
- Total of 16 Projects Ranked Using Life Cycle BCA
- Improvements are Low Cost Congestion Relief Projects (e.g., addition of auxiliary lanes, extending acceleration lanes)
- VISSIM Used as Analysis Tool
- Performed Sensitivity Analysis on RR/VOR Impact on Project Selection



Step 1 – Diagnosis

- Identify Unreliable Segments
- SHA uses PTI (95th % TT)

Step 2 – Analysis

- Identify project alternatives
- B/C prioritization
- SHA uses RR=0.75 for VTRR Benefits

Step 3 – Selection

- Work with Stakeholders to select projects & program for design/construction

Step 4 – Assessment

- Assess reliability improvement
- SHA uses PTI (95th % TT)

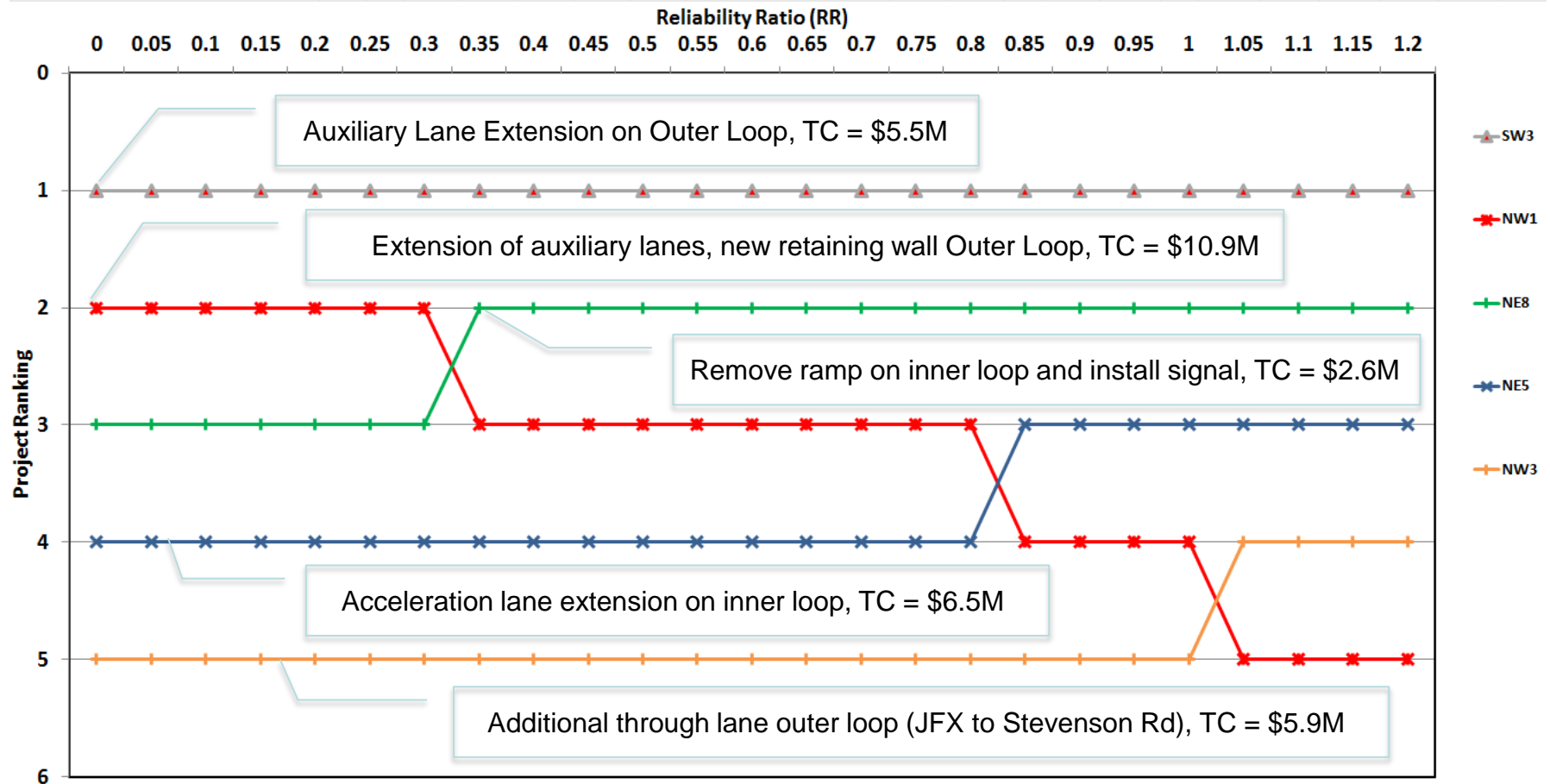


Incorporating Application Results (Short Term Projects)



- Benefits include cost savings related to: delay reduction, auto, freight, fuel as well as reliability ($VOR=RR*VOT$), and safety
- Costs include construction as well as O&M
- How do changes in the RR impact project B/C ranking?

Incorporating Application Results (Short Term Projects)



Incorporating Application Results (Long Term Projects)



- *Note: This was a “proof of concept” using the Maryland Statewide Transportation Model (MSTM)*
- However, proof of concept shows how a post-processing module can be used with any travel demand model to determine long term travel time reliability valuation

Incorporating Application Results (Long Term Projects)

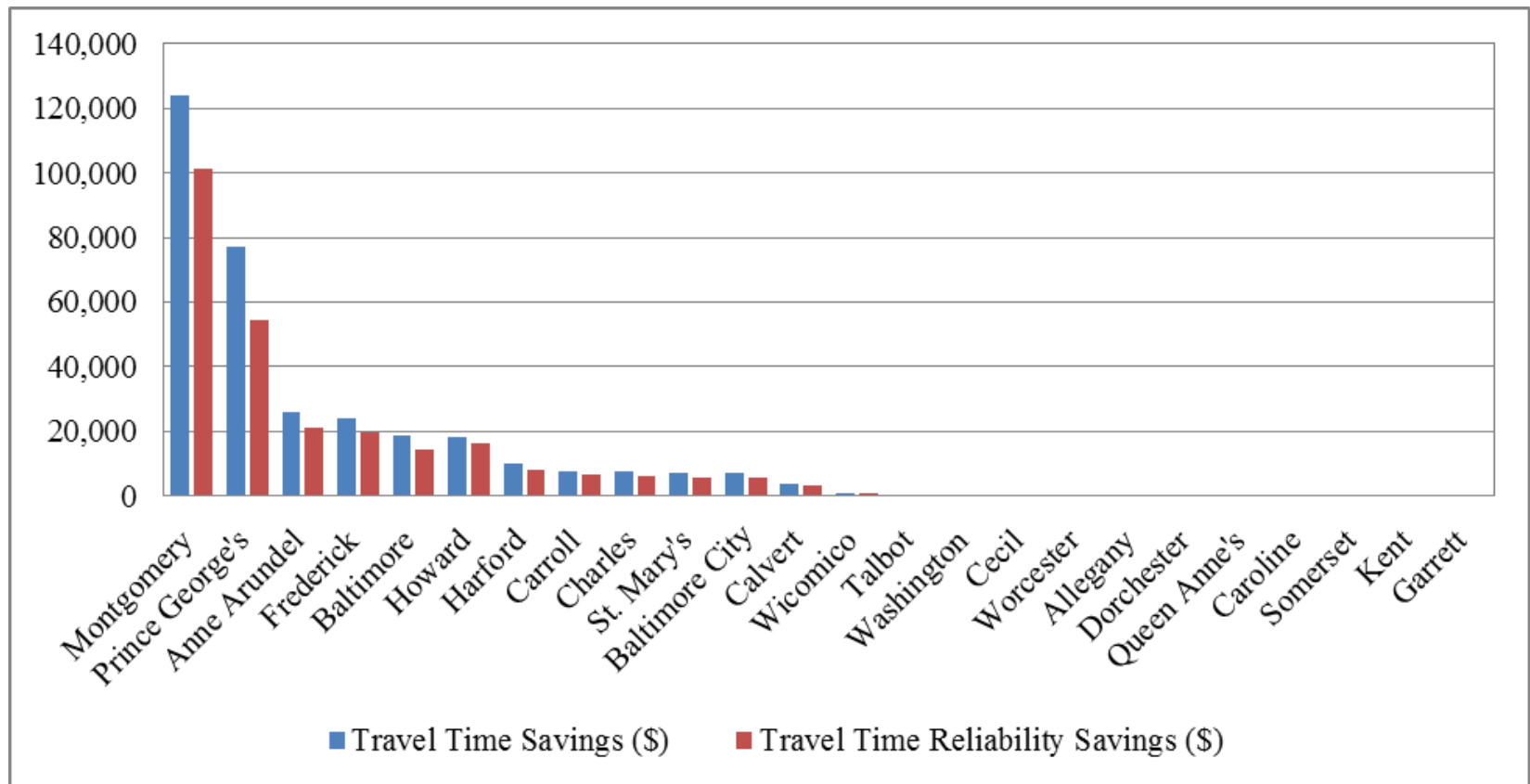
- RR vs average TT function used with MSTM to compute travel time & travel time reliability savings for:
 - Base year no build (pre-ICC)
 - Base year build (post – ICC)
 - Future year – no build
 - Future year build

Intercounty Connector (ICC)



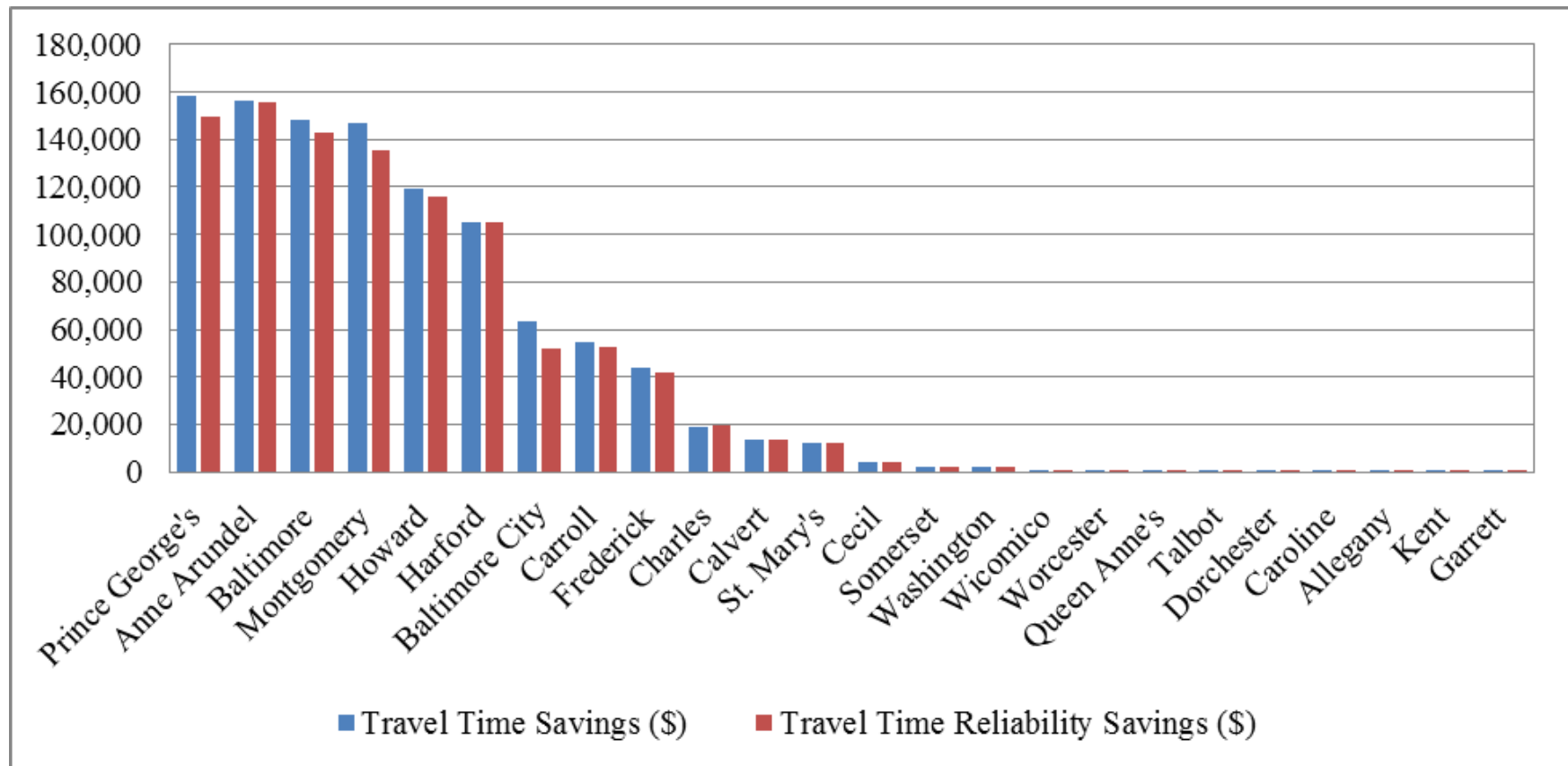
County Level Findings

- Typical day, AM peak period, base year post-ICC vs. pre ICC



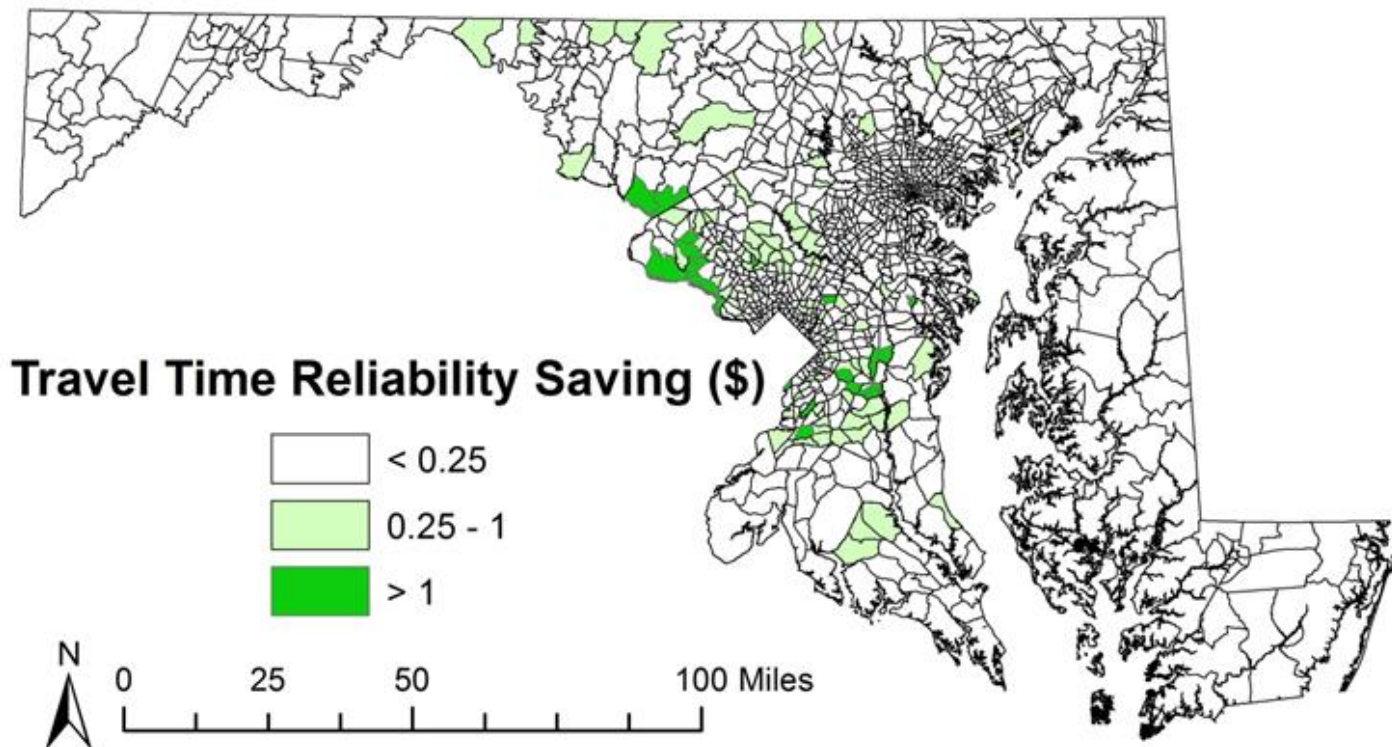
County Level Findings

- Typical day, AM peak period, future year build



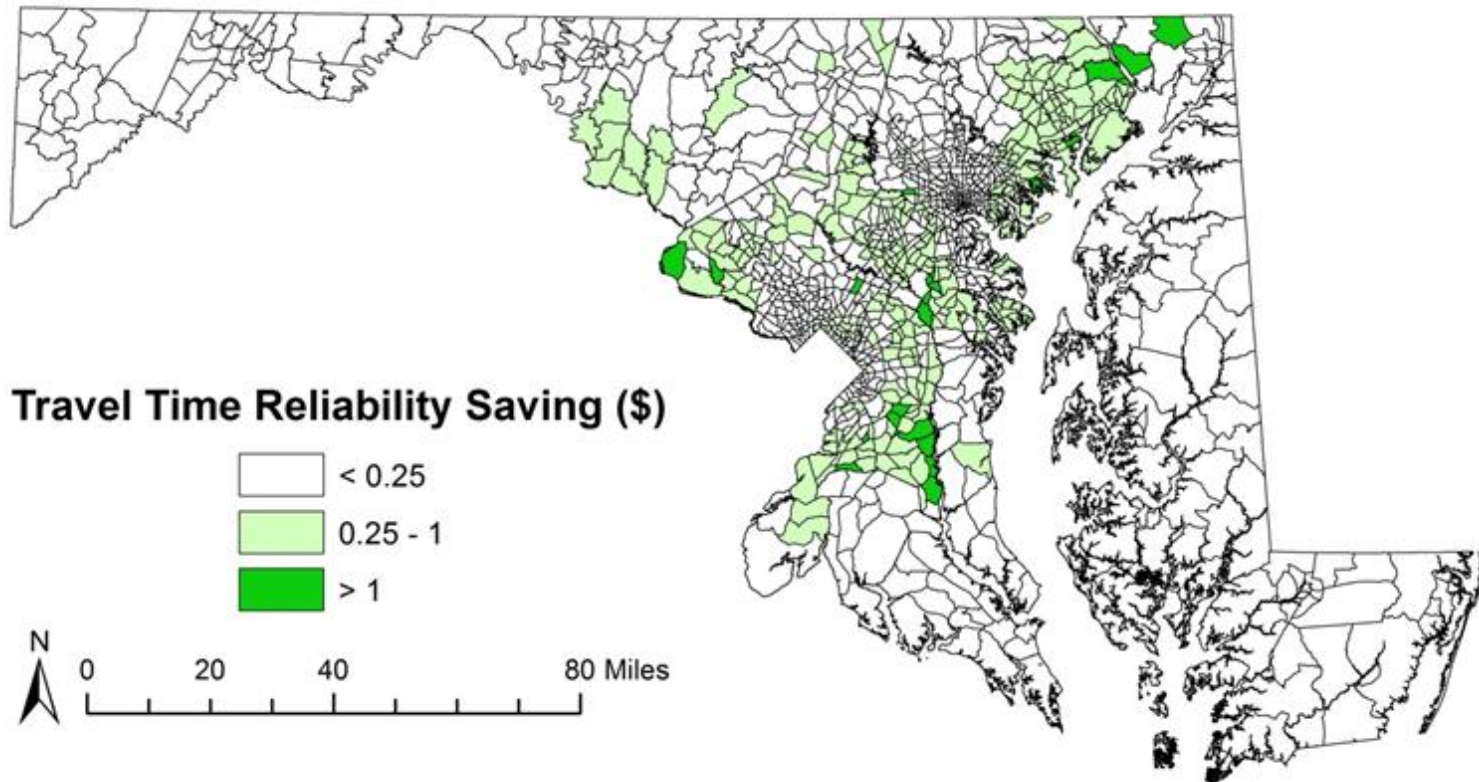
TAZ Level Findings

- Travel time reliability savings \$/trip post-ICC vs. pre-ICC



TAZ Level Findings

- Travel time reliability savings \$/trip post- future year build vs. future year no build



Caveats & Conclusions



- SHA's use of 0.75 RR appears reasonable based on TTDDM application
 - However, TTDDM Must be Validated
- Caution! Results for Short-term Improvement Projects are Based on Aggregate Travel Time Savings
- Travel Time Data Driven Methodology has Promise, but Additional Research is Needed
- Methodology is Transferable to other DOT's as TT Data as Become More Readily Available
- SHA is Plans to Build Upon Research Results