Value of Travel Time Reliability and its Use in Transportation Decision Making: A Data-Driven Approach

Kaveh Sadabadi
Center for Advanced Transportation Technology (CATT)
University of Maryland, College Park

NATMEC
Miami, FL
May 1-4, 2016

Collaborators

- Tom Jacobs (UMD-CATT)

- Fred Ducca (UMD-NCSG)

- Sevgi Erdogan (UMD-NCSG)

- Subrat Mahapatra (MD-SHA)

Today’s Presentation

- Introduction (SHRP2 Project L35-B)
- Existing Congestion Relief Process
- Different Approaches to VTTR Estimation
  – Survey-based (Stated/Revealed Preference)
  – Travel Time Data Driven Methodology (TTDDM)
- TTDDM Application Results & Implementation
  – Short-term projects
  – Long-term projects
- Caveats & Conclusions





U.S. Department of Transportation
Federal Highway Administration

TRB

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

SHA State Highway Administration

NCSG

University of Maryland 1856

CATT Center for Advanced Transportation Technology

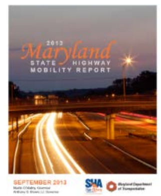
Cambridge Systematics
Transportation leadership you can trust.

dunbar transportation consulting

L35B Project Objectives

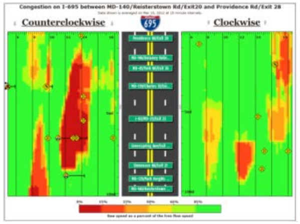
- "Select and defend a value or range of Values for Travel Time Reliability (VTTR) for the Maryland State Highway Network";
- "Use the VTTR in the Maryland SHA project development process to prioritize operational and capital improvements and determine if (and how) the ranking of projects changes due 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."

Congestion Relief DM Process



Step 1 – Diagnosis

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

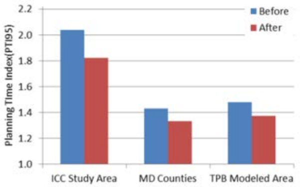


Step 2 – Analysis

- 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



b. PM Peak Hour (5:00-6:00 pm)

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)*

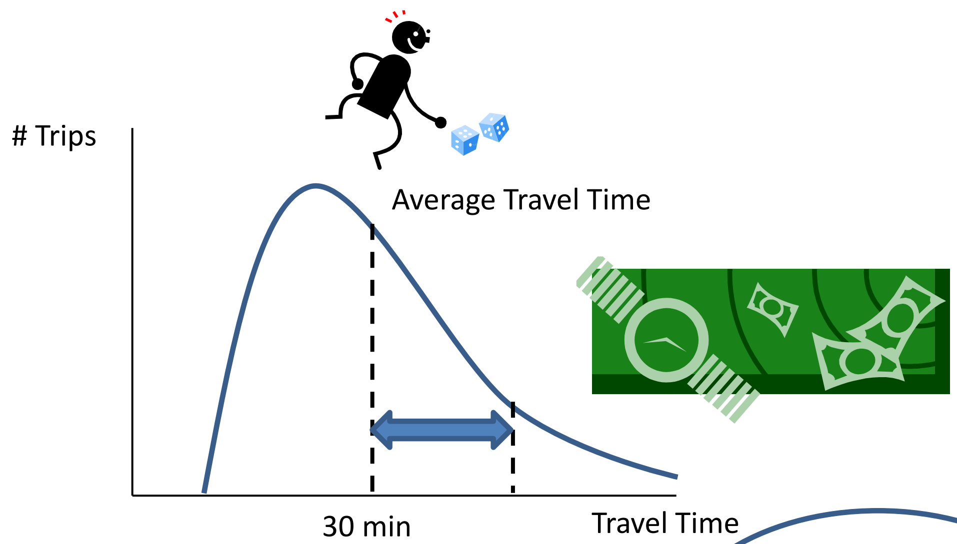
Previous Approaches to Estimate VTTR

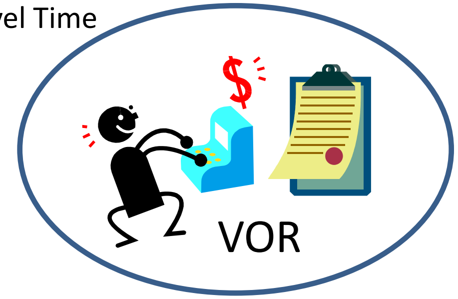
- **Statistical methods (early studies)**
  - Directly estimate TT distribution and variations
    - Mean-variance
    - Scheduling delay
    - Combined mean-variance and scheduling delay
- **Survey-based methods (later)**
  - Discrete choice models
    - Disaggregate survey data, stated preferences (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

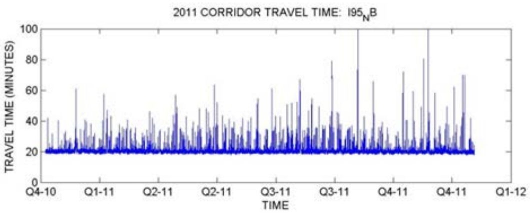


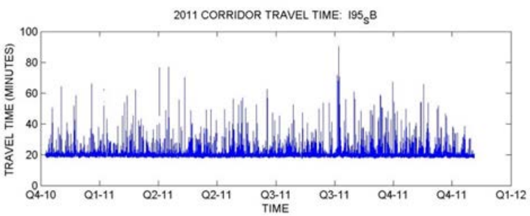


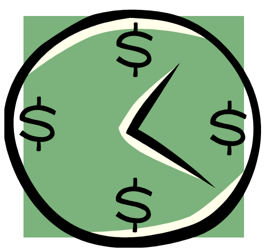
Travel Time Data Driven Methodology

Inputs

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

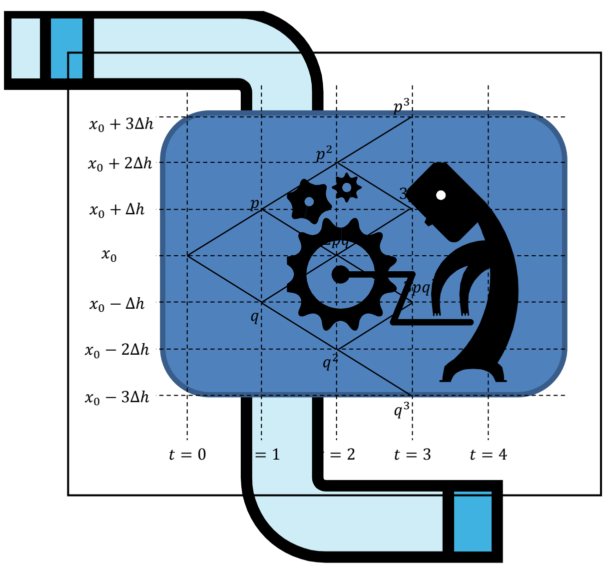






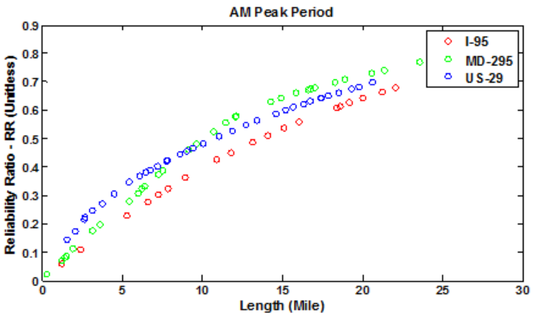
Calculations

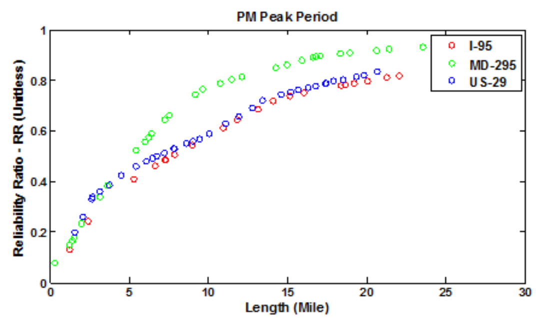
- Travel time distribution
- Stochastic process
- Binomial tree
- Certainty-equivalent probabilities



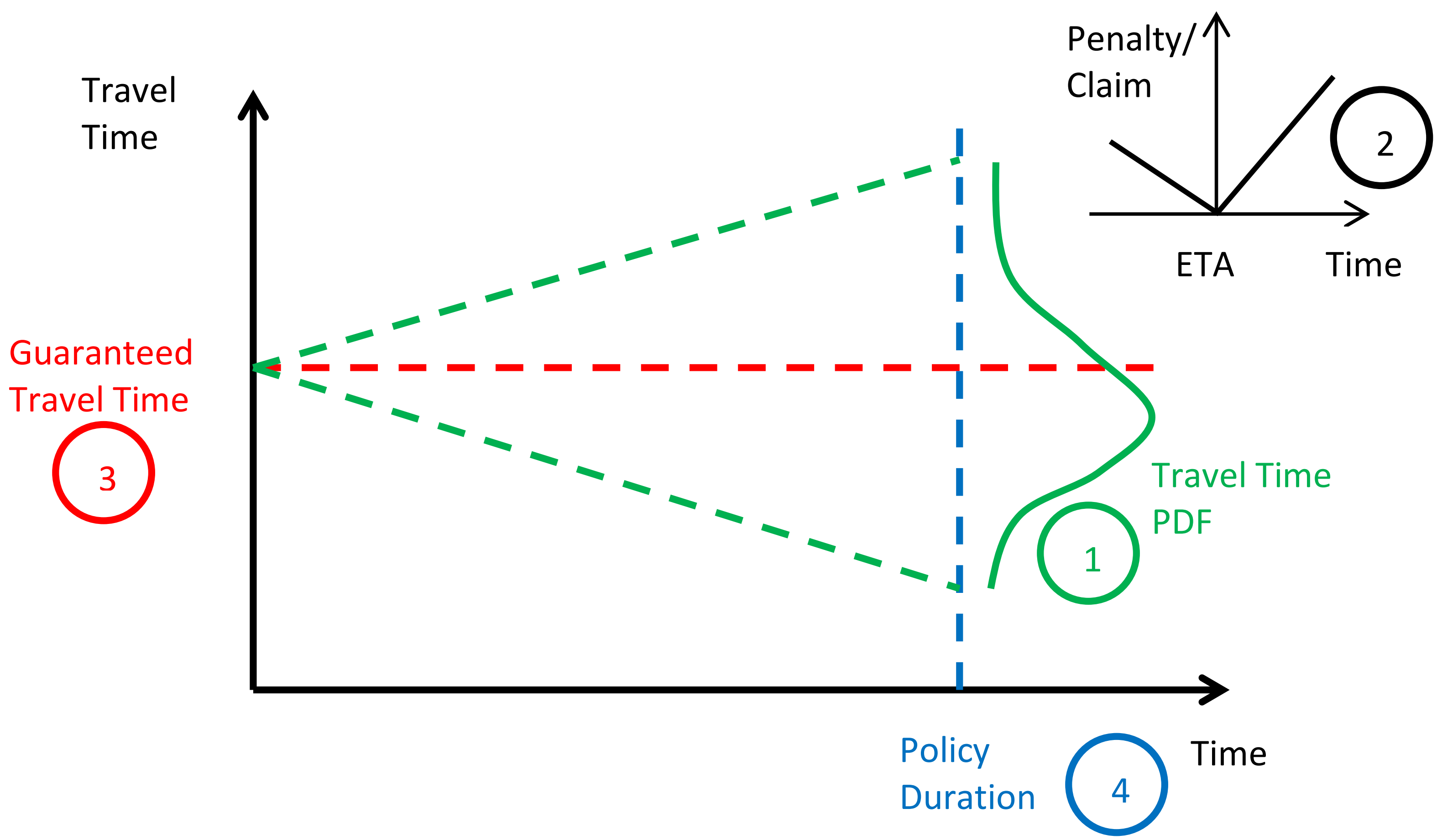
Outputs

- Value of reliability
- Reliability ratio





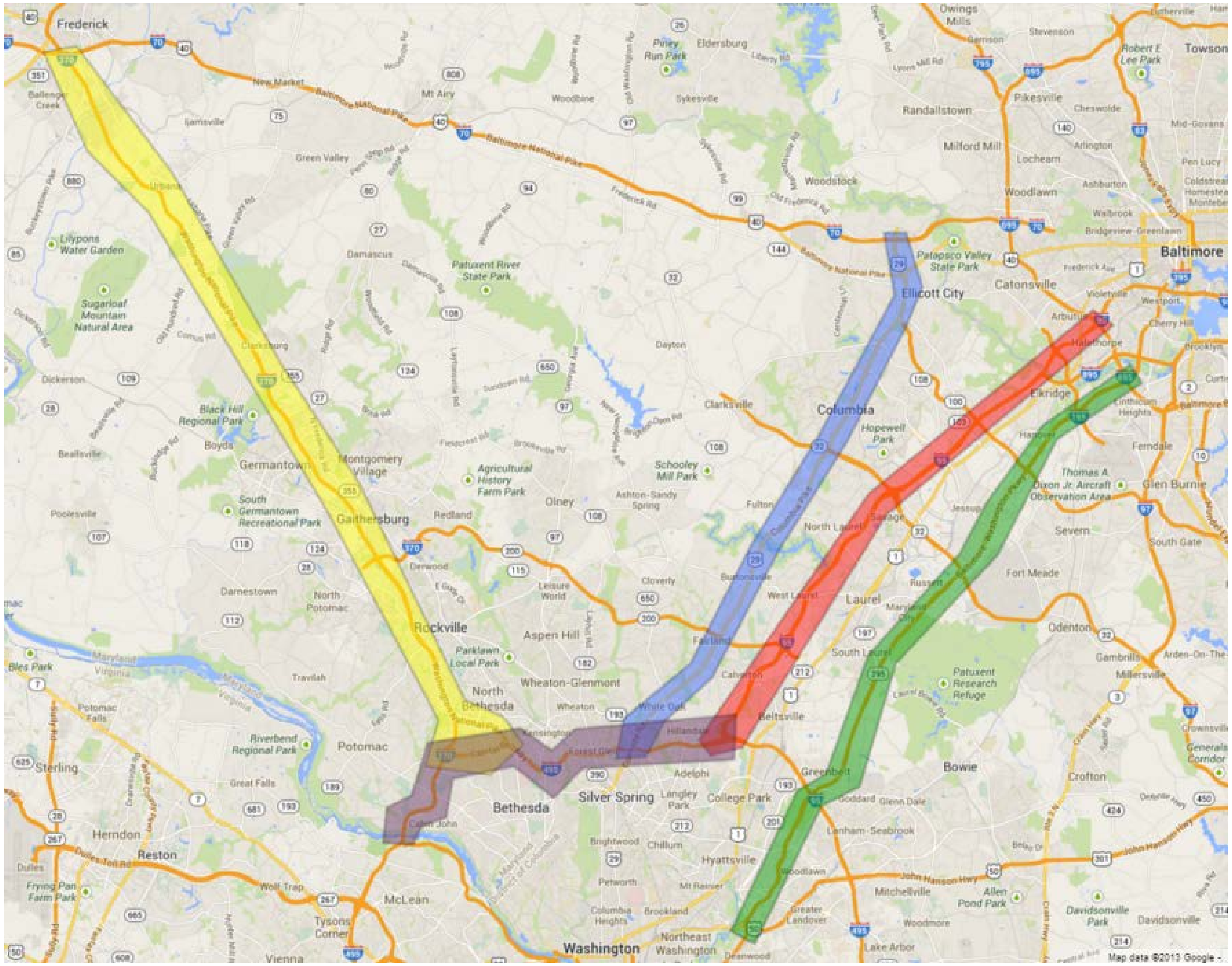
Components of TTDDM



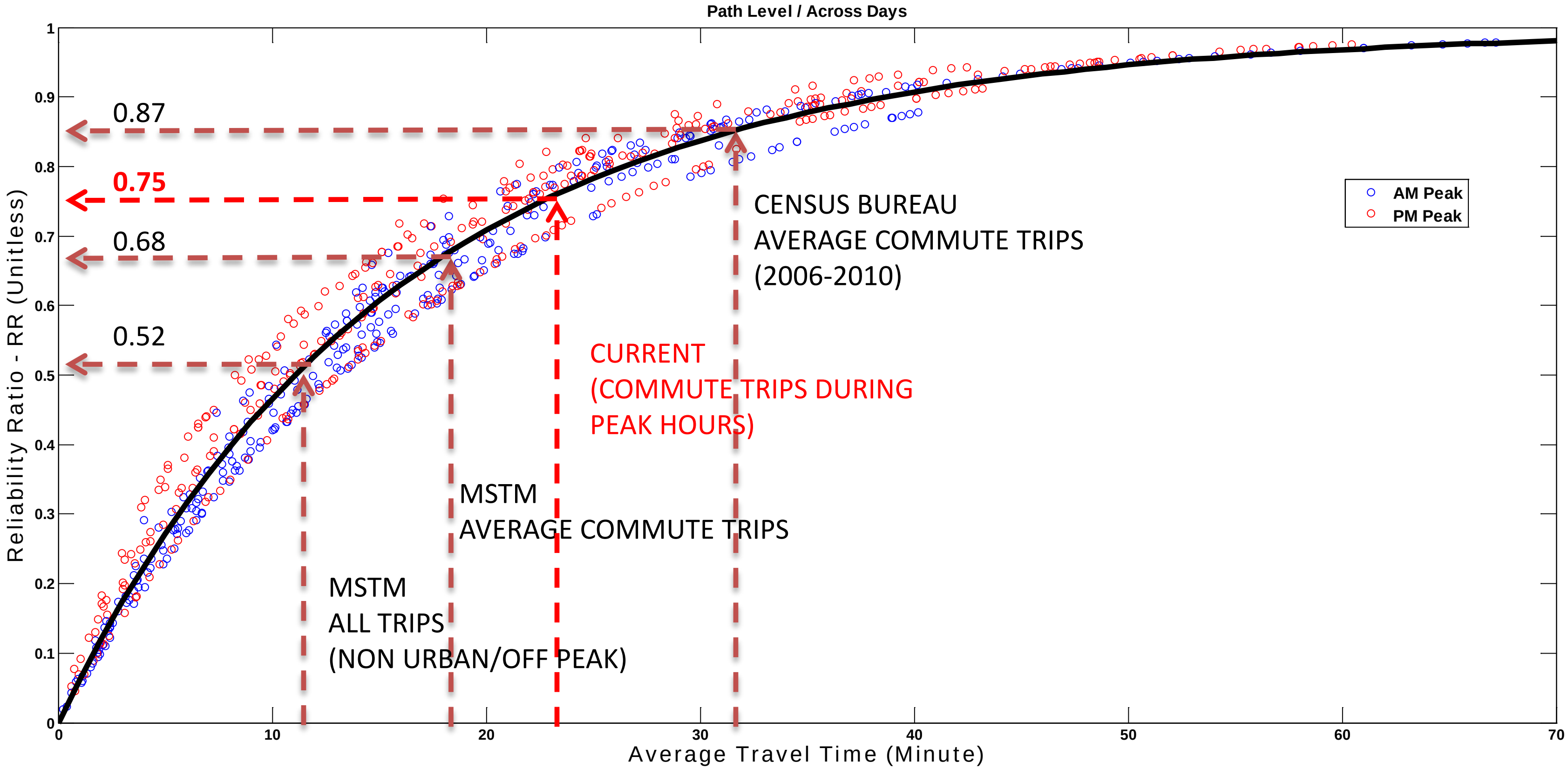
Steps Involved in the TTDDM

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



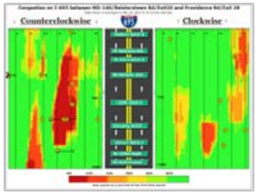
TTDDM Application Results



Incorporating Application Results (Short Term Projects)

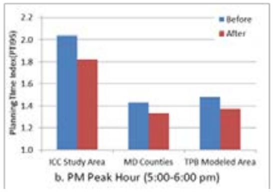
- Improvement Projects Identified for I-695 Using Existing Process Selected as Case Study
- Total of 16 Projects Ranked Using Life Cycle BCA
- Improvements are Low Cost Congestion Relief Projects (e.g., addition of auxiliary lanes, extending acceleration lanes)
- VISSIM Used as Analysis Tool
- Performed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

Step 1 – Diagnosis
- Identify Unreliable Segments
- SHA uses PTI (95th % TT)



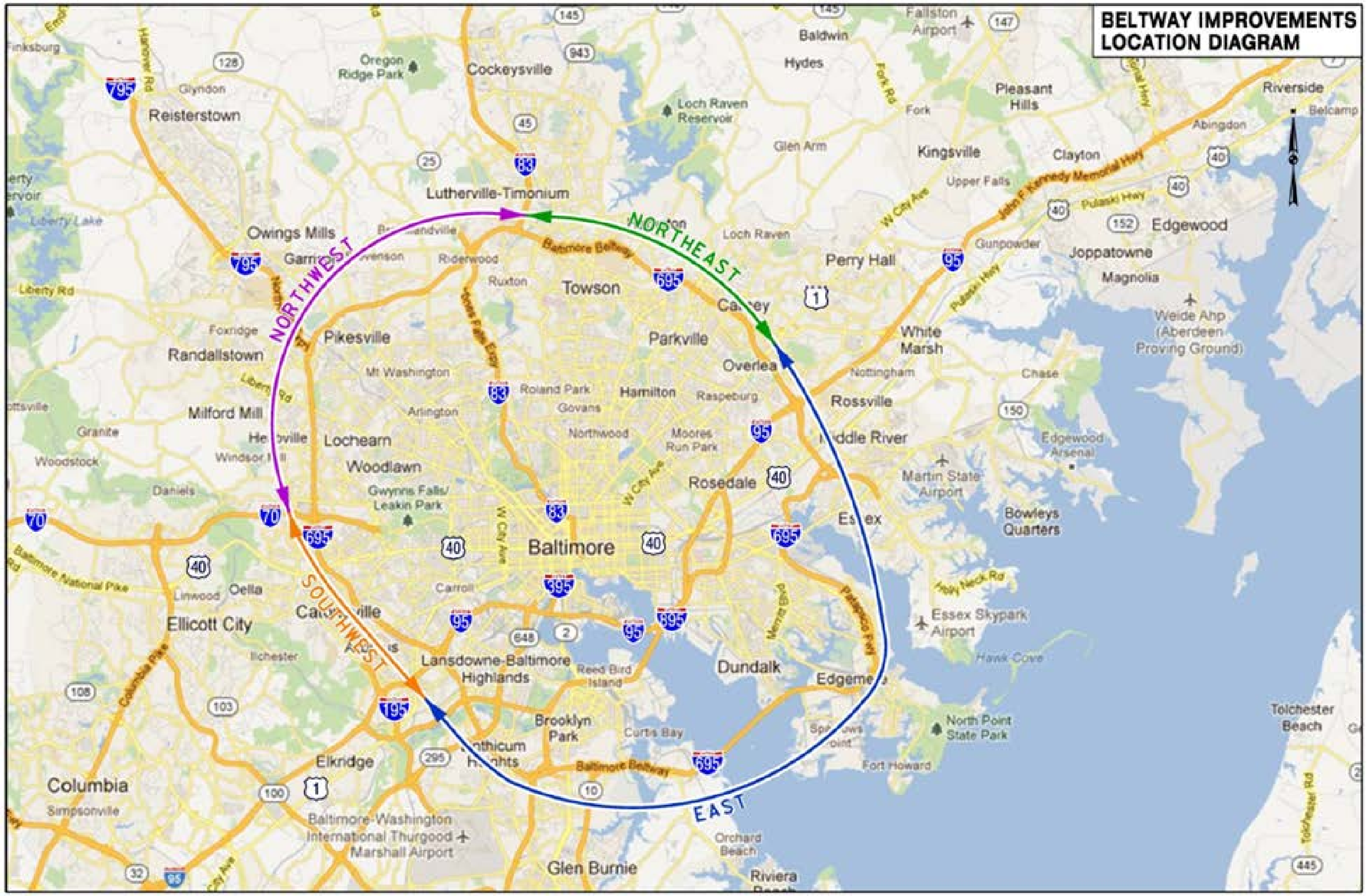
Step 2 – Analysis
- Identify project alternatives
- B/C prioritization
- SHA uses RR=0.75 for VTTR Benefits

Step 3 – Selection
- Work with Stakeholders to select projects & program for design/construction



Step 4 – Assessment
- Assess reliability improvement
- SHA uses PTI (95th % TT)

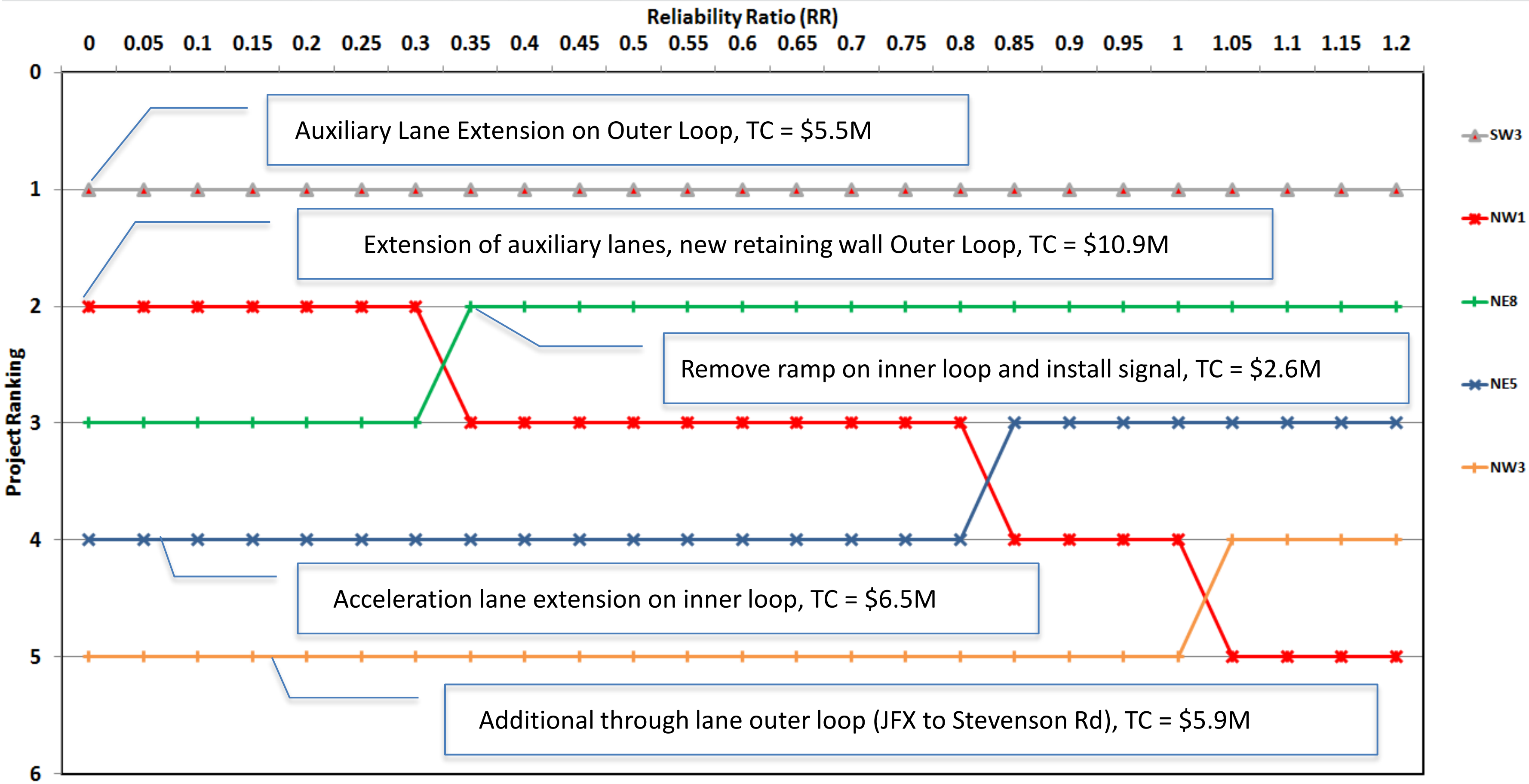
Incorporating Application Results (Short Term Projects)



Incorporating Application Results (Short Term Projects)

- Benefits include cost savings related to:
  - delay reduction (auto, freight, fuel)
  - 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

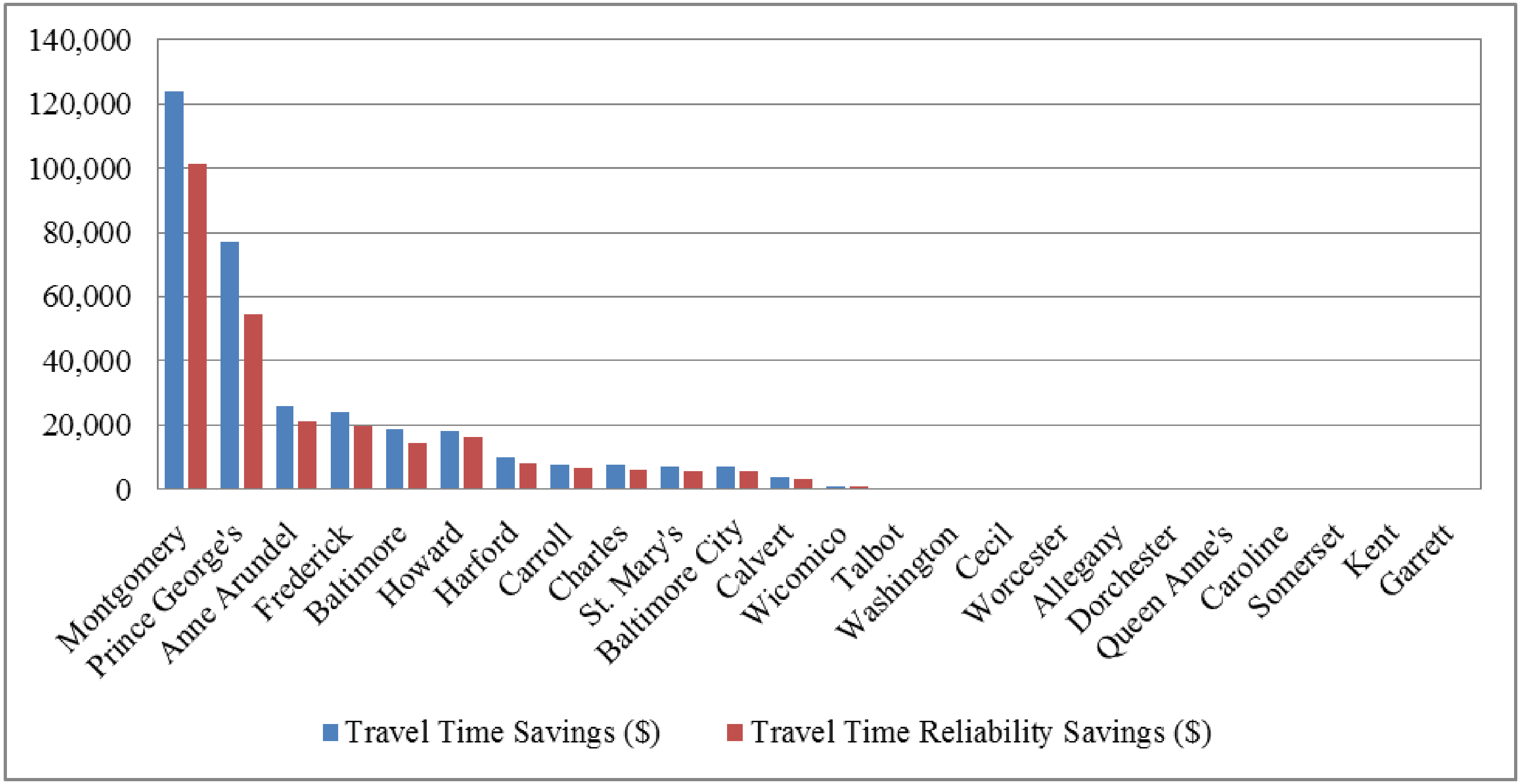
Incorporating Application Results (Long Term Projects)

- 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)

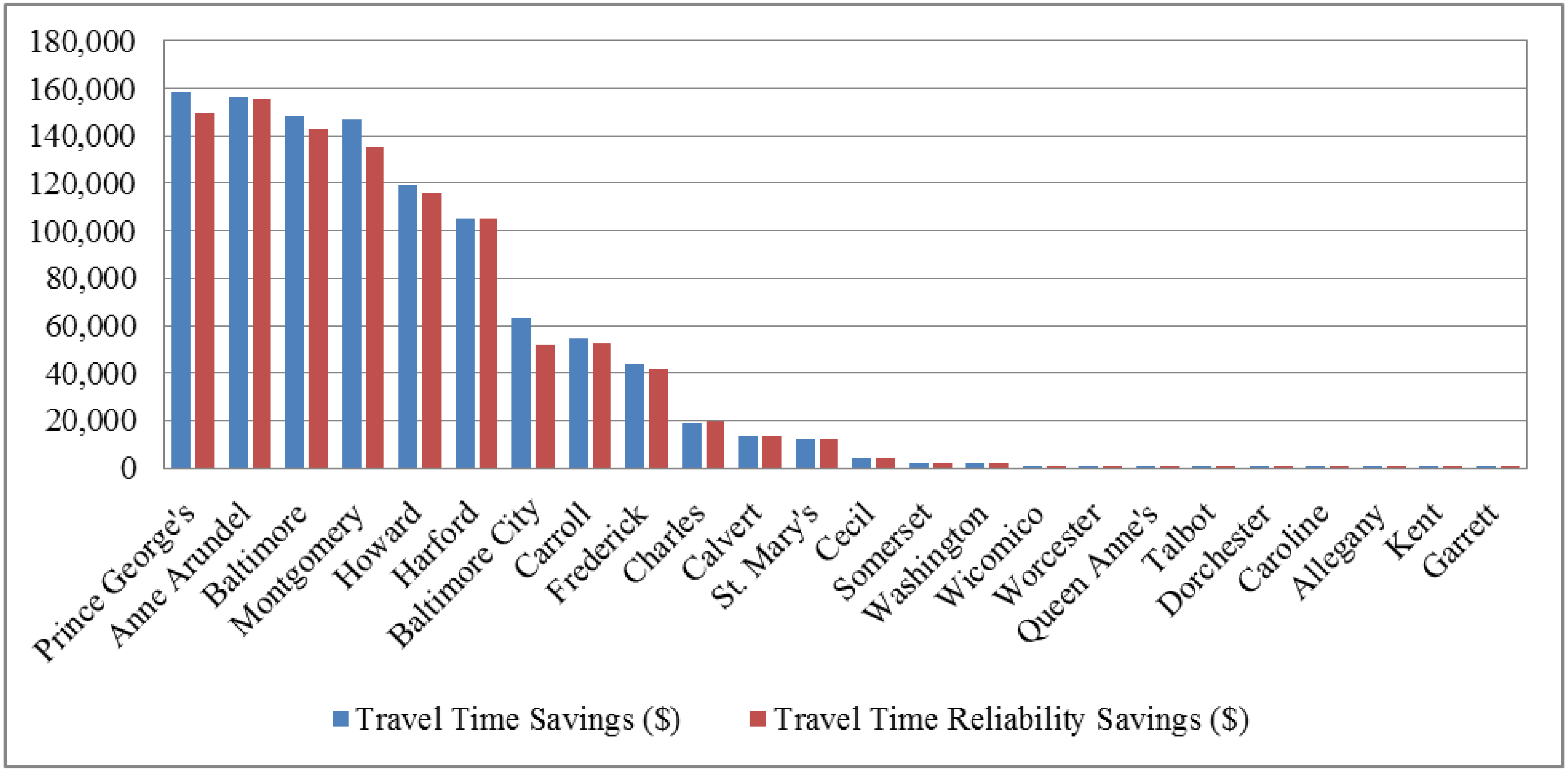
County Level Findings

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



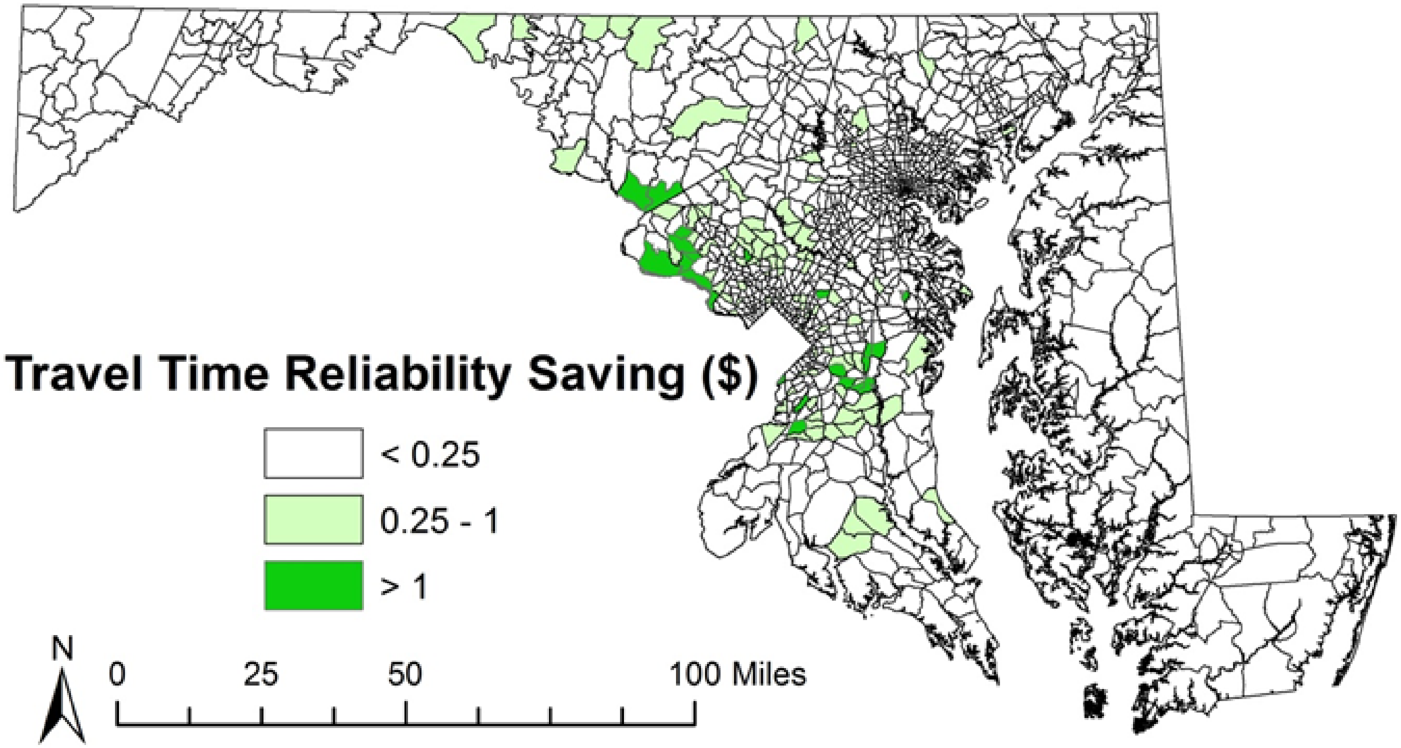
County Level Findings

- Typical day, AM peak period, future year build



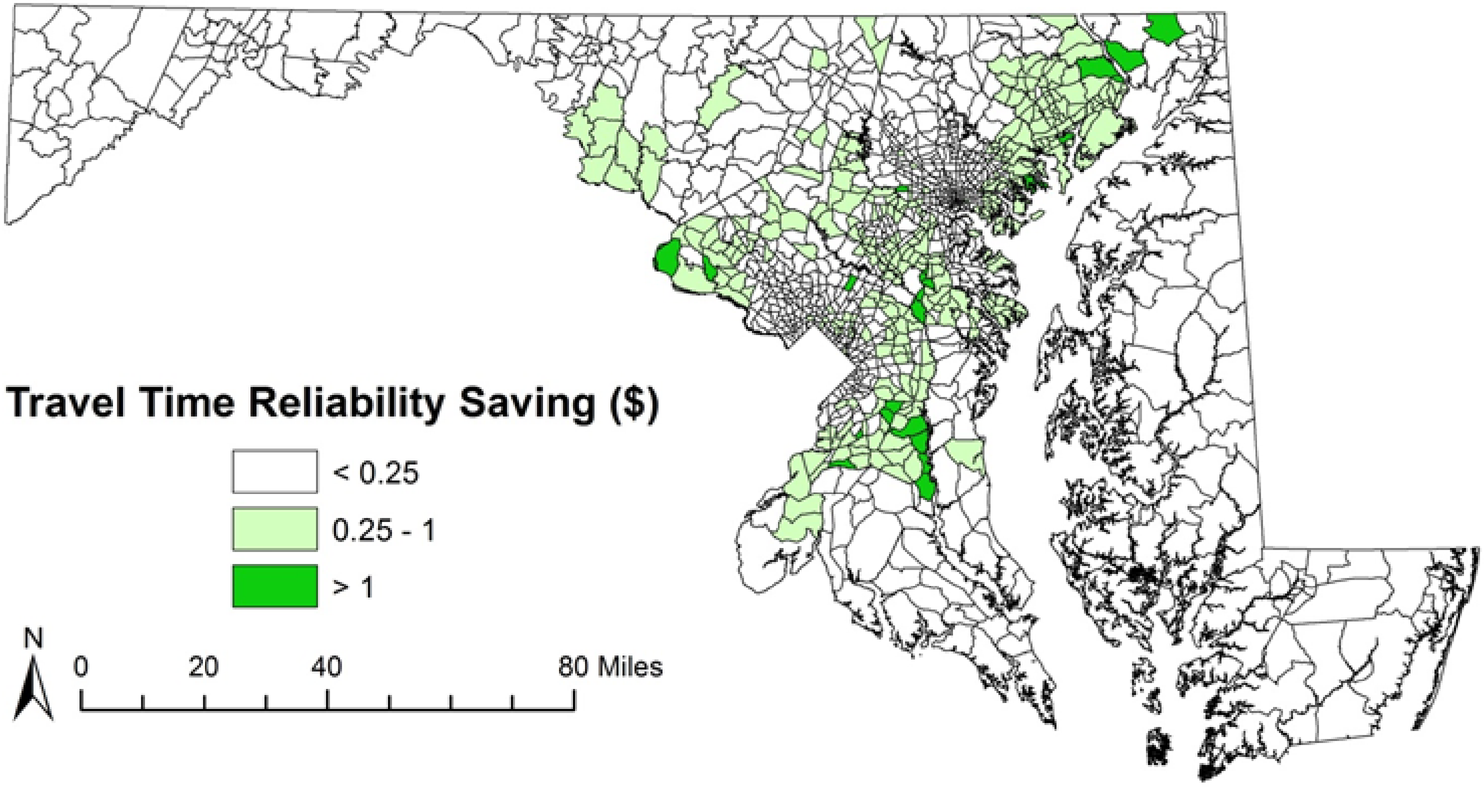
TAZ Level Findings

- 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

- Historic probe data is used in a data-driven method to estimate VOR/RR
- TTDDM has promise, but additional research is needed
- Methodology is transferable to other DOT's as TT data has become more readily available
- SHA's use of 0.75 RR appears reasonable based on TTDDM application
- Caution! Results for short-term improvement projects are based on aggregate travel time savings
- SHA has incorporated the research results in its BCA tools for routine project evaluation

Reference

- SHRP2 Report S2-L35B-RW-1

  Project L35 (B)

  - Value of Travel Time Reliability in Transportation Decision Making: Proof of Concept—Maryland
  - http://www.trb.org/Publications/Blurbs/171444.aspx

  – Part 1: Background and Applications of the Method

  – Part 2: Detailed Description of the Method

Contacts

Thomas H. Jacobs
Director
tjacobs@umd.edu
301.405.7328

Frederick W. Ducca
Senior Research Scientist
fducca@umd.edu
301.405.1945

Subrat Mahapatra
Transportation Engineering Manager
smahapatra@sha.state.md.us
410.545.5649

Kaveh Farokhi
Faculty Research Assistant
kfarokhi@umd.edu
301.405.1352

Sevgi Erdogan
Faculty Research Associate
serdogan@umd.edu
301.405.9877

Center for Advanced Transportation Technology (CATT)
University of Maryland
College Park, MD 20742

National Center for Smart Growth (NCSG)
University of Maryland
College Park, MD 20742

Office of Planning and Preliminary Engineering
Maryland State Highway Administration