Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs (SHRP2 C05)

Brandon Nevers, PE, PTOE
Kittelson & Associates, Inc.

WDCSITE Technical Meeting
George Mason University
September 16, 2010

Presentation Overview

- Project Background
- Key Products
- Strategy Testing Plan and Preliminary Findings
- Conclusion

Project Background

- Project team:
  - *Kittelson & Associates, Inc.*
  - *Institute for Transportation Research and Education, North Carolina State University*
  - *Ruhr University Bochum, Germany*
  - *University of Utah*
- Principal Investigator: Wayne Kittelson, KAI

Project Motivation

- Backlog of needs to improve the performance of our transportation system
- Increasingly limited resources
- Long and tedious process for implementing major capacity additions (8-10 years minimum)
- Strong desire for identifying easier-to-implement options that have three characteristics:
  - *High potential to increase capacity and/or performance*
  - *Within purview of the decision maker*
  - *Feasible, practical, and proven strategy*

Project Scope and Objectives

- Objectives:
  - *Quantify capacity benefits of improvements at the network level*
  - *Provide information and tools to analyze operational improvements as an alternative to traditional construction*
  - *Develop guidelines for "sustainable service rates" to be used in planning networks*
- Limits of project scope:
  - *Automobile mode focus, not transit or non-motorized travel*
  - *Capacity focus, not demand management*

Categories of Potential Strategies

- Operations-based, such as
  - *Signal coordination*
  - *Ramp metering*
- Design-based, such as
  - *Narrow lanes*
  - *Alternative left turn treatments*
- Technology-based (ATIS, Advanced Traveler Information System), such as
  - *Pre-trip information*
  - *In-vehicle information*
- Strategies to improve freeway performance, arterial performance, or both

25 Non-Lane Widening Strategies to Improve Capacity Selected for Evaluation

Freeway	Arterial	Both
HOV Lanes	Signal Retiming	Narrow Lanes
Ramp Metering	Signal Coordination	Reversible Lanes
Ramp Closures	Adaptive Signals	Variable Lanes
Congestion Pricing	Queue Management	Truck Only Lanes
Pricing by Distance	Raised Medians	Truck Restrictions
HOT Lanes	Access Points	Pre-Trip Information
Weaving Section	Right/Left Turn Channelization	In-Vehicle Info
Frontage Road	Alt LT/RT Treatments	VMS/DMS
Interchange Modifications		

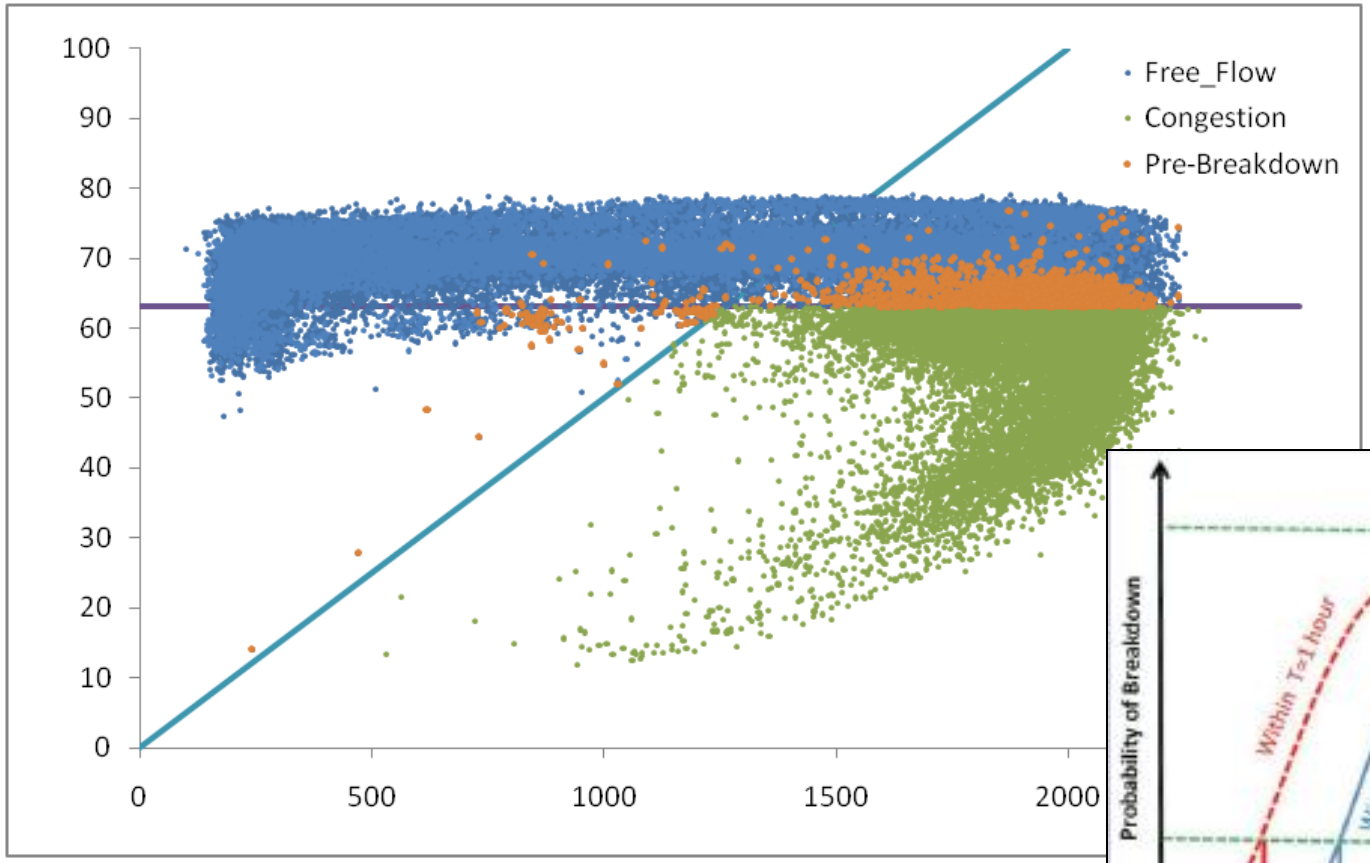
Insights on Strategy Effectiveness

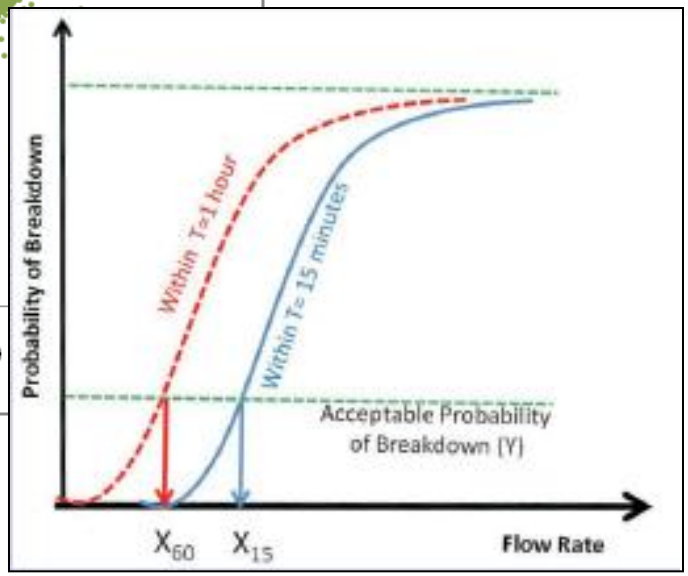
- Effectiveness needs to be tested in network context
  - *Requires the use of a travel demand/dynamic traffic assignment (DTA) model*
  - *Cannot be done with static look-up tables or simple spreadsheets*
- Impacts most pronounced at the link and corridor levels, and often difficult to see at the network level
  - *Demand-side issues are best viewed from an O-D perspective*
  - *Supply-side issues are best viewed at the link and corridor level*
- Pre-trip information can reduce buffer time and improve reliability
- En-route information may create instabilities

Key Products of this Project

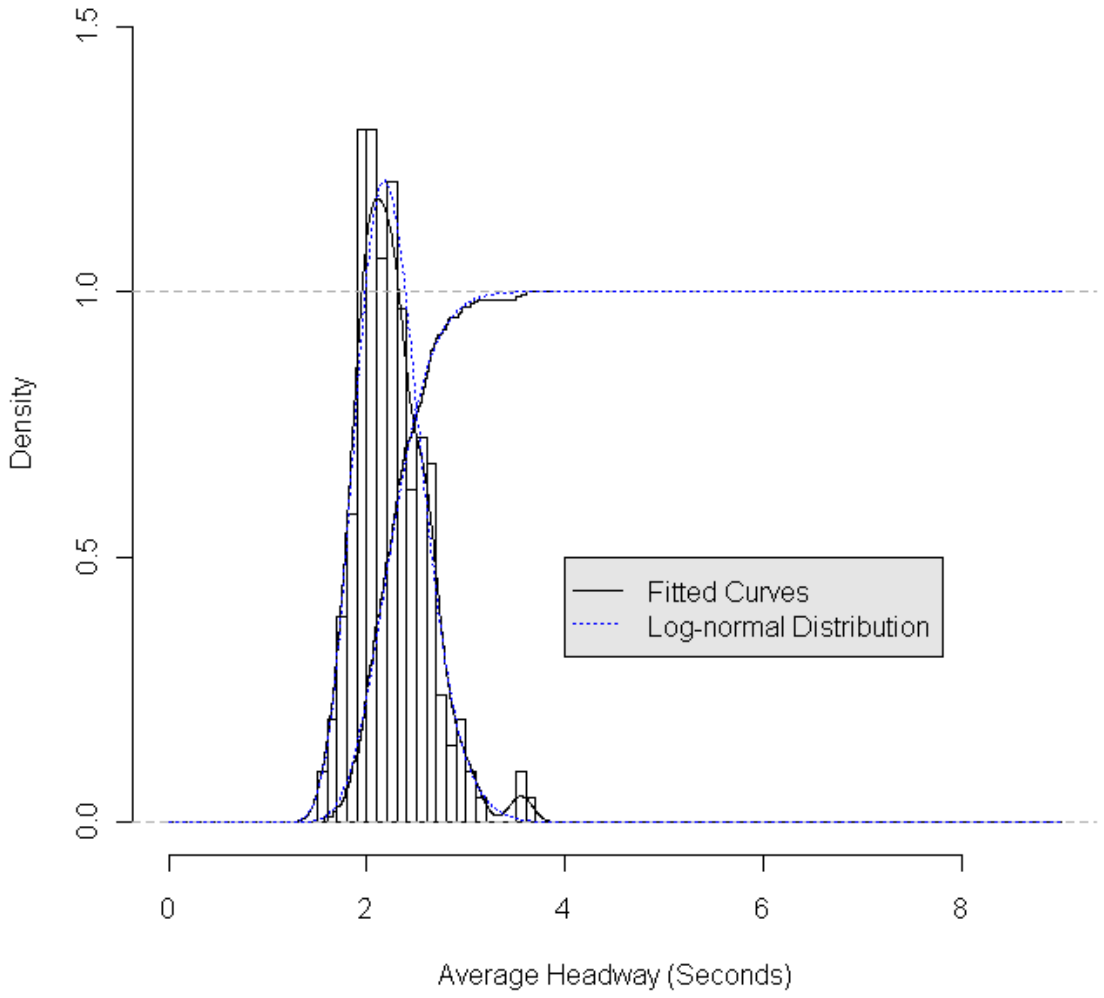
- Traffic Model Enhancements
- Diagnostic Tools
- Strategy Evaluation Approach
- Simplified Spreadsheet-Based Models
- Final Report
- Guidebook

Traffic Model Enhancements: Stochastic Capacity for Freeway Bottlenecks





Traffic Model Enhancements: Stochastic Capacity for Arterials



Other Traffic Model Enhancements

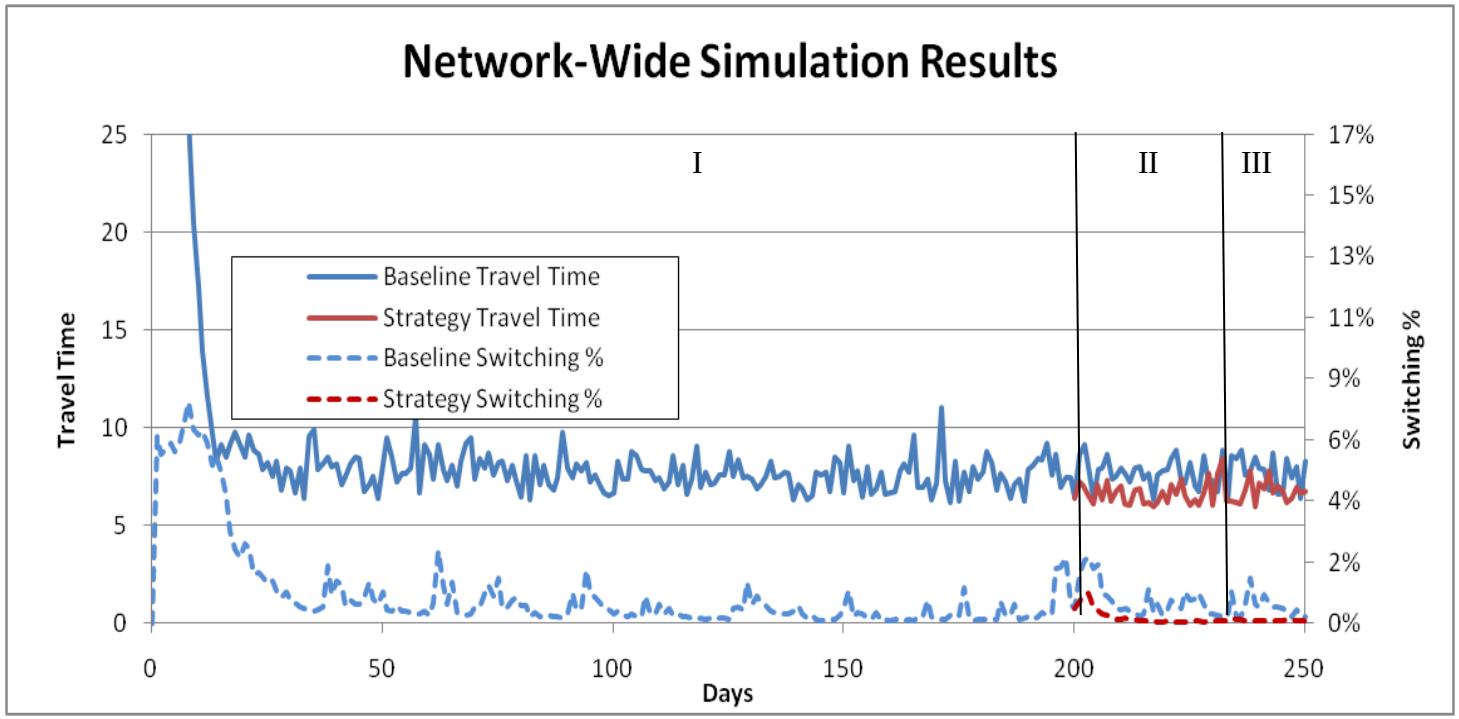
- Day-to-day traveler learning
  - *Traveler's route choice is based on experiences remembered from the past two weeks*
  - *Limits applied to number of travelers who will adjust their trip each day*
  - *Expected to be important in the evaluation of non-recurring congestion*
- Improved bottleneck representation
- Active bottleneck identification
- Written in open source coding for implementation in any dynamic traffic assignment (DTA) model
- Tested on DTALite (open source software) and Dynasmart-P (commercial software)

Overview of Strategy Testing Plan

- Two networks tested:
  - *Freeway corridor with parallel arterials (Dallas-Fort Worth, Texas)*
  - *More complex and realistic subarea network (Portland, Oregon)*
- Geometric, volume, and operational inputs
- Selection of performance evaluation MOE's

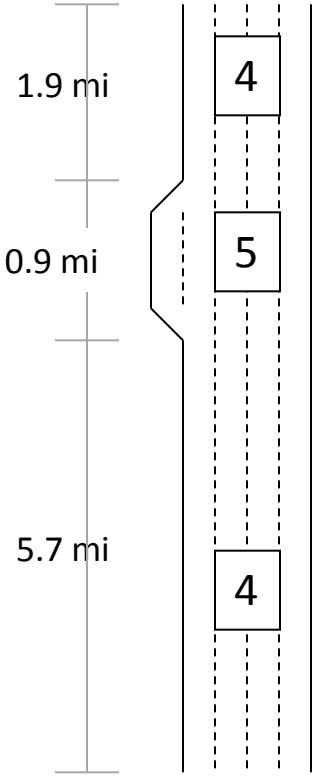
Overview of Strategy Testing Plan (cont.)

- Test Protocol
  - *I: Baseline stabilization*
  - *II: Strategy stabilization*
  - *III: 20-day results comparison period*



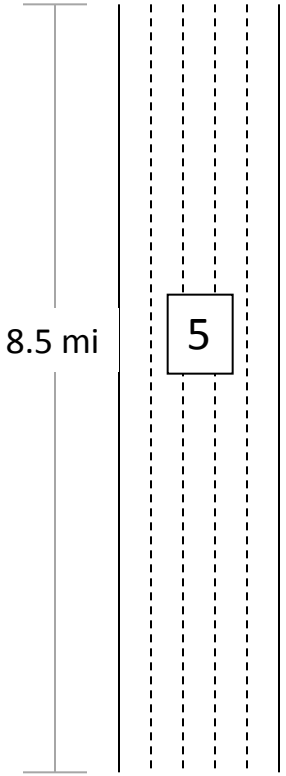
Capacity Addition Scenarios Tested on DFW Network (Southbound Freeway Corridor)

Baseline # of Lanes



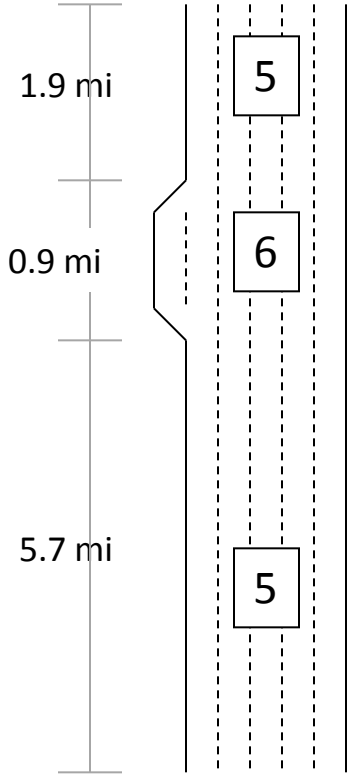
Option A

+7.6 lane mi (22%)



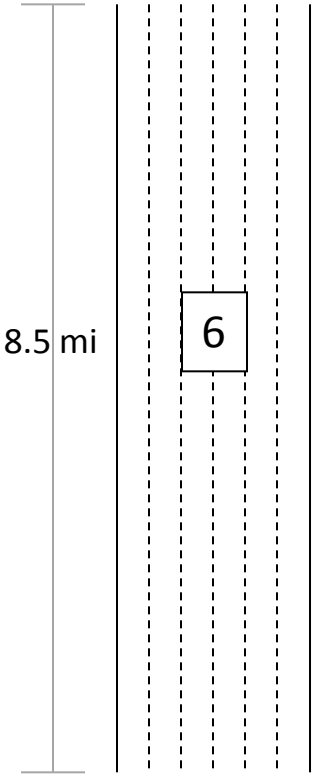
Option B

+8.5 lane mi (24%)



Option C

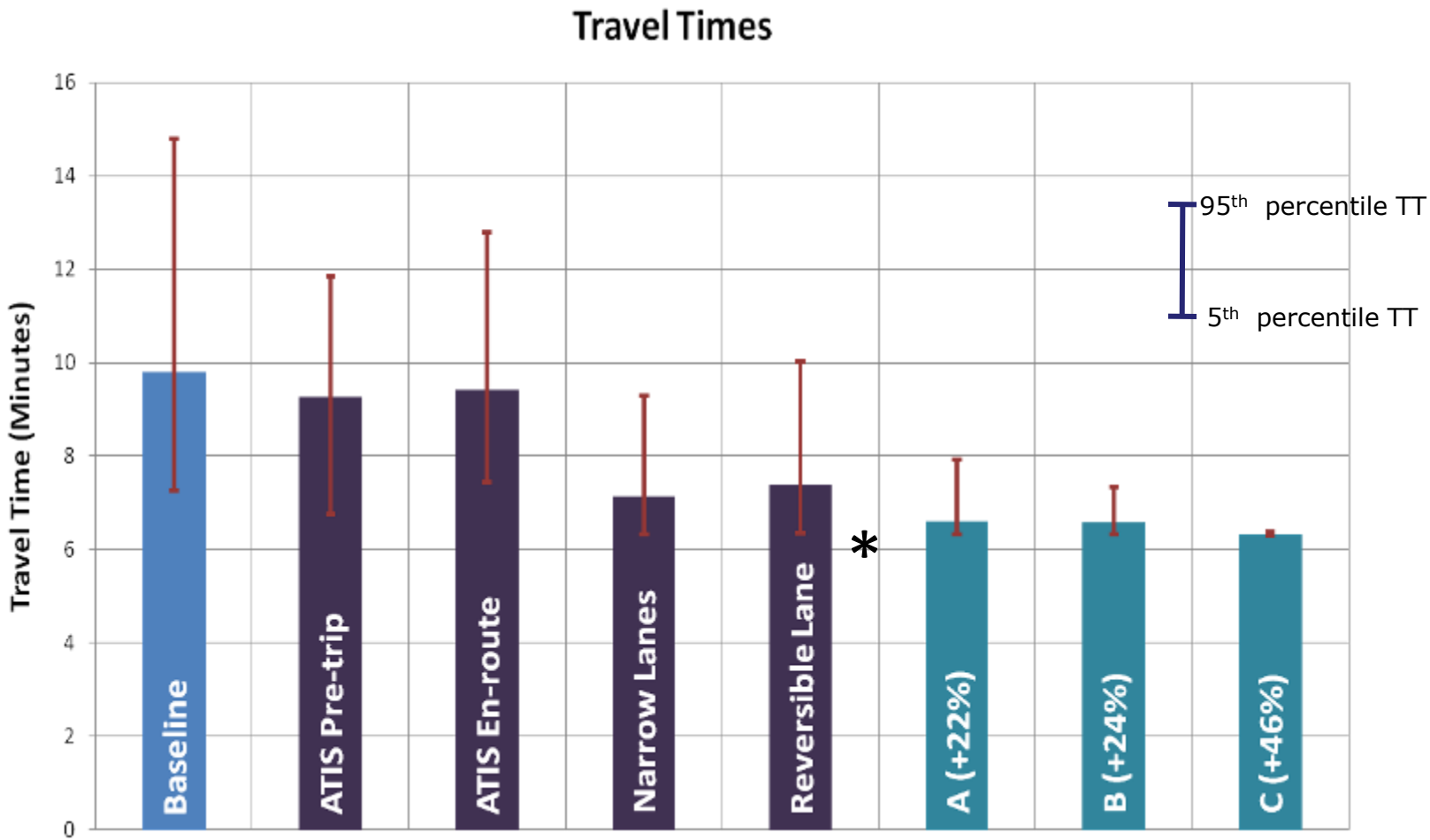
+16.0 lane mi(+46%)



Alternative Scenarios Tested

- ATIS Pre-Trip (10% of travelers instead of assumed 1% of travelers)
- ATIS En-Route (10% of travelers instead of assumed 1% of travelers)
- Narrow Lanes
  - *Equivalent to a 0.6 lane addition*
- Reversible Lane
  - *Equivalent lane reduction in the off-peak direction*

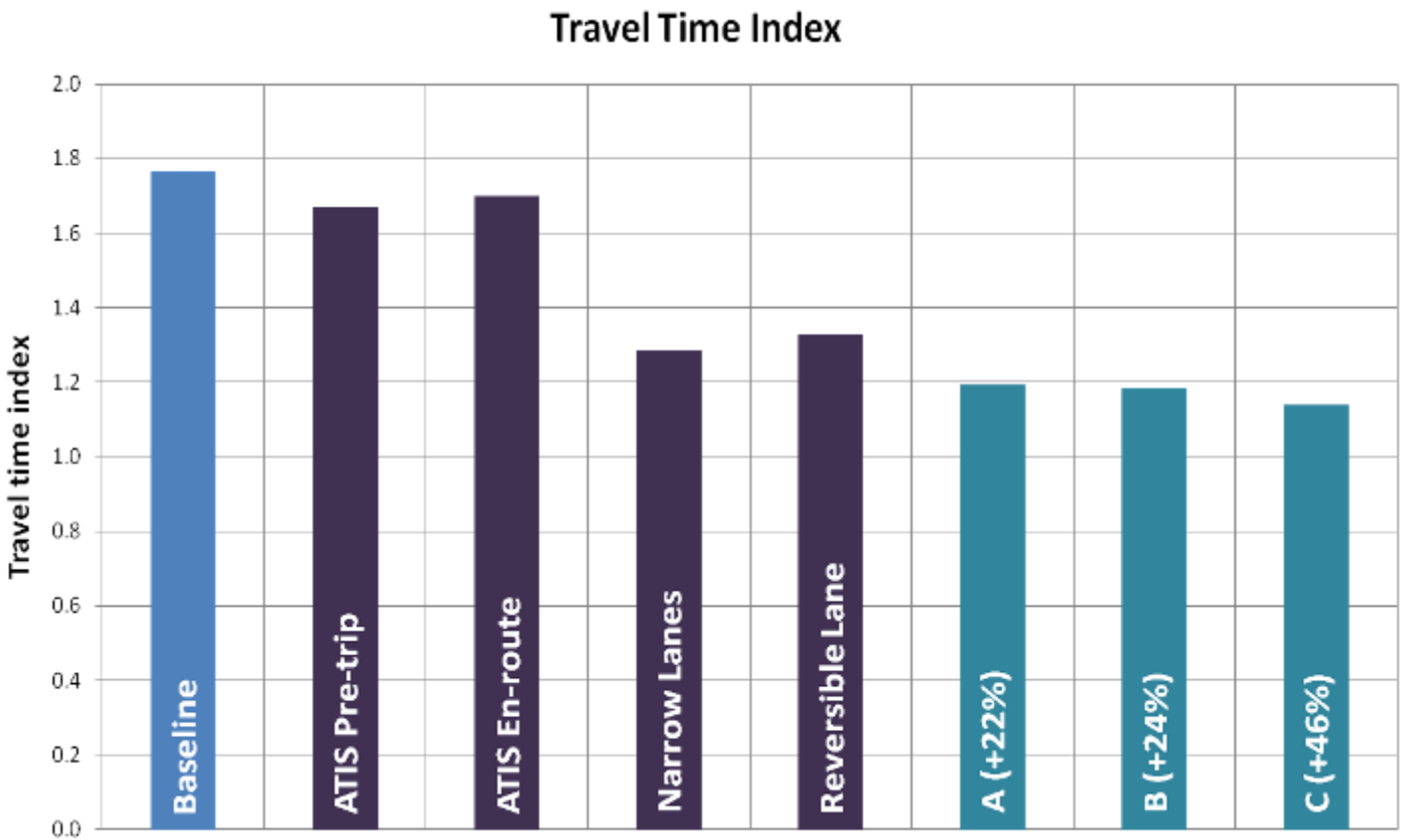
20-Day Average Results for the Primary SB O-D



* Effects in peak direction with lane addition for one hour

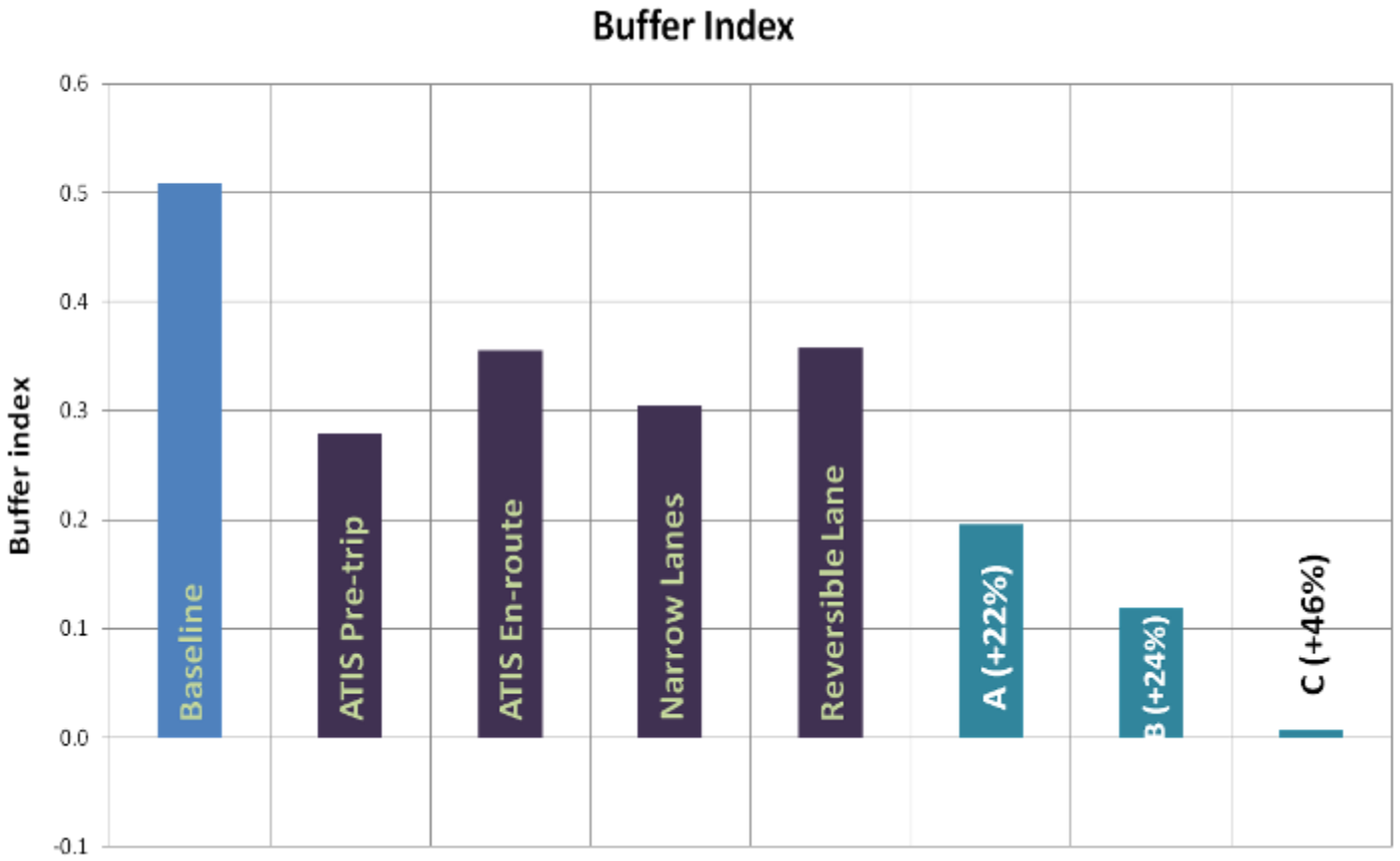
20-Day Average Results (cont.)

- Travel Time Index = Mean TT/Free Flow TT



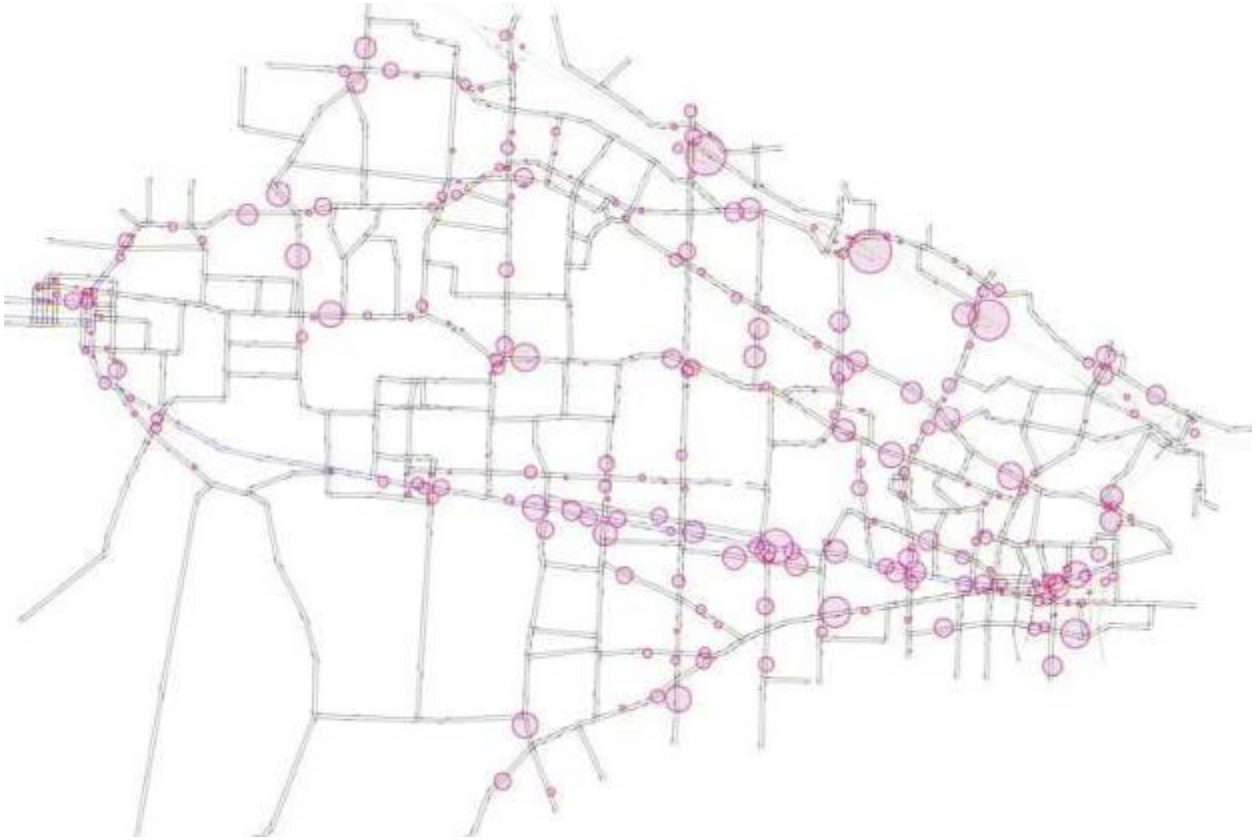
20-Day Average Results (cont.)

- Buffer Index = (95th %ile TT – Mean TT)/Mean TT



Other Tests Conducted: Portland subarea

- Bottleneck identification for realistic network
- Identifying and testing non-lane widening alternatives



Future Applications and Extensions

- Adding non-recurrent congestion capability
  - *Develop strategy to represent effects of nonrecurring congestion*
  - *Produce necessary software code*
  - *Apply enhanced model to network (Portland network or use another)*
  - *Summarize and document findings*

- Use on real-world projects
  - *Adaptation of stochastic capacity distribution functions for freeways and arterials*
  - *Development and calibration of DTA model to local conditions*
  - *Capacity adjustments for individual improvements need to be calibrated to local conditions*

Conclusion

- Dynamic Traffic Assignment (DTA) models can be effective in assessing lower-cost strategies
- New modeling capabilities are available that can be extended to a variety of DTA models
- Capacity reliability can be tied together with travel time reliability
- Further enhancement to include nonrecurrent congestion will create additional value

Thank you!

- Brandon Nevers, PE, PTOE
- Kittelson & Associates, Inc.
- Reston, Virginia

- bnevers@kittelson.com
- (703) 885-8970