Benefit Cost Analysis (BCA) for Transportation Systems Management and Operations (TSMO)

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National Operations Center of Excellence

Presented by

The U.S. Department of Transportation

Federal Highway Administration

Office of Operations
Federal Highway Administration
1200 New Jersey Avenue SE
Washington, DC 20590

U.S. Department of Transportation
Federal Highway Administration

Opening Remarks

Jim Hunt

Transportation Specialist

Federal Highways (FHWA) Office of Operations

Office of Operations
Federal Highway Administration
1200 New Jersey Avenue SE
Washington, DC 20590

Webinar Objectives

- Introduce Benefit Cost Analysis (BCA) concepts and tools
- Discuss the applications of BCA to Transportation Systems Management and Operations (TSMO) investments analysis
- Introduce FHWA's Tool for Operations Benefit Cost Analysis (TOPS-BC) tool
- Provide examples of using TOPS-BC or other analysis tools in the field

Agenda

Title	Presenter
Opening Remarks	Jim Hunt, FHWA
Benefit Cost Analysis (BCA) for TSMO	Jim Hunt, FHWA
Benefit Cost Analysis for TSMO Strategies and Introduction to TOPS-BC	Michael Lawrence, Jack Faucett Associates (JFA)
US-23 Flex Route Cost-Benefit	Stephanie Palmer, Michigan Department of Transportation (MDOT)
Developing and Providing Parking Information to Truckers	Matt Hansen, California Department of Transportation

The Team

FHWA TOPS-BC (Review) and Contractor (Developer) Team Members

- Jim Hunt, FHWA*
- Ralph Volpe, FHWA*
- Tom Kearney, FHWA*
- Jeff Purdy, FHWA
- Roemer Alfelor, FHWA
- Mike Lawrence, JFA*
- Mathies Wahner, JFA
- Jon Skolnik, JFA
- Jocelyn Bauer, Leidos
- Mae Fromm, Leidos

* Available today to answer questions

Benefit Cost Analysis (BCA) for TSMO

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What is Transportation Systems Management & Operations (TSMO)?

TSMO consists of "integrated strategies to optimize the performance of existing infrastructure…"

- Implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects…
- Coordination of regional transportation investments …requiring agreements, integration, and interoperability to achieve targeted system performance reliability, safety, and customer service levels.

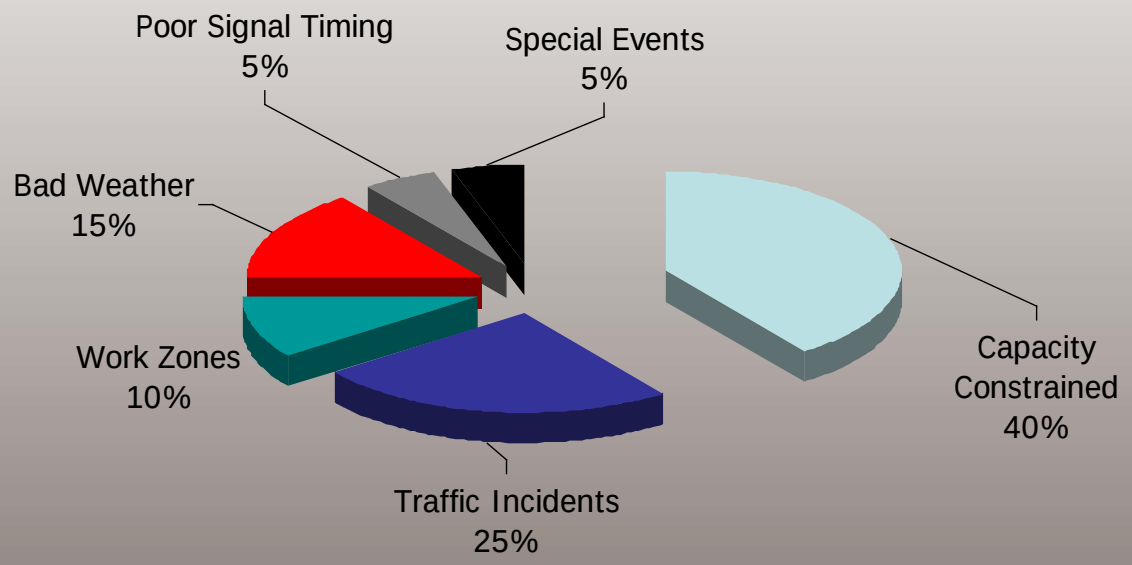
Moving Ahead for Progress in the 21st Century (MAP-21)

TSMO Strategies

- Influence travel demand (how much, when, where)
- Effectively manage resulting traffic
- Anticipate and respond to planned and unplanned events (traffic incidents, work zones, bad weather, special events)
- Provide travelers with high quality traffic and road condition information
- Ensure that the unique needs of the freight community are considered and included in all of the above

See: USDOT, FHWA Office of Operations, *The Operations Story*

Congestion Sources



Source: FHWA

TSMO strategies address multiple sources of congestion, not just limitations in capacity.

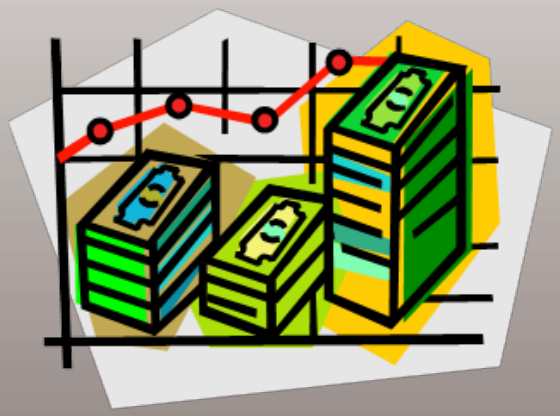
TSMO Strategies Include…

- Integrated corridor management
- Active traffic management
- Traffic incident management
- Traffic signal coordination
- Transit signal priority
- Freight management
- Work zone management
- Special event management
- Road Weather Management
- Congestion pricing
- Managed lanes
- Ridesharing programs
- Parking management
- Electronic toll collection
- Traveler information
- Coordination of highway, rail, transit, bike, pedestrian operations

As stand-alone projects or part of larger infrastructure projects

What is a BCA?

A weighing of the net present value of direct benefits with the net present value of lifecycle costs of a project.



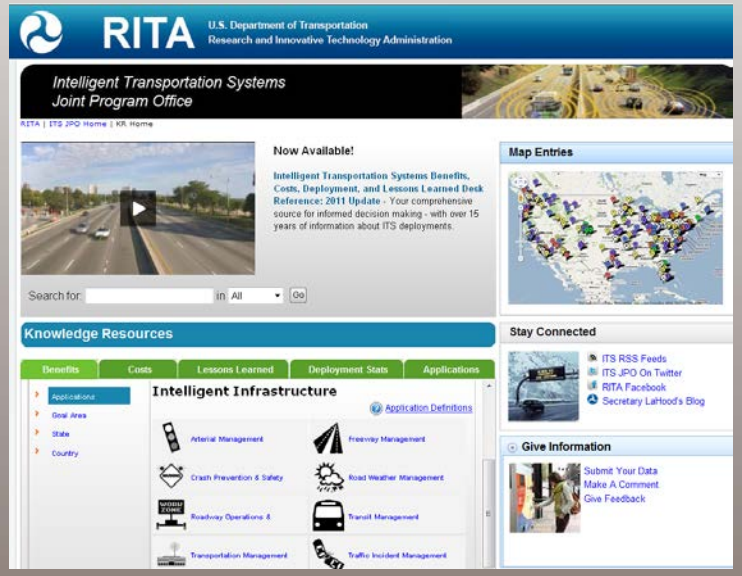
Why is a BCA Important for TSMO?

- BC Analysis provides the ability to:
  - **Prioritize** operations projects based on expected efficiency of investment
  - **Compare** operations with non-operations projects on an even playing field
  - **Justify** operations projects and strategies for consideration
- BCA supports pre- and post-deployment evaluations

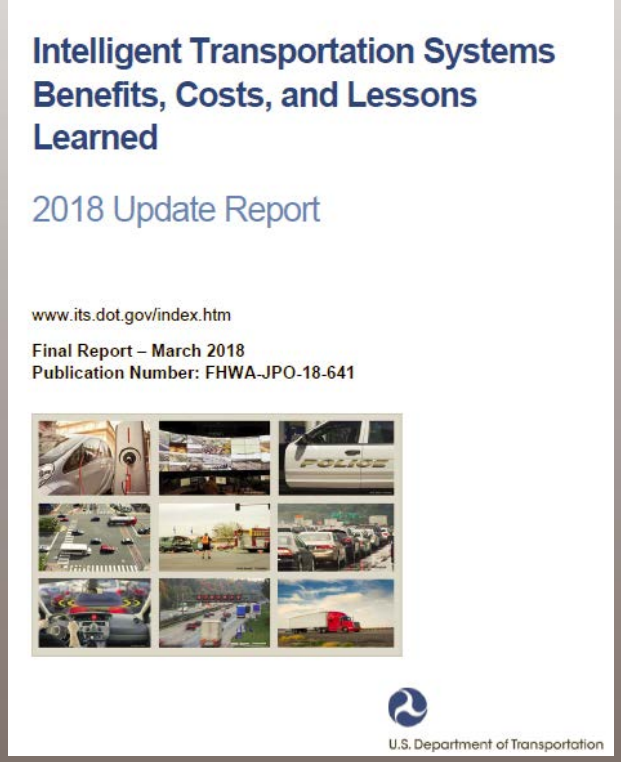
BCA Can Be a Component of Performance Management

- Condition/performance of the National Highway System
- Asset management plan
- Progress in achieving performance targets
- How the State is addressing congestion at freight bottlenecks
- Effectiveness of the investment

USDOT Intelligent Transportation Systems (ITS) Benefit-Cost Database (TSMO)



Source: US DOT



Source: US DOT

https://www.itskrs.its.dot.gov/its/itsbcllwebpage.nsf/KRHomePage

TOPS/BC 2018 Versions

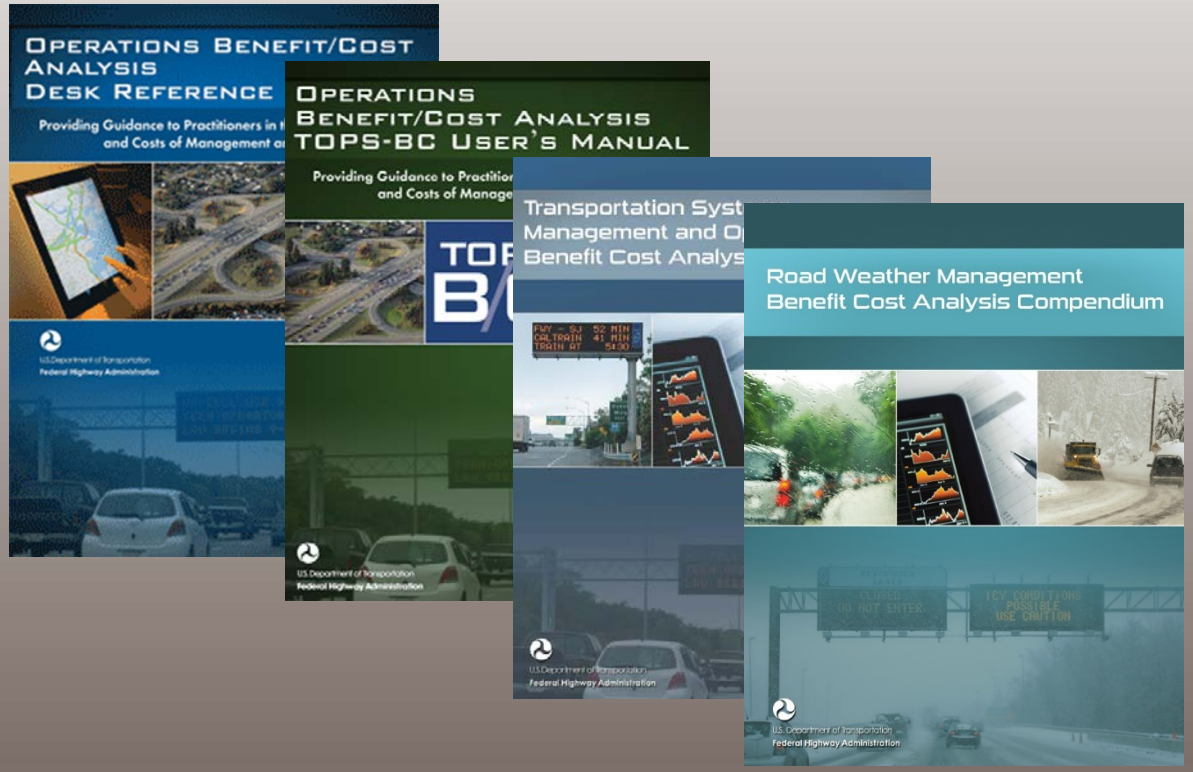
Official FHWA Version 1.2
https://ops.fhwa.dot.gov/plan4ops/topsbctool/index.htm

The new version, 3.1 Beta, is still undergoing extensive testing, but you are encouraged to download it and test it yourself. Let us know of any challenges you have with 3.1 and we will be happy to address them.

TOPS 3.1 Beta
https://www.sugarsync.com/pf/D714209_07174599_2101724

Other Related Operations Resources can be found at
https://ops.fhwa.dot.gov/plan4ops/focus_areas/analysis_p_measure/benefit_cost_analysis.htm

FHWA Resources to Support TSMO and RWM BCA



TSMO BCA TOOLS

- Federal Highway Administration (FHWA) developed TOPS-BC to support operators and others in conducting evaluations of planned and implemented TSMO strategies.
- TOPS-BC has undergone extensive updating and revision over the past two years.
- The next presentation will bring you up to speed on what TOPS-BC is, how it was expanded, and how it can support your TSMO programs.

Disclaimer

This material is based upon work supported by the U.S. Department of Transportation. Any opinions, findings and conclusions or recommendations expressed in this presentation are those of the author(s) and do not necessarily reflect the views of the U.S. Department of Transportation.

Benefit Cost Analysis for TSMO Strategies and Introduction to TOPS-BC

Session 2

Mike Lawrence

President

Jack Faucett Associates, Inc.

Office of Operations
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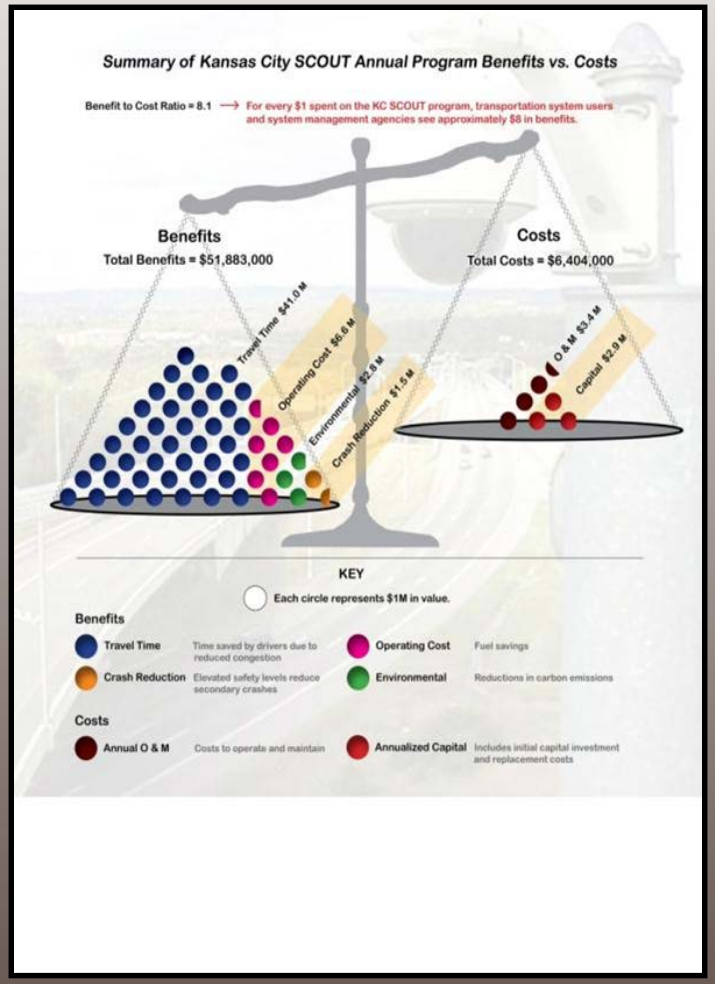
Weighty Decisions

- It is often difficult for decisionmakers to weigh the benefits of investing in operations strategies vs. more traditional capacity projects
- Benefit/Cost Analysis helps decision makers consider the value of operations projects



Source: Missouri DOT

What Will We Cover This Session

- Introduction to BC Analysis
- Specific Steps for Conducting TSMO BC Analysis
- Measuring Costs and Quantifying Benefits
- Introduction to TOPS-BC

FHWA Provides BCA Resources

- Economic Analysis Primer
  - http://www.fhwa.dot.gov/infrastructure/asstmgmt/primer00.cfm
- Operations Benefit/Cost Analysis Desk Reference
  - http://ops.fhwa.dot.gov/publications/fhwahop12028/index.htm
- TIGER/BUILD BCA Resource Guide
  - http://www.dot.gov/policy-initiatives/tiger/tiger-bca-resource-guide

Types of Economic Analysis

- Benefit Cost Analysis
  - Life-Cycle Cost Analysis
  - Cost Effectiveness Analysis
- Equity Analysis
- Financial Analysis
- Activity Forecasting
- Risk Analysis
- Economic Impact Analysis

BC Analysis is Not the Same as "Economic Impact Analysis"

- BC Analysis - **It's About Efficiency**
  - Considers the **direct** impacts of the project on measures of effectiveness (MOEs):
    - Travel time
    - Safety
    - Emissions
    - Fuel costs
    - Productivity
- For Decisionmakers

- Economic Impact Analysis – **It's About Change, Positive or Negative**
  - Focused on more broad regional economic activity and jobs
  - Considers **the direct, indirect and induced** impacts of the project
- For Politicians and the Public

Starting a BCA

1. Establish objectives
2. Identify constraints and specify assumptions
3. Define base case and identify alternatives
4. Set analysis period
5. Define level of effort for screening alternatives
6. Analyze traffic effects
7. Estimate benefits and costs relative to base case (discounting)
8. Evaluate risk
9. Compare net benefits and rank alternatives
10. Make recommendations

Benefits and Costs – A List

- **Benefits**
- ✓ Reduced Congestion
- ✓ Travel Time
- ✓ Reliability
- ✓ Safety
- ✓ Energy
- ✓ Others

- **Costs**
- ✓ Equipment
- ✓ O&M
- ✓ Software
- ✓ Communications
- ✓ Installation
- ✓ Others

What's Missing?
How About Agency Costs?

Cost Quantification

- Price lists
- Data such as FHWA ITS Cost Database www.itscosts.its.dot.gov
  - Provides historic ITS deployment costs
  - Unit costs, System costs
  - ITS Capital and Operations and Management (O&M) Cost
- Previous Projects

Benefit Quantification

- Often the heart of the matter!
- Identify Measures of Effectiveness (MOE)
  - Traditional – Travel Time Savings, Vehicle Operating Cost, Safety, Emissions
  - Emerging MOEs – Travel Time Reliability, Induced Travel/Consumer Surplus, Climate Change
  - Other MOEs – Quality of Life, Customer Satisfaction, Feelings of Safety and Security

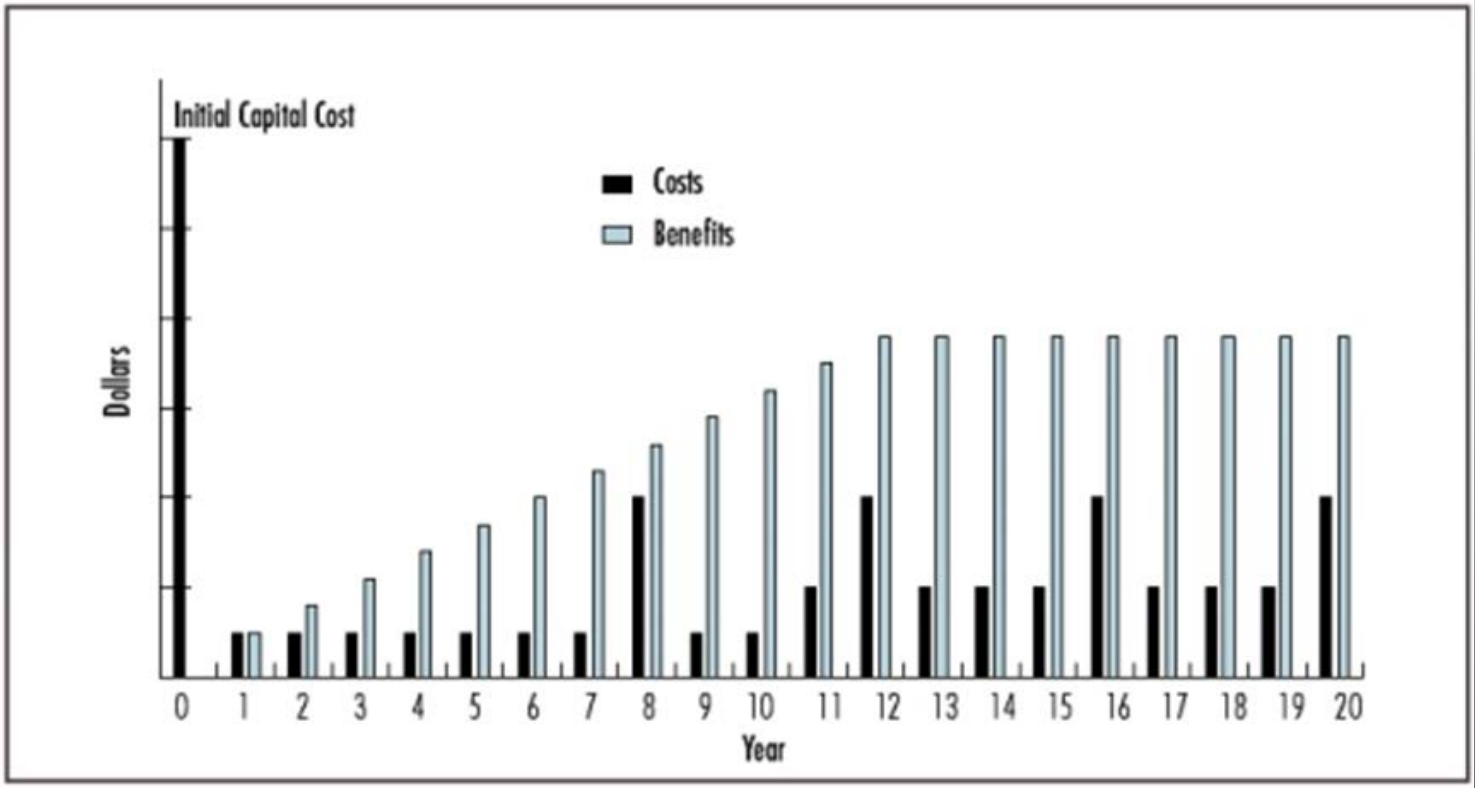
Benefit Monetization

- Where we need to get to for BCA
- Pair MOEs with value estimates and prices
  - Value of time
  - Value of reliability
  - Value of life
  - Cost of injury and property damage
  - Fuel price
  - Value of emissions reductions
  - Others

Other Important BCA Concepts

- Risk and Uncertainty
- Calculating the Benefit Cost Ratio (BCR)
- Use of BCR and Net benefits
- Present Value and Discounting
- Unquantified Benefits
- Presenting BCA Results to Decisionmakers
- Tools for BCA analysis of TSMO

Schedules of Costs and Benefits



Present Value and Discounting

- A dollar is not always worth a dollar
- **Inflation** in the general price level means a 2018 dollar will not buy as much in 2023: at 2% inflation, you need ~ $1.10!
- Also having a dollar in the future is not as good as having a dollar today, this is the **time value** of money
- Discounting allows all $ to be equal in a BCA

Hierarchy of BCA Tools

- General Tools
  - Various Spreadsheets
- Transportation Tools
  - bca.net
- Transportation Program Areas
  - ITS Deployment Analysis System (IDAS), TOPS-BC
- Technology-Specific Tools
  - Clear Roads RWM BCA Toolkit, Traffic Incident Management Benefit-Cost (TIM-BC)

What Is TOPS-BC?

- A tool to assist operations, planning and other State DOT and MPO staff conduct a sketch planning level Benefit Cost Analyses (BCA) of Operations Projects
- It is a user friendly Excel based BCA tool that addresses most types of operations strategies and technologies
- Allow the user to organize TSMO BCA data for further analysis.

Strategies and Technologies: TOPS 2.0

Traveler Information

- En-Route Traveler Information
- Pre-Trip Traveler Information

Traffic Signal Systems (TSS)

- Preset Timing
- Traffic Actuated Timing
- Central Control
- Transit Signal Priority

Ramp Metering

- Central Control
- Traffic Actuated
- Preset Timing

Freight Strategies

- Truck Only Lanes
- Screening and Permitting Systems*
- Truck Parking and Reservation Systems*
- Climbing Lanes

Other Strategies

- Traffic Incident Management
- Active Traffic Management
- Travel Demand Management
- Hot Lanes
- Road Weather Management
- Work Zone Management

Supporting Strategies

- Traffic Management Center
- Loop Detection, CCTV

* = Active Phase 2

TOPS-BC OVERVIEW: For Each Strategy

BENEFITS:

- User Inputs
- TOPS Defaults
- User Overrides

Time Savings
Reliability
Safety
Environment
Energy

COSTS:

- User Inputs
- TOPS Defaults
- User Overrides

Basic
Incremental
O & M
Useful Life Expectancy

BCA RESULTS:

NPV Benefits & Costs
PV Net Benefits
Benefit-Cost Ratio

NPV – Net Present Value
PV – Present Value

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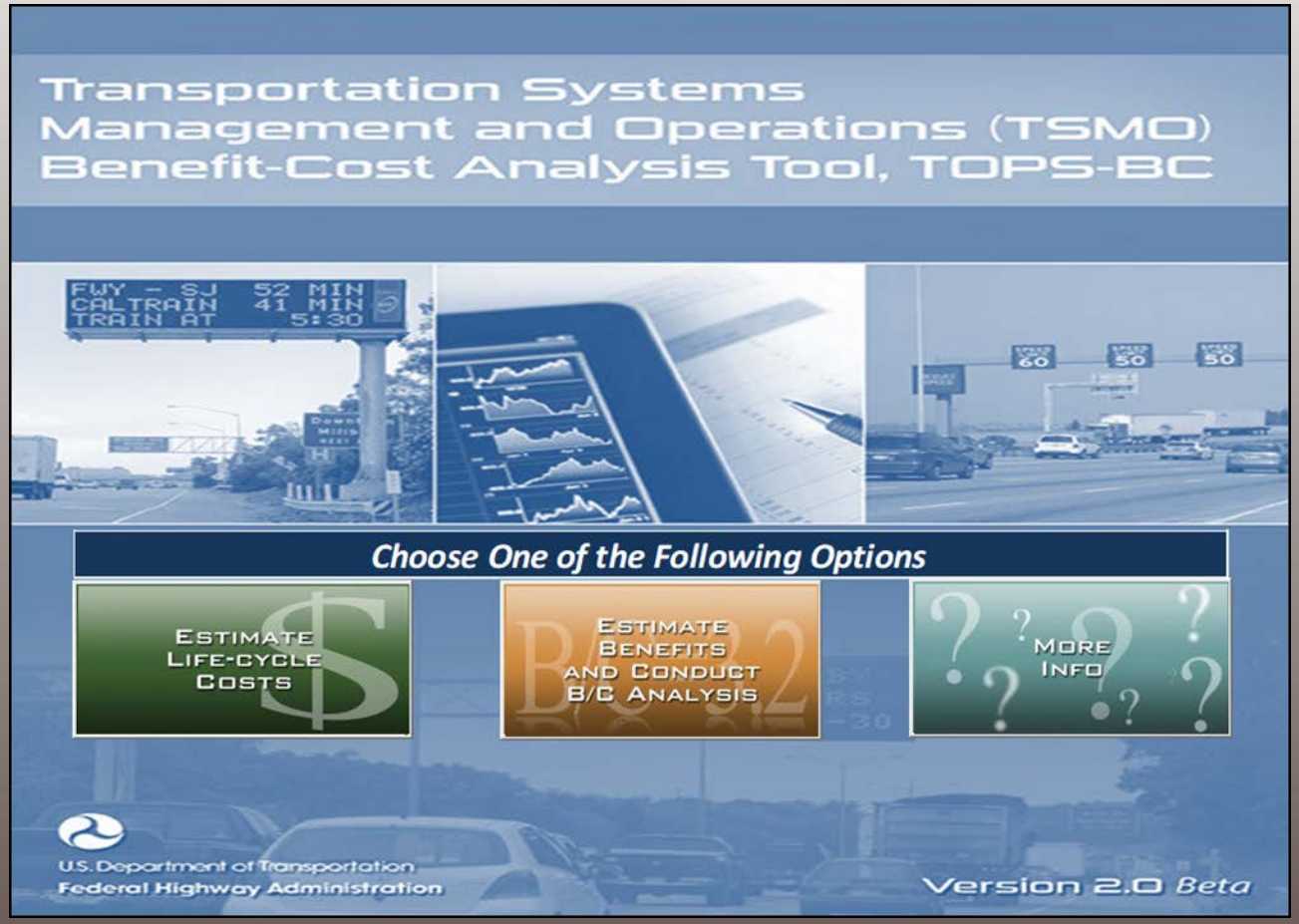
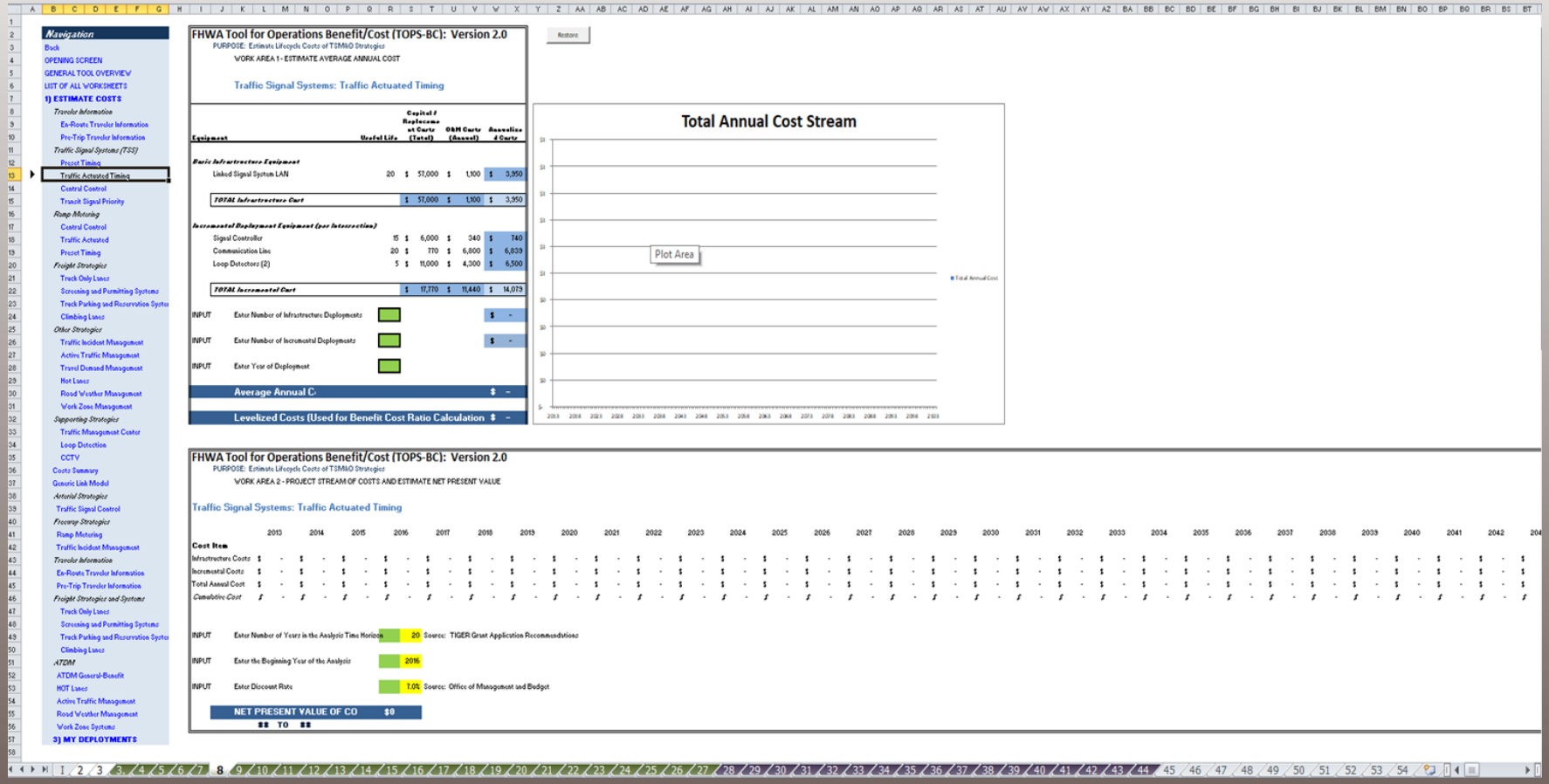
What it Takes to Make TOPS Run

Data Required	Costs	Benefits
User Inputs	Select Technology Number of Deployments Deployment Year Analysis Period	Length of Peak Facility Type Number of Lanes Segment Length Throughput
TOPS Defaults (part) For each Strategy or Technology	Basic Cost Incremental Cost Life Expectancy O&M Costs Discount Rate	Data Display Year Time Horizon Vehicle Mix Speed/Flow Model Crash Rates, By Type Many Others Values (time, crash, etc.)
User Overrides (part) Green Cells Override Yellow	All Cost Inputs	All Benefit Inputs

TOPS-BC Opening Screen



TOPS-BC Overview



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TOPS-BC Cost Page 1 of 2

FHWA Tool for Operations Benefit/Cost (TOPS-BC): Version 2.0

PURPOSE: Estimate Lifecycle Costs of TSM&O Strategies

WORK AREA 1 - ESTIMATE AVERAGE ANNUAL COST

Traffic Incident Management

Equipment	Useful Life	Capital / Replacement Costs (Total)	O&M Costs (Annual)	Annualized Costs
Basic Infrastructure Equipment				
Video Monitors/Wall for Incident Detection	5	$ 3,000	$ 150	$ 750
TMC Incident Response Hardware	5	$ 3,000	$ 150	$ 750
TMC System Integration	20	$ 200,000	$ -	$ 10,000
TMC Incident Response Software	2	$ 15,000	$ 750	$ 8,250
TMC Labor	0	$ -	$ 100,000	$ 100,000
Emergency Management Center Hardware	10	$ 22,500	$ 450	$ 2,700
Emergency Management Center Software	10	$ 110,000	$ 2,000	$ 13,000
Emergency Response Labor	0	$ -	$ 100,000	$ 100,000
Communication Line	20	$ 750	$ 900	$ 938
TOTAL Infrastructure Cost		$ 354,250	$ 204,400	$ 236,388

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TOPS-BC Cost Page 2 of 2

Incremental Deployment Equipment (per FSP Vehicle)								
	Incident Response Vehicle	7	$	87,000	$	15,500	$	27,929
	Incident Response Labor	0	$	-	$	96,000	$	96,000
	Communication Line	25	$	770	$	260	$	291
	TOTAL Incremental Cost		$	87,770	$	111,760	$	124,219
INPUT	Enter Number of Infrastructure Deployments	1					**$**	**259,119**
INPUT	Enter Number of Incremental Deployments	20					**$**	**2,484,387**
INPUT	Enter Year of Deployment	2019						
	Average Annual Cost						**$**	**2,743,506**
	Levelized Costs (Used for Benefit Cost Ratio Calculation)						**$**	**3,083,662**

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TOPS-BC Benefit Page

FHWA Tool for Operations Benefit/Cost (TOPS-BC): Version 2.0

Restore

Estimate Benefits of TSM&O Strategies

Traffic Incident Management

Length of Analysis Period (Hours): 3

Facility Characteristics

Link Facility Type: Urban Freeway

			Baseline Override	Baseline	Improvement Override	Improvement	Change
Link Length (Miles)	20						
Total Number of Lanes	3			3		3	0
Link Capacity (All Lanes - Per Period)		19800		19800		19800	0
Free Flow Speed (MPH)	65	55					

Facility Performance

Link Volume (Per Period): 18810

	Baseline Override	Baseline	Improvement Override	Improvement	Change
Congested Speed		48.130		48.130	0.000
Vehicles Miles Traveled (VMT)		376200.0000		376200.0000	0.0000
V/C		0.9500		0.9500	0.0000
TTI(m)		1.3505		1.3505	0.0000
TTI(80)		1.5155		1.5155	0.0000
TTI(95)		2.1027		2.1027	0.0000
Vehicle Hours of Travel		7816.2864		7816.2864	0.0000
Incident Related Delay (hours) per vehicle per mile		1.77806E-05		1.06684E-05	-7.11225E-06
Number of **Fatality** Crashes		2.48292E-03		2.23463E-03	-2.48292E-04
Number of **Injury** Crashes		2.60142E-01		2.60142E-01	0.00000E+00
Number of **Property Damage Only** Crashes		3.30247E-01		3.30247E-01	0.00000E+00
Fuel consumption (Gallons)		15436.7781		15436.7781	0.0000

What's New in TOPS 3.0

- Updated all defaults
- New cost data for strategies
- Cost Default Matrix
- Added four Freight strategies
- Added new ATM detail
- Added SHRP2 reliability estimates
- Added graphics to cost and benefits sheets
- Set up methods for iterative analysis

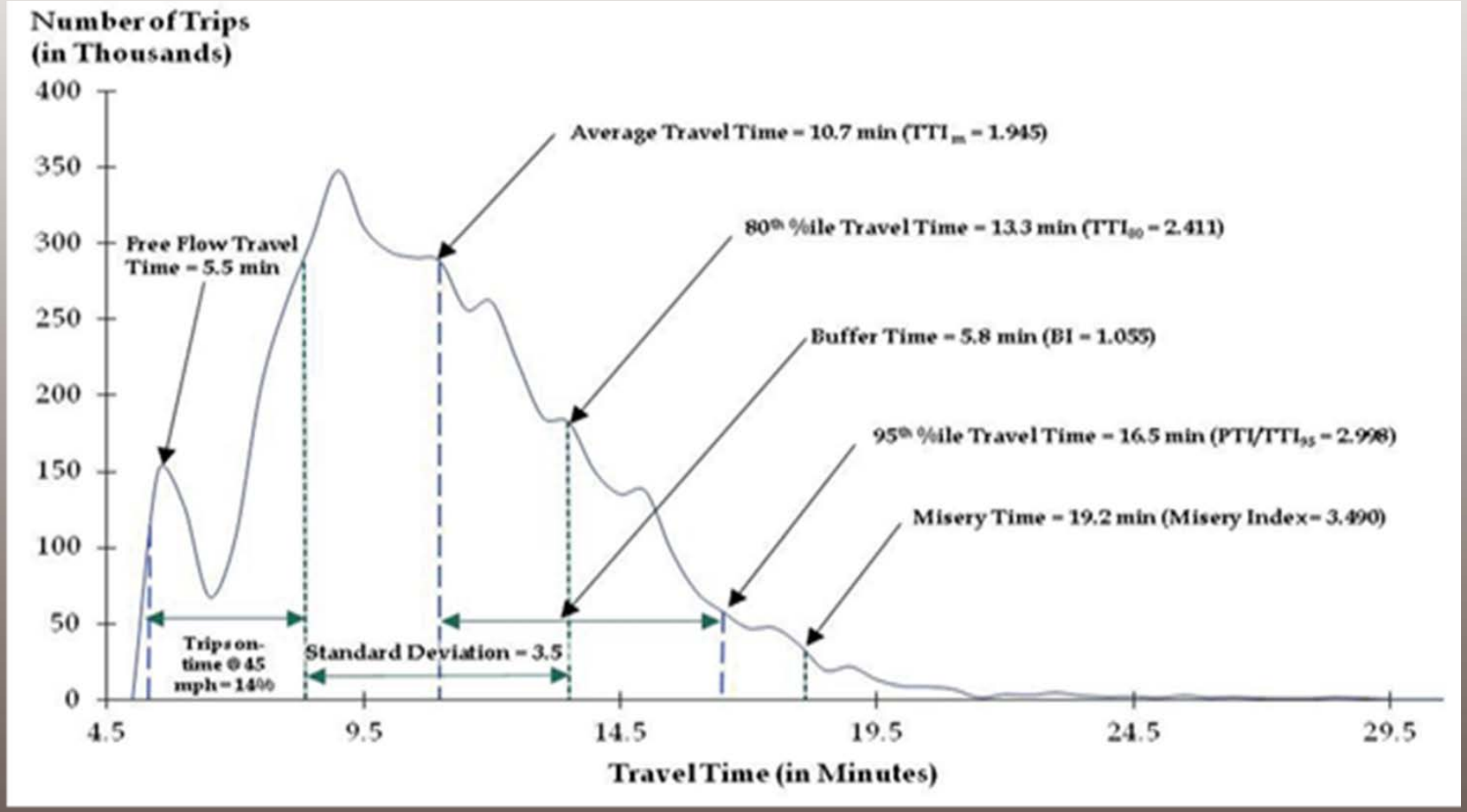
New Freight Strategies

- Truck parking and reservation systems
- E-compliance for trucks
- Truck only lanes
  - Tolled and non-tolled lanes
  - Short: less than 5 miles
  - Long: up to hundreds of miles
- Truck climbing lanes

Estimating Reliability Benefits

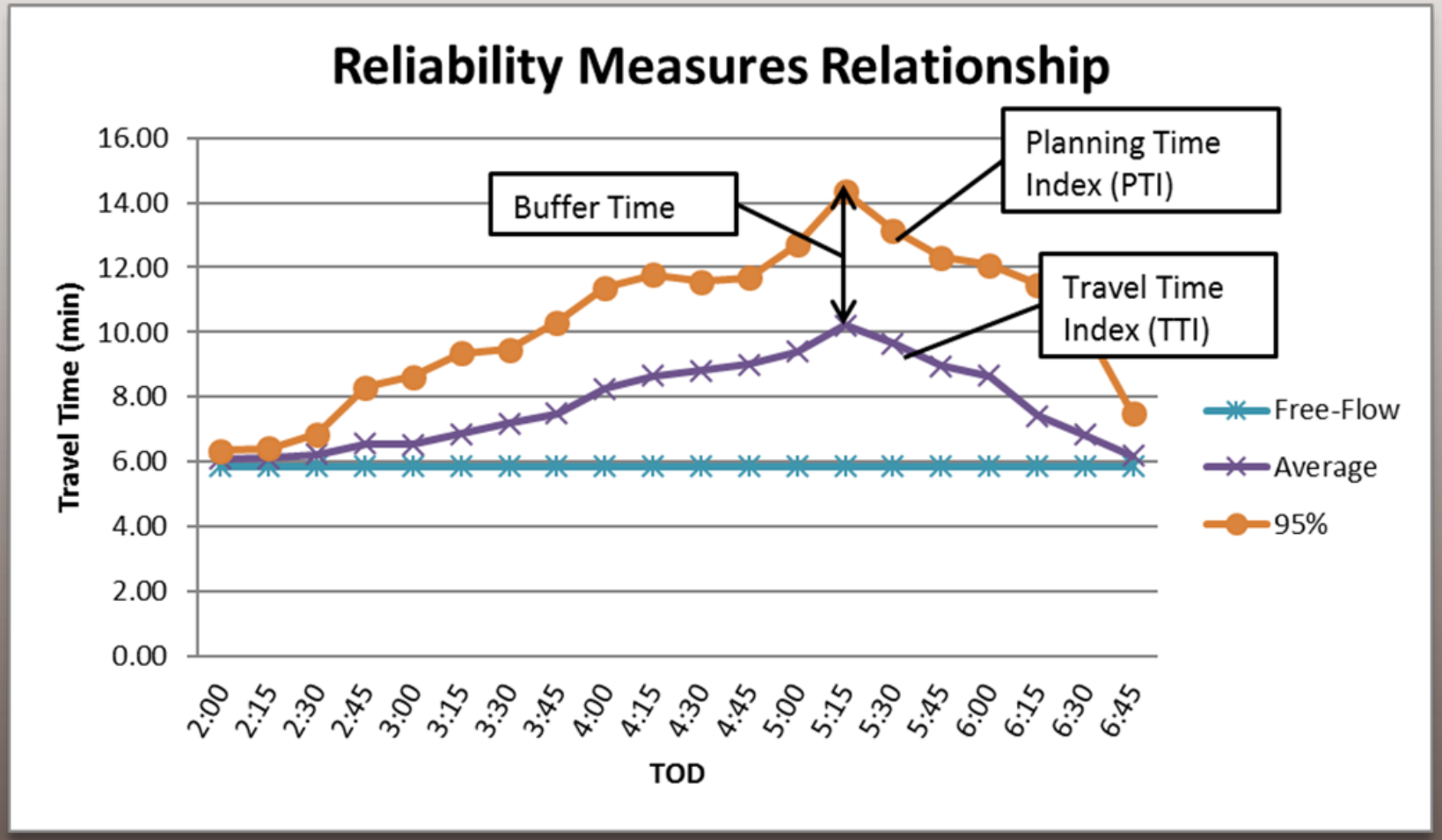
- Understanding travel time variability
- Travel Time Index (TTI)
  - TTIm=Mean travel time/Free flow travel time
- Probability of on-time assurance
  - TTI_{80}=On time arrival 80% of trips
  - Travel Time @ 80%/TTIm
- Buffer time is time added over the mean time to assure 80% on time arrival

Distribution of Trip Time



Source: SHRP 2 L-11

Reliability by Time of Day



Source: SHRP 2 L-11

State Experiences with BCA

Placeholder for MI and FL Presentations

QUESTIONS?

Attendee Questions

- What did you learn and how will it help you?
- How can we make the Webinar better?
- Did we meet your expectations?
- Don’t hesitate to ask for Technical Assistance from FHWA to keep moving in the right direction with BCA.

Contact Information

Jim Hunt
jim.hunt@dot.gov
202-680-2679

Michael Lawrence
lawrence@jfaucett.com
301-961-8835