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
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<td>Jim Hunt, FHWA</td>
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<td>US-23 Flex Route Cost-Benefit</td>
<td>Stephanie Palmer, Michigan Department of Transportation (MDOT)</td>
</tr>
<tr>
<td>Developing and Providing Parking Information to Truckers</td>
<td>Matt Hansen, California Department of Transportation</td>
</tr>
</tbody>
</table>
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

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

Source: FHWA
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:
  o **Prioritize** operations projects based on expected efficiency of investment
  o **Compare** operations with non-operations projects on an even playing field
  o **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)

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

Intelligent Transportation Systems Benefits, Costs, and Lessons Learned
2018 Update Report

www.its.dot.gov/index.htm
Final Report – March 2018
Publication Number: FHWA-JPO-18-641

Source: US DOT
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
• 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
Federal Highway Administration
1200 New Jersey Avenue SE
Washington, DC 20590
• 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

- TIGER/BUILD BCA Resource Guide
Types of Economic Analysis

• Benefit Cost Analysis
  o Life-Cycle Cost Analysis
  o 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)
  o Traditional – Travel Time Savings, Vehicle Operating Cost, Safety, Emissions
  o Emerging MOEs – Travel Time Reliability, Induced Travel/Consumer Surplus, Climate Change
  o 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
  o Value of time
  o Value of reliability
  o Value of life
  o Cost of injury and property damage
  o Fuel price
  o Value of emissions reductions
  o 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
# What it Takes to Make TOPS Run

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

Transportation Systems Management and Operations (TSMO) Benefit-Cost Analysis Tool, TOPS-BC

Choose One of the Following Options

- Estimate Life-Cycle Costs
- Estimate Benefits and Conduct B/C Analysis
- More Info

U.S. Department of Transportation
Federal Highway Administration

Version 2.0 Beta
### TOPS-BC Overview

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

**PURPOSE:** Estimate Benefit-Cost Ratio (BCR) and Benefit-Cost Analysis (BCA) for Traffic Signal Systems and Traffic Automated Timing

**WORK AREA:** Estimate Average Annual Amount

#### Total Annual Cost Stream

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost Stream</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>$123,456</td>
<td>Investment Costs</td>
</tr>
<tr>
<td>2016</td>
<td>$34,567</td>
<td>Operations and Maintenance Costs</td>
</tr>
<tr>
<td>2017</td>
<td>$78,901</td>
<td>Benefit from Reduced Travel Time</td>
</tr>
<tr>
<td>2018</td>
<td>$10,123</td>
<td>Benefit from Improved Traffic Flow</td>
</tr>
</tbody>
</table>

#### Average Annual Cost (AAC)

- **Initial Investment:** $123,456
- **Annual Operations Costs:** $34,567

#### Benefit Calculation

- Net Benefit = Annual Benefit - Annual Costs
- Benefit-Cost Ratio (BCR) = Net Benefit / Annual Costs

**Net Benefit:** $78,901

**Annual Costs:** $10,123

**Benefit-Cost Ratio (BCR):** 7.76

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**Note:** The above information is a simplified representation of the FHWA Tool for Operations Benefit/Cost (TOPS-BC) version 2.0. For detailed analysis, refer to the full tool documentation provided by the Federal Highway Administration.
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

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Useful Life</th>
<th>Capital / Replacement Costs (Total)</th>
<th>O&amp;M Costs (Annual)</th>
<th>Annualized Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Infrastructure Equipment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Video Monitors/Wall for Incident Detection</td>
<td>5</td>
<td>$3,000</td>
<td>$150</td>
<td>$750</td>
</tr>
<tr>
<td>TMC Incident Response Hardware</td>
<td>5</td>
<td>$3,000</td>
<td>$150</td>
<td>$750</td>
</tr>
<tr>
<td>TMC System Integration</td>
<td>20</td>
<td>$200,000</td>
<td></td>
<td>$10,000</td>
</tr>
<tr>
<td>TMC Incident Response Software</td>
<td>2</td>
<td>$15,000</td>
<td>$750</td>
<td>$8,250</td>
</tr>
<tr>
<td>TMC Labor</td>
<td>0</td>
<td>$100,000</td>
<td></td>
<td>$100,000</td>
</tr>
<tr>
<td>Emergency Management Center Hardware</td>
<td>10</td>
<td>$22,500</td>
<td>$450</td>
<td>$2,700</td>
</tr>
<tr>
<td>Emergency Management Center Software</td>
<td>10</td>
<td>$110,000</td>
<td>$2,000</td>
<td>$13,000</td>
</tr>
<tr>
<td>Emergency Response Labor</td>
<td>0</td>
<td>$100,000</td>
<td></td>
<td>$100,000</td>
</tr>
<tr>
<td>Communication Line</td>
<td>20</td>
<td>$750</td>
<td>$900</td>
<td>$938</td>
</tr>
<tr>
<td><strong>TOTAL Infrastructure Cost</strong></td>
<td></td>
<td>$354,250</td>
<td>$204,400</td>
<td>$236,388</td>
</tr>
</tbody>
</table>
### Incremental Deployment Equipment (per FSP Vehicle)

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost 1</th>
<th>Cost 2</th>
<th>Cost 3</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Incident Response Vehicle</td>
<td>7</td>
<td>$87,000</td>
<td>$15,500</td>
<td></td>
<td>$27,929</td>
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<tr>
<td>Incident Response Labor</td>
<td>0</td>
<td>$-</td>
<td>$96,000</td>
<td></td>
<td>$96,000</td>
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<tr>
<td>Communication Line</td>
<td>25</td>
<td>$770</td>
<td>$260</td>
<td></td>
<td>$291</td>
</tr>
</tbody>
</table>

**TOTAL Incremental Cost**

|                | $87,770 | $111,760 | $124,219 |

**INPUT**

- Enter Number of Infrastructure Deployments: 1
  - Total: $259,119
- Enter Number of Incremental Deployments: 20
  - Total: $2,484,387
- Enter Year of Deployment: 2019

**Average Annual Cost**

- $2,743,506

**Levelized Costs (Used for Benefit Cost Ratio Calculation)**

- $3,083,662
### FHWA Tool for Operations Benefit/Cost (TOPS-BC): Version 2.0

**Estimate Benefits of TSM&O Strategies**

#### Traffic Incident Management

<table>
<thead>
<tr>
<th>Facility Characteristics</th>
<th>Baseline</th>
<th>Improvement</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Link Facility Type</strong></td>
<td><strong>Baseline Override</strong></td>
<td><strong>Baseline</strong></td>
<td><strong>Improvement Override</strong></td>
</tr>
<tr>
<td><strong>Baseline Override</strong></td>
<td>1.5155</td>
<td>0.0000</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Number of Lanes</strong></td>
<td>3</td>
<td>19800</td>
<td>19800</td>
</tr>
<tr>
<td><strong>Link Capacity (All Lanes - Per Period)</strong></td>
<td>19800</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Free Flow Speed (MPH)</strong></td>
<td>65</td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>

#### Facility Performance

<table>
<thead>
<tr>
<th>Facility Performance</th>
<th>Baseline</th>
<th>Improvement</th>
<th>Change</th>
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</thead>
<tbody>
<tr>
<td><strong>Baseline Override</strong></td>
<td>1.77806E-05</td>
<td>1.06684E-05</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>Congested Speed</strong></td>
<td>1.3505</td>
<td>1.5155</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>Vehicles Miles Traveled (VMT)</strong></td>
<td>376200.0000</td>
<td>376200.0000</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>V/C</strong></td>
<td>0.9500</td>
<td>0.9500</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>TTI(m)</strong></td>
<td>1.3505</td>
<td>1.5155</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>TTI(80)</strong></td>
<td>2.1027</td>
<td>2.1027</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>TTI(95)</strong></td>
<td>2.1027</td>
<td>2.1027</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>Vehicle Hours of Travel</strong></td>
<td>7816.2864</td>
<td>7816.2864</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>Incident Related Delay (hours) per vehicle per mile</strong></td>
<td>1.77806E-05</td>
<td>1.06684E-05</td>
<td>-7.11225E-06</td>
</tr>
<tr>
<td><strong>Number of Fatality Crashes</strong></td>
<td>2.48292E-03</td>
<td>2.23463E-03</td>
<td>-2.48292E-04</td>
</tr>
<tr>
<td><strong>Number of Injury Crashes</strong></td>
<td>2.60142E-01</td>
<td>2.60142E-01</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>Number of Property Damage Only Crashes</strong></td>
<td>3.30247E-01</td>
<td>3.30247E-01</td>
<td>0.00000E+00</td>
</tr>
<tr>
<td><strong>Fuel consumption (Gallons)</strong></td>
<td>15436.7781</td>
<td>15436.7781</td>
<td>0.00000E+00</td>
</tr>
</tbody>
</table>
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)
  - $TTI_m = \frac{\text{Mean travel time}}{\text{Free flow travel time}}$
- Probability of on-time assurance
  - $TTI_{80} = \text{On time arrival 80\% of trips}$
  - Travel Time @ 80%/TTI_m
- Buffer time is time added over the mean time to assure 80\% on time arrival
Distribution of Trip Time

Number of Trips (in Thousands)

- Average Travel Time = 10.7 min (TTI_m = 1.945)
- 80th %ile Travel Time = 13.3 min (TTI_80 = 2.411)
- Buffer Time = 5.8 min (BI = 1.055)
- 95th %ile Travel Time = 16.5 min (PTI/TTI_95 = 2.998)
- Misery Time = 19.2 min (Misery Index = 3.490)

Source: SHRP 2 L-11
Reliability by Time of Day

Source: SHRP 2 L-11
State Experiences with BCA
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

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301-961-8835