Benefit/Cost Analysis for Operations Planning

NTOC Webinar
March 4, 2012
Overview of FHWA B/C Analysis Desk Reference Project
Operations B/C Analysis Desk Reference Project

• Sponsored by the FHWA Office of Operations under the “Planning for Operations” Initiative in recognition of multiple needs:
  – Operations personnel are increasingly being required to conduct B/C, yet many are unfamiliar with the basic process
  – Many Operations strategies require unique analysis that may be taxing to even seasoned B/C analysts
Expected Project Outcomes

- Two primary outputs:
  - Desk Reference Document
  - Supporting “Tool for Operations Planning Benefit/Cost (TOPS-BC)"
  - Interim versions available
  - Outreach effort initiated
    - Training/Workshops
B/C Cost Analysis Agenda

- Introduction to B/C Analysis
- B/C Analysis of KC SCOUT
- Specific Challenges of B/C Analysis for Operations
- New and Emerging Performance Measures
- Comparing ITS/Operations Strategies with Traditional Capacity Projects
Agenda (continued)

• Availability of Analysis Tools/Methods for Conducting B/C of Operations Projects (Selection of the Appropriate Tools/Methods)
• Measurement of Benefit Performance Measures in Florida (District 4)
• Overview of Guidance Available in the Desk Reference
• Demonstration of Analysis Capabilities of the TOPS-BC Tool
• Questions/Discussion
Introduction to B/C Analysis
What is B/C Analysis?

• Benefit/Cost (B/C) analysis provides a systematic process for calculating and comparing benefits and costs of a project for two purposes:
  – Determine if the investment is sound (justification/feasibility); and
  – Compares it with alternate projects (ranking/priority assignment)
    • Prioritizing different operational strategies
    • Comparing operational strategies with traditional strategies
What is B/C Analysis?

• B/C analysis can either be:
  – Forward looking (forecasting benefits)
  – Backwards looking (evaluation of benefits received)
B/C Analysis is Not the Same as “Economic Impact Analysis”

- **B/C Analysis**
  - Considers the *direct* impacts of the project on measures of effectiveness (MOEs):
    - Travel time
    - Safety
    - Emissions
    - Fuel costs
    - Productivity

- **Economic Impact Analysis**
  - Focused on more broad regional economic activity and jobs
  - Considers *the direct, indirect and induced* impacts of the project
What is B/C Analysis?

- In structuring your B/C analysis, it is important to:
  - Select comprehensive measures of effectiveness
    - Include both positive and negative impacts
    - Avoid double counting
    - Avoid considering transfers as benefits
What is B/C Analysis?

– Include estimates of the full lifecycle costs
  • Up-front capital costs
  • On-going Operations and Maintenance (O&M) costs
  • Supporting infrastructure costs
– Consider difficult to quantify benefits and costs
  • Qualitative assessment if necessary
– Select an appropriate geographic scope
What is B/C Analysis?

– Identify appropriate baselines and alternatives

Project

Project #1
2010 Medium Growth

Alternative

Alternative A
No-Build

Alternative B
New HOV Lane

Alternative C
New Transit Line

Control Alternative

Alt. A
No ITS

Alt. B
No ITS

Alt. C
No ITS

TSM&O Options

Option A-1
Ramp Metering

Option A-2
Incident Management

Option A-3
Ramp Metering + Incident Management

Option B-1
Ramp Metering

Option B-2
Incident Management

Option C-1
Ramp Metering

Option C-2
Electronic Fare Payment

Alt. A
No ITS

Alt. B
No ITS

Alt. C
No ITS
KC SCOUT EXAMPLE
Specific Challenges of B/C Analysis for Operations
Specific Challenges of B/C Analysis for Operations

• Structure Based Challenges – Traditional vs. Operations Focus
  • Existing measures of effectiveness may not be sensitive to the unique benefits of operations
  • Specified data may be inappropriate for assessment of operations benefits
  • Required analysis methods or tools may not be capable of capturing the full benefits of operations strategies
  • Cost estimation parameters and framework may be inadequate
Specific Challenges of B/C Analysis for Operations

• Strategy Based Challenges
  – Limited field data on impacts for new and emerging strategies
  – Challenge of assessing strategies targeted at non-recurring conditions
  – Effect and value of traveler information
  – Assigning costs for backbone infrastructure
  – Analysis challenges of non-physical improvements (e.g., ATDM, interagency coordination)
Assessing the Synergistic Benefits of Integration
### Assessing Non-Typical Conditions

#### Weekday Travel Times
**5:00-6:00 P.M., on State Route 520 Eastbound, Seattle, WA**

<table>
<thead>
<tr>
<th>Travel Time (in Minutes)</th>
<th>Number of Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>2 Incidents with Rain</td>
</tr>
<tr>
<td></td>
<td>1 Incident with Rain</td>
</tr>
<tr>
<td>25</td>
<td>3 Incidents</td>
</tr>
<tr>
<td></td>
<td>4 Incidents</td>
</tr>
<tr>
<td>20</td>
<td>1 Incident Rain</td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1 Incident Martin Luther King Day</td>
</tr>
<tr>
<td></td>
<td>1 Incident Presidents Day</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**Incidents with Rain:**
- Jan 3
- Feb 2
- Mar 4
- Apr 3

**Number of Incidents:**
- 20
New and Emerging Performance Measures
New and Emerging Performance Measures

• Travel Time Reliability
  – Many new “index” measures available
  – B/C analysis requires quantifiable measure
    • Incident delay
    • Total travel delay
  – SHRP2 and other efforts developing enhanced measurement and analysis methods
New and Emerging Performance Measures

- **Consumer Surplus**
  - More traveler based than network based
- **Green House Gas Emissions**
  - Valuations fluctuate significantly
Comparing Operations and Traditional Capacity Projects
Comparing Operations and Traditional Capacity Projects

• B/C analysis provides a vehicle for “apples-to-apples” comparison, but only if:
  – Measures of effectiveness are sensitive to the unique benefits of the strategies
  – Data inputs are appropriate for assessment
  – Required analysis methods or tools are capable of capturing the full benefits of operations strategies
  – Appropriate cost estimation parameters and framework
Comparing Operations and Traditional Capacity Projects

ICM Benefits Without Incidents

- Arterial
- Freeway
- Total

ICM Benefits With Incidents

- Arterial
- Freeway
- Total
Availability of Analysis Tools/Methods for Conducting B/C of Operations
• Wide range of tools and methods available
  – Research and decision support tools
  – Sketch planning tools
  – Post-processing tools
  – Multi-resolution / multi-scenario tools

• Analysis tool/method selected should be appropriate to the objectives of the analysis
Tools/Methods for Ops B/C

- Research and Decision Support Tools
  - TOPS-BC
  - ITS JPO Benefit Cost Database
- Assist practitioners in identifying the appropriate impacts of costs of strategies and analysis parameters
Tools/Methods for Ops B/C

- Sketch planning tools
  - TOPS-BC
  - Cal-BC
  - SCRITS
  - VDOT Spreadsheet
- Analysis
  - Provide quick, order of magnitude estimates of benefits and costs of many operational strategies
Tools/Methods for Ops B/C

- Post processing tools
  - IDAS
  - FITSEval

- Integrate with travel demand model data to provide enhanced analysis of operational strategies
Tools/Methods for Ops B/C

• Simulation Models
  – Allow for the assessment of discrete conditions and traveler behaviors (route diversion)
  – Resource intensive development and analysis
• Complex multi-resolution and multi-scenario methods
  – ICM AMS framework
  – HCM ATDM structure

• Provide the most detailed results

• Most appropriate approach for strategies focused on non-recurring conditions
TOPS-BC: Select Methodology

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

Guidance on Appropriate Benefit/Cost Methods

Instructions: Please indicate the needs of your analysis associated with the following criteria then press "GO".
A list of appropriate methodologies will be displayed to the right and will change in response to your answers to the input analysis criteria.

INPUT CRITERIA

1. What is the geographic scope of the analysis? (Select 1)
   - Do not care
   - Statewide
   - Regional
   - Corridor
   - Isolated Location
   - Other

2. What is the desired accuracy of the analysis results? (Select 1)
   - Do not care
   - High (extremely accurate)
   - Medium
   - Low (order of magnitude)

3. What TSM&O strategy(ies) do you want to analyze?
   - Arterial Management Systems
     - Corridor Traffic Signal Coordination Strategies (Choose multiple)
       - Pre Set Timing
       - Traffic Actuated Timing
       - Centrally Controlled Timing
   - Traffic Signal Priority Strategies (Choose multiple)
     - Transit Priority
   - Freeway Management Systems
     - Ramp Metering Strategies (Choose multiple)
       - Pre Set Timing
       - Traffic Actuated Timing
       - Centrally Controlled Timing

Guides users to appropriate analysis methodology based on their analysis needs.
Measurement of Benefit Performance Measures in Florida (District 4)
Overview of Guidance Available in the Desk Reference
Guidance Available in the Desk Reference Document

- Interim Report available
- Document and other products anticipated to evolve as a result of outreach efforts
• Provides comprehensive, one-stop-shopping for B/C information related to TSM&O

• Serves as a primer for Operations personnel unfamiliar with B/C analysis

• Advanced guidance to support analysis of more difficult to quantify issues
Guidance Available in the Desk Reference Document

– B/C analysis primer information
– Definition of Ops strategies and their likely impacts
– Available tools/methods and selection criteria
– Strategies for addressing identified challenges of B/C analysis for operations
– Methodologies for assessing travel time reliability
– Discussion of multi-scenario analysis methods
• Innovative presentation of results
Example of Analysis Capabilities Available in the TOPS-BC Tool (Demo)
What would you like to do today?

Investigate the Range of Expected Values Associated with Various TSM&O Strategies

Map Different Benefit/Cost Methodologies to Your Organization’s Needs

Estimate Life-Cycle Costs of TSM&O Strategies

Conduct Simple Spreadsheet-Based Benefit-Cost Analysis for Selected TSM&O
• Requirements
  – Macro-driven spreadsheet environment
  – Designed to be intuitive to use
  – Default figures are documented and understandable
  – Formulas are reviewable
  – Easy maintenance and customization
• Four Key Capabilities…
Investigate the Range of Impact Values Associated with Various TSM&O Strategies

Instructions: Please select the "TSM&O Strategy" and the "Impact Category" you are interested in from the list below. If sufficient data is available, a range of expected impacts will be shown below. Click on the hyperlink to be taken to a table displaying the datapoints comprising the range.

TSMO Strategy Selected:
- Freeway Management System: Ramp Metering: Pre-set Timing

Impact Category:
- Travel Time and Speed

Data Source
- Provides database and look-up function for the observed impacts of many TSM&O strategies

Noted Impacts
- Expected travel time reductions range between 10% and 45%. Expected percent speed improvements between 10% and 55%. Expect delay reductions between 15% and 20%.
TOPS-BC: Estimate Lifecycle Costs

Estimates life-cycle costs of many TSM&O strategies – Average Annual Costs and Stream of Costs over time

<table>
<thead>
<tr>
<th>Equipment Description</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>Basic Infrastructure Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMC Hardware for Information Dissemination</td>
<td>5</td>
<td>$ 7,500</td>
<td>$ 375</td>
<td>$ 1,875</td>
</tr>
<tr>
<td>TMC Software for Information Dissemination</td>
<td>5</td>
<td>$ 20,000</td>
<td>$ 1,000</td>
<td>$ 5,000</td>
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<tr>
<td>TMC System Integration</td>
<td>20</td>
<td>$ 100,000</td>
<td>$ 5,000</td>
<td>$ 10,000</td>
</tr>
<tr>
<td>Labor</td>
<td></td>
<td></td>
<td>$ 100,000</td>
<td>$ 100,000</td>
</tr>
<tr>
<td><strong>TOTAL Basic Infrastructure Cost</strong></td>
<td></td>
<td><strong>$ 127,500</strong></td>
<td><strong>$ 106,375</strong></td>
<td><strong>$ 116,875</strong></td>
</tr>
</tbody>
</table>

| Incremental Equipment                         |             |                                     |                    |                  |
| Communication Line                            | 25          | $ 750                               | $ 900              | $ 930            |
| Variable Message Sign                         | 25          | $ 92,500                            | $ 4,400            | $ 8,100          |
| Variable Message Sign Tower                   | 25          | $ 125,000                           | $ 275              | $ 5,275          |
| **TOTAL Incremental Cost**                    |             | **$ 218,250**                       | **$ 5,575**        | **$ 14,305**     |

**Average Annual Cost**: $145,485
**TOPS-BC: Benefits Estimation**

**FHWA Tool for Operations Benefit/Cost (TOPS-BC)**

Estimate Benefits of TSM&O Strategies

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**Strategy: Dynamic Message Signs**

Notes:
- For additional information on this analysis method, please see Section X.X.X of the Desk Reference
- For information on alternative methods for performing analysis of this strategy, please see Section X.X.X of the Desk Reference

**Primary Benefits Estimated by this Method:**
- Travel Time Reliability

**Other Benefits that may be Considered:**
- Safety, Customer Satisfaction, Agency Efficiency, Emissions, Fuel Use

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**Impact** | **User Input** | **Default** | **Modeled**
---|---|---|---
**INPUT** | Average Number of Vehicles Passing Sign Location (per period) | 60,000 | |
**INPUT** | Average Vehicle Occupancy | 1.2 | |
**INPUT** | % of Time Sign is Displaying Information | 5% | |
**INPUT** | Type of Information Being Displayed | 3 | 
 1 = Comparative Travel Times
 2 = Congestion Warning
 3 = Alternative Route Recommendations

**% of Drivers Passing the Sign that Act on the Information** | 10% | 10% | 
**Average Time (Minutes) Saved by Drivers Acting on the Information** | 5.5 | | 
**Average Time (Minutes) Saved by Drivers Not Acting on the Information** | 0 | | 

**Average Hours of Vehicle Delay Saved Per Period** | | | 28
**Number of Periods Per Year** | | | 260
**Average Hours of Vehicle Delay Saved per Year** | | | 7,150
**Average Hours of Person Delay Saved per Year** | | | 8,580
**$ Value of Person Hour (per hour)** | | | $14.00

**Total Average Annual Modeled Travel Time Benefit** | | | $120,120

**User Entered Benefit (Annual $’s)** | | | 
**TOTAL AVERAGE ANNUAL BENEFIT** | | | $120,120

**Average Annual Equipment Deployment and Replacement Costs** | | | $60,000
**Average Annual Equipment Operations and Maintenance Costs** | $25,000 | | $20,000

**TOTAL AVERAGE ANNUAL COST** | | | $85,000

**Benefit Cost Ratio (Average Annual Benefits / Average Annual Costs)** | | | 1.41
**Annual Net Benefit (Average Annual Benefits - Average Annual Costs)** | | | $35,120

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Sketch planning B/C framework provided for many TSM&O strategies. Users may enter data and estimate B/C directly or use as a framework to develop their own customized analysis.
## TSM&O Strategies Covered

<table>
<thead>
<tr>
<th>TSM&amp;O Strategy</th>
<th>Discussed in Desk Reference</th>
<th>TOPS-BC Analysis Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arterial Signal Coordination</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Arterial Transit Signal Priority</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Transit Automatic Vehicle Location</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Ramp Metering</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Incident Management</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Pretrip Traveler Information</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>En-route Traveler Information</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Work Zone Management</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>HOT Lanes</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Speed Harmonization</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Hard Shoulder Running</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Travel Demand Management</td>
<td>●</td>
<td>●</td>
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</tbody>
</table>
### TSM&O Strategies Covered (continued)

<table>
<thead>
<tr>
<th>TSM&amp;O Strategy</th>
<th>Discussed in Desk Reference</th>
<th>TOPS-BC Analysis Capability</th>
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</thead>
<tbody>
<tr>
<td><strong>Supporting Strategies</strong></td>
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<tr>
<td>Traffic Surveillance</td>
<td>●</td>
<td>$</td>
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<tr>
<td>Traffic Management Centers</td>
<td>●</td>
<td>$</td>
</tr>
<tr>
<td>Communications</td>
<td>●</td>
<td>$</td>
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<td><strong>Non-physical Strategies</strong></td>
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<tr>
<td>Active Transportation and Demand Management (ATDM)</td>
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<tr>
<td>System Integration</td>
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<tr>
<td>Interagency Coordination</td>
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<td></td>
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<tr>
<td>Regional Concepts for Transportation Operations</td>
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</tr>
</tbody>
</table>
It's QUESTION TIME!!
For More Info on B/C Analysis

• Interim Draft of the Desk Reference Document Available
  – http://www.camsys.com/kb_pubs_oper.htm
Comparison of Tool Capabilities

Role in Planning Process

Archived Operations Data – Monitor, Evaluate, Data Source

Signal Optimization Tools

Simulation

Travel Demand Models

Deterministic Tools

Sketch Planning

Order of Magnitude

Preliminary Screening

Alternatives Analysis

Define Operational Strategies/Design

Detailed

Analysis Sensitivity
Multi-Scenario Methods
Multi-Scenario Methods

- Used to assess impacts during non-typical days
- Frequency of non-recurring conditions is identified
- Different analysis scenarios are developed to represent these non-recurring conditions
- May be applied to most of the tools and methods discussed
Current Methods and Tools
Multi-Scenario Methods

I-394 ICM Corridor
Incident Severity vs. Demand
AM Peak Period Only 6am-9am

Hourly Demand

Incident Clearance Time

Minimal Impact to Traffic
Moderate Impact to Traffic
Severe Impact to Traffic
Current Methods and Tools
Multi-Scenario Methods

- Frequency used to develop distribution of scenarios

<table>
<thead>
<tr>
<th>Capacity Reduction</th>
<th>5% Demand</th>
<th>20% Demand</th>
<th>50% Demand</th>
<th>80% Demand</th>
<th>95% Demand</th>
<th>Row Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Incidents, Good Weather</td>
<td>0%</td>
<td>6.04%</td>
<td>15.10%</td>
<td>18.12%</td>
<td>15.10%</td>
<td>6.04%</td>
</tr>
<tr>
<td>Single Lane Closure, Good Weather</td>
<td>42%</td>
<td>2.16%</td>
<td>5.40%</td>
<td>6.48%</td>
<td>5.40%</td>
<td>2.16%</td>
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<tr>
<td>Dual+ Lane Closure, Good Weather</td>
<td>75%</td>
<td>0.07%</td>
<td>0.19%</td>
<td>0.22%</td>
<td>0.19%</td>
<td>0.07%</td>
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<tr>
<td>No Incidents, Bad Weather</td>
<td>7%</td>
<td>1.26%</td>
<td>3.15%</td>
<td>3.78%</td>
<td>3.15%</td>
<td>1.26%</td>
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<td>Single Lane Closure, Bad Weather</td>
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<td>0.45%</td>
<td>1.13%</td>
<td>1.35%</td>
<td>1.13%</td>
<td>0.45%</td>
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<td>Dual+ Lane Closure, Bad Weather</td>
<td>82%</td>
<td>0.02%</td>
<td>0.04%</td>
<td>0.05%</td>
<td>0.04%</td>
<td>0.02%</td>
</tr>
<tr>
<td>Column Totals</td>
<td>10.00%</td>
<td>25.00%</td>
<td>30.00%</td>
<td>25.00%</td>
<td>10.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
• There is no one analytical tool that can do everything or solve every problem

• Method or tool should be consistent with planning objectives and matched with budget and resource requirements
  – Using a too-sophisticated tool results in poor use of resources
  – Using a too basic tool results in inaccurate or unreliable results