2014 Road Weather Management Stakeholder Meeting

Optional Training Session
9:10 – 10:00

Tools for Road Weather Management Benefit/Cost Analysis

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What I Will Cover in this Presentation

• Why is BCA Important for Transportation Operations/WRTM and What are the Challenges?
• Introduction to BCA
• Steps for Conducting BCA
• Measuring Costs and Quantifying WRTM Benefits
• Tools and Resources for Conducting WRTM BCA
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 including WRTM.
Challenges for Transportation Operations BCA

- Estimating and quantifying the effects of strategies
  - e.g. traveler response to information?
- Including “non-typical” days in the analysis
- Measuring & Valuing travel time reliability
- Operations is often a collection of integrated elements (e.g. field, center, vehicle)
  - Not all physical (procedures)
  - Data sharing
  - Synergies
  - Cost attribution
- Operation and Maintenance Costs
Specific Challenges for WRTM BCA

- Frequency, intensity and specific location of weather events are unknown/unpredictable
- Impacts of weather on traffic mobility and safety not well established
- Limited knowledge on the effectiveness of WRTM strategies in mitigating weather impacts
Types of Economic Analysis

- Benefit Cost Analysis
  - Life-Cycle Cost Analysis
- Equity Analysis
- Financial Analysis
- Activity Forecasting
- Risk Analysis
- Economic Impact Analysis
Steps for Conducting 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
8. Evaluate risk
9. Compare net benefits and rank alternatives
10. Make recommendations
### Benefits & Costs – A List

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Reduced Congestion</td>
<td>✓ Equipment</td>
</tr>
<tr>
<td>✓ Travel Time</td>
<td>✓ O&amp;M</td>
</tr>
<tr>
<td>✓ Reliability</td>
<td>✓ Software</td>
</tr>
<tr>
<td>✓ Safety</td>
<td>✓ Communications</td>
</tr>
<tr>
<td>✓ Energy</td>
<td>✓ Installation</td>
</tr>
<tr>
<td>✓ Others</td>
<td>✓ Others</td>
</tr>
</tbody>
</table>

What’s Missing?
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 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 & Security
Benefit Monetization

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

• Traffic Data (Volume, Speed, Travel Time)
• Safety Data (Crash rates, Crash costs)
• Mobility Costs (Value of time/delay)
• Agency Costs (labor rate, material, equipment costs)
• Vehicle Operating Costs (fuel cost etc.)
• Discounting Rates (interest, inflation)
Hierarchy of BCA Tools

• General Tools
  – Various Spreadsheets

• Transportation Tools
  – bca.net

• Transportation Program Areas
  – IDAS, TOPS-BC

• Technology-Specific Tools
  – Clear Roads BCA Toolkit
WRTM BCA Resources - ITS Benefits Database

- www.itsbenefits.its.dot.gov/
WRTM BCA Resources - ITS Costs Database

- www.itscosts.its.dot.gov/
Road Weather Management
BCA Compendium

• Several case studies being developed that describe BCAs for road weather management technologies or strategies
• Hypothetical examples demonstrate how TOPS-BC, Clear Roads & Other BCA tools can be used
• Shows how analysts have conducted or in the future could conduct a BCA for road weather management

<table>
<thead>
<tr>
<th>ROAD WEATHER MANAGEMENT STRATEGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveillance, Monitoring and Prediction</td>
</tr>
<tr>
<td>Response and Treatment</td>
</tr>
<tr>
<td>Traffic Control</td>
</tr>
<tr>
<td>Information Dissemination</td>
</tr>
</tbody>
</table>

TOPS-BC: An Introduction

• TOPS-BC is a sketch planning Excel spreadsheet model designed to assist planners evaluate TSMO projects
• Designed for Visioning & Screening
• Also useful for some Long-Range Planning
• Not designed for more detailed BCA required in project development
What Can You do With TOPS?

What would you like to do today?

- Investigate Potential Impacts of Strategies
- Research Available Analysis Methods and Tools
- Estimate Life-cycle Costs
- Estimate Benefits and Conduct B/C Analysis
- More Info
TOPS-BC Application

• Conduct simple sketch planning level B/C analysis for selected TSM&O strategies
  – Develop a set of input data for project type, facility type, number of lanes, analysis period
  – Use TOPS defaults for facility performance or use your own data (freeway link capacity, etc.)
  – Select MOE impact levels or use TOPS national level defaults (travel time savings, etc.)
  – Select values for key variables including; travel time, reliability, crash costs, etc.
Multiple Strategies

• You can select multiple strategies
• You can select supporting strategies
• You select the timeframe for analysis
• You select the discount rate
• You can vary inputs to run sensitivities
• You see your results instantly
Choose the active strategies:
- Generic Link Analysis
- Signal Coordination: Central Control
- Ramp Metering: Preset Timing
- Traffic Incident Management
- Dynamic Message Sign
- Highway Advisory Radio
- Pre Trip Traveler Information
- HOT Lanes
- Hard Shoulder Running
- Speed Harmonization
- Road Weather Management
- Work Zone Systems
- Traffic Management Center
- Loop Detection
- CCTV

### Benefit/Cost Summary

#### Annual Benefits

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Generic Link Analysis</th>
<th>Signal Coordination: Central Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Travel Time Reliability</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Energy</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Safety</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Other</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>User Entered</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Total Annual Benefits</strong></td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

#### Annual Costs

<table>
<thead>
<tr>
<th>Cost</th>
<th>Generic Link Analysis</th>
<th>Signal Coordination: Central Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

#### Benefit/Cost Comparison

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Generic Link Analysis</th>
<th>Signal Coordination: Central Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Benefit</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Benefit Cost Ratio</strong></td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Stream of Net Benefits
Clear Roads BCA
Road Weather Strategies

- Anti-icing
- Deicing
- Carbide blades
- Front plows
- Underbody plows
- Zero velocity spreader
- Maintenance Decision Support Systems (MDSS)

- Automatic Vehicle Location and Geographic Positioning Systems (AVL/GPS)
- Road Weather Information Systems (RWIS)
- Mobile pavement or air/pavement temperature sensors
Clear Roads BCA 5-Step Process

- **Step 1: Define Project Parameters** – the user will provide specific parameters related to the application they plan to analyze.

- **Step 2: Enter Costs** – the user enters initial and annual costs specific to the agency. Such costs include the purchase price of the item of interest, installation, maintenance, communications, and so forth.

- **Step 3: Benefits** – This page presents the user with a list of quantified and nonquantified benefits that may be achieved by the agency, user, and society through the use of the item being examined.

- **Step 4: Benefit Quantification** – the user enters values related to the determination of benefits that use an item will produce for the agency, user, and society.

- **Step 5: Results** - the user will see the results of their analysis.
• Tools are available for general Operations BCA as well as specific WRTM BCA
• Not a single 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 tool that is too sophisticated results in poor use of resources
  – Using a tool that is too basic results in inaccurate or unreliable results
Latest FHWA Materials to Support Planning for Operations
FHWA BCA of TSMO Support

- BCA Desk Reference & Other Pubs
- BCA Data & Tool Development
- BCA Workshops for SDOT, MPO, Others
- Technical Assistance
- For Info Contact Jim Hunt
Clear Roads BCA Toolkit

DEICING BCA EXAMPLE
Getting Logged on to the BCA Toolkit

• Go to the following website: [http://clearroads.org/](http://clearroads.org/)
• On the left bar, click on “Research Projects,” then scroll down to “Completed Projects” and click on “Cost-benefit Analysis Toolkit Phase II (June 2013)”
• Scroll down to “Final Deliverables,”
• Click on “Final Report” to download the Final Report
• Click on “Cost-Benefit” to download the Toolkit User's Manual
• Click on “Cost-Benefit Toolkit”
• You are off and running!
Selecting Your Technology

Cost-Benefit Analysis Toolkit

Select the technology you are interested in.

After you conduct an assessment for your first technology, you will be given an option to save the results and compare them against other technologies.

Practices
- Anti-icing
- Deicing

Equipment
- Carbide blades
- Front plows
- Underbody plows
- Zero velocity spreader

Operations
- Maintenance Decision Support Systems (MDSS)
- Automatic Vehicle Location and Geographic Positioning Systems (AVL/GPS)
- Road Weather Information Systems (RWIS)
- Mobile pavement temperature sensors
- Mobile air/pavement temperature sensors
Entering Basic Run Data

Analyst Name: Iowa example
Agency: Iowa DOT
Date: 07/09/2010
Project Description: Deicing example
Year represented in the analysis: 2010
Discount rate: 7
Analysis period (years): 10
Number of equipped trucks: 900
Total trucks: 900
Number of facilities (sheds/garage) with brine making infrastructure: 0
Loaded labor cost per hour (shop rate): 21.42
Average labor hours per storm event per vehicle: 12
Average labor hours per storm to produce materials: 0
Annual hours per vehicle to maintain deicing-specific equipment: 10
Annual number of storm events: 20
Average deicer application rate (tons or gallons per lane mile): 0.05
Lane miles covered per storm (all trucks): 251200
# Initial Costs Worksheet - Deicing

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit rate ($)</th>
<th># of units</th>
<th>Unit</th>
<th>Amount ($)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deicing equipment - Material spreaders (spinner, gravity drop, etc.)</td>
<td>3</td>
<td>900</td>
<td>vehicles</td>
<td>720000</td>
<td></td>
</tr>
<tr>
<td>Deicing equipment - Sprayers (liquid deicing)</td>
<td>0</td>
<td>900</td>
<td>vehicles</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td>2389</td>
<td>900</td>
<td>vehicles</td>
<td>2150100</td>
<td></td>
</tr>
<tr>
<td>Infrastructure (brine making equipment if employing liquid deicing activities)</td>
<td>0</td>
<td>110</td>
<td>building</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other 1 (define)</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other 2 (define)</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Total initial expenditure</strong></td>
<td></td>
<td></td>
<td></td>
<td>2870100</td>
<td></td>
</tr>
</tbody>
</table>
### Annual Costs Worksheet - Deicing

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit costs per year</th>
<th># of units</th>
<th>Unit</th>
<th>Amount ($)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material costs (year)</td>
<td>30</td>
<td>254200</td>
<td>tons</td>
<td>73200</td>
<td></td>
</tr>
<tr>
<td>Production costs (liquid deicers)</td>
<td>0</td>
<td>20</td>
<td>storms</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Equipment maintenance</td>
<td>214</td>
<td>900</td>
<td>vehicles</td>
<td>192780</td>
<td></td>
</tr>
<tr>
<td>Brine plant maintenance</td>
<td>0</td>
<td>0</td>
<td>years</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Corrosion/environmental cost per ton</td>
<td>0</td>
<td>254200</td>
<td>tons</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other 1 (define)</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other 2 (define)</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cost of Alternative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minus cost of sanding and gritting</td>
<td>0</td>
<td>1</td>
<td>years</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Total Annual O&amp;M Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>268070</strong></td>
<td></td>
</tr>
</tbody>
</table>
Agency Costs

<table>
<thead>
<tr>
<th>Agency Costs</th>
<th>Initial costs calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Costs: $</td>
<td>73347</td>
</tr>
<tr>
<td>Annual operating/maintenance costs: $</td>
<td>266070</td>
</tr>
</tbody>
</table>

Other Costs
The literature does not include costs to users or society, but if you would like to include these, you can add them. Note: Any cost information entered by the user is being done solely at their discretion and employs values that may be of an assumed form.

Results

| Annualized Costs: $ | 276513 |
| Present Value: $ | 1942111 |
| Annualized Costs per unit: $ | 307 |
Cost Benefit Analysis Toolkit - Deicing

Step 3 of 5: Benefits

Research has identified the following potential benefits for MDSS. Those in **bold** are included as tangible benefits, while those in regular typeface are included as intangible.

**Agency**
- Generally inexpensive

**User (Motorists)**
- Improved safety
- Reduced traffic delay

**Societal**
- None identified
# The User Benefits Worksheet

## User Benefits Worksheet - Deicing

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit rate ($)</th>
<th># of units</th>
<th>Unit</th>
<th>Amount ($)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved safety and mobility</td>
<td>4.5</td>
<td>12162720</td>
<td>Deicing Cost</td>
<td>54732240</td>
<td></td>
</tr>
<tr>
<td>Other 1 (define)</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other 2 (define)</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Total Annualized Benefit</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>54732240</strong></td>
<td></td>
</tr>
</tbody>
</table>

![Checkmark and X symbols](image)
### Benefit Calculations

#### Agency Benefits

<table>
<thead>
<tr>
<th>Benefit Calculations</th>
<th>Agency Benefits</th>
<th>Annualized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Value</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Annualized Benefit per Truck</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

#### User (Motorist) Benefits

<table>
<thead>
<tr>
<th>Benefit Calculations</th>
<th>User (Motorist) Benefits</th>
<th>Annualized (click on field for calculator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Value</td>
<td>384415351</td>
<td>54732240</td>
</tr>
<tr>
<td>Annualized Benefit per Truck</td>
<td>60814</td>
<td></td>
</tr>
</tbody>
</table>

#### Society Benefits

<table>
<thead>
<tr>
<th>Benefit Calculations</th>
<th>Society Benefits</th>
<th>Annualized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Value</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Annualized Benefit per Truck</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

#### Total Benefits

<table>
<thead>
<tr>
<th>Benefit Calculations</th>
<th>Total Benefits</th>
<th>Annualized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Value</td>
<td>384415351</td>
<td>54732240</td>
</tr>
<tr>
<td>Annualized Benefit per Truck</td>
<td>60814</td>
<td></td>
</tr>
</tbody>
</table>

#### Benefit-Cost Ratio

<table>
<thead>
<tr>
<th>Benefit-Cost Ratio</th>
<th>Agency Benefits</th>
<th>Total Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>6.7</td>
</tr>
</tbody>
</table>
### Summary of Results

#### Agency Costs - Initial

<table>
<thead>
<tr>
<th>Item</th>
<th>Iowa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material spreader ($800)</td>
<td>$720,000</td>
</tr>
<tr>
<td>Flow controller ($2389)</td>
<td>$2,150,100</td>
</tr>
</tbody>
</table>

#### Agency Costs - Annual

<table>
<thead>
<tr>
<th>Item</th>
<th>Iowa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material costs ($30/ton)</td>
<td>$4,536,000</td>
</tr>
<tr>
<td>Production Costs ($14.42)</td>
<td>$0</td>
</tr>
<tr>
<td>Equipment maintenance ($14.42)</td>
<td>$192,780</td>
</tr>
<tr>
<td>Corrosion/environmental costs/ton ($0)</td>
<td>$0</td>
</tr>
</tbody>
</table>

#### Total Costs - Summary

<table>
<thead>
<tr>
<th>Item</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized cost</td>
<td>$8,137,418</td>
</tr>
<tr>
<td>Present value</td>
<td>$57,153,817</td>
</tr>
<tr>
<td>Present value</td>
<td>$9,042</td>
</tr>
</tbody>
</table>

#### User Benefits

<table>
<thead>
<tr>
<th>Item</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>General savings</td>
<td>$0</td>
</tr>
</tbody>
</table>

#### Total Benefits - Summary

<table>
<thead>
<tr>
<th>Item</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash and travel time savings</td>
<td>$54,732,240</td>
</tr>
</tbody>
</table>

#### Cost-Benefit Ratios

<table>
<thead>
<tr>
<th>Item</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>6.7</td>
</tr>
</tbody>
</table>
Mike Lawrence, President

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Lawrence@jfaucett.com