

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

Session 4

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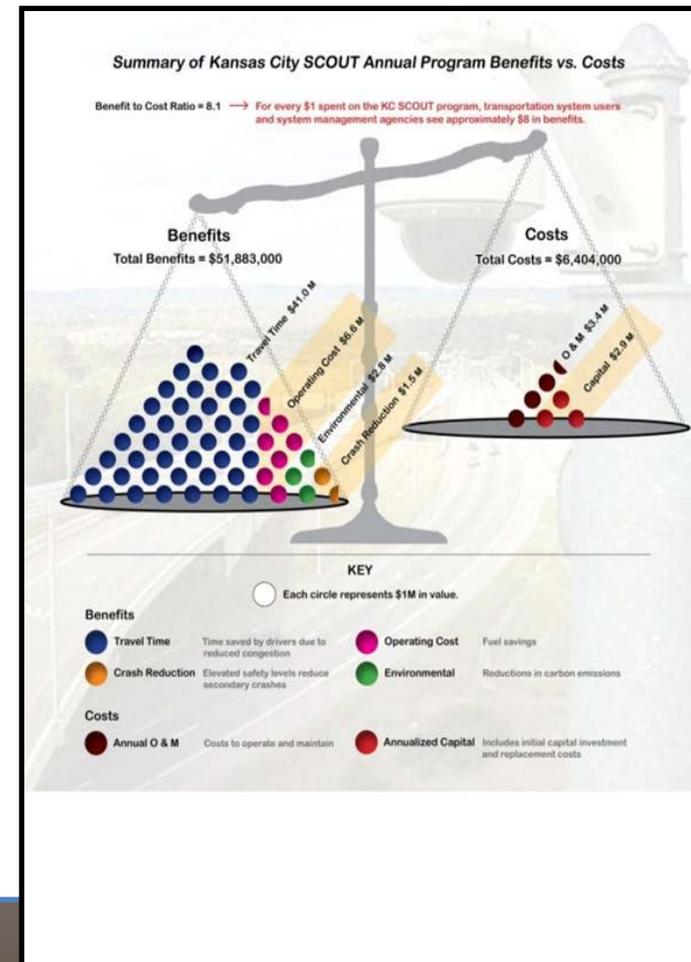
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Weighty Decisions

- 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



What Will We Cover This Session

- Introduction to BC Analysis
- Specific Steps for Conducting TSMO BC Analysis, Particularly for Truck Projects
- Most TSMO Strategies Impact Truck Operations
- Measuring Costs and Quantifying Benefits
- Introduction to TOPS-BC Freight Components



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>



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 including freight



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

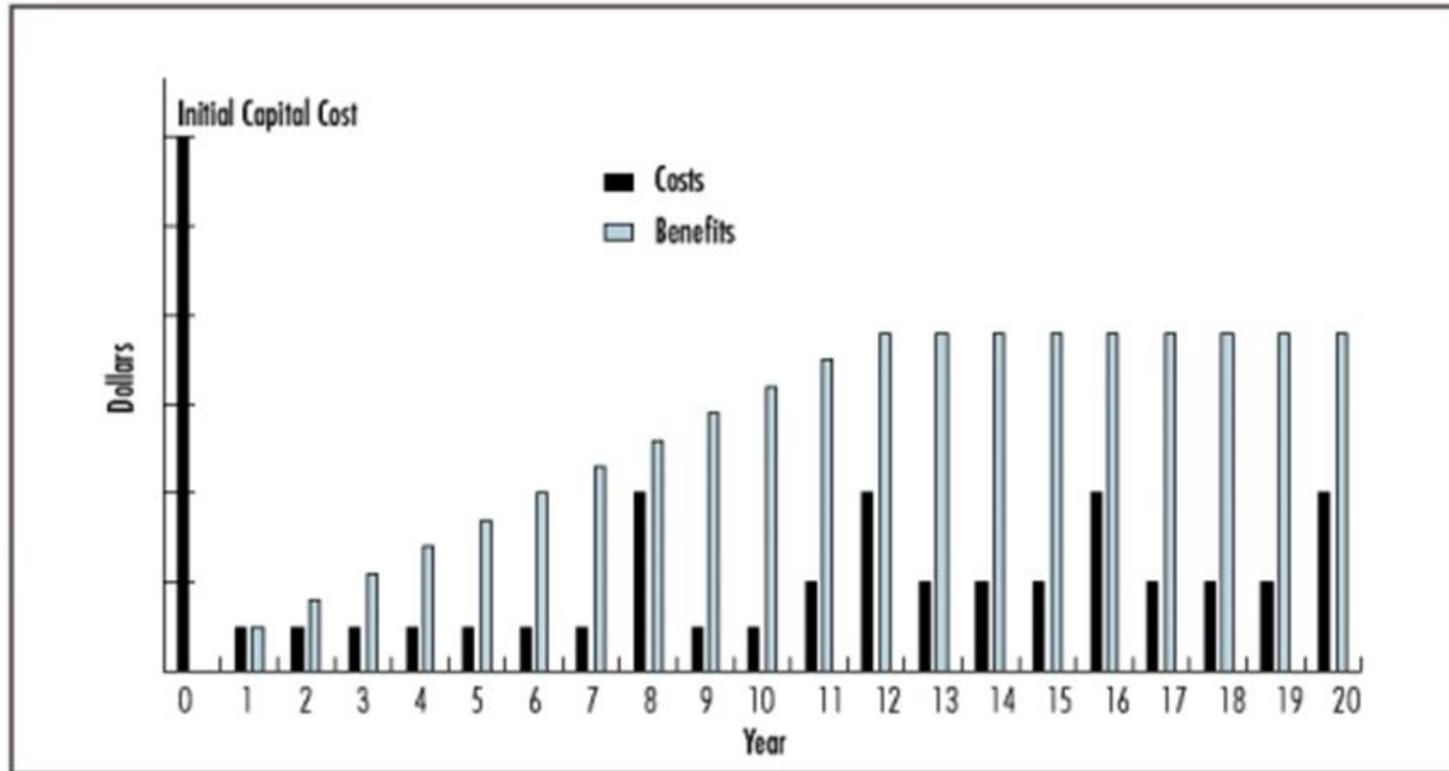


Other Important BCA Concepts

- 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, Safety BCA
- Technology-Specific Tools
 - Clear Roads RWM BCA Toolkit, Traffic Incident Management Benefit-Cost (TIM-BC), Smart Roadside Initiative Tool (SRI)



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.

[TOPS-BC](#)



Strategies and Technologies: TOPS 3.0

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

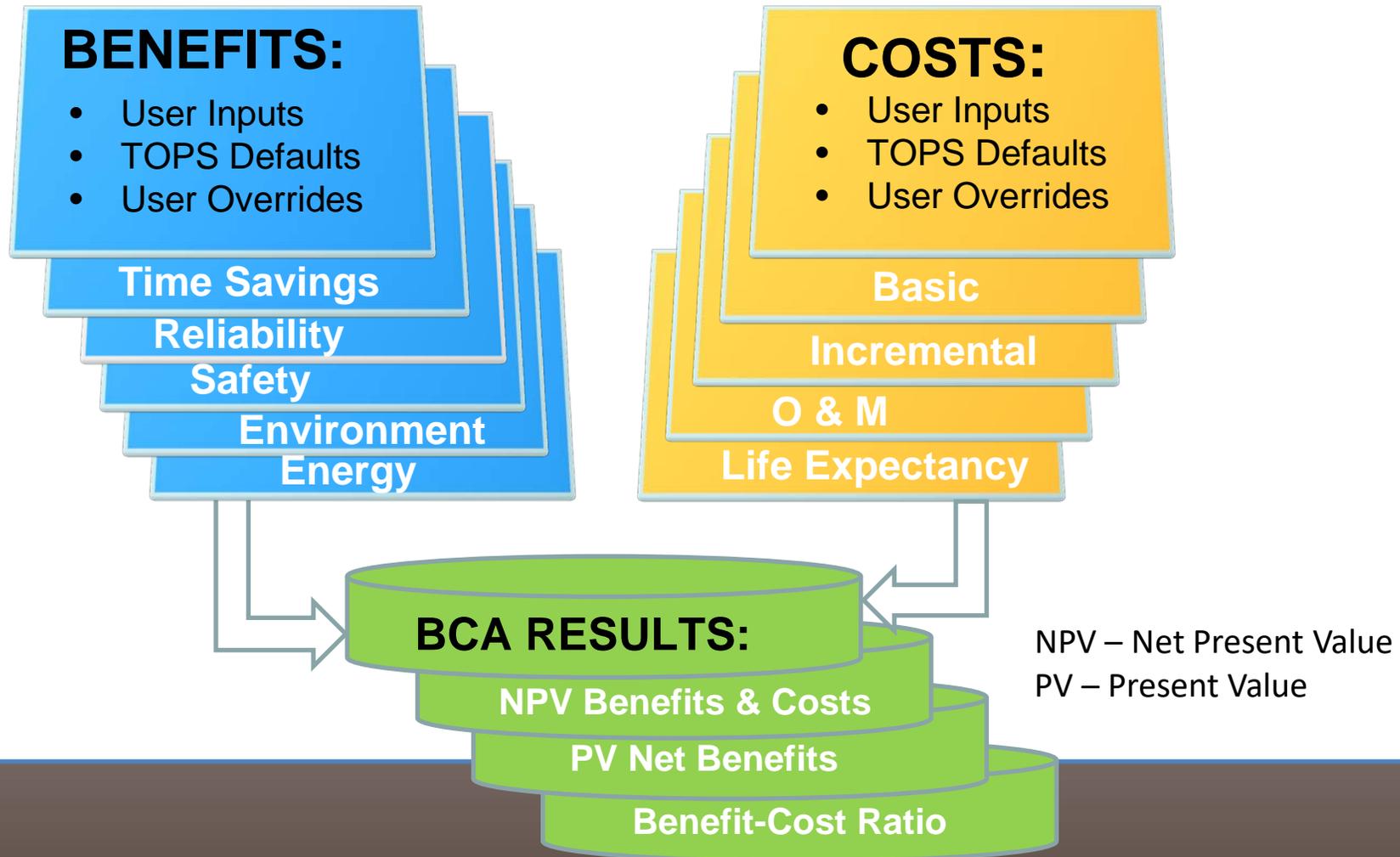
Supporting Strategies

Traffic Management Center

Loop Detection, CCTV



TOPS-BC OVERVIEW: For Each Strategy



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 (auto/truck)
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

Transportation Systems Management and Operations (TMSO)
Benefit-Cost Analysis Tool. TOPS-BC Version 3.0



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

[TOPS-BC](#)



TOPS-BC Overview

Navigation

Back

OPENING SCREEN

GENERAL TOOL OVERVIEW

LIST OF ALL WORKSHEETS

1) ESTIMATE COSTS

Transfer Information

Ex-Rates, Transfer Information

Pre-Trip Transfer Information

Traffic Signal Systems (TSS)

Project Timing

Traffic Actuated Timing

Control Control

Traffic Signal Priority

Ramp Metering

Control Control

Traffic Actuated

Project Timing

Freight Strategies

Track Only Lanes

Screening and Permitting Systems

Track Purling and Reservation System

Climbing Lanes

Other Strategies

Traffic Incident Management

Active Traffic Management

Traffic Demand Management

Hot Lanes

Road Weather Management

Work Zone Management

Supporting Strategies

Traffic Management Center

Loop Detection

CCTV

Costs Summary

Generic Link Model

Artificial Strategies

Traffic Signal Control

Freeway Strategies

Ramp Metering

Traffic Incident Management

Transfer Information

Ex-Rates, Transfer Information

Pre-Trip Transfer Information

Freight Strategies and Systems

Track Only Lanes

Screening and Permitting Systems

Track Purling and Reservation System

Climbing Lanes

ATDM

ATDM General-Benefit

HOT Lanes

Active Traffic Management

Road Weather Management

Work Zone System

3) MY DEPLOYMENTS

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

PURPOSE: Estimate Lifecycles Costs of TSMGO Strategies

WORK AREA 1 - ESTIMATE AVERAGE ANNUAL COST

Traffic Signal Systems: Traffic Actuated Timing

Equipment	Useful Life	Capital Expenses at Curbs (Total)	OMB Curbs (Base)	Base Rate	Annual Cost
Basic Infrastructure Equipment					
Linked Signal System LAN	20	\$ 57,000	\$ 1,900	\$ 3,950	
TOTM Infrastructure Cost					
		\$ 57,000	\$ 1,900	\$ 3,950	
Incremental Deployment Equipment (per Intersection)					
Signal Controller	15	\$ 6,000	\$ 340	\$ 740	
Communication Line	20	\$ 770	\$ 6,800	\$ 6,839	
Loop Detectors (2)	5	\$ 11,000	\$ 4,300	\$ 6,500	
TOTM Incremental Cost					
		\$ 17,770	\$ 11,440	\$ 16,079	
INPUT	Enter Number of Infrastructure Deployments	<input type="text" value="1"/>		\$ -	
INPUT	Enter Number of Incremental Deployments	<input type="text" value="1"/>		\$ -	
INPUT	Enter Year of Deployment	<input type="text" value="1"/>			
Average Annual C:					\$ -
Levelized Costs (Used for Benefit Cost Ratio Calculation)					\$ -

Total Annual Cost Stream

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

PURPOSE: Estimate Lifecycles Costs of TSMGO Strategies

WORK AREA 2 - PROJECT STREAM OF COSTS AND ESTIMATE NET PRESENT VALUE

Traffic Signal Systems: Traffic Actuated Timing

Cost Item	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Infrastructure Costs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Incremental Costs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Total Annual Cost	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
Cumulative Cost	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	
INPUT	Enter Number of Years in the Analysis Time Horizon		<input type="text" value="20"/>	Source: TIGER Grant Application Recommendations																											
INPUT	Enter the Beginning Year of the Analysis		<input type="text" value="2016"/>																												
INPUT	Enter Discount Rate		<input type="text" value="7.0%"/>	Source: Office of Management and Budget																											
NET PRESENT VALUE OF CO			\$ 0																												

U.S. Department of Transportation
Federal Highway Administration

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What's New in TOPS 3.0

- Updated all defaults
- New cost data for strategies
- Cost Default Matrix for user modification
- 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

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



1 - Truck Only Lanes

- Restrict a lane or lanes to only large vehicles such as trucks and RVs
- Can be configured as a toll for access or an open HDV access lane
- Can Require:
 - Taking an existing lane
 - Repurposing or rebuilding a shoulder lane
 - Building new right of way



TOPS-BC TOL Cost Page 1 of 4

Navigation

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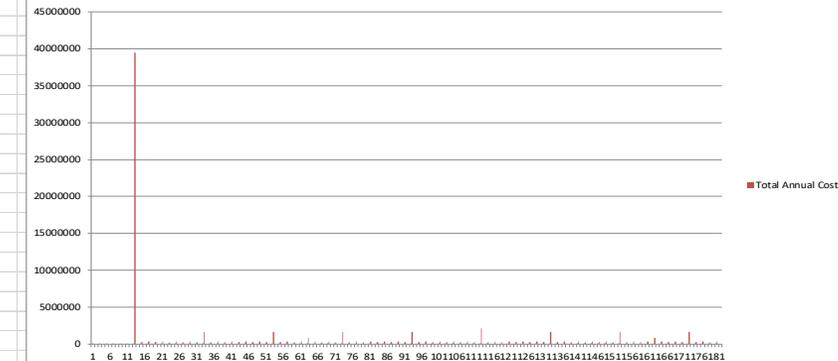
FHWA Tool for Operations Benefit/Cost (TOPS-BC): Version 3.0					
PURPOSE: Estimate Lifecycle Costs of TSM&O Strategies					
WORK AREA 1 - ESTIMATE AVERAGE ANNUAL COST					
Freight Strategies: Truck Only Lanes					
TAB 1 - TRUCK ONLY LANES WITH TOLLS					
Equipment	Useful Life	Capital / Replacement Costs (Total)	O&M Costs (Annual)	Annualized Costs	
Basic Infrastructure Equipment					
TMC Lane Control Hardware	5	\$ 8,200	\$ 1,200	\$	2,840
TMC System Integration	10	\$ 260,000	\$ -	\$	26,000
TMC Lane Control Software	2	\$ 36,000	\$ 770	\$	18,770
TMC Labor		\$ -	\$ 110,000	\$	110,000
Toll Processing Center Hardware	10	\$ 18,500	\$ 370	\$	2,220
Toll Processing Center Software	10	\$ 110,000	\$ 2,000	\$	13,000
Toll Processing Center Labor		\$ -	\$ 110,000	\$	110,000
Communications	5	\$ 2,050	\$ 2,050	\$	2,460
TOTAL Infrastructure Cost		\$ 434,750	\$ 226,390	\$	285,290
Incremental Deployment Equipment					
<i>Incremental costs for toll lane deployments are extremely variable depending on the type of deployment. User should enter and edit costs appropriate to their planned strategy. Example costs include:</i>					
Communication Line	5	\$ 770	\$ 930	\$	1,084
Variable Message Sign	10	\$ 89,000	\$ 4,200	\$	13,100
Variable Message Sign Tower	25	\$ 100,000	\$ 220	\$	4,220
Lane Signal Controller	10	\$ 85,000	\$ 1,900	\$	10,400
Loop Detectors (2)	10	\$ 10,500	\$ 480	\$	1,530
TOTAL Incremental Cost		\$ 285,270	\$ 7,730	\$	30,334
INPUT	Enter Number of Infrastructure Deployments	1		\$	285,290
INPUT	Enter Number of Incremental Deployments	5		\$	151,670
INPUT	Enter Year of Deployment	2019			
Average Annual Cost				\$	2,303,051
Levelized Costs (Used for Benefit Cost Ratio Calculation)				\$	3,797,862

The user can choose to toll or not toll the truck only lanes. TAB 1 is focused on the ITS cost to instrument and support a tolled truck lane or lanes. Items like TMC facility, electronics, software for back office operations as well as on site signage, gantries, communications lines, etc. If the TOL, with or without tolls, requires lane improvement or construction, those costs are included in TAB 2. The user follows steps 1 and 2 to use drop down menus to describe the particular project and roadway category, type, and terrain. TOPS will use these selections to look up the HERS Cost per Lane Mile assumption. The user must also select the number of lane miles and the expected life of the project. These costs are then included in the average and levelized cost estimate in Column W.

TAB 2 - TRUCK ONLY LANE CONSTRUCTION COST

STEP 1: Chose a Project Category and Type	Project Category Reconstruct	Project Type and Widen Lane	
STEP 2: Chose Roadway Category, Type and City or Terrain Type	Roadway Category Rural	Roadway Type Interstate	Terrain Type Rolling
Resulting Typical Costs per Lane Mile Assumed in HERS			\$ 1,866,091
Assumed Number of Miles			20
Assumed Useful Life of the Project			20
Total Construction Costs			\$ 37,321,818

Total Annual Cost Stream



TOPS-BC Cost Page 2 of 4

FHWA Tool for Operations Benefit/Cost (TOPS-BC): Version 3.0

PURPOSE: Estimate Lifecycle Costs of TSM&O Strategies

WORK AREA 1 - ESTIMATE AVERAGE ANNUAL COST

Freight Strategies: Truck Only Lanes

TAB 1 - TRUCK ONLY LANES WITH TOLLS

Equipment	Useful Life	Capital / Replacement Costs (Total)	O&M Costs (Annual)	Annualized Costs
Basic Infrastructure Equipment				
TMC Lane Control Hardware	5	\$ 8,200	\$ 1,200	\$ 2,840
TMC System Integration	10	\$ 260,000	\$ -	\$ 26,000
TMC Lane Control Software	2	\$ 36,000	\$ 770	\$ 18,770
TMC Labor		\$ -	\$ 110,000	\$ 110,000
Toll Processing Center Hardware	10	\$ 18,500	\$ 370	\$ 2,220
Toll Processing Center Software	10	\$ 110,000	\$ 2,000	\$ 13,000
Toll Processing Center Labor		\$ -	\$ 110,000	\$ 110,000
Communications	5	\$ 2,050	\$ 2,050	\$ 2,460
TOTAL Infrastructure Cost		\$ 434,750	\$ 226,390	\$ 285,290



TOPS-BC Cost Page 3 of 4

Incremental Deployment Equipment												
<i>Incremental costs for toll lane deployments are extremely variable depending on the type of deployment.</i>												
<i>User should enter and edit costs appropriate to their planned strategy. Example costs include:</i>												
	Communication Line					5	\$	770	\$	930	\$	1,084
	Variable Message Sign					10	\$	89,000	\$	4,200	\$	13,100
	Variable Message Sign Tower					25	\$	100,000	\$	220	\$	4,220
	Lane Signal Controller					10	\$	85,000	\$	1,900	\$	10,400
	Loop Detectors (2)					10	\$	10,500	\$	480	\$	1,530
	TOTAL Incremental Cost						\$	285,270	\$	7,730	\$	30,334
INPUT	Enter Number of Infrastructure Deployments					1					\$	285,290
INPUT	Enter Number of Incremental Deployments					5					\$	151,670
INPUT	Enter Year of Deployment					2019						
Average Annual Cost											\$	2,303,051
Levelized Costs (Used for Benefit Cost Ratio Calculation)											\$	3,797,862



TOPS-BC Cost Page 3 of 4

The user can choose to toll or not toll the truck only lanes. TAB 1 is focused on the ITS cost to instrument and support a tolled truck lane or lanes. Items like TMC facility, electronics, software for back office operations as well as on site signage, gantries, communications lines, etc. If the TOL, with or without tolls, requires lane improvement or construction, those costs are included in TAB 2. The user follows steps 1 and 2 to use drop down menus to describe the particular project and roadway category, type, and terrain. TOPS will use these selections to look up the HERS Cost per Lane Mile assumption. The user must also select the number of lane miles and the expected life of the project. These costs are then included in the average and levelized cost estimate in Column W.

TAB 2 - TRUCK ONLY LANE CONSTRUCTION COST			
STEP 1: Chose a Project Category and Type	Project Category	Project Type	
	Reconstruct	and Widen Lane	
STEP 2: Chose Roadway Category, Type and City or Terrain Type	Roadway Category	Roadway Type	Terrain Type
	Rural	Interstate	Rolling
Resulting Typical Costs per Lane Mile Assumed in HERS			\$ 1,866,091
Assumed Number of Miles			20
Assumed Useful Life of the Project			20
Total Construction Costs			\$ 37,321,818



TOPS-BC TOL Benefit Page

FHWA Tool for Operations Benefit/Cost (TOPS-BC): Version 3.0

Estimate Benefits of TSM&O Strategies

Freight Strategies: Truck-Only Lanes

Length of Analysis Period (Hours) 1

Cost Information

Facility Characteristics	Link Facility Type						
	Rural Freeway			Baseline	Improvement	Improvement	Change
	Freeway General Purpose Volume (PCE)	3000					
	Freeway General Purpose Number of Lanes	3		Baseline Override	Baseline	Improvement Override	Change
	Freeway General Purpose Capacity		6600		6600	6600	0
	General Purpose Free Flow Speed (MPH)		70				
	Percent Trucks		10%				
	Grade (0-5)		0%				
	Passenger Car Equivalent (PCE)		2.5				
	Freeway Link Length (Miles)	20					
	Freeway TOL Volume (PCE)	660					
	Freeway TOL Number of Lanes	1		Baseline Override	Baseline	Improvement Override	Change
	Freeway TOL Capacity		2200		2200	2200	0.000
	TOL Free Flow Speed (MPH)		55				



2 - TOPS E-Compliance for Trucks

- Electronic credential and safety verification checks
- Cost estimates for WIM, thermal detection, software, hardware, construction, etc.
- Allows external running of the Smart Roadside Initiative (SRI) cost tool
- https://rosap.ntl.bts.gov/view/dot/4038/dot_4038_DS1.pdf?



TOPS E-Compliance Benefits

- Facility Characteristics, # inspections, days/hours open, % rural trucks
- Facility Performance, OOS Rates before, after 1 year, after 10th year
- Impacts Due to Strategy, fuel & time saving /truck, false positive time loss
- Value of travel time savings



3 - Truck Parking & Reservations

- Two cost options:
 - Cost per parking spot ID or
 - Entry exit count, based on FLDOT Experience
 - Based on FLDOT Experience
- Benefits from assumptions on:
 - Number of spots, utilization, coverage
 - Time, Miles & Crashes saved/avoided



4 - Truck Climbing Lanes

- Cost based on Utah DOT study including: design, ROW, utilities, construction, aesthetes, etc.
- Generalized with HERS cost per lane mile: flat, rolling, mountainous mix
- Benefits based on: % trucks, change in speed, change in crashes, time saved



Summary of My Deployments

Benefit/Cost Summary

Show Benefit/Cost Watch Window

Annual Benefits

Travel Time	\$	32,947
Travel Time Savings: Non-Recurring Delay	\$	1,734,755
Energy	\$	0
Safety	\$	9,957,045
Reliability	\$	3,492,831
Other	\$	0
User Entered	\$	0
Total Annual Benefits	\$	15,217,579

Freight Strategies: Truck-Only Lanes

Levelized Annual Costs

\$ 3,797,862

Benefit/Cost Comparison

Net Benefit	\$	11,419,717
Benefit Cost Ratio		4.01



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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Back-up Slides

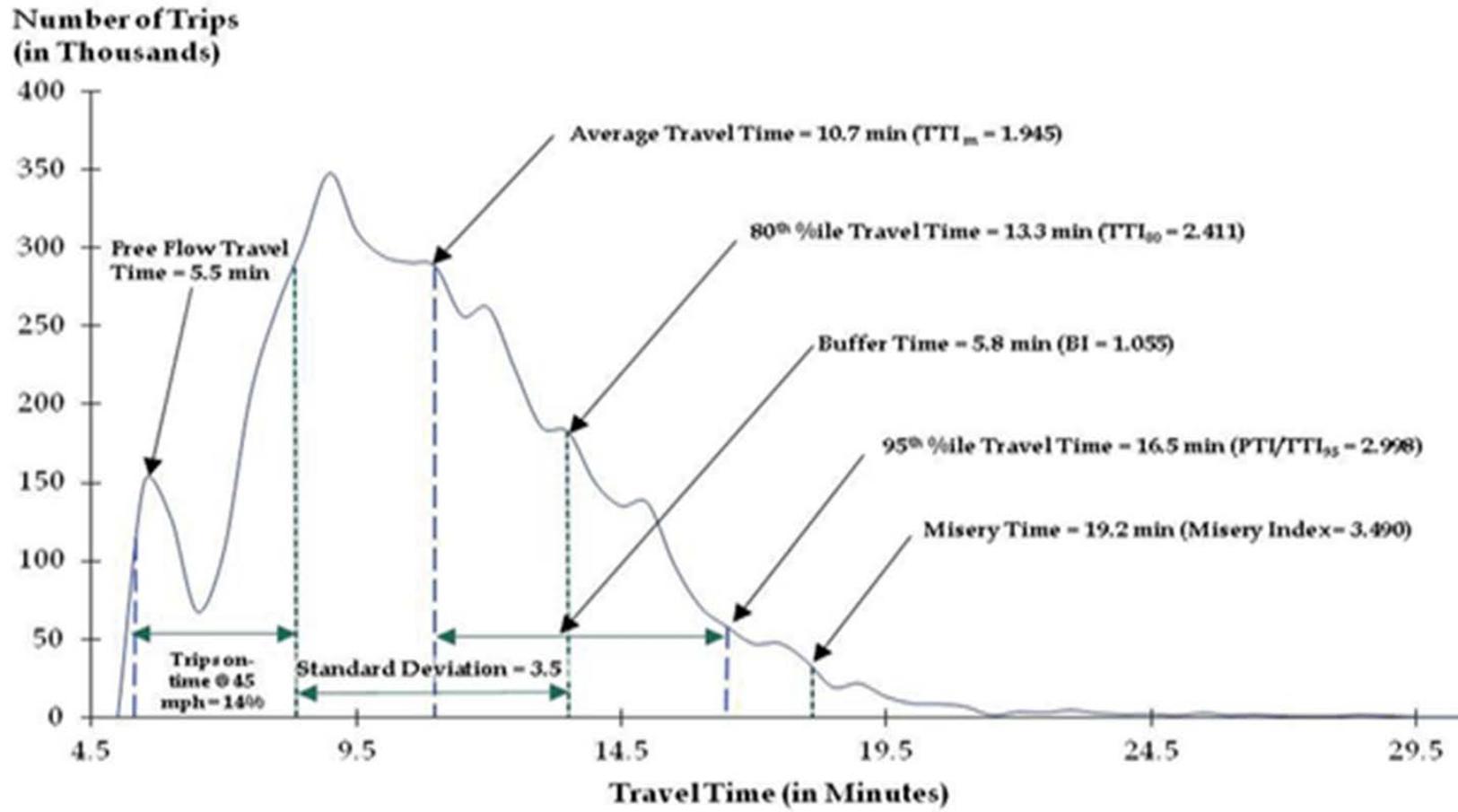


Estimating Reliability Benefits

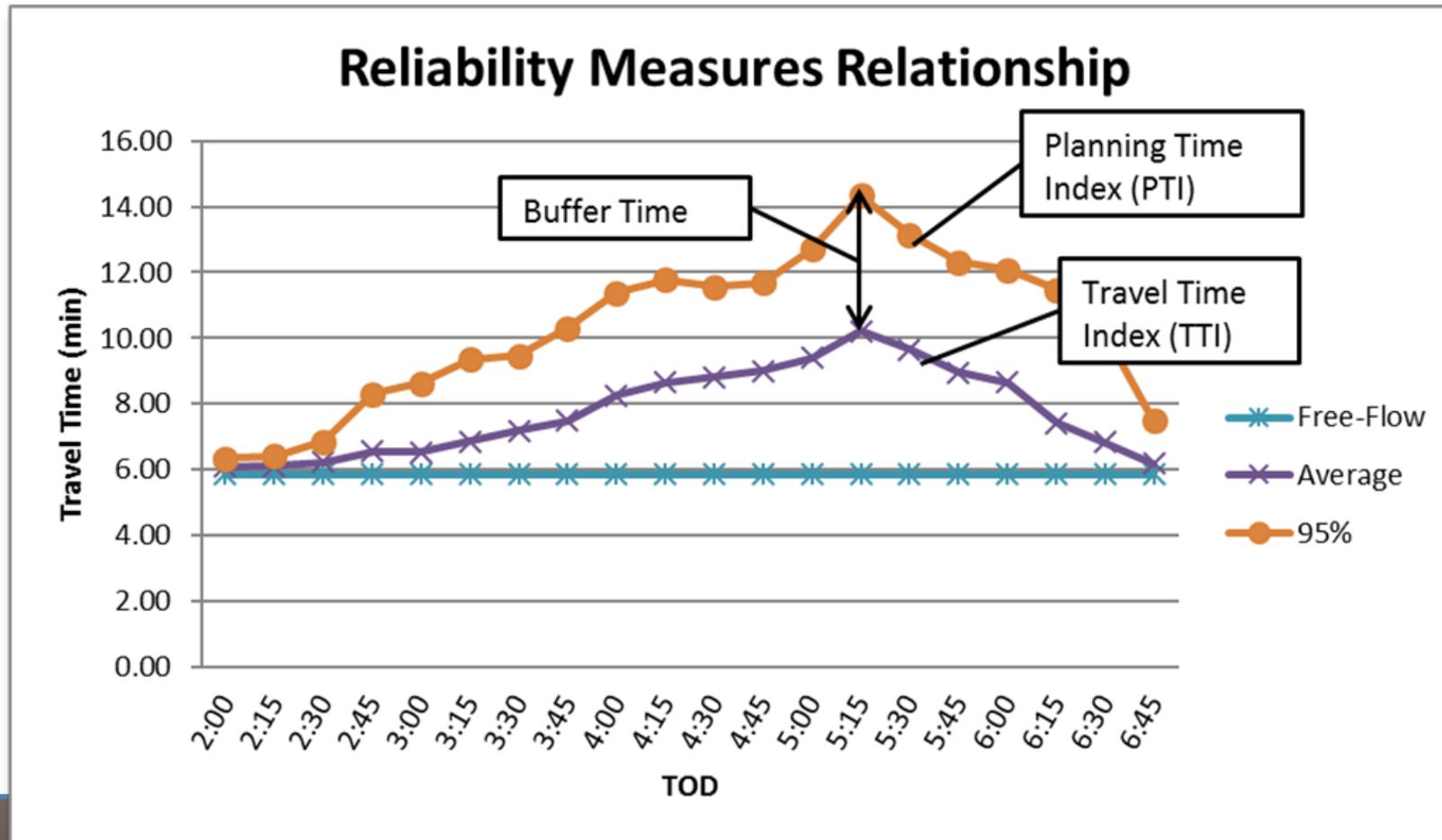
- Understanding travel time variability
- Travel Time Index (TTI)
 - $TTI_m = \text{Mean travel time} / \text{Free flow travel time}$
- Probability of on-time assurance
 - $TTI_{80} = \text{On time arrival } 80\% \text{ of trips}$
 - Travel Time @ 80% / TTI_m
- Buffer time is time added over the mean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



Distribution of Trip Time



Reliability by Time of Day



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

