2007 Benefit-Cost Analysis Conference

Transportation Benefit-Cost Analysis: It's All About Inputs!

Session 1: Case Studies in Benefit-Cost Analysis

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May 18, 2007

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- Charles Babbage (1791-1871), mathematician and inventor of the Difference Engine

Topics Covered

- Transportation Benefit-Cost Analysis
- Cal-B/C Model
- A Recent Application of the Model
- Lessons

Most transportation benefit-cost assessments include three types of user benefits

- *Travel time savings* - difference in the time users spend traveling before and after construction of projects
- *Vehicle operating cost reductions* - fuel consumption, break wear, tire wear, and use-related vehicle depreciation
- *Safety improvements* - reductions in the number or severity of accidents

This presentation focuses on highway benefit-cost analysis (BCA)

Societal Benefits Versus User Benefits

USER

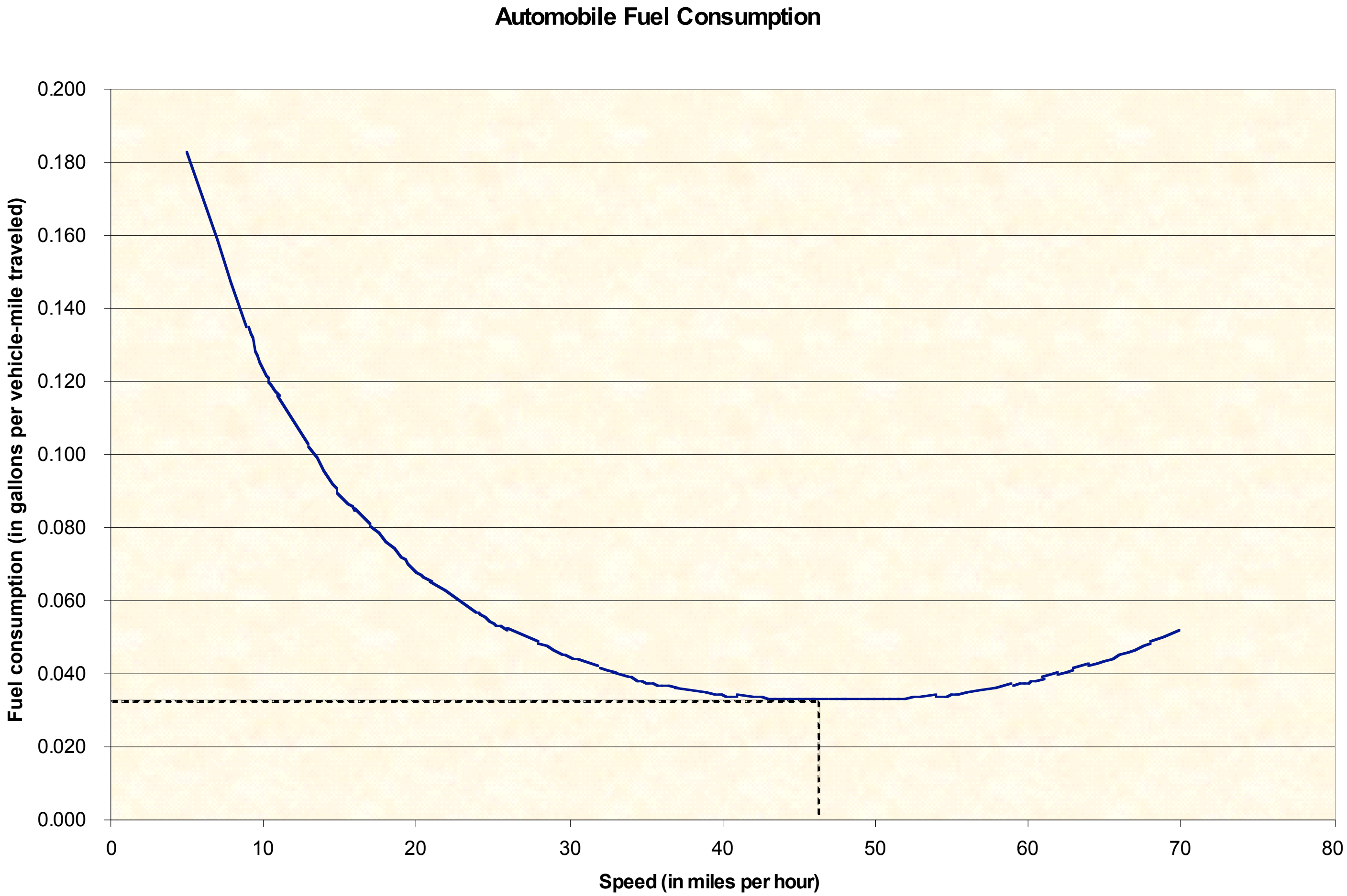
- Travel Time Savings
- Vehicle Operating Cost Reductions
- Safety Improvements

SOCIETAL

- Emissions
- Noise
- Global Warming

BCA for transportation projects takes a user benefit approach

Many transportation benefits are non-linear



Source: Cal-B/C Model

Almost all are a function of traffic volume or travel speed

Traffic Volume = number of people affected

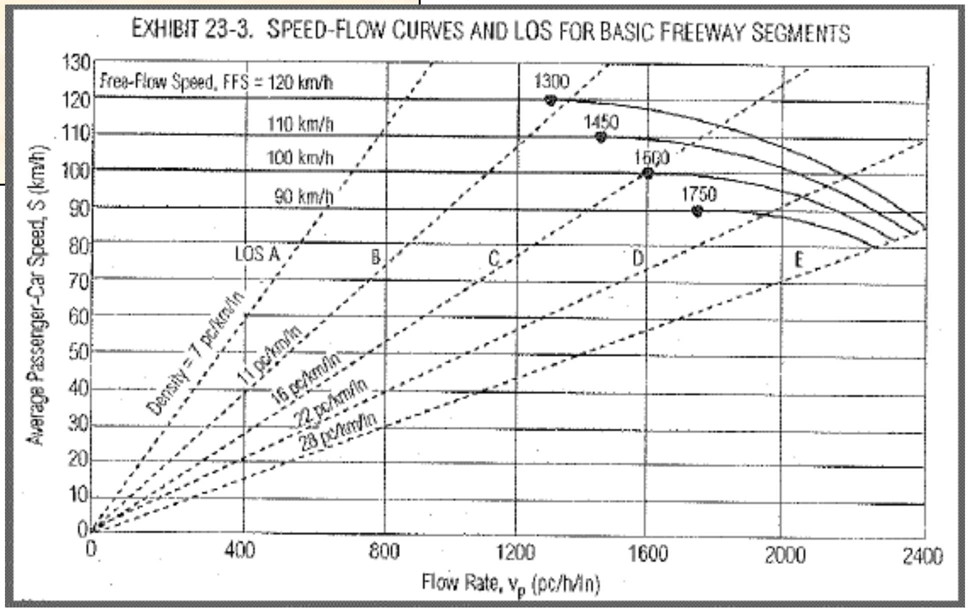
- Travel time savings = f (volume, speed)
- Vehicle operating cost reductions = f (volume, speed, fuel consumption, wear factors)
- Safety improvements = f (volume, accident rate, facility type)

In addition, speed can be estimated as a function of traffic volume and roadway geometry

- Example: 2000 Highway Capacity Manual

Speed = Free-Flow Speed / (1 + 0.15*(v/c) ^ 10)

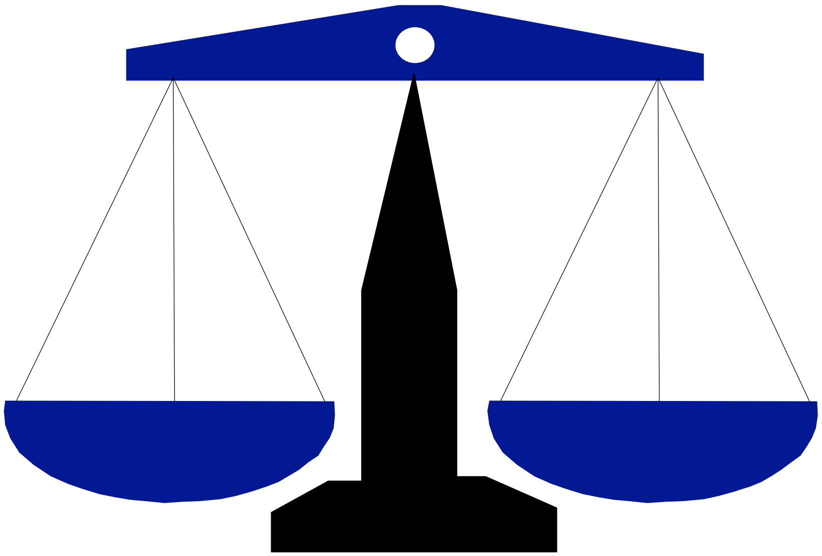
where,
v = traffic volume
c = capacity of facility



Sources of Traffic Volume and Travel Speed Data

- Traffic counts
  - Estimate number of vehicles using facility
  - States, cities, and counties collect their own data
  - Ad hoc (e.g. specific study) or regular (e.g., annual) basis
- Regional travel demand models
  - Forecast travel on regional transportation networks
  - Incorporate traffic counts, travel and housing projections, and probability models
  - Regional planning agencies required to use
- Micro-simulation models
  - Model operational performance
  - Use a variety of techniques
  - Favored by traffic engineers

Tradeoff in Transportation Benefit-Cost Models



Simplicity (easy-to-use)

Accuracy (flexibility to address multiple project types and their network effects)

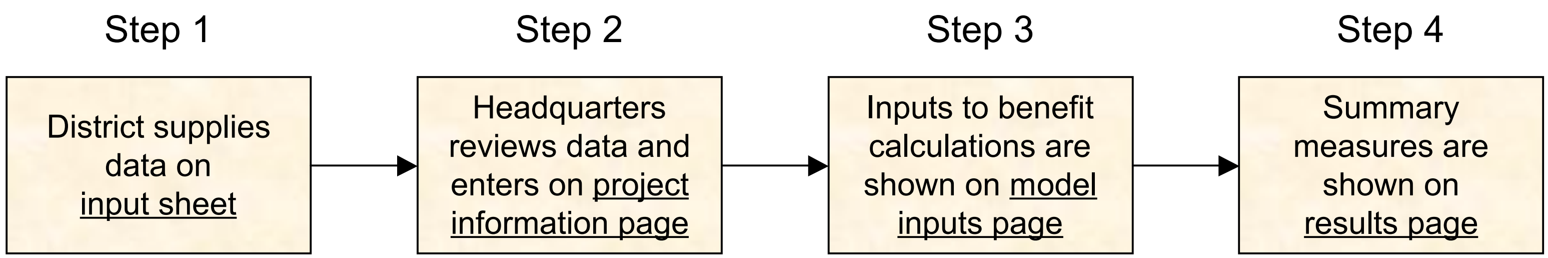
Two Approaches

- Sketch planning
  - Single highway corridor
  - Ignores benefits beyond the immediate project area
  - Example: Sketch Planning Analysis Spreadsheet Model (SPASM)
- Network-based
  - Project benefits for entire roadway network
  - Uses outputs of a network transportation model
  - Examples: Highway Economic Requirements System (HERS) and state version (HERS-ST), NET_BC, StratBENCOST, Surface Transportation Efficiency Analysis Model (STEAM)

Cal-B/C is intended to be a simple benefit-cost model

- Excel worksheet (i.e., not a black box)
- Developed in mid-1990s to conduct investment analysis of State Transportation Improvement Program (STIP)
- Handles both highway and transit projects
- Estimates four user benefits (including emissions) in a corridor analysis
- Can accept regional planning model inputs
- Uses a 20-year life-cycle
- Estimates speeds from volumes (v/c ratios)

Process for Verifying Data in Cal-B/C

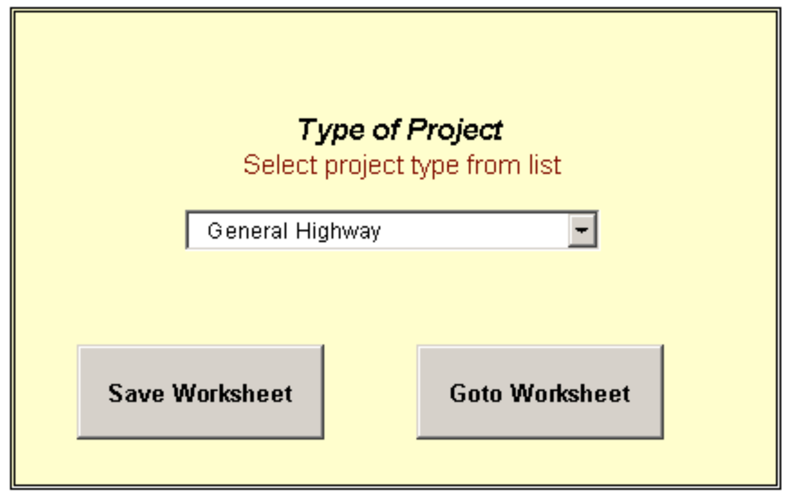


Step 1: Caltrans districts submit input sheets for specific projects

- Six input sheets for different types of projects:
  - Highway project (lane addition, carpool lane, passing lane, pavement rehabilitation)
  - Interchanges (includes freeway and carpool lane connectors)
  - Ramps
  - Bypasses
  - Intelligent transportation system projects (ramp metering, incident management, and traveler information)
  - Transit projects
- An Excel spreadsheet helps District staff pick correct input sheet

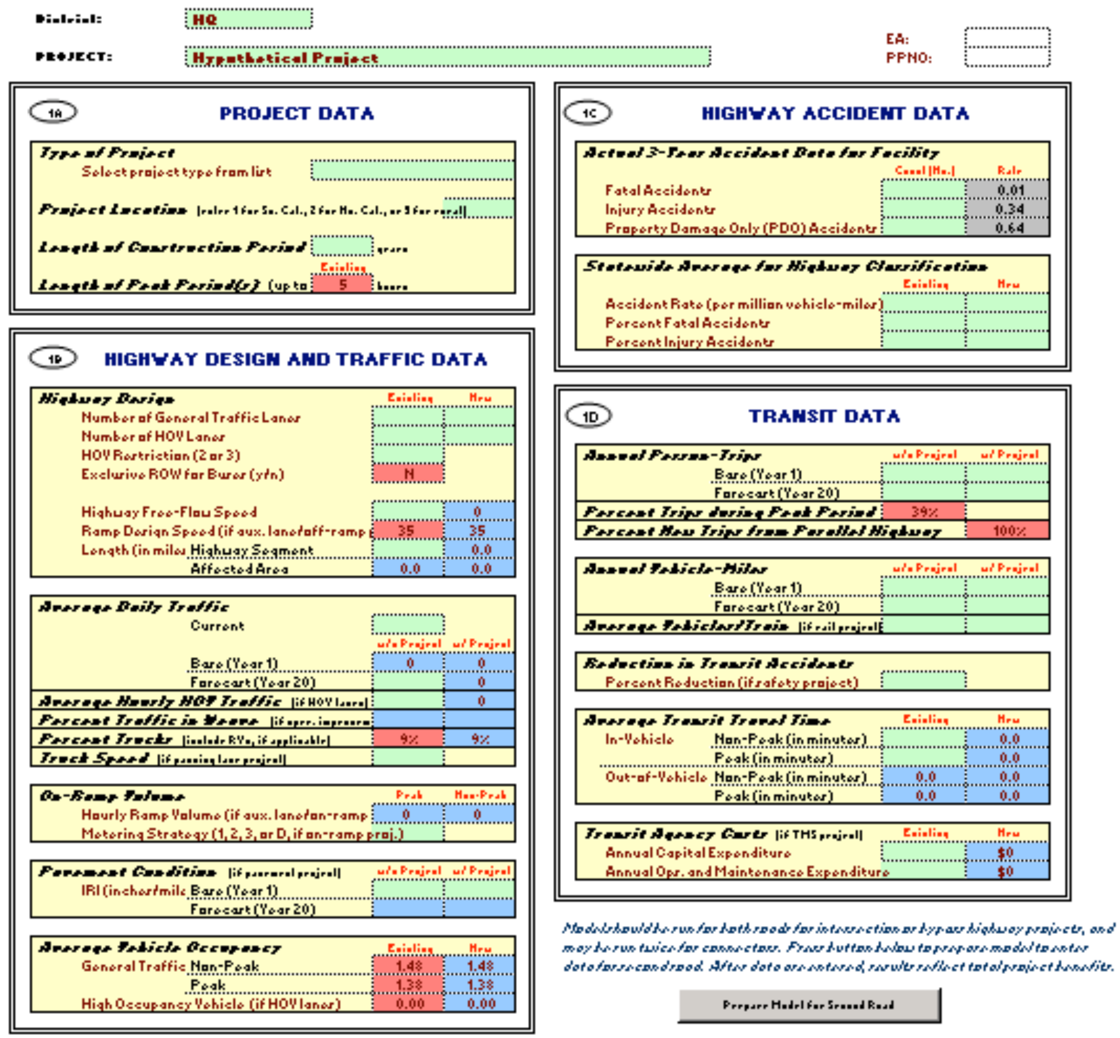
INTRODUCTION

The Cal-B/C model provides a method for preparing a simple economic analysis of both highway and transit projects. Given certain input data for a project, the model calculates its life-cycle cost, life-cycle benefits, net present value, benefit/cost ratio, internal rate of return, and payback period. First-year benefits are also calculated.

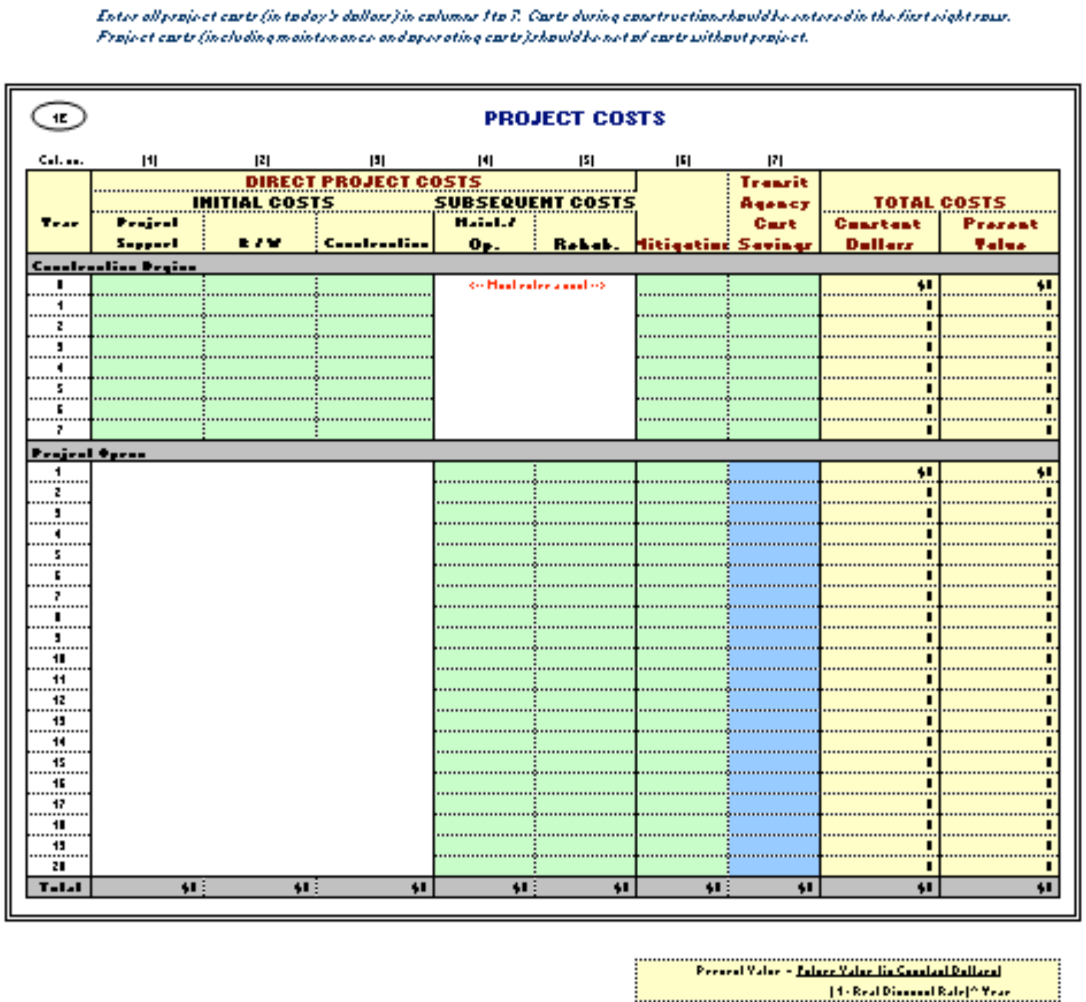


Transportation Economics enters information supplied by the Districts into the model

Step 2: Information about a project is entered using data supplied by Caltrans districts



Step 2 (continued): The Caltrans districts also supply life-cycle cost information



- Initial capital costs
  - Project support
  - Right-of-way
  - Construction
  - Equipment
- Operating costs
- Other costs
  - Rehabilitation
  - Mitigation

Step 3: Data can be adjusted if detailed information is available from regional planning or micro-simulation models

2A

HIGHWAY SPEED AND VOLUME INPUTS

	Calculated by Model	Changed by User	Used for Proj. Eval.	Reason for Change
Without Project				
Year 1				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	0		0	
Weaving Volume	0		0	
Truck Volume	0		0	
HOV Speed	55.0		55.0	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	
Non-Peak Period				
Non-HOV Volume	0		0	
Weaving Volume	0		0	
Truck Volume	0		0	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	
Year 20				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	0		0	
Weaving Volume	0		0	
Truck Volume	0		0	
HOV Speed	55.0		55.0	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	
Non-Peak Period				
Non-HOV Volume	0		0	
Weaving Volume	0		0	
Truck Volume	0		0	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	

Step 4: Cal-B/C provides summary results

District: HQ

PROJECT: Hypothetical Project

EA:

PPNO:

③

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$0.0
Life-Cycle Benefits (mil. $)	$0.0
Net Present Value (mil. $)	$0.0
Benefit / Cost Ratio:	#DIV/0!
Rate of Return on Investment:	#NUM!
Payback Period:	21 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$0.0	$0.0
Veh. Op. Cost Savings	$0.0	$0.0
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$0.0	$0.0
TOTAL BENEFITS	$0.0	$0.0
Person Hours of Delay Saved	0	0

Should results include:

1) Induced Travel? (y/n)	Y (Default = Y)
2) Vehicle Emissions? (y/n)	N (Default = N)

The model makes detailed benefit estimations, but the user does not need to adjust these calculations

The model includes a number of economic parameters and rate tables

General Economic Values
- Year of current dollars for model
- Economic update factor (using GDP deflator)
- Real discount rate

Highway Operations Measures
- Maximum volume-capacity (v/c) ratio
- Percent average daily traffic (ADT) in average peak hour
- Capacity per lane (general)
- Capacity per high occupancy vehicle (HOV) lane

Travel Time Values
- Average hourly wage (for Transportation and Utilities industry and all industries statewide)
- Automobile, truck, and transit

User Operating Costs
- Fuel cost per gallon
- Non-fuel cost per mile (automobile and truck)

Highway Accident Costs
- Cost of a fatality
- Cost of an injury (Level A Severe, Level B Moderate, Level C Minor)
- Cost of a highway accident (fatal, injury, and property damage only, PDO)
- Statewide highway accident rates (fatal, injury, PDO)

Fuel Consumption Rates
- Gallons per vehicle miles traveled (VMT) for autos and trucks

Passing Lane Accident Reduction Factors

Transit Accident Rates and Costs
- Fatality, injury, and PDO accidents
- Passenger train, light-rail, and bus

Highway Emissions Rates
- CO, NOX, PM10, SOX, and VOC
- Automobile, truck, and bus

Rail Emissions Rates
- CO, NOX, PM10, and VOC
- Passenger train and light-rail

Emissions Costs
- Urban Southern California, urban Northern California, and rural California
- Automobile, truck, and bus.

Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act (Proposition 1B)

- Approved in November 7, 2006 election
- Infrastructure Bond Package - $19.9 billion
- Some important components:
  - Corridor Mobility Improvement Account (CMIA) - $4.5 billion
  - STIP Augmentation - $2.0 billion
  - SHOPP Augmentation - $500 million

The California Transportation Commission (CTC) adopted guidelines for nominating projects to the CMIA program

- Project fact sheet
- Description of travel corridor
- Description of project benefits
  - Improve travel times or reduce the number of daily vehicle hours of delay
  - Improve the connectivity of the state highway system between areas
  - Improve the safety of a highway or roadway segment
  - Improve air quality and other benefits
- Description of how the project improves access to jobs, housing, markets, and commerce.
- Description of the risks inherent in the nomination's estimates of project cost, schedule, and benefit.
- Description of the corridor management approach
- Documentation of the basis for costs, benefits and schedules cited

The CTC decided to give priority to projects with greatest benefits relative to costs

Recent Application

The CTC adopted the Cal-B/C model and developed a project input sheet specifically for the CMIA program

California Transportation Commission | APPENDIX B | CMIA Guidelines

CORRIDOR MOBILITY IMPROVEMENT ACCOUNT PROGRAM
BENEFIT/COST ANALYSIS: PROJECT INPUT SHEET

Region/District: ______ County: ______ Route: ______ EA: ______

Describe Project: ______ Post mile: ______ PPNO: ______

PROJECT DATA

Type of Project	Enter "X"
Hwy Capacity Expansion	
Operational Improvement	
Transp MGMT System (TMS)	
Other (describe:)	

Project Location (1 = So. Cal., 2 = No. Cal., or 3 = rural)		
Length of Construction Period		years
Duration of Peak Period (AM+PM)		hours

HIGHWAY ACCIDENT DATA

Actual 3-Year Accident Data for Facility

	Count (No.)
Fatal Accidents	
Injury Accidents	
Property Damage Only (PDO) Accidents	

Statewide Average for Highway Classification

	w/o Project	w/ Project
Accident Rate (per mil. veh-miles)		
% Fatal Accidents		
% Injury Accidents		

HIGHWAY DESIGN AND TRAFFIC DATA

Highway Design

	w/o Project	w/ Project	HOV Restriction
Number of General Traffic Lanes			
Number of HOV Lanes			
Highway Free-Flow Speed (in mph)			(2 or 3)
Project Length (in miles)			

Average Daily Traffic	w/o Project	w/ Project
Current		
Forecast (20 years after construction)		
Average Hourly HOV Traffic (if HOV lanes)		
Percent Trucks (include RVs, if applicable)		
Truck Speed (if passing lane project)		

TOTAL PROJECT COSTS (in escalated dollars)

From Project Nomination Fact Sheet:

Fiscal Year:	
2007-08	$
2008-09	$
2009-10	$
2010-11	$
2011-12	$
2012-13	$

COMMENTS: ______

Prepared by: ______ Phone No: ______ E-Mail: ______

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Transportation Economics, DOTP, Caltrans 11/08/2006

Over 100 projects were to be assessed in a few weeks

- Project nominations were due January 15, 2007
- CMIA program was adopted February 28, 2007
- Caltrans conducted a Cal-B/C training session
- Staff identified preferred project information sources and method for validating data

The CTC received 149 nominations for $11.3 billion in proposed projects

- Caltrans received multiple project input sheets for some projects
  - Over 200 project information sheets
  - Multiple submitting agencies
  - Reflected different data
- Other problems included:
  - Missing data or unknown values
  - Corridor level data for projects that have network impacts
  - Differences in definitions of “capacity”
  - Attempts at “gaming” that result in lower rather than higher benefits
  - Projects thought to be beneficial, but with no quantified benefits

Judgment was needed to identify best input data, but benefit-cost analysis provided a relatively unbiased way of making comparisons

- Fifty-five (55) projects qualified for the CMIA program
- Average benefit-cost ratio of about 2.4
- Selected projects ranged from under 1.0 to over 8.0
- The CTC used multiple selection criteria
  - Unquantifiable benefits
  - Need for judgment
- Data difficulties attributed to steep learning curve and short analysis timeframe
- Some agencies did not like the use of benefit-cost evaluation
  - Favored projects not selected
  - The model was an easy culprit

Future of BCA in California Transportation Planning

- The CTC is continuing to use benefit-cost analysis for other Proposition 1B programs
- Caltrans is convening a committee to guide further benefit-cost analysis
  - Develop guidance on how to use benefit-cost modeling in corridor analysis
  - Test sensitivity of Cal-B/C to data inputs
- The lack of consistent input data drives a fundamental decision in the model's evolution…

Should Cal-B/C remain an economic tool that can helps quantify and summarize user benefits, or become planning/engineering judgment tool that replaces traditional analysis?

Lessons for “Real-World” Analysis

- *Practitioners need to scrutinize the input data*
  - Economists as transportation planners and engineers
  - Multiple sets of information - which data are best?
- *Non-practitioners need training in benefit-cost analysis*
  - Transportation planners and engineers are the experts
  - With greater knowledge can lead to “gaming the system”
- *Practitioners need to be cognizant of the inputs that drive results*
  - Every user benefit is a function of travel speed or traffic volume
  - Estimation of these values typically occurs outside benefit-cost models
  - Greater impact on benefit-cost results than any of the assumptions inside transportation benefit-cost models (the value of time, the value of life, fuel and non-fuel vehicle operating costs, emissions tables)
- *Academic research needs to provide guidance on important economic values*
  - About 60 to 80 percent of the user benefits are due to travel time savings
  - Further research needed on value of time (differs with length of time, the time of day, goods moved, etc.)
- *Guidelines on the appropriate input data are important*

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