Tool Summary Sheets

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■ Bridge LCCA Software Tool

Overview

NCHRP Project 12-43 produced a Bridge Life Cycle Cost Analysis (BLCCA) tool as part of a study to develop a comprehensive bridge life cycle costing methodology. The tool can be used to compute the present value of life cycle costs for alternative sets of bridge management alternatives, including consideration of agency costs for construction and maintenance; user costs related to construction delays, accidents, and detours; and vulnerability costs (risks of damage due to earthquakes, floods, collisions, overloads, and scour). It is designed to support analysis of individual bridges (as opposed to networks of bridges).

General Information

Developer:	National Engineering Technology Corporation (NET)
Available From:	NCHRP
Date of Last Update:	June 2002
Software Platform:	Windows 98/NT4.x (system developed using Visual Basic, Crystal Reports, FoxPro 5.0, Dynazip, and Gigasoft ProEssentials II; all included in compiled code)
Source Code Available?:[1]	No
Level of Use:	Not yet formally released

[1] This item indicates the research team's understanding of whether the source code could potentially be made available for modification or integration as part of this project. Formal inquiries were not made on this topic.

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Life-cycle cost analysis	Calculates life cycle cost for different bridge management alternatives for an individual bridge. Examples of analyses are: - Alternative schedules of repair and rehabilitation over a specified time horizon. - Alternative project scopes (e.g., replace deck or more extensive rehabilitation) - Alternative project designs, including use of differing materials - Do nothing versus seismic retrofit
Probabilistic analysis	Incorporates models to account for uncertainty in the magnitude and timing of costs.
Traffic projections	Users may specify a generic model or select a model based on application of the NBI traffic growth rate assumption.
Agency cost models	

Impacts Analyzed

Type of Impact	Description
Distributed Agency Costs	Calculates inspection and maintenance costs based on user-specified generic model.
User Costs	Calculates the following user cost components: - Accidents related to width deficiencies - User costs related to vertical clearance - Detours due to load capacity - Traffic congestion delays - Environmental damage - Work zone-related costs
Vulnerability Costs	Calculates agency and user cost components related to: - Earthquakes - Scour - Structural damage due to fatigue - Structural damage due to overloads - Collision damage - Flooding

Type of Impact	Description
Life Cycle Costs	System calculates constant and discounted costs associated with a defined scenario and alternative. User can specify several options: • Annual or cumulative costs • Initial and after repair event costs or during event costs • Cost category: distributed agency costs, user costs, agency vulnerability costs, user vulnerability costs • Idling VOC
Deterioration	Health Index and Load Capacity values throughout the analysis time horizon, based on generic model (curve fitting based on 2, 3 or 4 points) or Markov model for condition index; Bridgit BMS model for load capacity.

Input Requirements

Input	Default Provided?
Bridge inventory data (NBI)	No
Scenario Definition (base year, analysis period, discount rate)	No
Traffic Projection model parameters	Yes
Deterioration model parameters – condition and load capacity	Yes
User cost model parameters	Yes
Vulnerability cost models	Yes
Distributed agency costs	No
Definition of alternatives, including events, costs and impacts	No

Methodology

Use of the BLCCA software involves:

1. Selecting a structure for analysis from the NBI file or entering information for a new structure.

2. Setting up an analysis scenario, including specification of the base year, analysis period, and discount rate.

3. Setting up models for traffic projection, condition, and load capacity deterioration, user costs, vulnerability costs, and distributed agency costs (maintenance and inspections). This involves selecting the model and entering model parameters.

4. Defining alternatives to be analyzed.

5. For each alternative, defining the sequence of events (e.g., profile of repairs and rehabilitation projects throughout the analysis period), including indication of uncertainty in their timing.

6. For each event:

   – Specifying changes to traffic and deterioration models which would be expected after the event (e.g., due to changes in condition);

   – Specifying agency cost components;

   – Specifying effects of the event – both during and after (user cost models for accidents, congestion, etc.).

7. Running reports to view life cycle costs associated with each alternative.

Assessment

Strengths

- Simple user interface.
- Optional interface with standard NBI file.
- Includes probabilistic modeling approach as an option.
- Supports sensitivity analysis.
- Incorporates North Carolina user cost models for accidents and detour costs, and Bridgit models for load capacity changes.
- Includes many graphic displays of results.
- Allows for future incorporation of new model DLL's.

Limitations

- Users must specify every event and its impacts in detail; no simulation capability for condition-based triggers of events.
- Good results will depend on agencies' ability to research and develop appropriate model parameters and other inputs.
- Includes only structure-level deterioration models.

Source(s):

Review copy of software CD with documentation obtained from David Beal, NCHRP.

■ EAROMAR

Overview

EAROMAR (Economic Analysis of Roadway Occupancy for Maintenance and Rehabilitation) provides an economic-based framework for analyzing tradeoffs among construction, maintenance, rehabilitation, and operations strategies as they apply to roadways. The system is used by the FHWA to conduct pavement life-cycle cost analyses on high-standard roads.

General Information

Developer:	CMT Inc. for the FHWA
Available From:	FHWA
Date of Last Update:	1998 (Version 2)
Software Platform:	Fortran with DOS interface
Source Code Available?:	No
Level of Use:	FHWA and a few state DOT's have used EAROMAR as a research and analysis tool

Type and Scope of Tool

Function	**Scope (Types of strategies, needs, or projects)**
Life-cycle Agency Cost Analysis	Analyzes high-standard roadways and predicts highway agency expenditures for pavement reconstruction, overlays, and maintenance (preventive, corrective, and deferred) activities.
User Cost Analysis	Estimates vehicle operation costs, travel time costs, accident costs, and pollution levels.
Pavement Performance Analysis	EAROMAR incorporates a set of damage models for flexible, rigid, and composite pavements.
Work Zone Analysis	EAROMAR can be used to investigate the staging of projects and the effects of construction or maintenance packaging, as well as options to limit road occupancy to particular hours of the day or to particular months or seasons of the year.

Impacts Analyzed

Type of Impact	Description
Life-cycle Agency Costs	Predicted agency costs reflect the collective influences of: • Pavement structural and materials properties • Imposed traffic loadings • Environmental factors • Maintenance policies • Local practices of work scheduling • Prevailing unit costs of maintenance labor, equipment and materials
Life-cycle User Costs	Vehicle operating costs, travel time costs, accident costs, and pollution levels are modeled as functions of: • Vehicle/driver characteristics • Trip purpose • Road physical characteristics (surface condition, roadway geometry, etc.) • Road operational characteristics (e.g., work zone characteristics, speed limit, etc.)

Input Requirements

Input	Default Provided?
Highway characteristics (number of lanes, lane width, shoulder width, length, radius of curvature, design speed, speed limit, grade)	No
Pavement information (pavement layer properties, PSI, roughness, other surface distress)	No
Traffic usage information (AADT, AADT growth rate, traffic composition, hourly traffic variation)	No
Vehicle characteristics (gross weight, axle loads, fuel costs)	No
Environmental conditions (seasonal temperatures, seasonal precipitation)	No
Value of Time	No
Project descriptions (duration of project, impacts of work zone on users)	No
Maintenance activity descriptions (costs, duration of project, impacts of work zone on users)	No
Policy information (economic parameters, values to trigger actions, types of corrective or preventive actions to be taken, etc.)	No

Several example input data sets exist for EAROMAR. Although the data in these files are not considered default values, they can be used as a starting point for developing a customized data set. Most agencies have access to these data items, but they require substantial effort to compile.

Methodology

EAROMAR's simulation procedure begins with the user developing a problem description, which consists of route and traffic characteristics, a maintenance policy, and initial costs. Problem descriptions encompass a single roadway – EAROMAR does not analyze networks. After the problem description is defined, traffic is imposed on the roadway. Structural and operational aspects of the roadway are then simulated for a given season of a year within the analysis period. Structural aspects include the prediction of pavement damage and resulting condition; pavement repair in response to condition, policy, and scheduling; and updating pavement condition based on deterioration and repairs applied. Operational aspects include computing seasonal, daily, and hourly traffic volumes; computing roadway capacity (work zones for maintenance or rehabilitation reduce capacity); and computing the volume/capacity ratio and effects of flow on speed. The results of these two simulation branches (structural and operational) are then combined in order to compute traffic speed and user consequences for that season.

Assessment

Strengths

- Comprehensive analysis of the impact of construction, maintenance, and operation strategies on user costs.
- Economic-based (life cycle cost) approach to performing tradeoff analyses.
- Combines structural and operational simulations through the use of work zone impacts on user costs.
- Multiple scenarios representing various policy alternatives can be evaluated simultaneously with EAROMAR.
- Has supported the development of vehicle size/weight regulations.
- Supports the analysis of preventive versus deferred maintenance strategies.
- Supports the analysis of capital versus maintenance investments.

Limitations

- Analytic models for pavement deterioration and congestion are old and need to be reviewed and updated.
- Input data are extensive and creating an input set requires significant research.
- Since the model analyzes each highway section independently, EAROMAR cannot reflect how changes in one part of the highway system affect other parts (such as how traffic might be redistributed as improvements are made).
- Program platform and interface are obsolete.

Source(s):

M.J. Markow and B.D. Brademeyer, EAROMAR Version 2, Final Technical Report, FHWA/RD-82/086, April 1984.

■ HDM-4

Overview

The Highway Development and Management Tool (HDM-4) supports the analysis of roadway management and investment alternatives (e.g., developing new roads, improving existing roads, maintaining existing roads, applying new vehicle technologies, and implementing new funding and management approaches). The system has been used throughout the world to evaluate the validity of road projects, justify increases in maintenance and rehabilitation budgets, and explore the implications of roadway policy options.

General Information

Developer:	World Road Association (PIARC) – developed through the International Study of Highway Development and Management Tools project (ISOHDM)
Available From:	McTrans, Presses de l'ENPC (Paris), and Asociación Técnica de Carreteras (Madrid)
Date of Last Update:	Version 1.3 released January 2002 (Version 2 schedule to be released by the end of 2002)
Software Platform:	Windows-based
Source Code Available?:	Yes
Level of Use:	Used in more than 100 countries

Type and Scope of Tool

Function	**Scope (Types of strategies, needs, or projects)**
Strategy Analysis	Analysis can be done at road network, subnetwork or individual segment level
	Predicts medium to long term expenditures (5 to 40 years)
	Predicts pavement deterioration for various funding levels and management strategies
	Recommends optimal allocation of funds by activity (e.g., periodic maintenance, routine maintenance, improvement, and development etc.)
	Recommends optimal allocation of funds by asset grouping (e.g., functional class, administrative responsibility, etc.)

Function	Scope (Types of strategies, needs, or projects)
Program Analysis	Prepares multi-year program of projects that meets resource constraints. Project candidates are selected based on user-defined selection criteria (e.g., maintenance thresholds, improvement thresholds, and development standards). Evaluates life-cycle costs, net present value (NPV), and internal rate of return (IRR) for candidates. Projects are prioritized based on incremental net preset value (NVP)/cost.
Project Analysis	Analyzes costs and benefits of one or more project or investment alternative (e.g., maintenance, rehabilitation, widening, geometric improvements, new construction, pavement upgrades, etc.) Includes models for concrete, bituminous, and unsealed roads; and cold and temperate climates

Impacts Analyzed

Type of Impact	Description
Road deterioration	Pavement deterioration is modeled as a function of: • Traffic loading; • Weather; • Drainage adequacy; and • Maintenance and improvement standards (e.g., condition thresholds)
Agency costs	Predicts life-cycle pavement expenditures
Road user costs	Road user costs consist of: • Vehicle operation costs (fuel, tires, depreciation, etc.) • Travel time costs; and • Accident costs (e.g., loss of life, injuries, and vehicle damage, etc.)
Social and environmental impacts	Calculates social and environmental impacts based on: • Vehicle emissions; • Energy consumption; • Traffic noise; • Welfare benefits to surrounding population

Input Requirements

The following table summarizes input data required for HDM-4.

Input	**Default Provided?**
Road network data (network aggregate level)	
Road class	No
Geometry	No
Structural adequacy	No
Ride quality	No
Surface condition	No
Surface texture	No
Construction quality	No
Traffic data	
Traffic categories (e.g., normal, diverted, and generated)	No
Traffic composition (e.g., volumes and growth rates)	No
Axle loading	No
Road capacity and speed-flow relationships	No
Traffic-flow pattern	No

In addition to providing the input data described above, users are also required to adjust several data items and calibration factors provided in the system's default models. These adjustments fall under three categories:

1. **Level 1 – Basic Application**. Required for all uses of HDM-4; adequate where approximate results are desired. Consists of adopting many defaults and calibrating the most sensitive parameters based on available data. HDM-4 provides default calibration factors.

2. **Level 2 – Calibration**. Suggested for detailed analyses where higher degree of reliability is desired. Requires moderate field surveys to collect data required to calibrate predictive relationships. May require slight modifications to source code.

3. **Level 3 – Adaptation**. Requires detailed field surveys, controlled experiments, and source code adjustments; involves significant changes to models or substitution of new ones.

The following table provides a few examples of the types of data used in the HDM-4 models, along with the calibration level in which the items would be adjusted.

Input	**Level of Adjustment**
Road User Effects Model (111 items)	
Vehicle operation costs (e.g., cost of oil, cost of tire, cost of replacement vehicle, etc.)	1
Aerodynamic data (e.g., drag coefficient, drag coefficient multiplier, etc.)	2
Tire stiffness factors	3
Pavement Deterioration and Work Effects Model (46 items)	
Unit costs for construction and maintenance activities	1
Work trigger values	2
Base layer standards (e.g., number and thickness of layers)	2
Traffic Loading Model (3 items)	
AADT	1
Traffic growth rate	1
Hourly distribution of traffic	1
Economic (2 items)	
Discount rate	1
Analysis period	1

Methodology

The HDM-4 analytical framework combines technical and economical concepts in order to perform life cycle pavement analyses. The system applies a set of four models (road deterioration, road work effects, road user effects, and socioeconomic and environmental effects) and a set of user-defined maintenance and improvement policies to a road network in order to predict pavement condition, life cycle agency costs, and impacts on road users. HDM-4 performs these analyses for a large number of investment alternatives for each year of a user-specified analysis period. The economic benefits of an investment are calculated by comparing the total cost stream of each alternative to a base case (e.g., do nothing option).

Assessment

Strengths

- Provides strong support for economic analysis of alternative roadway investments, both at the network and project level.
- Supports the analysis of alternative maintenance strategies.
- Flexible data requirements and import/export tools enable the use of a wide range of data types to populate the HDM-4 data sets.
- Modular structure facilitates use/adaptation of individual model components.
- Technical support, training, and a user group are available.
- Opportunities for future enhancements may benefit from the pooling of funds from a number of sponsors (the World Bank, the Asian Development Bank, the Swedish National Road Administration, the Department for International Development (UK), and others).

Limitations

- The validity of HDM-4 results depends on the extent to which an agency has calibrated a detailed default data set in order to match local conditions.
- Models not based on US data, and have not been widely used or calibrated by US agencies.
- The model is not designed to explicitly account for uncertainty, although the effects of changing key assumptions can be handled through sensitivity analyses.

Source(s):

http://hdm4.piarc.org/main/home-e.htm

HERS/ST

Overview

The Highway Economic Requirements System for State Use (HERS/ST) analyzes the relationship between investment levels and the condition and performance of a state's highway system, using the state's Highway Performance Monitoring System (HPMS) data set.

General Information

Developer:	Cambridge Systematics and Battelle (under contract to FHWA)
Available From:	FHWA Office of Asset Management
Date of Last Update:	September 2002 (Version 2.0)
Software Platform:	FORTRAN (with graphical user interface)
Source Code Available?:	Yes
Level of Use:	Oregon and Indiana use an earlier version of HERS/ST in determining future highway needs and planning highway projects. Also, representatives of 17 State Departments of Transportation reviewed HERS/ST Version 1.0 favorably.

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Identify Needs and Candidate Solutions	Identifies deficiencies and candidate improvements for individual highway sections
Benefit-Cost Analysis	Performs benefit-cost analysis for candidate improvements
Investment versus Performance Tradeoffs	Forecasts how changes in highway investment levels affect system condition and performance Forecasts the level of future investment required to ensure specified performance levels are achieved Forecasts the level of future investment required to implement all projects that exceed a specified minimum benefit-cost ratio

Impacts Analyzed

Type of Impact	**Description**
Agency Initial Costs	Calculates initial costs for all selected improvements
Agency Future Costs	Calculates maintenance costs for all sections
Asset Condition	Includes pavement deterioration models. Calculates systemwide average PSR (a measure of pavement condition).
Asset Life	Determines residual value of improvements
Congestion/Mobility Impacts	Includes delays due to incidents as well as recurring congestion. Outputs include: • Travel time benefits • Average speed
Safety Impacts	Accounts for the effects of highway geometric features (e.g., lane widths) on crash rates. Outputs include: • Crashes avoided • Injuries avoided • Lives saved • Safety benefits
Vehicle Operating Cost Impacts	Calculates vehicle operating costs as a function of speed for seven vehicle classes.
Environmental Impacts	Estimates air pollution damage as a function of speed.
Other	Uses short-run and long-run elasticities to account for the effects on traffic volumes of highway system improvements and other changes affecting the cost of highway travel.

Input Requirements

Input	**Default Provided?**
Highway Performance Monitoring System (HPMS) data	No
Unit costs for various types of highway improvements	Yes
Factors to account for state-to-state variations in highway construction costs	Yes
Discount rate to account for time value of money	Yes
Elasticities for estimating the effect of changes in travel time and other user costs on future traffic volumes	Yes
Coefficients for calculating air pollution damage costs as a function of average speed	Yes

Input	Default Provided?
Design levels and various deficiency levels (e.g., minimum tolerable conditions) for highway section features such as lane widths, shoulder widths, etc.	Yes
Unit costs (e.g., value of life, cost per injury) for estimating safety benefits	Yes
Value of time, vehicle costs, and inventory costs by vehicle type	Yes
Price indices to account for changes over time in various unit costs	Yes
Weights specifying the relative importance of various types of benefits in the improvement selection process	Yes
Other parameters affecting the selection of highway system improvements	Yes

Methodology

HERS/ST identifies and evaluates candidate improvement alternatives for individual highway sections in the HPMS data set. For each section, the model predicts future conditions based on current traffic levels, projected traffic growth rates, and pavement deterioration rates. Deficiencies in pavement type and condition, volume-to-capacity ratio, lane and shoulder width, shoulder type, vertical, and horizontal alignment, and median width are identified. Candidate combinations of pavement (resurface, reconstruct), width (widen shoulders, widen lanes, add lanes), and alignment (vertical, horizontal) improvements are identified to correct these deficiencies. In each funding period, benefit-cost ratios are determined for each candidate improvement and the best candidate is selected based on performance criteria and/or funding constraints specified by the user. Systemwide investment and performance levels are then calculated by aggregating results for individual sections.

Assessment

Strengths

- Has recently been reviewed by the Government Accounting Office (GAO), which found the HERS approach to be reasonable and appropriate for application at both the Federal and State level.
- Uses economic criteria (e.g., benefit-cost ratio) rather than strictly engineering criteria in selecting highway improvements.
- Operates with HPMS data, which are compiled by all States for submission to FHWA.

- Accounts for the effects on traffic volumes of highway system improvements and other changes affecting the cost of highway travel.
- Will benefit from future improvements to the national HERS model maintained by FHWA.

Limitations

- Since the model analyzes each highway section independently, it cannot reflect how changes in one part of the highway system affect other parts (such as how traffic might be redistributed as improvements are made).
- The model is not designed to explicitly account for uncertainty, although the effects of changing key assumptions can be handled through sensitivity analyses.
- The model currently excludes certain highway systems (rural minor collectors, rural local roads, and urban local roads) and types of investments (new highways).
- Congestion and environmental effects (e.g., noise) occurring during the construction period are not considered.

Source(s):

http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersdoc.htm

http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersrprep.htm

IDAS

Overview

The ITS Deployment Analysis System (IDAS) is an intelligent transportation systems (ITS) sketch planning tool designed to assist users with planning and deploying ITS. IDAS is used by transportation agencies to integrate the analysis of ITS projects into their long range planning efforts, evaluate the costs and benefits of specific ITS alternatives, and evaluate current systems.

General Information

Developer:	Cambridge Systematics, Inc. for the Oak Ridge National Laboratory and the FHWA
Available From:	McTrans and PCTrans
Date of Last Update:	Early 2002 (Version 2.2)
Software Platform:	Windows-based
Source Code Available?:	No
Level of Use:	150 licenses – used by the FHWA, State DOTs and MPOs

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Benefit cost analysis	IDAS predicts relative costs and benefits for 60 types of ITS investments in the following areas: • Arterial traffic management systems; • Freeway management systems; • Advanced public transit systems; • Incident management systems; • Electronic payment systems; • Railroad grade crossing monitors; • Emergency management services; • Regional multimodal traveler information systems; • Commercial vehicle operations; • Advanced vehicle control and safety systems; • Supporting deployments; and • Generic deployments

Function	Scope (Types of strategies, needs, or projects)
Risk analysis	Performs a Monte Carlo simulation to generate probability distributions for outputs, so that users can assess levels of uncertainty.

Impacts Analyzed

Type of Impact	Description
Travel time/throughput impacts	IDAS determines the impacts in transportation system capacity resulting from the deployment of ITS improvements (e.g., route diversion, mode shift, temporal diversion, and induced/foregone demand)
Environment impacts	IDAS provides a flexible method for users to identify mobile emissions, energy consumption, and noise impacts
Safety impacts	IDAS estimates safety benefits resulting from implementation of ITS strategies. The system uses performance output (e.g., traffic volumes, vehicle miles traveled, and accident rate look-up tables) to determine changes in the number and severity of accidents.
Operating cost impacts	IDAS models impacts to user operating costs and, for transit projects, agency operating efficiency.
Travel time reliability impacts	Improvements to the reliability of travel time are estimated in IDAS by a post-processor following the completion of the final trip assignment. Travel delay can be attributed to congestion, accidents, and vehicle breakdowns.
Customer satisfaction impacts	IDAS quantifies the impacts of customer satisfaction with IT deployment alternatives.

Input Requirements

Input	Default Provided?
ITS projects and alternative descriptions (e.g., option name, component locations, element definitions, etc.)	No
Input from travel demand models (e.g., node coordinate file, network link file, and matrix data file, etc.)	No
Cost data (ITS equipment capital, operations, and maintenance costs, discount rate, etc.)	Yes
Range of impact values (value of time, cost per gallon of gasoline, noise damage costs per vehicle mile, etc.)	Yes

Methodology

IDAS operates as a post-processor to travel demand models, used by Metropolitan Planning Organizational (MPO) and State DOT's for transportation planning purposes. Although a sketch planning tool, IDAS implements the modal split and traffic assignment steps associated with a traditional planning model. These steps are key to estimating the changes in the modal, route, and temporal decisions of travelers resulting from ITS technologies.

Assessment

Strengths

- Economic-based (benefit cost) approach to analyzing operations alternatives.
- Input data generally available at DOTs.
- Default data represent nationally reported benefits and are updated regularly.
- Analysis approach enables users to integrate ITS analyses into their overall planning processes.
- Incorporates risk analysis and produces not only a single best estimate of user costs and NPV but also probability ranges.

Limitations

- IDAS is a sketch planning analysis system. Therefore, it is intended for use as an alternatives analysis tool, not for ITS operations optimization.
- Although many of the input data required for IDAS are available in most DOT's travel demand models, potential users perceive the system's input requirements to be extensive.

Source(s):

http://idas.camsys.com/documentation.htm

MicroBENCOST

Overview

MicroBENCOST analyzes the benefits and cost of proposed highway improvements, including added capacity, bypass, intersection/interchange, pavement rehabilitation, bridge, safety, and highway-railroad grade crossing projects.

General Information

Developer:	Texas Transportation Institute
Available From:	McTrans
Date of Last Update:	June 1999 (Version 2.0)
Software Platform:	DOS-based
Source Code Available?:	No
Level of Use:	To date (August 2002), McTrans has distributed 265 copies of MicroBENCOST

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Diversion Analysis	Allocates traffic between parallel routes in a corridor
Benefit-Cost Analysis	Analyzes highway improvement projects and provides: • Estimates of user benefits, including reductions in travel time, accidents, and vehicle operating costs. • Benefit-cost ratios and net present values of highway user and agency costs.

Impacts Analyzed

Type of Impact	Description
Cost Analysis	Allocates total construction among cost categories with different service lives and salvage values.
Congestion/Mobility Impacts	Calculates capacity based on facility type, number of lanes, lane width, shoulder width, and design speed. Applies average hourly speed by demand-to-capacity ratio and facility type. Adjust speeds for pavement condition Calculates added delays due to incidents and work zones.
Safety Impacts	Applies fatal, injury, and property damage only accident rates by facility type and AADT range
Vehicle Operating Cost Impacts	Applies rates for fuel consumption, oil consumption, tire wear, maintenance and repair cost, and depreciable value by vehicle type, speed, geometric features, and pavement condition.
Environmental Impacts	Applies CO emission rates as a function of speed and vehicle type.

Input Requirements

Input	Default Provided?
Total construction cost	No
Distribution of construction costs by categories, service lives, and salvage values	Yes
Discount rate	Yes
Auto and truck value of time and unit vehicle operating costs	Yes
Discomfort costs for stopped time, congestion, and rough pavements	Yes
Unit costs for fatal, injury, and property damage only accidents	Yes
Functional class, length, number of lanes, intersections/interchanges, median width, curves, and grades for highway segments (with and without improvement)	No
Year-by-year segment AADT for with and without improvement cases (can also be input as base year with growth rate or interpolated)	No
Distribution of traffic by vehicle type and hour of the day	Yes
Lane widths, shoulder widths, capacities, design speed, speed limit	Yes
Special inputs for railroad grade crossing problems (e.g., type of warning device, train speeds, trains per day)	No

Input	Default Provided?
Special inputs for bridge problems (e.g., diversion distances, percent of vehicles diverting, etc.)	No
Pavement condition, maintenance and rehabilitation costs	Yes
Ambient temperatures, altitude, and percent cold start for CO emissions	Yes
Number of days, beginning and ending hour, and number of lanes closed for workzones	No
Number of incidents per million VMT, number of lanes closed, and duration	No
Average speeds by highway type and hourly demand/capacity ratio	Yes
Intersection delays by intersection type and volume	Yes

Methodology

The user specifies highway segment characteristics for "Existing" and "Proposed" routes. Segments may also be specified for "Alternate" routes from which traffic may be diverted. MicroBENCOST will distribute traffic between competing routes so that user costs for the two competing routes are equal. MicroBENCOST does not estimate induced traffic itself, but it allows the user to specify different traffic levels for with and without improvement cases to account for this effect. User benefits are calculated using consumer surplus.

A gross benefit-cost ratio is calculated as the net present value of user benefits divided by the net present value of all agency costs. A net benefit-cost ratio is calculated as total benefits (user benefits plus salvage value plus maintenance cost savings) divided by construction costs.

CO emissions are calculated but not included in the benefit-cost ratios.

Assessment

Strengths

- Provides sufficient detail in inputs to support in-depth benefit-cost analysis of project planning alternatives.
- Provides an extensive set of default values to support system planning and screening of alternatives without specifying design details.

Limitations

- Emissions analysis is limited to carbon monoxide only. Emissions and costs for hydrocarbons, nitrogen oxides, and particulates are not estimated.
- Pavement deterioration is not modeled. However, pavement condition in each year of the analysis period can be input by the user.

Source(s)

Texas Transportation Institute, "MicroBENCOST Version 2.0 User's Manual", prepared for National Cooperative Highway Research Program Project 7-12(2), June 1999.

NBIAS

Overview

The National Bridge Investment Analysis System (NBIAS) is an analysis tool for predicting nationwide bridge, maintenance, improvement, and replacement needs, as well as more than 50 other measures of effectiveness, over a multi-year period for a range of different budget levels.

General Information

Developer:	Cambridge Systematics, Inc. for the FHWA
Available From:	FHWA
Date of Last Update:	July 2001 (Version 2.0); Version 3.0 is currently under development
Software Platform:	Windows-based
Source Code Available?:	Yes
Level of Use:	Used by the FHWA to support development of the national bridge investment strategy

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Estimate Bridge Needs	Estimates needs for an analysis period up to 30 years for range of budget alternatives for a network of bridges: • Improvement needs (widening, raising, and strengthening) • Replacement needs • Maintenance, repair, and replacement (MR&R) needs
Analysis of alternative investment strategies	Provides interactive capability to analyze bridge needs and user benefits for a given budget, and budget required to achieve a set level of needs or benefits. Produces results for different functional classes of bridge, and for National Highways System (NHS) bridges versus non-NHS bridges.

Impacts Analyzed

Type of Impact	Description
Safety impacts	Estimates benefits associated with a decrease in accident rates due to widening or replacing bridges.
Mobility impacts	Estimates benefits associated with: • A decrease in travel time due to strengthening, raising, and replacing bridges. These activities decrease travel time by alleviating truck detours. • A decrease in travel time due to improved deck conditions
Vehicle operation cost (VOC) impacts	Estimates benefits associated with: • A decrease in travel time due to strengthening, raising, and replacing bridges. • A decrease in VOC's due to improved deck conditions

Input Requirements

Input	Default Provided?
NBI data	No
Statistical coefficients for generating element quantities and condition state distributions	Yes
Bridge stratification scheme	Yes
Improvement model parameters (e.g., accident probabilities, constraints on project costs, percentages of trucks detoured by clearance or load deficiencies)	Yes
Policy standards for each functional class, NHS status, and ADT class (level of service standards and design standards)	Yes
Element specifications (e.g., number of environments, condition states, feasible actions per condition state, etc.)	Yes
Unit costs of improvement and replacement actions	Yes
Element condition transition probabilities	Yes
MR&R costs for each element, environment, condition state, and action	Yes
User costs for each element, environment, condition state, and action	Yes

Methodology

The NBIAS Analytical Module calculates improvement and replacement needs based on standard NBI data. The data is also used to synthesize a distribution of bridge elements and conditions for the MR&R analysis. MR&R policy recommendations for this set of elements are based on a Markov decision model. The result of these analyses is a multi-year bridgework program for each scenario defined by the user. Scenarios can be developed using different technical parameters and policies as input. The main outputs of the Analytical Module are simulated measures of effectiveness for each scenario for a number of different budgets or cost benefit ratios.

The NBIAS What-If analysis Module provides a variety of interactive screens and reports that allow the user to investigate the outcomes of a selected scenario.

Assessment

Strengths

- Easy to user interface that enables users real-time access to what-if results.
- Comprehensive, widely accepted analysis methodology.
- Analyzes expenditures based on the combination of economic criteria (e.g., benefit-cost ratio) and engineering criteria.

Limitations

- NBIAS is a network-level tool that is not designed to support analysis of individual projects or their impact on an overall network.
- Projects needs and benefits based on an optimal programming approach that may not yield results that are consistent with the set of projects that would actually be selected in an agency given a particular budget constraint.
- Default models are data intensive and would require significant adaptation for a different scope of application.

Source(s)

Cambridge Systematics, Inc. NBIAS 3.0 (alpha) User Manual, Prepared for FHWA, October 1, 2002.

■ Pavement LCCA Software Tool

Overview

In 1998 the FHWA published a guide on analyzing the life cycle costs of pavement designs. Subsequently, it developed a Life Cycle Cost Analysis (LCCA) software tool that supports the recommended approach.

General Information

Developer:	FHWA – developed through Demonstration Project 115, "Life-Cycle Cost Analysis in Pavement Design"
Available From:	FHWA
Date of Last Update:	Beta version currently available; production version scheduled for release in 2003
Software Platform:	Excel 2000
Source Code Available?:	Yes
Level of Use:	Beta version is being used by one DOT

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Life-cycle cost analysis	Analyzes pavement design alternatives for an individual project. • Relies on user estimates of agency costs. • Predicts user costs due to work zones. • Calculates net present value (NPV).
Risk analysis	Performs a Monte Carlo simulation to generate probability distributions for model inputs and outputs, so that users can assess levels of uncertainty.

Impacts Analyzed

Type of Impact	Description
User costs impacts	Calculates the NPV of user costs associated with encountering a work zone-related queue: • Stopping delay • Vehicle operation costs (VOC) of stopping • Queue delay; and • Idling VOC

Input Requirements

Input	Default Provided?
Project details (e.g., route, project name, region, beginning and ending mile post, etc.)	No
Analysis options (e.g., year of construction, analysis period, discount rate, etc.)	No
Alternative descriptions (e.g., user cost, maintenance cost, expected life, work zone hours and length)	No
Traffic data (AADT, % passenger vehicles, single unit trucks, and combination trucks, annual growth rate)	No
Hourly traffic distribution	Yes
Value of user time (for passenger cars, single unit trucks, and combination trucks)	No
Added time and vehicle stopping costs (added hours per 1,000 stops per vehicle and added cost of 1,000 stops per vehicle)	Yes

Methodology

The LCCA software tool supports steps 4 through 6 of the LCC procedure developed through the FHWA's Demonstration Project 115:

1. Establish design alternatives.
2. Determine activity timing.
3. Estimate agency costs.

4. Estimate user costs – automates user cost method recommended by the FHWA; performs a Monte Carlo simulation to generate probability distributions of inputs and outputs.

5. Develop expenditure streams – predicts costs for up to 40 years then adds residual values for user costs and agency costs for additional years.

6. Calculate net present value – uses constant dollars with a real discount rate.

7. Analyze results.

8. Reevaluate design strategies.

Assessment

Strengths

- Tools supports LCCA procedure that was recommended by FHWA and adopted by AASHTO.

- Input data generally available at DOTs.

- Spreadsheet interface is easy to use.

- User group will be available as more DOT's adopt tool.

- Incorporates risk analysis and produces not only a single best estimate of user costs and NPV but also probability ranges.

Limitations

- Certain defaults may need to be reviewed and updated (some values are from 1996).

- Software reflects limitations of LCCA procedure that it supports:

  – Designed to analyze design alternatives for a single project/location; not intended to support comparison of different projects;

  – Analyzes highway sections independently; does not model impacts of project on the larger network;

  – User cost analysis limited to work zone impacts; model does not consider changes in vehicle operating costs, accidents, or congestion due to the project.

Source(s)

Federal Highway Administration, Life Cycle Cost Analysis in Pavement Design, Pavement Division Interim Technical Bulletin, Report No. FHWA-SA-98-079, September 1998.

www.fhwa.dot.gov/infrastructure/asstmgmt

■ STEAM

Overview

The Surface Transportation Efficiency Analysis Model (STEAM) performs an economic evaluation of multimodal urban transportation system alternatives using the results of the "four-step" travel forecasting processes employed by most Metropolitan Planning Organizations (MPOs).

General Information

Developer:	Cambridge Systematics (under contract to FHWA)
Available From:	FHWA (www.fhwa.dot.gov/steam)
Date of Last Update:	2001 (Version 2.0)
Software Platform:	C++ (with graphical user interface)
Source Code Available?:	Yes
Level of Use:	Used in Portland to analyze regional freight improvements, in New Jersey to estimate user benefits of highway corridor improvements, and in the New York metropolitan area to analyze regional freight strategies.

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Benefit-Cost Analysis	Analyzes highway and transit capital projects, pricing, and travel demand management (TDM) actions and provides: • Estimates of user benefits, including reductions in travel time, accidents, and vehicle operating costs. • Estimates of non-user benefits, including reductions in costs for air pollution, noise, and greenhouse gas emissions • Net benefits and benefit-cost ratios
Accessibility Analysis	Provides estimates of the number of jobs within x minutes of a user-defined district.
Risk Analysis	Produces probability distributions for model outputs, so that users can assess levels of uncertainty.

Impacts Analyzed

Type of Impact	Description
Agency Costs	Annualizes agency costs for comparison to analysis year benefits
Congestion/Mobility Impacts	Post-processes traffic assignment volumes generated from conventional four-step planning models in order to get more accurate highway travel speeds, especially under congested conditions. Accounts for delays due to incidents (using data on the frequency, severity, and duration of incidents), peak spreading that occurs when facilities become more congested, and day-to-day variations in traffic. Outputs include person hours of in-vehicle and out-of-vehicle time
Safety Impacts	Applies accident rates by facility type. Outputs include: • Fatal accidents • Injury accidents • Property damage only accidents • Accident costs
Vehicle Operating Cost Impacts	Applies fuel consumption rates (gallons per mile) as a function of speed and vehicle type. Applies unit costs for non-fuel operating costs as a function of vehicle type.
Environmental Impacts	Calculates emissions for autos, trucks, and carpools as the sum of: 1) mileage-based emissions on the highway system (calculated under the assumption that vehicles are already warmed up); and 2) added emissions due to cold starts. Mileage-based emissions are calculated as a function of speed. Calculates noise costs based on noise damage rates by type of vehicle and facility. Outputs include: • HC, CO, NOx, and PM_{10} emissions and costs • CO_2 emissions and costs • Noise costs
Other	Calculates accessibility measures such as the number of jobs within x minutes of a specified area Calculates revenue transfers associated with changes in tolls and fares.

Input Requirements

Input	Default Provided?
Highway network files produced by traffic assignment procedures (for Base Case and each alternative to be analyzed)	No
Trip tables indicating the number of trips between each pair of analysis zones	No
Zone-to-zone transit travel times (if transit improvements are included in the system alternatives to be analyzed)	No
Population and employment by zone (if accessibility measures are to be produced)	No
Transit service changes (systemwide vehicle miles, vehicle hours, and peak vehicles)	No
Capital costs	No
Maintenance costs	No
Residual values	No
Discount rate to account for time value of money	Yes
Cost and tax per gallon of fuel	Yes
Emission rates (by speed range) and emission costs for HC, CO, NOx, and PM_{10}	Yes
Accident rates (by highway class) and unit costs for fatal, injury, and property damage accidents	Yes
Fuel consumption rates by speed range	Yes
Non-fuel vehicle operating cost per mile	Yes
Value of in-vehicle and out-of-vehicle travel time	Yes
Noise cost per vehicle mile by facility type	Yes
Transit agency costs (per vehicle mile, vehicle hour, and peak vehicle)	Yes
Other external costs per vehicle mile and non-mileage-based external cost (e.g., construction period impacts)	No

Methodology

STEAM 2.0 consists of four modules:

1. A User Interface Module, which includes on-line help files.

2. A Highway Network Analysis Module, which reads a file containing vehicular traffic volumes, highway segment lengths, highway capacities, and other link data and produces zone-to-zone travel times and distances based on minimum time paths through the network.

3. A Trip Table Analysis Module, which produces estimates of user benefits, based on a comparison of Base Case and Improvement Case conditions for travel between each pair of zones. It also produces estimates of emissions, noise costs, accident costs, energy consumption, and other external costs associated with highway use.

4. An Evaluation Summary Module, which calculates net benefits and a benefit-cost ratio for the improvement under consideration. It also provides summary information on individual benefit and cost items (including results by user-defined districts), and probability distributions for selected outputs.

Assessment

Strengths

- Uses the outputs of the four-step travel forecasting models used by most MPOs.
- Can evaluate multimodal investment alternatives, as well as pricing policies.
- Produces systemwide measures of the effects of transportation system changes, and also shows distributional effects by producing results for different modes, trip purposes, and geographic areas.

Limitations

- Highway network travel times may differ from those used in the traffic assignment process.
- Does not produce estimates of systemwide traffic increases that might result from highway improvements (though it can account for these increases if they are reflected in the MPO's forecasting models).
- Does not incorporate economic development impacts.

Source(s)

Cambridge Systematics, Inc. Surface Transportation Efficiency Analysis Model (STEAM 2.0) User Manual, prepared for Federal Highway Administration, December 2000.

http://www.fhwa.dot.gov/steam/

■ StratBENCOST

Overview

StratBENCOST estimates the effects of proposed highway improvements and performs economic efficiency analyses. With the amount of required engineering and design detail held to a minimum, it is designed to assist in comparing large numbers of projects in the concept stage.

General Information

Developer:	Hickling Lewis Brod Inc. (under NCHRP Project 2-18(4))
Available From:	McTrans
Date of Last Update:	August 1999 (StratBENCOST32)
Software Platform:	Windows-based
Source Code Available?:	No
Level of Use:	To date (August 2002), McTrans has distributed 9 copies of StratBENCOST

Type and Scope of Tool

Function	**Scope (Types of strategies, needs, or projects)**
Benefit-Cost Analysis	Analyzes highway improvement projects and provides: • Estimates of user benefits, including reductions in travel time, accidents, and vehicle operating costs. • Estimates of benefits due to reduction in air pollution. • Benefit cost ratios, net present value, rate of return, and payback period.
Risk Analysis	Produces probability distributions for model outputs, so that users can assess levels of uncertainty.

Impacts Analyzed

Type of Impact	Description
Congestion/Mobility Impacts	Applies speed by V/C ratio and facility type
Safety Impacts	Applies fatal, injury, and property damage only accident rates by facility type and AADT range
Vehicle Operating Cost Impacts	Calculates constant speed vehicle operating costs and excess costs due to speed changes. Applies rates for fuel consumption, oil consumption, tire wear, maintenance and repair cost, and depreciable value by speed, V/C, and pavement condition for autos, trucks, and buses.
Environmental Impacts	Applies HC, CO, and NOx emission rates as a function of speed for autos, buses, and trucks.
Other	Uses elasticity of demand with respect to user cost to account for the effects on traffic volumes of highway system improvements.

Input Requirements

Input	Default Provided?
Discount rate	Yes
Elasticity of demand with respect to travel cost	Yes
Project duration	Yes
Pavement condition variables, including current PSI, PSI after resurfacing, PSI after repaving, PSI deterioration rates following resurfacing and repaving	Yes
Facility type, capacity, number of lanes, grade	Yes
Current AADT, AADT growth rate, and vehicle mix (autos, trucks, buses)	Yes
Length of peak period and percent of vehicles in peak	Yes
Construction, right-of-way, maintenance, and other costs	Yes
Unit costs for fatal, injury, and property damage only accidents	Yes
Unit costs for vehicle operating cost components	Yes
Unit costs for CO, HC, and NOx emissions	Yes
Value of time for autos, trucks, and buses (with and without congestion premium)	Yes
Threshold for congestion premium (V/C ratio)	Yes

Input	Default Provided?
Fatal, injury, and property damage only accident rates by facility type and AADT range	Yes
Auto, truck and bus emission rates for CO, HC, and NOx by speed	Yes
Speed and congestion delay by facility type and V/C ratio	Yes
Fuel consumption, oil consumption, tire wear, maintenance and repair cost, and vehicle depreciation rates by speed, V/C ratio, and pavement condition.	Yes

Methodology

StratBENCOST contains both single segment and network analysis models.

In the single segment model, "Base Case" and "Alternative" facility characteristics are input for the segment. Default characteristics are provided for several different types of highway improvement projects (e.g., pavement reconstruction, widening, new location, etc.). Differences between Base Case and Alternative highway user and environmental costs are estimated.

In the network analysis model, Base Case and Alternative vehicle miles of travel and vehicle hours of travel (such as might be produced by a conventional traffic assignment model) are input by facility type.

In both models, differences between Base Case and Alternative highway user and environmental costs, along with construction and maintenance costs input by the user, are used to calculate economic efficiency measures.

Assessment

Strengths

- Provides an extensive set of default values for calculating highway user costs, so that minimal inputs are required and projects in the conceptual stage of design can be analyzed.
- Incorporates risk analysis and produces not only a single best estimate of user costs and NPV but also probability ranges.
- Incorporates an elasticity that allows demand on highway sections to vary in response to changes in speed.

Limitations

- Does not calculate the effects of highway improvements on delays due to incidents. Travelers find unanticipated delays (such as those caused by incidents) to be much more costly than normal travel time. Hence, ignoring these delays can result in an understatement of highway improvement benefits.

- The single segment model is designed to analyze projects in sparsely populated or rural areas and does not account for traffic diverted to or from other facilities. However, the network analysis model can handle projects in dense urban settings since it includes other facilities.

- Uses some relationships in calculating costs that are now significantly out of date. For example, air pollution costs are calculated using emission rates taken from a 1982 study. Also, speed-volume relationships are from the 1985 *Highway Capacity Manual*.

Source(s)

Hickling Lewis Brod, Inc. "Users's Manual For STRATBENCOST32", NCHRP 2-18(4), August 20, 1999.

"Development and Demonstration of StratBENCOST Procedure", National Cooperative Highway Research Program Research Results Digest, March 2001 – Number 252

TransDec

Overview

TransDec is designed to provide structure to multimodal transportation investment decisions by requiring the user to specify a hierarchy of goals, objectives, measures, and rating scales. It calculates total scores for decision alternatives based on rating scales values and weights provided by the user.

General Information

Developer:	Texas Transportation Institute
Available From:	McTrans
Date of Last Update:	1998
Software Platform:	Windows-based (Visual Basic)
Source Code Available?:	No
Level of Use:	To date (August 2002), McTrans has distributed 10 copies of TransDec

Type and Scope of Tool

Function	Scope (Types of strategies, needs, or projects)
Multi-criteria investment analysis	Can be applied to decisions involving the application of multiple criteria at the system or project level.
State and MPO planning	Encourages explicit definitions of goals and objectives as well as uniformity of data and performance measures.

Impacts Analyzed

Type of Impact	Description
NA	Does not perform impact analysis. Rating scale values for each alternative must be input by user.

Input Requirements

Input	**Default Provided?**
List of goals	No
List of objectives for each goal	No
A measure for each objective	No
A rating scale for each measure	No
Rating scale weights and values for each alternative	No

Methodology

TransDec leads the user through a process of specifying goals, objectives, and measures that will serve as the basis for evaluating decision alternatives. A "dictionary" of transportation-related goals, objectives and measures is provided (though the user can specify their own if they so choose). TransDec then asks the user to define a rating scale for each measure, to assign weights to each scale (to reflect their relative importance), and to apply the rating scales to evaluate each of the decision alternatives under consideration. It can handle different types of rating scales (e.g., numerical, yes/no, excellent/good/fair/poor) and provides different ways for the user to assign weights to each rating scale (e.g., pairwise, normalized numbers).

Assessment

Strengths

- Easy to install and use.
- Provides lists of general transportation-related goals along with a list of objectives and measures for each goal.
- Useful in structuring and making explicit the basis for decisions.

Limitations

- Provides no analytical capability beyond applying user-defined rating scale weights and scores to assign an overall score to alternatives.
- Goals in the "dictionary" are vague and overlapping (e.g., "Improve mobility," "Improve accessibility," "Increase cost-effectiveness," "Improve the economy").
- Does not deal with possible interdependencies among rating scales, such as instances where two rating scales are different measures of the same thing (so that using them both is double-counting).

Source(s)

"Development of a Computer Model for Multimodal, Multicriteria Transportation Investment Analysis", National Cooperative Highway Research Program Research Results Digest, September 2001 – Number 258